EFFECT OF BISPYRIBAC-SODIUM AND SPACING ON THE WEED CONTROL AND PERFORMANCE OF AROMATIC RICE VARIETIES

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*This is to certify that thesis entitled, "**EFFECT OF BISPYRIBAC-SODIUM AND SPACING ON THE WEED CONTROL AND PERFORMANCE OF AROMATIC RICE VARIETIES**" submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfilment of the requirements for the degree of **MASTER OF SCIENCE (M.S.) in AGRONOMY**, embodies the result of a piece of bona-fide research work carried out by **Fatema Tuz Zannat Bushra,** Registration no.**14-05828** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.*

I further certify that such help or source of information, as has been availed of during the course of this investigation ,has duly been acknowledged.

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DEDICATED TO

MY

BELOVED PARENTS

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ABSTRACT

A field experiment was carried out at the Agronomy research field of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh from July to December-2019, to investigate the effect of bispyribac-sodium and spacing on the weed control, growth, and yield of aromatic rice varieties in Bangladesh. The experiment consisted of three factors i.e., weed control treatment (2) *viz.*weedy check (no weeding) and Bispyribac - sodium WP @ 150 gha^{-1}; aromatic rice varieties (2) *viz.* Kalizira and BRRI dhan37, and spacings (4) *viz.* 20 cm × 15 cm, 25 cm × 15 cm, 20 cm × 20 cm, 25 cm × 25 cm. The experiment was laid out in a split-split plot design with three replications. Thirteen different weed species infested the experimental plots belonging to nine families where the most dominating was broad leaf and sedge weed species and among different weeds, *Monochoria vaginalis* was the most dominant weed (24.67 and 19.67 density m^{-2} and 15.93 and 16.98 % relative density) at 30 and 60 DAT. Application of different weed control treatments, varieties, spacings and their combination significantly influenced weed regime and crop performance. Application of bispyribac-sodium WP @ 150 g ha^{-1} reduced weed growth and biomass and increased grain yield. BRRI dhan37 rice variety recorded the maximum grain yield (2.99 t ha^{-1}). Among different spacing 20 cm × 20 cm reduced weed density and recorded the maximum grain yield allowing a relevant reduction of herbicide input. Although optimal weed control and good yield were achieved without significant differences between all treatments, the highest yield (3.20 t ha^{-1}) and benefit-cost ratio (1.48) was achieved by the combination of Bispyribac-sodium WP @ 150 g ha^{-1} along with BRRI dhan37 and 20 cm × 20 cm. Therefore, the application of bispyribac-sodium WP @ 150 g $ha^{-1}$with 20 cm × 20 cm spacing seemed to be the best way of controlling complex weed flora and enhancing productivity and profitability from transplanted aromatic rice.

LIST OF CONTENTS

LIST OF CONTENTS (Cont'd)

LIST OF CONTENTS (Cont'd)

LIST OF CONTENTS (Cont'd)

LIST OF TABLES

LIST OF TABLES (Cont'd)

LIST OF TABLES (Cont'd)

LIST OF TABLES (Cont'd)

LIST OF FIGURES

LIST OF FIGURES (Cont'd)

LIST OF FIGURES (Cont'd)

LIST OF FIGURES (Cont'd)

LIST OF FIGURES (Cont'd)

LIST OF APPENDICES

LIST OF APPENDICES (Cont'd)

LIST OF PLATES

LIST OF ACRONYMS

AEZ	Agro-Ecological Zone
BARI	Bangladesh Agricultural Research Institute
BAU	Bangladesh Agricultural University
BBS	Bangladesh Bureau of Statistics
CV%	Percentage of coefficient of variance
cv.	Cultivar
DAE	Department of Agricultural Extension
DAT	Days after transplanting
^{0}C	Degree Celsius
et al	And others
FAO	Food and Agriculture Organization
g	gram(s)
ha^{-1}	Per hectare
HI	Harvest Index
i.e.	That is
kg	Kilogram
Max	Maximum
mg	Milligram
Min	Minimum
MoP	Muriate of Potash
Nk	Nitrogen
No.	Number
NS	Not significant
%	Percent
SAU	Sher-e-Bangla Agricultural University
SRDI	Soil Resources and Development Institute
t	Ton
TSP	Triple Super Phosphate
Wt.	Weight
q	Quintal
Rs	Rupees
B:C	Bnefit: Cost
@	At the rate
cm	Centimeter
m	Meter

CHAPTER-I

INTRODUCTION

Rice (*Oryza sativa* L.) is the most important food crop and a primary food source for more than one-third of the world's population (Sarkar *et al.,* 2017). Worldwide, rice provides 27% of dietary energy supply and 20% dietary protein (Kueneman, 2006). It constitutes 95% of the cereal consumed and supplies more than 80% of the calories and about 50% of the protein in the diet of the general people of Bangladesh (Yusuf, 1997). The world's rice demand is projected to increase by 25% from 2001 to 2025 to keep pace with population growth (Hossain *et al.,* 2016), and therefore, meeting this ever-increasing rice demand in a sustainable way with shrinking natural resources is a great challenge. In Bangladesh, the majority of food grains come from rice. Rice has a tremendous influence on the agrarian economy of the country. The annual production of rice in Bangladesh is about 36.28 million tons from 11.52 million ha of land (BBS, 2018). The country is expected to import 200,000 tonnes of rice in the 2020-21 marketing year to ease food security tensions brought on by the COVID-19 pandemic situation (USDA, 2021).

There are three distinct growing seasons of rice in Bangladesh, according to changes in seasonal conditions such as *aus, aman*, and *boro*. More than half of the total production (55.50 %) is obtained in *boro* season occurring in December–May, second largest production in *aman* season (37.90 %) occurring in July-November and little contribution from *aus* season (6.60 %) occurring in April-June (APCAS, 2016). Among three growing seasons, *aman* rice occupies the highest area coverage. The *aman* rice crop occupies 67 percent of the cropped area of 85.77 hectares. Almost 78 percent of the land is occupied by the HYV varieties supported by the Department of Agricultural Extension with pesticides, and laboratory seeds, while only 12.5 percent are local/traditional varieties cultivated by the farmers on their own initiatives in low lands (BBS, 2017). In 2020, the amount of land used for HYV varieties is 44.47 lakh (4.44 million) hectares, hybrid 2.40 lakh (0.24 million) hectares, local varieties 7.15 lakh (0.75 million) hectares and for broadcast aman 3.12 lakh (0.31 million) hectares of cultivable land. The total land under the aman crop was 57.14 lakh (5.71 million) hectares (Magzter, 2021).

Aromatic rice is a special type of rice containing a natural ingredient named 2-acetyl-1-pyrroline, which is responsible for their fragrant, taste, and aroma (Gnanavel and Anbhazhagan,2010) and had 15 times more 2-acetyl-1- pyrroline content than non-aromatic rice, ranges 0.14 -0.009 ppm, respectively (Singh, 2000). In addition, there are about 100 other volatile compounds, including 13 hydrocarbons, 14 acids, 13 alcohols, 16 aldehydes, 14 ketones, 8 esters, 5 phenols, and some other compounds, which are associated with the aroma development in rice. Most of the aromatic rice varieties in Bangladesh are traditional photo-period sensitive types and are grown during *aman* season (Chowdhury *et al.,* 2017). Cultivation of aromatic rice has been gaining popularity in Bangladesh over recent years, because of its huge demand both for internal consumption and export (Das and Baqui, 2000). The popularity came at a time when Bangladesh has been struggling in the aromatic rice export market due to a lack of price competitiveness owing to low-yield potentials. Aromatic rice is there in Bangladesh's export basket since 2012 fetching a yearly earning of Tk 80 crore (Salam *et al*., 2020). But further growth is being hindered due to the farmers' reluctance in growing fragrant rice, which yields less compared to non-aromatic fine varieties. The average yield of rice is almost less than 50% of the world's average rice grain yield. The national mean yield (2.60 t ha^{-1}) of rice in Bangladesh is lower than the potential national yield (5.40 t ha^{-1}) and world average yield (3.70 t ha^{-1}) (Pingali *et al.,* 1997). The lower yield of aromatic rice has been attributed to several reasons such as lack of high-yielding varieties, weed infestation, fluctuation of the market prices, lack of knowledge of the handling of agronomic managements practices, etc. In such conditions, increasing rice production can play a vital role. Therefore, attempts must be made to increase the yield per unit area by adopting modern rice varieties, applying improved technology, and agronomic management practices.

Crop performance is closely related to weed growth. Weeds are the most important threat, resulting in yield losses between 30 and 98 percent (Ramana *et al.,* 2014). Among the harmful pest, weeds contribute maximum losses in crop production, which may potentially reduce crop production by 34%, followed by animal pests (18%) and pathogens by 16% (Abbas *et al.,* 2018). The high competitive ability of weeds exerts a serious negative effect on crop production. Globally, actual yield losses due to pests have been estimated at approximately 40%, of which weeds caused the highest loss (32%) (Rao *et al.,* 2007). Weeds compete with rice plants severely for space, nutrients, air, water, and light and adversely affect the plant height, leaf architecture, tillering habit, and crop growth (Salam *et al*., 2020). In Bangladesh, weed infestation reduces the grain yield by 70-80% in *aus* rice (early summer), 30- 40% for transplanted *aman* rice (autumn), and 22-36% for modern *boro* rice varieties winter rice) (BRRI, 2008). Although hand weeding is the popular weed control method in Bangladesh, weed control is often imperfect or delayed due to the unavailability of labor during the peak period. Mechanical weeding and chemical weed control are the alternatives to hand weeding. In recent years, chemical weed control (herbicide application) has increased in Bangladesh (Ahmed *et al*., 2014).

Nowadays the use of herbicide is gaining popularity in rice culture due to their rapid effects and less cost involvement compared to traditional methods of weeding (Hasan, 2016). However, removal of weeds at their critical period by traditional means may not be possible at the peak period of labor demand. In such a situation herbicides are promising alternatives in controlling weed (MacLaren *et al*., 2020). But continuous and indiscriminate use of herbicides may alter their degradation and pose persistence problems due to residual effects beyond harvest, threatening health and ecology. The use of herbicides of a different mode of action and chemistry is desirable to reduce the problem of residue buildup, a shift in weed flora (Rajkhowa *et al.,* 2006), and the development of herbicide resistance in weeds (Rao, 1999). Most of the herbicides do not have much potential to be toxic to humans and animals as other pesticides. However, they should be used with care and proper awareness. A good herbicide is effective against a broad spectrum of weeds, when does not injure the crop and remains in soil sufficiently to control the weeds within the crop growth period. Bispyribac-sodium [sodium 2,6-bis-(4,6-dimethoxy-2-pyrimidinyl)oxy benzoate] belongs to benzoic acid group of herbicides and is a selective, systemic, broad-spectrum, and post-emergent new generation herbicide recommended for paddy field to control a broad spectrum of weeds. This herbicide has become more popular due to its high activity at low application rates and low mammalian toxicity (De *et al*., 2014).

Rice varieties colossally affect the development and pervasion of weed in the field. Normally short-height varieties face more weed infestation than the taller ones (Rabbani, 2016). Thus, to keep away from the weed rivalry and to get the greatest yield from rice, an appropriate variety ought to be chosen. The major aromatic varieties identified are Kalizira, Chinigura, Kataribhog, BR5(Dulabog), Bashful, BRRI dhan34, BRRI dhan37, BRRI dhan38 (Bashmotitype), Khaskani, Badshabhog, Dudshagar, Tulshimala, Khirshabhog, Horibhog, Parbatjira, Khasha, Modhumadab, Tilkapur,Chinikanai, Khirkon, and Shakhorkora. Local varieties can yield 1.87-2.99 t $ha^{-1}$of rice, while the high-yielding ones produce 4.48-8.21 t ha^{-1}. In Bangladesh, BINA, BRRI, IRRI, and diverse seed organizations have been presented high-yielding rice varieties and it acquires positive monumental in rice production for the particular three distinct growing seasons (Haque and Biswas, 2011). Improving and expanding the world's supply will likewise rely on the development and improvement of rice varieties with better yield potential, and to adopt different traditional and biotechnological approaches for the advancement of high yielding varieties that have resistance against various biotic and abiotic stresses (Khush, 2005). Recently various new rice varieties were developed by BRRI with exceptionally high yield potential. Nowadays different high-yielding rice varieties are available in Bangladesh which has more yield potential than different conventional varieties (Akbar, 2004). In the fiscal year 2015-16, aromatic rice production was around 2,90,000 tonnes, of them, about 105,000 tonnes were of BRRIdhan34.The growth process of rice plants under different agro-climatic conditions differs due to the specific rice variety (Alam *et al*., 2012). Compared with conventional varieties, the high-yielding varieties have larger panicles resulting in an average increase of rice grain is 7.27% (Bhuiyan *et al*., 2014). These high-yielding and hybrid rice variety, however, needs further evaluation under the different adaptive condition to interact with different agro-climatic conditions.

Plant spacing is one of the key variables deciding rice productivity and its weed suppressive capacity. Plant spacing decides solar-based radiation interception, canopy coverage, and dry matter accumulation of rice and hence impacts its weed competitiveness (Anwar *et al.,* 2011).As reported by (Sunyob *et al*., 2012), closer spacing may result in mutual shading, high intra-specific competition, and pest and disease infestation. But at higher plant density, canopy development is very fast,which helps to suppress weeds effectively and in contrast, at lower plant density, space and resources remain unutilized,which encourages weed growth (Guillermo *et al*., 2009). Wide row spacing with simultaneous high intra row plant population may induce dense weed growth. But the square method of planting is ideal to reduce intra row competition. Therefore, rice plant spacing must be optimized for ensuring higher rice yield and better weed suppression (Anwar *et al.,*2013). Optimum plant spacing for rice cultivation may vary depending upon varietal characters, growing season, planting method, and agronomic management.

In Bangladesh, few studies have been conducted to find out the effect of varieties and spacing on the weed control, growth, and yield of aromatic rice. Research work on the combined effect of weed control, variety, and spacing was limited. Considering the above facts the present study was undertaken with the following objectives:

i. Identify competitiveness of local and modern aromatic *aman* rice varieties of Bangladesh against weeds
ii. Find out the efficiency of Bispyribac-sodium on the weed control of aromatic rice
iii. Assess the different spacings for suppressing weeds in aromatic rice.
iv. Work out economics of the treatments

CHAPTER II

REVIEW OF LITERATURE

Reduction in crop yields due to weeds result from their multifarious ways of interfering with crop growth and crop culture. Weeds compete with crops for one or more plant growth factors such as mineral nutrients, water, solar energy, space and they can also host pests and diseases that can spread to cultivated crops and hinder crop cultivation operations.In agronomic point of view, weed management has become a vital issue for modern rice cultivation. Increasing the yield of rice by using appropriate varieties, maintaining proper spacing,and proper weed management methods plays an important role in increasing crop yield by reducing weed competition and providing proper spacing for growth and development of rice, which influences grain yield. Considering those points, the available literature is mentioned below.

2.1 Presence of weed species in rice field

Bhuiyan and Mahbub (2020) experimented to know the performance of Bensulfuron Methyl 1.1% + Metsulfuron Methyl 0.2%+ Acetochlor 14% WP against a wide range of weed control in transplanted rice of Bangladesh. Field trials were conducted at Bangladesh Rice Research Institute (BRRI), Gazipur during *aman*, 2016 and *boro*, 2016-17 to evaluate the efficacy of Bensulfuron methyl 1.1% + Metsulfuron methyl 0.2%+ Acetochlor 14% WP on weed suppression and performance of transplanted rice. Bensulfuron methyl 1.1% + Metsulfuron methyl 0.2%+ Acetochlor 14% WP @ 75, 90 and 105 g ha^{-1}were applied along with Bensulfuran methyl 14%+ Acetochlor 14% WP @ 750 g ha^{-1}, weed-free and unweeded control was used for assessment. In this experiment, the rice field was infested with different types of weeds. Among the infesting different categories of weeds, two were grasses, two sedges, and four broadleaves. The weed species were belonging to the families of Poaceae, Cyperaceae, Pontederiaceae, Marsileaceae, Sphenocleaceae, and Asteraceae. The broad-leaved were: *Monochoria vaginalis, Marsilea minuta*, *Sphenoclea zeylanica*,and *Eclipta alba*; grasses were: *Echinochloa crus-galli, Cynodon dactylon*; and sedges were *Cyperus difformis* and *Scirpus maritimus.*

Mishra (2019) carried out a field study through front line demonstrations during Kharif season of 2017 and 2018 in villages of Ganjam district i.e., Gudiapalli, Jharapadar, Putipadar in Odisha on farmers field with the active participation of farmers to evaluate the effect of herbicide Bensulfuron methyl plus pretilachlor in weed management of transplanted Kharif rice. The results revealed that the predominant weed flora observed during the study was *Digitaria sanguinalis, C. dactylon,E. colonum* among the grasses,*C. difformis, C. iria, C. rotundus* among the sedges, and *Ludwigia parviflora, Ageratum conyzoides, Cleome viscose, Ammania baccifera* and *Eclipta alba* among the broadleaved weeds were present as major weeds throughout the cropping period.

Yadav *et al.* (2018) conducted a field experiment at CCS HAU, Regional Research Station, Karnal during Kharif 2010 to 2014 to evaluate the bio-efficacy of pretilachlor 6.0% + pyrazosulfuron-ethyl 0.15% GR (ready-mix) against complex weed flora in transplanted rice and also to study its residual effects. Results from on station experiment (2010 and 2011) revealed that the weed flora of the experimental field consisted of *E. crus-galli* (grassy), *Ammannia baccifera* broad-leaf weed (BLW), and *C. difformis* and *Fimbristylis miliaceae* among sedges during Kharif 2010. During Kharif 2011, the weed flora of the experimental field consisted of *E. crus-galli, Leptochloa chinensis, Eragrostis tenella* among grasses, *A. baccifera* (BLW), and *C. rotundus, C. difformis* and *F. miliaceae* among sedges.

Yadav *et al.* (2009) carried out a study on the efficacy of bispyribac-sodium during Kharif 2006 and 2007 at CCS Haryana Agricultural University Regional Research Station. The treatments included bispyribac 15, 20, 25, 30 and 60 g/ha each at 15 days after transplanting 25 DAT, pretilachlor 750 and 1000 g ha^{-1} at 3 DAT, and butachlor 1500 g ha^{-1} at 3 DAT along with weedy and weed-free checks. The experiment was laid out in a randomized block design with three replications. The major associated weeds in rice fields were *E.*glabrescens, and *E. colona* (L.) among grasses, *A. baccifera* L. and *Euphorbia* sp. among broad-leaved weeds, and *F. miliacea* (L.), *C. iria* L., *C. rotundus* L. and *C. difformis* L. among sedges.

Bari *et al*. (1995) in the experiment at BAU reported that the three important weeds of transplanted *aman* rice fields were *F. miliacea*, *Paspalum scrobiculatum*, and *C. rotundus*.

Mamun *et al.* (1993) reported that *F. miliacea*, *Lindernia antipola* and *Eriocaulen cenerseem* were important species of weeds in transplant *aman* rice field.

2.2 Effect of weed control treatment

Weed density

Bhuiyan and Mahbub (2020) based on their experiment observed that Bensulfuron methyl 1.1% + Metsulfuron methyl 0.2%+ Acetochlor 14% WP @ 105 g ha^{-1} showed a good weed control efficiency but slightly phytotoxicity found in this dose. So it may be suggested from this study that Bensulfuron methyl 1.1% + Metsulfuron methyl 0.2%+ Acetochlor 14% WP @ 90 g ha^{-1} applied at one to two-leaf stage of weed may be effective for annual weed control option instead of hand weeding at the peak period of labor to increase yield in transplanted rice.

Paulraj *et al.* (2019) carried out a field study during Samba season of 2017 to evaluate the efficacy of pre and post-emergence herbicides in transplanted rice. The herbicides evaluated were Pretilachlor 6% + Pyrazosulfuron-ethyl 0.15% GR @ 10 kg ha^{-1} along with post-emergence herbicides Fenoxaprop-p-ethyl 9.3% w/w @ 875 ml ha^{-1}, Bispyribac-sodium 10% SC @ 200 ml ha^{-1}. Results of the study revealed that among the treatments, application of (Pretilachlor + Pyrazosulfuron ethyl) + Bispyribac-sodium recorded the least weed count of 3.22 m^{-2}, 0.52 m-^{2}, 2.59 m^{-2}, 1.54 m^{-2}, 0.52 m^{-2}, 0.54 m^{-2}, 1.26 m^{-2} of *E. colona,L. chinensis*, *C. rotundus*, *Marsilea quardrifolia*, *S. zeylanica*, *E.alba* ,respectively on 60 DAT. The treatment (Pretilachlor + Pyrazosulfuron ethyl + Fenoxaprop-p-ethyl was next in order and the treatment twice hand weeding on 20 and 40 DAT were on par. The highest weed count of 33.37 m^{-2}, 12.96 m^{-2}, 22.44 m^{-2}, 16.06 m^{-2}, 12.96 $m^{-2}$of *E. colona*, *L. chinensis*, *C. rotundus*, *M.quardrifolia*, *S. zeylanica*, *E. alba*on 60 DAT, respectively were recorded in unweeded control.

Mishra (2019) reported that pre-emergence application of Bensulfuron methyl 60g /ha + Pretilachlor 600 g/ha at 3 DAT recorded better weed control than hand weeding with weed density 14.2, 27.3, and 37.4 m^{-2} at 30, 60, and 90 DAT, respectively. This was due to the application of herbicide, which might have prevented the germination of susceptible weed species and also reduced the growth of germinated weeds by inhibiting the process of photosynthesis. Weedy check recorded the maximum weed density 73.4, 104.2, and 128.6 m^{-2} at 30, 60, and 90 DAT, respectively.

Mahbub and Bhuiyan (2018) observed that the mixture of herbicides gave 80% control of annual and perennial weeds comparable to individual application of herbicides.

Yadav *et al.* (2009) reported that reduction density of grassy, as well as broadleaved weeds and sedges, increased with a corresponding increase in the dose of bispyribac-sodium.

Rekha *et al.* (2003) reported that the weed density was highest in the weed check condition, and weed density was decreased under different weed management treatments, and among various treatments, all herbicidal treatments reduced weed density significantly compared with weedy check.

Reddy *et al*. (2000) reported that weed control through herbicide effect on the germinating weed seeds over a prolonged duration and thereby exhausting the weed seeds over a prolonged duration and thereby exhausting the weed seed reserves in the soil and thus reducing weed density in the crop field.

Weed dry matter weight

Mishra (2019) reported that the lowest weed dry weight was recorded with the application of Bensulfuron methyl 60g ha^{-1} + pretilachlor 600 gha^{-1} at 3 DAT with 8.13, 21.3, and 26.9 g m^{-2} at 30, 60 and 90 DAT,respectively might be due to effective control of weeds during early stages of crop growth by the herbicide. Untreated weedy check produced the maximum weed dry weight at all the crop growth stages (31.3 to 54.3g m^{-2}) because of higher weed intensity and its dominance in utilizing the sunlight, nutrients, moisture,etc.

Suryakala *et al.* (2019) reported that all the weed control measures caused a significant reduction in the density of all the weeds over the weedy check. Weed dry matter was highly influenced by the differen tial application of herbicides, their combinations, and integration with manual weeding. Significantly lowest weed dry matter (26.82 kg ha^{-1}) was recorded in treatment *i.e.,* Pretilachlor + Pyrazosulfuron-ethyl + Bispyribac-sodium, followed by Pretilachlor + Pyrazosulfuron-ethyl+ Fenoxaprop-p-ethyl (70.07 kg ha^{-1}) and the treatment twice hand weeding on 20 and 40 DAT (74.54 kg ha^{-1}) was on par. The highest weed dry matter production of 349.38 kg ha^{-1} on 60 DAT was recorded in unweeded control.

Das *et al.* (2017) reported that among the tested herbicides, bispyribac-sodium 10 WP at 30 g ha^{-1} applied at 25 days after transplanting (DAT) was most effective to check all types of weed population and their growth resulting in the lowest biomass of weeds due to its higher weed control efficiency.

Kumar *et al.* (2014) reported that pre-emergence application of bensulfuron methyl + pretilachlor at 660 g a.i. ha^{-1} on 3 DAT and one hand weeding on 35 DAT recorded significantly higher grain and straw yield (6710 and 7717 kg ha^{-1}, respectively), lower weed population (31.33 no. m^{-2}), and their dry weight (37.80 kg ha^{-1}).

Weed control efficiency

Bhuiyan, and Mahbub (2020) reported that the lower weed biomass as well as higher weed control efficiency in all the growing seasons exhibited by Bensulfuron methyl 1.1% + Metsulfuron methyl 0.2%+ Acetochlor 14% WP. Weed control efficiency improved with increase of herbicide dose irrespective of weed species.

Mishra (2019) reported that the weed control efficiency was higher with the application of Bensulfuron methyl 60g /ha + Pretilachlor 600 g/ha at 3 DAT than hand weeding which varies from 74% at 30 DAT to 42.9% at 90 DAT. This might be due to the effect of weed during the initial stages of crop growth with herbicide application

Mukherjee and Malty (2007) experimented with transplanted rice, with Butachlor 1.0 kg ha^{-1} at 3 days after transplanting + almix 20 WP (Chlorimuron7 ethyl + Metsulfuron-methyl) 4.0 g ha^{-1} at 20 days after transplanting registered higher weed control efficiency and grain yield compared with season-long weed control weed-free condition.

Walker *et al.* (2002) reported that various herbicides give satisfactory weed control without reducing yield and increasing weed population pressure even if applied at lower rates. Weed control efficiency at a reduced dose of herbicide tends to be lower than recommended doses, although in many cases it may be 60–100% and acceptable commercially. Application of both pre and post-emergence herbicides at proper dose suppresses weed flora effectively, however, the use of a single herbicide rarely gives an effective weed control in rice.

Weed control index

Suryakala *et al.* (2019) conducted a study was during Samba season of 2017 to evaluate the efficacy of pre and post-emergence herbicides in transplanted rice in the Cuddalore district. The new herbicides evaluated were Pretilachlor 6% + Pyrazosulfuron-ethyl 0.15% GR @ 10 kg ha^{-1} along with postemergence herbicides Fenoxaprop-p-ethyl 9.3% w/w @ 875 ml ha^{-1}, Bispyribac-sodium 10% SC @ 200 ml ha^{-1}. Results of the study revealed that the weed control index (WCI) ranged from 78.66-92.32% with various herbicide combinations. Highest WCE (92.32) was recorded in Pretilachlor + Pyrazosulfuron-ethyl + Bispyribac-sodium, while the lowest was recorded with twice hand weeding on 20 and 40 DAT (78.66).

Priya and Kubsad (2013) reported higher weed control efficiency and lower weed index in herbicide treatments compared to weedy check owing to lower weed dry weight, higher weed control efficiency, and lower weed index due to effective control of complex weed flora.

Plant height

Manisankar *et al.* (2019) revealed that application of glyphosate 2.5 kg ha^{-1} as a pre-plant herbicide registered significantly higher growth parameters like plant height, tillers, and dry matter production and yield attributes and grain yield (4232 kg ha^{-1}) than control.

Das *et al.* (2017) reported that the application of herbicides did not show any phytotoxic symptoms on rice plants.

Teja *et al.* (2017) conducted a field experiment during the wet season of 2012 and 2013 at farmer's field of West Bengal, India with rice variety '*Swarna'* (MTU 7029) to study the effect of bensulfuron-methyl + pretilachlor and other herbicides on the growth of different weed species and productivity of transplanted rice. Among twelve treatments results revealed that the plant height of rice varied significantly among the treatments. The highest plant height was recorded under the treatment with hand weeding at 20 and 40 DAT which was statistically at par with bensulfuron methyl 0.6%+ pretilachlor 6% at 60+600 g $ha^{-1}$and all other doses of bensulfuron methyl 0.6%+ pretilachlor 6%, azimsulfuron at 35 g $ha^{-1}$and metsulfuron methyl + chlorimuron-ethyl (Almix)+ azimsulfuron at 4+35 g ha^{-1}at 45 DAT and the minimum in the control treatment (Weedy check).

Lodhi (2016) experimented to know the efficacy of bensulfuron methyl + pretilachlor against weeds in transplanted rice at the: Krishi Nagar Farm, unit, Department of Agronomy, JNKVV, and Jabalpur duringKharifseason 2015. The experiment consisted of 7 treatments*viz,*Weedy check (Control), Bensulfuron methyl + Pretilachlor (48+480) g ha^{-1} application at 3 DAT, Bensulfuron methyl + Pretilachlor (60+600) g ha^{-1} application at 3 DAT, Bensulfuron methyl + Pretilachlor (72+720) g ha^{-1} application at 3 DAT, Pendimethalin 1300 g ha^{-1} application at 3 DAT, Butachlor 1500 g ha^{-1} application at 3 DAT, hand weeding at 20 and 40 DAT. The experiment was laid out with randomized block design (RCBD) and replicated 4 times. At 30 DAT, the plant height was affected significantly under different treatments. Plant height was maximum (49.80 cm) under two hand weeding (20 and 40 DAT) followed by Bensulfuron methyl + Pretilachlor (60+600) g ha^{-1} (48.23 cm) and (72+720) g ha^{-1}(47.85 cm) being at par amongst each other and significantly superior over remaining treatments. The lowest plant height (40.80 cm) was recorded in the weedy check.

Number of tillers

Paulraj *et al.* (2019) carried out a field study during Samba season of 2017 to evaluate the efficacy of pre and post emergence herbicides in transplanted rice. The herbicides evaluated were Pretilachlor 6% + Pyrazosulfuron-ethyl 0.15% GR @ 10 kg ha^{-1} along with postemergence herbicides Fenoxaprop-p-ethyl 9.3% w/w @ 875 ml ha^{-1}, Bispyribac-sodium 10% SC @ 200 ml ha^{-1}. Results of the study revealed that among the treatments, (Pretilachlor + Pyrazosulfuron ethyl) + Bispyribac-sodium recorded the highest number of tillers of 434 m^{-2}. The treatment (Pretilachlor + Pyrazosulfuron ethyl) + Fenoxaprop-p-ethyl was next in order and the treatment twice hand weeding on 20 and 40 DAT were on par. The least number of tillers of 323 m^{-2} were recorded in unweeded control.

Lodhi (2016) reported that different weed control treatments caused remarkable variations in the number of tillers m^{-2} at different days after transplanting. Weedy check plots have the minimum number of tillers m^{-2}, which increased appreciably at all the growth intervals as the plots received weed control treatments. Application of Bensulfuron methyl + Pretilachlor (60+600) g ha^{-1} resulted in a markedly higher number of tillers m^{-2} over rest of the doses (48+480) and (72+720) g ha^{-1} and check herbicide Pendimethalin and Butachlor at all growth intervals.

Dry matter accumulation

Lodhi (2016) reported that different weed control treatments caused remarkable variations in the quantity of dry matter accumulation at different days after transplanting and harvest respectively. Weedy check plots have the minimum quantity of dry matter production, which increased appreciably at all the growth intervals as the plots received weed control treatments. Application of Bensulfuron methyl + Pretilachlor (60+600) g ha^{-1} resulted in markedly higher dry matter accumulation (12.13, 49.85, and 99.25 g hill-^{1}) over the rest of the doses (48+480) and (72+720) g ha^{-1} and check herbicide Pendimethalin and Butachlor at all growth intervals.

Crop growth rate

Lodhi (2016) reported that weed control treatments have significant differences in crop growth rate (CGR). Hand weeding twice had the highest value of CGR (12.78 g m^{-2} day^{-1}) which was similar with Bensulfuron methyl + Pretilachlor @ (60+600) g a.i. ha^{-1} treated plot having GR (12.58 g m^{-2} day^{-1}) while the minimum in weedy check plot (8.96 g m^{-2} day^{-1}).

Relative growth rate

Olayinka and Etejere (2015) reported that all the weed control treatments had higher RGR as compared to the weedy check.

Net assimilation rate

Shultana *et al.* (2013) experimented at Bangladesh Rice Research Institute, Gazipur during the year 2012 to study the growth behavior of transplanted *aman* rice under different competition durations with *E. crus-galli*. Different durations of weed interference such as 20, 40, 60 days after transplanting, weeded and weed-free periods. The results revealed the highest net assimilation rate (NAR) was found with no weed competition (3.50). On the other hand, the lowest net assimilation rate was observed in 60 days weed competition (0.73) which is statistically similarthroughout the growing period of rice weed competition (0.90). These results showed that an increase in competition period decreased the NAR probably due to less leaf area and shortage of other growth factors (nutrient, space, water, etc).

Maqsood (1998) reported that mostly cereals such as rice had NAR up to 6 g m^{-2} day^{-1} and that LAI was positively associated with NAR.

Number of effective tillers

Yadav *et al.* (2018) observed that the number of effective tillers m^{-2} under pretilachlor + pyrazosulfuron-ethyl 615 gha^{-1} was at par with all other treatments except being superior to pyrazosulfuron-ethyl 15 g/ha and weedy check during both years.

Jabran *et al.* (2012) carried out a study with three herbicides (pendimethalin, penoxsulam, and bispyribac-sodium) and were evaluated for weed control in direct-planted rice on sandy loam soil. Weedy check and weed-free plots were established for comparison. Experiment results revealed that the herbicides' application effectively improved the yield and yield-related traits of DPR (Direct planted rice) over the control. The maximum amount of productive tillers (362.3) was recorded in the weed-free treatment, followed by the bispyribac-sodium (350.7) treatment, while the minimum number of productive tillers (244.3) was recorded in the weedy check .

Number of non effective tillers

Chowdhury (2012) noticed that weed controlled by Sunrise 150WG gave the highesteffective tillers $hill^{-1}$ while noneffective tillers $hill^{-1}$ were found from no weedingtreatment.

Raju *et al.* (2003) reported that the use of weedicide (Safener and Butachlor) gave thehighest tiller hill^{-1} and the control plot produced maximum noneffective tiller.

Panicle length

Jabran *et al.* (2012) carried out a study with three herbicides (pendimethalin, penoxsulam, and bispyribac-sodium) and were evaluated for weed control in direct-planted rice on sandy loam soil. Weedy check and weed-free plots were established for comparison. Experiment results revealed that the herbicides' application effectively improved the yield and yield-related traits of DPR (Direct planted rice) over the control. The maximum panicle length (23.5 cm) was observed in the bispyribac-sodium treatments and the minimum panicle length (16.4 cm) in the weedy check

Mahajan *et al.* (2003) reported that application of Pretilachlor alone or in combination with Safener and hand weeding resulted in the highest panicle length.

Filled grains

Paulraj *et al.* (2019) reported that pre-emergence herbicide application of Pretilachlor + Pyrazosulfuron-ethyl followed by postemergence herbicide application of Bispyribac-sodium produced more number of yield attributes and yield than unweeded control. The reason might be that the weed-free situation at the early stage favored the vigorous growth of seeding, without any crop weed competition and sustained nutrient availability leads to better uptake of NPK by the crop might have contributed to synchronous tillering and spikelet formation leading to a higher number of panicles m^{-2} and higher post-flowering photosynthesis and higher number of filled grains panicle^{-1}.

Teja *et al.* (2017) reported thateffective and timely management of weeds through herbicides application facilitated the crop plants to have sufficient space, light, nutrients, and moisture, and thus the yield components like the number of filled grains per panicle increased.

Total grains panicle^{-1}

Hossain (2015) carried out a field experiment at the Agronomy research field of Sher-e-Bangla Agricultural University, Dhaka, from April to August 2014 to study the efficacy of herbicides to control weeds and their residual activity on the growth and yield of transplanted *aus* rice, (Nerica). Results revealed that significant variation was observed in the total number of grains panicle^{-1} due to the effect of different herbicidal treatments. The highest number of grains panicle^{-1} (69.00) was found from Propyrisulfuron @ 380 ml ha^{-1} + Propanil 60 WG @ 1500 g ha^{-1} treated plot while the lowest number of grains panicle^{-1} (54.67) was found from treatment weedy check or control treatment.

1000-grain weight

Jabran *et al.* (2012) reported that the highest 1000 grains weight (22.5 g) of rice was observed in weed-free condition and the lowest 1000 grains weight(17.4 g) was observed in weedy check.

Grain yield

Suryakala *et al.* (2019) conducted a study was during Samba season of 2017 to evaluate the efficacy of pre and post-emergence herbicides in transplanted rice in the Cuddalore district. The new herbicides evaluated were Pretilachlor 6% + Pyrazosulfuron-ethyl 0.15% GR @ 10 kg ha^{-1} along with postemergence herbicides Fenoxaprop-p-ethyl 9.3% w/w @ 875 ml ha^{-1}, Bispyribac-sodium 10% SC @ 200 ml ha^{-1}. Results of the study revealed that significantly higher grain yield and straw yield were recorded with Pretilachlor + Pyrazosulfuron-ethyl + Bispyribac-sodium (5163 and 7654 kg ha^{-1}) followed by Pretilachlor + Pyrazosulfuron-ethyl + Fenoxaprop-p-ethyl(4965 and7366 kg ha^{-1}) and was at par with twice hand weeding on 20 and 40 DAT (4787 and 7150 kg ha^{-1}), respectively. The lowest grain and straw yield (3046 and 4600 kg ha^{-1}) were recorded with unweeded control, respectively indicating the importance of weed management in the critical growth period of the crop by herbicide application, which facilitated the efficient use of resources.

Das *et al.* (2017) reported that the effective control of weeds starting from the early crop growth stage might have resulted in better growth and yield of rice. The variation in grain yield under different treatments was the result of variation in weed density and weed biomass.

Hossain and Mondal (2014) observed that tank-mix application of bispyribac + ethoxysulfuron, pretilachlor fb. metsulfuron-methyl + chlorimuron-ethyl, and pretilachlor + bensulfuron resulted in more rice grain yield than their sole application.

Mastana *et al.* (2012) reported better performance of Bensulfuron methyl plus pretilachlor combination in controlling weeds and increasing yield in transplanted rice. Bari (2010) reported that herbicide treatments contributed to higher yield performance compared to control in all the growing seasons.

Straw yield

Hossain (2015) reported that the straw yield of rice differs, due to the application of different mix herbicides comparable to the weedy check. The highest straw yield (4.25 t ha^{-1}) was recorded from Propyrisulfuron @ 380 ml ha^{-1} + Propanil 60 WG @ 1500 g ha^{-1} herbicide treated plot while the lowest straw yield (1.42 t ha^{-1}) was found from weedy check

Chowdhury (2012) experimented with Sher-e-Bangla Agricultural University Agronomy field and scored the highest grain yield, straw yield, biological yield, harvest index from pre-emergence herbicide Sunrice 150WG treated plot.

Biological yield

Hasanuzzaman *et al.* (2008) observed that the yield and the yield contributing characters (plant height, number of effective tillers per hill, panicle length, and no. of filled grains) were influenced by the effectiveness of the herbicidal treatments, while T_2 (Ronstar® 25EC @ 1.25 L ha^{-1} + IR5878® 50 WP @ 120 g ha^{-1}), showed as highest yielding herbicidal treatment.

Harvest index

Hossain (2015) reported that the harvest index is significantly influenced due to different herbicide applications. Maximum harvest index (48.0 %) when rice was treated with Propyrisulfuron @ 130 ml ha^{-1}+Propanil 60 WG @ 2000 g ha^{-1} herbicide and the lowest harvest index (37.53 %) in weedy check which was due to the reason that the effective weed control in these combinations increased the number of productive tillers, crop dry matter, and the plants produced longer panicles which ultimately improve grain yield buy reducing the crop weed competition as compared to the weedy check.

2.3 Bispyribac-sodium in weed management

Kumaran *et al*. (2015) reported that early post-emergence application of Bispyribac - sodium 10 % SC 40 g ha^{-1} recorded higher weed control efficiency and lesser weed density.

Veeraputhiran and Balasubramanian (2013) studied the efficacy of bispyribacsodium in transplanted rice during 2010 and 2011 with three doses (25, 35 and 50 g ha^{-1}). The results revealed that total weed population and dry weight under bispyribac-sodium at 25 g ha^{-1} were at par with the higher doses during both the years of study. The weed control efficiency and weed index under bispyribac-sodium at lower dose were also comparable with that of higher doses indicating sufficiency of bispyribac-sodium at 25 g ha^{-1} for effective weed management in transplanted rice.

Chandra Prakash *et al*. (2013) reported that significantly lower weed density (9-10 number m^{-2}), weed dry weight (12.5-13.7 g m^{-2}), weed persistence index (0.03) and weed competition index (8.05-12.55) were recorded in the plots where bispyribac-sodium 35 g ha^{-1} at 15-20 days after transplanting (DAT) was applied. Significantly higher weed control efficiency and herbicidal efficiency index were recorded with bispyribac-sodium 35 g ha^{-1} at 15-20 DAT.

Rawat *et al*. (2012) conducted a field experiment was conducted to investigate the efficacy of bispyribacsodium at different doses (10, 20, 30, 40 & 80 g ha-1). Post-emergence application of bispyribac-sodium at 80 g ha^{-1} was found to be superior over others which yielded lowest weed density (2.74 number m^{-2}) and lowest weed dry weight (0.95 g m-2)

Rao *et al*. (2010) reported that application of bispyribac-sodium @ 20 g ha^{-1} at 15 DAT followed by 2,4-D Na salt @ 800 g ha-1 at 30 DAT was an effective and economically viable method of weed management in transplanted rice.

Gnanavel and Anbhazhagan (2010) reported that pre-emergence application of oxyfluorfen @ 0.25 kg ha^{-1} followed by postemergence application of Bispyribac - sodium 0.05 kg ha^{-1} recorded the least weed count and weed dry matter (11 number m^{-2} and 114.65 kg ha^{-1}, respectively) and higher weed control efficiency (90.12 %) favoring higher grain yield of aromatic rice (5.32 t ha^{-1}).

Yadav *et al*. (2009) reported that application of bispyribac 25 g ha^{-1} at 15 or 25 DAT was found to be the most suitable herbicidal treatment resulting in 174-199 per cent increase in the rice grain yield over weedy check.

Christos and Ilias (2008) stated that application of bispyribac-sodium at 24 g ha^{-1} at three to four leaf growth stages provided 89 per cent control of early water grass (*Echinochloa oryzoides*) and 84 per cent control of late water grass (*Echinochloa phyllopogan*)

2.4 Effect of bispyribac-sodium on growth and yield of transplanted rice

Kumaran *et al*. (2015) reported that among the weed management practices application of early post emergence herbicide Bispyribac - sodium 10 % SC 40 g ha^{-1} recorded higher grain yield of 5058 kg ha-1 and lower NPK uptake by weeds.

Priyanka Kabdal *et al*. (2014) reported that post-emergence application of bispyribac-sodium at 25 g ha-1 + ethoxysulfuron at 18.75 g ha-1 was most effective in controlling weed species and which was yielded maximum grain yield (6.51 t ha^{-1}) among the herbicidal treatments after weed free (6.74 t ha^{-1}).

Veeraputhiran and Balasubramanian (2013) reported that the effect of all the three doses of bispyribac-sodium (25, 35 and 50 g ha^{-1}) on grain yield was significantly higher than butachlor application and unweeded control.

Rawat *et al*. (2012) reported that bispyribac-sodium 80 g ha-1 recorded maximum grain yield (4.59 t ha^{-1}) which was at par with other lower doses (20, 30, and 40 g ha^{-1}) except for bispyribac 10 g ha^{-1} (3.35 t ha^{-1}), but was significantly higher as compared to cyhalofop-butyl (3.99 t ha-1) and butachlor (4.0 t ha^{-1}).

Yadav *et al*. (2009) stated that application of bispyribac-sodium at 25 g ha^{-1} at 25 DAT recorded higher plant height (90.8 cm), effective tillers (58.7 per meter row length) and panicle length (21.5) than bispyribac-sodium applied at 25 g ha^{-1} at 15

DAT where in lesser plant height (88.9 cm), effective tillers (57.8 mrl^{-1}) and panicle length (21.1 cm) were recorded.

Walia *et al*. (2008) reported that pre-emergence application of pendimethalin at 750 g ha^{-1} followed by postemergence application of bispyribac-sodium at 20 g ha^{-1} at 30 DAS recorded higher plant height (80.1 cm), tillers (310 number m^{-2}) and panicle weight (21.7 g).

2.5 Effect of rice varieties

Weed density

Sarker *et al.* (2021) conducted an experiment comprised of three aromatic fine rice varieties viz. BRRI dhan50, BRRI dhan63 and Basmati, and five weed management strategies viz. weedy check (no weeding), two hands weeding at 15 and 30 days after transplanting (DAT), pre-emergence herbicide, Panida 33 EC @ 2.5 l ha^{-1} + one hand weeding at 30 DAT, post-emergence herbicide, Granite 240 SC @ 95 ml ha^{-1} + one hand weeding at 30 DAT, pre-emergence herbicide, Panida 33 EC @ 2.5 l ha^{-1} + post-emergence herbicide, Granite 240 SC @ 95 ml ha^{-1}. The experiment was laid out in a randomized complete block design with three replications. Irrespective of the variety weed population in weedy check treatments decreased at maturity stage compared to weed populations at 60 DAT. The highest weed density (263.00 m^{-2}) and weed dry matter (137.30 g m^{-2}) were recorded in V2 × W0 (BRRI dhan63 × no weeding) and the lowest number of weed population (12.00 m^{-2}) and weed dry matter (2.67 g m^{-2}) were obtained in $V_1 \times W_3$ (BRRI dhan50 × post-emergence herbicide Granite 240 SC followed by one hand weeding at 30 DAT) while at maturity the highest (112.00 m-2) and lowest (15.00 m^{-2}) weed population were found in $V_1 \times W_0$ (BRRI dhan50 × no weeding) and $V_2 \times W_4$ (BRRI dhan63 × pre-emergence herbicide, Panida 33 EC + post-emergence herbicide Granite 240 SC), respectively. On the other hand, the highest (132.40 gm-2) and lowest weed dry matter (4.45 g m-2) were recorded in $V_2 \times W_0$ (BRRI dhan63 × no weeding) and $V_2 \times W_3$ (BRRI dhan63 × post-emergence herbicide Granite 240 SC followed by one hand weeding) treatments, respectively.

Sohel *et al.* (2020) conducted an experiment consisting of three varities BRRI dhan49, BRRI dhan51, and BRRI dhan52, and six different weeding regimes such as no weeding, one hand weeding at 30 DAT, two hand weedings at 30 DAT and 45 DAT, three-hand weedings at 30 DAT, 45 DAT and 60 DAT, application of Rifit 500 EC at 7 DAT and application of Rifit 500 EC at 7 DAT + One hand weeding at 30 DAT. The experiment result showed that the weed population at 30, 45, and 60 days after transplanting (DAT) was significantly affected by variety.The highest weed population (5.33m^{-2}) at 30 DAT, (9.39 m^{-2}) at 45 DAT, and (14.44m^{-2}) at 60 DAT were found in BRRI dhan51 and the lowest weed population was obtained in BRRI dhan52 (3.33 m^{-2}) at 30 DAT (4.44m^{-2}) at 45 DAT and (11.22m^{-2}) at 60 DAT.

Salam *et al.* (2020) experimented the Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh during the period from December 2017 through May 2018 to evaluate the effect of weed management practices on the performance of *boro* rice cultivars and observed that cultivars did not exert any significant effect on weed density at 20 and 40 days after transplanting (DAT) but showed a significant effect on weed density at 60 DAT. At 60 DAT, the highest weed density (15.17 m^{-2}) was found in BRRI dhan74 and the lowest one (12.44 m^{-2}) was obtained in BRRI dhan28.

Shawon *et al. (*2018) directed experiments on *aus*rice at the Agronomy Research Field of Sylhet Agricultural University, Sylhet, and in the farmer's field of Jaintapur and Gowainghat Upazila, Sylhet to find out the competitiveness of *aus*rice varieties against weed infestation. The experiments were carried out from April to August 2014. Five commercial rice varieties viz. BR3, BRRI dhan48, hybrid variety Aloron, BRRI dhan43, Iratom-24 along with three (3) local cultivars Aina Miah, Doom, and Kanihati were included in the research field trial. On the other hand, a survey of thirty farmer's fields along with the researcher's managed trial was conducted to know the weed situation. In farmer's field, 5 (five) varieties namely BR3, hybrid variety Aloron, BRRI dhan55, BRRI dhan48, and Aina Miah were included. Here each variety or cultivar is considered as treatment. The experiment was laid out in a randomized complete block (RCBD) design with three replications. Significant variation was observed in different kinds of weeds among different cultivars. The highest number of grasses (35m^{-2}) were recorded in the BR3 varieties field, on the other hand, the lowest number of grasses (24m^{-2}) was found from BRRI dhan43. The highest weed density was recorded in the rice variety BR3 plots and the lowest was in hybrid rice variety Aloron among all the tested varieties. The number of weeds was lower in the hybrid cultivated plots might be due to vigorous growth of the variety helped to reduce the weed population and hence lower in number.

Afrin *et al.* (2015) experimented to investigate the combined effect of herbicides on the weed management of rice at the Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh between December 2013 to May 2014. The experiment consisted of two varieties, BR14 (Gazi) and BRRI dhan28 along with nine different weed management treatments. Results revealed that the variety of rice significantly influenced the weed population, total weed dry weight, and weed control efficiency at 20, 40, and 60 days after transplanting (DAT). At all the sampling dates, a higher number of weeds was found in BRRI dhan28, showing the highest values of 63.81, 83.93, and 167.30m^2 at 20, 40, and 60 DAT, respectively, and a lower number of weedsm^2 was obtained in BR14, which exhibited the highest values of 49.33, 70.63 and 134.90m^{-2} at 20, 40, and 60 DAT, respectively. The number of weeds or the weed population depends on the soil, environment, varieties, and other factors. As a result, variations in the weed population occurred.

Kruepl *et al.* (2006) reported that height can compensate for an erectophile leaf habit, but a relatively short (and late-season) planophile habit can give the same shading rate and weed suppression of shorter weeds. Tall varieties may have an advantage over some very tall grasses and scrambling weeds but are not effective to grass or small weeds. On the other hand, tall varieties may cause problems, such as lodging, especially in winter-sown crops at lower and medium altitudes, and cause yield reduction.

Gibson and Fischer (2004) reported that rice variety(s) with strong weed competitiveness is deemed to be a lowcost safe tool for weed management. In general, cultivars with high tillering ability, high early growth rate, high leaf area index and specific leaf area, long leaves, and droopy plant type are more weed suppressive.

Gibson *et al*. (2001) reported that competitive rice cultivar viz., hybrids usually have better vigor than inbreeds and effectively suppressed the infestation of weed populations or density.

Singlachar *et al.* (1978) reported that dwarf plant with its erect leaf habit promoted more weed growth and caused more loss than the tall cultivar.

Weed dry matter weight

Sohel *et al.* (2020) reported that competitive ability of different rice varieties significantly reduce the weed population in the field which ultimately impact on the total dry matter accumulation by weed in m^{-2} area.

Afrin *et al.* (2015) reported that at the sampling dates, higher weed dry weight (g/m^2) was found in BRRI dhan28, the highest dry weight values were 2.93, 8.59 and 47.72 g/m^2 at 20, 40 and 60 DAT, respectively, and the lowest dry weight values were (g/m^2) found in BR 14 where the values were 2.26, 7.12 and 37.26 g/m^2 at 20, 40 and 60 DAT, respectively. The dry weight of weeds depended on the weed density, size, weight and type.

Chauhan and Johnson (2011) reported that the high competitive cultivars would be rapid canopy closure so that shade under the canopy would suppress the growth of weeds. Hybrids usually have better vigor than inbreeds; therefore, when possible, hybrids can also be used. He also reported that weed control index could be attributed to less weed biomass observed due to their ability to suppress weeds.

Weed control efficiency

Afrin *et al.* (2015) reported that higher weed control efficiency (%) at the sampling dates of 20 and 60 days after transplanting (DAT) was found in BR 14 of 65.52 and 66.98%, respectively, and lower weed control efficiency of 56.59 and 64.13% was obtained in BRRI dhan28 at 20 and 60 DAT, respectively. However, the highest weed control efficiency of 61.32% was found in BRRI dhan28 at 40 DAT and a lower weed population was found in BR 14 (60.35%) at 40 DAT.

Chowdhury *et al*. (2014) carried out an experiment to find out the performance of four aromatic rice cultivars viz. BRRI dhan34, BRRI dhan37, BRRI dhan50 and Chinigura with different weed control methods viz. control (no weeding), one hand weeding at 15DAT, two hand weeding 15DAT + 40DAT, Topstar® 400SC (Oxadiargyl 400 g L^{-1}) @ 100 g ha^{-1} as post-emergence and Sunrice® 150WG (Ethoxysulfuron 150 g kg^{-1}) @ 185 ml ha^{-1} as pre-emergence herbicide in the sub plot in split plot design. Result showed that the weed control efficiency (WCE) was higher at 30DAT than 60DAT.

BARI dhan37 (V2) was found to be the most competitive variety with the highest WCE (68.75 and 50.05%) than the others at both dates.

Weed control index

Chauhan and Johnson (2011) reported that weed control index could be attributed to less weed biomass due to high competitive cultivars ability to suppress weeds.

Plant height

Islam *et al.* (2021) conducted a research was to investigate the effect of fertilizer management on growth and yield performance of aromatic fine rice varieties. The experiment consisted of two factors were aromatic fine rice and fertilizer management. There were four varieties namely Kalizira, Kataribhog, Tulshimala and BRRI Dhan34 with four fertilizer treatments recommended dose of fertilizers (T_1), cowdung @ 10 t ha^{-1} (T_2), 50% of recommended dose of fertilizers + 50% cowdung(T_3), 75% of recommended dose of fertilizers + 50% cowdung (T_4). The result showed that varieties and fertilizer treatments were significantly influenced by plant height. It was observed that Tulshimala produced the tallest plant 161.44cm and the smallest 144.55cm by BRRI Dhan34. It was evident that plant height differed significantly from varieties due to genetic variation, nutrient uptake, photosynthesis rate, etc.

Salam *et al.* (2020) conducted an experiment at the Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh during the period from December 2017 through May 2018 to evaluate the effect of weed management practices on the performance of boro rice cultivars and reported that plant height was significantly influenced by cultivars. The tallest plant (91.34 cm) was recorded from BRRI dhan28 and the shortest one (84.66 cm) was produced in BRRI dhan74, which was statistically identical to BRRI dhan29.

Mahmud *et al.* (2017) carried out an experiment consisted of three transplanting dates *viz.* 26 July, 5 August and 15 August and seven short duration T. *aman* rice varieties viz. BRRI dhan33, BRRI dhan39, BRRI dhan49, BRRI dhan56, BRRI dhan57, BRRI hybrid dhan4 and Binadhan-7. The experiment was laid out in split plot design with three replications. Result showed that BRRI dhan56 produced the tallest plant of

128.53 cm. BRRI dhan57 produced the shortest plant of 110.04 cm which is statistically similar to Binadhan-7 (110.51 cm).

Tyeb *et al.* (2013) reported that the variation in plant height due to the effect of varietal differences. The variation of plant height is probably due to the genetic make-up of the cultivars.

Hossain *et al.* (2008) conducted a study at the Hajee Mohammad Danesh Science and Technology University Farm, Dinajpur, Bangladesh in *aman* season (July-December) of 2007 to observe the yield and quality of ten popular aromatic rice varieties of Bangladesh. The varieties were Kataribhog (Philippines), Kataribhog (Deshi), Badshabhog, Chinigura, Radhunipagal, Kalizera, Zirabhog, Madhumala, Chiniatab and Shakhorkora. Result showed that plant heights at maturity of the tested varieties showed significant variation. Highest plant height (165.8cm) was observed in Chinigura and the lowest (137.1cm) in Chiniatab. Lodging of local aromatic rice varieties at maturity stage was observed due to higher plant height. These may be due to genetic characteristics of the varieties. Results showed that the total number of tillers hill^{-1} ranged from 8.8 to 12.5.

Leaf area index

Akter *et al.* (2020) carried out an experiment to observed the growth and yield of traditional aromatic rice cultivars in boro season and reported that the maximum leaf area index (5.5) was obtained from Chinigura which was statistically differed from all other varieties. This might be due to cause of proper nutrient supply mechanism from soil to the plants, light intensity and light holding capacity of a variety and above all phenotypic characters of the varieties. The minimum leaf area index (3.10) was observed in Kataribhog-2 which was statistically similar with Kataribhog-1 Kataribhog-2, BRRI dhan34 , Badshabhog , BRRIdhan38 , Zirabhog , Chiniatap-1 and Chiniatap-2 .

Luh and Stefanou (1991) reported that the variation of the leaf area index might be due to cause of genotypic characters of varieties and proper nutrient availability.

Number of tillers

Paul *et al.* (2019) undertaken a study to detect short-statured rice plants with aromatic and long to medium slender grain where twelve advanced rice lines (derived from the local rice germplasm) with a local check Kataribhog were evaluated. Experiment rest showed that the highest total tiller numbers hill^{-1}at harvest was observed in the local aromatic rice genotype SAU ADL10 (18.75) followed by SAU ADL5 (15.58).The total tiller numbers hill^{-1} of SAU ADL1, SAU ADL3, SAU ADL4, SAU ADL6, SAU ADL8, SAU ADL11 and Kataribhog were statistically similar with SAU ADL5. The minimum tiller numbers hill^{-1} (6.58) was obtained from SAU ADL12.

Hossain *et al*. (2008) reported that the variation of tiller number hill^{-1} might be due to heredity that was directly related genetic characteristics of varieties.

Dry matter accumulation

Nahida *et al.* (2013) conducted an experiment to evaluate the performance of local aromatic rice cultivars viz. Kalijira, Khaskani, Kachra, Raniselute, Morichsail and Badshabhog. The rice cultivars varied considerably in terms of crop growth characteristics as well as yield and yield contributing characters. Results revealed that dry matter (DM) accumulation over time varied considerably due to variety. Among different Days After Transplanting (DAT), Kachra produced the highest dry matter (1420.7 g m^{-2}) and Kalijira produced the lowest dry matter (1105.7 g m^{-2}) at 92 DAT.

Amin *et al.* (2006) directed a field analysis to discover the impact of variable dosages of N compost on development, tillering and yield of three conventional rice varieties (viz. Jharapajam, Lalmota, Bansful Chikon) was compared with that of a modern variety (*viz*. KK-4) and observed that traditional rice varieties accumulated higher amount of vegetative dry matter than the modern rice variety.

Crop growth rate

Mia and Shamsuddin (2011) conducted a field experiment to determine the physio morphological attributes in relation to yield potential of modern and aromatic rice varieties and reported that the CGR is the product of LAI and NAR values and higher

CGR achieved in of the modern varieties than the aromatic varieties may be due to the higher LAI.

Toshiyuki *et al.* (2006) reported that the genotypic difference in grain yield was most closely related to that in crop growth rate.

Relative growth rate

Amin *et al.* (2002) carried ou an study to observed the varietal differences of rice (Oryza sativa L.) growth to low nitrogen supply and reported that the RGRs of local varieties were generally higher than those of improved varieties under low N supply.

Net assimilation rate

Lu *et al.* (2000) observed that decrease in the rate of photosynthesis in leaves cause parallel decrease in NAR and eventually low grain yield.

Effective tillers

Nahida *et al.* (2013) conducted an experiment to evaluate the performance of local aromatic rice cultivars viz. Kalijira, Khaskani, Kachra, Raniselute, Morichsail and Badshabhog. The rice cultivars varied considerably in terms of crop growth characteristics as well as yield and yield contributing characters. Results revealed the highest number of effective tillers hill^{-1} (13.0) was produced by Kalijira and the lowest number of effective tillers hill-1 (7.13) was observed in Morichasail. The reason of difference in effective tillers hill^{-1} is the genetic makeup of the variety, which is primarily influenced by heredity.

Hossain *et al.* (2005) who found variation among the evaluated native aromatic rice cultivars in case of fertile tillers hill^{-1} which ranged from 8.6 to 11.4.

Non effective tillers

Akter *et al.* (2020) carried out an experiment to observed the growth and yield of traditional aromatic rice cultivars in boro season and reported that the number of non-effective tiller hill-^{1} was significantly influenced due to different varieties . Result revealed that the maximum non effective tillers hill^{-1}(10.90) was observed in Chiniatap-2 which was statistically differed from all other varieties. Lowest non effective tillers hill^{-1} (2.33) was obtained from Badshabhog which was statistically identical with BRRIdhan38.

Panicle length

Islam *et al.* (2021) conducted a research was to investigate the effect of fertilizer management on growth and yield performance of aromatic fine rice varieties and observed that panicle length was significantly influenced due to varieties and fertilizer doses. The results indicated that the longest 26.67cm by BRRI Dhan34 and the shortest 24.45 cm produced by Tulshimala. Panicles length with varieties differed significantly among each other due to their differences in genetic variation.

Paul *et al.* (2019) undertaken a study to detect short-statured rice plants with aromatic and long to medium slender grain where twelve advanced rice lines (derived from the local rice germplasm) with a local check Kataribhog were evaluated. Experiment rest showed that maximum panicle length (32.63 cm) was recorded in genotype SAU ADL10 followed by SAU ADL9 (30.75 cm) which was statistically similar to SAU ADL3 (30.67), SAU AD6 (29.62) (Table 4). A minimum panicle length of 26.33 cm was recorded in SAU AD7 which was statistically similar to SAU AD1, SAU AD2, SAU AD4, SAU AD11 and Kataribhog.

Hossain *et al.* (2016). carried out a field experiment with Boro rice (cv. Binadhan-10 and BRRIdhan 28) at Kaligonj, Satkhira to evaluate performance of two rice varieties under different nutrient management practices in a saline soil. The rice varieties, such as BRRI dhan28 and Binadhan 10 were tested under 3 levels of nutrients (T_1= Recommended dose of N, P, K, S, Zn, T_2 = T_1 + additional Gypsum @ 125 Kg ha^{-1} and T_3 = T_1 + additional Gypsum @ 190 Kg ha^{-1}) and the treatments were assigned in a split plot arrangement with 3 replications. The study revealed that different rice varieties and nutrient levels along with their interaction have significant effect on growth and yield of rice. It was observed that panicle length of the crop influenced by variety. Binadhan-10 produced longer panicle (24.60 cm) compared to BRRI dhan28 (20.97 cm).

Chamely *et al.* (2015) reported that the longest panicle (23.19 cm) was found in the variety BRRI dhan29 and the smallest one was observed in BRRI dhan45. The variation as assessed might be due to genetic characters of the varieties primarily influenced by the heredity.

Diaz *et al.* (2000) also reported that panicle length varied among varieties.

Filled grains panicle^{-1}

Akondo *et al.* (2020) conducted a field experiment with six rice varieties to determine their growth and yield performance. The experiment was laid out in a randomized complete block design (RCBD) with three replications. All the growth and yield contributing attributes varied significantly among the six rice varieties. The results revealed that among the varieties Binadhan-16 had significantly maximum number of filled spikelets/panicle (108.43) which was statistically identical to Binadhan-17 (100.10 cm). Binadhan-20 (85.90) and Binadhan-7 (80.40) gave statistically identical result. Minimum number of filled spikelets/panicle (60.60) was observed in Binadhan-11 which was statistically identical to Binadhan-15 (63.87 cm). Variation in grain filling may have occurred due to genetic, environmental or cultural management practices adopted.

Sarkar (2014) reported that number of filled grains/panicles influenced significantly due to variety.

Mahamud *et al.* (2013) reported that the variation in filled grains panicle^{-1} was recorded due to genotypic differences of varieties.

Unfilled grains panicle^{-1}

Nahida *et al.* (2013) reported that among the undesirable traits, number of unfilled grains panicle^{-1} was important one and played a vital role in yield reduction. Effect of variety on the number of unfilled grains panicle^{-1} was highly significant. Morichsail produced the lowest number of unfilled grains panicle^{-1} (11.17) which contributed highest grain yield of that variety. This variation in number of unfilled grains panicle^{-1} might be due to genetic characteristics of the varieties.

Sohel *et al.* (2009) reported that difference in spikelets sterility varied significantly by variety and plant spacing.

Total grains panicle^{-1}

Laila *et al.* (2020) conducted an experiment at the Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh during July 2017 to December 2017 to study the combined effect of vermicompost with inorganic fertilizers on the yield and yield contributing characters of aromatic fine rice varieties. The experiment comprised three varieties *viz.* BRRI dhan34, Binadhan-13 and Kalizira and five nutrient managements *viz.* control (no application of manures and fertilizer), recommended dose of inorganic fertilizers (i.e. 150, 95, 70, 60, 12 kg ha^{-1} of Urea, TSP, MOP, Gypsum and Zinc Sulphate respectively), vermicompost @ 3 t ha^{-1}, 25% less than recommended dose of inorganic fertilizer + vermicompost @ 1.5 t ha^{-1}, 50 % less than recommended dose of inorganic fertilizer + vermicompost @ 3 t ha^{-1}. Result showed that the highest number of grains panicle^{-1} (141.69) was produced by Binadhan-13 variety while the lowest number of grains panicle^{-1} (98.33) was produced by Kalizira variety. It might be due to varietal character or heredity.

Jisan *et al.* (2014) carried out a study to examine the yield performance of some transplant aman rice varieties as influenced by different levels of nitrogen during the period of June to November 2013 at the Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh. Result showed that among different rice varieties BRRI dhan52 produced the highest number of total spikelets panicle^{-1} (155.20) and the lowest number of total spikelets panicle^{-1} (118.80) was obtained from BRRI dhan57.

Roy *et al.* (2014) reported that the number of spikelets per panicle in indigenous rice is generally lower compared to high yielding varieties.

1000 grain weight

Islam *et al.* (2021) conducted a research was to investigate the effect of fertilizer management on growth and yield performance of aromatic fine rice varieties and showed that the highest 1000 grain weight 14.05 gm was obtained from Kataribhog and the lowest 12.60 gm was from Tulshimala. It was evident that variation in 1000 grain weight might be due to differences in the size of the grains that are partly controlled by the genetic makeup of the studied varieties.

Latif *et al.* (2020) reported that 1000 grains weight were significantly differ due to the varietal performance.The highest 1000-grain weight (26.33 g) was obtained in BR14 than BRRI dhan28 (22.60 g) and BRRI dhan29 (22.43 g).

Khatun *et al.* (2020) conducted a field experiment with six rice varieties to determine their growth and yield performance. The experiment was laid out in a randomized complete block design (RCBD) with four replications. All the growth and yield contributing attributes varied significantly among the six rice varieties. The results revealed that Maximum 1000-grain weight was observed in Binadhan-17 (27.25 g) that was statistically similar to Binadhan-11 (26.45 g) and Binadhan- 16 (26.88 g). Minimum 1000-grain weight observed in Binadhan-7 (21.94 g) that was statistically different from other varieties

Roy *et al.* (2014) studied on 12 rice varieties and found difference in thousand grains weight due to morphological and varietal variation.

Aminpanah *et al.* (2013) conducted a field experiment to compare the competitive ability of rice cultivars and lines against barnyardgrass at Rice Research Station in Tonekabon, Iran. Results showed that there was a significant difference among rice cultivars and lines under both weedy and weed-free conditions for 1000-grain weight. Under weed-free conditions, Nemat and Khazar had the highest and lowest (31.8 and 25.87 gram, respectively) 1000- grain weight. But, under weedy conditions, Nemat with 30.7 gram and line 842 with 24.3 gram had the highest and lowest 1000-grain weight, respectively.

Grain yield

Sarker *et al.* (2021) conducted a experiment at the Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh during November 2016 to May 2017 to study the effect of weed management strategies on the yield of aromatic fine rice in Boro season and reported that Chinigura produced significantly the highest yield (3.46 t ha^{-1}) which was statistically similar with Kataribhog-1 , Kataribhog-2, BRRI dhan34 , Badshabhog , BRRI dhan38 and BRRI dhan50 .Lowest (2.00 t ha^{-1}) was observed from Madhumala which was statistically identical with Chiniatap-2. The higher grain yield in Chinigura could be attributed to higher panicle length, filled grains $panicle^{-1}$ and 1000-seed weight compared to other varieties.

Khatun *et al.* (2020) conducted a field experiment with six rice varieties to determine their growth and yield performance, and observed that among different rice varieties Maximum grain yield observed in Binadhan-17 (6.13 t/h) that was significantly different from other varieties. Minimum grain yield observed in BRRI dhan39 (4.49 t/h) that was statistically similar to BRRI dhan33 (4.57 t/h) and Binadhan- 7 (4.86 t/h) (Figure 6). Maximum absolute growth rate, total dry matter. Filled spikelet per panicle and also maximum 1000-seed weight collectively contributed to higher grain yield in Binadhan-17 compare to other varieties.

Shawon *et al.* (2019) carried an experiments on Aus rice at the Agronomy Research Field of Sylhet Agricultural University, Sylhet and in the farmer's field of Jaintapur and Gowainghat Upazila, Sylhet to find out the competitiveness of Aus rice varieties against weed infestation. and reported that among different rice varieties the highest grain yield (4.04 t ha^{-1}) was recorded in the hybrid variety Aloron which was statistically similar with the variety BRRI dhan48 (3.19 t ha^{-1})and Iratom-24 (3.06 t ha^{-1}) which was presented in. It might be the resultant effects of the highest tillers $hill^{-1}$ and grains $panicle^{-1}$ of those cultivars. The lowest grain yield (1.07 t ha^{-1}) was recorded in cultivar Doom which was at par with the variety BRRI dhan43 (1.32 t ha^{-1}).

Uppu and Shiv (2019) reported that grain yield of aromatic fine rice was significantly affected by variety.

Ferdous *et al.* (2016) carried out a field experiment to study the effect of weed management practices on the performance of transplanted aman rice varieties. The experimental treatments comprised three varieties viz. BR11, BRRI dhan39 and Binadhan7 and seven weeding treatments viz., weedy check, hand weeding at 15 and 35 DATs, application of early post-emergence herbicide Manage (Pyrazosulfuron ethyl), application of pre-emergence herbicide Rifit (Pretilachlor), Manage + one hand weeding at 35 DAT, application of Rifit + one hand weeding at 35 DAT and weed free. The experiment was laid out in a randomized complete block design with three replications. The results reveal that The highest grain yield was obtained from the interaction of BRRI dhan39 × weed free condition which was statistically identical (5.50 t ha^{-1}) with interaction of variety BR11 × two hand weedings at 15 and 35 DATs.

Therefore it may be concluded that BR11 rice could be cultivated using two hand weedings at 15 and 35 DATs for obtaining higher yield.

Islam *et al.* (2013) reported that the varieties which produced higher number of effective tillers hill^{-1} and higher number of filled grains panicle^{-1} also showed higher grain yield ha^{-1}.

Dutta (2002) reported that the genotypes, which produced higher number of effective tillers per hill and higher number of grains per panicle also showed higher grain yield in rice.

Straw yield

Islam *et al* (2018) carried out a study to evaluate the response of selected aromatic fine rice varieties of Bangladesh to different herbicides based weed management practices compare to farmers' practices. The experiment was conducted in a randomized complete block design with three replications. The experiment consisted of five aromatic rice varieties; Kalijira, BRRI dhan34, BRRI dhan37, BRRI dhan38 and Binadhan-13, and six different weed management practices comprising no weeding, weed free, mechanical + manual weeding, pre–emergence herbicide + manual weeding, post–emergence herbicide + manual weeding and pre– + post–emergence herbicide. Result showed that The highest straw yield (6.5 t ha^{-1}) was produced by BRRI dhan38, which was statistically identical with Binadhan-13 (5.9 t ha^{-1}). The lowest straw yield (4.2 t ha^{-1}) was produced by Kalijira, which was statistically identical with BRRI dhan34 (5.2 t ha^{-1})

Mahmud *et al.* (2017) carried out an experiment at the Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh during June to December, 2013 to investigate the response of some short duration *aman* rice varieties to date of transplanting and reported that among rice varieties the highest straw yield (5.67 t ha^{-1}) is produced by BRRIdhan49 which statistically similar to Binadhan-7. The lowest (3.96 t ha^{-1}) straw yield was produced by BRRI dhan57.

Tyeb *et al.* (2013) reported that the variation in straw yield due to the effect of varietal differences. Among different varietal performances the highest straw yield was produced in BRRI dhan46 (6.43 t ha^{-1}) which was identical to BRRI dhan52 (6.29 t ha^{-1}) and BRRI dhan51 (6.24 t ha^{-1}). The lowest one was obtained from BRRI dhan41 (4.22 t ha^{-1}).

Biological yield

Howlader *et al.* (2017) conducted the present experiment at the Research Field Laboratory of the Department of Agricultural Botany, Patuakhali Science and Technology University (PSTU), Patuakhali during the period from July to December 2013 to evaluate among the local T Aman rice genotypes for obtaining the most productive genotype regarding growth and yield performance under southern region and found that among the genotypes Moulata showed the highest biological yield (9.657 t ha^{-1}). However, Lalmota (7.75 t ha^{-1}) showed the statistically close biological yield to Lalchicon (7.537 t ha^{-1}).

Hossain *et al.* (2014) found that, the variation in biological yield was also found due to the variation in grain and straw yield.

Harvest index

Sarker *et al.* (2021) conducted a experiment at the Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh during November 2016 to May 2017 to study the effect of weed management strategies on the yield of aromatic fine rice in Boro season and reported that harvest index was varied among the rice varieties and among different rice variety cultivation the highest harvest index (44.74%) was recorded in BRRI dhan63 followed by BRRI dhan50 (43.03) while the lowest one was found in Basmati (40.36%).

Chowhan *et al.* (2019) found significant differences of harvest index among different rice varieties. From their experiment, they observed that Varieties Shakti-2 (V_4), Heera-1 (V_3) and BRRI dhan28 (V_1) had an identical harvest index of 50.9%, 48.5% and 47.9 respectively. OnlyBinadhan-14 (V_2) produced the harvest index (40.0%). It appears that hybrid rice maintained higher harvest index.

Rahman *et al.* (2017) conducted a study to observed the competitiveness of winter rice varieties against weed under dry direct seeded conditions during dry season (February to June) 2016 at the Agronomy Field Laboratory and Weed Management

Laboratory, Bangladesh Agricultural University, Mymensingh. Fourteen rice varieties namely, BRRI dhan28, BRRI dhan29, BRRI dhan47, BRRI dhan50, BRRI dhan55, BRRI dhan58, BRRI dhan59, BRRI dhan67, Binadhan- 5, Binadhan-6, Binadhan-8, Binadhan-10, BRRI hybrid dhan3 and Agrodhan-14 were grown under weedy and weed-free conditions. Result revealed that variety had significant effect on harvest index. However harvest index ranged from 40.73 to 42.78%. The highest harvest index was found in BRRI dhan59 (42.78%) and the lowest one was found in BRRI dhan28 (40.73%).

Uddin *et al.* (2011) reported that the harvest index differed significantly among the varieties due to its genetic variability.

Shah *et al.* (1991) reported that variety had a great influence on harvest index.

2.6 Effect of spacing

Weed density

Chadhar *et al.* (2020) conducted a study was to investigate the impact of different transplant spacing (PS) (20 cm × 20 cm, 25 cm × 25 cm and 30 cm × 30 cm) and the critical periods of weed competition (CP) *viz.,* 20, 40, 60, and 80 DAT (days after transplanting) in rice cultivated through SRI. A weedy check and a weed free for full crop season were kept as control treatments. After weed free control, minimum total weed density (17.0 and 21.3 m^{-2}) and minimum total weed dry biomass (5.5 and 8.4 gm^{-2}) were noted in the case of 20 cm × 20 cm rice transplant spacing in interaction with weed competition period for 20 DAT ($PS_1 \times CP_1$) during the full crop growing season. Weed density and weed dry biomass gradually increased and reached at their peaks by increasing weed competition periods and crop plant spacing for full growing season.

Eshaghi *et al.* (2013) reported that closer spacing had lowest weed density and dry weight than wider spacing.

Anwar *et al.* (2011) reported that highest weed density and dry weight of weeds in widest plant spacing might be due to more number of weeds and availability of suitable space to grow and flourish to its maximum number and face minimum weed crop competition. Light and nutrient availability in wider plant spacing provide a chance to weeds along with the crop to grow easily as compared to narrow plant spacing where chances of weeds to grow were less due to less space availability and high crop-weed competition.

Kim and Moody (1989) have shown that, as the planting distance between hills of transplanted rice is reduced, the crop becomes more competitive against weeds, and yield losses due to weeds are reduced.

Weed dry weight

Ashraf *et al*. (2014) carried out a study on planting geometry-induced alteration in weed infestation, growth and yield of puddled rice and noticed that significant decline in weed density and biomass by imposing closer planting geometry in puddled rice.

Chauhan and Johnson (2011) from their experiment they concluded that wider row spacing of rice prolonged weed competition period that resulted in significant increase in weed density and dry biomass.

Rao and Moody (1992) reported that, in addition to reducing weed weight and weed competition, closer plant spacing resulted in more options from which a farmer could select a suitable weed control practice.

Weed control efficiency

Tesfaye *et al.* (2011) who reported that the maximum weed control efficiency recorded at closest spacing might be due to more competition offered by cereal grains crop for growth resources as it occupied the space earlier that had smothering effect and better light interception.

Plant height

Saha *et al.* (2020) conducted an experiment at the Agronomy Field Laboratory, Bangladesh Agricultural University during November 2016 to June 2017 to investigate the effect of spacing of planting on the yield performance of some aromatic rice varieties in Boro season. The experiment comprised three varieties viz. BRRI dhan50, Basmati and BRRI dhan63, six spacing of planting viz. 25 cm × 20 cm, 25 cm × 15 cm, 20 cm × 20 cm, 20 cm × 15 cm, 15 cm × 15 cm and 20 cm × 10 cm. The experiment was laid out in a randomized complete block design with three replications. Results of the experiment showed that plant spacing had significant effect on plant height. The tallest plant (73.73 cm) was obtained from the spacing of 25 cm × 20 cm which was at par 25 cm × 15 cm whereas the shortest plant (68.51 cm) was observed in 20 cm × 15 cm spacing which was at par with other spacing.

Paul *et al.* (2017) noticed that optimum plant spacing helps plants to grow well, using more solar radiation and soil nutrients.

Ali *et al.* (2008) carried out an experiment at the Agronomy field, Sher-e-Bangla Agricultural University, Dhaka during the period from July to December, 2006 to evaluate the effect of integrated weed management and spacing on the weed flora and on the growth of transplanted aman rice and reported that plant height increased with the advancement of crop duration and with wider spacing.

Tillers hill^{-1}

Halder *et al.* (2018) conducted an experiment was at the Agronomy Field of Patuakhali Science and Technology University, Dumki, Patuakhali from June to December, 2013 to find out the effect of variety and planting density on the yield and yield attributing characters of local aromatic rice. The experiment was laid out in a factorial randomized complete block design with three replications, which consisted of three local aromatic rice varieties (Chinigura, Shakhorkhora and Kalizira) and four planting densities were viz. S_1 (25 cm × 20 cm), S_2 (20 cm × 20 cm), S_3 (20 cm × 15 cm) and S_4 (20 cm × 10 cm). The results revealed that the higher number of tillers per hill (14.8), number of grains per panicle (140 nos.) were found in 20 cm × 20 cm spacing with higher grain yield.

Leaf area index

Ashraf *et al.* (2014) reported that closed spacing reduced the leaf area index. This might be due to an increased intra plant competition.

Kumar *et al.* (2014) reported that the synthesis of photosynthates and their translocation in the metabolic activity to produce more grain per panicle as an indicator of yield expression.

Singh *et al.* (2014) conducted a study during kharif 2011 and 2012 at the research farm of College of Post Graduate Studies, Central Agriculture University, Umiam, Meghalaya in order to explore the effects of varying planting geometries of different rice cultivars in puddle condition and reported that maximum LAI was recorded in 20 cm × 25 cm followed by 20 cm × 20 cm and the lowest from the closest spacing 20cm x 10cm throughout the crop growth period. Weed infestation reduced the LAI of the crop significantly. The LAI continuously increased up to 90 DAT and then it gradually declined towards maturity due to leaf senescence. The improved leaf area index in spacing 20 cm × 25 cm might be due to reduced intra plant competition, maximum light interception and provision of a weed free environment where weeds are discouraged to grow after the application of spraying of herbicides.

Riahinia and Dehdashti (2008) concluded from their study that leaf area index affecting in photosynthesis and it was significantly increased by decreasing plant spacing.

Dry matter accumulation plant^{-1}

Mirza *et al.* (2009) studying the effect of tiller dynamics and dry matter production in transplanted rice as affected by spacing and number of seedlings per hill and observed that wider spacing coupled with higher number of seedlings per hill accumulated maximum amount of dry matter, emphasizing that productivity of tillers as well as dry matter yield was lower with closer spacing and transplanting single seedlings per hill.

Crop growth rate

Ashraf *et al.* (2014) reported that the maximum CGR was attained in widest plant spacing while closest spacing resulted in minimum growth rate of crop under both conditions weedy and weed free. Lowest CGR was found in the closest spacing which might be to due maximum intra plant competition for acquisition of resources and ultimately crop growth rate declined.

Singh *et al.* (2014) conducted a study during kharif 2011 and 2012 at the research farm of College of Post Graduate Studies, Central Agriculture University, Umiam, Meghalaya in order to explore the effects of varying planting geometries of different rice cultivars in puddle condition. Three cultivars of rice - Arize 6444, Shahsarang1 and Mynri were tested under four different planting geometries viz; 20cm × 25cm, 20cm × 20cm, 20cm × 15cm and 20cm × 10cm on weed dynamics, weed dry weight. The experiment was laid out in a factorial randomized block design (FRBD) with three replications. Result showed that crop growth rate (CGR) is the accumulative growth rate of the crop all over the season. The maximum CGR was attained in widest plant spacing while closest spacing resulted in minimum growth rate of crop. Lowest CGR in the closest spacing which might be to due maximum intra plant competition for acquisition of resources and ultimately crop growth rate declined.

Relative growth rate

Obulamma and Reddy (2002) reported that the wider spacing recorded more CGR, RGR and NAR due to lesser competition among the plants that will boost more CHO assimilation leading to more TDMP(Total dry matter production).

Net assimilation rate

Sridevi and Chellamuthu (2015) conducted a field investigation was to determine the influence of various System of Rice Intensification (SRI) components on growth analysis and yield of rice variety ADT 43 in Karaikal during kharif season. Twelve treatment combinations (YOSC, NOSC, YMSC, YOSH, NMSC, NOSH, YMSH, YORH, NMSH, YMRH, NORH and NMRH) were replicated thrice in a Randomised block design in which Y refers to young seedlings of 14 days old raised in a modified rice mat nursery; N refers to normal seedlings of 21 days old raised in a conventional nursery; O refers to one seedling hill1 ; M refers to multiple seedlings (3 seedlings $hill^{-1}$); S refers to square planting (22.5 cm x 22.5 cm); R refers to rectangular planting (12.5 cm x 10.0 cm); C refers to conoweeding in both directions with conoweeder and H refers to hand weeding.. The results of the investigation showed that the SRI components of various treatments significantly influenced the NAR. In general, the rectangular planting with closer spacing recorded lesser NAR than square planting with wider spacing at all the growth stages, irrespective of age of seedlings, number of seedlings hill^{-1} and method of weeding. Reduction in NAR could be attributed to less leaf area and shortage of other growth factors (nutrient, space, water etc).

Effective tillers hill^{-1}

Salma *et al.* (2017) conducted an experiment at the Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh during Aman season from June to November 2016 to find out the effect of variety and planting density on weed dynamics and yield performance of transplant Aman rice. The experiment consisted of four varieties viz. Binadhan-7, BR25, BRRI dhan56 and BRRI dhan62 and four planting density viz. 25 cm × 15 cm, 25 cm × 10 cm, 20 cm × 15 cm and 20 cm × 10 cm. The experiment was laid out in a randomized complete block design with three replications. Result showed that the production of effective tillers hill^{-1} was significantly influenced by spacing. The highest number of effective tillers hill^{-1} (11.20) was obtained from 25 cm × 15 cm spacing and the lowest one (8.43) was found in 20 cm × 10 cm spacing. The highest number of total and effective tillers hill^{-1} in wider spacing might be due to having more sunlight thus more photosynthesis more space for producing more number of tillers.

Ashraf *et al.* (2014) reported that the taximum productive tillers were found in widest plant spacing under weed free conditions while minimum was obtained from closest spacing under weedy treatments. It was also observed that closest spacing proved inefficient regarding tillering ability and provided lowest number of total tillers and productive tillers as well. Moreover, weed free conditions proved most effective and better regarding plant height and tillering ability as compared to weedy conditions and differed significantly.

Non effective tillers hill^{-1}

Akondo and Hossain (2019) conducted an experiment at the experimental farm of BINA Sub-station, Gopalganj to determine the effect of spacing on the yield and yield attributing parameters of rice. Four spacings viz. 15 cm × 15 cm, 20 cm × 15 cm, 20 cm × 20 cm and 25 cm × 20 cm were included in the study. The experimental design was a randomized completely block with three replications. Spacing's 15 cm × 15 cm, 20 cm × 15 cm, 20 cm × 20 cm and 25 cm × 20 cm were adopted 49, 42, 36 and 30 hills per square meter, respectively. Results revealed that different spacing performed significantly differed yield contributing characters. The 15 cm × 15 cm spacing (1.60) produced significantly higher non-effective tillers per stand than all the spacing (20 cm × 20 cm; 20 cm × 15 cm and 15 cm × 15 cm). The lowest number of non-effective tillers (0.80) per stand was recorded under 20 cm × 15 cm spacing.

Moro *et al.* (2016) reported that growth attributes were significantly affected by spacing.

Mirza *et al.* (2009) also observed that closer spacing reduced the number of effective tillers and increased tiller mortality, hence lower number of panicles.

Panicle length

Ninad *et al*. (2017) conducted an experiment to know the effect of spacing and seedling per hill on the performance of aus rice var. performance of aus rice var. BRRI dhan48 and reported that closer spacing decreased panicle length.The longest panicle length (23.35 cm) was produced by 20 cm × 25 cm spacing and the shortest one (20.97 cm) by 20cm × 10 cm.

Filled grains panicle

Rajesh and Thanunathan (2003) reported that the use of wider spacing led to lesser below and above ground competition for better grain filling, higher grain weight and more number of filled grains/panicle.

Unfilled grains panicle^{-1}

Saju *et al.* (2019) conducted a field study was during the late Samba (September-January) season of 2018-19 at Wetland farms, TNAU, Coimbatore to study the effect of high density planting on growth and yield of rice (Oryza sativa L.) under modified system of rice intensification. The treatments comprised of T_1 - 25 x 25cm with 100% Recommended Dose of Fertiliser (RDF) (SRI), T_2 - 25 x 20cm with 100% RDF, T_3 - 25 x 15cm with 100% RDF, T_4 - 25 x 15cm with 125% RDF, T_5 - 20 x 20cm with 100% RDF, T_6 - 20 x 15cm with 100% RDF, T_7 - 20 x 15cm with 125% RDF and T_8 - Conventional cultivation with 100% RDF. The experiment was laid out in Randomised Complete Block Design with three replications. The results revealed that the spacing levels had a significant influence on number of unfilled grains/panicle, which was recorded higher under 20 x 10cm (50.0/panicle), followed by 20 x 15cm (48.1/panicle). The number of unfilled grains in a panicle were lower under 25 x 25cm (29.3), which was statistically identical to 25 x20 cm (31.6) and 25 x15 cm (33.8). The higher number of unfilled grains/panicle under closer spacing levels is due to higher competition for utilization of resources due to increased plant population.

Total grains panicle^{-1}

Ninad *et al*. (2017) reported that the highest number of grains panicle^{-1} (128.79) was observed in 20 cm × 25 cm spacing while lowest number of grains panicle^{-1} (104.17) in 20 cm × 10 cm spacing. Reduction in the number of grains panicle^{-1} under closer spacing might be due to increased number of plants per unit area. This increased number of plants per unit area exerted competition among plants for nutrients and light that might have caused lower crop growth rate with consequently a reduction in the number of filled grains panicle^{-1}.

1000 grains weight

Anwari *et al.* (2019) carried out a field experiment at the experimental station of the Agricultural Faculty of Kunduz University in 2016 to evaluate the effect of planting distance on yield and agro-morphological characteristics of Bara variety (local variety of rice). Randomized Completely Block Design (RCBD) with four replications was used in the experiment. Transplanting distances with four levels viz. 10x10 cm, 15x15 cm, 20x20 cm, and 25x25 cm were used as treatment. Results showed that 1000 grains weight was significantly affected by spacing The results indicated that with the increase in spacing the thousand grains weight also increased significantly. The highest 1000 grains weight (27.27g) was obtained when the crop was transplanted at 20x20 cm spacing and the lowest (26.47 g) at 10x10 cm spacing. Higher plant density was noted in narrow spacing than other spacing and this higher plant density was accompanied by strong intra and inter-row competition that might have caused the decrease in 1000 grains weight.

Biswas *et al.* (2015) reported that highest thousand-grain weight was obtained in wider spacing (30 x 20 cm) than narrow spacing (15 x20 cm).

Grain yield

Dass *et al*. (2017) documented that narrower plant spacing in puddled transplanted rice resulted in higher productivity with minimum weed infestations.

Bhownmilk *et al.* (2012) reported that optimum plant spacing ensures optimum number of plants per unit area which lead to proper growth, yield components and ultimately grain yield.

Rashid *et al.* (2010) carried out a field experiment was at the Agronomy Field Laboratory, Department of Agronomy during February to June, 2008 to evaluate the effect of row to row and hill to hill spacing on the yield performance and yield of boro rice cv. BRRI dhan36 under aerobic system of cultivation. The experiment consists of three row to row spacing viz.; 20.0 cm, 25.0 cm and 30.0 cm and five hill to hill spacings viz. 2.5 cm, 5.0 cm, 10.0 cm, 20.0 cm and 30.0 cm. The trial was laid out in a randomiz complete block design with 3 replications. The result revealed that the crop with 20.0 cm row to row spacing and 20.0 cm hill to hill spacing produced the highest grain yield (4.90 t ha^{-1}), whereas the lowest grain yield (2.55 t ha^{-1}) was found with 20.0 cm × 2.5 cm.

Verma *et al.* (2002) conducted a field experiment in Raipur, Madhya Pradesh, India, during the rainy season of 1998-99 to study the effect of spacing 20cm x 20cm, 20cm x15cm and 20cm x 10cm and crop density or transplanted rice hybrid Proagro 6201. They found that seedlings planted at 20cm x 20cm and 20cm x 15cm produced higher number of productive tillers, grain yield and harvest index than seedlings planted at 20cm x 10cm. Closer spacing (20cm x10cm) gave higher sterility percentage than wider spacing.

Patel (1999) also reported that maximum yield and yield related attributes in rice transplanted was obtained from 20 cm × 20cm planting distance as compared to narrower spacing than this.

Straw yield

Saha *et al.* (2020) conducted an experiment at the Agronomy Field Laboratory, Bangladesh Agricultural University during November 2016 to June 2017 to investigate the effect of spacing of planting on the yield performance of some aromatic rice varieties in Boro season. The experiment comprised three varieties viz. BRRI dhan50, Basmati and BRRI dhan63, six spacing of planting viz. 25 cm × 20 cm, 25 cm × 15 cm, 20 cm × 20 cm, 20 cm × 15 cm, 15 cm × 15 cm and 20 cm × 10 cm. The experiment was laid out in a randomized complete block design with three replications. Result showed that planting spacing significantly effect on grain and straw yield and among different planting spacing 20 cm × 10 cm gave the highest grain (4.54 t ha^{-1}) and straw (5.92 t ha^{-1}) yields compared to other spacing.

Biological yield

Dass *et al.* (2017) documented that narrower plant spacing in puddled transplanted rice resulted in higher biological yield comparable to widest spacing.

Harvest index

Saju *et al.* (2019) concluded from their study that higher harvest index was recorded under 20 x 20cm spacing (0.46) which was statistically similar to 25 x 25cm (0.44), 25 x 15cm at 100% RDF (0.43) and 125% RDF (0.44) and 25 x 20cm (0.44). Harvest index recorded was lower under conventional planting system (0.37) which is on par with 20 x 15cm at 100% RDF (0.38) and 125% RDF (0.39). Higher harvest index might be due to greater partitioning of photosynthesis towards the production of straw and higher grain ratio in total biological yield.

2.7 Economic return and benefit cost ratio

Salam *et al.* (2020) conducted an experiment at the Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh during the period from December 2017 through May 2018 to evaluate the effect of weed management practices on the performance of boro rice cultivars and reported that from the economic analysis of the study the highest BCR was obtained from BRRI dhan29 with application of pre-emergence herbicide followed by one hand weeding at 40 DAT (V_2W_3) which was close to BRRI dhan29 with application of early post emergence herbicide, BRRI dhan74 with application of pre-emergence herbicide Superhit and BRRI dhan74 with application of early post emergence herbicide. The lowest BCR was obtained from BRRI dhan28 with no weeding (control) treatment

Mishra (2019) reported that the pre-emergence application of Bensulfuron methyl 60g /ha + pretilachlor 600 g/ha at 3 DAT recorded the higher gross return of Rs.72320.8 ha^{-1} withl net return of Rs. 30688.2 ha^{-1} over farmers practice where in one hand weeding at 40 DAT observed the gross return of Rs 64944 ha^{-1} with net return of Rs 19631.8 qha^{-1}. Higher B:C ratio(1.74) was found in improved technology due to higher net return as compared to farmers practice(1.43).The weedy check showed the lowest net return this was due to higher yield with use of herbicide in the early growth stage.

Suryakala *et al.* (2019) reported that application of (Pretilachlor + Pyrazosulfuron ethyl) + Bispyribac- sodium registered the higher net income of Rs.52170 ha^{-1} and return $rupee^{-1}$ invested of Rs. 2.52. It was followed by (Pretilachlor + Pyrazosulfuron ethyl) + Fenoxaprop-p-ethyl. The lowest net income of Rs. 21171 ha^{-1} and return $rupee^{-1}$ invested of Rs. 1.71 was recorded in un weeded control.

Barla and Upasani (2018) carried out an experiment to know the effect of upland rice varieties on relative composition of weeds in jharkhandduring the wet cropping season of 2011 and 2012 at Zonal Research Station, East Singhbhum under upland ecology to assess and identify crop parameters responsible for competitiveness of rice varieties. Total thirteen upland varieties including ten improved and three traditional varieties were tested under weedy and weed free conditions. result revealed that among varieties Vandana produced significantly higher grain yield (2988 kg ha^{-1}) over other varieties consequently recorded higher net return and B:C ratio similar to variety Anjali.

Sunil *et al.* (2010) reported that pre-emergence application of bensulfuron methyl + pretilachlor (6.6 GR) @ 0.06 + 0.6 kg ha^{-1} + one intercultivation at 40 DAS recorded significantly higher grain and straw yields (4425 and 5020 kg ha^{-1}), lower weed population and dry weight (17 and 2.32 g m^{-2}). This treatment also resulted in higher net returns and B:C ratio.

Kim and Moody (1989) concluded that even though the highest net benefits were obtained when rice was transplanted at a 10 × 10 cm spacing, a farmer would probably 30 plant at a wider spacing (20 × 20 cm) and weed chemically or by hoe because of the greater benefit-cost ratio at the wider plant spacing.

CHAPTER III

MATERIALS AND METHODS

This chapter presents a concise depiction about of experimental period, site description, climatic condition, crop or planting materials that were being used in the experiment, treatments, experimental design and layout, crop growing technique, fertilizers application, uprooting of seedlings, intercultural operations, data collection, and statistical analysis.

3.1 Location of the experimental site

3.1.1 Geographical location

The experiment was conducted at the Agronomy field of Sher-e-Bangla Agricultural University (SAU),Sher-e-Bangla Nagar Agargong, Dhaka, 1207. The experimental site is geographically situated at 23°77′ N latitude and 90°33′ E longitude at an altitude of 8.6 meters above sea level.

3.1.2 Agro-Ecological Zone

The experimental field belongs to the Agro-ecological zone (AEZ) of "The Modhupur Tract", AEZ-28. This was a region of complex relief and soils developed over the Modhupur clay, where floodplain sediments buried the dissected edges of the Modhupur Tract leaving small hillocks of red soils as 'islands' surrounded by floodplain. For a better understanding of the experimental site has been shown in the Map of AEZ of Bangladesh in Appendix-I.

3.2 Experimental Duration

The experiment was conducted during the period from 1 Julyvto 20 December 2019 in the transplanting *aman* season.

3.3 Soil characteristics of the experimental field

The soil of the experimental site was silty clay loam in texture belonging to the Tejgaon series. The area represents the Agro-Ecological Zone of the Madhupur tract (AEZ No. 28) with pH 5.8–6.5, ECE-25–28. Soil samples from 0- 15 cm depths were collected from the experimental field. The analytical data of the soil sample collected from the experimental area were analyzed in the Soil Resources Development

Institute (SRDI), Soil Testing Laboratory, Khamarbari, Dhaka, and have been presented in Appendix II.

3.4 Climate condition of the experimental field

The experimental area was under the subtropical climate and was characterized by high temperature, high humidity, and heavy precipitation with occasional gusty winds during the period from July-December, but scanty rainfall associated with moderately low temperature prevailed during the period from March to August (Edris *et al*., 1979). The detailed meteorological data in respect of maximum and minimum temperature, relative humidity, and total rainfall were recorded by the meteorology center, Dhaka for the period of experimentation have been presented in Appendix III.

3.5 Crop/planting material

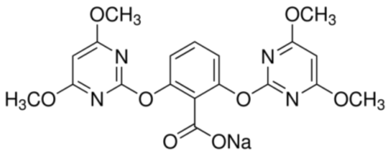
Kalizira and BRRI dhan37 were being used as test crops for this experiment.

3.6 Agronomic characteristics of aromatic rice varieties

Name of variety	Developed by	Year of Release	Growing season	Average yield (t ha^{-1})
Kalizira Rice	Local	Local	Aman	2.0-3.0
BRRI dhan37	BRRI	1998	Aman	3.0-3.50

3.7 Description of the herbicides, used for weeds control in the experimental field

Bispyribac - sodium

Trade name	Xtra power 20WP
Name of registration holder	ACI Crop Care
IUPAC Name	sodium 2,6-bis(4,6-dimethoxypyrimidin-2-yloxy) benzoate
Structural formula	
Molecular weight	452.3
Formulation types	Wettable powder herbicide
Mode of actions	A post-emergence herbicide for the control of grasses, sedges, and broad-leaved weeds in paddy rice and other crops/situations. It is a selective, systemic post-emergent herbicide. After application, it gets absorbed by foliage and roots. Inhibits plant amino acid synthesis - Aceto hydroxy acid synthase (AHAS).
Target Weeds	Alligator weed, duckweed, mosquito fern, water fern, water hyacinth, water pennywort, parrot feather; annual bluegrass; creeping bent grass
Major crops	Aquatic situations such as transplanted rice (Paddy), drainage ditches, lakes, marshes; Golf courses, turf grass & sod farms
Application rate	150 g ha^{-1}
Time of application	20 days after transplanting

3.8 Seed collection and sprouting

Kalizira and BRRI dhan37 were collected from BRRI (Bangladesh Rice Research Institute), Joydebpur, Gazipur. Healthy and disease-free seeds were selected following standard techniques. Seeds were immersed in water in a bucket for 24 hrs. These were then taken out of the water and kept in gunny bags. The seeds started sprouting after 48 hrs which were suitable for sowing in 72 hrs.

3.9 Raising of the aromatic rice seedlings

A typical system was followed in the raising of seedlings in the seedbed. The nursery bed was set up by puddling with continued ploughing followed by laddering. The sprouted seeds were planted as uniformly as possible. Irrigation was delicately given to the bed as and when required. No fertilizers were used in the nursery bed.

3.10 Preparation of experimental field

The experimental field was first opened on 30 July 2019 with the help of a power tiller, later the land was irrigated and prepared by three successive ploughings and cross-ploughings. Each ploughing was followed by laddering, to have a good puddled field. Various kinds of weeds and developments of pest crops were disposed of from the field. After final land preparation, the field layout was made on 2 Aug 2019. Each plot was cleared in and finally leveled out with the help of a wooden board.

3.11 Field operation

The different field operations performed during the present investigation are given below in chronological order in list form

List of schedule of field operations done during experimentation

Sl. No.	Field operations	Date
1	Preparation of nursery bed	6 July, 2019
2	Sowing of seeds	8 July, 2019
3	Land preparation for main field	2 August, 2019
4	Puddling and leveling	2 August, 2019
5	Fertilizer application except urea	2 August, 2019
6	Layout of the experiment at field	2 August, 2019
7	Transplanting	3 August, 2019
8	Spraying Bispyribac - sodium WP @ 150 g ha^{-1}	23 August, 2019
9	Top dressing of urea given at early stage	24 August, 2019
10	Top dressing of urea given at active vegetative stage	13 September, 2019
11	Top dressing of urea given at panicle initiation stage	28 September, 2019
12	Harvesting of crop	3 December, 2019
13	Threshing and winnowing of produce	3 December, 2019

3.12 Fertilizer management

Plant nutrients *viz*. N, P, K, S, and Zn for rice were given through urea (150 kg ha^{-1}), triple superphosphate (100 kg ha^{-1}), muriate of potash (70 kg ha^{-1}), gypsum (60 kg ha^{-1}), and zinc sulphate (10kg ha^{-1}), respectively. Based on the soil test the following doses of fertilizers were applied according to the recommendation by BRRI for the cultivation of T. *aman* rice. All of the fertilizers except urea were applied as basal dose at the time of final land preparation. Urea (150 kg ha^{-1}) was applied in equal three splits. The first dose of urea was applied at 21 days after transplanting (DAT). The second dose of urea was added as top dressing at 45 days (active vegetative stage) after transplanting and the third dose was applied at 60 days (panicle initiation stage) after transplanting recommended by BRRI.

3.13 Experimental treatments

The experiment consisted of three factors as mentioned below:

Factor A: weed control treatment (2) *viz:*

W_0 = Weedy check

W_1= Bispyribac - sodium WP @ 150 g ha^{-1}

Factor B: Aromatic rice varieties (2) *viz:*

V_1= Kalizira

V_2 = BRRI dhan37

Factor C: Spacings (4) *viz.*

S_1: 20 cm × 15 cm

S_2: 25 cm × 15 cm

S_3: 20 cm × 20 cm

S_4: 25 cm × 25 cm

3.14 Experimental design and layout

The experiment was laid out in a split-split plot design having 3 replications. In the main plot, there was weed treatment and in the subplot there was variety and sub-sub plot there was spacings treatment. There were 16 treatment combinations and 48 unit plots. The unit plot size was 5.04 m^2 (2.8 m × 1.8 m). The blocks and unit plots were separated by 1.0 m and 0.50 m spacing, respectively. The layout of the experimental field was shown in Appendix- IV.

3.15 Intercultural operations

3.15.1 Gap filling

Died off seedlings in some hills, were replaced by the vigorous and healthy seedling from the same source within 7 days of transplantation.

3.15.2 Application of irrigation water

Irrigation water was added to each plot according to the critical stage. Irrigation was done up to 5 cm.

3.15.3 Method of water application

The experimental plots were irrigated through irrigation channels. Centimeter marked sticks were installed in each plot which was used to measure the depth of irrigation water.

3.15.4 Herbicide application

Herbicide was taken into a knapsack sprayer and mixed with water then applied according to with par treatment requirement for each plot. For herbicide application, only 1 labor was required and maintaining 4-5 cm water level at 65-70 days after transplanting.

3.15.5 Weedy check

The weeds were allowed to grow along with the crop throughout the crop season in weedy check plots and no control measures were adopted to check the weeds. The weed flora present in the weedy check plots was noted.

3.15.6 Plant protection measures

The crop was attacked by *Scirpopagain certulas* (yellow rice stem borer) at the panicle initiation stage which was successfully controlled with Sumithion @ 1.5 L ha^{-1}. Yet to keep the crop growth normal, Basudin was applied at tillering stage @ 17 kg ha^{-1} while Diazinon 60 EC @ 850 ml ha^{-1} were applied to control *Leptocorisa oratorius* (rice bug) and *Cicadellidae* (leafhopper). The crop was protected from birds during the grain filling period by using the net and covering the experimental field.

3.15.7 General observations of the experimental field

Regular observations were made to see the growth and visual differences of the crops, due to the different treatments applied in the experimental field. In general, the field looked nice with normal green plants. Incidence of stem borer, green leafhopper, leaf roller was observed during the tillering stage and there was also rice bug present in the experimental field. But any bacterial and fungal disease was not observed.

3.15.8 Harvesting and post-harvest operation

The rice plant was harvested depending upon the maturity of grains and harvesting was done manually from each plot. The maturity of the crop was determined when 80–90% of the grains become golden yellow. Five(5) pre-selected hills per plot from which different data were collected and 1.00 m^2 areas from the middle portion of each plot were separately harvested and bundled, properly tagged, and then brought to the threshing floor. Threshing was done by a pedal thresher. The grains were cleaned and sun-dried to a moisture content of 12%. Straw was also sun-dried properly. Finally grain and straw yields $plot^{-1}$ were recorded and converted to t ha^{-1}.

3.16 Data collection

The data were recorded on the following parameters

a) Observation on weeds

i. Weed flora
ii. Weed population in weedy check plot ($No.m^{-2}$)
iii. Weed density (m^{-2})
iv. Relative weed density in weedy check plot (m^{-2})
v. Weed dry weight (g m^{-2})
vi. Weed control efficiency (%)
vii. Weed control index (%)

b) Observation on crop

i). Crop growth characters

viii. Plant height (cm)
ix. Number of tillers $hill^{-1}$
x. Leaf area index (LAI)
xi. Dry matter accumulation (g $plant^{-1}$)
xii. Crop growth rate (CGR) (mg cm^{-2} day^{-1})
xiii. Relative growth rate (mg g^{-1} day^{-1})
xiv. Net assimilation rate (NAR) (mg cm^{-2} day^{-1})

ii) Yield contributing characters

xv. Number of effective tillers hill^{-1}
xvi. Number of non-effective tillers hill^{-1}
xvii. Length of panicle (cm)
xviii. Number of filled grains panicle^{-1}
xix. Number of unfilled grains panicle^{-1}
xx. Total grains panicle^{-1}
xxi. Weight of 1000- grain (g)

3.17 Relations

i. Relationship of grain yield and leaf area index (LAI) and total dry matter production
ii. Correlation of grain yield with panicle m^{-2}, grains panicle^{-1} and1000-grainweight

3.17 Procedure of recording data

i) Weeds flora

During experiments weeds found in the experiment,the field was recorded and determine the weeds flora is present in T. *aman* rice

ii) Weed population in weedy check plot (No.m^{-2})

From the pre-demarcated area of 1 m^2 of weedy check plot, individual weed species name and their population were listed at 30 and 60 DAT for better understanding of the various weed interference of the experimented field.

iii) Relative weed density in weedy check plot

Relative weed density in the weedy check plot was estimated at 30 and 60 DAT. The relative weed density was worked out as per the formula given by Mishra (1968).

$$\text{Relative weed density (\%)} = \frac{\text{Number of individuals of same species}}{\text{Number of individuals of all species}} \times 100$$

iv) Weed density (m^{-2})

From the pre-demarcated area of 1 m^2 of each plot, the total weeds were uprooted and were counted at 30 and 60 DAS in the experimental field of rice.

v) Weed dry matter weight (m^{-2})

After counting the fresh weeds, weeds were then oven-dried at 80^0C until a constant weight was obtained. The sample was then transferred into desiccators and allowed to cool down to room temperature and then the final weight of the sample was taken at 30 and 60 DAT of rice, respectively.

vi) Weed control efficiency (WCE)

Weed control efficiency was measured by using the following formula given by Mani *et al.,* (1973).

$$\text{WCE} = \frac{\text{Weed population in control} - \text{weed population in treated plot}}{\text{Weed population in control}} \times 100$$

viii) Weed control index (WCI)

Weed control efficiency was measured by using the following formula given by Mishra and Tosh, (1979).

$$\text{WCI} = \frac{\text{Weed dry weight in control} - \text{weed dry weight in treated plot}}{\text{Weed dry weight in control}} \times 100$$

viiii) Plant height (cm)

The height of the randomly selected 5 plants was determined by measuring the distance from the soil surface to the tip of the leaf started from 15 DAT continued upto harvest respectively. Mean plant height of rice plant were calculated and expressed in cm.

ix) Number of tillers hill^{-1}

The number of tillers hill^{-1} were counted at 15 days intervals after transplanting up to harvest from pre-selected hills and finally averaged as their number hill^{-1}. Only those tillers having three or more leaves were considered for counting.

x) Dry matter accumulation plant^{-1}(g)

Dry matter accumulation plant^{-1} (g) was recorded at 30, 60 and 90 DAT. The sample plants were oven dried for 72 hours at 70°C and then data were recorded from plant samples plant^{-1} plot^{-1} selected at random from the outer rows of each plot leaving the border line and expressed in gram.

xi) Leaf area index

Leaf area index were estimated manually by counting the total number of leaves per plant and measuring the length and average width of leaf and multiplying by a factor of 0.75 (Kluen and Wolf, 1986). It was done at 30, 60 and 90 DAT.

$$\text{Leaf area index} = \frac{\text{Surface area of leaf sample } (\text{cm}^2) \times \text{Correction factor}}{\text{Ground area from where the leaves were collected}}$$

xii) Crop growth rate (CGR) (g plant^{-1} day^{-1})

The average daily increment in plant stand is an important characteristic. The CGR is an increase in dry matter production per unit ground area per unit time. In the present investigation the crop growth rate was worked out between 60 to 90 DAT with the help of following formula given by Radford(1967) and Hun(1978)shown below

Crop growth rate (CGR = $\frac{W2-W1}{(t2-t1)}$ g plant^{-1} day^{-1}

Where,

W_1 = Total plant dry matter at time at t_1 time

W_2 = Total plant dry matter at time at t_2 time

t_1 = time of first sampling

t_2 = time of second sampling

xiii) Relative growth rate (mg g^{-1} day^{-1})

The relative growth rate expresses the increase in dry weight at time interval in relation to initial weight. In practical situations, the mean relative growth rate was calculated from measurements on dry weight at the time intervals (Between 60 to 90 DAT) with the help of following equation suggested by Beadle (1985).

Relative growth rate = $\frac{Ln(W2)-\text{Ln}(W1)}{(t2-t1)}$

Where,

Ln = natural log values

W_1 = dry weight per unit area at t_1

W_2 = dry weight per unit area at t_2

t_1 = time of first sampling

t_2 = time of second sampling

Net assimilation rate (NAR) (mg cm^{-2} day^{-1})

It is an increase in dry weight of plant per unit leaf area per unit time (Between 60 to 90 DAT). The net assimilation rate was calculated from the following equation given by Gregory (1926).

xiv) Net assimilation rate = $\frac{(W2-W1)(\text{LnLA2}-\text{LnLA1})}{(t2-t1)(\text{LA2}-\text{LA1})}$ mg cm^{-2} day^{-1}

Where,

LA_1 = leaf area of the first sampling

LA_2 = leaf area of the second sampling

W_1 = dry weight per unit area at t1

W_2 = dry weight per unit area at t2

t_1 = time of first sampling

t_2 = time of second sampling

Ln = natural log values

ix) Panicle length

Measurement of panicle length was taken from the basal node of the rachis to the apex of each panicle. Panicle length was measured with a meter scale from 5 selected panicles and the average value was recorded

x) Number of effective tillers hill^{-1}

The total number of effective tillers hill^{-1} was counted as the number of panicle bearing tillers per hill. Data on effective tiller per hill were recorded from 5 randomly selected hills at harvesting time and the average value was recorded.

xi) Number of non-effective tillers hill^{-1}

The total number of non-effective tillers hill^{-1} was counted as the tillers, which have no panicle on the head. Data on non-effective tiller per hill were counted from 5 pre-selected (used in effective tiller count) hill at harvesting time and the average value was recorded.

xii) Number of filled grains panicle^{-1}

The total number of filled grains was collected randomly from selected 5 plants of a plot and then an average number of filled grains per panicle was recorded.

xiii) Number of unfilled grains penicle^{-1}

The total number of unfilled grains was collected randomly from selected 5 plants of a plot based on, no or partially developed grain in spikelet and then an average number of unfilled grains per panicle was recorded.

xvi) Number of total grains panicle^{-1}

The number of fertile grains panicle^{-1} alone with the number of sterile grains panicle^{-1} gave the total number of grains panicle^{-1}.

xv) Weight of 1000-grain

One thousand cleaned dried seeds were counted randomly from each sample and weighed by using a digital electric balance at the stage the grain retained 12% moisture and the mean weight was expressed in gram.

xvi) Grain yield

Grain yield was adjusted at 14% moisture. Grains obtained from each unit plot were sun-dried and weighed carefully. The dry weight of grains of the central 1m^2 area was measured and then record the final grain yield of each plot^{-1} and finally converted to t ha^{-1} in both locations. The grain yield t ha^{-1}was measured by the following formula:

$$\text{Grain yield (t ha}^{-1}\text{)}=\frac{\text{Grain yield per unti plot (kg)} \times 10000}{\text{Area of unit plot in square meter} \times 1000}$$

xvii) Straw yield

After separating the grains, the straw yield was determined from the central 1 m^2 area of each plot. After threshing the sub-samples were sun-dried to a constant weight and finally converted to t ha^{-1}. The straw yield t ha^{-1} was measured by the following formula:

$$\text{Straw yield (t ha}^{-1}\text{)} = \frac{\text{Straw yield per unti plot (kg)} \times 10000}{\text{Area of unit plot in square meter} \times 1000}$$

xviii) Biological yield (t ha^{-1})

The summation of grain yield and above-ground straw yield was the biological yield. Biological yield =Grain yield + Straw yield.

xix) Harvest index (%)

The harvest index was calculated on a dry weight basis with the help of the following formula.

$$\text{Harvest index (HI \%)} = \frac{\text{Grain yield}}{\text{Biological yield}} \times 100$$

Here, Biological yield = Grain yield + straw yield

3.18 Economic analysis of rice cultivation

In this research from the beginning to end of the experiment, individuals cost data of all the heads of expenditure in each treatment were recorded carefully and classified according to Mian and Bhuiya (1977) as well as posted under different heads of cost of production.

i. Input cost

Input costs were divided into two parts. These were as follows:

A. Non-material cost

Non-material cost is all the laborers cost. Human laborers were obtained from adult male laborers. In a day 8th hour working a laborer was considered as a man's day. The mechanical labor came from the tractor. A period of eight working hours of a tractor was taken to be tractor day.

Individual labor wages 400 taka day^{-1}.

B. Material cost

Its included seeds rate ha^{-1}, fertilizers, pesticide application, irrigation application cost

ii. Overhead cost

Overhead cost is the land cost. The value of the land varies from place to place. In this research,the value of land was taken Tk. 200000 per hectare. The interest on this cost was calculated for 6 months @ Tk. 12.5% per year based on the interest rate of the Bangladesh Krishi Bank.

iii. Miscellaneous cost (common cost)

It was 5% of the total input cost

iv. Gross Return from rice

Gross return from rice (Tk. ha^{-1}) = Value of grain yield (Tk. ha^{-1}) + Value of straw (Tk. ha^{-1})

v. Net return (NR)

Net return was calculated by using the following formula:

NR (Tk. ha^{-1}) = Gross return (Tk. ha^{-1}) – Total cost of production (Tk. ha^{-1}).

vi. Benefit-cost ratio of rice (BCR)

The benefit-cost ratio indicated whether the cultivation is profitable or not which was calculated as follows:

$$\text{BCR} = \frac{\text{Gross return (Tk/ha)}}{\text{Cost of production (Tk/ha)}}$$

3.19 Data analysis technique

The collected data were compiled and analyzed statistically using the analysis of variance (ANOVA) technique with the help of the computer package STATIX 10. The mean differences among the treatments were adjusted at a 5% level of significance.

CHAPTER IV

RESULTS AND DISCUSSION

Results obtained from the present study have been presented and discussed in this chapter to study varieties and spacing effects on the weed control, growth, and yield of aromatic rice in Bangladesh. The data are given in different tables and figures. The results have been discussed, and possible interpretations are given under the following headings.

4.1 Weed flora in the aromatic rice field

In this experiment, the rice field was infested with different types of weeds. Thirteen different weed species were observed in the experimental field where most dominating were broadleaf and sedge weed species (Table 1). Among the infesting different categories of weeds species, two were grasses, four sedges, and seven broadleaf. The weed species were belonging to the families of Alismataceae, Menyanthaceae, Asteraceae, Sphenocleaceae, Pontederiaceae, Onagraceae, Papayeraceae, Cyperaceae, and Poaceae. The broad-leaved were, *Sagittaria guayansis, Nymphoides cristatum, Enydra fluctuans, Sphenoclea zeylanica, Monochoria vaginalis, Ludwigia octovalvis*, *and Marsilea quadrifolia*; sedges were *Scirpus maritimus, Cyperus diformis*,and *C. rotundus*, and *grasses were Eleusine indica*, *Echinochloa cruss-galli*, and *E. colona*. The result obtained from the present study was similar to the findings of Bhuiyan and Mahbub (2020) who reported that among the infesting different categories of weeds in the rice field, two were grasses, two sedges, and four broadleaves. The weed species were belonging to the families of Poaceae, Cyperaceae, Pontederiaceae, Marsileaceae, Sphenocleaceae, and Asteraceae. The broadleaved were: *M. vaginalis, M. minuta*, *S. zeylanica*,and *Eclipta alba*; grasses were *E. crus-galli, Cynodon dactylon*, and sedges were *C. difformis* and *Scirpus maritimus.* Yadav *et al.* (2009) also reported that the major associated weeds in rice field were *E. glabrescens* and *E. colona* (L.) among grasses, *Ammannia baccifera* L. and *Euphorbia* sp. among broad-leaved weeds, and *Fimbristylis miliacea* (L.) Vahl*, C. iria* L.*, C. rotundus* L. and *C. difformis* L. among sedges. Bari *et al*. (1995) in the experiment at BAU reported that the three important weeds of transplanted *aman*rice fields were *F. miliacea*, *Paspalum scrobiculatum* and *C. rotundus.* Mamun *et al.*

(1993) also reported that *F. miliacea*, *Lindernia antipola,* and *Eriocaulen cenerseem* were important species of weeds in transplant *aman* rice fields.

Table 1. Weed flora of the experimental field in aromatic rice field

Local name	English name	Scientific name	Family	Habitet	Weed type
Shama	Barnyard Grass	*Echinochloa cruss-galli*	*Poaceae*	Annual	Grass
Choto shama	Jungle rice	*Echinochloa colona*	*Poaceae*	Perennial	Grass
Chapra	Indian goosegrass	*Eleusine indica*	*Poaceae*	Annual	Grass
Cechra	Dwarf Club-rush	*Scirpus maritimus*	*Cyperaceae*	Perennial	Sedge
Holde mutha	Yellow nutsedge	*Cyperus diformis*	*Cyperaceae*	Perennial	Sedge
Mutha	Java grass	*Cyperus rotundus*	*Cyperaceae*	Perennial	Sedge
Helenca	Buffalo spinach	*Enydra fluctuans*	*Asteraceae*	Annual	Broadleaf
Jheel-morich	Gooseweed	*Sphenoclea zeylanica*	*Sphenocleaceae*	Annual	Broadleaf
Pani kochu	Pickerel weed	*Monochoria vaginalis*	*Pontederiaceae*	Perennial	Broadleaf
Pani Long	Mexican Primrose Willow	*Ludwigia octovalvis*	*Onagraceae*	Perennial	Broadleaf
Shusni shak	European water clover	*Marsilea quadrifolia*	*Papayeraceae*	Perennial	Broadleaf
Chad mala	Duck weed	*Sagittaria guayansis*	*Alismataceae*	Perennial	Broadleaf

4.2 Species wise weed population (No. m^{-2}) and relative weed density (%)

Data on species wise weed population (No. m^{-2}) and relative density (%) of weeds recorded in the experimental area at 30 DAT and 60 DAT are presented in (Table 2).It is obvious from the data that there was a predominance of broadleaf and sedge weeds in the experiment field.Among different weeds, *Monochoria vaginalis* was the most dominant weed (24.67 and 19.67 density m^{-2} and 15.93 and 16.98 % relative density) at 30 and 60 DAT.This was followed by *Sagittaria guayansis and Cyperus rotundus* weed species both at 30 and 60 DAT. Whilethe dominancy of *Scirpus maritimus* was least at 30 DAT and *Marsilea quadrifolia* at 60 DAT among all the weed species.

Table 2. Species wise weed population (No. m^{-2}) and relative weeds density (%) in the experimental area at 30 and 60 DAT

	Weed population (No. m^{-2})		Relative weeds density (%)	
Scientific name	30 DAT	60 DAT	30 DAT	60 DAT
Sagittaria guayansis	19.1	17.85	11.80	11.81
Nymphoides cristatum	7.8	9.1	4.82	6.02
Enydra fluctuans	12.5	11.45	7.72	7.58
Sphenoclea zeylanica	13.44	12.34	8.3	8.17
Monochoria vaginalis	24.67	19.67	15.24	13.02
Ludwigia octovalvis	14.34	14.23	8.86	9.42
Marsilea quadrifolia	3.3	3.34	2.04	2.21
Scirpus maritimus	3.1	5.54	1.92	3.67
Eleusine indica	8.33	7.54	5.15	4.99
Echinochloa colona	11.66	11.5	7.2	7.61
Cyperus diformis	18.08	15.34	11.17	10.15
Cyperus rotundus	20.21	18.86	12.48	12.48
Echinochloa cruss-galli	5.34	4.35	3.3	2.87
Total weed	161.87	151.11	100	100

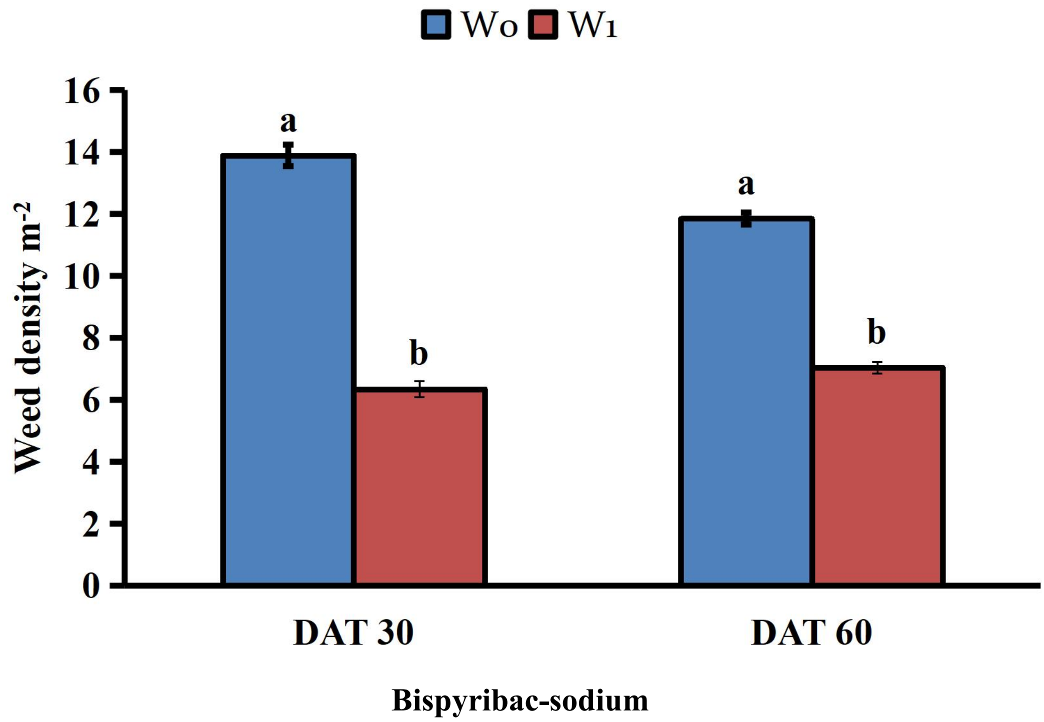
4.3 Weed density m^{-2}

Effect of weed control treatment

4.3 Weed density m^{-2}

Effect of Bispyribac-sodium

Application of herbicide significantly affects weed density on transplanting aromatic rice. (Figure 1). Results revealed that maximum weed density (13.89 and 11.85 m^{-2} at 30 and 60 DAT) was recorded in the weedy check plot while Bispyribac - sodium WP @ 150 g ha^{-1}herbicide treated plot was recorded minimum weed density (6.35 and 7.04 m^{-2}) at 30 and 60 DAT. This was due to the application of Bispyribac - sodium WP @ 150 g ha^{-1}herbicide which might have prevented the germination of susceptible weedspecies and also reduced the growth of germinated weeds by inhibiting the process of photosynthesis comparable to other herbicide treatments. The result obtained from the present study was similar to the findings of Mahbub and Bhuiyan (2018) also reported that the mixture of herbicides gave 80% control of annual and perennial weeds comparable to individual application of herbicides. Rekha *et al.* (2003) and Reddy *et al*. (2000) also found similar results with the present study and reported that the weed density was highest in the weed check condition, and weed density was decreased under different weed management treatments and among various treatments all herbicidal treatments reduced weed density significantly compared with a weedy check due to reason that herbicide effect on the germinating weed seeds over a prolonged duration and thereby exhausting the weed seeds over a prolonged duration and thereby exhausting the weed seed reserves in the soil and thus reduced weed density in the crop field.



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Here, W_0: Weedy check and W_1:Bispyribac - sodium WP @ 150 g ha^{-1}

Figure 1. Effect of Bispyribac - sodium weeds control treatment on weeds Density m^{-2} of aromatic rice at different days after transplanting (Bars represent±SD of values obtained from three biological replicates).

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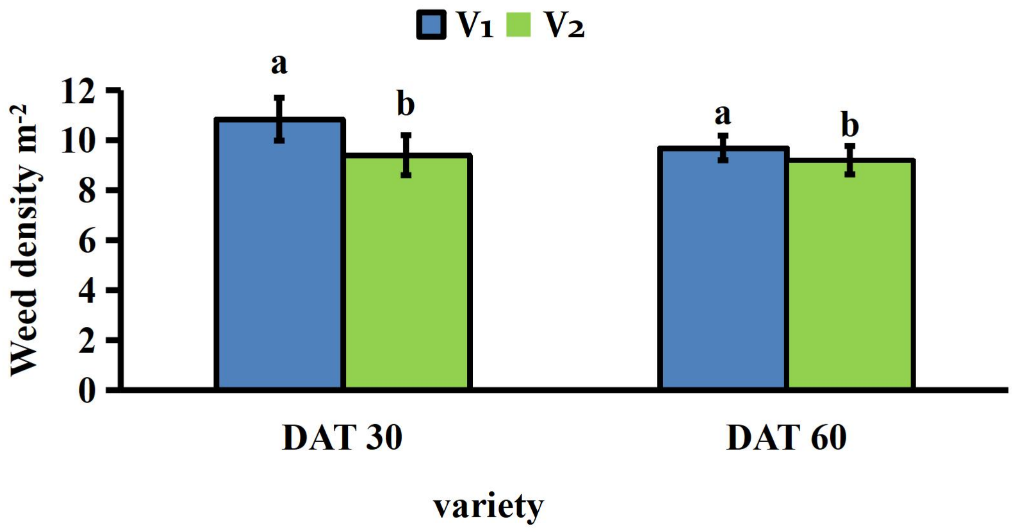
Effect of variety

The significant effect on weed density m^{-2} was found in different varietiess at 30 DAT and 60 DAT (Figure 3). Among the different rice varieties, the maximum weed density (10.84 and 9.69 m^{-2} at 30 and 60 DAT) was recorded in the Kalizira rice variety while the minimum weed density (9.40 and 9.20 m^{-2} at 30 and 60 DAT) was recorded in BRRI dhan37 cultivation. The number of weeds was lower in the high-yielding cultivated plots might be due to vigorous growth of the variety helped to reduce the weed population and hence lower in number.Afrin *et al.* (2015) also found similar results which supported the present finding and reported that the number of weeds or the weed population, depends on the soil, environment, varieties, and other factors. As a result, variations in the weed population occurred. Gibson *et al*. (2001) reported that competitive rice cultivar *viz*. hybrids usually have better vigor than inbreeds and effectively suppressed the infestation of weed populations or density.

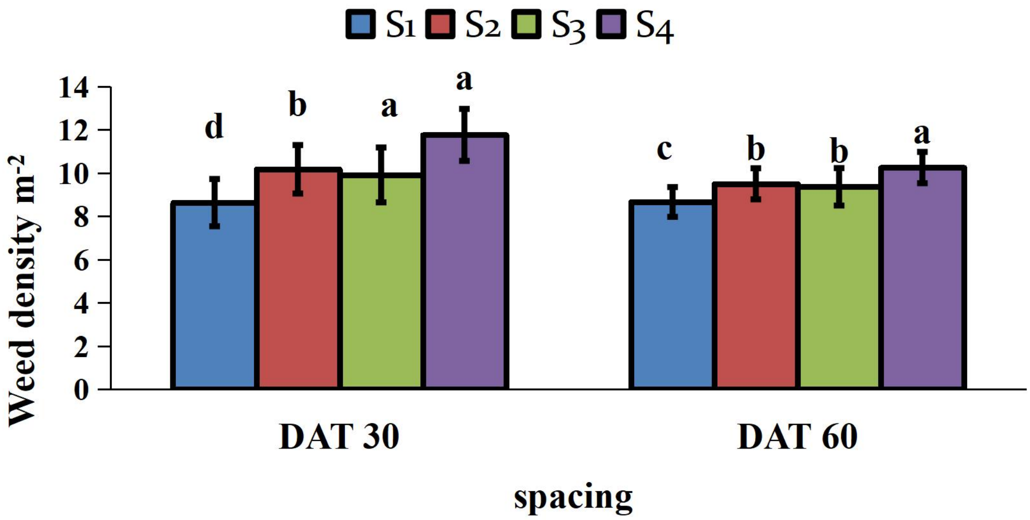


Here, V_1: Kalizira and V_2: BRRI dhan37

Figure 2. Effect of variety on weeds density m^{-2} of aromatic rice at different days after transplanting(Bars represent±SD of values obtained from three biological replicates).

Effect of spacing

The spacing of planting is one of the most important factors, which in the first place influences the yields, the quality, and quite often the earliness of the respective cultivar. Different spacing had significantly effect on weed density at 30 DAT and 60 DAT (Figure 3). The experiment results showed that the maximum weed density (11.76 and 10.25 m^{-2} at 30 and 60 DAT) was recorded at 25 cm × 25 cm spacing while the minimum weed density (8.63 and 8.66 m^{-2} at 30 and 60 DAT) was recorded at 20 cm × 15 cm spacing. Narrow row spacing reduces the time the crop needs to close the canopy, thereby providing rapid shading and decreasing weeds' competitive abilities, and simultaneously decreasing the reliance on herbicides. Chadhar *et al.* (2020) also found similar results ,which supported the present finding and reported that weed density and weed dry biomass gradually increased and reached their peaks by increasing weed competition periods and crop plant spacing for the full growing season. Eshaghi *et al.* (2013) reported that closer spacing had the lowest weed density and dry weight than wider spacing. Kim and Moody (1989) have shown that, as the planting distance between hills of transplanted rice is reduced, the crop becomes more competitive against weeds, and yield losses due to weeds are reduced.



Here, S_1: 20 cm × 15 cm, S_2: 25 cm × 15 cm, S_3: 20 cm × 20 cm and S_4: 25 cm × 25 cm

Figure 3. Effect of spacings on weeds density m^{-2} of aromatic rice at different days after transplanting(Bars represent±SD of values obtained from three biological replicates).

Combined effect of Bispyribac-sodium and variety

Combined effect of weed control and rice variety showed significant effect on weeds density m^{-2} at 30 and 60 DAT (Table 3). Experiment result revealed that weedy check plot along with Kalizira cultivation recorded maximum weeds density (14.75 and 12.00 m^{-2}) at 30 and 60 DAT. While application of herbicide *i.e.,*Bispyribac - sodium WP @ 150 g ha^{-1}along with BRRI dhan37 rice variety cultivation recorded minimum weeds density (5.77 and 6.71) at 30 and 60 DAT. The variation in weeds density m^{-2} was due to reason that effective herbicide and high yielding rice cultivars reduce the weed density m^{-2} comparable to weedy check plot and low yielding rice varieties cultivation.

Combined effect of Bispyribac-sodium and spacing

Combined effect of weed control and different spacing showed significant effect on weeds density m^{-2} at 30 and 60 DAT (Table 4). Experiment result revealed that weedy check plot along with 25 cm × 25 cm spacing recorded maximum weeds density (15.65 and 12.56 m^{-2}) at 30 and 60 DAT. While application of herbicide *i.e.,*Bispyribac - sodium WP @ 150 g ha^{-1}along with 20 cm ×15 cm spacing recorded minimum weeds density (5.09 and 6.750) at 30 and 60 DAT.

Combined effect of variety and spacing

Different rice varieties along with different spacing significant effect on weeds density m^{-2} at 30 and 60 DAT (Table 5). Experiment result revealed that Kalizira cultivation at 25 cm × 25 cm spacing recorded maximum weeds density (12.37 and 10.87 m^{-2}) at 30 and 60 DAT. While BRRI dhan37 cultivation at 20 cm × 15 cm spacing recorded minimum weeds density (8.07 and 8.16 m^{-2}) at 30 and 60 DAT.

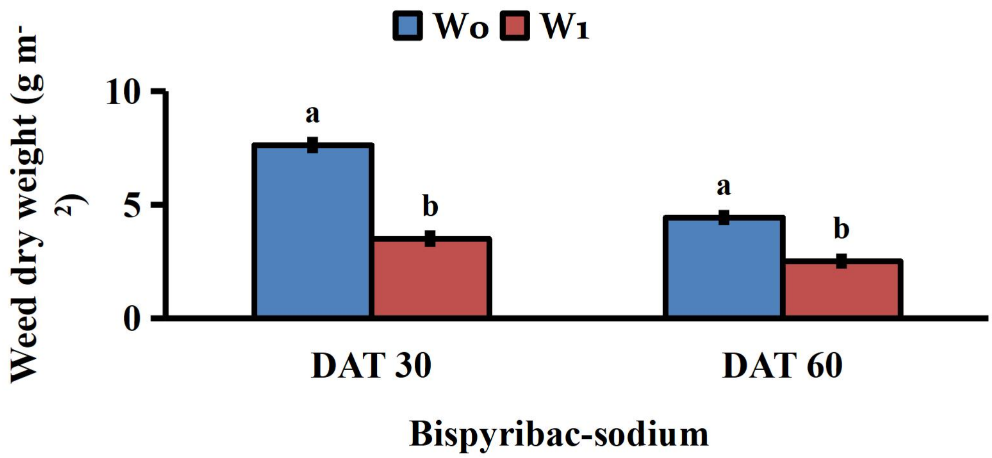
Combined effect of Bispyribac-sodium,variety and spacings

Weed control treatment along with different rice variety and spacings showed significant effect on weeds density m^{-2} at 30 and 60 DAT (Table 6). Experiment result revealed that weedy check plot along with Kalizira cultivation at 25 cm × 25 cm spacing recorded maximum weeds density (16.00 and 12.67 m^{-2}) at 30 and 60 DAT which was statistically similar with weedy check plot along with BRRI dhan37 cultivation at 20 cm × 20 cm spacing (12.67 m^{-2}) and with weedy check plot along with BRRI dhan37 cultivation at 25 cm × 25 cm spacing (12.44 m^{-2}) at 60 DAT. While weed control through Bispyribac - sodium WP @ 150 g ha^{-1} herbicide application along with BRRI dhan37 cultivation at 20 cm × 15 cm spacing recorded minimum weeds density (4.80 and 6.33 m^{-2}) at 30 and 60 DAT which was statistically similar with Bispyribac - sodium WP @ 150 g ha^{-1} herbicide along with BRRI dhan37cultivation at 20 cm × 15 cm spacing (6.34 m^{-2}) and with Bispyribac - sodium WP @ 150 g ha^{-1} herbicide along with Kalizira cultivation at 20 cm × 15 cm spacing (6.67 m^{-2}) at 60 DAT.

4.4 Weed dry weight (g m^{-2})

Effect of Bispyribac-sodium

Weed dry weight m^{-2} were significantly influenced due to different weed control treatment at 30 and 60 DAT (Figure 5). Result showed that the maximum weed dry weight (7.63 and 4.44 g m^{-2}) at 30 and 60 DAT was recorded in weedy check plot. While Application of herbicide *i.e.,*Bispyribac - sodium WP @ 150 g ha^{-1}recorded minimum weed dry weight (3.51 and 2.52 g m^{-2}) at 30 and 60 DAT. The differences of the dry matter accumulation by different weeds m^{-2} was due to reason that application of herbicide alter the physiological and morphological activities of the weeds as a result dry matter accumulation by different weeds m^{-2} were reduced comparable to non treated one. Mishra (2019) also found similar result which supported the present finding and reported that untreated weedy check produced the maximum weed dry weight at all the crop growth stages because of higher weed intensity and its dominance in utilizing the sunlight, nutrients, moisture *etc*. Suryakala *et al.* (2019) also reported that weed dry matter was highly influenced by differential application of herbicides

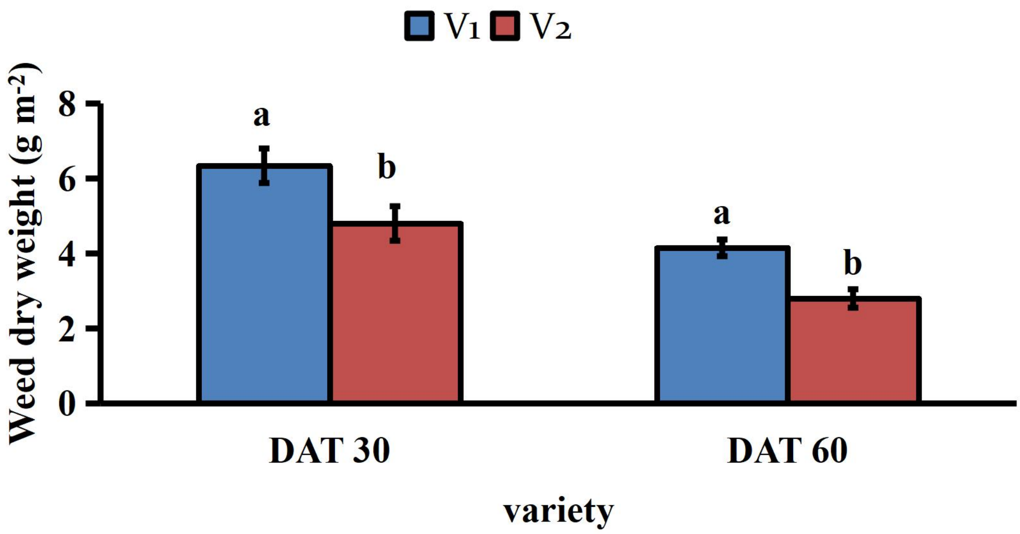


Here, W_0: Weedy check and W_1: Bispyribac - sodium WP @ 150 g ha^{-1}

Figure 4: Effect of weeds control on weed dry weight m^{-2} of aromatic rice at different days after transplanting.(Bars represent±SD of values obtained from three biological replicates).

Effect of variety

Rice varieties play an important role to control weed in some extent levels which ultimately impacts on dry weight accumulation by different weeds in the field. Rice variety showed significant variation in respect of weed dry weight m^{-2} at 30 and 60 DAT (Figure 4). Result showed that among different rice varieties the maximum weed dry weight (6.34 and 4.14 g m^{-2} at 30 and 60 DAT) was observed in Kalizira rice variety. While the minimum weed dry weight (4.80 and 2.80 g m^{-2} at 30 and 60 DAT) was observed in BRRI dhan37 rice variety. Similar result also observed by Sohel *et al.* (2020) who reported that competitive ability of different rice varieties significantly reduce the weed population in the field which ultimately impact on the total dry matter accumulation by weed in m^{-2} area. The result found in this experiment is agreed with Chauhan and Johnson (2011) who reported that the high competitive cultivars would be rapid canopy closure so that shade under the canopy would suppress the growth of weeds which ultimately reduce the dry matter accumulation by weeds.

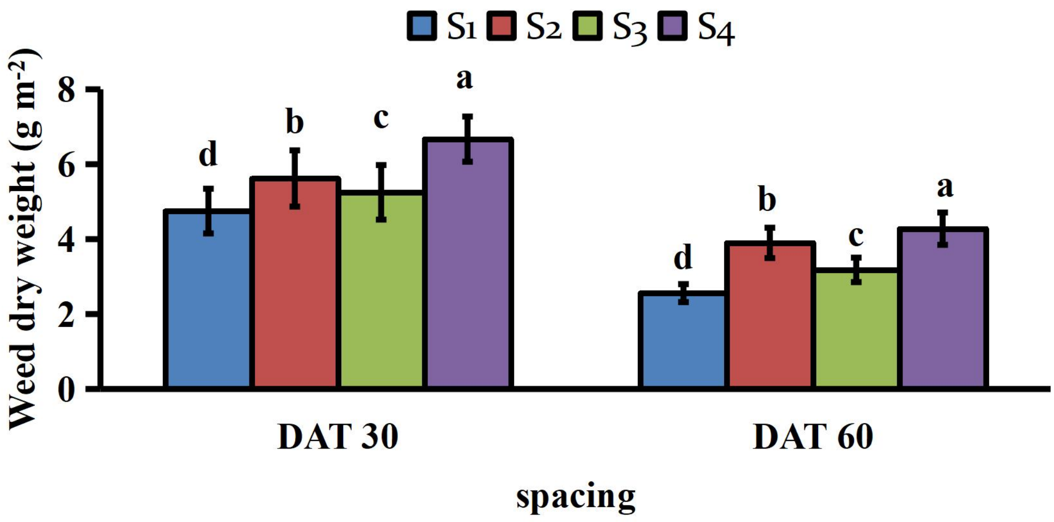


Here, V_1: Kalizira and V_2: BRRI dhan37

Figure 5. Effect of variety on weed dry weight m^{-2} of aromatic rice at different days after transplantin(Bars represent±SD of values obtained from three biological replicates).

Effect of spacing

Spacing play an important role as its influences on plant growth and development. Different spacings significantly influenced weed dry weight m^{-2} at 30 and 60 DAT (Figure 7). Experiment result showed that rice cultivated in wider spacing *i.e.,* 25 cm× 25 cm spacingrecorded maximum weed dry weight (6.67 and 4.28 g m^{-2})at 30 and 60 DAT while 20 cm × 15 cm spacing recorded minimum weed dry weight (4.75 and 2.56 g m^{-2})at 30 and 60 DAT. The present study support with the finding of Chauhan and Johnson (2011) who reported that wider row spacing of rice prolonged weed competition period that resulted in significant increase in weed density and dry biomass. Rao and Moody (1992) reported that in addition to reducing weed weight and weed competition, closer plant spacing resulted in more options from which a farmer could select a suitable weed control practice.



Here, S_1: 20 cm × 15 cm, S_2: 25 cm × 15 cm, S_3: 20 cm × 20 cm and S_4: 25 cm × 25 cm

Figure 6. Effect of spacing on weed dry weight m^{-2} of aromatic rice at different days after transplanting(Bars represent±SD of values obtained from three biological replicates).

Combined effect of Bispyribac-sodiumand variety

Weed control through herbicide application along with rice variety cultivation showed variation in weed dry matter production comparable to weedy check plot (Table 3). In this experiment significant effect recorded only at 60 DAT. Result showed that weedy check plot along with Kalizira cultivation recorded the maximum weed dry weight (8.39 and 4.95 g m^{-2}) at 30 and 60 DAT. While Bispyribac - sodium WP @ 150 g ha^{-1} herbicide along with BRRI dhan37 rice variety cultivation recorded the minimum weed dry weight (2.73 and 1.68 g m^{-2}) at 30 and 60 DAT.

Combined effect of Bispyribac-sodium and spacing

Different weed control treatment along with spacings showed significant effect on weeds dry weight m^{-2} at 30 and 60 DAT (Table 4). Experiment result revealed that weedy check plot along with 25 cm × 25 cm spacing recorded maximum weeds dry weight (8.49 and 5.32 g m^{-2}) at 30 and 60 DAT. While application of herbicide *i.e.,*Bispyribac - sodium WP @ 150 g ha^{-1}along with 20 cm ×15 cm pacing recorded minimum weeds dry weight (2.94 and 1.79 g m^{-2}) at 30 and 60 DAT which was statistically similar with Bispyribac - sodium WP @ 150 g ha^{-1} treated plot along with 20 cm ×15 cmspacing (3.02 g m^{-2}) at 30 DAT.

Combined effect of variety and spacing

Combined effect of variety and spacings showed significant effect on weeds dry weight m^{-2} at 30 and 60 DAT (Table 5). Result showed that cultivation of Kalizira rice variety at 25 cm × 25 cm recorded the maximum weed dry weight (7.42 and 5.11 g m^{-2}) at 30 and 60 DAT while cultivation of BRRI dhan37 rice variety at 20 cm × 15 cm recorded the minimum weed dry weight (4.02 and 2.09 g m^{-2}) at 30 and 60 DAT.

Combined effect of Bispyribac-sodium variety and spacing

Different weed control treatment along with different rice varieties cultivation at different spacing significantly effect on weed dry weight m^{-2} (Table 6). Experiment result showed that weedy check plot along with Kalizira cultivation at 25 cm × 25 cm spacing recorded maximum weeds dry weight (9.13 and 6.03 g m^{-2}) at 30 and 60 DAT while Bispyribac - sodium WP @ 150 g ha^{-1} herbicide along with BRRI dhan37 rice variety cultivation at 20 cm × 15 cm spacing recordedminimum weeds dry weight (2.10 and 1.22 g m^{-2}) at 30 and 60 DAT which was statitically similar with Bispyribac - sodium WP @ 150 g ha^{-1} herbicidealong with BRRI dhan37 rice variety cultivation at 20 cm × 20 cm spacing recorded weeds dry weight (2.23 and 1.33 g m^{-2}) at 30 and 60 DAT.

Table 3. Combined effect of Bispyribac-sodium and variety on weeds density and weed dry weight m^{-2} of aromatic rice at different DAT

Treatment Combinations	Weeds density m^{-2}		Weeds dry weight m^{-2}	
	DAT 30	DAT 60	DAT 30	DAT 60
W_0V_1	14.75±1.32a	12.00±1.08a	8.39±0.85	4.95±0.98a
W_0V_2	13.02±1.62b	11.69±0.72b	6.87±0.81	3.92±0.68b
W_1V_1	6.93±1.31c	7.38±1.15c	4.30±0.88	3.35±0.58c
W_1V_2	5.77±0.93d	6.71±0.48d	2.73±0.79	1.68±0.25d
SE	0.04	0.14	Ns	0.03
CV(%)	1.94	2.28	1.27	1.95

Here:W_0:Weedy check and W_1: Bispyribac - sodium V_1: Kalizira and V_2: BRRI dhan37

Table 4. Combined effect of weeds control and spacings on weeds density and weed dry weight m^{-2} of aromatic rice at different DAT

Treatment Combinations	Weeds density m^{-2}		Weeds dry weight m^{-2}	
	DAT 30	DAT 60	DAT 30	DAT 60
W_0S_1	12.17 ±1.08d	10.83±1.06 d	6.57 ±0.76d	3.33 ± 0.43d
W_0S_2	13.72±1.54c	11.84 ±0.59c	7.98±0.96b	4.97±0.71b
W_0S_3	14.00±1.28b	12.17±0.79b	7.48±1.1c	4.14 ±0.44c
W_0S_4	15.65±0.83a	12.56 ±0.59a	8.49±0.81a	5.32 ±0.82a
W_1S_1	5.09±0.39h	6.50 ±0.36g	2.94±0.93g	1.79 ±0.73h
W_1S_2	6.62±0.64f	7.17 ±0.38f	3.26±0.72f	2.83 ±1.03f
W_1S_3	5.82±0.76g	6.56 ±0.39g	3.02±0.87g	2.22 ±0.83g
W_1S_4	7.88±1.02e	7.95 ±1.27e	4.85±0.98e	3.24 ±1.17e
SE	0.06	0.20	0.07	0.04
CV(%)	1.39	2.43	1.45	2.06

Here:W_0:Weedy check and W_1: Bispyribac - sodium WP @ 150 g ha^{-1},S_1: 20 cm × 15 cm, S_2: 25 cm × 15 cm, S_3: 20 cm × 20 cm and S_4: 25 cm × 25 cm

Table 5. Combined effect of variety and spacings on weeds density and weed dry weight m^{-2} of aromatic rice at different DAT

Treatment Combinations	Weeds density m^{-2}		Weeds dry weight m^{-2}	
	DAT 30	DAT 60	DAT 30	DAT 60
V_1S_1	9.19 de±4.21	9.17 d±2.04	5.49±1.89e	3.03±0.49f
V_1S_2	11.07 b±4.35	9.50 bc ±2.78	6.35±2.69b	4.67±1.02b
V_1S_3	10.74 c±4.7	9.22 cd±2.72	6.12±2.56c	3.80±0.79c
V_1S_4	12.37 a±4.02	10.87 a ±1.87	7.42±1.91a	5.11±1.04a
V_2S_1	8.07 f±3.61	8.16 e±2.77	4.02±2.11h	2.09±0.79h
V_2S_2	9.27 d±3.5	9.50 bc±2.42	4.89±2.51f	3.12±1.36e
V_2S_3	9.09 e±4.31	9.51 bc±3.49	4.38±2.36g	2.56±1.2g
V_2S_4	11.16 b±4.58	9.64 b±3.1	5.92±2.14d	3.44±1.39d
SE	0.06	0.20	0.07	0.04
CV(%)	1.39	2.43	1.45	1.95

Here:V_1: Kalizira and V_2: BRRI dhan37;S_1: 20 cm × 15 cm, S_2: 25 cm × 15 cm, S_3: 20 cm × 20 cm and S_4: 25 cm × 25 cm

Table 6. Combined effect bispyribac-sodium, variety and spacings on weeds density and weed dry weight m^{-2} of aromatic rice at different DAT

Treatment Combinations	Weeds density m^{-2}		Weeds dry weight m^{-2}	
	DAT 30	DAT 60	DAT 30	DAT 60
$W_0V_1S_1$	13.00±0.68d	11.67±0.52b	7.20 ±0.38e	3.70±0.19f
$W_0V_1S_2$	15.00±0.79c	12.00±0.63b	8.79±0.46b	5.58±0.29b
$W_0V_1S_3$	15.00±0.78c	11.67±0.61b	8.44±0.44c	4.50±0.24c
$W_0V_1S_4$	16.00±0.84a	12.67 ±0.65a	9.13±0.48a	6.03 ±0.32a
$W_0V_2S_1$	11.34±0.59f	9.98 ±0.61c	5.94±0.31g	2.96 ±0.16h
$W_0V_2S_2$	12.44±0.65e	11.67±0.61b	7.17±0.38e	4.35 ±0.23d
$W_0V_2S_3$	13.00±0.68d	12.67 ±0.67a	6.52±0.34f	3.78 ±0.19f
$W_0V_2S_4$	15.30±0.81b	12.44 ±0.65a	7.85±0.42d	4.60 ±0.24c
$W_1V_1S_1$	5.37±0.28k	6.67±0.33fg	3.77±0.19j	2.35 ±0.15i
$W_1V_1S_2$	7.13±0.38h	7.00 ±0.37ef	3.90 ±0.21ij	3.76 ±0.2f
$W_1V_1S_3$	6.47±0.34i	6.77 ±0.37f	3.80±0.2j	3.10 ±0.16g
$W_1V_1S_4$	8.74 ±0.46g	9.06 ±0.48d	5.71±0.3h	4.19 ±0.22e
$W_1V_2S_1$	4.80 ±0.25l	6.33 ±0.35g	2.10±0.11l	1.22 ±0.08k
$W_1V_2S_2$	6.10 ±0.32j	7.33 ±0.39e	2.62 ±0.14k	1.89 ±0.09j
$W_1V_2S_3$	5.17 ±0.27k	6.34 ±0.33g	2.23±0.18l	1.33 ±0.08k
$W_1V_2S_4$	7.01±0.37h	6.84 ±0.36f	3.98±0.21i	2.28 ±0.11i
SE	0.08	0.28	0.10	0.05
CV(%)	1.39	2.43	1.45	1.95

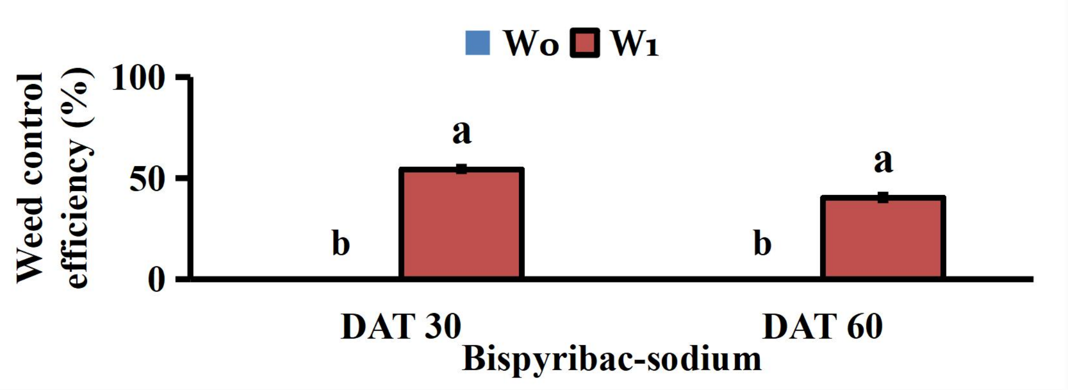
In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability.

Note viz:NS=Non- significant;W_0:Weedy check and W_1: Bispyribac - sodium WP @ 150 g ha^{-1}V_1: Kalizira and V_2: BRRI dhan37;S_1: 20 cm × 15 cm, S_2: 25 cm × 15 cm, S_3: 20 cm × 20 cm and S_4: 25 cm × 25 cm

4.5 Weed control efficiency (%)

Effect of bispyribac-sodium

Weed control is an essential and important component of rice production because uncontrolled weeds can lead to yield loss of rice. Application of herbicide significantly effect on weed control efficiency of aromatic rice at 30 and 60 DAT (Figure 7). Due to herbicide application weed control efficiency was ranged from 40.44 to 54.55 % over weedy check plot. Experiment result revealed that the higher weed control efficiency was noticed in plots receiving Bispyribac - sodium WP @ 150 g ha^{-1}comparable to weedy check plots.Bispyribac - sodium WP @ 150 g ha^{-1} herbicide treated plot recorded the maximum weed control efficiency (54.55 and 40.44 %) at 30 and 60 DAT. While the minimum weed control efficiency (0.0 and 0.0 %) at 30 and 60 DAT was observed in weedy check plot. The differences of weed control efficiency was due to variation of weed density in the experiment plot which was attend by means of herbicide application. Herbicide deteriorate the physiological and morphological feature of weed and thus reduced weed density and increasing weed control efficiency. The result found in this experiment is agreed with Bhuiyan, and Mahbub (2020) who reported that weed control efficiency improved with increases of herbicide dose irrespective of weed species. Similar result also observed by Mishra (2019) reported that the weed control efficiency was higher with application of Bensulfuron methyl 60g /ha + Pretilachlor 600 g/ha at 3 DAT than hand weeding which varies from 74% at 30 DAT to 42.9% at 90 DAT. This might be due to effect of weed during initial stages of crop growth with herbicide application.

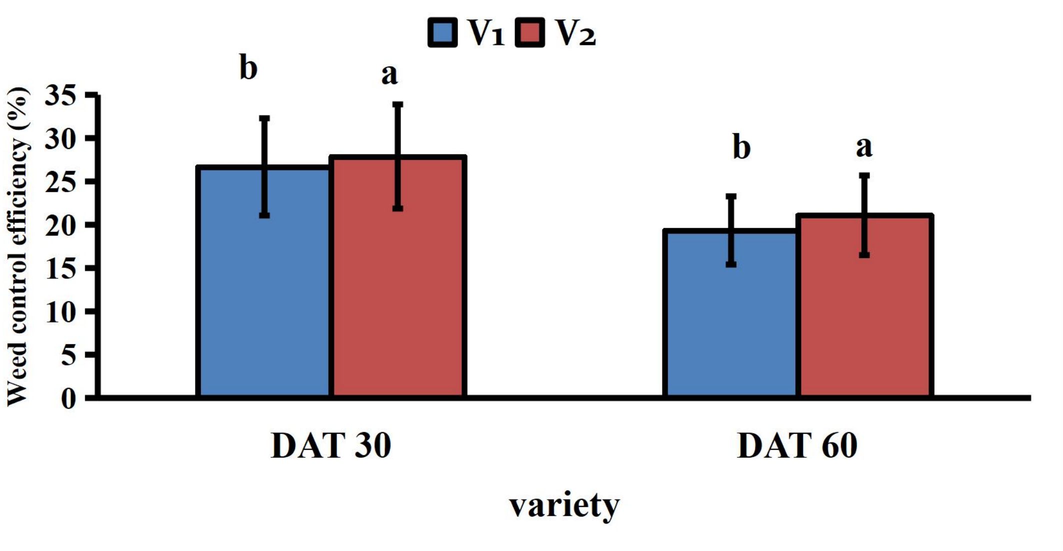


Here, W_0: Weedy check and W_1: Bispyribac - sodium WP @ 150 g ha^{-1}

Figure 7. Effect of weeds control on Bispyribac-sodium efficiency of aromatic rice at different days after transplanting(Bars represent±SD of values obtained from three biological replicates).

Effect of variety

Rice variety significantly effect on weed control efficiency of aromatic rice at 30 and 60 DAT (Figure 9). Due to different rice varieties treatment the weed control efficiency was ranged from 19.34 to 27.88 % over weedy check plot. Experiment result revealed that cultivation of BRRI dhan37 recorded the maximum weed control efficiency (27.88 and 21.09 %) at 30 and 60 DAT while cultivation of Kalizira recorded the minimum weed control efficiency (26.68 and 19.34 %) at 30 and 60 DAT. Similar result also found by Afrin *et al.* (2015) who reported that weed control efficiency significantly influenced by different rice varieties.



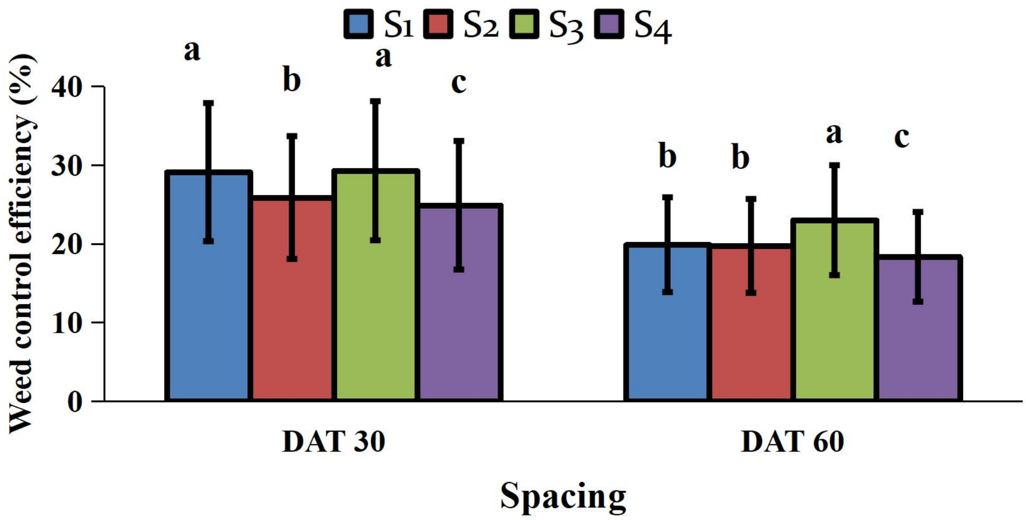
Here, V_1: Kalizira and V_2: BRRI dhan37

Figure 8. Effect of variety on weed control efficiency of aromatic rice at different days after transplanting(Bars represent±SD of values obtained from three biological replicates).

Effect of spacing

Different spacing significantly effect on weed control efficiency of aromatic rice at 30 and 60 DAT (Figure 9). Due to different spacings treatment the weed control efficiency was ranged from 18.32 to 29.27 % over weedy check plot. Experiment result revealed that aromatic rice cultivated at 20 cm × 20 cm spacing recorded the maximum weed control efficiency (29.27 and 22.98 %) at 30 and 60 DAT which was statistically similar with aromatic rice cultivated at 20 cm × 15 cm spacing (29.09 %) at 30 DAT while cultivated at 25 cm × 25 cm spacing recorded the minimum weed control efficiency (24.88 and 18.32 %) at 30 and 60 DAT. Similar result observed by

Tesfaye *et al.* (2011) who reported that the maximum weed control efficiency recorded at closest spacing might be due to more competition offered by cereal grains crop for growth resources as it occupied the space earlier that had smothering effect and better light interception which ultimately impact on weed density.



Here, S_1: 20 cm × 15 cm, S_2: 25 cm × 15 cm, S_3: 20 cm × 20 cm and S_4: 25 cm × 25 cm

Figure 9. Effect of spacings on weed control efficiency of aromatic rice at different days after transplanting(Bars represent±SD of values obtained from three biological replicates).

Combined effect of Bispyribac-sodium and variety

Weed control through herbicide application along with rice variety cultivation showed significant variation in weed control efficiency at 30 and 60 DAT (Table 7). Due to combined effect of weed control and rice variety the weed control efficiency was ranged from 38.69 to 55.75 % over weedy check plot. Experiment result revealed that the Bispyribac - sodium WP @ 150 g ha^{-1} herbicide along with BRRI dhan37 rice variety cultivation recorded the maximum weed control efficiency (55.75 and 42.18 %) at 30 and 60 DAT while the minimum weed control efficiency (0.0 and 0.0 %) at 30 and 60 DAT was recorded in weedy check plot along with aromatic rice variety cultivation.

Combined effect of Bispyribac-sodium and spacings

Different weed control treatment along with spacings showed significant effect on weed control efficiency at 30 and 60 DAT (Table 8). Due to combined effect of weed control and different spacings the weed control efficiency was ranged from 36.64 to 58.55 % over weedy check plot. Experiment result revealed that Bispyribac - sodium WP @ 150 g ha^{-1} herbicide treated plot along with 20 cm × 20 cm spacing recorded the maximum weed control efficiency (58.55 and 45.97 %) at 30 and 60 DAT. While the minimum weed control efficiency (0.0 and 0.0 %) at 30 and 60 DAT was recorded in weedy check plot along with aromatic rice variety cultivated at different spacings.

Combined effect of variety and spacing

Combined effect of variety and spacings showed significant effect on weed control efficiency at 30 and 60 DAT (Table 9). Due to combined effect of variety and different spacings the weed control efficiency was ranged from 14.13 to 30.12 % over weedy check plot. Experiment result revealed that BRRI dhan37 cultivation along with 20 cm × 20 cm spacing recorded the maximum weed control efficiency (30.12 and 24.98 %) at 30 and 60 DAT which was statistically similar with Kalizira cultivation along with 20 cm × 25 cm spacing recorded weed control efficiency 29.35 % at 30 DAT. While Kalizira cultivation along with 25 cm × 25 cm spacing recorded the minimum weed control efficiency (22.69 and 14.13 %) at 30 and 60 DAT.

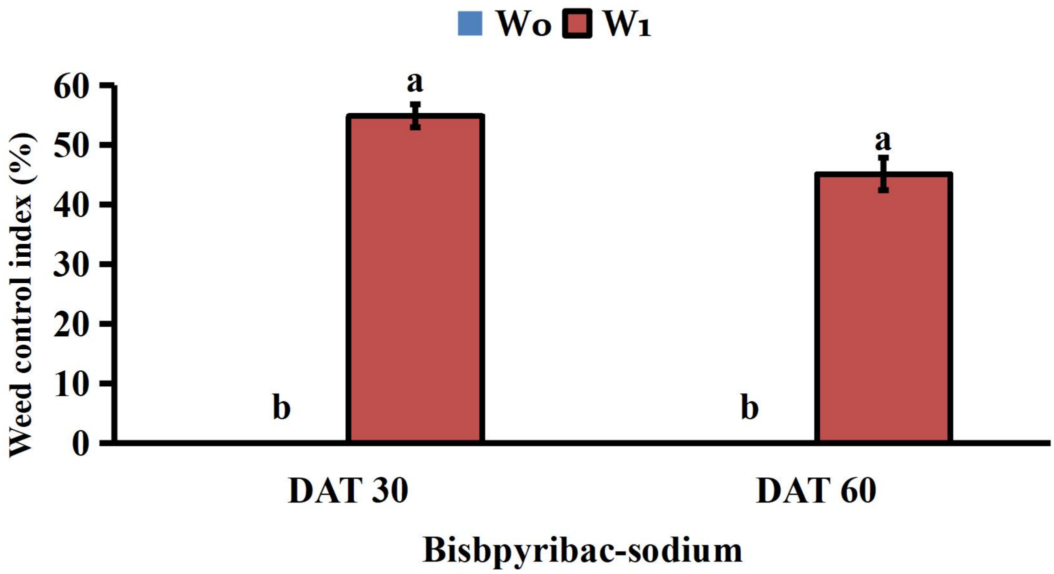
Combined effect of Bispyribac-sodium, variety and spacing

Combination of different treatment significant effect on weed control efficiency at 30 and 60 DAT (Table 10). Due to combined effect of different treatment the weed control efficiency was ranged from 14.13 to 30.12 % over weedy check plot. Bispyribac - sodium WP @ 150 g ha^{-1} herbicide treated plot along with BRRI dhan37 rice variety cultivation at 20 cm × 20 cm spacing recorded the maximum weed control efficiency (60.23 and 49.96 %) at 30 and 60 DAT. While the minimum weed control efficiency (0.0 and 0.0 %) at 30 and 60 DAT was recorded in weedy check plot along with aromatic rice variety cultivation at different spacings.

4.6 Weed control index (%)

Effect of weed control treatment

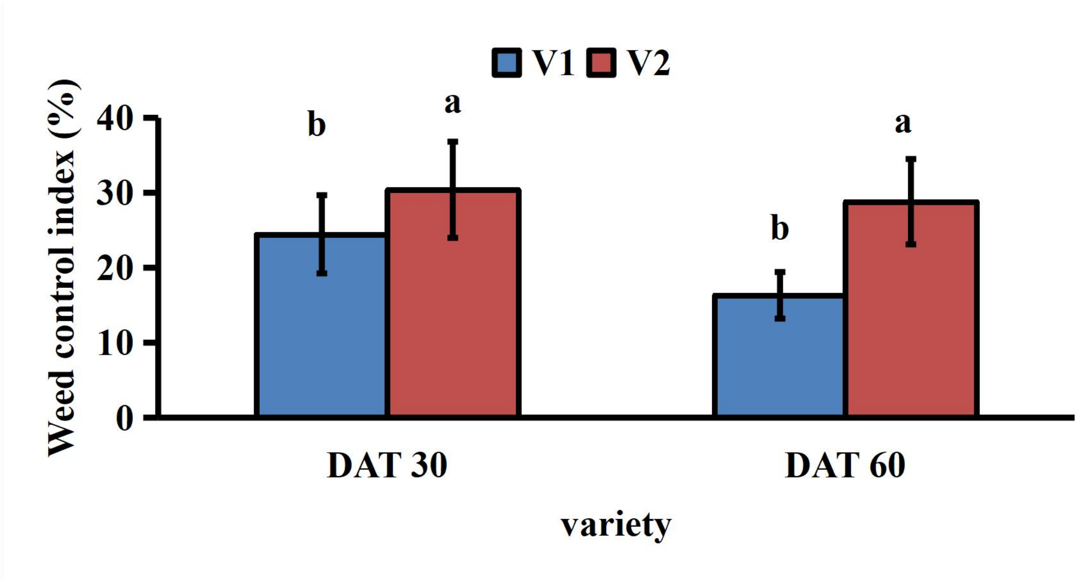
Weed control through herbicide application significantly effect on weed control index of aromatic rice at 30 and 60 DAT (Figure 11). Due to herbicide application weed control index was ranged from 45.13 to 54.87 % over weedy check plot. . Experiment result revealed that the higher weed control index was noticed in plots receiving Bispyribac - sodium WP @ 150 g ha^{-1}comparable to weedy check plots.Bispyribac - sodium WP @ 150 g ha^{-1} herbicide treated plot recorded the maximum weed control efficiency (54.87 and 45.13 %) at 30 and 60 DAT. While the minimum weed control efficiency (0.0 and 0.0 %) at 30 and 60 DAT was observed in weedy check plot. The differences of weed control index was due to herbicide effect on weeds which helps to alter the physiological and morphological feature of the weeds and reduce solar energy absorption and thus reduction of dry matter accumulation and ultimately cause reduction of weed density in the crop field.The result obtained from the present study was similar with the findings of Suryakala *et al.* (2019) who reported that the weed control index (WCI) ranged from 78.66-92.32% with various herbicide combinations. Priya and Kubsad (2013) also reported higher weed control efficiency and lower weed index in herbicide treatments compared to weedy check owing to lower weed dry weight, higher weed control efficiency and lower weed index due to effective control of complex weed flora.



Here, W_0: Weedy check and W_1: Bispyribac - sodium WP @ 150 g ha^{-1}

Figure 10. Effect of weeds control on weed control index of aromatic rice at different days after transplanting(Bars represent±SD of values obtained from three biological replicates).

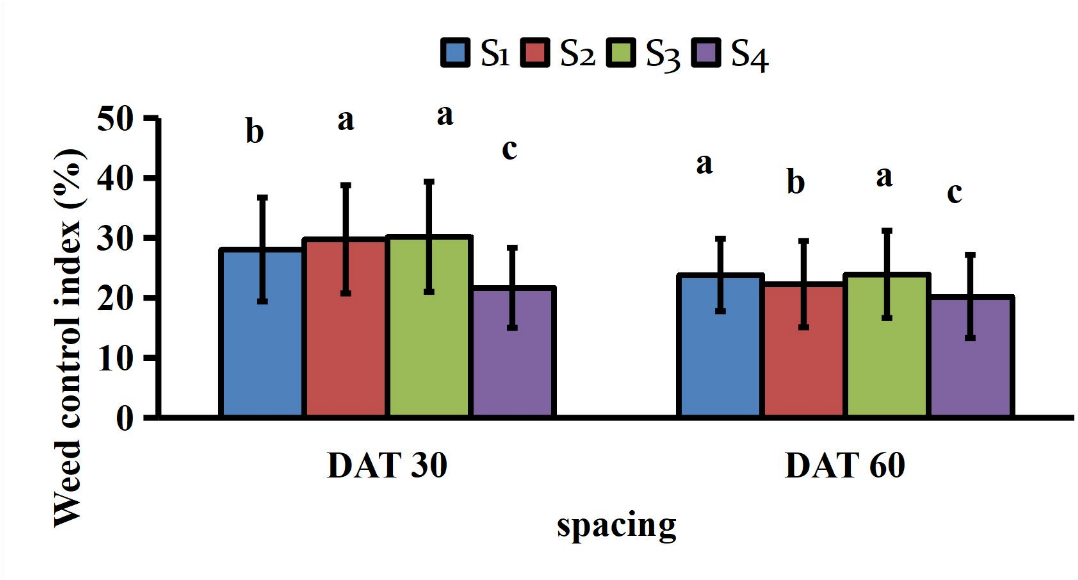
Rice variety significantly effect on weed control index of aromatic rice at 30 and 60 DAT (Figure 12). Due to different rice varieties treatment the weed control index was ranged from 16.32 to 30.40 % over weedy check plot. Experiment result revealed that cultivation of BRRI dhan37 rice variety recorded the maximum weed control index (30.40 and 28.82 %) at 30 and 60 DAT while cultivation of Kalizira recorded the minimum weed control index (24.46 and 16.32 %) at 30 and 60 DAT. Different rice varieties may have higher competitive ability which help to suppress weeds population and reduced the resources utilization thus increasing weed control index by decreasing weeds biomass production. Similar result also observed by Chauhan and Johnson (2011) who reported that weed control index could be attributed to less weed biomass due to high competitive cultivars ability to suppress weeds.



Here, V_1: Kalizira and V_2: BRRI dhan37

Figure 11. Effect of variety on weed control efficiency of aromatic rice at different days after transplanting (Bars represent±SD of values obtained from three biological replicates).

Different spacing significantly effect on weed control index of aromatic rice at 30 and 60 DAT (Figure 12). Due to different spacings treatment the weed control index was ranged from 20.24 to 30.20 % over weedy check plot. Experiment result revealed that aromatic rice cultivated at 20 cm × 20 cm spacing recorded the maximum weed control efficiency (30.20 and 23.92 %) at 30 and 60 DAT which was statistically similar with aromatic rice cultivated at 25 cm × 15 cm spacing, recorded weed control index (29.77 %) at 30 DAT and with aromatic rice cultivated at 20 cm × 15 cm spacing, recorded weed control index (23.82 %) at 60 DAT. While cultivated at 25 cm × 25 cm spacing recorded the minimum weed control index (21.69 and 20.24 %) at 30 and 60 DAT. The maximum weed control index recorded at optimum spacing might be due to more competition offered by cereal grains crop for growth resources as it occupied the space earlier that had smothering effect and better light interception which ultimately impact on weed density and biomass production.



Here, S1: 20 cm × 15 cm, S2: 25 cm × 15 cm, S3: 20 cm × 20 cm and S4: 25 cm × 25 cm

Figure 12. Effect of spacings on weed control index of aromatic rice at different days after transplanting(Bars represent±SD of values obtained from three biological replicates).

Combined effect of Bispyribac-sodium and variety

Weed control through herbicide application along with rice variety cultivation showed significant variation in weed control index at 30 and 60 DAT (Table 7). Due to combined effect of weed control and rice variety the weed control index was ranged from 32.64 to 60.80 % over weedy check plot. Experiment result revealed that the Bispyribac - sodium WP @ 150 g ha^{-1} herbicide treated plot along with BRRI dhan37 rice variety cultivation recorded the maximum weed control index (60.80 and 57.63 %) at 30 and 60 DAT while the minimum weed control index (0.0 and 0.0 %) at 30 and 60 DAT was recorded in weedy check plot along with aromatic rice variety cultivation.

Combined effect of Bispyribac-sodium and spacings

Different weed control treatment along with spacings showed significant effect on weed control index at 30 and 60 DAT (Table 8). Due to combined effect of weed control and different spacings the weed control index was ranged from 40.47 to 60.39 % over weedy check plot. Experiment result revealed that Bispyribac - sodium WP @ 150 g ha^{-1} herbicide treated plot along with 20 cm × 20 cm spacing recorded the maximum weed control index (60.39 and 47.84 %) at 30 and 60 DAT which was statistically similar with Bispyribac - sodium WP @ 150 g ha^{-1} herbicide along with 20 cm × 20 cm spacing, recorded weed control index (47.64 %) at 60 DAT. While the minimum weed control index (0.0 and 0.0 %) at 30 and 60 DAT was recorded in weedy check plot along with aromatic rice variety cultivated at different spacings.

Combined effect of variety and spacings

Combined effect of variety and spacings showed significant effect on weed control index at 30 and 60 DAT (Table 9). Due to combined effect of variety and different spacings the weed control index was ranged from 15.26 to 32.90 % over weedy check plot. Experiment result revealed that BRRI dhan37cultivation along with 20 cm × 20 cm spacing recorded the maximum weed control index (32.90 and 32.37 %) at 30 and 60 DAT which was statistically similar with BRRI dhan37 rice variety cultivation along with 20 cm × 15 cm spacing, recorded weed control index 29.35 % at 30 DAT. While Kalizira cultivation along with 25 cm × 25 cm spacing recorded the minimum weed control index (18.73 and 15.26 %) at 30 and 60 DAT which was statistically similar with Kalizira cultivation along with 20 cm × 20 cm spacing, recorded weed control index 15.48 % and with Kalizira rice variety cultivation along with 25 cm × 15 cm spacing, recorded weed control index 16.31 % at 60 DAT.

Combined effect of Bispyribac-sodium , variety and spacings

Combination of different treatment significant effect on weed control index at 30 and 60 DAT (Table 10). Due to combined effect of different treatment the weed control index was ranged from 30.51 to 65.80 % over weedy check plot. Bispyribac - sodium WP @ 150 g ha^{-1} herbicide treated plot along with BRRI dhan37 cultivation at 20 cm × 20 cm spacing recorded the maximum weed control efficiency (65.80 and 64.73 %) at 30 and 60 DAT. While the minimum weed control index (0.0 and 0.0 %) at 30 and 60 DAT was recorded in weedy check plot along with aromatic rice variety cultivation at different spacings.

Table 7. Combined effect of Bispyribac-sodium and variety on weed control efficiency and weed control index of aromatic rice at different DAT

Treatment Combinations	Weed control efficiency		Weed control index	
	DAT 30	DAT 60	DAT 30	DAT 60
W_0V_1	0.00±0c	0.00±0c	0.00 ±0c	0.00±0c
W_0V_2	0.00±0c	0.00±0c	0.00 ±0c	0.00 ±0c
W_1V_1	53.35±5.43b	38.69±6.54b	48.93±7.69b	32.64±3.93b
W_1V_2	55.75±4.18a	42.18±4.82a	60.80±7.07a	57.63 ±3.81a
SE	0.46	0.27	0.71	0.61
CV(%)	3.88	5.99	3.29	4.26

Here:W_0: Weedy check and W_1: Bispyribac - sodium WP @ 150 g ha^{-1} ;V_1: Kalizira and V_2: BRRI dhan37

Table 8. Combined effect of Bispyribac-sodium and spacings on weed control efficiency and weed control index of aromatic rice at different DAT

Treatment Combinations	Weed control efficiency		Weed control index	
	DAT 30	DAT 60	DAT 30	DAT 60
W_0S_1	0.00±0d	0.00±0d	0.00±0e	0.00±0d
W_0S_2	0.00±0d	0.00±0d	0.00 ±0e	0.00±0d
W_0S_3	0.00±0d	0.00±0d	0.00±0e	0.00±0d
W_0S_4	0.00±0d	0.00±0d	0.00±0e	0.00±0d
W_1S_1	58.18±1.18a	39.71±3.51b	56.15±9.37c	47.64±14.01a
W_1S_2	51.71±1.24b	39.43±2.56b	59.55±4.42b	44.58±13.13b
W_1S_3	58.55±2.12a	45.97±4.44a	60.39±6.02a	47.84±14.57a
W_1S_4	49.76±8.46c	36.64±9.88c	43.38±6.53d	40.47±13.32c
SE	0.50	0.61	0.77	0.83
CV(%)	1.94	6.11	2.04	4.63

Here:W_0: Weedy check and W_1: Bispyribac - sodium WP @ 150 g ha^{-1} ;S_1: 20 cm × 15 cm, S_2: 25 cm × 15 cm, S_3: 20 cm × 20 cm and S_4: 25 cm × 25 cm

Table 9. Combined effect of variety and spacing on weed control efficiency and weed control index of aromatic rice at different DAT

Treatment Combinations	Weed control efficiency		Weed control index	
	DAT 30	DAT 60	DAT 30	DAT 60
V_1S_1	29.35±32.15ab	21.42±20.04bc	23.82±26.1d	18.24±12.58d
V_1S_2	26.23±28.75cd	20.83±22.83c	27.82±30.48c	16.31±17.87e
V_1S_3	28.43±31.16b	20.99±23.01c	27.49±30.12c	15.48±17.04e
V_1S_4	22.69 ±24.86e	14.13±14.56e	18.73±20.52e	15.26±16.72e
V_2S_1	28.84 ±31.6b	18.29±3.47d	32.33±35.42ab	29.39±26.58b
V_2S_2	25.48 ±27.92d	18.60±0.38d	31.73±34.77b	28.28±30.98b
V_2S_3	30.12±32.99a	24.98±7.37a	32.90±36.05a	32.37±31.6a
V_2S_4	27.07 ±33.27c	22.50±4.42b	24.65±27.01d	25.22±30.01c
SE	0.50	0.61	0.77	0.83
CV(%)	1.94	6.11	2.04	4.63

Here:V_1: Kalizira and V_2: BRRI dhan37;S_1: 20 cm × 15 cm, S_2: 25 cm × 15 cm, S_3: 20 cm × 20 cm and S_4: 25 cm × 25 cm

Table 10. Combined effect of weeds control, variety and spacings on weed control efficiency and weed control index of aromatic rice at different DAT

Treatment Combinations	Weed control efficiency		Weed control index	
	DAT 30	DAT 60	DAT 30	DAT 60
$W_0V_1S_1$	0.00±0h	0.00 ±0f	0.00 ±0h	0.00 ±0h
$W_0V_1S_2$	0.00±0h	0.00 ±0f	0.00 ±0h	0.00 ±0h
$W_0V_1S_3$	0.00±0h	0.00 ±0f	0.00 ±0h	0.00 ±0h
$W_0V_1S_4$	0.00±0h	0.00 ±0f	0.00 ±0h	0.00 ±0h
$W_0V_2S_1$	0.00±0h	0.00 ±0f	0.00 ±0h	0.00 ±0h
$W_0V_2S_2$	0.00±0h	0.00 ±0f	0.00 ±0h	0.00 ±0h
$W_0V_2S_3$	0.00±0h	0.00 ±0f	0.00 ±0h	0.00 ±0h
$W_0V_2S_4$	0.00±0h	0.00 ±0f	0.00 ±0h	0.00 ±0h
$W_1V_1S_1$	58.69±1.17b	42.85±0.73c	47.64±0.95f	36.49±0.46e
$W_1V_1S_2$	52.47±1.05e	41.67±0.83c	55.63±1.11d	32.62±0.65f
$W_1V_1S_3$	56.87±1.14c	41.98±0.84c	54.98 ±1.1d	30.96 ±0.62fg
$W_1V_1S_4$	45.38±0.91g	28.27±0.53e	37.46±0.75g	30.51 ±0.61g
$W_1V_2S_1$	57.67±1.15c	36.57±0.86d	64.65±1.29b	58.78 ±0.97b
$W_1V_2S_2$	50.95±1.02f	37.19±0.74d	63.46±1.27c	56.55 ±1.13c
$W_1V_2S_3$	60.23±1.2a	49.96±0.99a	65.80±1.32a	64.73±1.15a
$W_1V_2S_4$	54.15±1.24d	45.00 ± 0.89b	49.30 ±0.99e	50.44±1.1a
SE	0.71	0.87	1.09	1.17
CV(%)	1.94	6.11	2.04	4.63

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability.

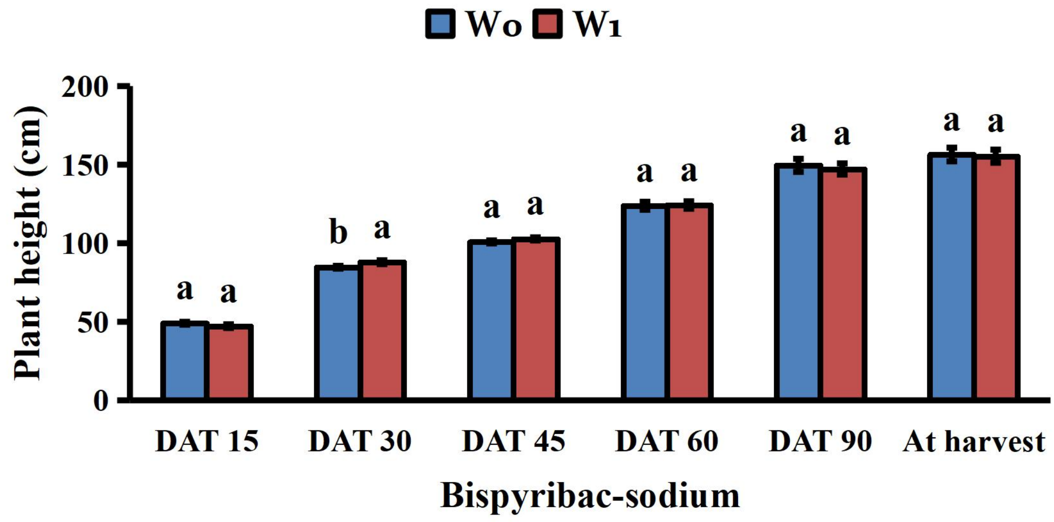
Note viz: NS= Non- significant; W_0: Weedy check and W_1: Bispyribac - sodium WP @ 150 g ha^{-1} ; V_1: Kalizira and V_2: BRRI dhan37; S_1: 20 cm × 15 cm, S_2: 25 cm × 15 cm, S_3: 20 cm × 20 cm and S_4: 25 cm × 25 cm

4.7 Crop growth characters

4.7.1 Plant height (cm)

Effect of Bispyribac-sodium

Plant height is an important morphological character that acts as a potential indicator of availability of growth resources in its approach. From the experiment, result revealed that, plant height showed variation due to effect of weed control treatments (Figure 14). In this experiment significant variation was recorded only at 30 DAT. Result revealed that Bispyribac - sodium WP @ 150 g ha^{-1} herbicide treated plot recorded the maximum plant height (47.21, 87.92, 102.76 and 124.32) at 15, 30, 45 and 60 DAT. At 90 DAT and harvest respectively maximum plant height (149.57 and 156.47 cm) was recorded in weedy check plot. While weedy check plot recorded minimum plant height (49.07, 84.71, 100.83 and 123.83 cm) 15, 30, 45 and 60 DAT. At 90 DAT and harvest respectively the minimum plant height (147.25 and 155.39 cm) was recorded in Bispyribac - sodium WP @ 150 g ha^{-1} herbicide treated plot. The variation of plant height is due to the fact that plant height is an genetic factor which can't alter much due to different weed control treatment. Das *et al.* (2017) reported that application of herbicides did not show any phytotoxic symptom on rice plant.

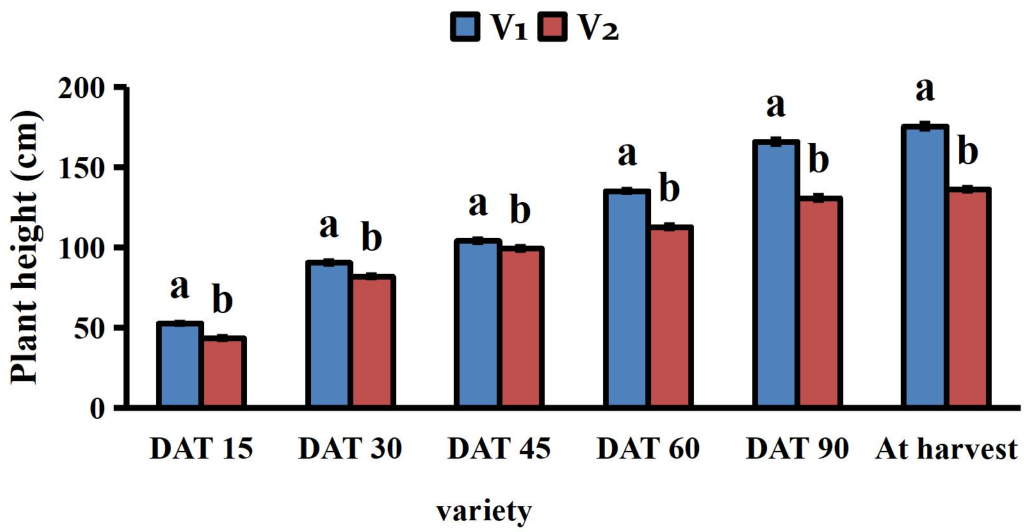


Here, W_0: Weedy check and W_1: Bispyribac - sodium WP @ 150 g ha^{-1}

Figure 13. Effect of Bispyribac-sodium treatment on plant height of aromatic rice at different days after transplanting(Bars represent±SDvalues obtained from three biological replicates).

Effect of variety

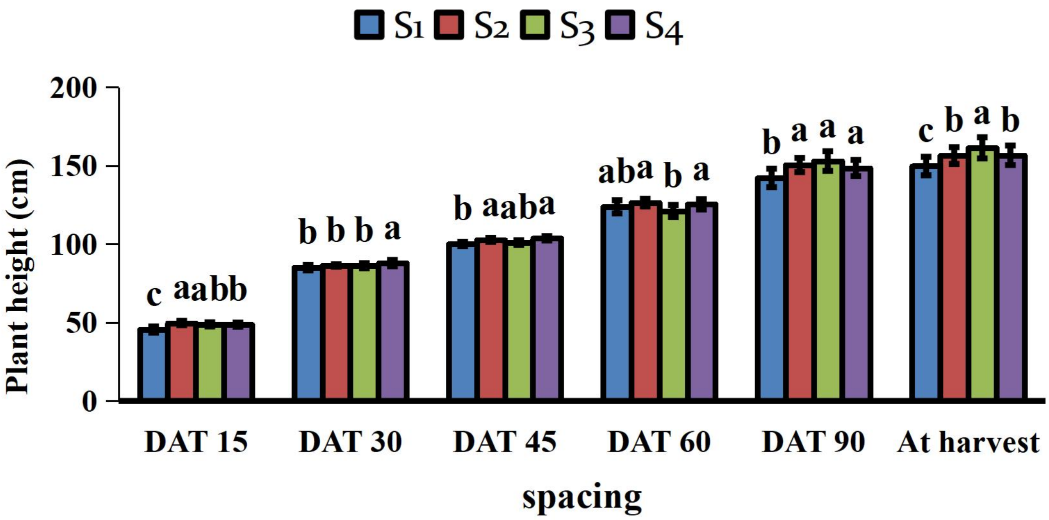
Different rice variety significantly differ plant height at different days after transplanting (Figure 14). Experiment result revealed that Kalizira rice variety recorded the maximum plant height (52.72, 90.60, 104.20, 135.26, 165.92 and 175.59 cm) at 15, 30, 45, 60, 90 DAT and at harvest respectively while BRRI dhan37 rice variety recorded minimum plant height (43.56, 82.03, 99.40, 112.89, 130.90 and 136.27 cm) at 15, 30, 45, 60, 90 DAT and at harvest respectively. The variation in plant height due to the effect of varietal differences. The variation of plant height is probably due to the genetic make-up of the variety. Similar result also observed by Salam *et al.* (2020) who reported that plant height was significantly influenced by different cultivars.



Here, V_1: Kalizira and V_2: BRRI dhan37

Figure 14. Effect of variety on plant height of aromatic rice at different DAT Effect of spacing(Bars represent±SD of values obtained from three biological replicates).

Different spacings significantly effect on plant height of aromatic rice at different DAT (Figure 15). Experiment result revealed that aromatic rice cultivated at 25 cm×15 cm spacing recorded maximum plant height (49.67 cm) which was statistically similar with 20 cm×20 cm spacing recorded plant height (48.80 cm) at 15 DAT. At 30 and 45 DAT aromatic rice cultivated at 25 cm × 25 cm recorded maximum plant height (103.61 cm) was statistically similar with 25 cm ×15 cm spacing recorded plant height (102.61 cm) at 45 DAT. At 60 DAT aromatic rice cultivated at 25 cm ×15 cm spacing recorded maximum plant height (126.36 cm) which was statistically similar with 25 cm × 25 cm recorded plant height (125.29 cm) and with 20 cm ×15 cm recorded plant height (123.67 cm). At 90 DAT and harvest respectively aromatic rice cultivated at 20 cm × 20 cm spacing recorded maximum plant height (152.83 and 161.24 cm) which was statistically similar with 25 cm × 15 cm recorded plant height (15033 cm) and with 25 cm×55 cm recorded plant height (148.39 cm) at 90 DAT. While aromatic rice cultivated at 20 cm ×15 cm recorded minimum plant height (45.46, 84.96 and 100.03 cm) at 15, 30 and 45 DAT which was statistically similar with 20 cm ×20 cm spacing recorded plant height (86.18 cm) and with 25 cm ×15 cm cm recorded plant height (86.28 cm) at 30 DAT and with 20 cm ×20 cm recorded plant height (100.94 cm) at 45 DAT. At 60 DAT aromatic rice cultivated at 20 cm × 20 cm recorded minimum plant height (120.97 cm). At 90 DAT and harvest respectively aromatic rice cultivated at 20 cm × 15 cm recorded minimum plant height (142.08 and 149.66 cm). The result obtained from the present study was similar with the findings of Saha *et al.* (2020) who reported that plant spacing had significant effect on plant height. The tallest plant (73.73 cm) was obtained from the spacing of 25 cm × 20 cm which was at par 25 cm × 15 cm whereas the shortest plant (68.51 cm) was observed in 20 cm × 15 cm spacing which was at par with other spacing. Paul *et al.* (2017) noticed that optimum plant spacing helps plants to grow well, using more solar radiation and soil nutrients.



Here, S_1: 20 cm × 15 cm, S_2: 25 cm × 15 cm, S_3: 20 cm × 20 cm and S_4: 25 cm × 25 cm

Figure 15. Effect of spacings on plant height of aromatic rice at different DAT Combined effect of Bispyribac-sodium and variety(Bars represent±SD value obtained from three biological replicates).

Combined effect of weeds control and variety showed significant effect on plant height only at 30 DA(Table 11). Weedy check plot along with Kalizira rice variety cultivation recorded maximum plant height (53.16 cm) at 15 DAT. At 30, 45 and 60 DAT, Bispyribac - sodium WP @ 150 g ha^{-1} herbicide treated plot along with Kalizira cultivation recorded maximum plant height (93.11, 104.53 and 135.28 cm). At 90 DAT and harvest respectively, weedy check plot along with Kalizira rice variety cultivation recorded maximum plant height (168.72 and 176.37 cm). While Bispyribac - sodium WP @ 150 g ha^{-1} herbicidealong with BRRI dhan37 rice variety cultivation recorded minimum plant height (42.15 cm) at 15 DAT. AT 30, 45, 60 and 90 DAT weedy check plot along with BRRI dhan37 rice variety cultivation recorded minimum plant height (81.33, 97.80, 112.42, and 130.42 cm). At harvest respectively Bispyribac - sodium WP @ 150 g ha^{-1} herbicide along with BRRI dhan37 cultivation recorded minimum plant height (135.97 cm).

Combined effect of Bispyribac-sodium and spacing

Different weed control treatment along with spacings showed significant effect on plant height at 15, 30, 45 DAT and at harvest respectively (Table 12). Experiment result revealed that weedy check plot along with cultivation of aromatic rice at 20 cm × 20 cm spacing recorded the maximum plant height (50.30 cm) which was statistically similar with Bispyribac - sodium WP @ 150 g ha^{-1} herbicide treated plot along with cultivation of aromatic rice at 25 cm × 15 cm spacing recorded plant height (50.02 cm), with weedy check plot along with cultivation of aromatic rice at 25 cm × 25 cm spacing recorded plant height (49.75 cm) and with weedy check plot along with cultivation of aromatic rice at 25 cm × 15 cm spacing recorded plant height (49.33 cm). At 30 and 45 DAT Bispyribac - sodium WP @ 150 g ha^{-1} herbicide treated plot along with cultivation of aromatic rice at 25 cm × 25 cm spacing recorded the maximum plant height (90.69 and 107.67 cm). At 60 DAT weedy check plot along with cultivation of aromatic rice at 25 cm × 15 cm spacing recorded the maximum plant height (50.02 cm). At 90 DAT and harvest respectively Bispyribac - sodium WP @ 150 g ha^{-1} herbicide treated plot along with cultivation of aromatic rice at 20 cm × 20 cm spacing recorded the maximum plant height (154.95 and 161.38 cm) which was statistically similar with weedy check plot along with cultivation of aromatic rice at 20 cm × 20 cm spacing recorded plant height (161.10 cm), with weedy check plot along with cultivation of aromatic rice at 25 cm × 15 cm spacing recorded plant height (159.52 cm) and with weedy check plot along with cultivation of aromatic rice at 25 cm × 25 cm spacing recorded plant height (158.15 cm) at harvest respectively.While Bispyribac - sodium WP @ 150 g ha^{-1} herbicidealong with cultivation of aromatic rice at 20 cm × 15 cm spacing recorded the minimum plant height (44.02 cm) at 30 DAT. At 30 weedy check plot along with cultivation of aromatic rice at 20 cm × 15 cm spacing recorded the minimum plant height (82.36 cm). At 45 DAT Bispyribac - sodium WP @ 150 g ha^{-1} herbicide treated plot along with cultivation of aromatic rice at 20 cm × 20 cm spacing recorded the minimum plant height (97.78 cm) which was statistically similar with weedy check plot along with cultivation of aromatic rice at 20 cm × 15 cm spacing recorded plant height (99.78 cm) and with weedy check plot along with cultivation of aromatic rice at 25 cm × 25 cm spacing recorded plant height (99.56 cm). At 60 DAT weedy check plot along with cultivation of aromatic rice at 20 cm × 20 cm spacing recorded the minimum plant height (119.72 cm). At 90 DAT Bispyribac - sodium WP @ 150 g ha^{-1} herbicide treated plot along with cultivation of aromatic rice at 20 cm × 15 cm spacing recorded the minimum plant height (141.38 cm) and at harvest respectively weedy check plot along with cultivation of aromatic rice at 20 cm × 15 cm spacing recorded the minimum plant height (147.13 cm) which was statistically similar with Bispyribac - sodium WP @ 150 g ha^{-1} herbicide treated plot along with cultivation of aromatic rice at 20 cm × 15 cm spacing recorded plant height (152.19 cm).

Combined effect of variety and spacings

Different rice variety along with spacings showed significant effect on plant height at 15, 30, 45,60 and 90 DAT (Table 13). Experiment result revealed that at Kalizira cultivated at 25 cm × 15 cm spacing recorded the maximum plant height (53.99 cm) at 15 DAT, Which was statistically similar with Kalizira rice variety cultivated at 20 cm × 20 cm spacing recorded plant height (52.74 cm) and with Kalizira cultivated at 25 cm × 25 cm spacing recorded plant height (52.56 cm). At 30 DAT Kalizira cultivated at 25 cm × 25 cm spacing recorded the maximum plant height (93.58 cm). At 45 DAT Kalizira cultivated at 25 cm × 15 cm spacing recorded the maximum plant height (105.83 cm) which was statistically similar with Kalizira rice variety cultivated at 25 cm × 15 cm spacing recorded plant height (104.11cm). At 60 DAT Kalizira cultivated at 20 cm × 15 cm spacing recorded the maximum plant height (137.22 cm) which was statistically similar with Kalizira rice variety cultivated at 25 cm × 25 cm spacing recorded plant height (136.03) and with Kaliziracultivated at 25 cm × 15 cm spacing recorded plant height (134.22 cm) and with Kalizira rice variety cultivated at 20 cm × 20 cm spacing recorded plant height (133.56 cm). At 90 DAT and harvest respectively Kalizira cultivated at 20 cm × 20 cm spacing recorded the maximum plant height (173.22 and 183.44 cm). While BRRI dhan37 cultivated at 20 cm × 15 cm spacing recorded the minimum plant height (39.33, 79.86 and 97.16 cm) at 15, 30 and 45 DAT which was statistically similar with BRRI dhan37 cultivated at

20 cm × 20 cm spacing recorded plant height (81.08 cm), with BRRI dhan37 cultivated at 25 cm × 25 cm spacing recorded plant height (82.08 cm) at 30 DAT, and with BRRI dhan37 cultivated at 20 cm × 20 cm spacing recorded plant height (97.94 cm) at 45 DAT. At 60 DAT BRRI dhan37 cultivated at 20 cm × 20 cm spacing recorded the minimum plant height (108.39 cm) which was statistically similar with BRRI dhan37 cultivated at 20 cm × 15 cm spacing recorded plant height (110.11 cm). At 90 DAT and harvest respectively BRRI dhan37 cultivated at 20 cm × 15 cm spacing recorded the minimum plant height (123.05 and 130.68 cm).

Combined effect of Bispyribac-sodium, variety and spacings

Combination of different treatment significant effect on plant height at 15, 30 and 45 DAT (Table 14). From the experiment result showed that Bispyribac - sodium WP @ 150 g ha^{-1} herbicide treated plot along with Kalizira cultivation at 25 cm × 15 cm spacing recorded the maximum plant height (54.48 cm) at 15 DAT which was statistically similar with weedy check plot along with Kalizira cultivation at 20 cm × 20 cm spacing recorded plant height (54.14 cm) and with weedy check plot along with Kalizira rice variety cultivation at 25 cm × 15 cm spacing recorded plant height (53.50 cm). At 30 and 45 DAT Bispyribac - sodium WP @ 150 g ha^{-1} herbicide along with Kalizira rice variety cultivation at 25 cm × 25 cm spacing recorded the maximum plant height (96.78 and 108.67 cm) which was statistically similar with weedy check plot along with Kalizira cultivation at 20 cm × 20 cm spacing recorded plant height (107.78 cm) and with Bispyribac - sodium WP @ 150 g ha^{-1} herbicide along with Kalizira rice variety cultivation at 20 cm × 20 cm spacing recorded plant height (107.78 cm) at 45 DAT. At 60 DAT weedy check plot along with Kaliziraycultivation at 20 cm × 15 cm spacing recorded the maximum plant height (140.00 cm). At 90 DAT and harvest respectively Bispyribac - sodium WP @ 150 g ha^{-1} herbicide along with Kalizira cultivation at 20 cm × 20 cm spacing recorded the maximum plant height (174.89 and 183.99 cm). While Bispyribac - sodium WP @ 150 g ha^{-1} herbicide treatedplot along with BRRI dhan37 rice variety cultivation at 20 cm × 15 cm spacing recorded the minimum plant height (36.49 cm) at 15 DAT. At 30, 45, 60, 90 and harvest respectively weedy check plot along with BRRI dhan37ultivation at 20 cm × 15 cm spacing recorded the minimum plant height (78.11, 93.33, 107.89, 120.67 and 130.98 cm) which was statistically similar with Bispyribac - sodium WP @ 150 g ha^{-1} herbicide treatedplot along with BRRI dhan37 rice variety cultivation at 20 cm × 20 cm spacing recorded plant height (79.28 and 95.45 cm) at 30 and 45 DAT.

Table 11. Combined effect of Bispyribac-sodium and variety on plant heightof aromatic rice at different DAT

Treatment Combinations	Plant height (cm)					
	DAT 15	DAT 30	DAT 45	DAT 60	DAT 90	At harvest
W_0V_1	53.16 ±1.49	88.08±2.31b	103.86 ±3.77	135.24 ± 3.93	168.72 ± 4.45	176.37 ± 8.47
W_0V_2	44.97 ±2.01	81.33 ±3.06c	97.80 ±3.54	112.42 ± 5.37	130.42 ± 7.15	136.58 ± 4.22
W_1V_1	52.27 ±1.74	93.11 ±3.27a	104.53 ±4.5	135.28 ± 2.63	163.11 ± 8.1	174.80 ± 6.72
W_1V_2	42.15 ±3.66	82.72 ±2.97c	101.00 ±4.67	113.36 ± 3.89	131.39 ± 4.98	135.97 ± 4.13
SE	0.51	0.79	0.73	1.92	2.46	4.11
CV(%)	2.60	2.26	1.77	3.79	4.07	6.46

Here:W_0: Weedy check and W_1: Bispyribac - sodium WP @ 150 g ha^{-1} ,S_1: 20 cm × 15 cm, S_2: 25 cm × 15 cm, S_3: 20 cm × 20 cm and S_4: 25 cm × 25 cm

Table 12. Combined effect of Bispyribac-sodium nd spacings on plant height of aromatic rice at different DAT

Treatment Combinations	Plant height (cm)					
	DAT 15	DAT 30	DAT 45	DAT 60	DAT 90	At harvest
W_0S_1	46.89 ± 5.28b	82.36 ± 4.92e	98.78 ± 6.36d	123.95 ± 17.73	142.77 ± 24.43	147.13± 17.85d
W_0S_2	49.33 ± 4.69a	85.22 ± 2.29cd	100.89 ±3.99c	126.83 ± 8.64	154.05 ± 18.04	159.52 ± 21.86ab
W_0S_3	50.30 ± 4.36a	86.28 ±3.11 b-d	104.11 ±4.64b	119.72 ± 13.142	150.72 ± 23.07	161.10 ± 24.01a
W_0S_4	49.75 ± 4.14a	84.98 ± 6.16d	99.56 ± 2.23cd	124.81 ± 11.33	150.73 ± 19.47	158.15 ± 24.07ab
W_1S_1	44.02 ± 8.31c	87.56 ± 6.74b	101.28 ± 2.29c	123.39 ± 12.31	141.38 ± 17.76	152.19 ±24.07cd
W_1S_2	50.02 ± 5.02a	87.33 ±2.72bc	104.33 ±4.44b	125.89 ± 9.17	146.61 ± 13.26	153.11 ± 16.03c
W_1S_3	47.31 ± 4.54b	86.08 ±7.64 b-d	97.78 ± 3.36d	122.22 ± 14.77	154.95 ± 22.12	161.38 ± 24.9a
W_1S_4	47.51 ± 4.74b	90.69± 6.89a	107.67 ± 2.65a	125.78 ± 12.62	146.06 ± 17.65	154.87 ± 20.75bc
SE	0.59	1.02	0.89	2.61	3.15	2.81
CV(%)	2.14	2.05	1.53	3.65	3.68	3.12

Here:W_0: Weedy check and W_1: Bispyribac - sodium WP @ 150 g ha^{-1} ·S_1: 20 cm × 15 cm, S_2: 25 cm × 15 cm, S_3: 20 cm × 20 cm and S_4: 25 cm × 25 cm

Table 13. Combined effect of variety and spacings on plant height of aromatic rice at different DAT

Treatment Combinations	Plant height (cm)					
	DAT 15	DAT 30	DAT 45	DAT 60	DAT 90	At harvest
V_1S_1	51.58b±1.15	90.06 ±4.16 bc	102.89 ±2.72 b	137.22±3.91 a	161.11±5.48 b	168.64 ± 6.49
V_1S_2	53.99 ± 1.32a	87.97 ± 2.23c	105.83±3.18 a	134.22±2.41 a	164.27 ±7.47 b	173.45 ±7.04
V_1S_3	52.74±1.94ab	90.78±2.91b	103.95 ±4.8 b	133.56 ±3.24 a	173.22 ±4.28 a	183.44± 3.04
V_1S_4	52.56±1.49 ab	93.58 ± 3.94 a	104.11 ±5.51 ab	136.03 ±2.71 a	165.06 ±5.07 b	176.83± 4.5
V_2S_1	39.33±3.23d	79.86 ± 2.47 e	97.16±4.73 d	110.11±3.13 cd	123.05 ±3.79 d	130.68± 2.15
V_2S_2	45.36± 1.04 c	84.58 ±1.87 d	99.39 ± 2.76 c	118.50±2.26 b	136.39 ±3.46 c	139.18± 2.34
V_2S_3	44.87 ± 2.01c	81.58 ± 2.98 e	97.94 ±3.5 cd	108.39 ±2.02 d	132.45 ±4.08 c	139.04± 2.28
V_2S_4	44.71± 1.84c	82.08 ± 3.19 e	103.11 ±4.53 b	114.56 ±2.05 bc	131.72 ±3.37 c	136.19 ±2.22
SE	0.59	1.02	0.89	2.61	3.15	2,81
CV(%)	2.14	2.05	1.53	3.65	3.68	3.12

Here: V_1: Kalizira and V_2: BRRI dhan37; S_1: 20 cm × 15 cm, S_2: 25 cm × 15 cm, S_3: 20 cm × 20 cm and S_4: 25 cm × 25 cm

Table14. Combined effect of weed control, variety and spacings on plant height of aromatic rice at different DAT

Treatment Combinations	Plant height (cm)					
	DAT 15	DAT 30	DAT 45	DAT 60	DAT 90	At harvest
$W_0V_1S_1$	51.61 ±1.29 c	86.61 ±1.88 ef	104.22 bc ±2.6	140.00 ± 2.8	164.88 ± 4.12	163.28 ± 2.97
$W_0V_1S_2$	53.50 ±1.34 a	86.67 ±1.88 ef	103.89 cd ±2.6	134.44 ± 2.69	170.21 ± 4.26	179.33 ± 3.26
$W_0V_1S_3$	54.14 a ±1.35	88.66 ±1.93 de	107.78 a ±2.69	131.56 ± 2.63	171.56 ± 4.29	182.88 ± 3.33
$W_0V_1S_4$	53.39 ±1.33 ab	90.39 ±1.97 cd	99.56 ef ±2.49	134.95 ± 2.69	168.23 ± 4.21	180.00 ± 3.27
$W_0V_2S_1$	42.17 ±1.05 e	78.11 ± 1.7 i	93.33 h ±2.33	107.89 ± 2.16	120.67 ± 3.02	130.98 ± 2.38
$W_0V_2S_2$	45.16 ±1.12 d	83.78 ±1.82 fg	97.89 ±2.45 fg	119.22 ± 2.38	137.89 ± 3.45	139.71 ± 2.5
$W_0V_2S_3$	46.45 ±1.16 d	83.89 fg ±1.82	100.44 ±2.51 ef	107.89 ± 2.16	129.89 ± 3.25	139.31 ± 2.53
$W_0V_2S_4$	46.11 ±1.15 d	79.56 hi ±1.73	99.55 ±2.49 ef	114.67 ± 2.29	133.22 ± 3.33	136.31 ± 2.48
$W_1V_1S_1$	51.55 ±1.29 c	93.50 b ±2.03	101.56 ±2.54 de	134.44 ± 2.69	157.33 ± 3.93	174.00 3.16
$W_1V_1S_2$	54.48 ±1.36 a	89.28 de ±1.94	107.78 ±2.69 a	134.00 ± 2.68	158.34 ± 3.96	167.57 ± 3.05
$W_1V_1S_3$	51.33 ±1.28 c	92.89 bc ±2.02	100.11 ±2.5 ef	135.55 ± 2.71	174.89 4.37	183.99 ± 3.35
$W_1V_1S_4$	51.72 ±1.29 bc	96.78 a ± 2.1	108.67 ±2.72 a	137.11 ± 2.74	161.89 ± 4.05	173.67 ± 3.16
$W_1V_2S_1$	36.49 ±0.91 f	81.61 gh ±1.77	101.00 ±2.53 e	112.34 ± 2.25	125.43 ± 3.14	130.39 ± 2.37
$W_1V_2S_2$	45.55 d ±1.14	85.39 f ±1.86	100.89 ±2.52 e	117.78 ± 2.36	134.89 ± 3.37	138.66 ± 2.52
$W_1V_2S_3$	43.28 1.08 e	79.28 hi ±1.72	95.45 ±2.38 gh	108.89 ± 2.18	135.00 3.38	138.78 ± 2.52
$W_1V_2S_4$	43.30 ±1.08 e	84.61 f ±1.84	106.67 ±2.67 ab	114.45 ± 2.29	130.22 ± 3.25	136.07 2.47
SE	0.84	1.44	1.26	3.69	4.45	3.87
CV(%)	2.14	2.05	1.53	3.65	3.68	3.12

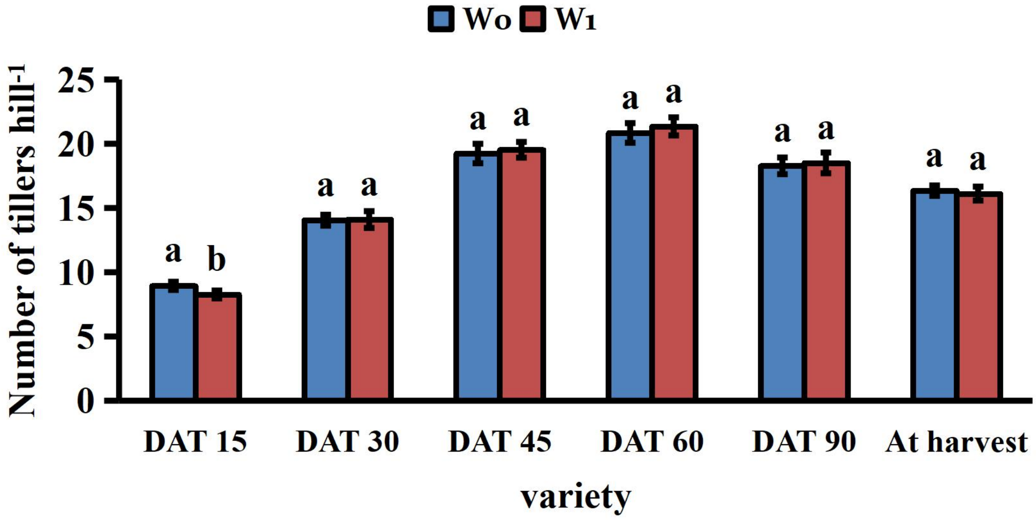
In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability

Note viz:NS= Non- significant;Here:W_0: Weedy check and W_1: Bispyribac - sodium WP @ 150 g ha^{-1};V_1: Kalizira and V_2: BRRI dhan37;S_1: 20 cm × 15 cm, S_2: 25 cm × 15 cm, S_3: 20 cm × 20 cm and S_4: 25 cm × 25 cm

4.7.2 Number of tillers hill^{-1}

Effect of Bispyribac-sodium

Weed control through herbicide application significantly influenced tillers number hill^{-1} only at 15 DAT (Figure 16). Experiment result revealed that weedy check plot recorded the maximum number of tillers hill^{-1} (8.94) at 15 DAT. At 30, 45, 60 and 90 DAT Bispyribac - sodium WP @ 150 g ha^{-1} herbicide recorded the maximum number of tillers hill^{-1} (14.10, 19.53, 21.35 and 18.51) and at harvest respectively weedy check plot recorded the maximum number of tillers hill^{-1} (16.35). While Bispyribac - sodium WP @ 150 g ha^{-1} herbicide treated plot recorded the minimum number of tillers hill^{-1} (8.27) at 15 DAT. At 30, 45, 60 and 90 DAT weedy check plot recorded the minimum number of tillers hill^{-1} (14.05, 19.24, 20.84 and 18.28) and at harvest respectively Bispyribac - sodium WP @ 150 g ha^{-1} herbicide treated plot recorded the minimum number of tillers hill^{-1} (16.12). The present study is dissimilar with the finding of Paulraj *et al.* (2019) who reported that weed control through herbicide application significantly effect on tillers number production in transplanting rice but show negative effect in unweeded controlplot.Lodhi (2016) reported that different weed control treatments caused remarkable variations in the tillers number at different days after transplanting.



Here, W_0: Weedy check and W_1: Bispyribac - sodium WP @ 150 g ha^{-1}

Figure 16. Effect of weeds control treatment on number of tillers $hill^{-1}$ of aromatic rice at different days after transplanting (Bars represent±SD of values obtained from three biological replicates).

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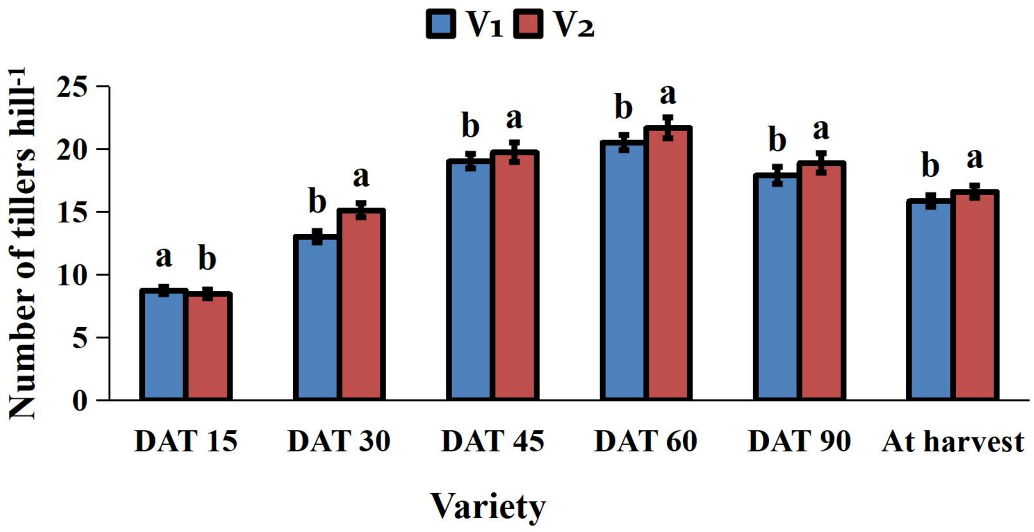
Effect of variety

Rice variety significantly differ tiller number $hill^{-1}$ at different days after transplanting (Figure 17). Experiment result revealed that Kalizira recorded the maximum tiller number $hill^{-1}$ (8.74) at 15 DAT. At 30, 45, 60, 90 DAT and harvest respectively BRRI dhan37 rice variety recorded the maximum tiller number $hill^{-1}$ (15.13, 19.74, 21.68, 18.89 and 16.60). While BRRI dhan37 rice variety recorded the minimum tiller number $hill^{-1}$ (8.47) at 15 DAT. At 30, 45, 60, 90 DAT and harvest respectively Kalizira rice variety recorded the minimum tiller number $hill^{-1}$ (13.02, 19.03, 20.51, 17.90 and 15.86). The variation in tiller number $hill^{-1}$due to the effect of varietal differences. The variation of tiller number $hill^{-1}$ is probably due to the genetic make-up of the cultivars. Similar result also observed by Hossain *et al*. (2008) reported that the variation of tiller number $hill^{-1}$ might be due to heredity that was directly related genetic characteristics of varieties.

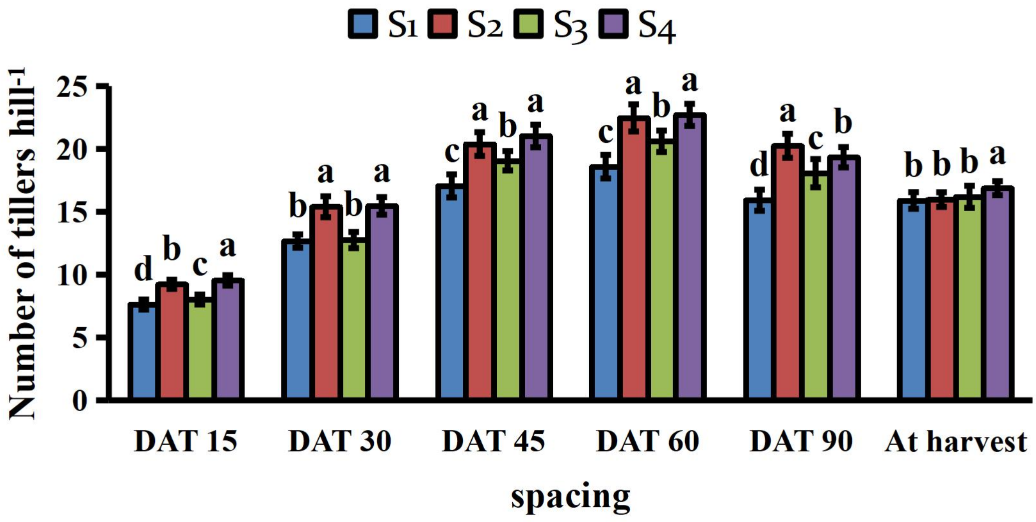


Here, V_1: Kalizira and V_2: BRRI dhan37

Figure 17. Effect of variety on number of tillers hill^{-1} of aromatic rice at different days after transplanting (Bars represent±SD of values obtained from three biological replicates).

Effect of spacing

Different spacings significantly effect on number of tiller hill^{-1}of aromatic rice at different DAT (Figure 18). Experiment result revealed that aromatic rice cultivated at 25 cm × 25 cm spacing recorded the maximum number of tillers hill^{-1} (9.54, 15.47, 21.03 and 22.71) at 15, 30, 45 and 60 DAT which was statistically similar with 25 cm × 15 cm spacing recorded tiller number hill^{-1} (15.40, 20.39 and 22.47) at 30 , 45 and 60 DAT. At 90 DAT aromatic rice cultivated at 25 cm × 15 cm spacing recorded the maximum number of tillers hill^{-1} (22.47). At harvest respectively aromatic rice cultivated at 25 cm × 25 cm spacing recorded the maximum number of tillers hill^{-1} (16.88). While aromatic rice cultivated at 20 cm × 15 cm spacing recorded the minimum number of tillers hill^{-1} (7.62, 12.67, 17.06, 18.59, 15.92 and 15.90) at 15, 30, 45, 60, 90 DAT and harvest respectively which was statistically similar with 20 cm × 20 cm spacing recorded tiller number hill^{-1} (12.75) at 30 DAT, and with 25 cm × 15 cm spacing recorded tiller number hill^{-1} (15.97) and 20 cm × 20 cm spacing recorded tiller number hill^{-1}(16.97) at harvest respectively. Halder *et al.* (2018) also found similar result which supported the present finding and reported that wider spacing increasing tillers number hill^{-1} comparable to closest spacing.



Here, S_1: 20 cm × 15 cm, S_2: 25 cm × 15 cm, S_3: 20 cm × 20 cm and S_4: 25 cm × 25 cm

Figure 18 Effect of spacings on number of tillers hill^{-1} of aromatic rice at different days after transplanting (Bars represent±SD of values obtained from three biological replicates).

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Combined effect of Bispyribac-sodium and variety

Combined effect of weeds control and variety showed significant effect on number of tillers hill^{-1} at different DAT (Table 15). Experiment result showed that at weedy check plot along with BRRI dhan37 rice variety cultivation recorded the maximum number of tillers hill^{-1} (9.07) at 15 DAT. At 30, 45, 60, 90 DAT and harvest respectively Bispyribac - sodium WP @ 150 g ha^{-1} herbicide treated plot along with BRRI dhan37 rice variety cultivation recorded the maximum number of tillers hill^{-1} (15.81, 20.53, 22.69, 20.43 and 17.38) which was statistically similar with weedy check plot along with Kalizira cultivation recorded tillers number hill^{-1} (16.87). While Bispyribac - sodium WP @ 150 g ha^{-1} herbicide treated plot along with BRRI dhan37 rice variety cultivation recorded the minimum number of tillers hill^{-1} (7.87) at 15 DAT. At 30, 45, 60, 90 DAT and harvest respectively Bispyribac - sodium WP @ 150 g ha^{-1} herbicide t along with Kalizira cultivation recorded the minimum number of tillers hill^{-1} (12.39, 18.53, 20.01, 16.58 and 14.85) which was statistically similar with weedy check plot along with BRRI dhan37 cultivation recorded tillers number hill^{-1} (18.95) at 45 DAT, with weedy check plot along with BRRI dhan37 rice variety cultivation recorded tillers number hill^{-1} (20.67) and with weedy check plot along with Kalizira cultivation recorded tillers number hill^{-1} (21.00) at 60 DAT and with

with weedy check plot along with BRRI dhan37 rice variety cultivation recorded tillers number hill^{-1} (17.35) at 90 DAT.

Combined effect Bispyribac-sodium and spacings

Combined effect of weeds control and spacings showed significant effect on number of tillers hill^{-1} at different DAT (Table 16). Experiment result showed that at weedy check plot along with aromatic rice variety cultivated at 25 cm × 25 cm spacing recorded the maximum number of tillers hill^{-1} (10.00) at 15 DAT. At 30 DAT Bispyribac - sodium WP @ 150 g ha^{-1} herbicide along with aromatic rice variety cultivated at 25 cm × 15 cm spacing recorded the maximum number of tillers hill^{-1} (15.78). At 45 and 60 DAT weedy check plot along with aromatic rice variety cultivated at 25 cm × 25 cm spacing recorded the maximum number of tillers hill^{-1} (22.61 and 23.73) which was statistically similar with Bispyribac - sodium WP @ 150 g ha^{-1} herbicide treated plot along with aromatic rice variety cultivated 25 cm × 15 cm spacing recorded tiller number hill^{-1} (23.38) at 60 DAT. At 90 DAT weedy check plot along with aromatic rice variety cultivated at 20 cm × 20 cm spacing recorded the maximum number of tillers hill^{-1} (22.10) and at harvest respectively weedy check plot along with aromatic rice variety cultivated at 20 cm × 15 cm spacing recorded the maximum number of tillers hill^{-1} (17.53) which was statistically similar with Bispyribac - sodium WP @ 150 g ha^{-1} herbicide along with aromatic rice variety cultivated 25 cm × 15 cm spacing recorded tiller number hill^{-1} (17.17) and with Bispyribac - sodium WP @ 150 g ha^{-1} herbicide along with aromatic rice variety cultivated 25 cm × 25 cm spacing recorded tiller number hill^{-1} (17.05). While Bispyribac - sodium WP @ 150 g ha^{-1} herbicide along with aromatic rice variety cultivated 20 cm × 15 cm spacing recorded the minimum number of tiller hill^{-1} (7.17 and 12.00) at 15 and 30 DAT. At 45 and 60 DAT weedy check plot along with aromatic rice variety cultivated 20 cm × 15 cm spacing recorded the minimum number of tiller hill^{-1} (15.06 and 16.72). At 90 DAT Bispyribac - sodium WP @ 150 g ha^{-1} herbicide along with aromatic rice variety cultivated 25 cm × 25 cm spacing recorded the minimum number of tiller hill^{-1} (15.15) which was statistically similar with weedy check plot along with aromatic rice variety cultivated 25 cm × 25 cm spacing recorded tiller number hill^{-1} (16.29) and at harvest respectively Bispyribac - sodium WP @ 150 g ha^{-1} herbicide treated plot along with aromatic rice variety cultivated 20 cm × 15 cm spacing recorded the minimum number of tiller hill^{-1} (14.28) which was statistically similar with weedy check plot along with aromatic rice variety cultivated 25 cm × 15 cm spacing recorded tiller number hill^{-1} (14.78).

Combined effect of variety and spacings

Combination of different variety and spacing showed significant effect on number of tillers hill^{-1} at different DAT (Table 17). From the experiment result showed that Kalizira cultivated at 25 cm × 25 cm spacing recorded the maximum number of tillers hill^{-1} (10.00) at 15 DAT. At 30, 45, 60 and 90 DAT BRRI dhan37 rice variety cultivated at 25 cm × 15 cm spacing recorded the maximum number of tillers hill^{-1} (16.78, 21.50, 23.86 and 20.35) which was statistically similar with BRRI dhan37 rice variety cultivated at 25 cm × 25 cm spacing recorded tiller number hill^{-1}(16.55) at 30 DAT, with BRRI dhan37 cultivated at 25 cm × 25 cm spacing recorded tiller number hill^{-1}(21.11) and with Kalizira cultivated at 25 cm × 25 cm spacing recorded tiller number hill^{-1} (20.95) at 45 DAT, with BRRI dhan37 rice variety cultivated at 25 cm × 25 cm spacing recorded tiller number hill^{-1}(23.09) at 60 DAT, and with BRRI dhan37 rice variety cultivated at 25 cm × 25 cm spacing recorded tiller number hill^{-1} (20.19) and with BRRI dhan37 rice variety cultivated at 20 cm × 20 cm spacing recorded tiller number hill^{-1}(19.83) at 90 DAT. AT harvest respectively BRRI dhan37 rice variety cultivated at 20 cm × 20 cm spacing recorded the maximum number of tillers hill^{-1} (17.27) which was statistically similar with BRRI dhan37 rice variety cultivated at 25 cm × 25 cm spacing recorded tiller number hill^{-1} (17.21). While BRRI dhan37 rice variety cultivated at 20 cm × 15 cm spacing recorded the minimum number of tillers hill^{-1} (6.87) at 15 DAT. At 30 DAT Kalizira cultivated at 20 cm × 20 cm spacing recorded the minimum number of tillers hill^{-1} (11.27). At 45, 60, and 90 DAT BRRI dhan37 rice variety cultivated at 20 cm × 15 cm spacing recorded the minimum number of tillers hill^{-1} (16.50, 18.09 and 15.20) which was statistically similar with Kalizira rice variety cultivated at 20 cm × 15 cm spacing recorded tiller number hill^{-1} (19.09) at 60 DAT. At harvest respectively Kalizira cultivated at 20 cm × 20 cm spacing recorded the minimum number of tillers hill^{-1} (15.11) which was statistically similar with Kalizira rice variety cultivated at 20 cm × 20 cm spacing recorded tiller number hill^{-1} (15.69) and with BRRI dhan37 rice variety cultivated at 25 cm × 15 cm spacing recorded tiller number hill^{-1} (15.83).

Combined effect of Bispyribac-sodium ,variety and spacings

Combination of different treatment showed significant effect on plant height at 15, 30 and 45 DAT (Table 18). From the experiment result showed that Bispyribac - sodium WP @ 150 g ha^{-1} herbicide treated plot along with Kalizira cultivation at 25 cm × 25 cm spacing recorded the maximum number of tillers $hill^{-1}$ (10.00) which was statistically similar with weedy check plot along with Kalizira rice variety cultivation at 25 cm × 25 cm recorded tillers number $hill^{-1}$ (10.00) and with weedy check plot along with BRRI dhan37 rice variety cultivation at 25 cm × 25 cm recorded tillers number $hill^{-1}$ (10.00) at 15 DAT. At 30, 45, 60 and 90 DAT Bispyribac - sodium WP @ 150 g ha^{-1} herbicide treated plot along with BRRI dhan37 cultivation at 25 cm × 15 spacing cm recorded the maximum number of tillers $hill^{-1}$ (18.67, 23.78, 26.51 and 23.18) which was statistically similar with weedy check plot along with BRRI dhan37 rice variety cultivation at 25 cm × 25 cm spacing recorded tillers number $hill^{-1}$ (23.22) at 45 DAT and with Bispyribac - sodium WP @ 150 g ha^{-1} herbicide along with BRRI dhan37 rice variety cultivation at 20 cm × 20 cm spacing recorded tillers number $hill^{-1}$ (21.51) at 90 DAT. At harvest respectively Bispyribac - sodium WP @ 150 g ha^{-1} herbicide along with BRRI dhan37 rice variety cultivation at 20 cm × 20 cm spacing recorded the maximum number of tillers $hill^{-1}$ (19.31) which was statistically similar with Bispyribac - sodium WP @ 150 g ha^{-1} herbicide along with BRRI dhan37 rice variety cultivation at 25 cm × 25 cm spacing recorded tillers number $hill^{-1}$ (18.33).While Bispyribac - sodium WP @ 150 g ha^{-1} herbicide treated plot along with BRRI dhan37 rice variety cultivation at 20 cm × 15 cm spacing recorded the minimum number of tillers $hill^{-1}$ (6.81) which was statistically similar with weedy check plot along with BRRI dhan37 rice variety cultivation at 20 cm × 15 cm spacing recorded tillers number $hill^{-1}$ (6.93) and with Bispyribac - sodium WP @ 150 g ha^{-1} herbicide treated plot along with BRRI dhan37 cultivation at 20 cm × 20 cm spacing recorded tillers number $hill^{-1}$ (7.00) at 15 DAT.

At 30 DAT Bispyribac - sodium WP @ 150 g ha^{-1} herbicide treated plot along with Kalizira rice variety cultivation at 20 cm × 20 cm spacing recorded the minimum number of tillers $hill^{-1}$ (11.10) which was statistically similar with Bispyribac - sodium WP @ 150 g ha^{-1} herbicide treated plot along with Kalizira rice variety cultivation at 20 cm × 15 cm spacing recorded tillers number $hill^{-1}$ (11.11) and with weedy check plot along with BRRI dhan37 cultivation at 20 cm × 20 cm spacing recorded tillers number hill^{-1} (11.44). At 45, 60 and 90 DAT weedy check plot along with BRRI dhan37 rice variety cultivation at 20 cm × 15 cm spacing recorded the minimum number of tillers hill^{-1} (13.56, 15.16 and 12.93) which was statistically similar with Bispyribac - sodium WP @ 150 g ha^{-1} herbicide treated plot along with Kalizira rice variety cultivation at 20 cm × 20 cm spacing recorded tillers number hill^{-1} (13.22) at 90 DAT. At harvest respectively Bispyribac - sodium WP @ 150 g ha^{-1} herbicide treated plot along with Kalizira cultivation at 20 cm × 20 cm spacing recorded the minimum number of tillers hill^{-1} (12.65).

Table 15. Combined effect of and variety on Bispyribac-sodium number of tillers hill^{-1} of aromatic rice at different DAT

Treatment Combinations	Tillers hill^{-1} No.					
	DAT 15	DAT 30	DAT 45	DAT 60	DAT 90	At harvest
W_0V_1	8.81± 1.44 b	13.65 ± 2.21 c	19.53 ± 3.14 b	21.00 ± 3.13 b	19.21 ± 2.44 b	16.87 ± 1.85 a
W_0V_2	9.07 ± 1.72 a	14.44 ± 1.97 b	18.95 ±4.32 bc	20.67 ± 4.4 b	17.35 ± 3.65 c	15.83 ± 2.03 b
W_1V_1	8.67 ± 1.45 b	12.39 ± 2.1 d	18.53± 2.52 c	20.01 ± 2.79 b	16.58 ± 3.65 c	14.85 ± 2.2 c
W_1V_2	7.87 ± 1.49 c	15.81 ± 3.26 a	20.53 ± 3.2 a	22.69 ± 3.62 a	20.43 ± 3.35 a	17.38 ± 2.52 a
SE	0.08	0.17	0.33	0.36	0.39	0.31
CV(%)	2.66	3.10	4.20	4.22	5.32	4.82

Here:W_0: Weedy check and W_1: Bispyribac - sodium WP @ 150 g ha^{-1} ;V_1: Kalizira and V_2: BRRI dhan37

Table 16. Combined effect of Bispyribac-sodium and spacings on number of tillers hill^{-1} of aromatic rice at different DAT

Treatment Combinations	Tillers hill^{-1} No.					
	DAT 15	**DAT 30**	**DAT 45**	**DAT 60**	**DAT 90**	**At harvest**
W_0S_1	8.08 ± 1.64 e	13.33 ± 1.74 c	15.06 ± 2.54 e	16.72 ± 2.75 e	18.28 ±3.49 cd	17.53 ± 1.76 a
W_0S_2	9.17 ± 1.42 bc	15.02 ± 1.93 b	19.56 ± 2.53 c	21.56 ± 2.78 b	17.37 ±2.54 de	14.78 ± 1.59 d
W_0S_3	8.50 ± 1.51 d	13.06 ± 2.44 c	19.72 ± 2.52 c	21.33 ±2.76 bc	22.10± 2.49 a	16.39 ±2.08 bc
W_0S_4	10.00 ± 1.28 a	14.78 ± 1.95 b	22.61 ± 2.97 a	23.73 ± 3.18 a	16.29 ±2.64 ef	16.71 ±1.79 a-c
W_1S_1	7.17 ± 0.99 g	12.00 ± 1.82 e	19.06 ±2.47 cd	20.46 ±2.69 cd	20.40 ± 2.45 b	14.28 ± 1.43 d
W_1S_2	9.30 ± 1.21 b	15.78 ± 3.77 a	21.22 ± 3.91 b	23.38 ± 4.57 a	18.77 ± 3.06 c	17.17 ±1.73 ab
W_1S_3	7.54 ± 1.13 f	12.44 ± 2.17 d	18.39 ± 2.87 d	19.88 ± 3.2 d	18.40 ±5.08 cd	15.98 ± 3.99 c
W_1S_4	9.07 ± 1.55 c	16.17 ± 2.81 a	19.45 ± 2.53 c	21.68 ± 2.77 b	15.55 ± 2.73 f	17.05±2.2 ab
SE	0.07	0.18	0.45	0.52	0.58	0.40
CV(%)	1.60	2.32	4.04	4.32	5.48	4.34

Here:W_0: Weedy check and W_1: Bispyribac - sodium WP @ 150 g ha^{-1} ;S_1: 20 cm × 15 cm, S_2: 25 cm × 15 cm, S_3: 20 cm × 20 cm and S_4: 25 cm × 25 cm

Table 17. Combined effect of variety and spacings on number of tillers $hill^{-1}$ of aromatic rice at different DAT

Treatment Combinations	No. Tillers $hill^{-1}$					
	DAT 15	DAT 30	DAT 45	DAT 60	DAT 90	At harvest
V_1S_1	8.38 ± 1.43 e	12.39 ±2.12 d	17.61 ±2.53 d	19.09 ±2.59 ef	16.63 ± 2.71 c	15.69 ±2.34 bc
V_1S_2	8.76 ± 1.17 d	14.02 ±2.18 b	19.28 ±2.56 bc	21.08 ±2.85 d	20.15 ± 2.75 a	16.11 ± 1.81 b
V_1S_3	7.81 ± 1.04 f	11.27 ± 1.45 e	18.28 ±2.79 cd	19.53 ± 2.95 e	16.31 ±3.99 cd	15.11 ± 3.09 c
V_1S_4	10.00 ± 1.28 a	14.39 ±1.84 b	20.95 ± 2.92 a	22.32 ±2.91 bc	18.49 ±2.89 b	16.55 ±1.86 ab
V_2S_1	6.87 ± 0.88 g	12.95 ± 1.66 c	16.50 e ± 3.87 e	18.09 ± 3.97 f	15.20 ±3.17 d	16.11 ±2.43 b
V_2S_2	9.71 ± 1.26 b	16.78 ± 2.99 a	21.50 ± 3.72 a	23.86 ± 4.23 a	20.35 ± 4.06 a	15.83 ±2.37 bc
V_2S_3	8.22 ± 1.71 e	14.22 ±1.89 b	19.83 ±2.53 b	21.68 ±2.77 cd	19.83 ± 3.14 a	17.27 ± 2.83 a
V_2S_4	9.07 ± 1.55 c	16.55 ± 2.58 a	21.11 ± 3.56 a	23.09 ±3.39 ab	20.19 ± 2.67 a	17.21 ± 2.11 a
SE	0.07	0.18	0.45	0.52	0.58	0.40
CV(%)	1.60	2.32	4.04	4.32	5.48	4.34

Here:V_1: Kalizira and V_2: BRRI dhan37;S_1: 20 cm × 15 cm, S_2: 25 cm × 15 cm, S_3: 20 cm × 20 cm and S_4: 25 cm × 25 cm

Table 18. Combined effect of Bispyribac-sodium , variety and spacings on number of tillers hill^{-1} of aromatic rice at different DAT

Treatment Combinations	No. Tillers hill^{-1}					
	DAT 15	DAT 30	DAT 45	DAT 60	DAT 90	At harvest
$W_0V_1S_1$	9.24 ± 1.32 cd	13.67 ± 1.95 g	16.56 ± 2.37 d	18.29 ± 2.61 g	18.16 ± 2.59 ef	17.28 ± 1.92 b-d
$W_0V_1S_2$	8.44 ± 1.21 e	15.16 ± 2.17 c	19.89 ± 2.84 c	21.92 ± 3.13 cd	19.28 ± 2.75 de	15.33 ± 1.7 fg
$W_0V_1S_3$	7.55 ± 1.01 g	11.44 ± 1.63 i	19.67 ± 2.81 c	20.96 ± 2.99 d-f	19.40 ± 2.77 c-e	17.56 ± 1.95 bc
$W_0V_1S_4$	10.00 ± 1.43 a	14.33 ± 2.05 ef	22.00 ± 3.14 b	22.87 ± 3.27 c	20.00 ± 2.86 b-d	17.33 ± 1.93 bc
$W_0V_2S_1$	6.93 ± 0.99 h	13.00 ± 1.86 h	13.56 ± 1.94 e	15.16 ± 2.17 h	12.93 ± 1.85 h	17.78 ± 1.98 bc
$W_0V_2S_2$	9.89 ± 1.41 a	14.89 ± 2.13 cd	19.22 ± 2.75 c	21.20 ± 3.03 d-f	17.53 ± 2.5 f	14.22 ± 1.58 gh
$W_0V_2S_3$	9.44 ± 1.35 bc	14.67 ± 2.1 c-e	19.78 ± 2.83 c	21.71 ± 3.1 c-e	18.14 ± 2.59 ef	15.22 ±1.69 f-h
$W_0V_2S_4$	10.00 ± 1.43 a	15.22 ± 2.17 c	23.22 ± 3.32 ab	24.60 ± 3.51 b	20.80 ± 2.97 b-d	16.09 ± 1.79 d-f
$W_1V_1S_1$	7.52 ± 1.07 g	11.11 ± 1.59 i	18.67 ± 2.67 c	19.89 ± 2.84 f	15.11 ± 2.19 g	14.11 ± 1.57 h
$W_1V_1S_2$	9.07 ± 1.29 d	12.89 ± 1.84 h	18.67 ± 2.67 c	20.25 ± 2.89 ef	21.02 ± 3 bc	16.89 ± 1.88 c-e
$W_1V_1S_3$	8.07 ± 1.15 f	11.10 ± 1.59 i	16.89 ± 2.41 d	18.11 ± 2.59 g	13.22 ± 1.89 h	12.65 ± 1.41 i
$W_1V_1S_4$	10.00 ± 1.43 a	14.44 ± 2.06 de	19.89 ± 2.84 c	21.78 ± 3.11 c-e	16.99 ± 2.43 f	15.76 ± 1.75 ef
$W_1V_2S_1$	6.81 ± 0.97 h	12.89 ± 1.84 h	19.45 ± 2.78 c	21.03 ± 3 d-f	17.47 ± 2.49 f	14.44 ± 1.6 gh
$W_1V_2S_2$	9.52 ± 1.36 b	18.67 ± 2.67 a	23.78 ± 3.4 a	26.51 ± 3.79 a	23.18 ± 3.31 a	17.44 ± 1.94 bc
$W_1V_2S_3$	7.00 ± 1h	13.78 ± 1.97 fg	19.89 ± 2.84 c	21.65 ± 3.09 c-e	21.51 ± 3.07 ab	19.31 ± 2.15 a
$W_1V_2S_4$	8.15 ± 1.16 f	17.89 ± 2.56 b	19.00 ± 2.71 c	21.58 ± 3.08 c-e	19.57 ± 2.8 c-e	18.33 ±2.04 ab
SE	0.11	0.26	0.63	0.74	0.82	0.57
CV(%)	1.60	2.32	4.04	4.32	5.48	4.34

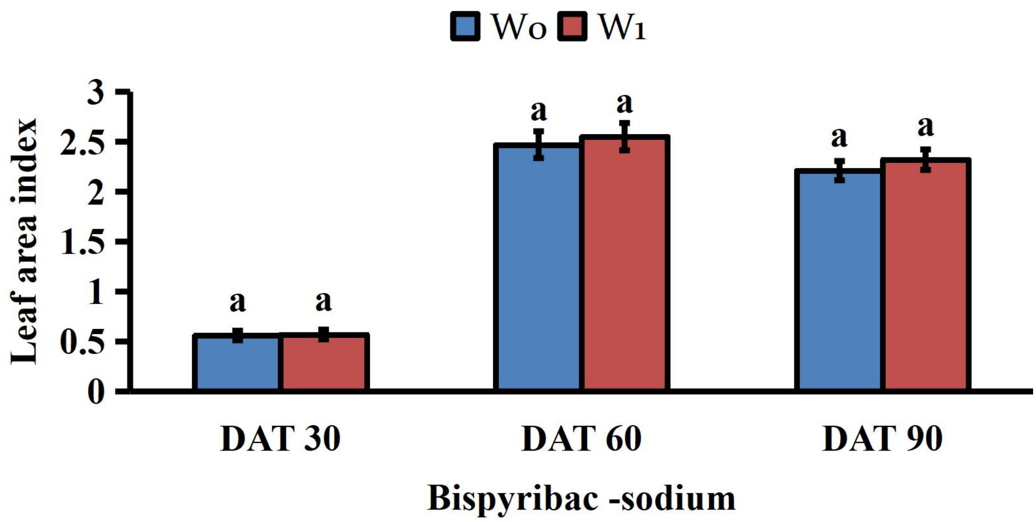
In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability.

Note viz:NS= Non- significant;Here:W_0: Weedy check and W_1: Bispyribac - sodium WP @ 150 g ha^{-1};V_1: Kalizira and V_2: BRRI dhan37;S_1: 20 cm × 15 cm, S_2: 25 cm × 15 cm, S_3: 20 cm × 20 cm and S_4: 25 cm × 25 cm

4.7.3 Leaf area index

Effect of Bispyribac-sodium

Weed control treatment showed non significant effect on leaf area index at different DAT (Figure 20). Experiment result showed that Bispyribac - sodium WP @ 150 g ha^{-1} herbicide treated plot recorded the maximum leaf area index (0.57, 2.55 and 2.32) at 30, 60 and 90 DAT. While Weedy check plot recorded the minimum leaf area index (0.56, 2.47 and 2.21) at 30, 60 and 90 DAT. Application of Bispyribac - sodium WP @ 150 g ha^{-1} herbicide treated plot gave higher leaf area index comparable to weedy check plot due to the fact that application of herbicide gave good weed control in the early growth stage which helps plant to easily establishment and resources utilization thus suppress weed population comparable to weedy check plot.

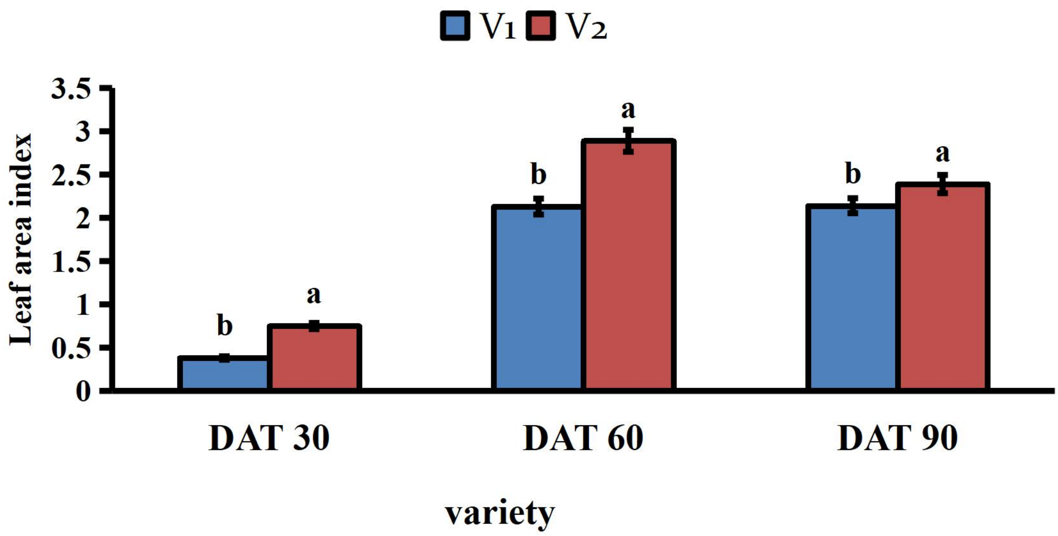


Here, W_0: Weedy check and W_1: Bispyribac - sodium WP @ 150 g ha^{-1}

Figure 19. Effect of weeds control treatment on leaf area index of romatic rice at different days after transplanting (Bars represent±SD of values obtained from three biological replicates).

Effect of variety

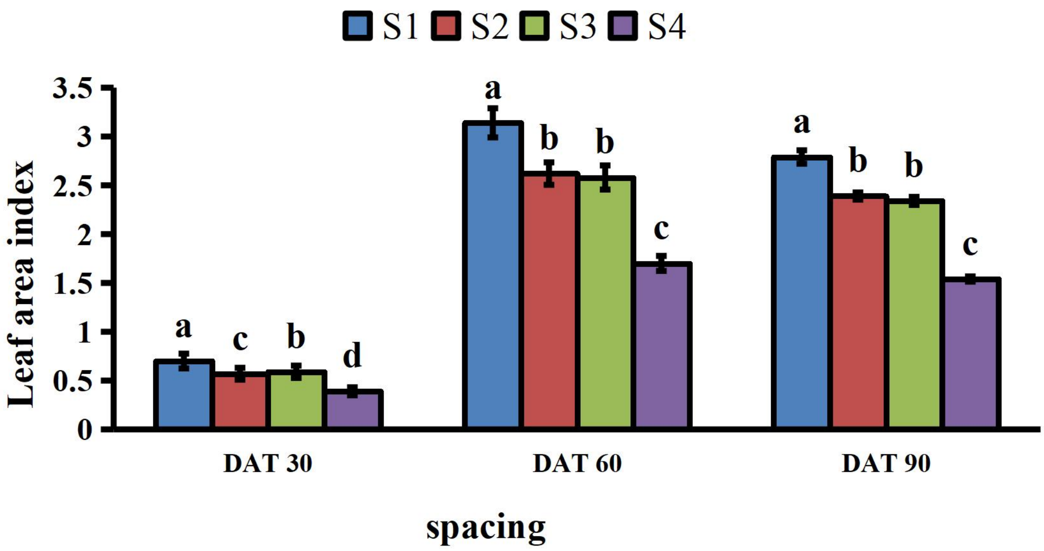
The leaf area index (LAI) of the crop is crucial in the quantitative description of the canopy structure and photosynthetic processes. Since leaves are essential for photosynthesis and produce the bulk of biomass, the number of leaves and leaf area index will also influence yield. Leaf area index significantly affected by different rice varieties at different DAT (Figure 21). Experiment result showed that BRRI dhan37 rice variety recorded the maximum leaf area index (0.75, 2.89 and 2.39) at 30, 60 and 90 DAT which was due to the varietal potentiality comparable to others rice varieties. While the Kalizira rice variety recorded minimum leaf area index (0.38, 2.13and 2.14) at 30, 60 and 90 DAT. The variation in leaf area index due to the effect of varietal differences. The result obtained from the present study was similar with the findings of Luh and Stefanou (1991) who reported that the variation of the leaf area index might be due to cause of genotypic characters of varieties and proper nutrient availability.



Here, V_1: Kalizira and V_2: BRRI dhan37

Figure 20. Effect of variety on leaf area index of aromatic rice at different DAT Effect of spacing (Bars represent±SD of values obtained from three biological replicates).

Spacing play an important role as its influences plant growth and development and in this experiment different spacing significantly effect on leaf area index at different DAT (Figure 21). Result showed that aromatic rice cultivated at 20 cm × 15 cm spacing recorded the maximum leaf area index (0.70, 3.14 and 2.79) at 30, 60 and 90 DAT. While aromatic rice cultivated at 25 cm × 25 cm spacing recorded the minimum leaf area index (0.39,1.70 and 1.54) at 30, 60 and 90 DAT. As leaf area index depend on surface area of plant increasing surface area gradually decreasing leaf area index. Riahinia and Dehdashti (2008)found similar results with the present study and reported that leaf area index affecting in photosynthesis and it was significantly increased by decreasing plant spacing.



Here, S_1: 20 cm × 15 cm, S_2: 25 cm × 15 cm, S_3: 20 cm × 20 cm and S_4: 25 cm × 25 cm

Figure 21. Effect of spacings on leaf area index of aromatic rice at different DAT Combined effect of Bispyribac - sodium and variet (Bars represent±SD of values obtained from three biological replicates).

Different weed control treatment along with different rice variety cultivation showed non significant effect at different DAT (Table 19). Experiment result showed that Bispyribac - sodium WP @ 150 g ha^{-1} herbicide treated plot along with BRRI dhan37 rice variety cultivation recorded the maximum leaf area index (0.76, 2.93 and 2.46) at 30, 60 and 90 DAT. While Weedy check plot along with Kalizira rice variety cultivation recorded the minimum leaf area index (0.37, 2.10 and 2.09) at 30, 60 and 90 DAT.

Combined effect of Bispyribac - sodium and spacing

Different weed control treatment and spacings showed non significant effect at different DAT (Table 20). Experiment result showed that among different treatment combination Bispyribac - sodium WP @ 150 g ha^{-1} herbicide treated plot along with aromatic rice cultivated at 20 cm × 15 cm spacing recorded the maximum leaf area index (0.70, 3.15 and 2.85) at 30, 60 and 90 DAT. While weedy check plot along with aromatic rice cultivated at 25 cm × 55 cm spacing recorded the maximum leaf area index (0.39, 1.68 and 1.51) at 30, 60 and 90 DAT.

Combined effect of variety and spacing

Leaf area index significantly influenced due to combined effect of variety and spacings at different DAT (Table 21). Experiment result revealed that BRRI dhan37 rice variety cultivated at 20 cm × 15 cm spacing recorded the maximum leaf area index (0.93, 3.63 and 3.00) at 30, 60 and 90 DAT. While Kalizira rice variety cultivated at 25 cm × 55 cm spacing recorded the minimum leaf area index (0.27, 1.45 and 1.46) at 30, 60 and 90 DAT.

Combined effect of weeds control, variety and spacing

Combination of different treatment showed non significant effect on leaf area index at different DAT (Table 22). Experiment result revealed that Bispyribac - sodium WP @ 150 g ha^{-1} herbicide treated plot along with BRRI dhan37 rice variety cultivation at 20 cm × 15 cm spacing recorded the maximum leaf area index (0.93) at 30 DAT. At 60 DAT weedy check plot along with Kalizira rice variety cultivation at 20 cm × 15 cm recorded the maximum leaf area index (3.65) and at 90 DAT Bispyribac - sodium WP @ 150 g ha^{-1} herbicide treated plot along with BRRI dhan37 rice variety cultivation at 20 cm × 15 cm spacing recorded the maximum leaf area index (3.11). While weedy check plot along with BRRI dhan37 rice variety cultivation at 25 cm × 25 cm spacing recorded the minimum leaf area index (0.26) at 30 DAT. At 60 DAT Bispyribac - sodium WP @ 150 g ha^{-1} herbicide treated plot along with BRRI dhan37 rice variety cultivation at 25 cm × 25 cm spacing recorded the minimum leaf area index (1.44) and at 90 DAT weedy check plot along with Kalizira rice variety cultivation at 25 cm × 25 cm spacing recorded the minimum leaf area index (1.41)

Table 19. Combined effect of and variety on Bispyribac - sodium leaf area index of aromatic rice at different DAT

Treatment Combinations	Leaf area index		
	DAT 30	DAT 60	DAT 90
W_0V_1	0.37±0.09	2.10±0.46	2.09±0.44
W_0V_2	0.74±0.17	2.84±0.63	2.33±0.49
W_1V_1	0.38±0.09	2.16±0.46	2.18±0.42
W_1V_2	0.76±0.18	2.93±0.63	2.46±0.55
SE	0.007	0.04	0.01
CV(%)	2.78	4.44	1.46

Here:W_0: Weedy check and W_1: Bispyribac - sodium WP @ 150 g ha^{-1} ;V_1: Kalizira and V_2: BRRI dhan37.

Table 20. Combined effect of weeds control and spacings leaf area index of aromatic rice at different DAT

Treatment Combinations	Leaf area index		
	DAT 30	DAT 60	DAT 90
W_0S_1	0.70±0.28	3.13±0.53	2.74±0.18
W_0S_2	0.57±0.22	2.56±0.41	2.33±0.09
W_0S_3	0.58±0.22	2.51±0.43	2.27±0.14
W_0S_4	0.39±0.15	1.68±0.26	1.51±0.11
W_1S_1	0.70±0.28	3.15±0.55	2.85±0.29
W_1S_2	0.58±0.22	2.68±0.41	2.45±0.14
W_1S_3	0.60±0.24	2.65±0.45	2.41±0.12
W_1S_4	0.40±0.15	1.72±0.29	1.57±0.07
SE	0.008	0.05	0.04
CV(%)	2.58	4.02	3.36

Here;W_0: Weedy check and W_1: Bispyribac - sodium WP @ 150 ;S_1: 20 cm × 15 cm, S_2: 25 cm × 15 cm, S_3: 20 cm × 20 cm and S_4: 25 cm × 25 cm

Table 21. Combined effect of variety and spacings on leaf area index of aromatic rice at different DAT

Treatment Combinations	Leaf area index		
	DAT 30	DAT 60	DAT 90
V_1S_1	0.46 ±0.08 e	2.65 ±0.08 c	2.58 ±0.02 b
V_1S_2	0.38 ±0.07 f	2.25 ±0.09 d	2.29 ±0.04 d
V_1S_3	0.39 ±0.07 f	2.18 ±0.09 d	2.22 ±0.09 d
V_1S_4	0.27 ±0.04 g	1.45 ±0.05 f	1.46 ±0.06 f
V_2S_1	0.93 ±0.11 a	3.63 ±0.09 a	3.00 ±0.12 a
V_2S_2	0.76 ±0.09 c	2.99 ±0.1 b	2.49 ±0.09 c
V_2S_3	0.78 ±0.09 b	2.98 ±0.11 b	2.46 ±0.06 c
V_2S_4	0.52 ±0.06 d	1.95 ±0.06 e	1.62 ±0.03 e
SE	0.008	0.05	0.04
CV(%)	2.58	4.02	3.36

Here:V_1: Kalizira and V_2: BRRI dhan37;S_1: 20 cm × 15 cm, S_2: 25 cm × 15 cm, S_3: 20 cm × 20 cm and S_4: 25 cm × 25 cm

Table 22. Combined effect of spacing ,variety and Bispyribac - sodium,spacings on leaf area index of aromatic rice at different DAT

Treatment Combinations	Leaf area index		
	DAT 30	DAT 60	DAT 90
$W_0V_1S_1$	0.46±0.09	3.65±0.09	2.57±0.02
$W_0V_1S_2$	0.38±0.08	3.60±0.08	2.25±0.02
$W_0V_1S_3$	0.39±0.07	3.05±0.08	2.14±0.02
$W_0V_1S_4$	0.26±0.05	3.05±0.05	1.41±0.01
$W_0V_2S_1$	0.93±0.12	2.93±0.1	2.90±0.01
$W_0V_2S_2$	0.75±0.1	2.90±0.08	2.41±0.02
$W_0V_2S_3$	0.76±0.1	2.65±0.08	2.40±0.02
$W_0V_2S_4$	0.52±0.07	2.65±0.06	1.60±0.03
$W_1V_1S_1$	0.46±0.09	2.31±0.09	2.58±0.02
$W_1V_1S_2$	0.39±0.08	2.24±0.08	2.32±0.03
$W_1V_1S_3$	0.39±0.07	2.19±0.08	2.30±0.02
$W_1V_1S_4$	0.27±0.05	2.12±0.05	1.51±0.02
$W_1V_2S_1$	0.93±0.13	1.98±0.11	3.11±0.03
$W_1V_2S_2$	0.77±0.11	1.91±0.09	2.57±0.02
$W_1V_2S_3$	0.80±0.11	1.45±0.09	2.51±0.02
$W_1V_2S_4$	0.52±0.07	1.44±0.06	1.63±0.03
SE	0.01	0.08	0.06
CV(%)	2.58	4.02	3.36

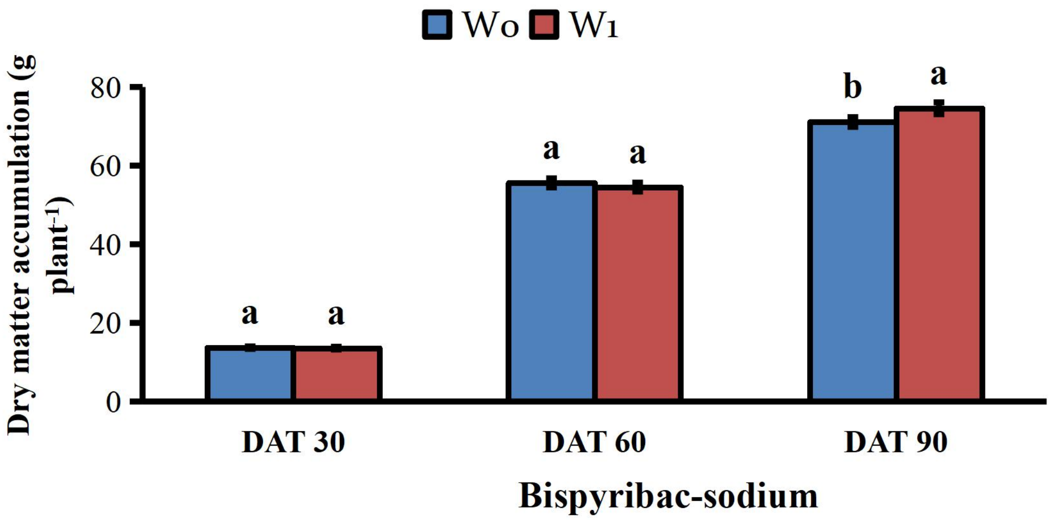
In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability.

Note viz:NS= Non- significant;Here:W_0: Weedy check and W_1: Bispyribac - sodium WP @ 150 g ha^{-1};V_1: Kalizira and V_2: BRRI dhan37;S_1: 20 cm × 15 cm, S_2: 25 cm × 15 cm, S_3: 20 cm × 20 cm and S_4: 25 cm × 25 cm

4.7.4 Dry matter accumulation (g plant^{-1})

Effect of weed control treatment

The dry matter accumulation (g plant^{-1}) consists of all its constituents excluding water. Weed control through herbicide application significantly effect on dry matter accumulation (g plant^{-1}) of aromatic rice only at 90 DAT (Figure 23). Experiment result revealed that weedy check plot recorded the maximum dry matter accumulation (13.70 and 55.61 g plant^{-1}) at 30 and 60 DAT. At 90 DAT Bispyribac - sodium WP @ 150 g ha^{-1} herbicide recorded the maximum dry matter accumulation (74.59). While Bispyribac - sodium WP @ 150 g ha^{-1} herbicide treated plot recorded the minimum dry matter accumulation(13.58 and 54.54 g plant^{-1}) at 30 and 60 DAT. At 90 DAT weedy check plot recorded the minimum dry matter accumulation (71.10 g plant^{-1}). The dry matter accumulation (g plant^{-1}) differences over weedy check treatment was due to reason that application of herbicide reduced weed density which ultimate help undisturbed plant growth by utilizing its surrounded resources. Similar result also observed by Lodhi (2016) who reported that different weed control treatments caused remarkable variations in the quantity of dry matter accumulation at different days after transplanting. Weedy check plots have the minimum quantity of dry matter production, which increased appreciably at all the growth intervals as the plots received weed control treatments.

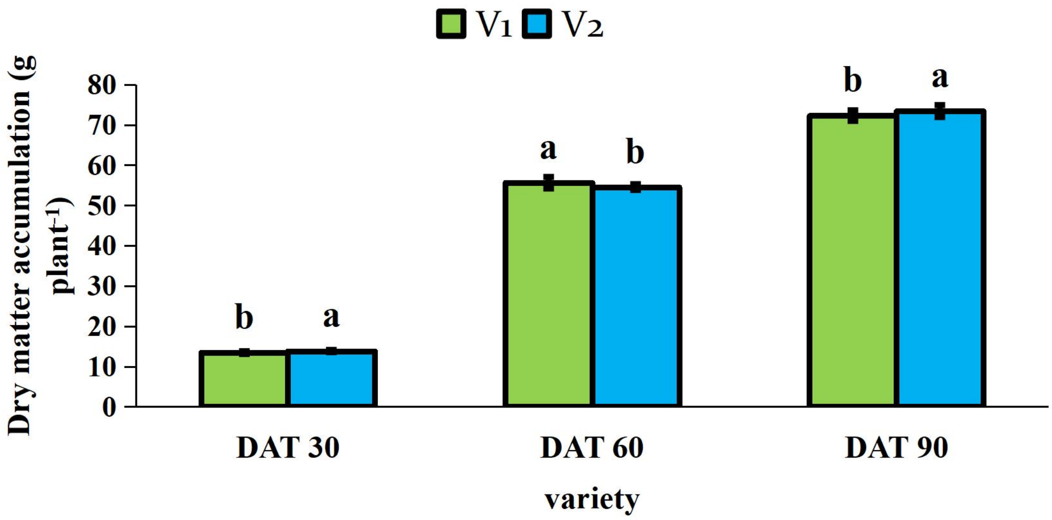


Here, W_0: Weedy check and W_1: Bispyribac - sodium WP @ 150 g ha^{-1}

Figure 22. Effect of on dry matteBispyribac-sodium accumulation plant^{-1} of aromatic rice at different days after transplanting (Bars represent±SD of values obtained from three biological replicates).

Effect of variety

The dry matter accumulation (g plant^{-1}) differ among different varieties due to reason that individual variety have individual leaf area, growth stage, and resources utilization its surrounded which influences the dry matter accumulation (g plant^{-1}). In this experiment result showed that different rice varieties significantly effect on dry matter accumulation (g plant^{-1}) of aromatic rice at different DAT (Figure 23). Experiment result revealed that BRRI dhan37 rice variety recorded the maximum dry matter accumulation (13.83 g plant^{-1}) at 30 DAT. At 60 DAT Kalizira rice variety recorded the maximum dry matter accumulation (55.62 g plant^{-1}) and at 90 DAT BRRI dhan37 rice variety recorded the maximum dry matter accumulation (73.40 g plant^{-1}). While cultivation of Kalizira rice variety recorded the minimum dry matter accumulation (13.45 g plant^{-1}) at 30 DAT. At 60 DAT cultivation of BRRI dhan37 rice variety recorded the minimum dry matter accumulation (54.53 g plant^{-1}) and at 90 DAT Kalizirarecorded the minimum dry matter accumulation (72.28 g plant^{-1})

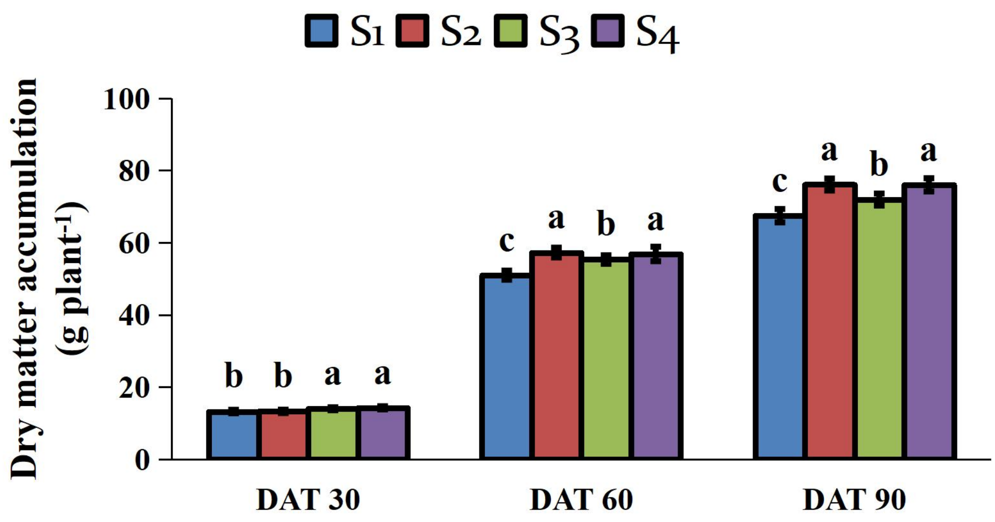


Here, V_1: Kalizira and V_2: BRRI dhan37

Figure 23. Effect of variety on dry matter accumulation plant^{-1} (g) of aromatic rice at different days after transplanting (Bars represent±SD of values obtained from three biological replicates).

Effect of spacing

Different spacing significantly effect on dry matter accumulation (g plant^{-1}) at different DAT (Figure 24). Experiment result showed that aromatic rice cultivated at 25 cm × 25 cm spacing recorded the maximum dry matter accumulation (14.20 g plant^{-1}) at 30 DAT while was statistically similar with aromatic rice cultivated at 20 cm × 20 cm spacing recorded dry matter accumulation (13.95 g plant^{-1}). At 60 and 90 DAT aromatic rice cultivated at 25 cm × 15 cm spacing recorded the maximum dry matter accumulation (57.22 and 76.06 g plant^{-1}) which was statistically similar with aromatic rice cultivated at 25 cm × 25 cm spacing recorded dry matter accumulation (56.83 and 75.98) at 60 and 90 DAT. While aromatic rice cultivated at 20 cm × 15 cm spacing recorded the minimum dry matter accumulatikon (13.178, 50.96 and 67.43 g plant^{-1}) at 30, 60 and 90 DAT which was statistically similar with aromatic rice cultivated at 25 cm × 15 cm spacing recorded dry matter accumulation (13.23) at 30 DAT. The result obtained from the present study was similar with the findings of Mirza *et al.* (2009) who reported that wider spacing coupled with higher number of seedlings per hill accumulated maximum amount of dry matter, emphasizing that productivity of tillers as well as dry matter yield was lower with closer spacing and transplanting single seedlings per hill.



Here, S_1: 20 cm × 15 cm, S_2: 25 cm × 15 cm, S_3: 20 cm × 20 cm and S_4: 25 cm × 25 cm

Figure 24. Effect of spacings on dry matter accumulation plant^{-1} (g) of aromatic rice at different days after transplanting (Bars represent±SD of values obtained from three biological replicates).

Combined effect of Bispyribac-sodium and variety

Combined effect of weeds control and variety showed significant effect on dry matter accumulation (g plant^{-1}) at 60 and 90 DAT (Table 23). Experiment result showed that weedy check plot along with BRRI dhan37 rice variety cultivation recorded the maximum dry matter accumulation (13.90 plant^{-1}) at 30 DAT. At 60 DAT weedy check plot along with Kalizira rice variety cultivation recorded the maximum dry matter accumulation (59.01 plant^{-1}) and at 90 DAT Bispyribac - sodium WP @ 150 g ha^{-1} herbicide treated plot along with BRRI dhan37 rice variety cultivation recorded the maximum dry matter accumulation (79.09 plant^{-1}). While Bispyribac - sodium WP @ 150 g ha^{-1} herbicide treated plot along with Kalizira rice variety cultivation recorded the minimum dry matter accumulation (13.41 plant^{-1}) at 30 DAT. At 60 and 90 DAT weedy check plot along with BRRI dhan37 rice variety cultivation recorded the minimum dry matter accumulation (52.21 and 67.71 plant^{-1}) which was statistically similar with Bispyribac - sodium WP @ 150 g ha^{-1} herbicide treated plot along with Kalizira rice variety cultivation recorded dry matter accumulation (52.24 plant^{-1}) at 60 DAT.

Combined effect of Bispyribac-sodium and spacings

Different weed control along with spacings showed significant effect on dry matter accumulation (g plant^{-1}) at different DAT (Table 24). Experiment result showed that Bispyribac - sodium WP @ 150 g ha^{-1} herbicide treated plot along with aromatic rice cultivated at 25 cm × 25 cm spacing recorded the maximum dry matter accumulation (14.51 g plant^{-1}) at 30 DAT. At 60 and 90 DAT Bispyribac - sodium WP @ 150 g ha^{-1} herbicide treated plot along witharomatic rice cultivated at 25 cm × 15 cm spacing recorded the maximum dry matter accumulation (59.56 and 78.36 g plant^{-1}) which was statistically similar with weedy check plot along with aromatic rice cultivated at 25 cm × 25 cm spacing recorded the dry matter accumulation (59.21 g plant^{-1}) at 60 DAT. While Bispyribac - sodium WP @ 150 g ha^{-1} herbicide treated plot along witharomatic rice cultivated at 20 cm × 15 cm spacing recorded the minimum dry matter accumulation(12.55 and 48.88 g plant^{-1}) at 30 and 60 DAT. At 90 DAT weedy check plot along with aromatic rice cultivated at 20 cm × 15 cm spacing recorded the minimum dry matter accumulation (65.29 g plant^{-1}).

Combined effect of variety and spacings

Different rice variety along with diffrent spacing showed significant effect on dry matter accumulation (g plant^{-1}) at different DAT (Table 25). Experiment result showed that Kalizira rice variety cultivated at 25 cm × 25 cm spacing recorded the maximum dry matter accumulation (14.26 g plant^{-1}) which was statistically similar with BRRI dhan37 rice variety cultivated at 25 cm × 15 cm spacing recorded dry matter accumulation (14.18 g plant^{-1}), with BRRI dhan37 rice variety cultivated at 25 cm × 25 cm spacing recorded dry matter accumulation (14.14 g plant^{-1}), with BRRI dhan37 rice variety cultivated at 20 cm × 20 cm spacing recorded dry matter accumulation (13.95 g plant^{-1}) and with Kalizira rice variety cultivated at 20 cm × 20 cm spacing recorded dry matter accumulation (13.95 g plant^{-1}) at 30 DAT. At 60 and 90 DAT Kalizira rice variety cultivated at 25 cm × 15 cm spacing recorded the maximum dry matter accumulation (60.64 and 80.60 g plant^{-1}) which was statistically similar with Kalizira rice variety cultivated at 25 cm × 25 cm spacing recorded dry matter accumulation (60.52 g plant^{-1}) at 60 DAT. While Kalizira rice variety cultivated at 25 cm × 15 cm spacing recorded the minimum dry matter accumulation (12.27 g plant^{-1}) at 30 DAT. At 60 and 90 DAT Kalizira rice variety cultivated at 20 cm × 15 cm spacing recorded the minimum dry matter accumulation (49.10 and 66.77 g plant^{-1}) which was statistically similar with BRRI dhan37 rice variety cultivated at 20 cm × 15 cm spacing recorded dry matter accumulation (68.08 g plant^{-1}) at 90 DAT.

Combined effect of Bispyribac-sodium , variety and spacings

Combination of different treatment showed significant effect on dry matter accumulation (g plant^{-1}) at different DAT (Table 26). Experiment result showed that Bispyribac - sodium WP @ 150 g ha^{-1} herbicide treated plot along with Kalizira rice variety cultivation at 25 cm × 25 cm spacing recorded the maximum dry matter accumulation (15.18 g plant^{-1}) which was statistically similar with weedy check plot along with Kalizira rice variety cultivated at 20 cm × 15 cm spacing recorded dry matter accumulation (14.81 g plant^{-1}) at 30 DAT. At 60 DAT weedy check plot along with Kalizira rice variety cultivated at 25 cm × 25 cm spacing recorded the maximum dry matter accumulation (67.76 g plant^{-1}) and at 90 DAT Bispyribac - sodium WP @ 150 g ha^{-1} herbicide treated plot along with BRRI dhan37 rice variety cultivation at 25 cm × 25 cm spacing recorded the maximum dry matter accumulation (84.21 g plant^{-1}). While Bispyribac - sodium WP @ 150 g ha^{-1} herbicide treated plot along with Kalizira rice variety cultivation at 20 cm × 15 cm spacing recorded the minimum dry matter accumulation (11.83, 44.04 and 63.32 g plant^{-1}) which was statistically similar with Bispyribac - sodium WP @ 150 g ha^{-1} herbicide treated plot along with Kalizira rice variety cultivation at 25 cm × 15 cm spacing recorded dry matter accumulation (12.15 g plant^{-1}) and with weedy check plot along with Kalizira rice variety cultivation at 25 cm × 15 cm spacing recorded dry matter accumulation (12.40 g plant^{-1}) at 30 DAT.

Table 23. Combined effect of Bispyribac -sodium and variety on dry matter accumulation plant^{-1} (g) of aromatic rice at different DAT

Treatment Combinations	Dry matter accumulation plant^{-1} (g)		
	DAT 30	DAT 60	DAT 90
W_0V_1	13.50±1.56	59.01 a±5.85	74.48 b±5.12
W_0V_2	13.90±1.48	52.21 c±2.65	67.71 d±4.98
W_1V_1	13.41±1.97	52.24 c±6.72	70.08 c±7.2
W_1V_2	13.76±1.38	56.84 b±2.84	79.09 a±4.13
SE	0.10	0.14	0.26
CV(%)	2.87	2.25	1.55

Here:W_0: Weedy check and W_1: Bispyribac - sodium WP @ 150 g ha^{-1} ;V_1: Kalizira and V_2: BRRI dhan37

Table 24. Combined effect of Bispyribac-sodium and spacings on dry matter accumulation plant^{-1} (g) of aromatic rice at different DAT

Treatment Combinations	Dry matter accumulation plant^{-1} (g)		
	DAT 30	DAT 60	DAT 90
W_0S_1	13.81 ±1.75 b	53.04 ±1.62 c	65.29 ±5.56 e
W_0S_2	13.18 ±1.57 c	54.89 b±5.32 b	73.76 ±6.85 c
W_0S_3	13.90 ±1.47 b	55.30 b±1.42 b	69.76 ±1.45 d
W_0S_4	13.89 b±1.5 b	59.21 ±9.44 a	75.58 ±3.5 b
W_1S_1	12.55 ±1.47 d	48.88 ±5.39 d	69.56 ±6.98 d
W_1S_2	13.28 ±1.81 c	59.56 ±2.58 a	78.36 ±3.62 a
W_1S_3	13.99 b±1.49 b	55.26 b±5.89 b	74.04 ±7.73 c
W_1S_4	14.51 ±1.62 a	54.45 ±1.68 bc	76.38 ±8.71 b
SE	0.14	0.30	0.35
CV(%)	2.80	2.37	1.48

Here:W_0: Weedy check and W_1: Bispyribac - sodium WP @ 150 g ha^{-1} ;S_1: 20 cm × 15 cm, S_2: 25 cm × 15 cm, S_3: 20 cm × 20 cm and S_4: 25 cm × 25 cm

Table 25. Combined effect of variety and spacings on dry matter accumulation plant^{-1} (g) of aromatic rice at different DAT

Treatment Combinations	Dry matter accumulation plant^{-1} (g)		
	DAT 30	DAT 60	DAT 90
V_1S_1	13.32 ±2.1 b	49.10±5.63 d	66.77 ±4.01 g
V_1S_2	12.27 ±1.23 c	60.64 ±1.63 a	80.60 a±1.79 a
V_1S_3	13.95 ±1.5 a	52.23 ±2.67 c	68.25 ±1.84 f
V_1S_4	14.26 ±1.74 a	60.52 ±8.02 a	73.51 ±5.62 d
V_2S_1	13.04 ±1.32 b	52.82 ±1.44 c	68.08±8.58 fg
V_2S_2	14.18±1.43 a	53.80 ±4.16 c	71.51 ±4.46 e
V_2S_3	13.95 ±1.46 a	58.34 ±2.68 b	75.55 ±6.12 c
V_2S_4	14.14±1.44 a	53.14 ±2.91 c	78.45 ±6.5 b
SE	0.14	0.30	0.35
CV(%)	2.80	2.37	1.48

Here:V_1: Kalizira and V_2: BRRI dhan37;S_1: 20 cm × 15 cm, S_2: 25 cm × 15 cm, S_3: 20 cm × 20 cm and S_4: 25 cm × 25 cm

Table 26. Combined effect of Bispyribac-sodium,variety and spacings on dry matter accumulation plant^{-1} (g) of aromatic rice at different DAT

Treatment Combinations	Dry matter accumulation plant^{-1} (g)		
	DAT 30	DAT 60	DAT 90
$W_0V_1S_1$	14.81±1.64 ab	54.16 e-g±1.2	70.22±1.56f
$W_0V_1S_2$	12.40±1.38 gh	59.64±1.33 bc	79.86 ±1.78 bc
$W_0V_1S_3$	13.44 ±1.49 d-f	54.48 ±1.21 e-g	69.39 ±1.54 fg
$W_0V_1S_4$	13.35 ±1.48 d-f	67.76±1.51 a	78.46 ±1.74 c
$W_0V_2S_1$	12.82 ±1.42 fg	51.91 hi±1.15	60.35 ±1.34 j
$W_0V_2S_2$	13.96 ±1.55 cd	50.14 ±1.11 i	67.65 ±1.5 gh
$W_0V_2S_3$	14.37 bc±1.6	56.13 ±1.25 de	70.13 ±1.56 f
$W_0V_2S_4$	14.43 bc±1.6	50.68 ±1.13 i	72.69 ±1.62 e
$W_1V_1S_1$	11.83 h±1.31	44.04 ±0.98 j	63.32 ±1.41i
$W_1V_1S_2$	12.15 h±1.35	61.65 ±1.37 b	81.34 ±1.81 b
$W_1V_1S_3$	14.47±1.61 bc	49.98 ±1.11 i	67.11 ±1.49 h
$W_1V_1S_4$	15.18 ±1.69 a	53.28±1.18 gh	68.56 ±1.52 f-h
$W_1V_2S_1$	13.26 ±1.48 ef	53.72±1.19 f-h	75.81±1.68d
$W_1V_2S_2$	14.40±1.6 bc	57.47 ±1.28 cd	75.37±1.67d
$W_1V_2S_3$	13.52 ±1.5 de	60.54 ±1.35 b	80.96 ±1.8 b
$W_1V_2S_4$	13.85±1.54 c-e	55.62 ±1.24 d-f	84.21 ±1.87 a
SE	0.20	0.42	0.50
CV(%)	2.80	2.37	1.48

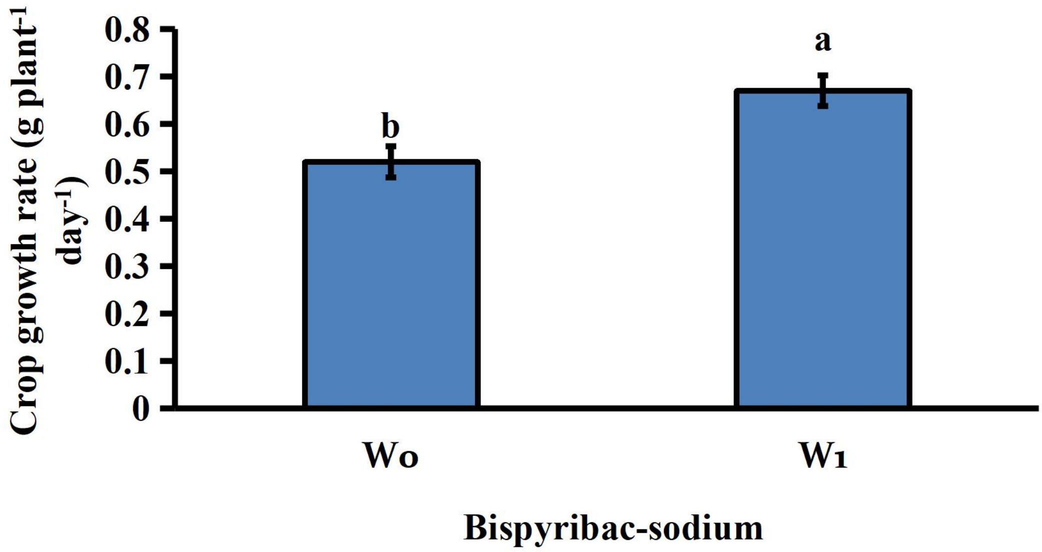
In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability.

Note viz:NS= Non- significant;Here:W_0: Weedy check and W_1: Bispyribac - sodium WP @ 150 g ha^{-1};V_1: Kalizira and V_2: BRRI dhan37;S_1: 20 cm × 15 cm, S_2: 25 cm × 15 cm, S_3: 20 cm × 20 cm and S_4: 25 cm × 25 cm

4.7.5 Crop growth rate (g plant^{-1} day^{-1})

Effect of Bispyribac-sodium

Crop growth is less than potential when the uptake of water, oxygen, or nutrients is less than the demand of the crop. Less nutrients occurred due to weeds infestation in the crop field. Weed control through effective herbicide application reduced weed crop competition and increasing crop growth. Weed control treatment significantly effect on crop growth rate by reducing weed density in crop field (Figure 25). Result showed that Bispyribac - sodium WP @ 150 g ha^{-1} herbicide treated plot recorded the maximum crop growth rate (0.67 g plant^{-1} day^{-1}) while weedy check plot recorded the minimum crop growth rate (0.52 g plant^{-1} day^{-1}). Similar result also observed by Lodhi (2016) who reported that different weed control treatment increasing crop growth rate comparable to weedy check.

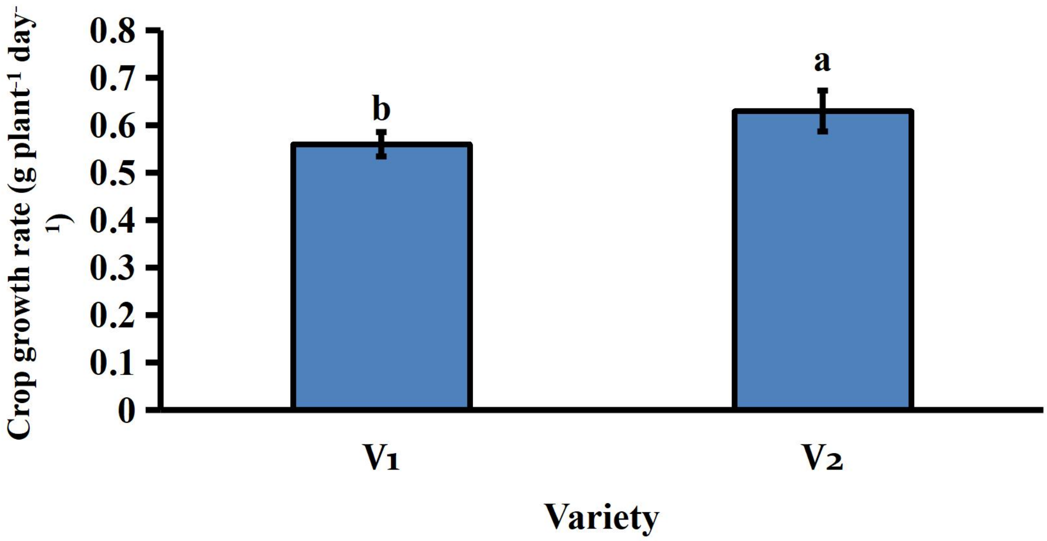


Here, W_0: Weedy check and W_1: Bispyribac - sodium WP @ 150 g ha^{-1}

Figure 25. Effect of on crop growth rate of Bispyribac-sodium aromatic rice (Bars represent±SD of values obtained from three biological replicates).

Effect of variety

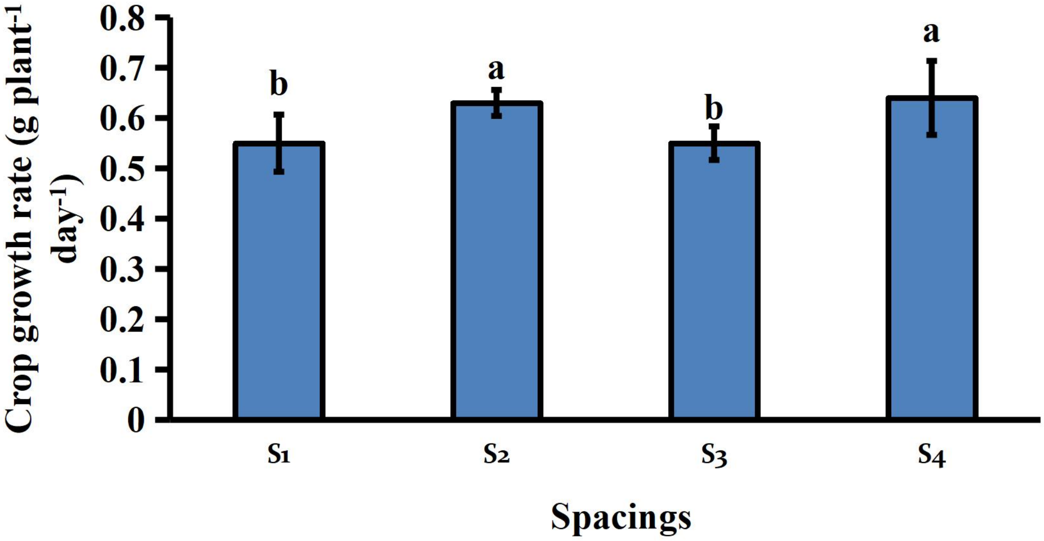
Different rice varieties significantly effect on crop growth rate (Figure 27). It was clear from the experiment result that the maximum crop growth rate (0.63 g plant^{-1} day^{-1}) was recorded under BRRI dhan37 rice variety while the minimum crop growth rate (0.56 g plant^{-1} day^{-1}) was recorded under Kalizira rice variety. In this experiment it was observed that high yielding varieties give better response to nutrients utilization and thus, their production rate increases substantially comparatively to local variety. Mia and Shamsuddin (2011) also found similar result with the present study and reported that the CGR is the product of LAI and NAR values and higher CGR achieved in of the modern varieties than the aromatic varieties may be due to the higher LAI.



Here, V_1: Kalizira and V_2: BRRI dhan37

Figure 26. Effect of variety on crop growth rate of aromatic rice Effect of spacings (Bars represent±SD of values obtained from three biological replicates).

Different spacing significantly effect on crop growth rate (Figure 27). From the experiment result revealed that aromatic rice cultivated at 25 cm × 25 cm spacing recorded the maximum crop growth rate (0.64 g plant^{-1} day^{-1}) which was statistically similar with aromatic rice cultivated at 25 cm × 15 cm spacing recorded crop growth rate (0.63 g plant^{-1} day^{-1}). While aromatic rice cultivated at 20 cm × 15 cm spacing recorded the minimum crop growth rate (0.55 g plant^{-1} day^{-1}) which was statistically similar with aromatic rice cultivated at 20 cm × 20 cm spacing recorded crop growth rate (0.55 g plant^{-1} day^{-1}). Ashraf *et al.* (2014) also found similar result with the present study and reported that the maximum CGR was attained in widest plant spacing while closest spacing resulted in minimum growth rate of crop under both conditions weedy and weed free. Lowest CGR was found in the closest spacing which might be to due maximum intra plant competition for acquisition of resources and ultimately crop growth rate declined.



Here, S_1: 20 cm × 15 cm, S_2: 25 cm × 15 cm, S_3: 20 cm × 20 cm and S_4: 25 cm × 25 cm

Figure 27. Effect of spacings on crop growth rate of aromatic rice Combined effect of Bispyribac-sodium and variety(Bar represent±SD of values obtained from three biological replicates).

Combined effect of weeds control and variety showed significant effect on crop growth rate of aromatic rice (Table 27). Experiment result showed that Bispyribac - sodium WP @ 150 g ha^{-1} herbicide treated plot along with BRRI dhan37 rice variety cultivation recorded the maximum crop growth rate (0.74 g plant^{-1} day^{-1}) while weedy check plot along with Kalizira rice variety cultivation recorded the minimum crop growth rate (0.52 g plant^{-1} day^{-1}) which was statistically similar with weedy check plot along with Kalizira rice variety cultivation recorded crop growth rate (0.52 g cm^{-2} day^{-1}).

Combined effect of Bispyribac-sodium and spacings

Combined effect of weeds control and spacings showed significant effect on crop growth rate of aromatic rice (Table 28). Experiment result showed that Bispyribac - sodium WP @ 150 g ha^{-1} herbicide treated plot along with aromatic rice variety cultivated at 25 cm × 25 cm recorded the the maximum crop growth rate (0.73 g plant^{-}

^{1} day^{-1}) while weedy check plot along with aromatic rice variety cultivated at 20 cm × 15 cm recorded the minimum crop growth rate (0.41 g plant^{-1} day^{-1})

Combined effect of variety and spacing

Different aromatic rice variety along with spacings showed significant effect on crop growth rate of aromatic rice (Table 29). Result showed that BRRI dhan37 rice variety cultivated at 25 cm × 25 cm spacing recorded the maximum crop growth rate (0.84 g plant^{-1} day^{-1}) while Kalizira rice variety cultivated at 25 cm × 25 cm spacing recorded the minimum crop growth rate (0.43 g plant^{-1} day^{-1}).

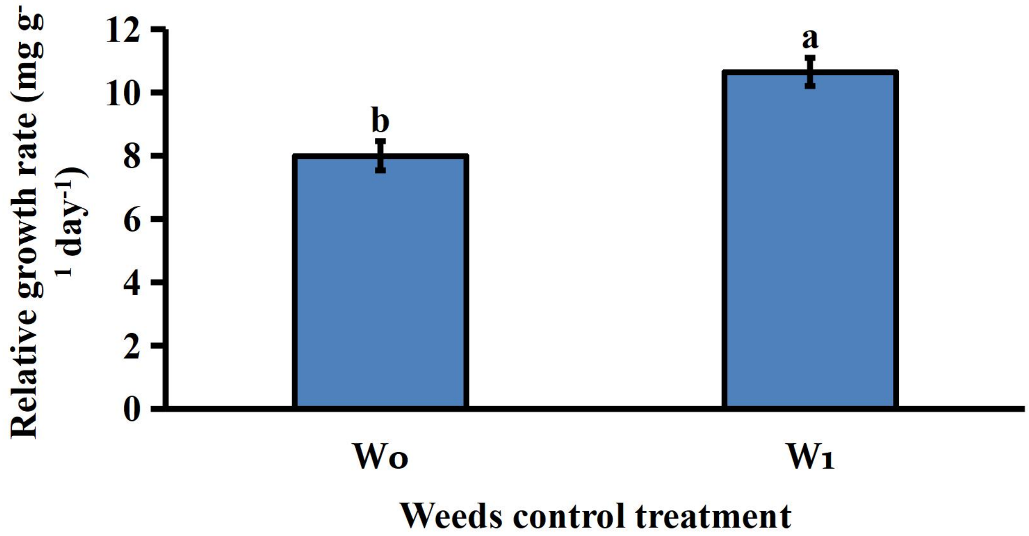
Combined effect of Bispyribac-sodium, variety and spacing

Combination of different treatment showed significant effect on crop growth rate of aromatic rice (Table 30). Experiment result showed that Bispyribac - sodium WP @ 150 g ha^{-1} herbicide treated plot along with BRRI dhan37 rice variety cultivated at 25 cm × 25 cm spacing recorded the maximum crop growth rate (0.95 g plant^{-1} day^{-1}) while weedy check plot along with Kalizira rice variety cultivated at 20 cm × 15 cm spacing recorded the minimum crop growth rate (0.28 g plant^{-1} day^{-1}).

4.7.6 Relative growth rate (mg g^{-1} day^{-1})

Effect of Bispyribac-sodium

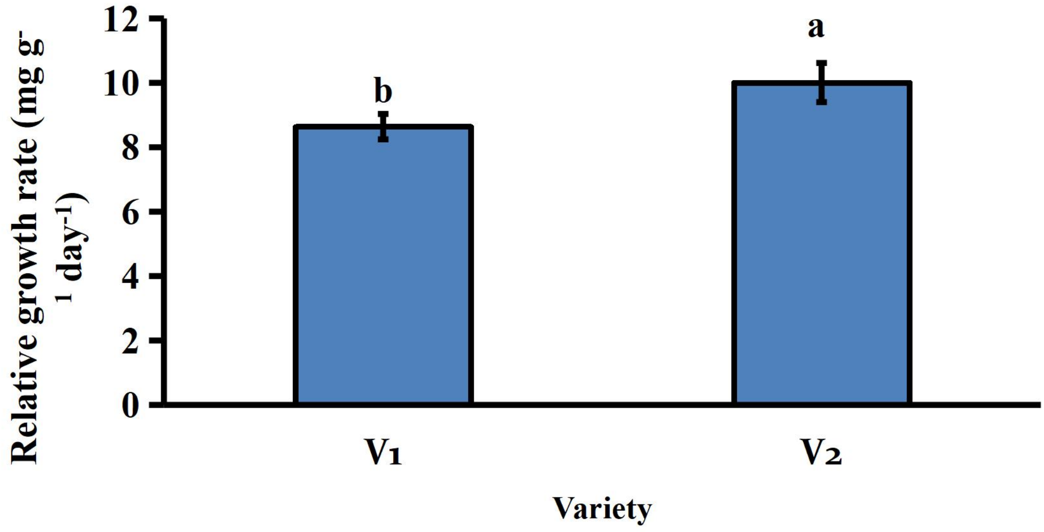
Weed control treatment significantly effect on relative growth rate (mg g^{-1} day^{-1}) of aromatic rice (Figure 28). Experiment result revealed that Bispyribac - sodium WP @ 150 g ha^{-1} herbicide treated plot recorded the maximum relative growth rate (10.65 mg g^{-1} day^{-1}) while weedy check plot recorded the minimum relative growth rate (8.00 mg g^{-1} day^{-1}). Olayinka and Etejere (2015) also found similar result which supported the present finding and reported that all the weed control treatments had higher RGR as compared to the weedy check.



Here, W_0: Weedy check and W_1: Bispyribac - sodium WP @ 150 g ha^{-1}

Figure 28. Effect of t on relative growth Bispyribac-sodium of aromatic rice Effect of variety(Bars represent±SD of values obtained from three biological replicates).

Variety in an important factor because it's impact on crop growth, development and grain production. High yielding or hybrid rice varieties produce more grain yield and dry matter accumulation (g $plant^{-1}$) comparable to local variety (Figure 29). As relative growth rate is related to dry matter accumulation (g $plant^{-1}$) and in this experiment the maximum relative growth rate (10.01 mg g^{-1} day^{-1}) was recorded under BRRI dhan37 rice variety cultivation while Kalizira rice variety recorded the minimum relative growth rate (8.64 mg g^{-1} day^{-1}). The result found from this experiment result quite dissimilar with the finding of Amin *et al.* (2002) who reported that RGRs of local varieties were generally higher than those of improved varieties under low N supply.

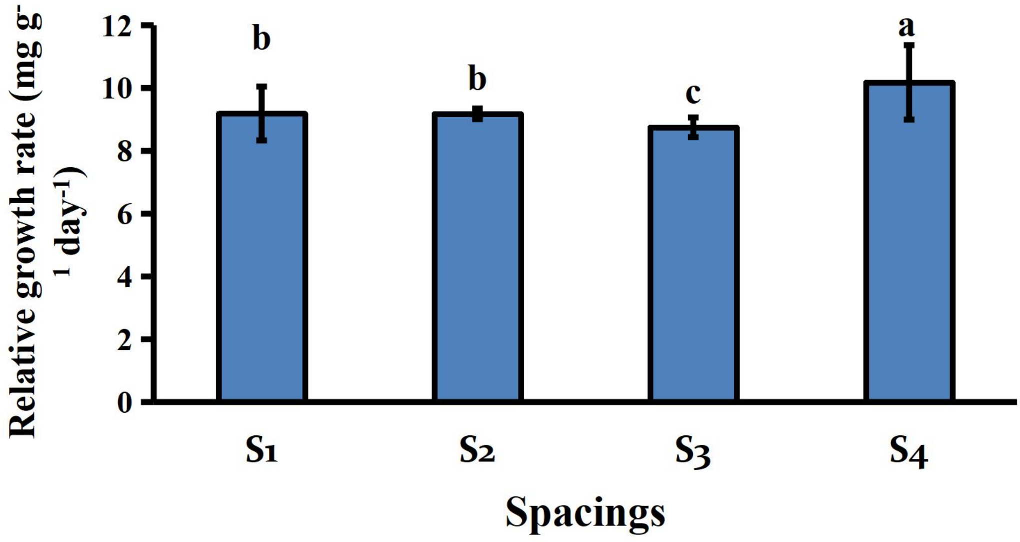


Here, V_1: Kalizira and V_2: BRRI dhan37

Figure 29. Effect of variety on relative growth rate of aromatic rice (Bars represent±SD of values obtained from three biological replicates).

Effect of spacing.

Different spacing significantly effect on relative growth rate (mg g^{-1} day^{-1}) of aromatic rice (Figure 30). Result showed that aromatic rice cultivated at 25 cm × 25 cm spacing recorded the maximum relative growth rate (10.18 mg g^{-1} day^{-1}) while aromatic rice cultivated at 20 cm × 20 cm spacing recorded the minimum relative growth rate (8.75 mg g^{-1} day^{-1}). Similar result observed by Obulamma and Reddy (2002) and they reported that the wider spacing recorded more CGR, RGR and NAR due to lesser competition among the plants that will boost more CHO assimilation leading to more TDMP (Total dry matter production).



Here, S_1: 20 cm × 15 cm, S_2: 25 cm × 15 cm, S_3: 20 cm × 20 cm and S_4: 25 cm × 25 cm

Figure 30. Effect of spacings on relative growth rate of aromatic rice (Bars represent±SD of values obtained from three biological replicates).

Combined effect of Bispyribac -sodium and variety

Combined effect of weeds control and variety showed significant effect on relative growth rate (mg g^{-1} day^{-1}) of aromatic rice (Table 27). Experiment result showed that Bispyribac - sodium WP @ 150 g ha^{-1} herbicide treated plot along with BRRI dhan37 rice variety cultivation recorded the maximumrelative growth rate (11.40 mg g^{-1} day^{-1}) while weedy check plot along with Kalizira rice variety cultivation recorded the minimum relative growth rate (7.39 mg g^{-1} day^{-1}).

Combined effect Bispyribac -sodium and spacing

Combined effect of weeds control and spacings showed significant effect on relative growth rate of aromatic rice (Table 28). Experiment result showed that Bispyribac - sodium WP @ 150 g ha^{-1} herbicide treated plot along with aromatic rice variety cultivated at 25 cm × 25 cm spacing recorded the maximumrelative growth rate (11.89 mg g^{-1} day^{-1}) which was statistically similar with Bispyribac - sodium WP @ 150 g ha^{-1} herbicide treated plot along with aromatic rice variety cultivated at 20 cm × 15 cm spacing recorded relative growth rate (11.79 mg g^{-1} day^{-1}) while weedy check plot along with aromatic rice variety cultivated at 20 cm × 15 cm recorded the minimumrelative growth rate (6.58 mg g^{-1} day^{-1}).

Combined effect of variety and spacing

Different aromatic rice variety along with spacings showed significant effect on relative growth rate of aromatic rice (Table 29). Result showed that BRRI dhan37 rice variety cultivated at 25 cm × 25 cm spacing recorded the maximum relative growth rate(13.70 mg g^{-1} day^{-1}) while Kalizira rice variety cultivated at 25 cm × 25 cm spacing recorded the minimum relative growth rate(6.65 mg g^{-1} day^{-1}).

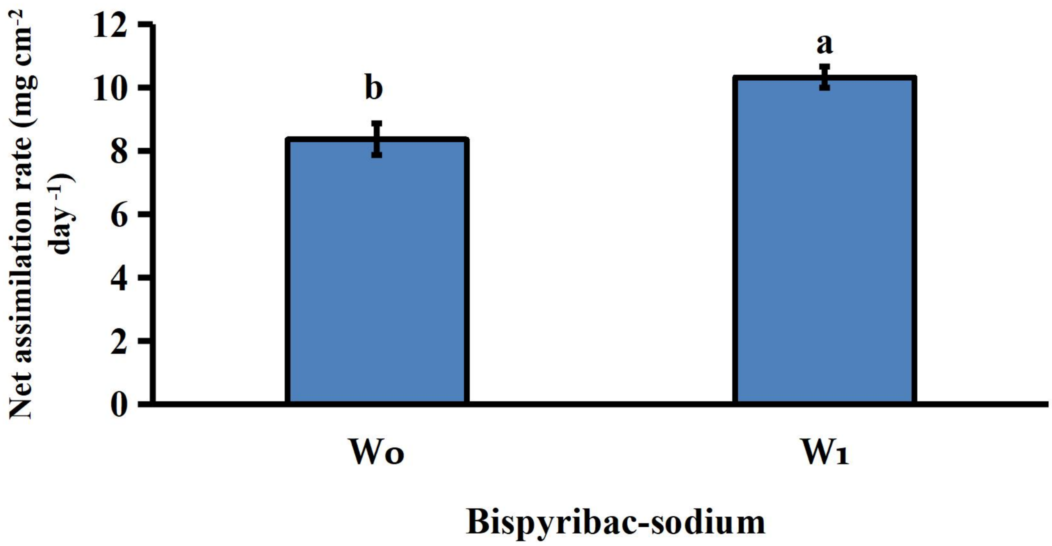
Combined effect of Bispyribac -sodium , variety and spacing

Combination of different treatment showed significant effect on relative growth rate of aromatic rice (Table 30). Experiment result showed that Bispyribac - sodium WP @ 150 g ha^{-1} herbicide treated plot along with BRRI dhan37 rice variety cultivated at 25 cm × 25 cm spacing recorded the maximum relative growth rate(15.38 mg g^{-1} day^{-1}) while weedy check plot along with BRRI dhan37 rice variety cultivated at 20 cm × 20 cm spacing recorded the minimum relative growth rate(7.43 mg g^{-1} day^{-1}).

4.7.7 Net assimilation rate (mg cm^{-2} day^{-1})

Effect of weed control treatment

The net assimilation rate is an important factor as its related to crop growth and development. Net assimilation rate significantly differ due to weed control treatments (Figure 32). It is clear from experiment result that Bispyribac - sodium WP @ 150 g ha^{-1}herbicide treated plot recorded the maximum net assimilation rate (10.33 mg cm^{-2} day^{-1}) while weedy check plot recorded the minimum net assimilation rate (8.37 mg cm^{-2} day^{-1}). Shultana *et al.* (2013) reported that increase in competition period between weeds and crop decreased the NAR probably due to less leaf area and shortage of other growth factors (nutrient, space, water etc).Maqsood (1998) also reported that mostly cereals such as rice had NAR up to 6 g m-2 day-1 and that LAI was positively associated with NAR.

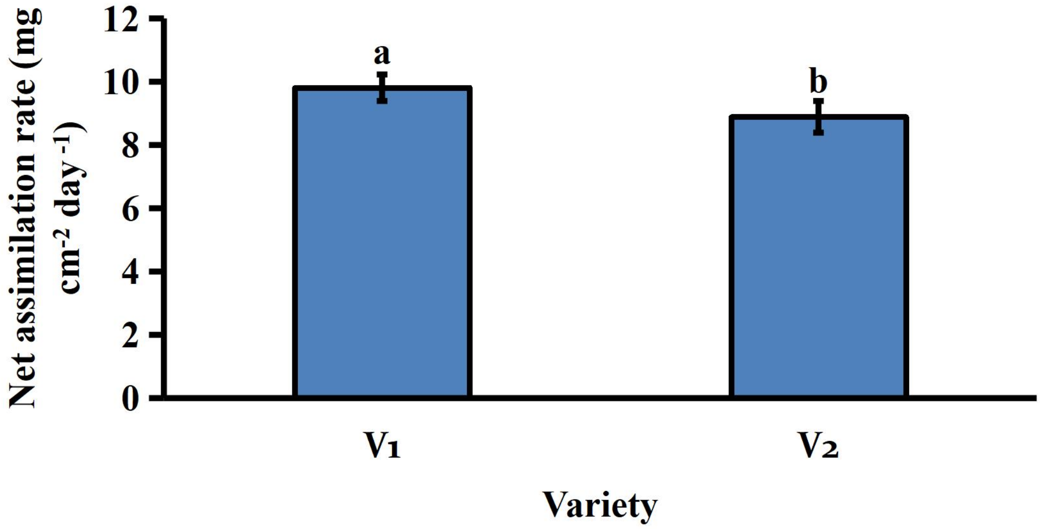


Here, W_0: Weedy check and W_1: Bispyribac - sodium WP @ 150 g ha^{-1}

Figure 31. Effect of Bispyribac -sodium on net assimilation rate of aromatic rice (Bars represent±SD of values obtained from three biological replicates).

Effect of variety

Different rice variety significantly influenced on net assimilation rate due to reason that individual variety had individual leaf area, growth rate and resources utilization ability and genetic make-up (Figure 32). Experiment result revealed that Kalizira rice variety cultivation recorded the maximum net assimilation rate (9.81 mg cm^{-2} day $^{-1}$) while BRRI dhan37 rice variety cultivation recorded the minimum net assimilation rate (8.89 mg cm^{-2} day^{-1}). *Lu et al.* (2000) observed that decrease in the rate of photosynthesis in leaves cause parallel decrease in NAR and eventually low grain yield.



Here, V_1: Kalizira and V_2: BRRI dhan37

Figure 32. Effect of variety on net assimilation rate of aromatic rice(Bars represent±SD of values obtained from three biological replicates).

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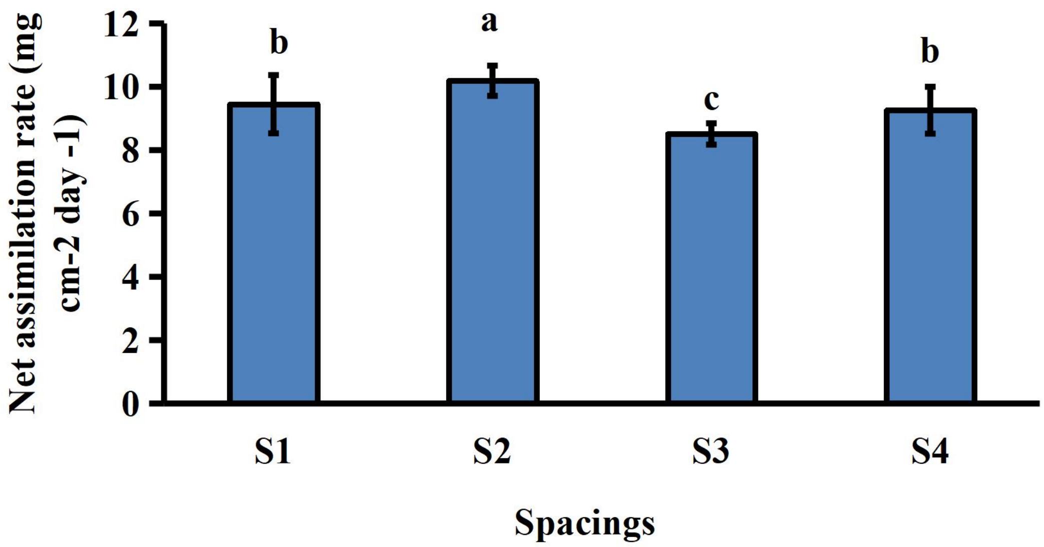
Effect of spacings

Different spacings significantly influenced on net assimilation rate of aromatic rice (Figure 34). Result revealed that aromatic rice cultivated at 25 cm × 15 cm spacing recorded the maximum net assimilation rate (10.19 mg cm^{-2} day^{-1}) while aromatic rice cultivated at 20 cm × 20 cm spacing recorded the minimum net assimilation rate (8.51 mg cm^{-2} day^{-1}). The result obtained from the present study was similar with the findings of Sridevi (2009) and they reported that In general, the rectangular planting with closer spacing recorded lesser NAR than square planting with wider spacing at all the growth stages, irrespective of age of seedlings, number of seedlings $hill^{-1}$ and method of weeding. Reduction in NAR could be attributed to less leaf area and shortage of other growth factors (nutrient, space, water etc).



Here, S_1: 20 cm × 15 cm, S_2: 25 cm × 15 cm, S_3: 20 cm × 20 cm and S_4: 25 cm × 25 cm

Figure 33. Effect of spacings on net assimilation rate of aromatic rice(Bars represent±SD of values obtained from three biological replicates).

Combined effect of Bispyribac -sodium and variety.

Combined effect of weeds control and variety showed significant effect on net assimilation rate (mg cm^{-2} day $^{-1}$) of aromatic rice (Table 27). Experiment result showed that Bispyribac - sodium WP @ 150 g ha^{-1} herbicide treated plot along with BRRI dhan37 rice variety cultivation recorded the maximumnet assimilation rate (10.34 mg cm^{-2} day^{-1}) which was statistically similar with Bispyribac - sodium WP @ 150 g ha^{-1} herbicide treated plot along with Kalizira rice variety cultivation recorded net assimilation rate (10.33 mg cm^{-2} day^{-1}) while weedy check plot along with BRRI dhan37 rice variety cultivation recorded the minimum net assimilation rate (7.45 mg cm^{-2} day^{-1}).

Combined effect of Bispyribac -sodium and spacing

Combined effect of weeds control and spacings showed significant effect on net assimilation rate of aromatic rice (Table 28). Experiment result showed that Bispyribac - sodium WP @ 150 g ha^{-1} herbicide treated plot along with aromatic rice variety cultivated at 20 cm × 15 cm spacing recorded the maximumnet assimilation rate (11.61 mg cm^{-2} day^{-1}) while weedy check plot along with aromatic rice variety cultivated at 20 cm × 15 cm recorded spacing the minimumnet assimilation rate (7.30

mg cm^{-2} day^{-1}) which was which was statistically similar with weedy check plot along with aromatic rice variety cultivated at 20 cm × 20 cm spacing recorded net assimilation rate (7.69 mg cm^{-2} day^{-1}).

Combined effect of variety and spacings

Different aromatic rice variety along with spacings showed significant effect on net assimilation rate of aromatic rice (Table 29). Result showed that Kalizira rice variety cultivated at 25 cm × 15 cm spacing recorded the maximum net assimilation rate (11.73 mg cm^{-2} day^{-1}) which was statistically similar with BRRI dhan37 rice variety cultivated at 25 cm × 25 cm spacing recorded net assimilation rate (11.38 mg cm^{-2} day^{-1}) and with Kalizira rice variety cultivated at 20 cm × 15 cm spacing recorded the maximum net assimilation rate (11.28 mg cm^{-2} day^{-1}) while Kalizira rice variety cultivated at 25 cm × 25 cm spacing recorded the minimum net assimilation rate (7.14 mg cm^{-2} day^{-1}) which was statistically similar with BRRI dhan37 rice variety cultivated at 20 cm × 15 cm spacing recorded net assimilation rate (7.63 mg cm^{-2} day^{-1}).

Combined effect of Bispyribac -sodium , variety and spacings

Combination of different treatment showed significant effect on net assimilation rate of aromatic rice (Table 30). Experiment result showed that Bispyribac - sodium WP @ 150 g ha^{-1} herbicide treated plot along with BRRI dhan37 rice variety cultivated at 25 cm × 25 cm spacing recorded the maximum net assimilation rate (12.70 mg cm^{-2} day^{-1}) which was statistically similar with Bispyribac - sodium WP @ 150 g ha^{-1} herbicide treated plot along with Kalizira rice variety cultivated at 20 cm × 15 cm spacing recorded net assimilation rate (12.70 mg cm^{-2} day^{-1}) and with weedy check plot along with Kalizira rice variety cultivated at 25 cm × 15 cm spacing recorded net assimilation rate (12.14 mg cm^{-2} day^{-1}) while weedy check plot along with BRRI dhan37 rice variety cultivated at 20 cm × 15 cm spacing recorded the minimum net assimilation rate(4.34 mg cm^{-2} day^{-1}).

Table 27. Combined effect of Bispyribac -sodium and variety on Crop growth rate, relative growth rate and net assimilation rate of aromatic rice

Treatment Combinations	Crop growth rate	Relative growth rate	Net assimilation rate
W_0V_1	0.52±0.13 c	7.39 ±1.52 d	9.29±2.34 b
W_0V_2	0.52±0.19 c	8.62±2.76 c	7.45±2.27 c
W_1V_1	0.59±0.11 b	9.89±1.4 b	10.33±1.65 a
W_1V_2	0.74±0.17 a	11.40±2.58 a	10.34±1.69 a
SE	0.005	0.06	0.20
CV(%)	2.32	1.63	5.49

Here:W_0: Weedy check and W_1: Bispyribac - sodium WP @ 150 g ha^{-1} ;V_1: Kalizira and V_2: BRRI dhan37

Table 28. Combined effect of Bispyribac -sodium and spacings on crop growth rate,relative growth rate and net assimilation rate of aromatic rice

Treatment Combinations	Crop growth rate	Relative growth rate	Net assimilation rate
W_0S_1	0.41±0.15 f	6.58±1.71 f	7.30±3.24 e
W_0S_2	0.63±0.09 c	9.22± 0.85 c	10.45±1.85 b
W_0S_3	0.48±0.07 e	7.74±0.36 e	7.69±1.16 e
W_0S_4	0.55±0.22 d	8.46±3.91 d	8.03±2.21 d
W_1S_1	0.69±0.12 b	11.79±0.38 a	11.61±0.77 a
W_1S_2	0.63±0.09 c	9.14±0.16 c	9.92± 1.55 bc
W_1S_3	0.63±0.11 c	9.76±0.15 b	9.32± 0.17 c
W_1S_4	0.73a±0.27	11.89a±3.82	10.49±2.43 b
SE	0.008	0.07	0.28
CV(%)	2.40	1.42	5.36

Here:W_0: Weedy check and W_1: Bispyribac - sodium WP @ 150 g ha^{-1} ;V_1: Kalizira and V_2: BRRI dhan37

Table 29. Combined effect of variety and spacings on crop growth rate, relative growth rate and net assimilation rate of aromatic rice

Treatment Combinations	Crop growth rate	Relative growth rate	Net assimilation rate
V_1S_1	0.59 ±0.11 c	10.13 ±2.17 b	11.28 ±1.12 a
V_1S_2	0.67 ±0.08 b	8.85 ±0.45 d	11.73 ±0.47 a
V_1S_3	0.53 ±0.09 d	8.94 ±0.97 d	9.09 ±0.39 b
V_1S_4	0.43 ±0.1 f	6.65 ±1.9 g	7.14 ±1.24 d
V_2S_1	0.50 ±0.26 e	8.25 ±3.54 f	7.63 ±3.61 cd
V_2S_2	0.59 ±0.09 c	9.51 ±0.53 c	8.64 ±0.18 b
V_2S_3	0.58 ±0.14 c	8.56 ±1.25 e	7.92 ±1.42 c
V_2S_4	0.84 ±0.17 a	13.70±1.84 a	11.38 ±1.46 a
SE	0.008	0.07	0.28
CV(%)	2.40	1.42	5.36

Here:V_1: Kalizira and V_2: BRRI dhan37;S_1: 20 cm × 15 cm, S_2: 25 cm × 15 cm, S_3: 20 cm × 20 cm and S_4: 25 cm × 25 cm

Table 30. Combined effect of Bispyribac -sodium , variety and spacings on crop growth rate, relative growth rate and net assimilation rate of aromatic rice

Treatment Combinations	Crop growth rate	Relative growth rate	Net assimilation rate
$W_0V_1S_1$	0.54 ±0.08 g	8.15 ±0.12 h	10.26 ±0.15 de
$W_0V_1S_2$	0.67 ±0.09 c	8.46 ±0.12 g	12.14 ±0.18 ab
$W_0V_1S_3$	0.50 ±0.08 h	8.06 ±0.12 h	8.74 ± 0.13 g-i
$W_0V_1S_4$	0.36 ±0.05 j	4.89 ±0.07 j	6.01 ±0.09 j

$W_0V_2S_2$	0.28 ±0.05 k	5.02 ±0.07 j	4.34 ±0.06 k
	0.58±0.1 ef	9.99±0.15 d	8.77 ±0.13 g-i
$W_0V_2S_3$	0.47±0.08 i	7.43±0.11 i	6.63 ±0.09 j
$W_0V_2S_4$	0.73±0.12 b	12.03 ±0.18 b	10.05 ±0.15 ef
$W_1V_1S_1$	0.64±0.12 d	12.11 ±0.18 b	12.29 ±0.18 a
$W_1V_1S_2$	0.66 ±0.09 cd	9.24 ±0.14 f	11.33±0.17 bc
$W_1V_1S_3$	0.57±0.1 f	9.82±0.14 de	9.44 ±0.14 e-g
$W_1V_1S_4$	0.51 ±0.09 h	8.41 ±0.12 g	8.27 ±0.12 i
$W_1V_2S_1$	0.74 ±0.12 b	11.48 ±0.17 c	10.92 ±0.16 cd
$W_1V_2S_2$	0.60 ±0.09 e	9.04 ±0.13 f	8.51 ±0.13 hi
$W_1V_2S_3$	0.68±0.09 c	9.69 ±0.14 e	9.21 ±0.14 f-h
$W_1V_2S_4$	0.95 ±0.16 a	15.38 ±0.23 a	12.70 ±0.19 a
SE	0.01	0.10	0.40
CV(%)	2.40	1.42	5.36

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability.

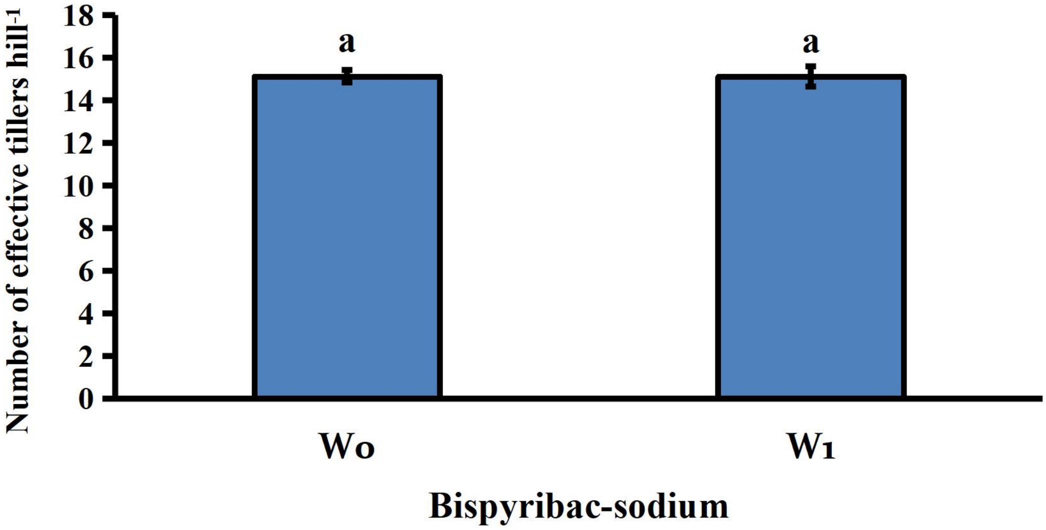
Note viz:NS= Non- significant;Here:W_0: Weedy check and W_1: Bispyribac - sodium WP @ 150 g ha^{-1};V_1: Kalizira and V_2: BRRI dhan37;S_1: 20 cm × 15 cm, S_2: 25 cm × 15 cm, S_3: 20 cm × 20 cm and S_4: 25 cm × 25 cm

4.8 Yield contributing characters

4.8.1 Number of effective tillers $hill^{-1}$

Effect of weed control

It is obvious from the data that number of effective tillers $hill^{-1}$ had showed non significant effect of weed control of aromatic rice (Figure 35). Experiment result showed that weedy check plot recorded the maximum effective tillers $hill^{-1}$ (15.13) while Bispyribac - sodium WP @ 150 g ha^{-1} herbicide treated plot recorded the minimum effective tillers $hill^{-1}$ (15.12).



Here, W_0: Weedy check and W_1: Bispyribac - sodium WP @ 150 g ha^{-1}

Figure 34. Effect of weeds control treatment on number of effective tillers $hill^{-1}$ of aromatic rice (Bars represent±SD of values obtained from three biological replicates).

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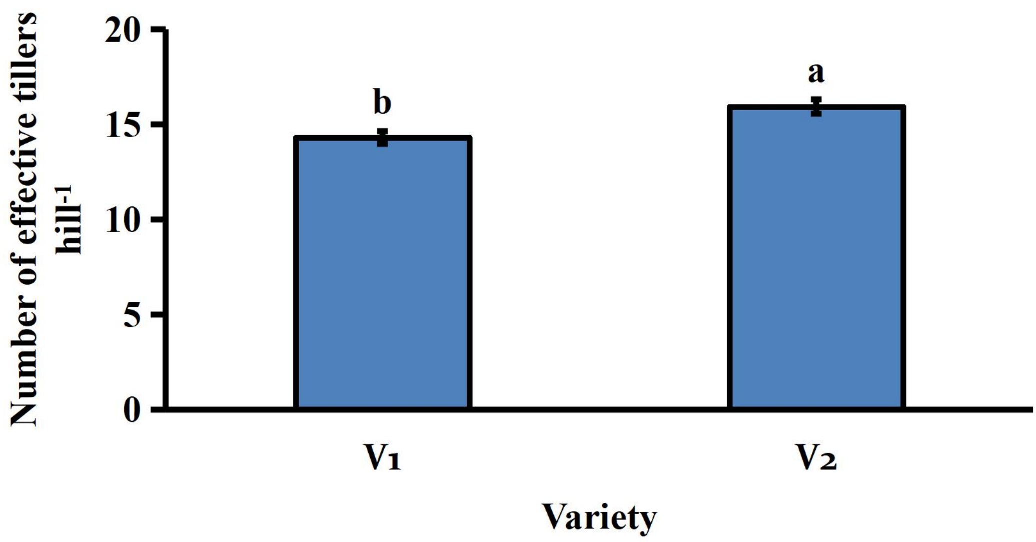
Effect of variety

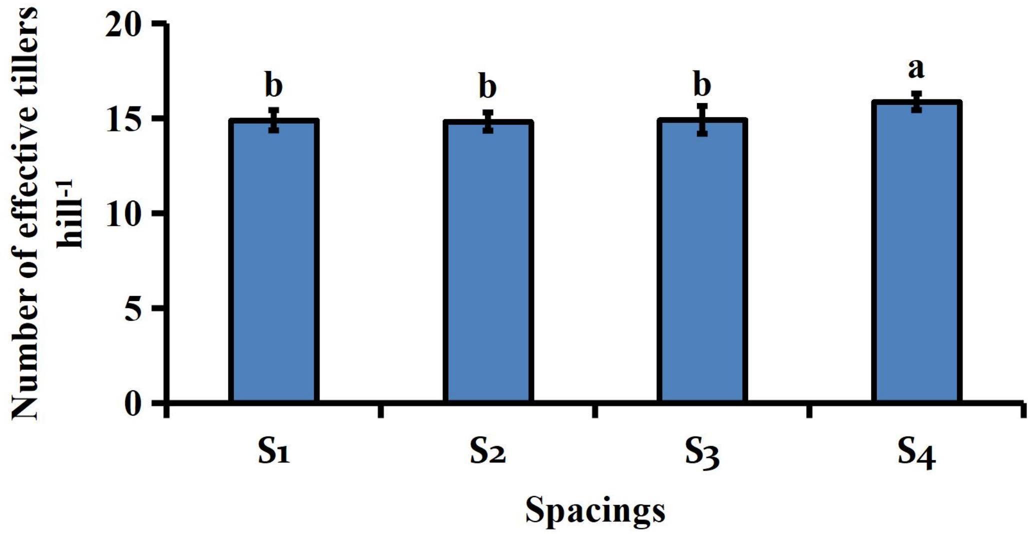
Rice variety significantly affect on number of effective tillers $hill^{-1}$ of aromatic rice (Fig 35). The maximum number of effective tillers $hill^{-1}$ (15.94) was recorded in BRRI dhan37 rice variety while the minimum number of effective tillers $hill^{-1}$ (14.31) was recorded in Kalizira rice variety. The variation of effective tillers $hill^{-1}$ is probably due to the genetic make-up of the variety. The result obtained from the present study was similar with the findings of Nahida *et al.* (2013) who reported that the reason of difference in effective tillers $hill^{-1}$ is the genetic makeup of the variety, which is primarily influenced by heredity.



Here, V_1: Kalizira and V_2: BRRI dhan37

Figure 35. Effect of variety on number of effective tillers hill^{-1} of aromatic rice Effect of spacings (Bars represent±SD of values obtained from three biological replicates).

Different spacing significantly affect on number of effective tillers hill^{-1} of aromatic rice (Fig 36). Experiment result revealed that aromatic rice variety cultivated at 25 cm × 25 cm spacing recorded the maximum number of effective tillers hill^{-1} (15.87) while aromatic rice variety cultivated at 25 cm × 15 cm spacing recorded the minimum number of effective tillers hill^{-1} (14.83) which was statistically similar with aromatic rice variety cultivated at 20 cm × 15 cm spacing recorded effective tillers hill^{-1} (14.90) and with aromatic rice variety cultivated at 20 cm × 20 cm spacing recorded effective tillers hill^{-1} (14.92). Salma *et al.* (2017) also found similar result which support the present study and reported that the production of effective tillers hill^{-1} was significantly influenced by spacing. The highest number of effective tillers hill^{-1} (11.20) was obtained from 25 cm × 15 cm spacing and the lowest one (8.43) was found in 20 cm × 10 cm spacing. The highest number of total and effective tillers hill^{-1} in wider spacing might be due to having more sunlight thus more photosynthesis more space for producing more number of tillers. Ashraf *et al.* (2014) also reported that the maximum productive tillers were found in widest plant spacing under weed free conditions while minimum was obtained from closest spacing under weedy treatments.



Here, S_1: 20 cm × 15 cm, S_2: 25 cm × 15 cm, S_3: 20 cm × 20 cm and S_4: 25 cm × 25 cm

Figure 36. Effect of spacings on number of effective tillers hill^{-1} of aromatic rice (Bars represent±SD of values obtained from three biological replicates).

Combined effect of Bispyribac-sodium and variety.

Combined effect of weeds control and variety showed non significant effect on number of effective tillers hill^{-1} of aromatic rice (Table 31). Experiment result showed that Bispyribac - sodium WP @ 150 g ha^{-1} treated plot along with BRRI dhan37 rice variety cultivation recorded the maximum number of effective tillers hill^{-1} (16.55) while Bispyribac - sodium WP @ 150 g ha^{-1} treated plot along with Kalizira rice variety cultivation recorded the minimum number of effective tillers hill^{-1} (13.69).

Combined effect of Bispyribac-sodium and spacing

Combined effect of weeds control and spacings showed significant effect on number of effective tillers hill^{-1} of aromatic rice (Table 32). Experiment result showed that weedy check plot along with aromatic rice variety cultivated at 20 cm × 15 cm spacing recorded the maximum number of effective tillers hill^{-1} (16.25) which was statistically similar with Bispyribac - sodium WP @ 150 g ha^{-1} herbicide treated plot along with aromatic rice variety cultivated at 25 cm × 25 cm spacing recorded effective tillers hill^{-1} (16.22), with Bispyribac - sodium WP @ 150 g ha^{-1} herbicide treated plot along with aromatic rice variety cultivated at 25 cm × 15 cm spacing recorded effective tillers hill^{-1} (16.11) and with weedy check plot along with aromatic rice variety cultivated at 25 cm × 25 cm spacing recorded effective tillers hill^{-1} (14.49) while weedy check plot along with aromatic rice variety cultivated at 25 cm × 15 cm spacing recorded the minimum number of effective tillers hill^{-1} (13.56) which was statistically similar with Bispyribac - sodium WP @ 150 g ha^{-1} herbicide treated plot along with aromatic rice variety cultivated at 20 cm × 15 cm spacing recorded effective tillers hill^{-1} (13.56).

Combined effect of variety and spacings

Different aromatic rice variety along with spacings showed significant effect on number of effective tillers hill^{-1} of aromatic rice (Table 33). Experiment result showed that BRRI dhan37 rice variety cultivated at 25 cm × 25 cm spacing recorded the maximum effective tillers hill^{-1} (16.60) which was statistically similar with BRRI dhan37 rice variety cultivated at 20 cm × 20 cm spacing recorded effective tillers hill^{-1} (16.33) while Kalizira rice variety cultivated at 20 cm × 20 cm spacing recorded the minimum effective tillers hill^{-1} (13.50) which was statistically similar with Kalizira rice variety cultivated at 20 cm × 15 cm spacing recorded effective tillers hill^{-1} (14.20).

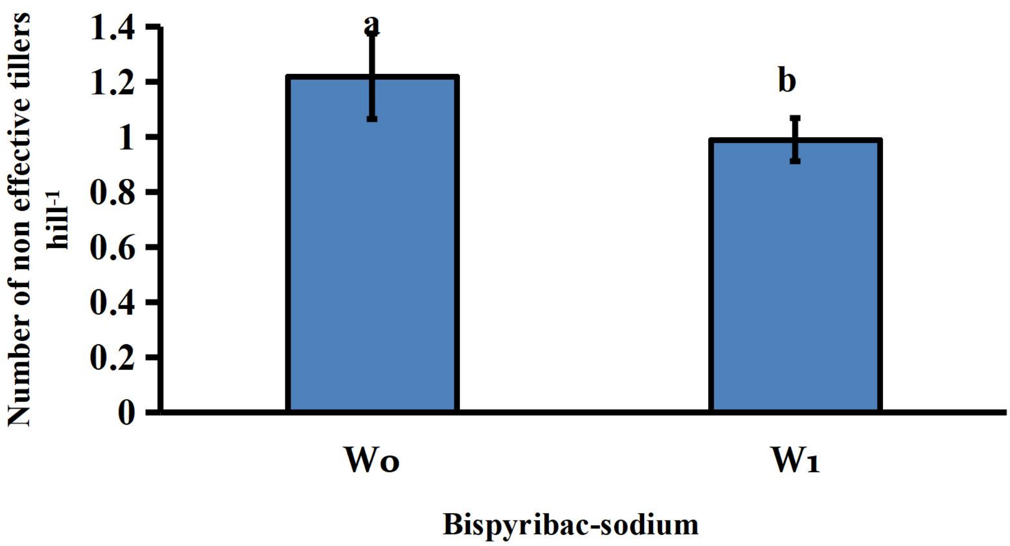
Combined effect of Bispyribac-sodium , variety and spacing

Combination of different treatment showed significant effect on number of effective tillers hill^{-1} of aromatic rice (Table 34). Experiment result showed that Bispyribac - sodium WP @ 150 g ha^{-1} herbicide treated plot along with BRRI dhan37 rice variety cultivated at 20 cm × 20 cm spacing recorded the maximum effective tillers hill^{-1} (17.78) which was statistically similar with Bispyribac - sodium WP @ 150 g ha^{-1} herbicide treated plot along with BRRI dhan37 rice variety cultivated at 25 cm × 15 cm spacing recorded effective tillers hill^{-1} (17.78), with Bispyribac - sodium WP @ 150 g ha^{-1} herbicide treated plot along with BRRI dhan37 rice variety cultivated at 25 cm × 25 cm spacing recorded effective tillers hill^{-1}(17.77) and with weedy check plot along with BRRI dhan37 rice variety cultivated at 20 cm × 15 cm spacing recorded effective tillers hill^{-1}(17.33) while Bispyribac - sodium WP @ 150 g ha^{-1} herbicide treated plot along with Kalizira rice variety cultivated at 20 cm × 20 cm spacing recorded the minimum effective tillers hill^{-1}(11.44).

4.8.2 Number of non effective tillers hill^{-1}

Effect of Bispyribac-sodium

Weeds compete with crops for water, nutrients and light. Being hardy and vigorous in growth habit, they grow faster then crops and consume large amount of water and nutrients, thus causing heavy losses in yields. In this experiment different weed control treatment showed significant effect on number of non effective tillers hill^{-1} (Figure 38). Experiment result revealed that weedy check plot recorded the maximum non effective tillers hill^{-1} (1.22) while Bispyribac - sodium WP @ 150 g ha^{-1} herbicide treated plot recorded the minimum non effective tillers hill^{-1} (0.99). The reduction of non effective tillers hill^{-1} was due to effective mixed herbicide application that reduce wider weed density and influences plant growth by reducing weed crop competition. Similar result also found by Raju *et al.* (2003) and reported that the use of weedicide gave the highest tiller hill^{-1} and control plot produced maximum non effective tiller.



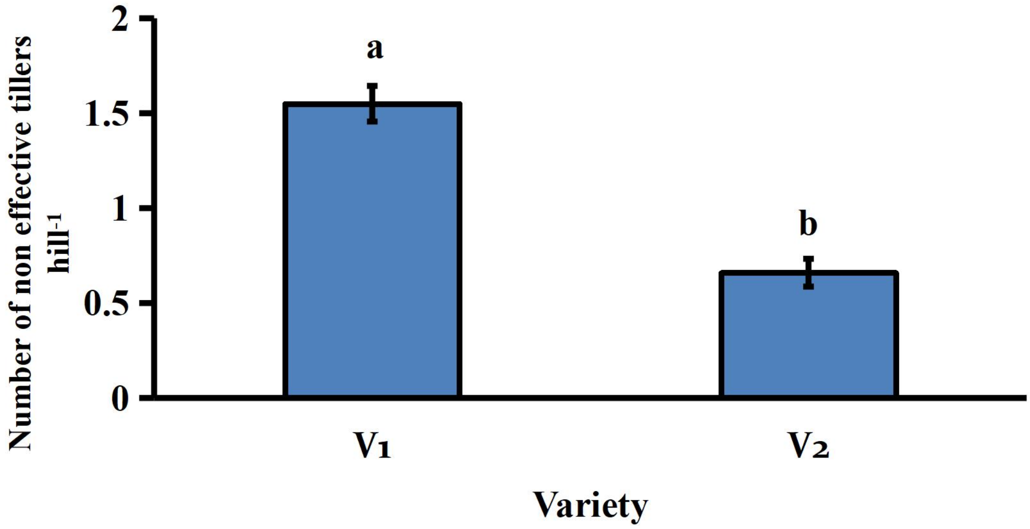
Here, W_0: Weedy check and W_1: Bispyribac - sodium WP @ 150 g ha^{-1}

Figure 37. Effect of weeds control treatment on number of non- effective tillers hill^{-1} of aromatic rice .(Bars represent±SD of values obtained from three biological replicates).

Effect of variety

Rice variety significantly effect on number of non effective tillers hill^{-1} of aromatic rice (Figure 38). Result revealed that cultivation of Kalizira rice variety recorded the maximum number of non effective tillers hill^{-1} (1.55) while cultivation of BRRI dhan37 rice variety recorded the minimum number of non effective tillers hill^{-1} (0.66).

The differences of non effective tillers hill^{-1} is the genetic makeup of the variety. The result obtained from the present study was similar with the findings ofAkter *et al.* (2020) who reported that non effective tillers hill^{-1} varied with different varieties and it is higher in local variety comparable to high yielding or hybrid varieties.

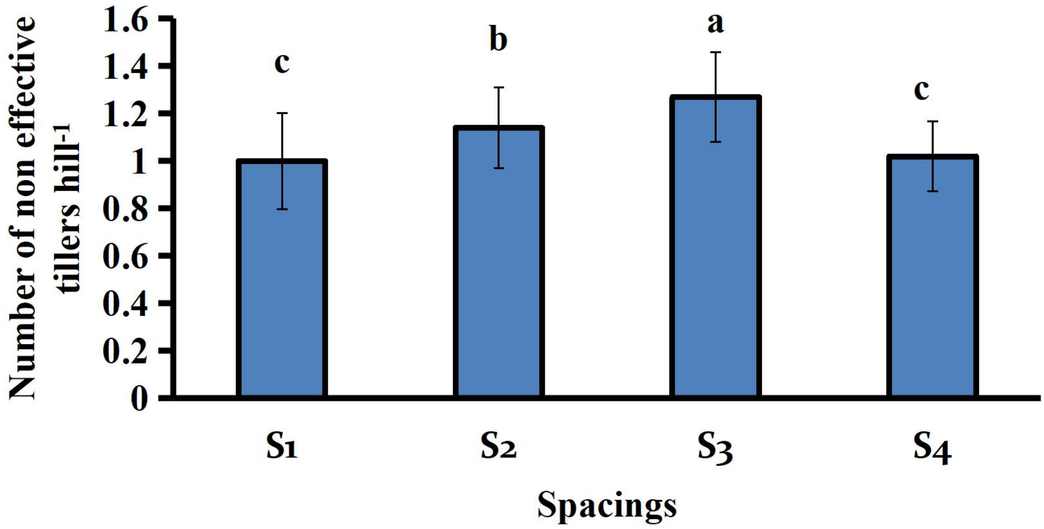


Here, V_1: Kalizira and V_2: BRRI dhan37

Figure 38. Effect of variety on number of non- effective tillers hill^{-1} of aromatic rice(Bars represent±SD of values obtained from three biological replicates).

Effect of spacings

Different spacing significantly affect on number of non effective tillers hill^{-1} of aromatic rice (Fig 39). Experiment result revealed that aromatic rice variety cultivated at 20 cm × 20 cm spacing recorded the maximum number of non effective tillers hill^{-1} (1.27) while aromatic rice variety cultivated at 20 cm × 15 cm spacing recorded the minimum number of non effective tillers hill^{-1} (1.00) which was statistically similar with aromatic rice variety cultivated at 25 cm × 25 cm spacing recorded non effective tillers hill^{-1} (1.02). Akondo and Hossain (2019) also found similar result with present study and reported that different spacing performed significantly differed yield contributing characters and the lowest number of non-effective tillers (0.80) per stand was recorded under 20 cm × 15 cm spacing. Moro *et al.* (2016) reported that growth attributes were significantly affected by spacing.



Here, S_1: 20 cm × 15 cm, S_2: 25 cm × 15 cm, S_3: 20 cm × 20 cm and S_4: 25 cm × 25 cm

Figure 39. Effect of spacings on number of non- effective tillers hill^{-1} of aromatic rice(Bars represent±SD of values obtained from three biological replicates).

Combined effect of Bispyribac-sodium and variety

Combined effect of weeds control and variety showed significant effect on number of non effective tillers hill^{-1} of aromatic rice (Table 31). Experiment result showed that weedy check plot along with Kalizira rice variety cultivation recorded the maximum number of non effective tillers hill^{-1} (1.94) while weedy check plot along with along with BRRI dhan37 rice variety cultivation recorded the minimum number of non effective tillers hill^{-1} (0.50).

Combined effect of Bispyribac-sodium and spacing

Combined effect of weeds control and spacings showed significant effect on number of non effective tillers hill^{-1} of aromatic rice (Table 32). Experiment result showed that Bispyribac - sodium WP @ 150 g ha^{-1} herbicide treated plot along with aromatic rice variety cultivated at 20 cm × 20 cm spacing recorded the maximum number of non effective tillers hill^{-1} (1.37) while Bispyribac - sodium WP @ 150 g ha^{-1} herbicide treated plot along with aromatic rice variety cultivated at 20 cm × 15 cm spacing recorded the minimum number of non effective tillers hill^{-1} (0.72).

Combined effect of variety and spacing

Different aromatic rice variety along with spacings showed significant effect on number of non effective tillers hill^{-1} of aromatic rice (Table 33). Experiment result showed that Kalizira rice variety cultivated at 25 cm × 15 cm spacing recorded the maximum number of non effective tillers hill^{-1} (1.67) which was statistically similar with Kalizira rice variety cultivated at 20 cm × 20 cm spacing recorded non effective tillers hill^{-1} (1.61) while BRRI dhan37 rice variety cultivated at 20 cm × 15 cm spacing recorded the minimum non effective tillers hill^{-1} (0.50).

Combined effect of Bispyribac-sodium , variety and spacing

Combination of different treatment showed significant effect on number of non effective tillers hill^{-1} of aromatic rice (Table 34). Experiment result showed that weedy check plot along with Kalizira rice variety cultivated at 20 cm × 15 cm spacing recorded the maximum number of non effective tillers hill^{-1} (2.11) while weedy check plot along plot along with BRRI dhan37 rice variety cultivated at 20 cm × 20 cm spacing recorded the minimum non effective tillers hill^{-1}(0.33).

Table 31. Combined effect of Bispyribac-sodium and variety on number of effective and non- effective tillers hill^{-1} of aromatic rice

Treatment Combinations	Effective tillers hill^{-1}No.	Non-effective tillers hill^{-1}No.
W_0V_1	14.93±1.25	1.94a±0.23
W_0V_2	15.33±1.63	0.50d±0.14
W_1V_1	13.69±1.77	1.16b±0.24
W_1V_2	16.55±1.91	0.83c±0.44
SE	0.30	0.01
CV(%)	4.87	4.52

Here:W_0: Weedy check and W_1: Bispyribac - sodium ; V_1: Kalizira and V_2: BRRI dhan37

Table32. Combined effect of weeds control and spacings on number of effective and non- effective tillers hill^{-1} of aromatic rice

Treatment Combinations	Effective tillers hill^{-1}	Non-effective tillers hill^{-1}
W_0S_1	16.25 ±1.53 a	1.28 ±0.92 b
W_0S_2	13.56 ±0.82 d	1.22 ±0.75 c
W_0S_3	15.22 ±0.97 bc	1.17 ±0.93 c
W_0S_4	15.49 ±0.93 ab	1.22 ±0.62 c
W_1S_1	13.56 ±0.88 d	0.72 ±0.19 g
W_1S_2	16.11 ±1.21 a	1.06 ±0.43 e
W_1S_3	14.61 ±3.58 c	1.37 ±0.22 a
W_1S_4	16.22 ±1.96 a	0.83 ±0.31 f
SE	0.39	0.02
CV(%)	4.48	3.72

Here:W_0: Weedy check and W_1: Bispyribac - sodium WP @ 150 g ha^{-1} ;S_1: 20 cm × 15 cm, S_2: 25 cm × 15 cm, S_3: 20 cm × 20 cm and S_4: 25 cm × 25 cm

Table 33. Combined effect of variety and spacings on number of effective and non- effective tillers hill^{-1} of aromatic rice

Treatment Combinations	Effective tillers hill^{-1}No.	Non-effective tillers hill^{-1}No.
V_1S_1	14.20 ±1.36 ef	1.50 ±0.69 b
V_1S_2	14.44 ±1.39 de	1.67 ±0.29 a
V_1S_3	13.50 ±2.39 f	1.61 ±0.46 a
V_1S_4	15.11 ±1.03 cd	1.44 ±0.39 b
V_2S_1	15.61 ±2.11 bc	0.50 ±0.08 e
V_2S_2	15.22 ±1.93 cd	0.61 ±0.09 d
V_2S_3	16.33 ±1.86 ab	0.93 ±0.67 c
V_2S_4	16.60 ±1.62 a	0.61 ±0.09 d
SE	0.39	0.02
CV(%)	4.48	3.72

Here:V_1: Kalizira and V_2: BRRI dhan37;S_1: 20 cm × 15 cm, S_2: 25 cm × 15 cm, S_3: 20 cm × 20 cm and S_4: 25 cm × 25 cm

Table 34. Combined effect of Bispyribac-sodium ,variety and spacings on number of effective and non- effective tillers hill^{-1} of aromatic rice

Treatment Combinations	Effective tillers hill^{-1}No.	Non-effective tillers hill^{-1} No.
$W_0V_1S_1$	15.17±1.01 b	2.11 ±0.23 a
$W_0V_1S_2$	13.44 ±0.89 e	1.89 ±0.21 c
$W_0V_1S_3$	15.56 ±1.04 b	2.00 ±0.22 b
$W_0V_1S_4$	15.56 ±1.04 b	1.77 ±0.2 d
$W_0V_2S_1$	17.33 ±1.16 a	0.45 ±0.05 l
$W_0V_2S_2$	13.67 ±0.91 de	0.55 ±0.06 k
$W_0V_2S_3$	14.89 ±0.99 bc	0.33 ±0.04 m
$W_0V_2S_4$	15.43 ±1.03 b	0.66 ±0.07 j
$W_1V_1S_1$	13.22 ±0.88 e	0.89 ±0.09 i
$W_1V_1S_2$	15.44 ±1.03 b	1.44 ±0.16 f
$W_1V_1S_3$	11.44 ±0.76 f	1.21 ±0.13 g
$W_1V_1S_4$	14.66 ±0.98 b-d	1.10 ±0.12 h
$W_1V_2S_1$	13.89 ±0.93 c-e	0.56 ±0.06 k
$W_1V_2S_2$	16.78 ±1.12 a	0.67±0.07 j
$W_1V_2S_3$	17.78 ±1.19 a	1.53 ±0.17 e
$W_1V_2S_4$	17.77 ±1.18 a	0.55 ±0.06 k
SE	0.55	0.03
CV(%)	4.48	3.72

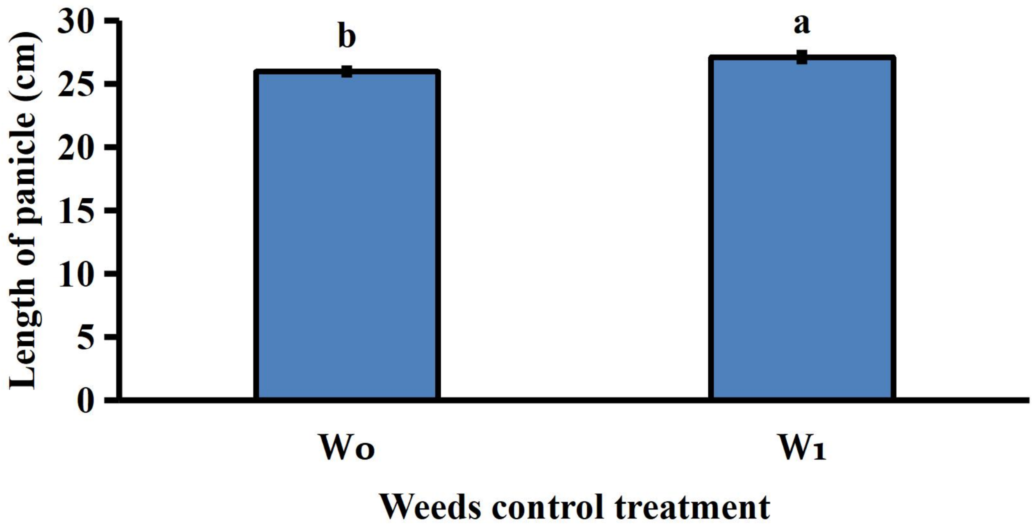
In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability.

Note viz:NS= Non- significant;Here:W_0: Weedy check and W_1: Bispyribac - sodium WP @ 150 g ha^{-1};V_1: Kalizira and V_2: BRRI dhan37;S_1: 20 cm × 15 cm, S_2: 25 cm × 15 cm, S_3: 20 cm × 20 cm and S_4: 25 cm × 25 cm

4.8.3 Length of panicle (cm)

Effect of Bispyribac-sodium

Panicle is an important yield contributing character as its bear grains and significantly influenced due to different weed control treatment (Figure 41). Result revealed that Bispyribac - sodium WP @ 150 g ha^{-1} herbicide treated plot recorded the maximum panicle length (27.12 cm) while weedy check plot recorded the minimum panicle length (25.98 cm). The variation of result due to the effectiveness of herbicide on weed diversity in crop field. Jabran *et al.* (2012) and Mahajan *et al.* (2003) from their study concluded that weed management through herbicide application resulted the highest panicle length comparable to weedy check (control).

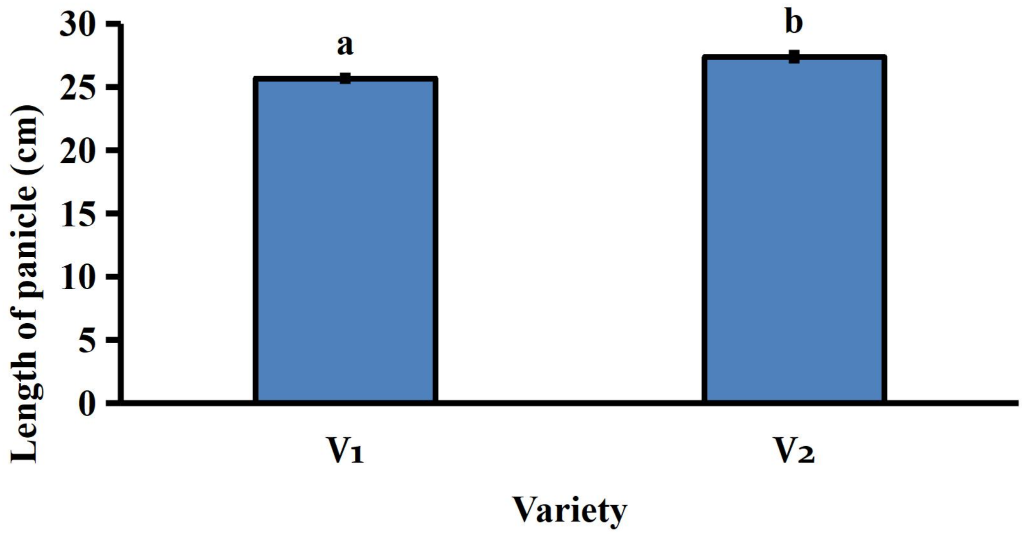


Here, W_0: Weedy check and W_1: Bispyribac - sodium WP @ 150 g ha^{-1}

Figure 40. Effect of Bispyribac-sodium on panicle length of aromatic rice Effect of variety (Bars represent±SD of values obtained from three biological replicates).

Panicle length is one aspect of panicle architecture and is usually measured as a yield-related trait. Panicle length, together with spikelet number and density, seed setting rate and grain plumpness, determines the grain number per panicle; hence, yield increases in rice. Experiment result revealed that different rice variety significantly influenced panicle length of aromatic rice (Figure 41). Result revealed that cultivation of BRRI dhan37 rice variety recorded the maximum panicle length (27.40 cm) while cultivation of Kalizira rice variety recorded the minimum panicle length (25.69 cm).

Different rice varieties have different panicle length due to the genetic makeup of the variety and higher panicle length is obtained from high yielding varieties comparable to low yielding rice varieties. Hossain *et al.* (2016); Chamely *et al.* (2015) and Diaz *et al.* (2000) found similar result which supported the present study and reported that panicle length varied among varieties.

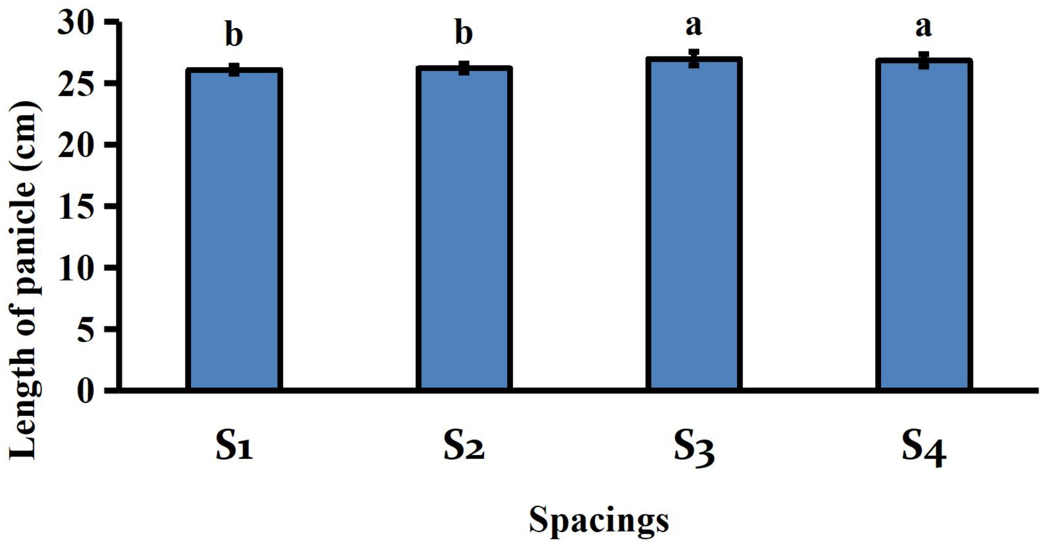


Here, V_1: Kalizira and V_2: BRRI dhan37

Figure 41. Effect of variety on panicle length of aromatic rice (Bars represent±SD of values obtained from three biological replicates).

Effect of spacings

Aromatic rice cultivated at different spacing showed significant effect (Figure 42). Result revealed that among different spacings aromatic rice cultivated at 20 cm × 20 cm spacing recorded the maximum panicle length (27.00 cm) which was statistically similar with aromatic rice cultivated at 25 cm × 25 cm spacing recorded panicle length (26.86 cm) while aromatic rice cultivated at 20 cm × 15 cm spacing recorded the minimum panicle length (26.10 cm) which was statistically similar with aromatic rice cultivated at 25 cm × 15 cm spacing recorded panicle length (26.23 cm). Ninad *et al*. (2017) also found similar result which supported the present finding and reported that closer spacing decreased panicle length.



Here, S_1: 20 cm × 15 cm, S_2: 25 cm × 15 cm, S_3: 20 cm × 20 cm and S_4: 25 cm × 25 cm

Figure 42. Effect of spacing on panicle length of aromatic rice (Bars represent±SD of values obtained from three biological replicates).

Combined effect of Bispyribac-sodium and variety.

Combined effect of weeds control and variety showed non significant effect on panicle length of aromatic rice (Table 35). Experiment result revealed that Bispyribac - sodium WP @ 150 g ha^{-1} herbicide treated plot along with BRRI dhan37 rice variety cultivation recorded the maximum panicle length (28.06 cm) while weedy check plot along with Kalizira rice variety cultivation recorded the minimum panicle length (25.21 cm).

Combined effect of Bispyribac-sodium and spacing

Combined effect of weeds control and spacings showed significant effect on panicle length of aromatic rice (Table 36). Experiment result showed that Bispyribac - sodium WP @ 150 g ha^{-1} herbicide treated plot along with aromatic rice variety cultivated at 20 cm × 20 cm spacing recorded the maximum panicle length (28.01) which was statistically similar with Bispyribac - sodium WP @ 150 g ha^{-1} herbicide treated plot along with aromatic rice variety cultivated at 25 cm × 25 cm spacing recorded panicle length (28.00) while weedy check plot along with aromatic rice variety cultivated at 25 cm × 25 cm spacing recorded the minimum panicle length (25.73).

Combined effect of variety and spacing

Different aromatic rice variety along with spacings showed significant effect on number of panicle length of aromatic rice (Table 37). Experiment result showed that BRRI dhan37 rice variety cultivated at 20 cm × 20 cm spacing recorded the maximum panicle length (28.24 cm) while Kalizira rice variety cultivated at 25 cm × 15 cm spacing recorded the minimum panicle length (25.42 cm) which was statistically similar with Kalizira rice variety cultivated at 20 cm ×15 cm spacing recorded panicle length (25.46 cm) and with Kalizira rice variety cultivated at 20 cm × 20 cm spacing recorded panicle length (25.76 cm).

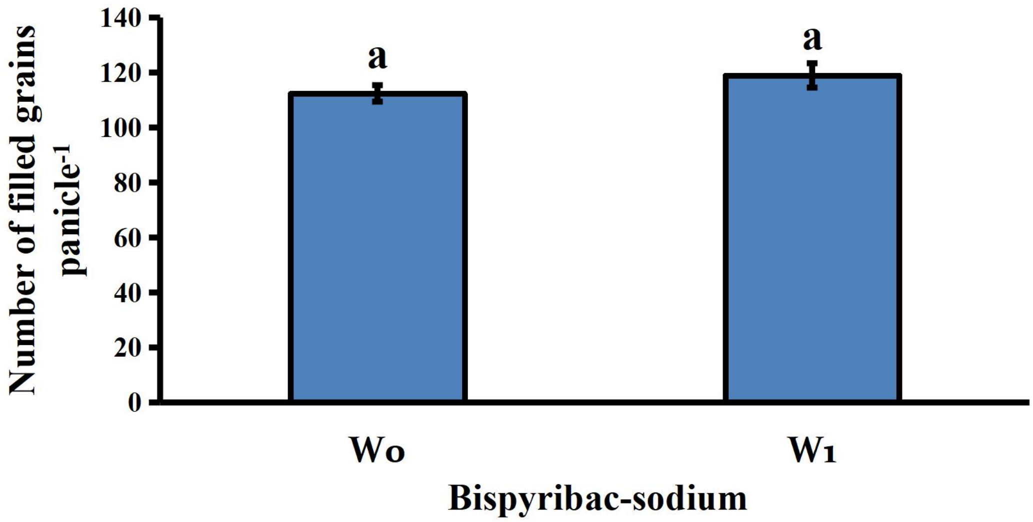
Combined effect of Bispyribac-sodium , variety and spacing

Combination of different treatment showed significant effect on panicle length of aromatic rice (Table 38). Experiment result showed that Bispyribac - sodium WP @ 150 g ha^{-1} herbicide treated plot along with BRRI dhan37 rice variety cultivated at 20 cm × 20 cm spacing recorded the maximum panicle length (29.57 cm) which was statistically similar with Bispyribac - sodium WP @ 150 g ha^{-1} herbicide treated plot along with BRRI dhan37 rice variety cultivated at 25 cm × 25 cm spacing recorded panicle length (29.14 cm) while weedy check plot along plot along with Kalizira rice variety cultivated at 25 cm × 15 cm spacing recorded the minimum panicle length (25.02 cm) which was statistically similar with weedy check plot along plot along with Kalizira rice variety cultivated at 25 cm × 15 cm spacing recorded panicle length (25.07 cm), with weedy check plot along plot along with Kalizira rice variety cultivated at 20 cm × 15 cm spacing recorded panicle length (25.37 cm), with weedy check plot along plot along with Kalizira rice variety cultivated at 25 cm × 25 cm spacing recorded panicle length (25.39 cm), with Bispyribac - sodium WP @ 150 g ha^{-1} herbicide treated plot along with Kalizira rice variety cultivated at 20 cm × 15 cm spacing recorded panicle length (25.56 cm) and with Bispyribac - sodium WP @ 150 g ha^{-1} herbicide treated plot along with Kalizira rice variety cultivated at 25 cm × 15 cm spacing recorded panicle length (25.83 cm).

4.8.4 Number of filled grains $panicle^{-1}$

Effect of Bispyribac-sodium

Weed control treatment had no significant effect on number of filled grains panicle^{-1} of aromatic rice (Figure 44). Result showed that Bispyribac - sodium WP @ 150 g ha^{-1} herbicide treatedplotrecorded the maximum number of filled grains panicle^{-1} (118.95) while weedy check plot recorded the minimum number of filled grains panicle^{-1} (112.41).



Here, W_0: Weedy check and W_1: Bispyribac - sodium WP @ 150 g ha^{-1}

Figure 43. Effect of Bispyribac-sodium treatment on filled grains panicle^{1} of aromatic rice (Bars represent±SD of values obtained from three biological replicates).

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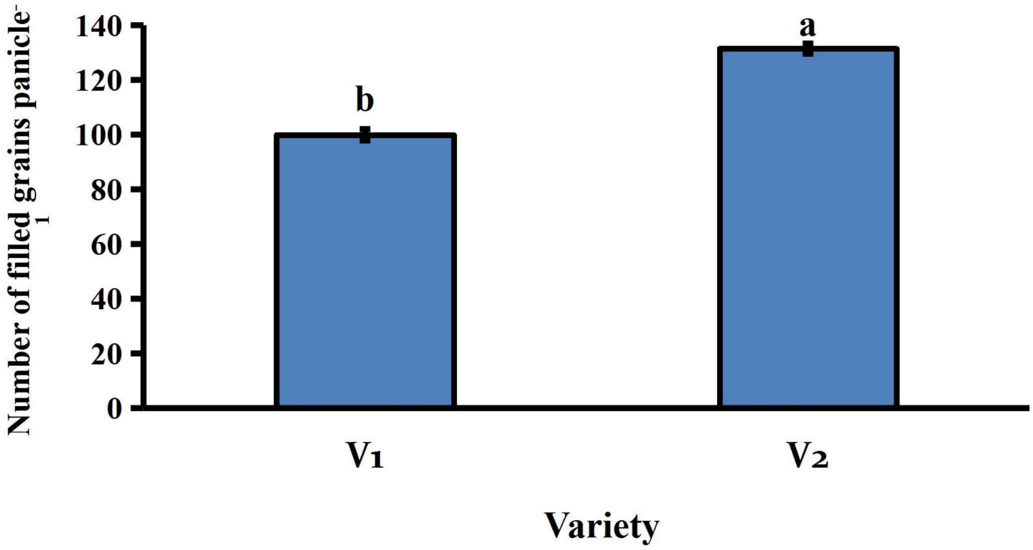
Effect of variety

It is clear from the experiment data that different rice variety significantly influenced number of filled grains panicle^{-1} of aromatic rice (Figure 44). Result showed that among different rice varieties cultivation of BRRI dhan37 rice variety recorded the maximum number of filled grains panicle^{-1} (131.44) while cultivation of Kalizira rice variety recorded the minimum number of filled grains panicle^{-1} (99.92). The result obtained from the present study was similar with the findings of Akondo *et al.* (2020) who reported that variation in grain filling may have occurred due to genetic, environmental or cultural management practices adopted. Sarkar (2014) and Mahamud *et al.* (2013) also concluded from their study that the variation in filled grains panicle^{-1} was recorded due to genotypic differences of varieties.

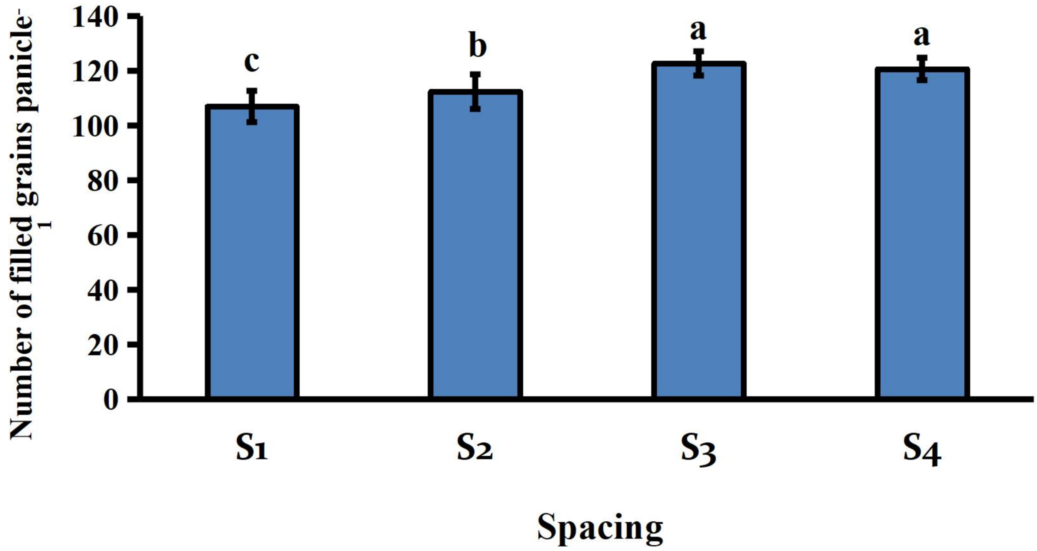


Here, V_1: Kalizira and V_2: BRRI dhan37

Figure 44. Effect of variety on filled grains panicle^{-1} of aromatic rice (Bars represent±SD of values obtained from three biological replicates).

Effect of spacings.

Different spacing significantly affect on filled grains panicle^{-1}of aromatic rice (Figure 46). Experiment result revealed that aromatic rice variety cultivated at 20 cm × 20 cm spacing recorded the maximum filled grains panicle^{-1} (122.69) which was statistically similar with aromatic rice variety cultivated at 25 cm × 25 cm spacing recorded filled grains panicle^{-1} (120.68) while aromatic rice variety cultivated at 20 cm × 15 cm spacing recorded the minimum filled grains panicle^{-1} (106.97).The result obtained from the present study was similar with the findings of Rajesh and Thanunathan (2003) and they reported that the use of wider spacing led to lesser below and above ground competition for better grain filling, higher grain weight and more number of filled grains panicle^{-1}.



Here, S_1: 20 cm × 15 cm, S_2: 25 cm × 15 cm, S_3: 20 cm × 20 cm and S_4: 25 cm × 25 cm

Figure 45. Effect of spacings on filled grains panicle^{-1} of aromatic rice Combined effect of weeds control and variety(Bars represent±SD of values obtained from three biological replicates).

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Combined effect of weeds control and variety showed significant effect on filled grains panicle^{-1} of aromatic rice (Table 35). Experiment result revealed that Bispyribac - sodium WP @ 150 g ha^{-1} herbicide treated plot along with BRRI dhan37 rice variety cultivation recorded the maximum filled grains panicle^{-1}(138.33) while Bispyribac - sodium WP @ 150 g ha^{-1} herbicide treated plot along with Kalizira rice variety cultivation recorded the minimum filled grains panicle^{-1}(99.57) which was statistically similar with weedy check plot along with Kalizira rice variety cultivation recorded filled grains panicle^{-1}(100.26).

Combined effect of Bispyribac-sodium and spacing

Combined effect of weeds control and spacings showed non significant effect on filled grains panicle^{-1} of aromatic rice (Table 36). Experiment result showed that Bispyribac - sodium WP @ 150 g ha^{-1} herbicide treated plot along with aromatic rice variety cultivated at 20 cm × 20 cm spacing recorded the maximum filled grains panicle^{-1} (127.87) while weedy check plot along with aromatic rice variety cultivated at 20 cm × 15 cm spacing recorded the minimum filled grains panicle^{-1} (106.36).

Combined effect of variety and spacing

Different aromatic rice variety along with spacings showed significant effect filled grains panicle^{-1} of aromatic rice (Table 37). Experiment result showed that BRRI dhan37 rice variety cultivated at 20 cm × 20 cm spacing recorded the maximum filled grains panicle^{-1} (135.50) which was statistically similar with BRRI dhan37 rice variety cultivated at 25 cm × 15 cm spacing recorded filled grains panicle^{-1} (132.32) and with BRRI dhan37 rice variety cultivated at 25 cm × 25 cm spacing recorded filled grains panicle^{-1} (132.18) while Kalizira rice variety cultivated at 20 cm × 15 cm spacing recorded the minimum filled grains panicle^{-1} (88.17) which was statistically similar with Kalizira rice variety cultivated at 25 cm ×15 cm spacing recorded filled grains panicle^{-1} (92.44).

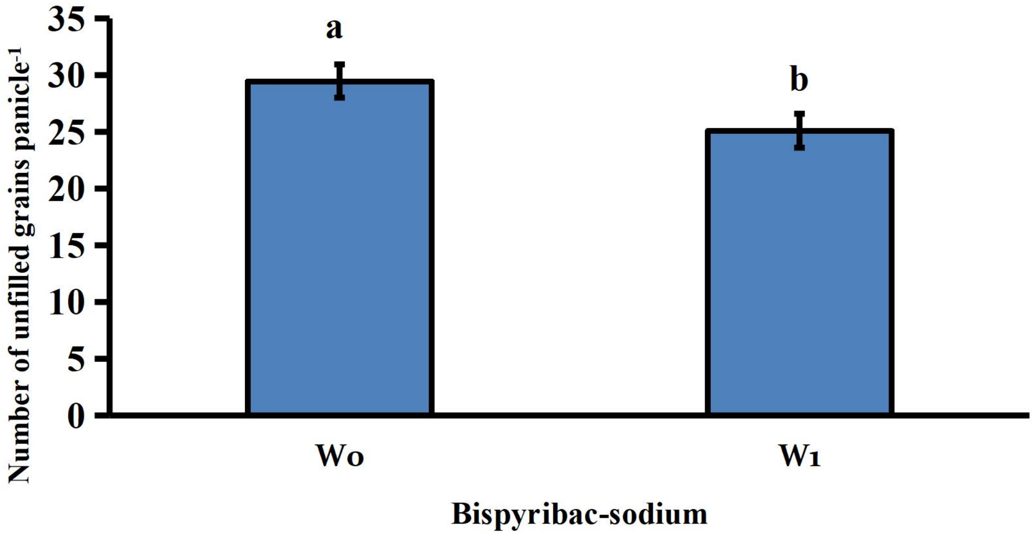
Combined effect of Bispyribac-sodium , variety and spacing

Combination of different treatment showed significant effect on filled grains panicle^{-1} of aromatic rice (Table 38). Experiment result showed that Bispyribac - sodium WP @ 150 g ha^{-1} herbicide treated plot along with BRRI dhan37 rice variety cultivated at 20 cm × 20 cm spacing recorded the maximum filled grains panicle^{-1} (144.89) while weedy check plot along plot along with Kalizira rice variety cultivated at 20 cm × 15 cm spacing recorded the minimum filled grains panicle^{-1} (87.61).

4.8.5 Number of unfilled grains panicle^{-1}

Effect of Bispyribac-sodium

Among the undesirable traits, number of unfilled grains panicle^{-1} was important one and played a vital role in yield reduction. Different weed control treatment significantly influenced number of unfilled grains panicle^{-1} of aromatic rice (Figure 47). Result showed that weedy checkplotrecorded the maximum number of unfilled grains panicle^{-1} (29.48) while Bispyribac - sodium WP @ 150 g ha^{-1} herbicide treated plot recorded the minimum number of unfilled grains panicle^{-1} (25.10). Weeds control through herbicide application reduced weed density and increasing better resources utilization of the plant growth and development which increasing filled grains and reduced unfilled grains panicle^{-1} comparable to weedy check treatment.

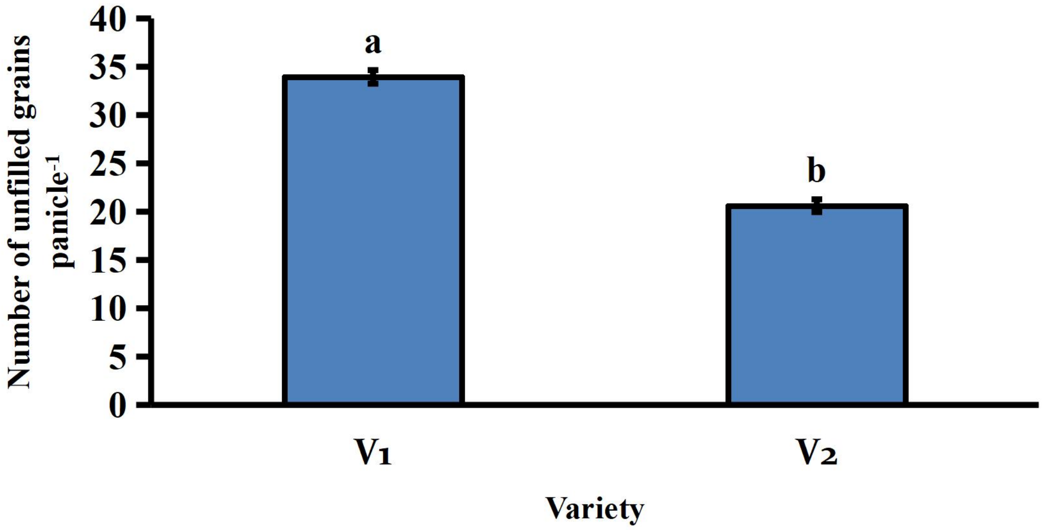


Here, W_0: Weedy check and W_1: Bispyribac - sodium WP @ 150 g ha^{-1}

Figure 46. Effect of Bispyribac-sodium on unfilled grains panicle^{-1} of aromatic rice(Bars represent±SD of values obtained from three biological replicates).

Effect of variety

Different rice variety showed significant effect on number of unfilled grains panicle^{-1} (Figure 47). Experiment result revealed that the maximum number of unfilled grains panicle^{-1} (33.95) was recorded in Kalizira rice variety cultivation while the minimum number of unfilled grains panicle^{-1} (20.62) was recorded in BRRI dhan37 rice variety cultivation. Similar result also found by Nahida *et al.* (2013) and reported that variation in number of unfilled grains panicle^{-1} might be due to genetic characteristics of the varieties.Sohel *et al. (*2009) also reported that difference in spikelets sterility varied significantly by variety and plant spacing.



Here, V_1: Kalizira and V_2: BRRI dhan37

Figure 47. Effect of variety on unfilled grains panicle^{-1} of aromatic rice Effect of spacing(Bars represent±SD of values obtained from three biological replicates).

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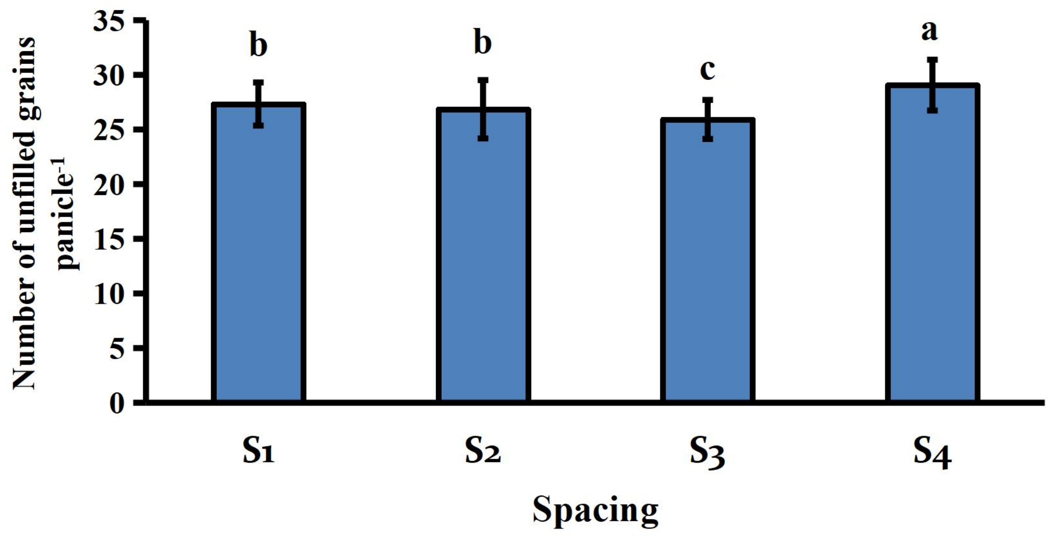
Different spacing significantly affect on unfilled grains panicle^{-1}of aromatic rice (Fig 49). Experiment result revealed that aromatic rice variety cultivated at 25 cm × 25 cm spacing recorded the maximum unfilled grains panicle^{-1} (29.06) while aromatic rice variety cultivated at 20 cm × 20 cm spacing recorded the minimum unfilled grains panicle^{-1} (25.92). Appropriate spacing helps plant growth and development while wider spacing influences weed growth which ultimately competitive with plant for nutrients, due to that reasons wider spacing recorded maximum unfilled grains panicle^{-1}.



Here, S_1: 20 cm × 15 cm, S_2: 25 cm × 15 cm, S_3: 20 cm × 20 cm and S_4: 25 cm × 25 cm

Figure 48. Effect of spacing on unfilled grains panicle^{-1} of aromatic rice (Bars represent±SD of values obtained from three biological replicates).

Combined effect of Bispyribac-sodium and variety.

Combined effect of weeds control and variety showed non significant effect on unfilled grains panicle^{-1} of aromatic rice (Table 35). Experiment result revealed that weedy check plot along with Kalizira rice variety cultivation recorded the maximum unfilled grains panicle^{-1}(35.80) while Bispyribac - sodium WP @ 150 g ha^{-1} herbicide treated plot along with BRRI dhan37 rice variety cultivation recorded the minimum unfilled grains panicle^{-1}(18.09).

Combined effect of Bispyribac-sodium and spacing

Combined effect of weeds control and spacings showed significant effect on unfilled grains panicle^{-1} of aromatic rice (Table 36). Experiment result showed that weedy check plot along with aromatic rice variety cultivated at 25 cm × 25 cm spacing recorded the maximum unfilled grains panicle^{-1} (32.11) while Bispyribac - sodium WP @ 150 g ha^{-1} herbicide treated plot along with aromatic rice variety cultivated at 20 cm × 20 cm spacing recorded the minimum unfilled grains panicle^{-1} (23.67).

Combined effect of variety and spacing

Different aromatic rice variety along with spacings showed significant effect unfilled grains panicle^{-1} of aromatic rice (Table 37). Experiment result showed that Kalizira rice variety cultivated at 25 cm × 25 cm spacing recorded the maximum unfilled grains panicle^{-1} (36.04) which was statistically similar with Kalizira rice variety cultivated at 25 cm × 15 cm spacing recorded unfilled grains panicle^{-1} (35.27) while BRRI dhan37 rice variety cultivated at 20 cm × 15 cm spacing recorded the minimum unfilled grains panicle^{-1} (18.43)

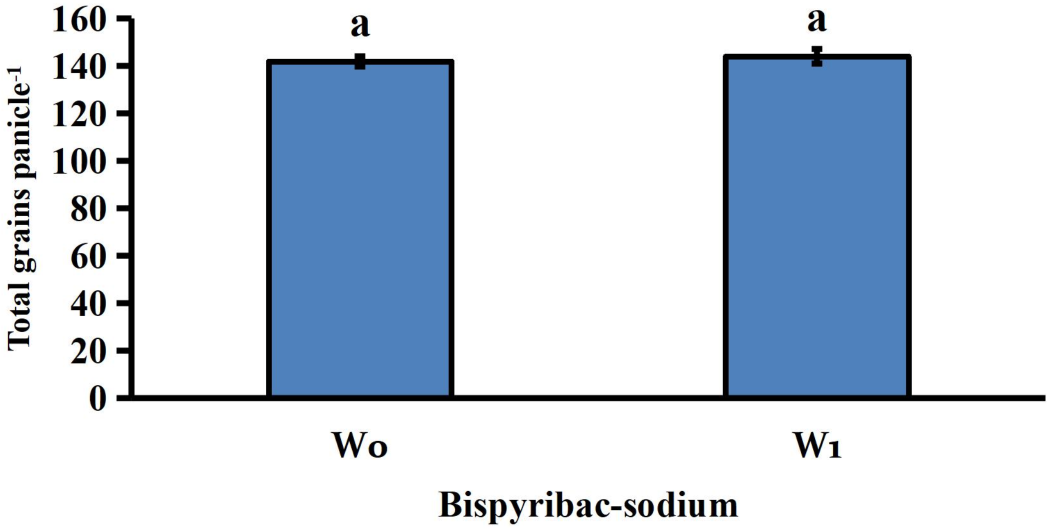
Combined effect of Bispyribac-sodium , variety and spacing

Combination of different treatment showed significant effect on ubfilled grains panicle^{-1} of aromatic rice (Table 38). Experiment result showed that weedy check plot along with Kalizira rice variety cultivated at 25 cm × 25 cm spacing recorded the maximum unfilled grains panicle^{-1} (39.39) which was statistically similar with weedy check plot along with Kalizira rice variety cultivated at 25 cm × 15 cm spacing recorded unfilled grains panicle^{-1} (38.71) while Bispyribac - sodium WP @ 150 g ha^{-1} herbicide treated plot along with BRRI dhan37 rice variety cultivated at 20 cm × 20 cm spacing recorded the minimum unfilled grains panicle^{-1} (17.33) which was statistically similar with Bispyribac - sodium WP @ 150 g ha^{-1} herbicide treated plot along with BRRI dhan37 rice variety cultivated at 25 cm × 15 cm spacing recorded unfilled grains panicle^{-1} (17.68) and with Bispyribac - sodium WP @ 150 g ha^{-1} herbicide treated plot along with BRRI dhan37 rice variety cultivated at 20 cm × 15 cm spacing recorded unfilled grains panicle^{-1} (17.99).

4.8.6 Total grains panicle^{-1}

Effect of weed control treatment

Weed control treatment had non significant effect on Total grains panicle^{-1} of aromatic rice (Figure 49). Experiment result revealed that Bispyribac - sodium WP @ 150 g ha^{-1} herbicide treated plot recorded the maximum number of total grains panicle^{-1} (144.05) while weedy check plot recorded the minimum number of total grains panicle^{-1} (141.88).

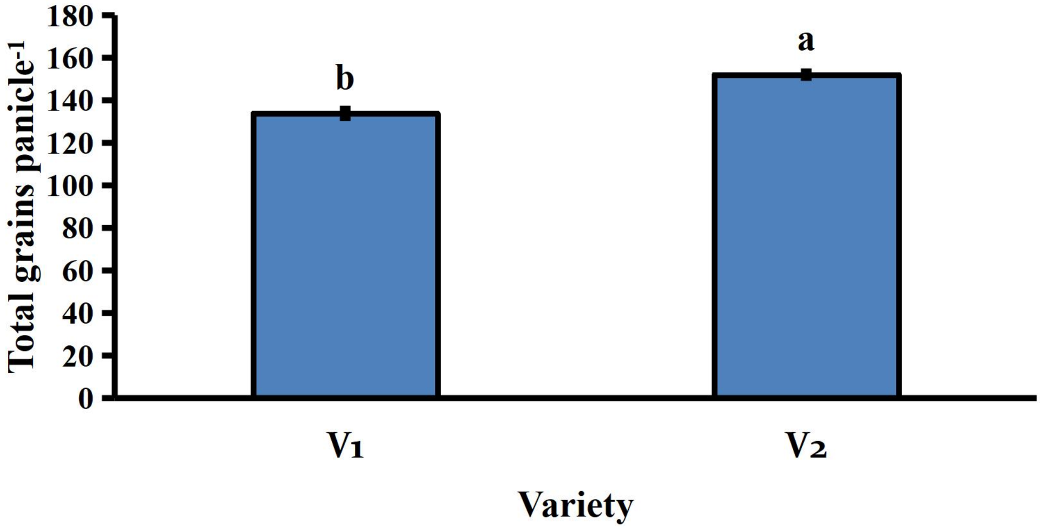


Here, W_0: Weedy check and W_1: Bispyribac - sodium WP @ 150 g ha^{-1}

Figure 49.Effect of Bispyribac-sodium on total grains panicle of aromatic rice(Bars represent±SD of values obtained from three biological replicates).

Effect of variety

It is clear from the experiment data that different rice variety significantly influenced on total grains $panicle^{-1}$ of aromatic rice (Figure 50). Result showed that among different rice varieties cultivation of BRRI dhan37 rice variety recorded the maximum total grains $panicle^{-1}$ (152.06) while cultivation of Kalizira rice variety recorded the minimum total grains $panicle^{-1}$ (133.87). Similar result also observed by Jisan *et al.* (2014) who reported that total grains $panicle^{-1}$ significantly differ among different rice varieties. Roy *et al.* (2014) also reported that the number of spikelets per panicle in indigenous rice is generally lower compared to high yielding varieties.

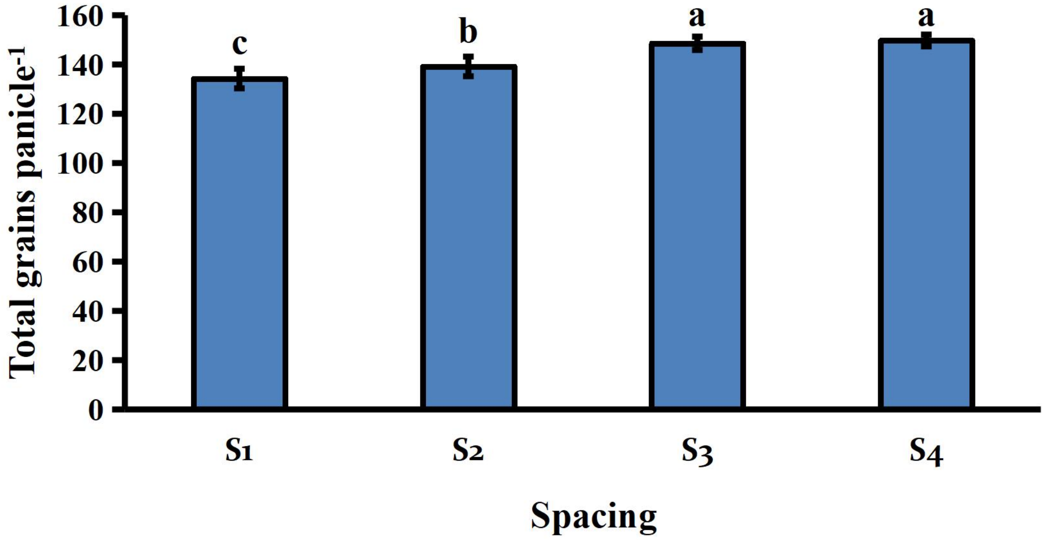


Here, V_1: Kalizira and V_2: BRRI dhan37

Figure 50. Effect of variety on total grains panicle^{-1} of aromatic rice (Bars represent±SD of values obtained from three biological replicates).

Effect of spacing.

Different spacing significantly affect on total grains panicle^{-1}of aromatic rice (Figure 51). Experiment result revealed that aromatic rice variety cultivated at 25 cm × 25 cm spacing recorded the maximum total grains panicle^{-1} (149.74) which was statistically similar with aromatic rice variety cultivated at 20 cm × 20 cm spacing recorded total grains panicle^{-1} (148.61) while aromatic rice variety cultivated at 20 cm × 15 cm spacing recorded the minimum total grains panicle^{-1} (134.30).The result obtained from the present study was similar with the findings of Ninad *et al*. (2017) who reported that the highest number of grains panicle^{-1} (128.79) was observed in 20 cm × 25 cm spacing while lowest number of grains panicle^{-1} (104.17) in 20 cm × 10 cm spacing. Reduction in the number of grains panicle^{-1} under closer spacing might be due to increased number of plants per unit area. This increased number of plants per unit area exerted competition among plants for nutrients and light that might have caused lower crop growth rate with consequently a reduction in the number of filled grains panicle^{-1}.



Here, S_1: 20 cm × 15 cm, S_2: 25 cm × 15 cm, S_3: 20 cm × 20 cm and S_4: 25 cm × 25 cm

Figure 51. Effect of spacings on total grains panicle^{-1} of aromatic rice (Bars represent±SD of values obtained from three biological replicates).

Combined effect of Bispyribac-sodium and variety.

Combined effect of weeds control and variety showed significant effect on total grains panicle^{-1} of aromatic rice (Table 35). Experiment result revealed that Bispyribac - sodium WP @ 150 g ha^{-1} herbicide treated plot along with BRRI dhan37 rice variety cultivation recorded the maximum total grains panicle^{-1}(156.41) while Bispyribac - sodium WP @ 150 g ha^{-1} herbicide treated plot along with Kalizira rice variety cultivation recorded the minimum total grains panicle^{-1}(131.68).

Combined effect of Bispyribac-sodium and spacing

Combined effect of weeds control and spacings showed non significant effect on total grains panicle^{-1} of aromatic rice (Table 36). Experiment result showed that Bispyribac - sodium WP @ 150 g ha^{-1} herbicide treated plot along with aromatic rice variety cultivated at 20 cm × 20 cm spacing recorded the maximum toatl grains panicle^{-1} (151.53) while Bispyribac - sodium WP @ 150 g ha^{-1} herbicide treated plot along with aromatic rice variety cultivated at 20 cm × 15 cm spacing recorded the minimum total grains panicle^{-1} (133.54).

Combined effect of variety and spacing

Different aromatic rice variety along with spacings showed significant effect total grains panicle^{-1} of aromatic rice (Table 37). Experiment result showed that BRRI dhan37 rice variety cultivated at 20 cm × 20 cm spacing recorded the maximum total grains panicle^{-1} (156.13) which was statistically similar with BRRI dhan37 rice variety cultivated at 25 cm × 25 cm spacing recorded total grains panicle^{-1} (154.25) and with BRRI dhan37 rice variety cultivated at 25 cm × 15 cm spacing recorded total grains panicle^{-1} (150.75) while Kalizira rice variety cultivated at 20 cm × 15 cm spacing recorded the minimum total grains panicle^{-1} (121.48).

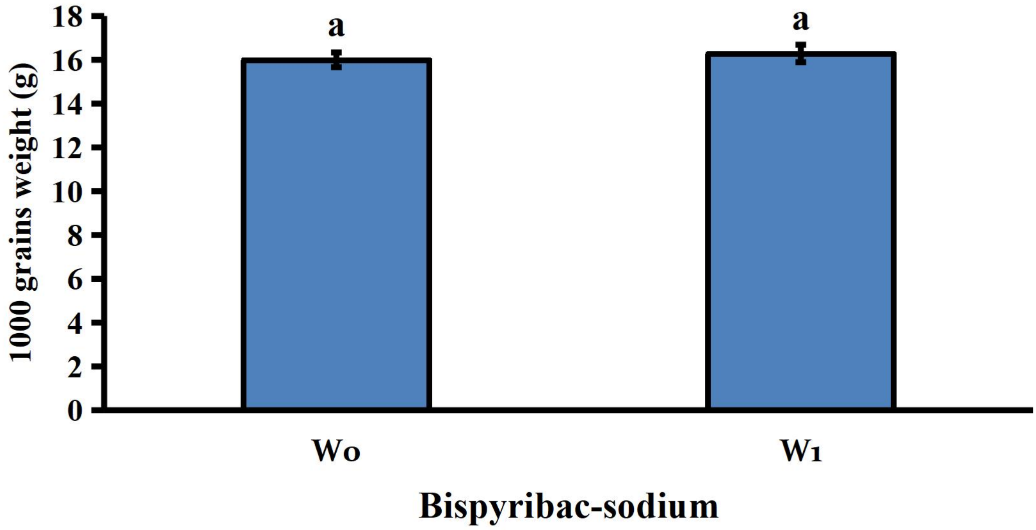
Combined effect of Bispyribac-sodium , variety and spacing

Combination of different treatment showed significant effect on total grains panicle^{-1} of aromatic rice (Table 38). Experiment result showed that Bispyribac - sodium WP @ 150 g ha^{-1} herbicide treated plot along with BRRI dhan37 rice variety cultivated at 20 cm × 20 cm spacing recorded the maximum total grains panicle^{-1} (162.22) which was statistically similar Bispyribac - sodium WP @ 150 g ha^{-1} herbicide treated plot along with BRRI dhan37 rice variety cultivated at 25 cm × 25 cm spacing recorded total grains panicle^{-1} (160.77) and with Bispyribac - sodium WP @ 150 g ha^{-1} herbicide treated plot along with BRRI dhan37 rice variety cultivated at 25 cm × 15 cm spacing recorded total grains panicle^{-1} (158.24) while weedy check plot along plot along with Kalizira rice variety cultivated at 20 cm × 15 cm spacing recorded the minimum total grains panicle^{-1} (120.30) which was statistically similar Bispyribac - sodium WP @ 150 g ha^{-1} herbicide treated plot along with Kalizira rice variety cultivated at 20 cm × 15 cm spacing recorded total grains panicle^{-1} (122.66) and with Bispyribac - sodium WP @ 150 g ha^{-1} herbicide treated plot along with Kalizira rice variety cultivated at 25 cm × 15 cm spacing recorded total grains panicle^{-1} (123.64)

4.8.7 1000-grains weight (g)

Effect of Bispyribac-sodium

Weed control treatment had non significant effect on 1000 grains weight of aromatic rice (Figure 53). Experiment result revealed that Bispyribac - sodium WP @ 150 g ha^{-1} herbicide treated plot recorded the maximum 1000 grains weight (16.29 g) while weedy check plot recorded the minimum 1000 grains weight (16.00 g).

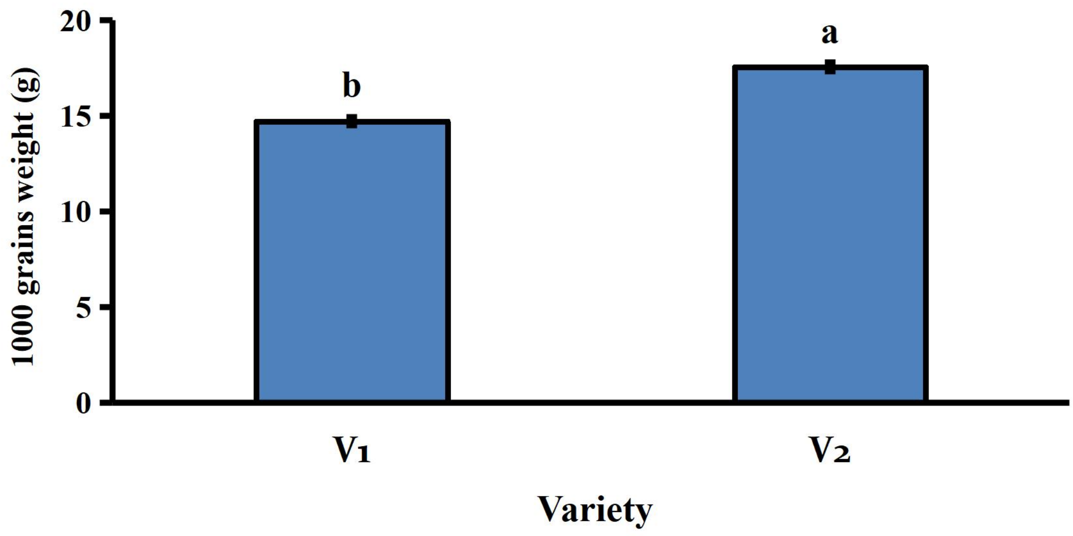


Here, W_0: Weedy check and W_1: Bispyribac - sodium WP @ 150 g ha^{-1}

Figure 52. Effect of Bispyribac-sodium on 1000 grains weight (g) of aromatic rice (Bars represent±SD of values obtained from three biological replicates).

Effect of variety

Different rice variety significantly effect on 1000 grains weight of rice (Figure 53). Experiment result revealed that the maximum 1000 grains weight (17.57 g) was recorded in BRRI dhan37 rice variety cultivation while the minimum 1000 grains weight (14.72 g) was recorded in Kalizira rice variety cultivation. The differences of the 1000 grains weight among different rice varieties may be attributes to the varietal performance and genetic makeup of the varieties. Khatun *et al.* (2020); Roy *et al.* (2014) and Aminpanah *et al.* (2013) found similar result which supported the present study and reported that different rice varieties showed different 1000 grains weight which is due to morphological and varietal variation.

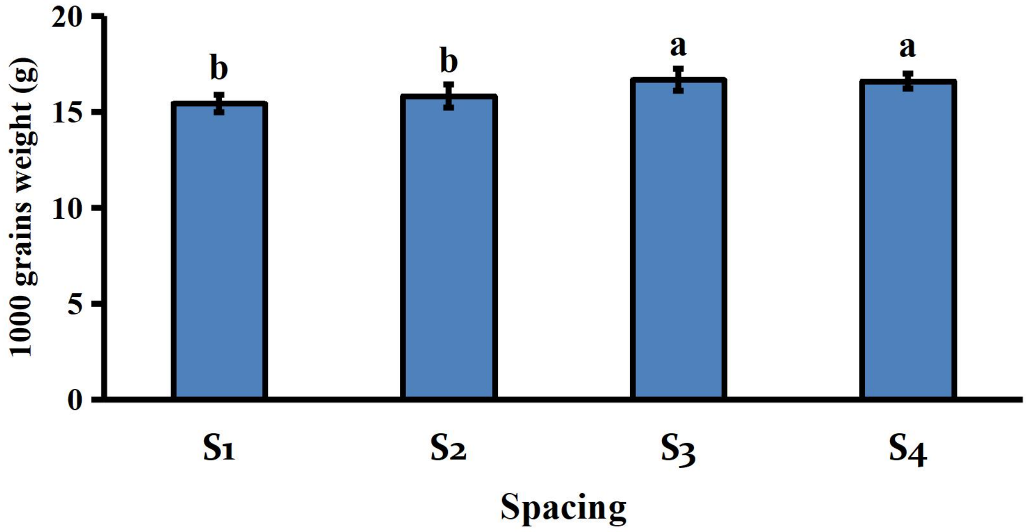


Here, V_1: Kalizira and V_2: BRRI dhan37

Figure 53. Effect of variety on 1000 grains weight (g) of aromatic rice (Bars represent±SD of values obtained from three biological replicates).

Effect of spacing.

Different spacings significantly effect on 1000 grains weight of aromatic rice (Figure 54). Result showed that aromatic rice cultivated at 20 cm × 20 cm spacing recorded the maximum 1000 grains weight (16.68 g) which was statistically similar with aromatic rice cultivated at 25 cm × 25 cm spacing recorded1000 grains weight (16.61 g) while aromatic rice cultivated at 20 cm × 15 cm spacing recorded the minimum 1000 grains weight (15.44 g) which was statistically similar with aromatic rice cultivated at 25 cm × 15 cm spacing recorded1000 grains weight (15.83 g). The result obtained from the present study was similar with the findings of Anwari *et al.* (2019) and reported that 1000 grains weight was significantly affected by spacing The results indicated that with the increase in spacing the thousand grains weight also increased significantly. Higher plant density was noted in narrow spacing than other spacing and this higher plant density was accompanied by strong intra and inter-row competition that might have caused the decrease in 1000 grains weight. Biswas *et al.* (2015) reported that highest thousand-grain weight was obtained in wider spacing than narrow spacing.



Here, S_1: 20 cm × 15 cm, S_2: 25 cm × 15 cm, S_3: 20 cm × 20 cm and S_4: 25 cm × 25 cm

Figure 54. Effect of spacings on 1000 grains weight (g) of aromatic rice(Bars represent±SD of values obtained from three biological replicates).

Combined effect of Bispyribac-sodium and variety.

Combined effect of weeds control and variety showed non significant effect on 1000 grains weight of aromatic rice (Table 35). Experiment result revealed that Bispyribac - sodium WP @ 150 g ha^{-1} herbicide treated plot along with BRRI dhan37 rice variety cultivation recorded the maximum 1000 grains weight (17.80 g) while weedy check plot along with Kalizira rice variety cultivation recorded the minimum 1000 grains weight (14.67 g).

Combined effect of Bispyribac-sodium and spacing

Combined effect of weeds control and spacings showed non significant effect on 1000 grains weight of aromatic rice (Table 36). Experiment result showed that Bispyribac - sodium WP @ 150 g ha^{-1} herbicide treated plot along with aromatic rice variety cultivated at 20 cm × 20 cm spacing recorded the maximum 1000 grains weight (17.30 g) while weedy check plot along with aromatic rice variety cultivated at 20 cm × 15 cm spacing recorded the 1000 grains weight (15.33).

Combined effect of variety and spacing

Different aromatic rice variety along with spacings showed significant effect on 1000 grains weight of aromatic rice (Table 37). Experiment result showed that BRRI dhan37 rice variety cultivated at 20 cm × 20 cm spacing recorded the maximum 1000 grains weight (17.58 g) which was statistically similar with BRRI dhan37 rice variety cultivated at 25 cm × 15 cm spacing recorded 1000 grains weight (17.66 g) and with BRRI dhan37 rice variety cultivated at 25 cm × 25 cm spacing recorded 1000 grains weight (17.58) while Kalizira rice variety cultivated at 25 cm × 15 cm spacing recorded the minimum 1000 grains weight (14.00 g) which was statistically similar with Kalizira rice variety cultivated at 25 cm × 15 cm spacing recorded 1000 grains weight (14.17 g).

Combined effect of Bispyribac-sodium, variety and spacing

Combination of different treatment showed non significant effect on 1000 grains weight of aromatic rice (Table 38). Experiment result showed that Bispyribac - sodium WP @ 150 g ha^{-1} herbicide treated plot along with BRRI dhan37 rice variety cultivated at 20 cm × 20 cm spacing recorded the maximum 1000 grains weight (19.10) while Bispyribac - sodium WP @ 150 g ha^{-1} herbicide treated plot along with Kalizira rice variety cultivated at 25 cm × 15 cm spacing recorded the minimum 1000 grains weight (13.67 g).

Table 35. Combined effect of Bispyribac-sodium and variety on panicle length (cm), filled, unfilled, total grains panicle^{-1} and 1000 grains weight (g),aromatic rice

Treatment Combinations	Panicle length (cm)	Filled grains panicle^{-1}	Unfilled grains panicle^{-1}	Total grains panicle^{-1}	1000 grains weight (g)
W_0V_1	25.21± 0.85	100.26 ± 10.82 c	35.80± 3.68	136.06 ± 12.05 c	14.67± 0.85
W_0V_2	26.74± 0.97	124.56 ± 2.93 b	23.15± 2.59	147.71 ± 3.74 b	17.32± 1.06
W_1V_1	26.17± 1.01	99.57 ± 10.11 c	32.11± 1.94	131.68 ± 9.19 d	14.77± 1.25
W_1V_2	28.06± 1.65	138.33 ± 7.93 a	18.09± 1.06	156.41 ± 7.81 a	17.80± 1.21
SE	0.28	1.95	0.43	2.32	0.28
CV(%)	2.67	3.10	3.17	2.38	4.29

Here:W_0: Weedy check and W_1: Bispyribac - sodium WP @ 150 g ha^{-1} ; V_1: Kalizira and V_2: BRRI dhan37

Table 36. Combined effect of Bispyribac-sodium and spacings on panicle length (cm),filled, unfilled, total grains panicle^{-1} and 1000 grains weight (g) of aromatic rice

Treatment Combinations	Panicle length (cm)	Filled grains panicle^{-1}	Unfilled grains panicle^{-1}	Total grains panicle^{-1}	1000 grains weight (g)
W_0S_1	26.16 ± 1.25 b	106.36± 20.68	28.69 ± 4.54 b	135.05± 16.33	15.33± 1.36
W_0S_2	26.04± 1.42 b	108.57± 17.17	28.94 ± 10.78 b	137.51± 6.72	16.00± 2.01
W_0S_3	25.99 ± 1.35 b	117.51± 9.78	28.17 ± 4.78 b	145.68± 5.39	16.07± 1.75
W_0S_4	25.73 ± 0.96 c	117.19± 6.79	32.11 ± 8.1 a	149.30± 3.09	16.58± 1.62
W_1S_1	26.05 ± 1.04 b	107.58± 20.79	25.96 ± 8.8 c	133.54± 12.14	15.55± 1.89
W_1S_2	26.42 ± 1.12 b	116.19± 26.82	24.75 ± 7.81 d	140.94± 19.11	15.66± 2.34
W_1S_3	28.01 ± 1.96 a	127.87± 18.87	23.67 ± 7 e	151.53± 11.99	17.30± 2.17
W_1S_4	28.00 ± 1.58 a	124.16± 19.13	26.01 ± 7.39 c	150.17± 11.89	16.63± 1.17
SE	0.30	2.71	0.61	2.76	0.41
CV(%)	1.99	4.28	3.04	3.52	4.42

Here:W_0: Weedy check and W_1: Bispyribac - sodium WP @ 150 g ha^{-1} ;S_1: 20 cm × 15 cm, S_2: 25 cm × 15 cm, S_3: 20 cm × 20 cm and S_4: 25 cm × 25 cm

Table 37. Combined effect of variety and spacings on panicle length (cm), filled, unfilled, total grains panicle^{-1} and 1000 grains weight (g) of aromatic rice

Treatment Combinations	Panicle length (cm)	Filled grains panicle^{-1}	Unfilled grains panicle^{-1}	Total grains panicle^{-1}	1000 grains weight (g)
V_1S_1	25.46 ± 0.88 f	88.17± 2.06 d	33.31 ± 1.52 b	121.48± 2.46 e	14.17± 0.77 d
V_1S_2	25.42 ± 0.98 f	92.44 ± 2.17 d	35.27 ± 4.04 a	127.70± 4.96 d	14.00 ± 0.82 d
V_1S_3	25.76 ±1.16 ef	109.88± 2.67 c	31.20 ± 1.83 c	141.08± 2.44 c	15.09 ± 0.92 c
V_1S_4	26.13 ±1.21 de	109.18± 3.5 c	36.04± 3.96 a	145.22 ± 6.67 bc	15.63 ± 0.88 c
V_2S_1	26.74 ±0.95 cd	125.77 ± 2.9 b	21.34± 3.77 de	147.11± 3.88 b	16.72 ± 0.98 b
V_2S_2	27.03 ±0.93 bc	132.32 ± 9.49 a	18.43± 1.11 f	150.75± 8.61 ab	17.66± 0.93 a
V_2S_3	28.24 ± 1.75 a	135.50± 10.72 a	20.63± 3.71 e	156.13 ± 7.19 a	18.28± 1.32 a
V_2S_4	27.60± 1.94 b	132.18 ± 10.56 a	22.08± 3.13 d	154.25± 7.62 a	17.58 ± 0.97 a
SE	0.30	2.71	0.61	2.76	0.41
CV(%)	1.99	4.28	3.04	3.52	4.42

Here:V_1: Kalizira and V_2: BRRI dhan37;S_1: 20 cm × 15 cm, S_2: 25 cm × 15 cm, S_3: 20 cm × 20 cm and S_4: 25 cm × 25 cm

Table 38. Combined effect of Bispyribac-sodium, variety and spacings on panicle length (cm), filled, unfilled, total grains panicle^{-1} and 1000 grains weight (g) of aromatic rice

Treatment Combinations	Panicle length (cm)	Filled grains panicle^{-1}	Unfilled grains panicle^{-1}	Total grains panicle^{-1}	1000- grains weight (g)
$W_0V_1S_1$	25.37 ± 0.98 fg	87.61 ± 2.19	32.69 ± 1.49 bc	120.30 ± 2.31 h	14.33 0.84
$W_0V_1S_2$	25.02 ± 0.96 g	93.05 ± 2.33	38.71 ± 1.76 a	131.77 ± 2.53 fg	14.33 0.84
$W_0V_1S_3$	25.07 ± 0.96 g	108.92 ± 2.72	32.40 ± 1.47 c	141.32 ± 2.72 de	14.67 0.86
$W_0V_1S_4$	25.39 ± 0.98 fg	111.47 ± 2.79	39.39 ± 1.79 a	150.86 ± 2.9 bc	15.33 ± 0.9
$W_0V_2S_1$	26.95 ± 1.04 bc	125.11 ± 3.13	24.69 ± 1.12 e	149.80 ± 2.88 b-d	16.33 ± 0.96
$W_0V_2S_2$	27.05 ± 1.04 b	124.09 ± 3.1	19.17 ± 0.87 f	143.25 ± 2.75 c-e	17.67 ± 1.04
$W_0V_2S_3$	26.91 ± 1.03 bc	126.11 ± 3.15	23.93 ± 1.09 e	150.04 ± 2.89 bc	17.46 ± 1.03
$W_0V_2S_4$	26.06 ±1 c-f	122.92 ± 3.07	24.82 ± 1.13 e	147.74 ± 2.84 c-e	17.83 ± 1.045
$W_1V_1S_1$	25.56 ±0.98 e-g	88.73 ± 2.22	33.93 ± 1.54 b	122.66 ± 2.36 h	14.00 ± 0.82
$W_1V_1S_2$	25.83 ±0.99 d-g	91.82 ± 2.3	31.82 ± 1.45 c	123.64 ± 2.38 gh	13.67 ± 0.8
$W_1V_1S_3$	26.45 ±1.02 b-e	110.85 ± 2.77	30.00 ± 1.36 d	140.85 ± 2.71 e	15.57 ± 0.91
$W_1V_1S_4$	26.86 ± 1.03 bc	106.89 ± 2.67	32.69 ± 1.49 bc	139.57 ± 2.68 ef	15.92 ± 0.94
$W_1V_2S_1$	26.53 ±1.02 b-d	126.43 ± 3.16	17.99 ± 0.82 fg	144.43 ± 2.78 c-e	17.11 ± 1.01
$W_1V_2S_2$	27.01 ± 1.04 b	140.55 ± 3.51	17.68 ± 0.8 g	158.24 ± 3.04 ab	17.66 ± 1.04
$W_1V_2S_3$	29.57 ± 1.14 a	144.89 ± 3.62	17.33 ± 0.79 g	162.22 ± 3.12 a	19.10 ± 1.12
$W_1V_2S_4$	29.14 ± 1.12 a	141.43 ± 3.54	19.34 ± 0.88 f	160.77 ± 3.09 a	17.33 ± 1.02
SE	0.43	3.83	0.86	3.91	0.58
CV(%)	1.99	4.28	3.04	3.52	4.42

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability.

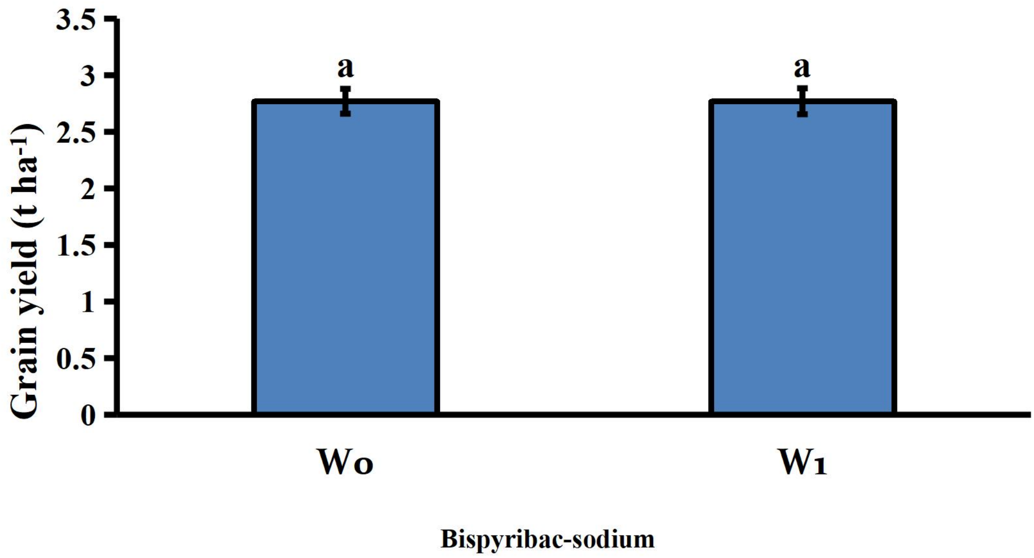
Note viz:NS= Non- significant;Here:W_0: Weedy check and W_1: Bispyribac - sodium WP @ 150 g ha^{-1};V_1: Kalizira and V_2: BRRI dhan37;S_1: 20 cm × 15 cm, S_2: 25 cm × 15 cm, S_3: 20 cm × 20 cm and S_4: 25 cm × 25 cm

4.9 Yield characters

4.9.1 Grain yield (t ha^{-1})

Effect of weed control treatment

Grain yield of rice showed non significant effect due to different weed control treatment (Figure 56). From the experiment, result revealed that both treated and weedy check plot recorded the same grain yield production of aromatic rice (2.77 t ha^{-1}).



Here, W_0: Weedy check and W_1: Bispyribac - sodium WP @ 150 g ha^{-1}

Figure 55. Effect of Bispyribac-sodium on grain yield (t ha^{-1}) of aromatic rice(Bars represent±SD of values obtained from three biological replicates).

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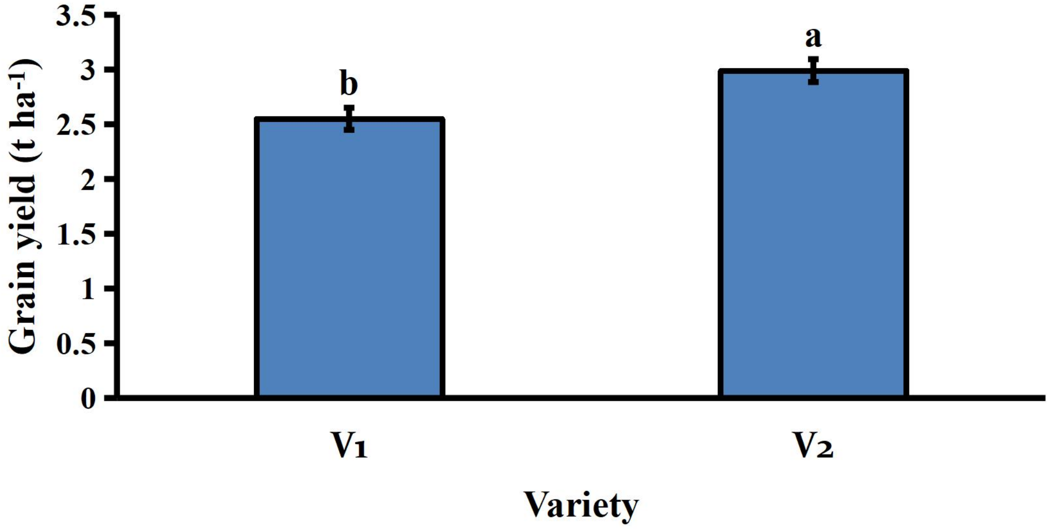
Effect of variety

Different rice varieties significantly influenced grain yield (Figure 57). Experiment result showed that among different rice varieties BRRI dhan37 rice variety recorded the maximum grain yield (2.99 t ha^{-1}) due to reason that higher number of filled grains per panicle along with maximum 1000-seed weight collectively contributed to higher grain yield while Kalizira rice variety recorded the minimum grain yield (2.55 t ha^{-1}) compared to others varieties cultivation. Different rice variety have individual genetic makeup which influenced the growth and yield among different varieties. The result obtained from the present study was similar with the findings of Islam *et al.* (2013)

who reported that the varieties which produced higher number of effective tillers hill^{-1} and higher number of filled grains panicle^{-1} also showed higher grain yield ha^{-1}. Dutta (2002) also reported that the genotypes, which produced higher number of effective tillers per hill and higher number of grains per panicle also showed higher grain yield in rice.

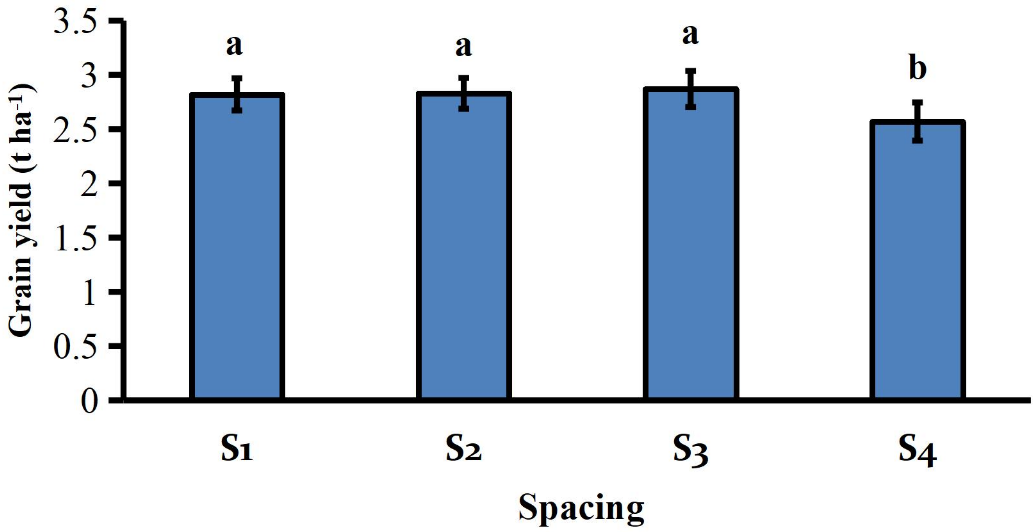


Here, V_1: Kalizira and V_2: BRRI dhan37

Figure 56. Effect of variety on grain yield (t ha^{-1}) of aromatic rice (Bars represent±SD of values obtained from three biological replicates).

Effect of spacing

Different spacings significantly effect on grain yield of aromatic rice (Figure 58). Result showed that aromatic rice cultivated at 20 cm × 20 cm spacing recorded the maximum grain yield (2.87 t ha^{-1}) which was statistically similar with aromatic rice cultivated at 25 cm × 15 cm spacing recorded grain yield (2.83 t ha^{-1}) and with aromatic rice cultivated at 20 cm × 15 cm spacing recorded grain yield (2.82 t ha^{-1}) while aromatic rice cultivated at 25 cm × 25 cm spacing recorded the minimum grain yield (2.57 t ha^{-1}). The result obtained from the present study was similar with the findings of Bhownmilk *et al.* (2012) who reported that optimum plant spacing ensures optimum number of plants per unit area which lead to proper growth, yield components and ultimately grain yield. Rashid *et al.* (2010) reported that that the crop with 20.0 cm row to row spacing and 20.0 cm hill to hill spacing produced the highest grain yield (4.90 t ha^{-1}), whereas the lowest grain yield (2.55 t ha^{-1}) was found with 20.0 cm × 2.5 cm. Patel (1999) also reported that maximum yield and yield related attributes in rice transplanted was obtained from 20 cm × 20 cm planting distance as compared to narrower spacing than this.



Here, S_1: 20 cm × 15 cm, S_2: 25 cm × 15 cm, S_3: 20 cm × 20 cm and S_4: 25 cm × 25 cm

Figure 57. Effect of spacings on grain yield (t ha^{-1}) of aromatic rice(Bars represent±SD of values obtained from three biological replicates).

Combined effect of Bispyribac-sodium and variety

Combined effect of weeds control and variety showed non significant effect on grain yield of aromatic rice (Table 39). Experiment result revealed that Bispyribac - sodium WP @ 150 g ha^{-1} herbicide treated plot along with BRRI dhan37 rice variety cultivation recorded the maximum grain yield (3.04 t ha^{-1}) while weedy check plot along with Kalizira rice variety cultivation recorded the minimum grain yield (2.59 t ha^{-1}).

Combined effect of Bispyribac-sodium and spacing

Combined effect of weeds control and spacings showed non significant effect on grain yield of aromatic rice (Table 40). Experiment result showed that weedy check plot along with aromatic rice variety cultivated at 20 cm × 20 cm spacing recorded the maximum grain yield (2.93 t ha^{-1}) while weedy check plot along with aromatic rice variety cultivated at 25 cm × 25 cm spacing recorded the minimum grain yield (2.56 t ha^{-1}).

Combined effect of variety and spacing

Different aromatic rice variety along with spacings showed significant effect on grain yield of aromatic rice (Table 41). Experiment result showed that BRRI dhan37 rice variety cultivated at 20 cm × 20 cm spacing recorded the maximum grain yield (3.13 t ha^{-1}) while Kalizira rice variety cultivated at 25 cm × 25 cm spacing recorded the minimum grain yield (2.18 t ha^{-1}).

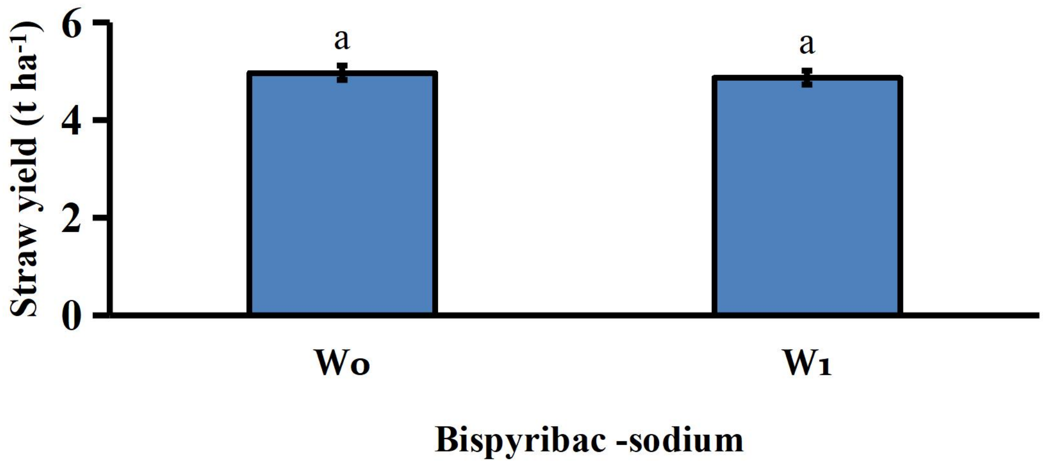
Combined effect of Bispyribac-sodium , variety and spacing

Combination of different treatment showed non significant effect on grain yield of aromatic rice (Table 42). Experiment result showed that Bispyribac - sodium WP @ 150 g ha^{-1} herbicide treated plot along with BRRI dhan37 rice variety cultivated at 20 cm × 20 cm spacing recorded the maximum grain yield (3.20 t ha^{-1}) while weedy check plot along with Kalizira rice variety cultivated at 25 cm × 25 cm spacing recorded the minimum grain yield (2.15 t ha^{-1}).

4.9.2 Straw yield (t ha^{-1})

Effect of Bispyribac-sodium

After removing grains from the panicle the rest part were considered as straw. It is evident from the data that the weed control through different herbicide treatments caused non significant effect on straw yield of rice (Figure 58). Experiment result revealed that weedy check plot recorded the maximum straw yield (4.97 t ha^{-1}) while Bispyribac - sodium WP @ 150 g ha^{-1} herbicide treated plot recorded recorded the minimum straw yield (4.87 t ha^{-1}).

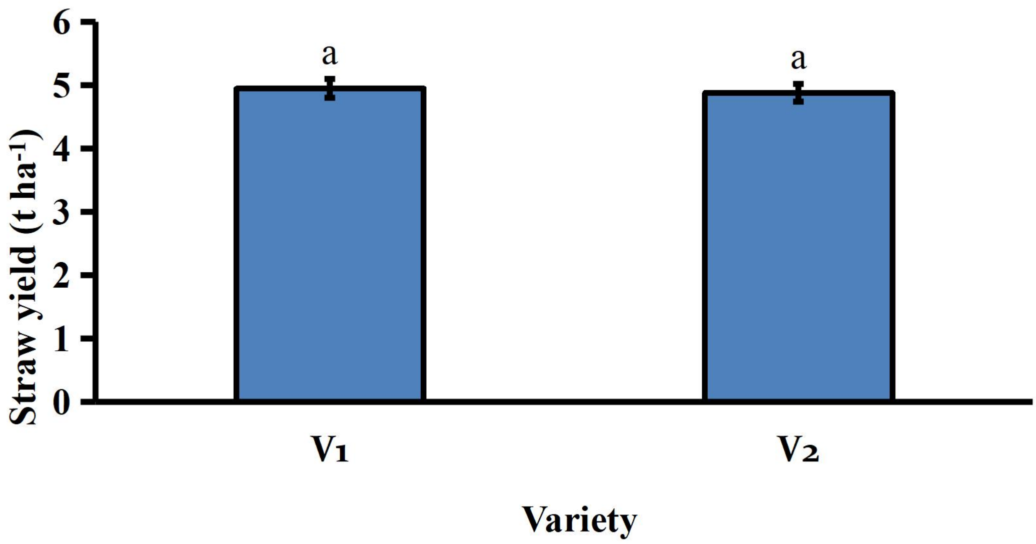


Here, W_0: Weedy check and W_1: Bispyribac - sodium WP @ 150 g ha^{-1}

Figure 58. Effect of Bispyribac-sodiumn on straw yield (t ha^{-1}) of aromatic rice (Bars represent±SD of values obtained from three biological replicates).

Effect of variety

Different aromatic rice variety cultivation showed non significant effect on straw yield production (Figure 59). Experiment result revealed that among different rice varieties Kalizira rice variety recorded the maximum straw yield (4.95 t ha^{-1}) while BRRI dhan37 rice variety recorded the minimum straw yield (4.88 t ha^{-1}).

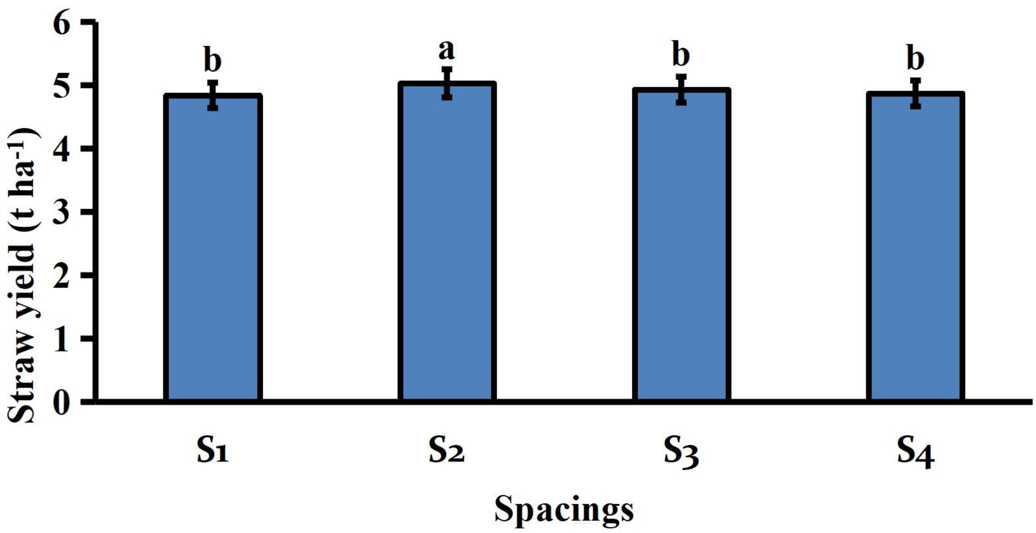


Here, V_1: Kalizira and V_2: BRRI dhan37

Figure 59. Effect of variety on straw yield (t ha^{-1}) of aromatic rice (Bars represent±SD of values obtained from three biological replicates).

Effect of spacing

Different spacings significantly effect on straw yield of aromatic rice (Figure 60). Result showed that aromatic rice cultivated at 25 cm × 15 cm spacing recorded the maximum straw yield (5.03 t ha^{-1}) while aromatic rice cultivated at 20 cm × 15 cm spacing recorded the minimum straw yield (4.84 t ha^{-1}) which was statistically similar with aromatic rice cultivated at 25 cm × 25 cm spacing recorded straw (4.87 t ha^{-1}) and with aromatic rice cultivated at 20 cm × 20 cm spacing recorded straw yield (4.93 t ha^{-1}). The result obtained from the present study was similar with the findings of Saha *et al.* (2020).



Here, S_1: 20 cm × 15 cm, S_2: 25 cm × 15 cm, S_3: 20 cm × 20 cm and S_4: 25 cm × 25 cm

Figure 60. Effect of spacings on straw yield (t ha^{-1}) of aromatic rice (Bars represent±SD of values obtained from three biological replicates).

Combined effect of Bispyribac-sodium and variety

Combined effect of weeds control and variety showed significant effect on straw yield of aromatic rice (Table 39). Experiment result revealed that weedy check plot along with plot Kalizira rice variety cultivation recorded the maximum straw yield (5.08 t ha^{-1}) which was statistically similar with Bispyribac - sodium WP @ 150 g ha^{-1} herbicide treated plot alongBRRI dhan37 rice variety cultivation recorded straw yield (4.91 t ha^{-1}) while Bispyribac - sodium WP @ 150 g ha^{-1} herbicide treated plot alongKalizira rice variety cultivation recorded the minimum straw yield (4.83 t ha^{-1})

which was statistically similar with weedy check plot along with along BRRI dhan37 rice variety cultivation recorded the straw yield (4.83 t ha^{-1}).

Combined effect of and spacings

Combined effect of weeds control and spacings showed non significant effect on straw yield of aromatic rice (Table 40). Experiment result showed that weedy check plot along with aromatic rice variety cultivated at 25 cm × 15 cm spacing recorded the maximum straw yield (5.08 t ha^{-1}) while Bispyribac - sodium WP @ 150 g ha^{-1} herbicide treated plot along with aromatic rice variety cultivated at 20 cm × 15 cm spacing recorded the minimum straw yield (4.79 t ha^{-1}).

Combined effect of variety and spacings

Different aromatic rice variety along with spacings showed significant effect on straw yield of aromatic rice (Table 41). Experiment result showed that Kalizira rice variety cultivated at 25 cm × 15 cm spacing recorded the maximum straw yield (5.28 t ha^{-1}) while BRRI dhan37 rice variety cultivated at 25 cm × 15 cm spacing recorded the minimum straw yield (4.79 t ha^{-1}) which was statistically similar with Kalizira rice variety cultivated at 25 cm × 25 cm spacing recorded straw yield (4.81 t ha^{-1}), with BRRI dhan37 rice variety cultivated at 20 cm × 15 cm spacing recorded straw yield (4.82 t ha^{-1}), with Kalizira rice variety cultivated at 20 cm × 20 cm spacing recorded straw yield (4.86 t ha^{-1}) and with Kalizira rice variety cultivated at 20 cm × 15 cm spacing recorded straw yield (4.87 t ha^{-1}).

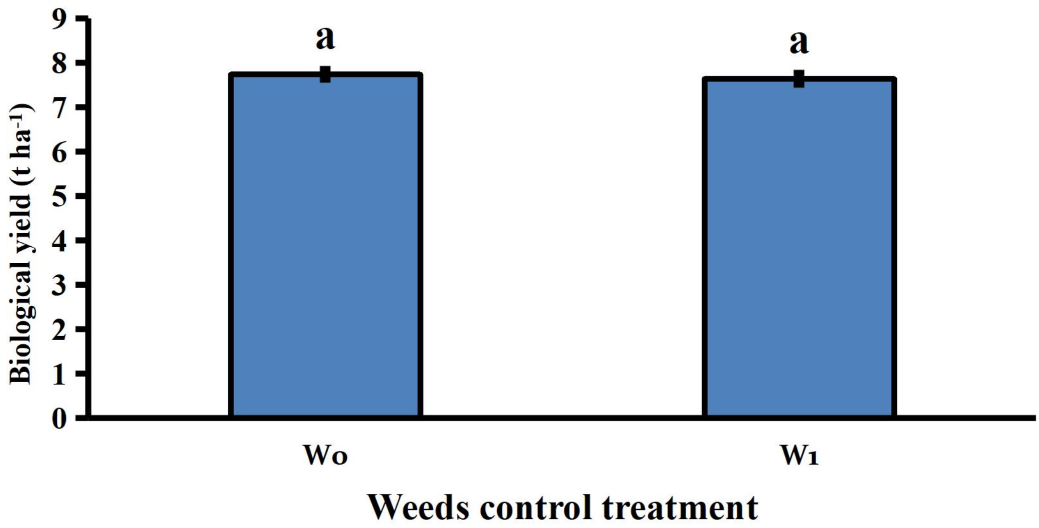
Combined effect of weeds control, variety and spacings

Combination of different treatment showed non significant effect on straw yield of aromatic rice (Table 42). Experiment result showed that weedy check plot along with Kalizira rice variety cultivated at 25 cm × 15 cm spacing recorded the maximum straw yield (5.41 t ha^{-1}) while Bispyribac - sodium WP @ 150 g ha^{-1} treated plot along with Kalizira rice variety cultivated at 25 cm × 25 cm spacing recorded the minimum straw yield (4.64 t ha^{-1}).

4.9.3 Biological yield (t ha^{-1})

Effect of weed control treatment

Weed control through different herbicide treatments caused non significant effect on biological yield aromatic of rice (Figure 61). Experiment result revealed that weedy check plot recorded the maximum biological yield (7.74 t ha^{-1}) while Bispyribac - sodium WP @ 150 g ha^{-1} herbicide ecorded the minimum biological yield (7.64 t ha^{-1}).

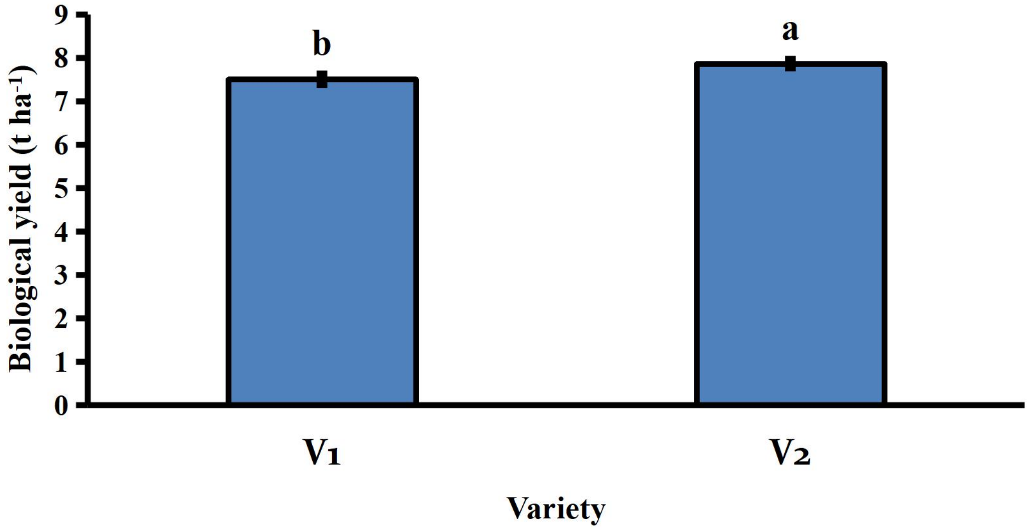


Here, W_0: Weedy check and W_1: Bispyribac - sodium WP @ 150 g ha^{-1}

Figure 61. Effect of Bispyribac-sodium on biological yield (t ha^{-1}) of aromatic rice(Bars represent±SD of values obtained from three biological replicates).

Effect of rice variety

Different rice variety caused significantly varied on biological yield of rice (Figure 62). Among different rice variety BRRI dhan37 rice variety cultivation recorded the maximum biological yield (7.87 t ha^{-1}) while Kalizira rice variety cultivation recorded the minimum biological yield (7.51 t ha^{-1}). The differences of straw yield may be attributed to the genetic makeup and variation of the different rice varieties. Hossain *et al.* (2014b) found similar results with the present study and reported that, the variation in biological yield was also found due to the variation in grain and straw yield.

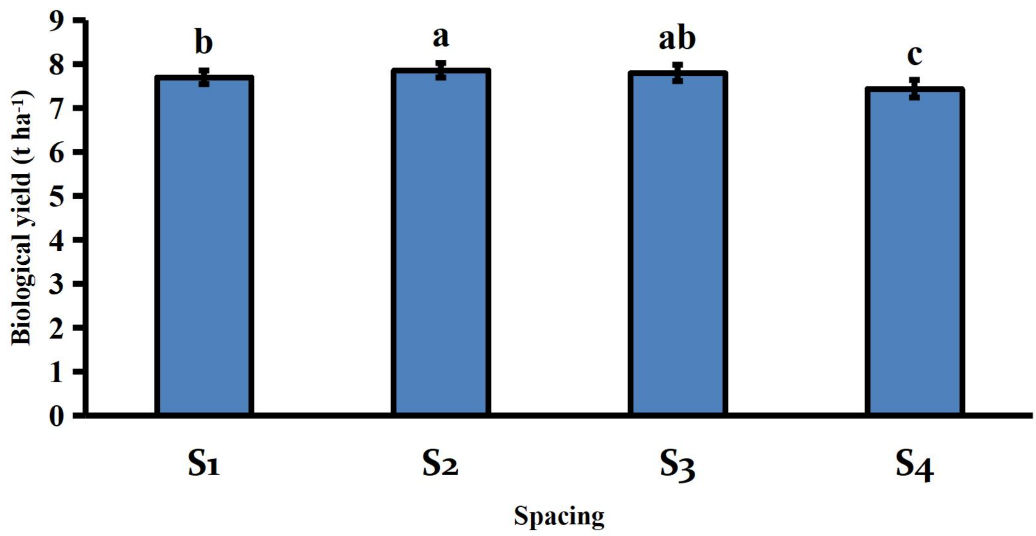


Here, V_1: Kalizira and V_2: BRRI dhan37

Figure 62. Effect of variety on biological yield (t ha^{-1}) of aromatic rice (Bars represent±SD of values obtained from three biological replicates).

Effect of spacing

Different spacings significantly effect on biological yield of aromatic rice (Figure 64). Result showed that aromatic rice cultivated at 25 cm × 15 cm spacing recorded the maximum biological yield (7.86 t ha^{-1}) which was statistically similar with aromatic rice cultivated at 20 cm × 20 cm spacing recorded biological yield (7.80 t ha^{-1}) while aromatic rice cultivated at 25 cm × 25 cm spacing recorded the minimum biological yield (7.44 t ha^{-1}). Dass *et al.* (2017) documented that narrower plant spacing in puddled transplanted rice resulted in higher biological yield comparable to widest spacing.



Here, S_1: 20 cm × 15 cm, S_2: 25 cm × 15 cm, S_3: 20 cm × 20 cm and S_4: 25 cm × 25 cm

Figure 63. Effect of spacings on biological yield (t ha^{-1}) of aromatic rice (Bars represent±SD of values obtained from three biological replicates).

Combined effect of Bispyribac-sodium and variety

Combined effect of weeds control and variety showed significant effect on biological yield of aromatic rice (Table 39). Experiment result revealed that Bispyribac - sodium WP @ 150 g ha^{-1} herbicide treated plot along with plot BRRI dhan37 rice variety cultivation recorded the maximum biological yield (7.94 t ha^{-1}) which was statistically similar with weedy check plot along BRRI dhan37 cultivation recorded biological yield (7.80 t ha^{-1}) and with weedy check plot alongKalizira rice variety cultivation recorded biological yield (7.67 t ha^{-1}) while Bispyribac - sodium WP @ 150 g ha^{-1} herbicide treated plot along with Kalizira rice variety cultivation recorded the minimum biological yield (7.34 t ha^{-1}).

Combined effect of weeds control and spacing

Combined effect of weeds control and spacings showed non significant effect on biological yield of aromatic rice (Table 40). Experiment result showed that weedy check plot along with aromatic rice variety cultivated at 25 cm × 15 cm spacing recorded the maximum biological yield (7.92 t ha^{-1}) while Bispyribac - sodium WP @ 150 g ha^{-1} herbicide along with aromatic rice variety cultivated at 25 cm × 25 cm spacing recorded the minimum biological yield (7.42 t ha^{-1}).

Combined effect of variety and spacings

Different aromatic rice variety along with spacings showed significant effect on biological yield of aromatic rice (Table 41). Experiment result showed that BRRI dhan37 rice variety cultivated at 20 cm × 20 cm spacing recorded the maximum biological yield (8.12 t ha^{-1}) which was statistically similar with Kaliziracultivated at 25 cm × 15 cm spacing recorded biological yield (8.06 t ha^{-1}) while Kaliziracultivated at 25 cm × 25 cm spacing recorded the minimum biological yield (6.99 t ha^{-1}).

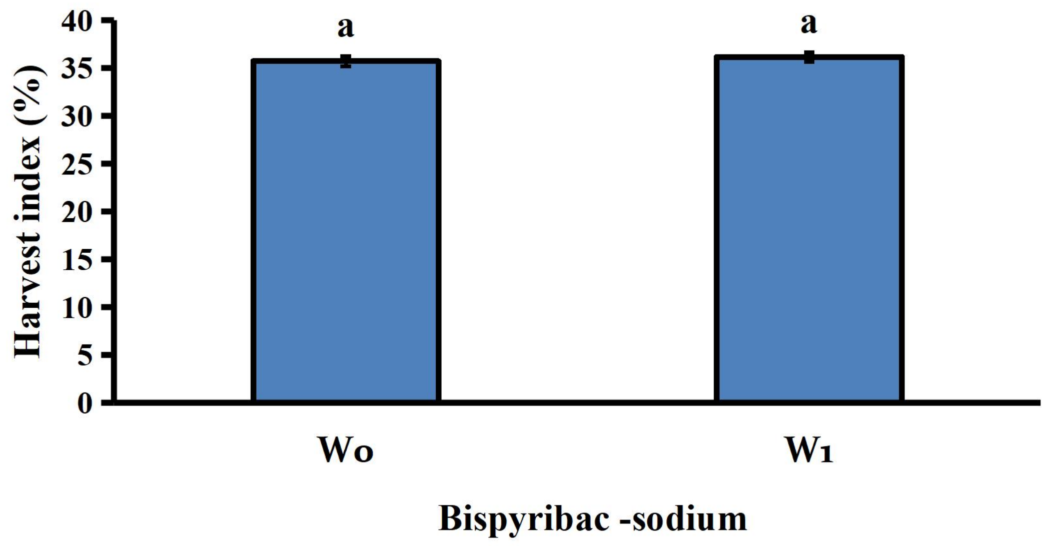
Combined effect of Bispyribac-sodium, variety and spacing

Combination of different treatment showed non significant effect on biological yield of aromatic rice (Table 42). Experiment result showed that weedy check plot along with Kalizira rice variety cultivated at 25 cm × 15 cm spacing recorded the maximum biological yield (8.18 t ha^{-1}) while Bispyribac - sodium WP @ 150 g ha^{-1} treated plot along with Kalizira rice variety cultivated at 25 cm × 25 cm spacing recorded the minimum biological yield (6.84 t ha^{-1}).

4.9.4 Harvest index (%)

Effect of Bispyribac-sodium

Different weed control treatment showed non significant effect on harvest aromatic of rice (Figure 64). Experiment result revealed that Bispyribac - sodium WP @ 150 g ha^{-1} herbicide gives the maximum harvest index (36.18 %) while weedy check plot recorded the minimum harvest index (35.75 %).



Here, W_0: Weedy check and W_1: Bispyribac - sodium WP @ 150 g ha^{-1}

Figure 64. Effect of Bispyribac-sodium on harvest index (%) of aromatic rice(Bars represent±SD of values obtained from three biological replicates).

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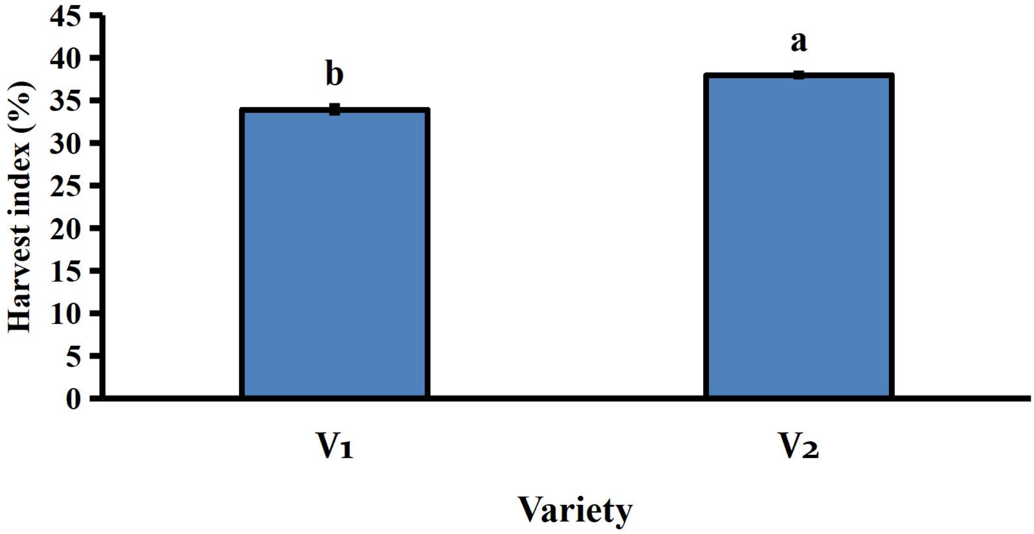
Effect of rice variety

It is evident from the data that different rice variety caused significantly varied on harvest index of rice (Figure 65). Among different rice variety BRRI dhan37 cultivation recorded the maximum harvest index (37.98 %) while Kalizira rice variety cultivation recorded the minimum harvest index (33.95 %). Chowhan *et al.* (2019) also found similar result which supported the present finding and reported that hybrid rice maintained higher harvest index. Uddin *et al.* (2011) reported that the harvest index differed significantly among the varieties due to its genetic variability. Shah *et al.* (1991) reported that variety had a great influence on harvest index.

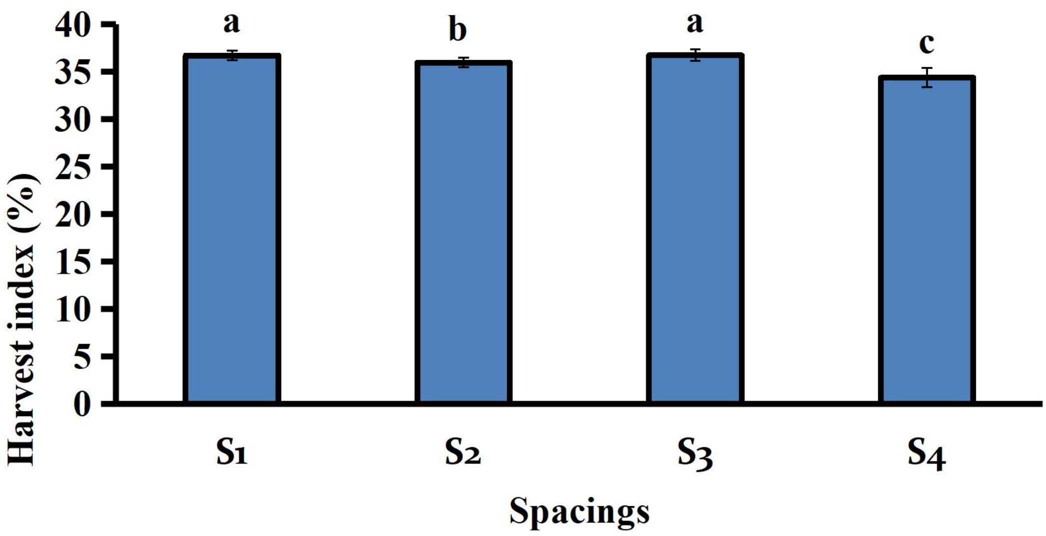


Here, V_1: Kalizira and V_2: BRRI dhan37

Figure 65. Effect of variety on harvest index (%) of aromatic rice (Bars represent±SD of values obtained from three biological replicant).

Effect of spacings

Aromatic rice cultivated at different spacings significantly effect on harvest index (Figure 67). Result showed that aromatic rice cultivated at 20 cm × 20 cm spacing recorded the maximum harvest index (36.75 %) which was statistically similar with aromatic rice cultivated at 20 cm × 15 cm spacing recorded harvest index (36.74 %) while aromatic rice cultivated at 25 cm × 25 cm spacing recorded the minimum harvest index (34.39 %). Saju *et al.* (2019) also found similar result which supported the present finding and concluded from their study that higher harvest index was recorded under 20 x 20cm spacing. Higher harvest index might be due to greater partitioning of photosynthesis towards the production of straw and higher grain ratio in total biological yield.



Here, S_1: 20 cm × 15 cm, S_2: 25 cm × 15 cm, S_3: 20 cm × 20 cm and S_4: 25 cm × 25 cm

Figure 66. Effect of spacings on harvest index (%) of aromatic rice (Bars represent±SD of values obtained from three biological replicates).

Combined effect of Bispyribac-sodium and variety

Combined effect of weeds control and variety showed non significant effect on harvest index of aromatic rice (Table 39). Experiment result revealed that Bispyribac -sodium WP @ 150 g ha^{-1} herbicide along with plot BRRI dhan37 cultivation recorded the maximum harvest index (39.19 %) while weedy check plot along with Kalizira rice variety cultivation recorded the minimum harvest index (33.73 %).

Combined effect Bispyribac-sodiumand spacing

Combined effect of weeds control and spacings showed non significant effect on harvest index of aromatic rice (Table 40). Experiment result showed that weedy check plot along with aromatic rice variety cultivated at 25 cm × 15 cm spacing recorded the maximum harvest index (36.99 %) while weedy check plot along with aromatic rice variety cultivated at 25 cm × 25 cm spacing recorded the minimum harvest index (34.10 %).

Combined effect of variety and spacings

Different aromatic rice variety along with spacings showed significant effect on harvest index of aromatic rice (Table 41). Experiment result showed that BRRI dhan37 rice variety cultivated at 20 cm × 20 cm spacing recorded the maximum harvest index (38.55 %) which was statistically similar with BRRI dhan37 cultivated at 20 cm × 15 cm spacing recorded harvest index (38.25 %) and with BRRI dhan37 rice variety cultivated at 25 cm × 25 cm spacing recorded harvest index (37.63 %) while Kalizira rice variety cultivated at 25 cm × 25 cm spacing recorded the minimum harvest index (31.16 %).

Combined effect of Bispyribac-sodium, variety and spacings

Combination of different treatment showed significant effect on harvest index of aromatic rice (Table 42). Experiment result showed that Bispyribac - sodium WP @ 150 g ha^{-1} herbicidealong with BRRI dhan37 rice variety cultivated at 20 cm × 20cm spacing recorded the maximum harvest index (39.03 %) which was statistically similar with Bispyribac - sodium WP @ 150 g ha^{-1} herbicidealong with BRRI dhan37 rice variety cultivated at 20 cm × 15 cm spacing recorded harvest index (38.41 %), with Bispyribac - sodium WP @ 150 g ha^{-1} herbicidet along with BRRI dhan37 rice variety cultivated at 25 cm × 15 cm spacing recorded the harvest index (38.12 %) with weedy check plot along with BRRI dhan37 rice variety cultivated at 25 cm × 15 cm spacing recorded the harvest index (38.08 %), with weedy check plot along with BRRI dhan37 rice variety cultivated at 20 cm × 20 cm spacing recorded the harvest index (38.07 %) and with weedy check plot along with BRRI dhan37 rice variety cultivated at 25 cm × 25 cm spacing recorded the harvest index (38.05 %), while weedy check plot along with Kalizira cultivated at 25 cm × 25 cm spacing recorded the minimum harvest index (30.15 %).

Table 39. Combined effect Bispyribac-sodium and variety on grain, straw, biological yield (t ha^{-1}) and harvest index (%) of aromatic rice

Treatment Combinations	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
W_0V_1	2.59 ± 0.52	5.08 ± 0.75 a	7.67 ± 0.64 ab	33.73 ± 2.33
W_0V_2	2.95 ± 0.52	4.85 ± 0.7 b	7.80 ± 0.55 a	37.77 ± 0.76
W_1V_1	2.51 ± 0.49	4.83 ± 0.72 b	7.34 ± 0.63 b	34.18 ± 1.43
W_1V_2	3.04 ± 0.53	4.91 ± 0.7 ab	7.94 ± 0.54 a	38.19 ± 0.88
SE	NS	0.06	0.11	NS
CV(%)	6.65	3.15	3.77	3.54

Table 40. Combined effect of Bispyribac -sodium and spacings on grain, straw, biological yield (t ha^{-1}) and harvest index (%) of aromatic rice

Treatment Combinations	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
W_0S_1	2.82±0.53	4.90±0.73	7.72±0.54	36.53±1.78
W_0S_2	2.77±0.49	5.08±0.84	7.85±0.65	35.38±1.73
W_0S_3	2.93±0.55	4.99±0.74	7.92±0.58	36.99±1.3
W_0S_4	2.56±0.64	4.91±0.74	7.46±0.63	34.10±4.35
W_1S_1	2.81±0.54	4.79±0.71	7.60±0.57	36.96±1.69
W_1S_2	2.88±0.52	4.99±0.77	7.87±0.54	36.59±1.76
W_1S_3	2.82±0.65	4.87±0.73	7.68±0.74	36.51±2.82
W_1S_4	2.59±0.63	4.83±0.75	7.42±0.81	34.68±2.81
SE	NS	NS	NS	NS
CV(%)	6.65	3.15	3.77	3.54

Here:W_0: Weedy check and W_1: Bispyribac - sodium WP @ 150 g ha^{-1} ;S_1: 20 cm × 15 cm, S_2: 25 cm × 15 cm, S_3: 20 cm × 20 cm and S_4: 25 cm × 25 cm

Table 41. Combined effect of variety and spacings on grain, straw, biological yield (t ha^{-1}) and harvest index (%) of aromatic rice

Treatment Combinations	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
V_1S_1	2.65 ±0.47 de	4.87±0.73 b-d	7.51 ±0.54 e	35.24 ±0.59 c
V_1S_2	2.78 ±0.49 cd	5.28 ±0.8 a	8.06 ±0.57 ab	34.47 ±0.83 c
V_1S_3	2.62 ±0.5 e	4.86 ±0.73 cd	7.48 ±0.59 e	34.95 ±1.18 c
V_1S_4	2.18 ±0.39 f	4.81 ±0.74 cd	6.99 ±0.51 f	31.16 ±1.19d
V_2S_1	2.99±0.53 b	4.82±0.72 cd	7.81±0.54 cd	38.25 ab±0.59 ab
V_2S_2	2.88 ±0.52 bc	4.79±0.72 d	7.66 ±0.55de	37.50±0.88 b
V_2S_3	3.13 ±0.56 a	4.99±0.74 b	8.12±0.56 a	38.55±0.78 a
V_2S_4	2.97±0.53 b	4.92 ±0.74 bc	7.89 ±0.55 bc	37.63±0.73 ab
SE	0.13	0.05	0.10	0.46
CV(%)	6.65	3.15	3.77	3.54

Here:V_1: Kalizira and V_2: BRRI dhan37;S_1: 20 cm × 15 cm, S_2: 25 cm × 15 cm, S_3: 20 cm × 20 cm and S_4: 25 cm × 25 cm

Table 42. Combined effect of Bispyribac -sodium, variety and spacings on grain, straw, biological yield (t ha^{-1}) and harvest index (%) of aromatic rice

Treatment Combinations	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
$W_0V_1S_1$	2.68± 0.54	4.97±0.83	7.65±0.59	34.98±0.58 ef
$W_0V_1S_2$	2.77± 0.55	5.41±0.9	8.18±0.62	33.88±0.56f
$W_0V_1S_3$	2.78± 0.56	4.96±0.83	7.74±0.59	35.92 ±0.6 de
$W_0V_1S_4$	2.15± 0.43	4.98±0.83	7.13±0.55	30.15 ±0.5 h
$W_0V_2S_1$	2.97± 0.59	4.83±0.8	7.80±0.6	38.08±0.63 a-c
$W_0V_2S_2$	2.77± 0.55	4.74±0.79	7.51±0.58	36.88±0.61 cd
$W_0V_2S_3$	3.08± 0.62	5.01±0.83	8.09±0.62	38.07±0.63 a-c
$W_0V_2S_4$	2.97± 0.59	4.83±0.8	7.80±0.6	38.05±0.63 a-c
$W_1V_1S_1$	2.62± 0.52	4.76±0.79	7.38±0.6	35.50±0.59 e
$W_1V_1S_2$	2.78± 0.56	5.15±0.86	7.93±0.61	35.06±0.58 ef
$W_1V_1S_3$	2.45± 0.49	4.76±0.79	7.21±0.56	33.98±0.57 f
$W_1V_1S_4$	2.20± 0.44	4.64±0.77	6.84±0.53	32.16±0.54 g
$W_1V_2S_1$	3.00± 0.6	4.81±0.8	7.81±0.6	38.41 ±0.64 ab
$W_1V_2S_2$	2.98± 0.59	4.83±0.81	7.81±0.6	38.12±0.64 a-c
$W_1V_2S_3$	3.20± 0.63	4.97±0.83	8.17±0.63	39.03 ±0.65 a
$W_1V_2S_4$	2.98± 0.59	5.01±0.83	7.99±0.61	37.20±0.62 b-d
SE	Ns	NS	NS	0.65
CV(%)	4.07	2.10	2.39	2.25

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability.

Note viz:NS= Non- significant;Here:W_0: Weedy check and W_1: Bispyribac - sodium WP @ 150 g ha^{-1};V_1: Kalizira and V_2: BRRI dhan37;S_1: 20 cm × 15 cm, S_2: 25 cm × 15 cm, S_3: 20 cm × 20 cm and S_4: 25 cm × 25 cm

4.10. Relationship of grain yield and leaf area index (LAI) and total dry matter production

A positive linear relationship was observed between grain yield, leaf area index and total dry matter production of aromatic rice. It was evident from the Figure 68 and 69 that the regression equation y = 0.309x + 2.072 and y = 0.008x + 2.154 gave a good fit to the data, and the co-efficient of determination (R^2 = 0.264 and 0.038) showed that, fitted regression line had positive regression co-efficient. From this regression analysis, it was evident that there was a strongly positive relationship between grain yield and leaf area index, and grain yield and total dry matter production of aromatic rice. In the present experiment the yield and yield contributing character were varied due to application of different weed control treatment, rice variety, spacings and among different treatment combination maximum grain yield (3.20 and 3.08 t ha^{-1}) were recorded in both treated and weedy check plot along with cultivation of BRRI dhan 37 at 20 cm × 20 cm spacing.

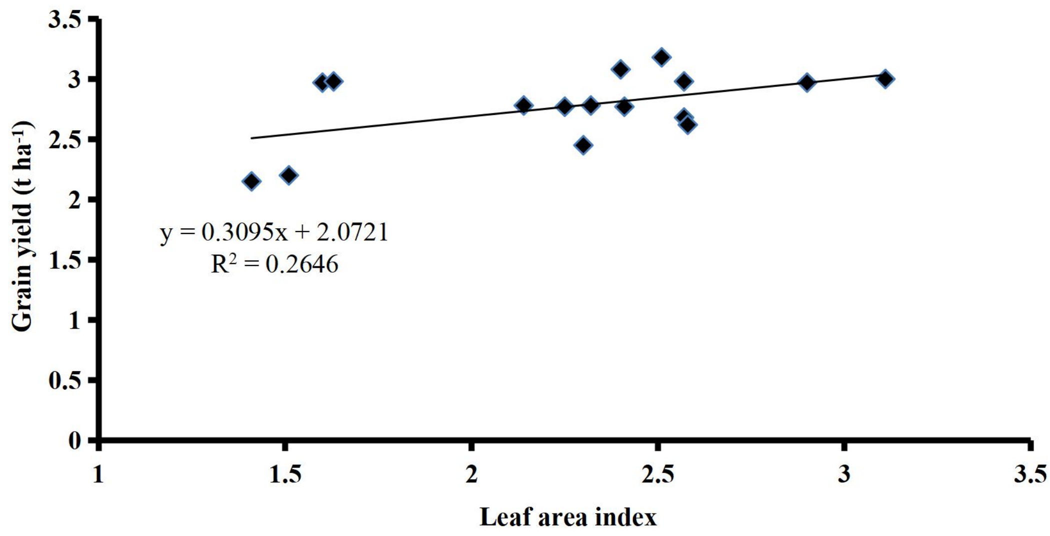


Figure 67. Relationship between leaf area index (LAI) and grain yield of aromatic rice.

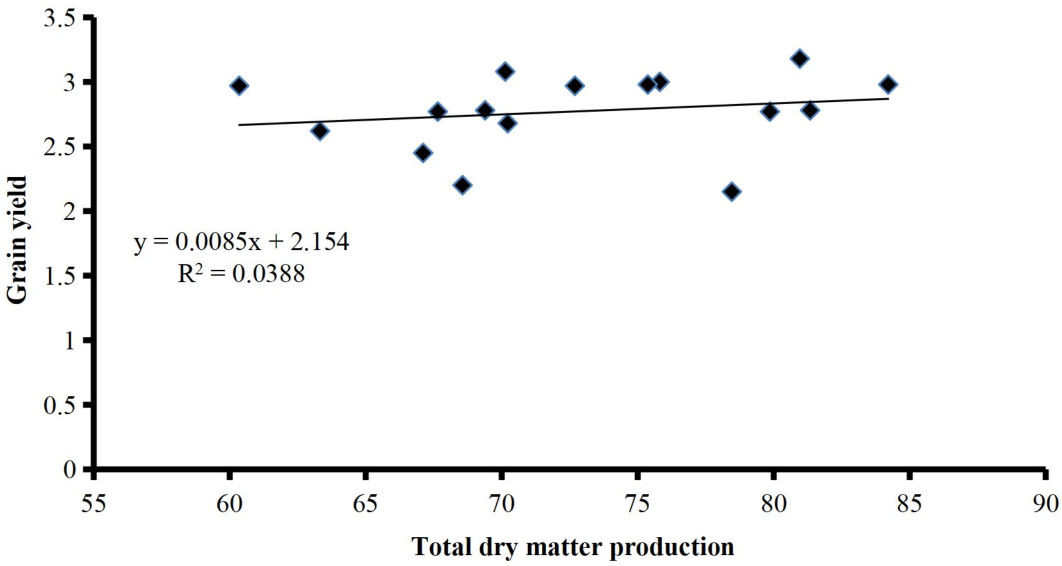


Figure 68. Relationship between total dry matter production and grain yield of aromatic rice.

4.11 Correlation of grain yield with panicle length, grains panicle^{-1} and 1000-grains weight

From the (Figure 70, 71 and 72) it was noticed that grain yield was positively correlated with panicle length (R^2=0.225) grains panicle^{-1} (R^2=0.146) and 1000-grains weight (R^2=0.301). From the correlation study, it appears that grain yield increase with increasing panicle length, grains panicle^{-1} and 1000 grains weight. And in this experiment maximum grain yield maximum grain yield (3.18 and 3.08 t ha^{-1}) were recorded in both treated and weedy check plot along with cultivation of BRRI dhan 37 at 20 cm × 20 cm spacing.

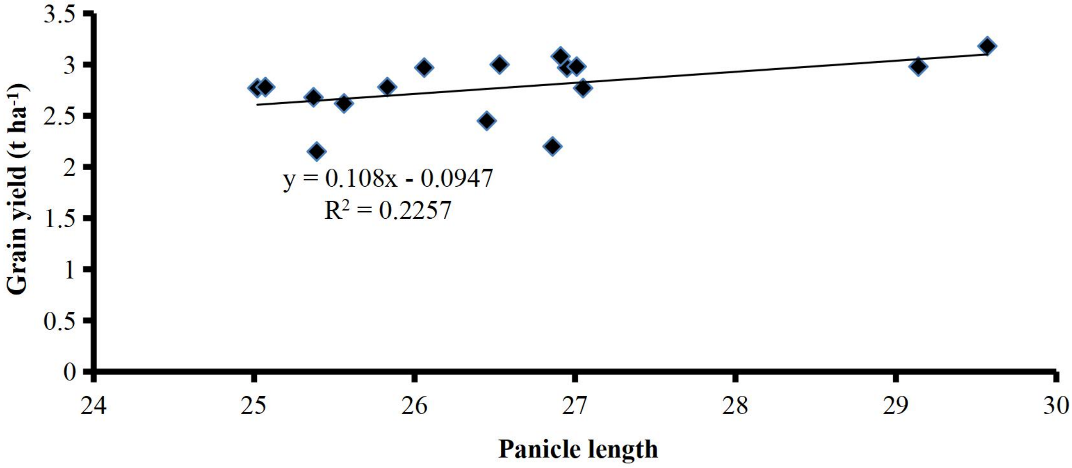


Figure 69. Relationship between panicle length and grain yield.

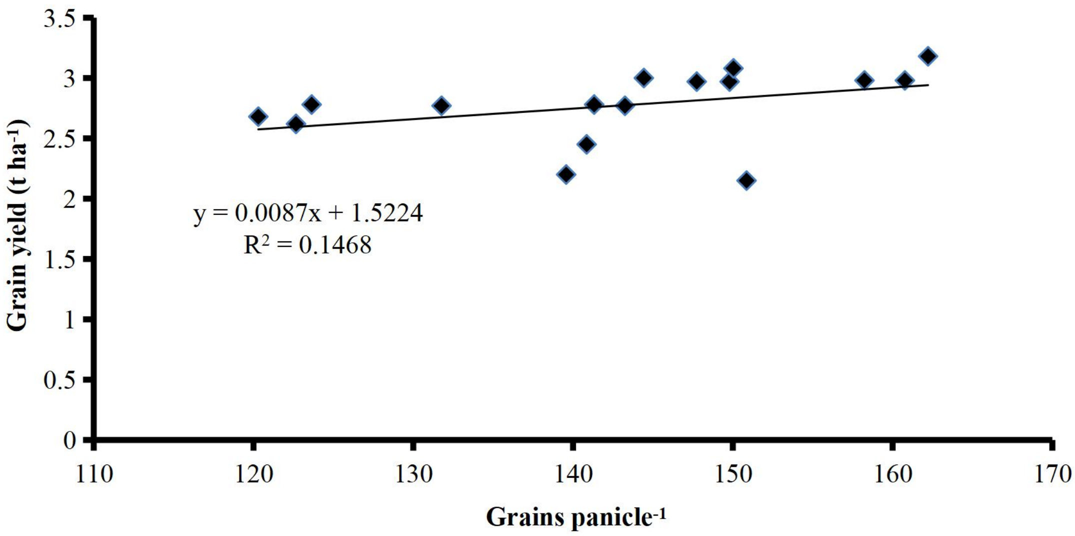


Figure 70. Relationship between grains panicle^{-1}and grain yield.

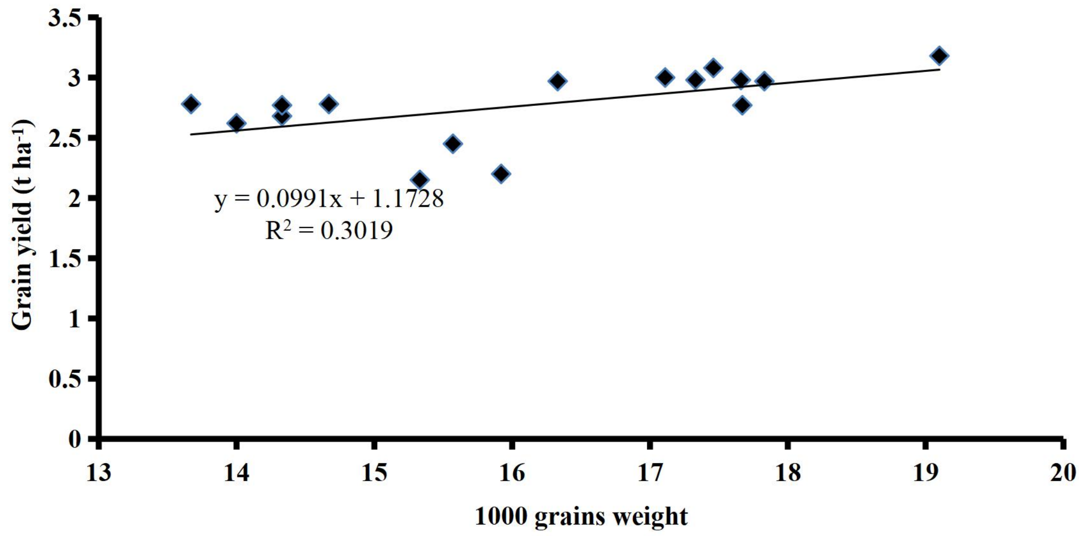


Figure 71. Relationship between 1000 grains weight and grain yield.

4.12 Economic viability of different treatments combination

The economic performance of different treatments combination were determined on per hectare area basis, which includes total cost of production, gross returns, net returns and benefit cost ratio (profit over per taka investment) under treatments imposed (Table 13).

4.12.1 Total cost of production

Cost of production varied due to different weed control treatment, rice variety cultivation and maintaining different spacing for rice cultivation. The cost of production was varied mainly for the herbicide application. In case of weedy check, there was no involvement of cost for herbicide application. In this experiment highest total cost of production was occurred in (57472 taka) Bispyribac - sodium WP @ 150 g ha^{-1} herbicide along with Kalizira cultivation at 20 cm × 15 cm spacing and lowest (55586 taka) in weedy check field along with BRRI dhan37 rice variety cultivation at 25 cm × 25 cm spacing.

4.12.2 Gross return (Tk)

Gross return was influenced by different weed control along with different rice variety cultivation at different spacings. The highest gross return (84970taka) was recorded in Bispyribac - sodium WP @ 150 g ha^{-1} herbicide along with cultivation of BRRI dhan 37 at 20 cm × 20 cm spacing followed by weedy check plot along with cultivation of BRRI dhan37 at 20 cm × 20 cm spacing having gross return (82010 taka) while the minimum (58730 taka) in weedy check plot along with Kalizira cultivation at 25 cm × 25 cm.

4.12.3 Net return (Tk)

Net return was varied by different treatments. The highest net return (27054 taka) was recorded in Bispyribac - sodium WP @ 150 g ha^{-1} herbicide along with cultivation of BRRI dhan 37 at 20 cm × 20 cm spacing followed by weedy check plot along with cultivation of BRRI dhan37 at 20 cm × 20 cm spacing having net return (26090 taka) while the minimum net return (58730 taka) recorded in Bispyribac - sodium WP @ 150 g ha^{-1} herbicide along with Kalizira cultivation at 25 cm × 25 cm.

4.12.4 Benefit cost ratio (BCR)

Benefit cost ratio varied in different weed control treatment along with different rice variety cultivation at different spacing. The highest benefit cost ratio (1.48) was recorded in Bispyribac - sodium WP @ 150 g ha^{-1} herbicide treated plot along with cultivation of BRRI dhan 37 at 20 cm × 20 cm spacing which was similar with weedy check plot along with cultivation of BRRI dhan 37 at 20 cm × 20 cm spacing having same benefit cost ratio (1.47) while the minimum benefit cost ratio (1.04) in Bispyribac - sodium WP @ 150 g ha^{-1} herbicide treated plot along with Kalizira rice variety cultivation at 25 cm × 25 cm spacing. In this experiment both weedy check and herbicide treated plot recorded same benefit cost ratio was due to reason that weed control had non significant effect on grain yield production of aromatic rice while different rice and spacings significantly influenced grains yield because individual rice variety has its own genetic variation and makeup which influences the yield and yield contribution characters while proper spacing influences optimum growth and development and maintaining optimum density of plant in the field which impact on grains yield comparable to wider or close spacings.This result supports the findings of Salam *et al.* (2020) who reported that benefit cost ratio varied among different rice varieties. Kim and Moody (1989)reported that benefit-cost ratio varied due to different spacings.

Table 43. Cost of production, return and benefit cost ratio (BCR) of transplanted aromatic rice varieties i.e, Kalizira and BRRI dhan37 under different treatments

Treatment	Weed management cost	Different spacing Seed rate cost (TK./ha)	Fixed cost	Total cost of production	Gross return (Tk.)	Net return (TK)	BCR
$W_0V_1S_1$	0	850	55126	55976	71970	15994	1.29
$W_0V_1S_2$	0	750	55115	55865	74660	18795	1.34
$W_0V_1S_3$	0	800	55120	55920	74460	18540	1.33
$W_0V_1S_4$	0	500	55086	55586	58730	3144	1.06
$W_0V_2S_1$	0	850	55126	55976	79080	23104	1.41
$W_0V_2S_2$	0	750	55115	55865	73990	18125	1.32
$W_0V_2S_3$	0	800	55120	55920	82010	26090	1.47
$W_0V_2S_4$	0	500	55086	55586	79080	23494	1.42
$W_1V_1S_1$	1345	850	56622	57472	70260	12788	1.22
$W_1V_1S_2$	1345	750	56611	57361	74650	17289	1.30
$W_1V_1S_3$	1345	800	56616	57416	66010	8594	1.15
$W_1V_1S_4$	1345	500	56582	57082	59640	2558	1.04
$W_1V_2S_1$	1345	850	56622	57472	79810	22338	1.39
$W_1V_2S_2$	1345	750	56611	57361	79330	21969	1.38
$W_1V_2S_3$	1345	800	56616	57416	84970	27054	1.48
$W_1V_2S_4$	1345	500	56582	57082	79510	22428	1.39

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability.

Note viz:NS= Non- significant;Here:W_0: Weedy check and W_1: Bispyribac - sodium WP @ 150 g ha^{-1};V_1: Kalizira and V_2: BRRI dhan37;S_1: 20 cm × 15 cm, S_2: 25 cm × 15 cm, S_3: 20 cm × 20 cm and S_4: 25 cm × 25 cm

CHAPTER V

SUMMARY AND CONCLUSION

The present piece of work was carried out at the Agronomy field of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during July to December-2019, to investigate different varieties and spacing effect on the weed control, growth and yield of aromatic rice in Bangladesh. The experimental field belongs to the Agro-ecological zone (AEZ) of "The Modhupur Tract", AEZ-28. The soil of the experimental field belongs to the General soil type, Deep Red Brown Terrace Soils under Tejgaon soil series. The experiment was consisted of three factors *viz,* Factor A: weed control treatment (2) *viz:* W_0 = Weedy check and W_1= Bispyribac - sodium WP @ 150 g ha^{-1}; Factor B: Aromatic rice varieties (2) *viz:* V_1= Kalizira and V_2 = BRRI dhan37 and Factor C: Spacings (4) *viz:* S_1: 20 cm × 15 cm, S_2: 25 cm × 15 cm, S_3: 20 cm × 20 cm and S_4: 25 cm × 25 cm. The total numbers of unit plots were 48. The size of unit plot was 5.04 m^2 (2.8 m × 1.8 m). The experiment was laid out in a split-split-plot design having three replications. In the main plot, there was weed control treatment and in the subplot was varieties then spacings. There were 16 treatment combinations and 48 unit plots. The unit plot size was 5.04 m^2 (2.8 m × 1.8 m). Twenty five days old seedlings of Kalizira and BRRI dhan37 rice varieties were transplanted on the well puddled experimental plots on August 3, 2019 by using two seedlings $hill^{-1}$. Bispyribac - sodium WP @ 150 g ha^{-1} post-emergence herbicide was applied at 20 DAT when weeds were 3-4 leaf stage.

The data on weed parameters were collected at 30 DAT and 60 DAT. Weed parameters such as total weed population in weedy check plot (no. m^{-2}); relative weed density (RWD %), weed density (no. m^{-2}); weed biomass (g m^{-2}); weed control efficiency (%) and weed control index were examined at different intervals. The data on growth characters *viz*. plant height, total tillers $hill^{-1}$; leaf area index; total dry matter accumulation $plant^{-1}$; crop growth rate; relative growth rate and net assimilation rate were recorded different intervals. At harvest yield and yield contributing characters like effective tillers $hill^{-1}$, non-effective tillers $hill^{-1}$, total grains $panicle^{-1}$, filled grains $panicle^{-1}$, unfilled grains $panile^{-1}$, total grains $panile^{-1}$, 1000 grain weight, grain yield, straw yield, biological yield and harvest index were recorded. Relationship between grains yield, leaf area index total dry matter production and correlation of grains yield with panicle length, grains per panicle and 1000 grains also estimated. To determine the economic viability of different treatment on aromaticrice cultivation, the total cost of production, gross return and net return were calculated to determine the benefit cost ratio.

Thirteen different weed species infested the experimental plots belonging to nine families where the most dominating was broad leaf and sedge weed species and among different weeds, *Monochoria vaginalis* was the most dominant weed (24.67 and 19.67 density m^{-2} and 15.93 and 16.98 % relative density) at 30 and 60 DAT.This was followed by *Sagittaria guayansis and Cyperus rotundus* weed species both at 30 and 60 DAT. Whilethe dominancy of *Scirpus maritimus* was least at 30 DAT and *Marsilea quadrifolia* at 60 DAT among all the weed species.

Different weed control treatment significantly effect on weeds and influence crop growth, yield and yield contributing characters. Among different treatment bispyribac - sodium WP @ 150 g ha^{-1} herbicide treated plot was recorded the minimum weed density m^{-2} (6.35 and 7.04 m^{-2}), weed dry weight m^{-2} (3.51 and 2.52 g m^{-2}). The maximum weed control efficiency (54.55 and 40.44 %) and weed control index (54.87 and 45.13 %) at 30 and 60 DAT were recorded in bispyribac - sodium WP @ 150 g ha^{-1} herbicide treated plot comparable to weedy check plot.Growth characters of rice *(viz.* plant height, number of tillers $hill^{-1}$,LAI, dry matter accumulation $plant^{-1}$ differ due to different weed control treatment. Maximum crop growth rate (CGR) (0.67 g $plant^{-1}$ day^{-1}), net assimilation rate (10.33 mg cm^{-2} day^{-1}) were higher in plots receiving bispyribac - sodium WP @ 150 g ha^{-1} herbicide comparable to weedy check.Yield contributing characters *viz.* panicle length (27.12 cm) was significantly higher under Bispyribac - sodium WP @ 150 g ha^{-1}herbicide .Yield *viz.* Grain yield, straw yield, biological yields and harvest index were differ among different treatment. Both herbicide treated and weedy check plot recorded the maximum grain yield (2.77 t ha^{-1}). Showing differences weedy check plot recorded the maximum straw yield (4.97 t ha^{-1}), biological yield (7.74 t ha^{-1}) production while Bispyribac - sodium WP @ 150 g ha^{-1} herbicide treated plot recorded the maximum harvest index (36.18 %).

Rice varieties significantly effect on weeds and influence crop growth, yield and yield contributing characters. Among different rice varieties, cultivation of BRRI dhan37 rice variety was recorded the minimum weed density m^{-2} (9.40 and 9.20 m^{-2}), weed dry weight (4.80 and 2.80 g m^{-2}), the maximum weed control efficiency (27.88 and 21.09 %) and weed control index (30.40 and 28.82 %) at 30 and 60 DAT.Growth characters of rice (*viz.* plant height, number of tillers $hill^{-1}$,LAI, dry matter accumulation $plant^{-1}$, crop growth rate (0.63 g $plant^{-1}$ day^{-1}), Relative growth rate (10.01 mg $g^{-1}day^{-1}$), were higher in BRRI dhan37 rice variety comparable to Kalizira rice variety cultivation.Yield contributing characters *viz.* the maximum effective tillers $hill^{-1}$(15.94) was recorded in BRRI dhan37 rice variety cultivation, panicle length (27.40 cm), filled grains $panicle^{-1}$ (131.44), total grains $panicle^{-1}$ (152.06) and 1000 grains weight (17.57 g) were significantly higher under BRRI dhan37 rice variety cultivation, while non effective tiller $hill^{-1}$ (0.66) and unfiled grains panicle $^{-1}$ (20.62) were markedly less under BRRI dhan37 rice variety cultivation.BRRI dhan37 gave the higher grain yield (2.99 t ha^{-1}), Biological yield (7.87 t ha^{-1}) and harvest index (37.98) was observed.

Aromatic rice cultivated at different spacing significantly effect on weeds and influence crop growth, yield and yield contributing characters. Among different treatment aromatic rice cultivated at 20 cm × 15 cm spacing given the highest minimum weed density m^{-2} (8.63 and 8.66 m^{-2}), weed dry weight m^{-2} (4.75 and 2.56 g). The maximum weed control efficiency (29.27 and 22.98 %) and weed control index (30.20 and 23.92 %) at 30 and 60 DAT were recorded in 20 cm × 20 cm pacing.Growth characters of rice (viz. plant height, number of tillers $hill^{-1}$,LAI, dry matter accumulation $plant^{-1}$ differ due to different spacing. Maximum crop growth rate (CGR) (0.64 g $plant^{-1}$ day^{-1}), relative growth rate (10.18 mg g^{-1} day^{-1}) were higher in cultivation of aromatic rice at 25 cm × 25 cm spacing.Yield contributing characters *viz*, panicle length (27.00 cm), filled grains $panicle^{-1}$ (122.69), and 1000 grains weight (16.68 g) were significantly higher aromatic rice cultivated at 20 cm × 20 cm spacing while and unfiled grains panicle $^{-1}$ (25.92) were markedly less when aromatic cultivated at 20 cm × 20 cm spacing.Yield *viz.* Grain yields, straw yields, biological yields and harvest index were significantly differ among different spacing. Aromatic rice cultivated at 20 cm × 20 cm spacing recorded the maximum grain yield (2.87 t ha^{-1}) and harvest index (36.75) while aromatic rice cultivated at 25 cm × 25 cm spacing gavethe minimum grain yield (2.57 t ha^{-1}), Biological yield (7.44 t ha^{-1}) and harvest index (34.39 %).

Bispyribac - sodium WP @ 150 g ha^{-1} herbicide along with BRRI dhan37 rice variety gave the maximum grain yield (3.04 t ha^{-1}), biological yield (7.94 t ha^{-1}) and harvest index (38.19 %) while weedy check plot along with kalizira rice variety recorded the minimum grain yield (2.59 t ha^{-1}) and harvest index. Weedy checkplot along with 20 cm × 20 cmspacing recorded the maximum grain yield (2.93 t ha^{-1}), biological yield (7.92 t ha^{-1}) and harvest index (36.99 %) test varieties.BRRI dhan37 combination of20 cm × 20 cmspacing recorded the maximum grain yield (3.13 t ha^{-1}), biological yield (8.12 t ha^{-1}) and harvest index (38.55 %)

Bispyribac - sodium WP @ 150 g ha^{-1} herbicide along with BRRI dhan37 rice variety cultivated at 20 cm × 20 cmspacing recorded the maximum grain yield (3.20 t ha^{-1}), biological yield (8.15 t ha^{-1}) and harvest index (39.03 %) while weedy check plot along with Kalizira rice variety cultivated at 25 cm × 25 cmspacinggave the minimum grain yield (2.15 t ha^{-1}), biological yield (7.13 t ha^{-1}) and harvest index (30.15 %).

Among different treatment combination maximum gross return 84970, net return 27054 and benefit cost ratio 1.48 were found bispyribac - sodium WP @ 150 g ha^{-1}treated plot along with cultivation of BRRI dhan 37 at 20 cm × 20 cm spacing.

Based on the results of the present experiment,it was observed that

There were dominance of *Monochoria vaginalis, Sagittaria guayansis and Cyperus rotundus* weed species in transplanted *aman r*iceand application of bispyribac - sodium WP @ 150 g ha^{-1} herbicide is effective for weed control.Modern aromatic rice variety was more weed suppessive and gave maximum yled (2.99 t ha^{-1}). 20 cm × 20 cm spacing reduce weed density and gave maximum yield of aromatic rice yield (2.87t ha^{-1}). Therefore, the application of bispyribac-sodium WP @ 150 g $ha^{-1}$with 20 cm × 20 cm spacing seemed to be the best way of controlling complex weed flora and enhancing productivity and profitability from transplanted aromatic rice.However,before making final conclusion further trails with the same treatment combination on different location of Bangladesh would be useful.

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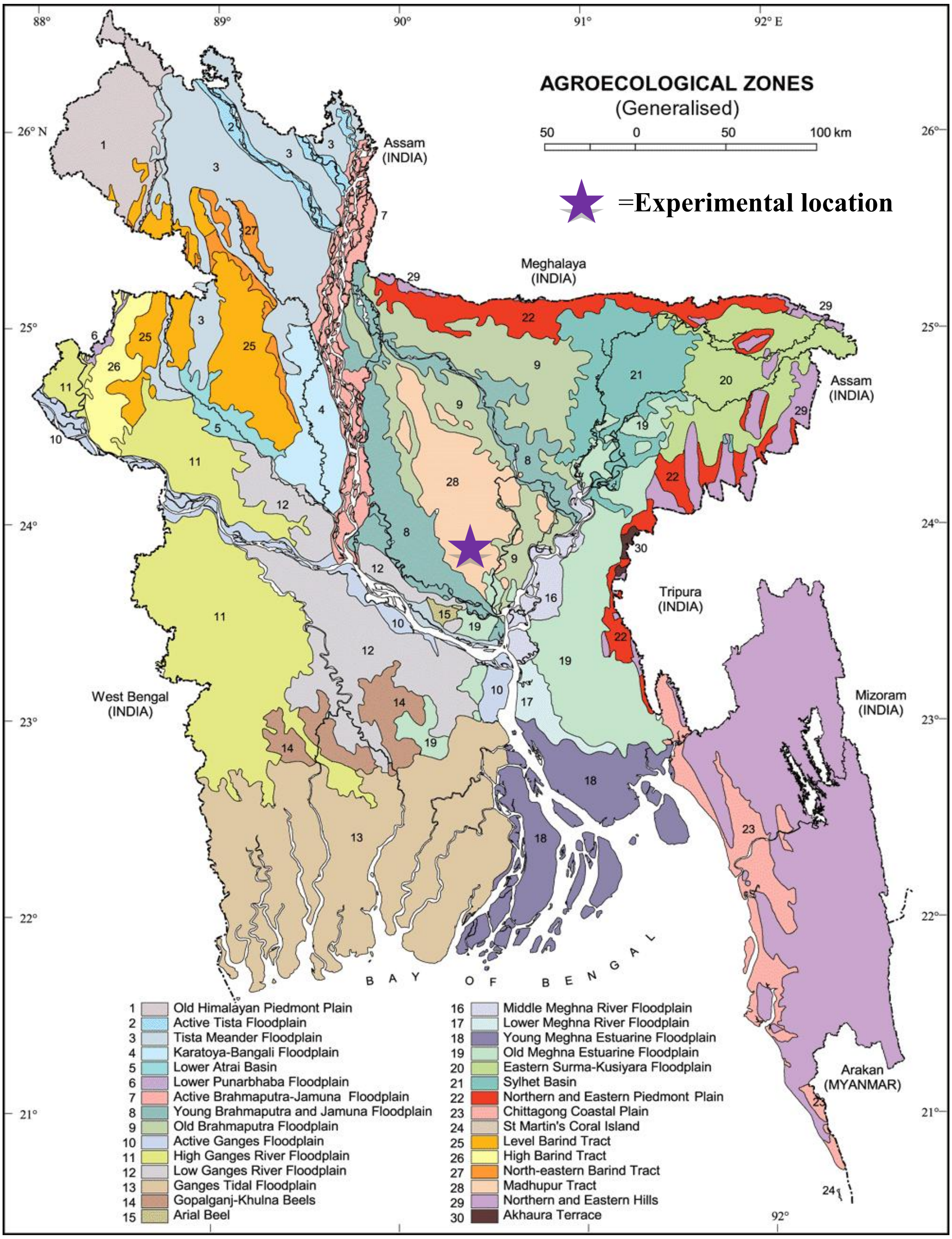
APPENDICES

Appendix I. Map showing the experimental location under study



Appendix II. Soil characteristics of the experimental field

A. Morphological features of the experimental field

Morphological features	**Characteristics**
Location	Sher-e-Bangla Agricultural University Agronomy research field, Dhaka
AEZ	AEZ-28, Modhupur Tract
General Soil Type	Shallow Red Brown Terrace Soil
Land type	High land
Soil series	Tejgaon
Topography	Fairly leveled

B. The initial physical and chemical characteristics of soil of the experimental site (0 - 15 cm depth)

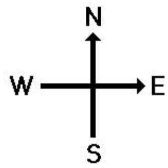
Physical characteristics	
Constituents	**Percent**
Sand	26 %
Silt	45 %
Clay	29 %
Textural class	Silty clay
Chemical characteristics	
Soil characteristics	**Value**
pH	5.6
Organic carbon (%)	0.45
Organic matter (%)	0.78
Total nitrogen (%)	0.03
Available P (ppm)	20.54
Exchangeable K (mg/100 g soil)	0.10

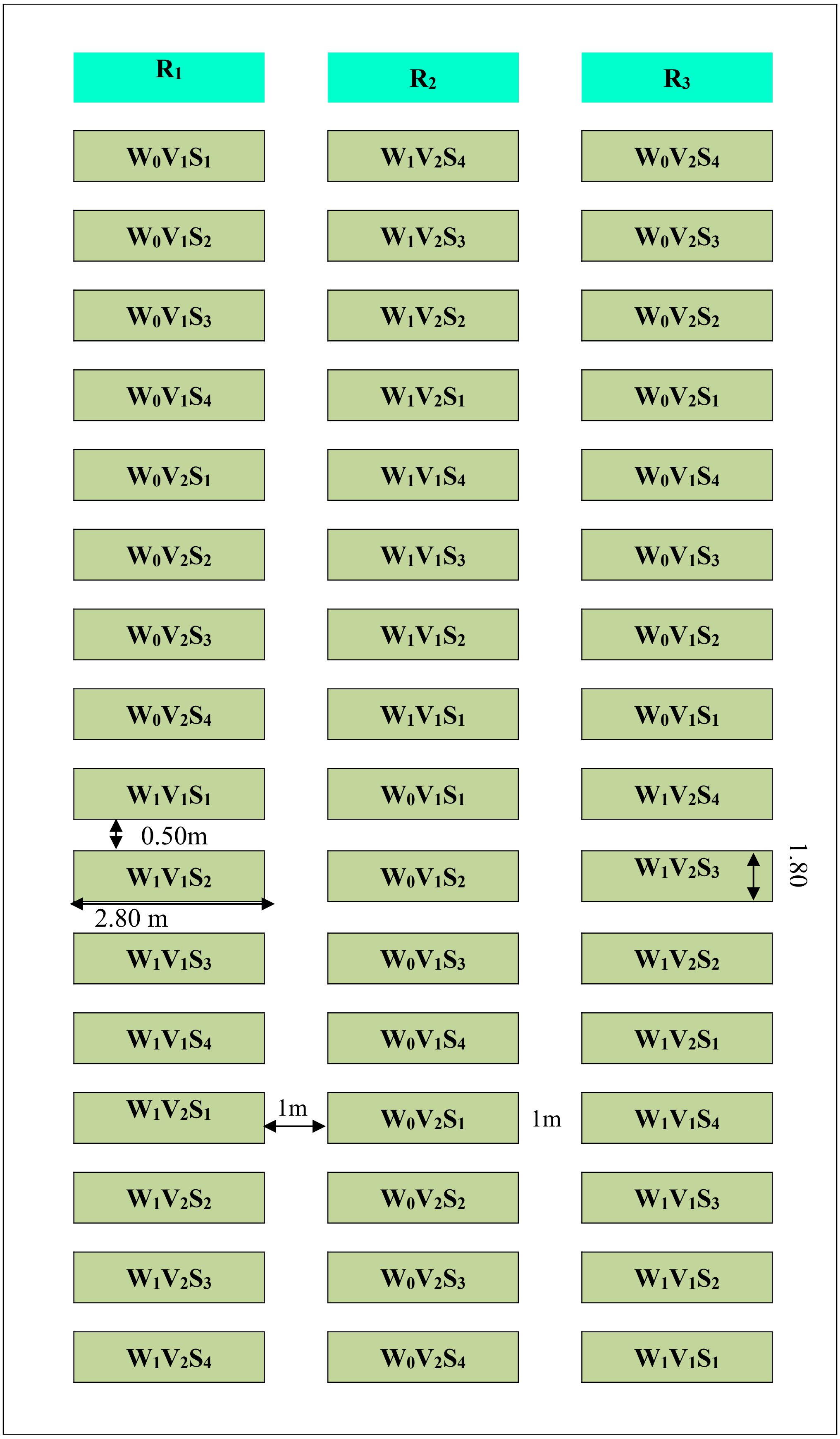
Appendix III. Monthly meteorological information during the period from July 2019 to December, 2019

Year	Month	Air temperature (^0C)		Relative humidity (%)	Total rainfall (mm)
		Maximum	Minimum		
2019	July	32.6	26.8	81	114
	August	32.6	26.5	80	106
	September	32.4	25.7	80	86
	October	31.2	23.9	76	52
	November	29.6	19.8	53	00
	December	28.8	19.1	47	00

Source: Metrological Centre, Agargaon, Dhaka (Climate Division

Appendix IV. Layout of the experimental field





LEGEND

Weed control treatments (2) viz;

W_0 = Weedy check,

Rice varieties (2) viz;

V_1= Kalizira

V_2= BRRI dhan37

Spacings (4)viz;

S_1: 20 cm×15cm

S_2: 25 cm ×15 cm

S_3: 20 cm ×20 cm

S_4: 25 cm ×25 cm

Appendix V. Analysis of variance of the data of weed density (m^{-2}) and weed dry weight ($g\ m^{-2}$) at 30 and 60 DAT

Source	Mean square of				
		Weed density (m^{-2}) at		Weed dry weight ($g\ m^{-2}$) at	
	Df	30 DAT	60 DAT	30 DAT	60 DAT
Replication (A)	2	0.037	0.113	0.002	0.0036
Weeds control (B)	1	681.54**	276.960**	203.322**	44.3329**
Error A×B	2	0.037	0.113	0.008	0.0046
Variety (C)	1	25.013**	2.871**	28.505**	21.8565**
B×C	1	0.983**	0.371*	0.005^{NS}	1.2256**
Error A×B×C	4	0.039	0.046	0.005	0.0051
Spacings (D)	3	19.887**	5.102**	7.917**	6.9848**
B×D	3	0.861**	0.944**	0.940**	0.2146**
C×D	3	0.326**	1.659**	0.057**	0.3260**
B×C×D	3	0.942**	1.939**	0.150**	0.0634**
Error A×B×C×D	24	0.020	0.053	0.007	0.0046

^{NS}: Non significant
**: Significant at 0.01 level of probability
* : Significant at 0.05 level of probability

Appendix VI. Analysis of variance of the data of weed control efficiency (%) and weed control index (%) at 30 and 60 DAT

Source	Mean square of				
		Weed control efficiency (%) at		Weed control index (%) at	
	Df	30 DAT	60 DAT	30 DAT	60 DAT
Replication (A)	2	0.5	3.0	0.8	1.3
Weeds control (B)	1	35709.1**	19620.0**	36122.0**	24445.3**
Error A×B	2	0.5	3.0	0.8	1.3
Variety (C)	1	17.3*	36.6**	423.0**	1872.3**
B×C	1	17.3*	36.6**	423.0**	1872.3**
Error A×B×C	4	1.1	1.5	0.8	0.9
Spacings (D)	3	60.2**	46.6**	186.0**	35.6**
B×D	3	60.2**	46.6**	186.0**	35.6**
C×D	3	17.1**	88.6**	11.0**	27.8**
B×C×D	3	17.1**	88.6**	11.0**	27.8**
Error A×B×C×D	24	0.3	1.5	0.3	1.1

^{NS}: Non significant
**: Significant at 0.01 level of probability
* : Significant at 0.05 level of probability

Appendix VII. Analysis of variance of the data of plant height of aromatic rice at different DAT

Mean square of plant height at							
Source	Df	15 DAT	30 DAT	45 DAT	60 DAT	90 DAT	At harvest
Replication (A)	2	0.81	5.688	1.750	35.90	22.8	84.7
Weeds control (B)	1	41.27^{NS}	123.425*	44.76^{NS}	2.93 ^{NS}	64.5 ^{NS}	14.2 ^{NS}
Error A×B	2	2.31	1.938	4.750	8.40	50.2	118.5
Variety (C)	1	1005.31**	881.425**	275.76**	6003.88**	14710.5**	18547.2**
B×C	1	11.18^{NS}	39.803*	19.241^{NS}	2.47 ^{NS}	129.8 ^{NS}	2.8 ^{NS}
Error A×B×C	4	1.56	3.813	3.250	22.15	36.5	101.6
Spacings (D)	3	40.97**	16.671**	31.262**	66.04*	253.5**	272.0**
B×D	3	8.93**	23.016**	109.066**	7.41 ^{NS}	75.4 ^{NS}	72.9*
C×D	3	13.24**	38.457**	19.423**	75.29*	96.1*	54.9 ^{NS}
B×C×D	3	4.62*	9.849*	23.262**	28.14 ^{NS}	17.9 ^{NS}	69.7 ^{NS}
Error A×B×C×D	24	1.06	3.146	2.417	20.48	29.8	23.7

^{NS}: Non significant
**: Significant at 0.01 level of probability
* : Significant at 0.05 level of probability

Appendix VIII. Analysis of variance of the data of number of tillers hill^{-1} of aromatic rice at different DAT

Mean square of number of tillers hill^{-1} at							
Source	Df	15 DAT	30 DAT	45 DAT	60 DAT	90 DAT	At harvest
Replication (A)	2	0.0362	0.1900	0.47	1.4534	1.98	0.50
Weeds control (B)	1	5.35**	0.029^{NS}	1.03 ^{NS}	3.13 ^{NS}	0.62 ^{NS}	0.65 ^{NS}
Error A×B	2	0.05	0.19	0.85	1.83	2.80	0.72
Variety (C)	1	0.87*	53.21**	6.03*	16.47*	11.90*	6.58*
B×C	1	3.32**	20.70**	20.01**	27.44**	97.55**	38.36**
Error A×B×C	4	0.04	0.19**	0.66**	0.79**	0.96**	0.61**
Spacings (D)	3	10.28**	29.80**	36.95**	43.98**	42.36**	2.39**
B×D	3	0.85**	4.64**	30.24**	22.55**	20.49**	16.32**
C×D	3	3.91**	3.55**	6.61**	8.39**	13.36**	3.16**
B×C×D	3	2.84**	5.44**	8.45**	10.48**	9.26**	11.78**
Error A×B×C×D	24	0.02	0.11	0.61	0.82	1.0142	0.4954

^{NS}: Non significant
**: Significant at 0.01 level of probability
* : Significant at 0.05 level of probability

Appendix IX. Analysis of variance of the data of leaf area index of aromatic rice at different DAT

Mean square of leaf area index at				
Source	Df	30 DAT	60 DAT	90 DAT
Replication (A)	2	0.00002	0.00792	0.01047
Weeds control (B)	1	0.00120 ^{NS}	0.07680 ^{NS}	0.13547 ^{NS}
Error A×B	2	0.00047	0.00792	0.01047
Variety (C)	1	1.66508**	6.79508**	0.78797**
B×C	1	0.00030 ^{NS}	0.00367 ^{NS}	0.00542 ^{NS}
Error A×B×C	4	0.00024	0.01242	0.00109
Spacings (D)	3	0.18823**	4.29845**	3.30052**
B×D	3	0.00025 ^{NS}	0.00925 ^{NS}	0.00262 ^{NS}
C×D	3	0.02363**	0.11523**	0.04352**
B×C×D	3	0.00035 ^{NS}	0.00052 ^{NS}	0.01207 ^{NS}
Error A×B×C×D	24	0.00021	0.01017	0.00578

^{NS}: Non significant
**: Significant at 0.01 level of probability
* : Significant at 0.05 level of probability

Appendix X. Analysis of variance of the data of dry matter accumulation plant^{-1} of aromatic rice at different DAT.

Mean square of dry matter accumulation plant^{-1}at				
Source	Df	30 DAT	60 DAT	90 DAT
Replication (A)	2	0.11109	1.033	0.462
Weeds control (B)	1	0.15527^{NS}	13.846 ^{NS}	146.224*
Error A×B	2	0.19547	2.673	2.074
Variety (C)	1	1.68975*	14.454*	14.952*
B×C	1	0.00677 ^{NS}	389.994**	747.451**
Error A×B×C	4	0.15328	1.540	1.268
Spacings (D)	3	3.17435**	98.690**	201.677**
B×D	3	1.95660**	57.209**	9.666**
C×D	3	3.18375**	147.503**	157.064**
B×C×D	3	5.35666**	26.977**	43.325**
Error A×B×C×D	24	0.14578	1.697	1.168

^{NS}: Non significant
**: Significant at 0.01 level of probability
* : Significant at 0.05 level of probability

Appendix XI. Analysis of variance of the data of crop growth rate, relative crop growth rate and net assimilation rate of aromatic rice.

Mean square of				
Source	Df	Crop growth rate	Relative crop growth rate	Net assimilation rate
Replication (A)	2	0.00005	0.0119	0.2256
Weeds control (B)	1	0.27785**	83.7950**	46.4441**
Error A×B	2	0.00038	0.0119	0.2519
Variety (C)	1	0.06534**	22.3469**	10.1365**
B×C	1	0.06403**	0.2262*	10.2044**
Error A×B×C	4	0.00019	0.0231	0.2637
Spacings (D)	3	0.02697**	4.3696**	5.7191**
B×D	3	0.04173**	15.0290**	12.0737**
C×D	3	0.16048**	46.4589**	38.7709**
B×C×D	3	0.01507**	2.3084**	2.7683**
Error A×B×C×D	24	0.00020	0.0175	0.2512

^{NS}: Non significant
**: Significant at 0.01 level of probability
* : Significant at 0.05 level of probability

Appendix XII. Analysis of variance of the data of effective tillers hill^{-1}, non-effective tillers hill^{-1} and panicle length of aromatic rice.

Mean square of				
Source	Df	Effective tillers hill^{-1}	Non-effective tillers hill^{-1}	Panicle length
Replication (A)	2	0.4375	0.00346	0.3390
Weeds control (B)	1	0.0004^{NS}	0.61880**	15.6408*
Error A×B	2	0.6458	0.00411	0.6640
Variety (C)	1	31.8502**	9.47852**	35.0892**
B×C	1	18.2040**	3.71297**	0.3888^{NS}
Error A×B×C	4	0.5417	0.00228	0.5015
Spacings (D)	3	2.8518**	0.18240**	2.4248**
B×D	3	14.6797**	0.32750**	4.2136**
C×D	3	2.2394**	0.08990**	0.8418*
B×C×D	3	9.6949**	0.35787**	1.2059*
Error A×B×C×D	24	0.4583	0.00170	0.2792
Total	47			

^{NS}: Non significant
**: Significant at 0.01 level of probability
* : Significant at 0.05 level of probability

Appendix XIII. Analysis of variance of the data of filled, unfilled, total grains panicle^{-1} and 1000 grains weight of aromatic rice.

Mean square of					
Source	Df	Filled grains panicle^{-1}	Unfilled grains panicle^{-1}	Total grains panicle^{-1}	1000- grains Weight
Replication (A)	2	44.5	0.25	47.40	0.1027
Weeds control (B)	1	513.3^{NS}	229.86**	56.16^{NS}	1.0208^{NS}
Error A×B	2	37.8	1.00	38.02	0.8112
Variety (C)	1	11925.9**	2133.87**	3970.51**	96.8440**
B×C	1	627.3**	5.67^{NS}	513.65**	0.4070^{NS}
Error A×B×C	4	12.9	0.75	11.58	0.4803
Spacings (D)	3	643.4**	20.85**	667.24**	4.3757**
B×D	3	44.2^{NS}	5.73**	30.31^{NS}	1.3575^{NS}
C×D	3	214.3**	22.21**	172.56**	1.6732*
B×C×D	3	73.5^{NS}	25.98**	165.11**	0.7388^{NS}
Error A×B×C×D	24	24.5	0.69	25.40	0.5101
Total	47				

^{NS}: Non significant
**: Significant at 0.01 level of probability
* : Significant at 0.05 level of probability

Appendix XIV. Analysis of variance of the data of on grain, straw, biological yield and harvest index of aromatic rice.

		Mean square of			
Source	Df	Grain yield	Straw yield	Biological yield	Harvest index
Replication (A)	2	0.01666	0.02771	0.05770	1.008
Weeds control (B)	1	0.00017^{NS}	0.11900^{NS}	0.11021^{NS}	2.241^{NS}
Error A×B	2	0.05553	0.02021	0.12623	2.080
Variety (C)	1	2.30125**	0.06675^{NS}	1.58413*	194.609**
B×C	1	0.08755^{NS}	0.28060*	0.68163*	0.002^{NS}
Error A×B×C	4	0.03401	0.02396	0.08388	1.620
Spacings (D)	3	0.21684**	0.08740**	0.41574**	14.770**
B×D	3	0.02607^{NS}	0.00130^{NS}	0.03723^{NS}	1.472^{NS}
C×D	3	0.26054**	0.25215**	0.95498**	8.160**
B×C×D	3	0.02997^{NS}	0.02070^{NS}	0.01488^{NS}	4.144**
Error A×B×C×D	24	0.01272	0.01062	0.03370	0.652

^{NS}: Non significant
**: Significant at 0.01 level of probability
* : Significant at 0.05 level of probability

Appendix XV. Wages and price of different items used in the experiment

i. Non material cost

Items	No. of labor required	Amount taka
Seed bed preparation	8	3200
Planting of transplanting rice plant	20	8000
Tractor operation	1	400
Harvesting & others works	20	8000
	Grand total= 19600	

(Individual labor wages 400 taka day^{-1}).

ii. Material cost

(a). Seed rate ha^{-1}	Quantity (kg/ha)	Items Cost (Tk/kg)	Cost (Tk/ha)
Spacings			
S_1: 20 cm × 15 cm	34	25	850
S_2: 25 cm × 15 cm	30	25	750
S_3: 20 cm × 20 cm	32	25	800
S_4: 25 cm × 25 cm	20	25	500

(b). Fertilizers & Others	Quantity (kg/ha)/times	Items Cost (Tk/kg)	Cost (Tk/ha)
Urea	150	16	2400
TSP	100	22	2200
MP	70	15	1050
Gypsum	60	8	480
Zinc sulphate	10	250	2500
Irrigation	2 times	2000	4000
Tractor	1	3000	3000
Pesticide	2	1500	3000
(Excluding weed controls)			Total: 18630 taka

(***Note viz***: For each spacing fertilizers and others working procedure were same)

Material cost for various spacings (a+b)

Spacings	Cost (Tk/ha)
S_1: 20 cm × 15 cm	19480
S_2: 25 cm × 15 cm	19380
S_3: 20 cm × 20 cm	19430
S_4: 25 cm × 25 cm	19130

(c). Weeds control cost

Items	Items Cost (Amount/ Taka)	Quantity/ha	Cost (Tk/ha)	Application cost (Tk) (Equipments and others)	Total cost
W_0	0	0	0	0	0
W_1	20g/126 taka	150 g/ha	945	400	1345

Note *viz. Here,* W_0 = Weedy check W_1= Bispyribac - sodium WP @ 150 g ha^{-1}

2. Overhead cost

Land value ha^{-1} was 200000 taka. Land cost at 12.5 % interest for 6 month was 12500 taka.

Appendix XVI. Total cost of production of aromatic rice variety cultivations

Non-material cost (i)	Material cost for various spacings (Excluding weeds controls) (ii. a)	Weeds control cost (ii. b)	Total input cost (A= i+ ii)	Interest on input cost @ 12.5% for 6 month (B)	Miscellaneous cost is 5% of total input cost (C)	Over head cost (D)	Total cost of production (A+B+C+D)
19600	19480	0	39080	2442	1954	12500	55976
19600	19380	0	38980	2436	1949	12500	55865
19600	19430	0	39030	2439	1951	12500	55920
19600	19130	0	38730	2420	1936	12500	55586
19600	19480	1345	40425	2526	2021	12500	57472
19600	19380	1345	40325	2520	2016	12500	57361
19600	19430	1345	40375	2523	2018	12500	57416
19600	19130	1345	40075	2504	2003	12500	57082

(Note: Fixed cost = total cost of production - weed control cost- different spacing seed rate cost)

Appendix XVII. Gross return from T. aman rice cultivation

Gross return from rice cultivation

Rice value (With husk) = 1 kg 25 taka so 1 ton = 25000 taka

Straw value= 1 kg 1 taka so 1 ton = 1000 taka

Treatment	Grain yield (t/ha)	Value	Straw yield (t/ha)	Value	Gross retrun (Tk)
$W_0V_1S_1$	2.68	67000	4.97	4970	71970
$W_0V_1S_2$	2.77	69250	5.41	5410	74660
$W_0V_1S_3$	2.78	69500	4.96	4960	74460
$W_0V_1S_4$	2.15	53750	4.98	4980	58730
$W_0V_2S_1$	2.97	74250	4.83	4830	79080
$W_0V_2S_2$	2.77	69250	4.74	4740	73990
$W_0V_2S_3$	3.08	77000	5.01	5010	82010
$W_0V_2S_4$	2.97	74250	4.83	4830	79080
$W_1V_1S_1$	2.62	65500	4.76	4760	70260
$W_1V_1S_2$	2.78	69500	5.15	5150	74650
$W_1V_1S_3$	2.45	61250	4.76	4760	66010
$W_1V_1S_4$	2.2	55000	4.64	4640	59640
$W_1V_2S_1$	3	75000	4.81	4810	79810
$W_1V_2S_2$	2.98	74500	4.83	4830	79330
$W_1V_2S_3$	3.20	80000	4.97	4970	84970
$W_1V_2S_4$	2.98	74500	5.01	5010	79510

PLATE


Plate 1. Picture showing layout of the experiment field

Plate 2. Picture showing giving net protection of the experiment field

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Plate 3. Picture showing aromatic rice varieties

Plate 4. Field view showing weeds in experiment field during early vegetative growth stage of aromatic rice

Plate 5. Field view of various weed infestation in weedy check plot

Plate 6. Picture showing weed found in experiment area