GROWTH AND YIELD PERFORMANCE OF MUNGBEAN (*Vigna radiata* L. Wilczek) UNDER THE APPLICATION OF DIFFERENT HERBICIDES

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CERTIFICATE

This is to certify that the thesis entitled **"GROWTH AND YIELD PERFORMANCE OF MUNGBEAN (*Vigna radiata* L. Wilczek) UNDER THE APPLICATION OF DIFFERENT HERBICIDES"** *submitted to the Department of AGRONOMY, 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 results of a piece of bona fide research work carried out by* ***MD. ANISUR RAHMAN,*** *Registration. No.* ***11-04458*** *under my supervision and guidance. No part of this 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.

Dated:

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GROWTH AND YIELD PERFORMANCE OF MUNGBEAN (*Vigna radiata* L. Wilczek) UNDER THE APPLICATION OF DIFFERENT HERBICIDES

ABSTRACT

An experiment was conducted at Agronomy farm of Sher-e-Bangla Agricultural University Dhaka-1207, Bangladesh during the period of March to June, 2017 to evaluate the growth and yield performance of mungbean (*Vigna radiata* L. Wilczek) under the application of different herbicides. The study had two factors, one with three varieties (V_1 = BARI Mung-5, V_2 = BARI Mung-6, V_3= BARI Mung-4) and another with four herbicides [T_1 = Whipsuper (Fenoxaprop-p-ethyl) @ 1.5 ml L^{-1}, T_2 = Panida 33 EC (Pendimethalin) @ 2.0 ml L^{-1}, T_3 = Paraxon (27.6% WV paraquat dichloride salt) @ 2.0 ml L^{-1}, T_4 = Topstar 40 WP (40% oxadiargyl) @ 1.0 g L^{-1}]. The experiment was laid out in a RCBD design using three replications. The herbicides were applied at twenty five days after emergence of mungbean seedlings and weeds were collected at 40 days after sowing from 1 m^{-2} area of each plot and oven dried to estimate weed growth. Results showed that both the varieties and herbicides and also their interactions had significant effect on most of the parameters studied. The highest number of pods plant^{-1} (23.44), number of seeds per pod (15.41), 1000-seed weight (54.54 g), pod yield (2827.63 kg ha^{-1}), seed yield (1893 kg ha^{-1}) and harvest index (24.98%) were found from the combination treatment of V_2T_4. The good performance of the herbicide topstar (T_4) was attributed to the maximum reduction (1.03 g m^{-2}) of weed population following the application of this herbicides in BARI Mung- 6. V_3T_1 showed the lowest seed yield (686 kg ha^{-1}) showing the highest values of weeds dry weight (10.33 g m^{-2}).

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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
DAS	Days after sowing
^{0}C	Degree Celsius
et al	And others
FAO	Food and Agriculture Organization
g	gram(s)
ha^{-1}	Per hectare
HI	Harvest Index
kg	Kilogram
mg	Milligram
MoP	Muriate of Potash
N	Nitrogen
No.	Number
NS	Not significant
%	Percent
SAU	Sher-e-Bangla Agricultural University
SRDI	Soil Resources and Development Institute
TSP	Triple Super Phosphate
$\Delta\psi$	Membrane potential

CHAPTER I

INTRIDUCTION

Bangladesh has climatic conditions favorable for growing a diverse array of crops including pulse. Many varieties of pulses are grown in different parts of Bangladesh. About 7.3 lakh hectare of land (9% of the net cropped area) of the country is devoted to pulse cultivation (BBS, 1999). Mung bean (*Vigna radiata* L. Wilczek) belongs to the family Fabaceae and it is an important pulse crop in Bangladesh covering an area of 162 thousand hectares of land with an annual production of 211 thousand metric ton. It is the third most important pulse crop in terms of area (101566 acres) and production (36954Mt) but ranks the highest in consumer preference and total consumption (BBS, 2016). It is a crop of the tropics and sub-tropics which requires a warm temperature regime. The optimum temperature ranges from 20°- 35°C depending upon the season.

It is a rich source of protein and several essential micronutrients. It contains 24.5% protein, and 59.9% carbohydrate. It also contains 75 mg calcium, 8.5 mg iron, and 49 mg B-Carotene per 100 g of a split. The foliage and stem are also a good source of fodder for livestock as well as a green manure. Like other leguminous crop, the crop can fix atmospheric nitrogen and improves soil fertility and fits well in many cropping systems because of its short maturity period. In Bangladesh, mungbean is grown in the area of 27.6 thousand hectares with the total production of 19.0 thousand tons with an average yield of 690 kg ha^{-1} (BBS, 1998). But the production is extremely insufficient compared to its requirement. To fulfill the demand of the country, the area and production of the crop seeds to be expanded.

The area and production of mungbean increased as 37% and 88% in 2010-11 over 2008-2009. Domestic pulse production satisfies less than half of the country’s needs. The rest, some 140,000 tones, is imported at a cost of about US$ 32.2 million per annum. Mung bean, purchased mostly from Australia, Nepal, Turkey and Canada, accounts for US$17.6 million (MoA, 2002). Mung bean seed is a rich source of protein and several essential micronutrients (Fe, Zn, b-carotene) (Bhatty, 1988).

Although many hectares are dedicated to its production, the per capita consumption of pulse in Bangladesh is only 12 gm day^{-1} which is much lower than the recommended daily consumption of 80 gm day^{-1} (FAO, 2011).

Mungbean is vulnerable to weed competition because of its short stature, slow establishment, and limited vegetative growth. Seed yield of mungbean was maximum (2108 kg ha^{-1}) in the weed free treatment and decreased by 29.5%, 23.5% and 45.8% with 160 plants m^{-2} of *Trianthema portulacastrum*, *Echinochloa colonum* and *Cyperus rotundus*, respectively (Punia *et al*., 2003). According to Raman and Krishnamoorthy (2005) presence of weeds reduced the seed yield of mungbean by 35%.

Besides causing crop losses, weeds creating competition for nutrients, space, water etc. reduce the crop yield and the quality of produce hence; reduce the market value of the turnout (Arif *et al*., 2006). As most mungbean is sown as broadcast, it is difficult to weed them and therefore, farmers do not weed at all in the mungbean field. In most cases, one to two weeding are necessary. For the success of summer production of mungbean in Bangladesh, the role of weeding needs to be emphasized (FAO/UNDP, 1984). Weed competition with mungbean persisting for 20-30 days after emergence was very critical and prolonged competition resulted in substantial yield reduction (Naeem *et al*., 1999). There are different weed control methods like manual, mechanical and chemical (herbicide) etc. But manual and mechanical weeding are laborious, time consuming and costly. Today, some herbicides are available in the market which is good to control weeds in crop fields.

Weed competition is maximal during the early stage of growth. However, the most critical period of weed competition varies with the growth behavior of the crop variety, environmental conditions, stage of growth, weed species presence and intensity of weed infestation. Weed control is a major problem in legumes, because of slow growth of seedlings and hence most of the fast-growing weeds smother pulse crops. Weed competition is very severe during rainy period, particularly at early stages (30 to 45 days after sowing) of the legume crops and hence early weed control is essential. Herbicides inhibit weed growth for a considerable period after their application as reported by Gupta (2003).

Although the vast majority of mungbean production is under rain-fed conditions, there is a little-published information on weed control with herbicides. Use of herbicides has provided producers with simple efficacious weed control and has lead to improved crop yields (Heap, 2014; Walsh and Powles, 2007).

According to Cheema *et al*. (2001) an inhibition of 44, 28 and 44% in total weed dry weight was noticed by three sorgaab sprays, one hand-weeding and pendimethalin treatment, respectively. But little information is available regarding the herbicide(s) that is actually suitable. Considering the above-mentioned facts herbicides have been selected to study the growth and development along with the yield of mungbean. It is expected that reasonable results will be obtained from this study. The objectives of the research work were as follows.

OBJECTIVES OF THE RESEARCH WORK:

a) To find out a good variety of mungbean having higher yield potential for cultivation in Bangladesh,
b) To evaluate the performance of different herbicide(s) on growth and yield attributes of mungbean plants,
c) To find out suitable herbicide(s) for controlling weeds in mungbean field and
d) To investigate the interaction effect of mungbean variety and herbicide(s) applied in mungbean field.

CHAPTER II

REVIEW OF LITERATURES

An experiment was conducted to find out the growth and yield performance of mungbean (*Vigna radiata*) under the application of different herbicides. Some closely related research findings of different researchers of national and international have been discussed in this chapter.

2.1 Effect of herbicids

Sumalapao *et al*. (2018) reported that, lactic acid is used as an environmentally safe herbicide against a variety of grass and broadleaf weed species. However, it was found to be toxic to certain leguminous weeds and may also be toxic to important legume crops including mung bean. The effect of varying concentrations of lactic acid on the growth and morphological characteristics of two types of mung bean seedlings was determined to test the possibility of its safe use on the crop. Our findings show that although an 8% lactic acid concentration was toxic to both types of mung bean, they differed in their tolerance to lower concentrations in terms of root and shoot length and fresh and dry weight of roots and shoots. Minimum tolerance was observed at 2% lactic acid for both mung bean types. These tolerable concentrations are already much higher than those reported to be toxic to certain weed species, indicating that high concentrations of lactic acid may be safe to use on mung bean. The findings of this research can provide relevant information on the potential use of lactic acid as an organic herbicide and its possible effects on the growth of mung beans as well as other important legume crops.

Marchioretto and Dal Magro (2017) stated that, there are few options of wide spectrum selective herbicides registered for post-emergence weed control in common beans crop. The experiment aimed to test crop selectivity and weed control of post-emergence herbicides on common beans. Weed control, injury and grain yield were evaluated. Treatments consisted on: cloransulam-methyl, imazethapyr, fomesafen, bentazon and diclosulam isolated and tank-mixed with clethodim; imazamox + bentazon, fomesafen + fluazifop, clethodim; cloransulam+bentazon and imazethapyr+bentazon. Treatments were tested on the cultivars 'ANfc 9', 'IPR Uirapuru' and 'BRS Estilo'.

The high-yielding treatments to the cultivar 'ANfc 9' were fomesafen alone and tank-mixed with clethodim or fluazifop, cloransulam and diclosulam tank-mixed with clethodim, and imazamox + bentazon. The high-yielding treatments with the cultivar 'IPR Uirapuru' was fomesafen tank-mixed with clethodim or fluazifop. High-yielding treatment to BRS Estilo was fomesafen + fluazifop. Bidenspilosa was controlled by all the treatments with broadleaf herbicides with exception of imazethapyr. Digitaria spp. was controlled by all treatments containing clethodim, fluazifop, fomesafen and imazethapyr. Treatments with cloransulam, diclosulam, fomesafen and imazamox were efficient to control Parthenium hysterophorus.

Aktar *et al*. (2016) was conducted a field experiment at the Pulse Research Centre of Bangladesh Agricultural Research Institute, Ishurdi, Pabna during Kharif-II season of 2010 to evaluate the efficacy of five herbicides for controlling weeds associated with mungbean (BARI Mung-6). The five herbicides such were: Paraxon (27.6% WV Paraquat dichloride salt), M-clor 5G (Butaclor), Topstar 40 WP (40% Oxadiargyl), Hammer 24 EC (Carfentrazone ethyl), and Panida 33 EC (Pendimethalin) with one control (no herbicide and also no weeding). Weed was collected species wise during weeding at 40 days after sowing from 1 m^2 area of each plot and oven dried to estimate weed growth. Among the herbicides, Panida performed the best for reducing the number and dry weight of weeds. The maximum reduction of weed population, the highest weed control efficiency, seed yield (1222 kg ha^{-1}), and maximum economic benefit were also obtained in the treatment receiving Panida 33 EC @ 2 ml L^{-1}.

Bibi *et al*. (2016) stated that, the efficiency of maize + mung bean intercropping method for yield and yield attributes were studied under different crop combination at the Research Farm of The University of Agriculture Peshawar, Pakistan during the year 2012. The study was carried out in a split-plot design with three replications. Herbicide treatments (herbicide used and herbicide not used) were assigned to main plots, while intercropping treatments (sole maize, sole mungbean, 5 rows of mungbean + 6 rows of maize, 10 row of mungbean + 6 rows of maize) were allotted to subplots. Results of the study revealed that weed density m^{-2}, fresh weed biomass in maize and mungbean crops were significantly affected by both the main-plot and sub-plot treatments. Similarly, number of seeds pod^{-1}, thousand grains weight, grain and biological yield of mungbean were also found significant.

In main plots, weed density m^{-2} (16.47) and fresh weed biomass (529.8) were lower in herbicide treated plots in mungbean crop. Number of seeds pod^{-1} (10.85), thousand grains weight (30.15g), grain yield (366.56 kg ha^{-1}) and biological yield of mungbean (1306.7 kg ha $^{-1}$) were higher in herbicide treated plots. Subplots sown with sole mungbean resulted in heavier 1000 grains weight (32.95g), higher number of seeds pod^{-1} (11), grain yield (427 kg ha^{-1}) and biological yield (1522 kg ha^{-1}). The intercropping treatments of 10 rows mungbean + 6 rows maize resulted in lighter 1000 grains weight (30.1g) and seeds pod^{-1} (10). Grain yield (269 kg ha^{-1}) and biological yield (1023 kg ha^{-1}) of mungbean were significantly lower in 5 rows mungbean + 6 row maize intercropping treatments. It is concluded from our results that sowing of mungbean as sole was the most effective in terms of mungbean grain and biological yields. Mungbean can also serve as a compatible component in intercropping system involving maize crop, based on our results.

Chaudhari *et al*. (2016) was conducted a field experiment at College farm, Navsari Agricultural University, Navsari (Gujarat) during summer season of the year 2014 to study the "Weed management study in summer green gram (*Vigna radiata* L.) under south Gujarat condition" Among the different herbicidal weed management treatments, Pendimethalin @ 1.0 kg ha^{-1} PE (T_4) recorded lowest weed population of monocot, dicot and sedge at 25, 50 and at harvest of crop, which resulted in lowest dry weight of weed (435 kg ha^{-1}), highest weed control efficiency (79.59 %) as well as lower weed index (7.55 %). Weed free treatment (T_1) registered significantly higher number of branches per plant at harvest (8.88), yield and yield attributing characters viz., number of pods per plant^{-1}(20.73) followed by T9(8.85 and 20.40), T8 (8.79 and 19.73) and T4 (8.17 and 18.40), respectively. The significantly higher seeds and stover yield (1378 and 1627 kg ha^{-1}, respectively) were recorded in weed free treatment. Effective weed control in green gram can be achieved by hand hoeing at 20 and 30 DAS during crop growth period with an alternative is application of pendimethalin 1.0 kg ha^{-1} PE.

Tamang *et al*. (2015) was carried out a field experiment at Bidhan Chandra Krishi Viswavidylaya (Nadia, West Bengal) during 2012 and 2013 (during March-May) in upland situation to judge the efficacy of the herbicides against weed flora in green gram crop field and also to find out the effect of herbicides on growth, yield and benefit cost ratio of green gram [*Vigna radiata* (L.) Wilczek] crop.

The soil of experimental site was sandy loam in texture having neutral in soil reaction. The experiment was conducted with 14 treatments and laid out in Randomized Block Design with 3 replications. The green gram variety used was IPM-2-3. It was observed that hand weeding resulted in significantly lower weed density and dry weight and gave better seed yield of green gram. Most of the herbicides were found effective in controlling weeds and maximizing seed yield of green gram. These treatments were at par with hand weeding twice at 20 and 40 DAS. Total weed free treatment showed the best performance in respect of yield and yield attributes of green gram crop and weeds management. The herbicidal treatments Fenoxaprop-p-ethyl@50 g a.i. ha^{-1} and @ 100 g a.i. ha^{-1} were found less effective for controlling weeds. Maximum benefit: cost ratio was obtained from Vellore 32(Pendimethalin 30 EC + Imazethapyr 2 EC) @1.00 kg a.i. ha^{-1}. Hand weeding treatments, though significantly reduced weed biomass and improved the grain yield, gave less benefit: cost ratio owing to higher cost of farm labour.

Shakibapour and Saeedipour (2015) reported that, crop-weed competition has a profound effect on the seed yield of mung bean. We evaluated the effects of both the seed rate and weeding regime on the weed infestation and crop performance of mung bean. Two factors via seed rate (15, 25 or 35 kg ha^{-1}) and different doses of haloxyfop-R-methyl (0, 0.4, 0.8 and 1.2 L ha^{-1}) were included in the experiment. The experiment was implemented in a split-plot design accommodating seed rate in the main plot and doses of herbicide in the subplot with four replications. Mean data from the experiment showed that weed density and weed dry weight were significantly affected by seed rate: these two variables decreased with the increase in the seed rate ($p<0.01$). The seed rate significantly influenced plant height, number of pod per plant, biological yield and seed yield. Different variables that included: Plant height, number of pod per plant, 1000 seed weight, harvest index and seed yield were significantly influenced by variations of herbicide doses. Seed yield was significantly improved in dose of 1.2 L ha^{-1}. Overall, the interaction effect of seed rate and herbicide doses was not significant in respect to the plant characteristics except harvest index and seed yield. Nevertheless, a seed rate of 35 kg ha^{-1}, coupled with volume of 0.8 L ha^{-1}, illustrated the best seed yield. Therefore, crop competition can be explored as an effective alternative weed management strategy and achieving optimal yield of mung bean.

Soltani *et al*. (2013) reported that, there are a limited number of postemergence (POST) herbicides available for weed management in mung bean production in Ontario. Five field studies were conducted in 2010, 2011 and 2012 near Exeter, Ontario and in 2011 and 2012 near Ridgetown, Ontario to determine the tolerance of mung bean to fomesafen, bentazon, bentazon + fomesafen and halosulfuron applied POST at the 1X and 2X proposed manufacturer's recommended rate. Bentazon caused 5%-29%, 4%-31%, and 2%-18% injury, fomesafen caused 3%-17%, 1%-7%, and 0%-6% injury, bentazon + fomesafen caused 6%-40%, 4%-37%, and 1%-20% injury, and halosulfuron caused 13%-65%, 8%-75%, and 5%-47% injury in mung bean at 1, 2, and 4 weeks after treatment (WAT), respectively. At Exeter, fomesafen had no adverse effect on height of mungbean but bentazon, bentazon + fomesafen and halosulfuron decreased mung bean height as much as 5% compared to the untreated control. At Ridgetown, there was no decrease in mung bean height due to the herbicides applied. Fomesafen had no adverse effect on shoot dry weight of mung bean but bentazon, bentazon + fomesafen and halosulfuron decreased shoot dry weight of mung beans as much as 43%, 47%, and 57%, respectively. Fomesafen, bentazon, bentazon + fomesafen and halosulfuron had no adverse effect on the seed moisture content and seed yield of mung bean with the exception of halosulfuron applied POST at 70 g ai ha^{-1} which increased seed moisture content 0.4% at Exeter and 1.4% at Ridgetown and decreased yield 16% at Exeter compared to the untreated control. Based on these results, there is not an adequate margin of crop safety for bentazon, bentazon + fomesafen and halosulfuron applied POST in mung bean. However, there is potential for fomesafen applied POST at the proposed manufacturer's rate of 240 g ai ha^{-1} in mung bean production.

Khaliq *et al*. (2012) stated that, cultural practices are often employed for enhancing weed competitiveness in crops and their integration with herbicides further broaden the spectrum and activity for weed suppression. A field study was carried out to evaluate the efficacy of herbicide tank mixture for weed control in direct seeded rice sown at two seeding densities (50 & 75 $kgha^{-1}$). Sunstar Gold 60WG (ethoxysulfuron ethyl) at 30 g a.i. ha^{-1} was tank mixed with Stomp 455CS (pendimethalin, 1137 g a.i. ha^{-1}) as preemergence (0 DAS), with Terminator 10WP (pyrazosulfuron ethyl, 30 g a.i. ha^{-1}), Nominee 100SC (bispyribac sodium, 30 g a.i. ha^{-1}) and Ryzelan 240SC (penoxsulam, 15 g a.i. ha^{-1}) and were applied as early post emergence (15 DAS).

A weedy check and weed free treatments were run for comparison. Higher seeding density resulted in less weed count and biomass and more grain yield even in weedy check. A combination of bispyribacsodium + ethoxysulfuron realized greater suppression of weeds both in terms of density and dry weight. This treatment also improved rice yield and kernel quality attributes over weedy check. Tank mixture of penoxsulam + ethoxysulfuron was the second effective treatment regarding its ability to suppress weeds and increase rice yield. Higher seeding density and herbicide tank mixture furnished effective weed control in direct seeded rice.

Khan *et al*. (2011) reported that, various rates of herbicide (pendimethalin) (2, 3 and 4 lha^{-1}) including hand weeding were tried for weed control, seed yield and economic return of mungbean at Arid Zone Research Institute, D.I. Khan, Pakistan during the year 2006 and 2007. Hand weeding produced higher yield (1092 and 743.3 kg ha^{-1}) compared to control (631 and 518.8 $kgha^{-1}$). Among herbicide rates the lowest rate (2 L ha^{-1}) yielded 1090 and 706.6 kg per hectare during the year 2006 and 2007, respectively. The dominant weed recorded was *Convolvulus arvensis* during both the years. All herbicidal rates including hand weeding significantly controlled the weeds. But generally, hand weeding offered the most effective control by 64 and 76 percent but at par with herbicide rate of 2 liter per hectare (54 and 75% weed control). However, hand weeding was highly labor intensive which required 30 to 32 labors per hectare for weeding and considered to be impracticable by local farmers. During 2006, herbicide dose of 2 L ha^{-1} increased the plant height (4.3 cm), pods per plant (24%), grains per pod (5%), 1000-seed weight (16%) and seed yield (73%) over control and appeared at par with hand weeding treatment in main contributing parameters of seed yield. During 2007, same dose of herbicide was also at par with hand weeding treatment which increased the plant height (19%), pods per plant (90%), grains per pod (13%), 1000-seed weight (4%) and seed yield (36%) over control. Herbicide application @ 2 L ha^{-1} also had the highest value/cost ratio (19.3) among the treatments, ranging from 9.6 to 19.3 and might be profitable approach for achieving maximum production of mungbean under rainfed conditions.

Ali *et al*. (2011) was conducted a field experiment during rainy season of 2009 on sandy loam soil to study the influence of weeds on yield of rainy season green gram (*Vigna radiata* L. Wilczek).

Application of imazethapyr 100 g ha^{-1} at 15-20 days after sowing was found most effective in reducing population and dry weight of weeds and maximum yield of green gram Quizalofop-p-ethyl 100 g ha^{-1} applied at 15-20 DAS was also equally effective.

Kundu *et al*. (2009) was undertaken field experiment during summer season of 2006 and 2007 under medium land situation of inception at instructional Farm, Bidhan Chandra Krishi Viswavidyalaya, Jaguli, Nadia, West Bengal to find out the effect of different weed management practices in mungbean. The maximum reduction of weed population, weed dry weight and the highest weed control efficiency vis-a-vis crop yield, and maximum benefit: cost ratio was obtained in the treatment receiving quizalofop-p-ethyl 50 g a.i. ha^{-1} at 21 days after emergence (DAE) + hand weeding (HW) at 28 DAE. This was closely followed by the treatment with quizalofop-p-ethyl 50 g a.i. ha^{-1} at 14 DAE + HW at 21 DAE. Weedy check treatment produced lowest yield of mungbean.

Chattha *et al*. (2007)was conducted a field study at National Agricultural Research Centre (NARC), Islamabad during two crop years (2003 - 2004) to determine the effect of different weed control methods on the yield and yield components of mungbean (*Vigna radiata* L.). In this study different weed control methods (chemical, mechanical, hand-weeding & their integration) were compared for their efficiency to control various weed species under rain-fed conditions of Pakistan. Among different weed control methods, use of herbicide tribunal 70 WP (methabenzthiazuron) @ 2 kg ha^{-1} at 2 - 3 leaf stage of weeds + hand-weeding at 50 DAS gave promising results in terms of weed reduction. This was closely followed by mechanical weeding after 20 days of crop sowing with a follow-up hand-weeding after 50 days of crop sowing and/or two hand-weeding after 20 and 40 days of crop sowing. Maximum reduction in density and biomass of the weeds was observed by chemical-weeding at 2 - 3 leaf stage of weeds + hand-weeding at 50 DAS. There was a significant increase (50%) in grain yield of mungbean due to chemical weeding at 2 - 3 leaf stage of weeds + hand-weeding at 50 DAS. Similarly, this treatment out yielded other treatments in terms of number of pods per plant, number of seeds per pod, 1000 grain weight, grain yield and net benefits. The economic analysis of these weed control methods also showed better performance of chemical-weeding at 2 - 3 leaf stage of weeds + hand weeding at 50 DAS as compared to rest of the treatments.

Reddy *et al*. (2007) were conducted field and greenhouse experiments during 2005 and 2006 at Stoneville, MS, to determine control of ragweed parthenium with several pre-emergence (PRE) and postemergence (POST) herbicides registered for use in corn, cotton, peanut, rice, and soybean. Norflurazon, pendimethalin, clomazone, diuron, fluometuron, pyrithiobac, dimethenamid, flumetsulam, imazaquin, *s*-metolachlor, metribuzin, chlorimuron, atrazine, simazine, flumioxazin, and quinclorac were applied PRE. Ragweed parthenium control was highest with norflurazon (100%) and clomazone (100%) followed by fluometuron (96%), metribuzin (90%), diuron (87%), flumioxazin (84%), chlorimuron (77%), and quinclorac (67%) at 6 wk after treatment (WAT) under greenhouse conditions. Control of ragweed parthenium was less than 58% with all other herbicides. Ragweed parthenium appears to be highly sensitive to pigment and photosynthetic inhibitors compared to herbicides with other modes of action. Glyphosate, glufosinate, paraquat, bentazon, acifluorfen, chlorimuron, halosulfuron, MSMA, bromoxynil, atrazine, 2, 4-D, flumioxazin, trifloxysulfuron, and clomazone were applied POST to field-grown rosette and bolted plants. Glyphosate, glufosinate, chlorimuron, and trifloxysulfuron applied at rosette stage provided greater than 93% control of ragweed parthenium at 3 WAT. Halosulfuron, MSMA, bromoxynil, 2, 4-D, and flumioxazin controlled 58 to 90% rosette ragweed parthenium at 3 WAT. Ragweed parthenium control with all other POST herbicides was less than 38%. At bolted stage, glyphosate, glufosinate, and trifloxysulfuron controlled 86 to 95% ragweed parthenium and control was 61 to 70% with chlorimuron, halosulfuron, and 2, 4-D 3 WAT. Overall, efficacy of POST herbicides was better on rosette plants than on bolted plants. Amino acid synthesis and glutamine synthase inhibitors were more active than herbicides with other modes of action. These results indicate that norflurazon, clomazone, fluometuron, flumioxazin, halosulfuron, chlorimuron, and trifloxysulfuron could provide effective control of ragweed parthenium.

Machado *et al*. (2006) stated that, this work aimed to evaluate the efficacy of combining the herbicides fomesafen, fluazifop-p-butyl and bentazon for integrated weed management in bean culture (no-tillage and conventional tillage), in areas previously cultivated with maize for grain and silage. Fomesafen residue in the soil was also evaluated at 125 days after application (DAA).

In the conventional tillage, *Cyperus rotundus* was the dominant species, while under no-tillage, infestation of this species was very low. None of the herbicide combinations was efficient in controlling C. rotundus. Except for fluazifop-p-butyl + bentazon (125 + 480 g ha^{-1}), all the combinations were efficient in controlling the dicotyledonous weed species. The herbicide treatments had no effect on bean productivity. Fomesafen, applied under no-tillage, caused toxicity to the bean culture after the dose of 100 g ha^{-1}, especially to silage corn. Under the conventional tillage, milder symptoms were only observed at the dose of 200 g ha^{-1}. Fomesafen residue was found in the soil only in the no-tillage area without straw on the soil surface, in the area previously cultivated with maize for silage. Fomesafen doses can be reduced when mixed with bentazon without affecting bean productivity. In areas where bean was cultivated after maize harvest for silage, it is important to use small doses of fomesafen to prevent subsequent toxicity of sensitive cultures.

Kozlowski *et al.* (2002) was carried out a field experimentat the Training Farm of Ponta Grossa State University, in Ponta Grossa-PR, Brazil, during the 1996/1997 growing season to determine the critical period of weed interference in the common bean under direct seeding system, associated with the phenological stage of the common bean growth. The experimental design was a randomized complete block arranged in a 2 x 8 factorial, with four replications. The 16 treatments tested resulted from a combination of two groups of weed interference treatments: (a) relative weedy period, and (b) relative weed-free period, in seven physiological stages of bean growth: V2, V3, V4, R5, R6, R7 and R8, and a check plot with the crop in coexistence with the weeds. The experiment was carried out on an area 8 year under direct seeding system. Sowing, fertilization, and insect and disease control were performed according to the technology recommended for the crop. The weed interference critical period occurred between the V4 and R6 phenological stages of growth, and bean yield was reduced in 71% when the crop was maintained in coexistence with the weeds during all the crop cycle. Regarding weed composition, the dicotyledons class of weed represented 61.3%, being *Bidenspilosa* and *Richardia brasiliensis* the most prevalent, with 30.6% and 16.6%, respectively. Monocotyledons represented 38.7%, and *Digitariahorizontalis* and *Brachiariaplantaginea*, were the most prevalent, with 23.6% and 14.3%, respectively.

Naeem *et al*. (1999) stated that, weed count, weed fresh weight m^{-2} of mungbean were found to be significantly different in various weed control treatments. However, maximum values of these parameters were obtained in weedy check and minimum in hand weeding treatments. Almost all herbicides at either dose or method of application produced similar results.

Chanprasert *et al*. (1993) reported that, effects of planting date and weed control by post emergence herbicide (imazethapyr 5 percent ai.) on mungbean seed quality and observations on seed storability of different mungbean cultivars were separately experimented. The results of planting date experiment showed that mungbean seeds of April to October 1989 planting dates were poorer in quality than seeds of March, November and December 1989 planting dates due mainly to the weathering effects during seed development and maturation in the field. For the effect of weed control on mungbean seed quality, seeds harvested from uncontrolled weed plots showed lower germination than seeds harvested from plots treated with post-emergence herbicide (imazethapyr) at the rate of 400 or 800 ml/rai. High competition between crop plants and weeds may cause a poorer food reserves in mungbean seeds from uncontrolled plots resulting in a poorer seed germinability. Poor ventilation and high humidity in the crop canopy of uncontrolled weed plots was suspected to be one of the causes. For the seed storability study, the 5 mungbean cultivars studied i.e. Uthong 1, KamphaengSaen 1, KamphaengSaen 2, Chainat 60 and PSU 1 maintained their seed germinabilities up to 7 months under ambient conditions with germination percentages higher than 90. There were no significant differences between cultivars in this study. Seed vigour measured by accelerated aging test and electrical conductivity test was decreased rapidly after 3 months of storage.

Moreland and Novitzky (1988) stated that, alterations imposed by herbicides on the membrane potential ($\Delta\psi$), oxygen utilization, and ATP synthesis of intact mung bean mitochondria were measured under state 3 conditions. Effects were correlated with changes imposed by classical electron transport inhibitors, energy transfer inhibitors, and uncouples. In the dose-response studies, complete inhibition of ATP synthesis produced by electron transport inhibitors (rotenone, antimycin A, KCN), uncouples [bis (hexafluoroacetonyl) acetone (1799) and carbonyl cyanide 4-trifluoromethoxyphenylhydrazone (FCCP)], and the herbicides was associated with a decrease in $\Delta\psi$ from the state 3 value of 126 mV to between 90 and 100 mV.

In contrast, the complete inhibition of phosphorylation produced by the energy transfer inhibitor *N,N′*-dicyclohexylcarbodimide correlated with an increase in Δψ from the state 3 to the state 4 potential (145 mV). In the titrations, the herbicides and classical uncouplers, but not the electron transport inhibitors, progressively collapsed Δψ below the potential associated with the complete inhibition of phosphorylation (to the apparent Donnan potential of 60 mV). The herbicides could be placed into two groups according to the dose-response relationships exhibited with respect to Δψ and oxygen utilization. The first group, designated as dinoseb types (dinitrophenols, benzimidazoles, benzonitriles, thiadiazoles, and bromofenoxim), uncoupled phosphorylation and collapsed Δψ to the Donnan level before oxygen utilization was inhibited. These compounds possess dissociable protons and are postulated to act as protonophores, much like 1799 and FCCP. With the second group, termed dicryl types (acylanilides, dinitroanilines, diphenylethers, bis-carbamates, and perfluidone), collapse of Δψ was paralleled by uncoupling of phosphorylation and inhibition of oxygen utilization. However, phosphorylation was inhibited to a greater extent than was respiration. The dicryl-type herbicides are not classical-type protonophores. Some of their action can be attributed to interference with the redox pumps. The complete collapse of Δψ to the Donnan potential is associated with alterations and perturbations induced in the membranes by classical uncouplers and by both types of herbicides. The perturbations are postulated to increase the permeability of the membranes to protons and other cations and to induce unfavorable conformational changes that impede interactions between redox enzymes. Conceivably, the combined responses collapse Δψ and inhibit electron transport.

Yadav *et al*. (1982) were conducted a field experiments in Haryana, India, to measure the effect on mung bean (*Vigna radiata* (L.) Wilczek) fields of six herbicides (fluchloralin, bentazone, alachlor, nitrofen, oxyfluorfen and prometryne) applied at different rates, compared with results in hand-hoed, weedy and weed-free control plots during two growing seasons. Application of fluchloralin at 1–2 kg a.i. ha^{-1} and alachlor at 1 kg a.i. ha^{-1} effectively controlled the major weeds *(Echinochloa colonum* (L.) *Trianthema monogyna* L. gave rise to a significantly higher grain yield than the weedy control. Prometryne controlled the weeds but had an adverse effect on crop growth and hence *on* yield. Nitrofen and bentazone did not provide satisfactory weed control in mung bean fields.

2.2 Effect of varieties

Lertmongkol*et al*. (2011) reported that, mungbean contains allelochemicals that can either inhibit or promote the growth and yield of subsequent crops in certain cropping systems. To examine the role of mungbean in a cropping system, the allelopathic effects of mungbean on the seed germination and plant growth of subsequent crops were evaluated in laboratory and pot experiments. In the laboratory experiment, the allelochemicals in mungbean inhibited the germination and root length of lettuce, whereas it had no negative effect on *Echinochloa crusgalli* seed germination. The pot experiment revealed that allelochemicals from decomposed mungbean in soil reduced the seed germination and plant height of subsequent crops especially in soybean (Glycine max) and lettuce (*Lactuca sativa*). The seed germination of soybean and lettuce was severely inhibited while the plant height of *Echinochloa crus-galli* was reduced. A high-performance liquid chromatogram of the allelochemical compounds from the mungbean root and stem was composed of one major peak that had a retention time identical to that of thioglycerol and four other different peaks with one of these peaks having a retention time similar to that of aglycone.

Uddin *et al*. (2009) was carried out an experiment in experimental field of the department of Agronomy, Sher-e-Bangla Agricultural University, Dhaka, Bangladesh to investigate the interaction effect of variety and fertilizers on the growth and yield of summer Mungbean during the summer season of 2007. Five levels of fertilizer viz. control, N + P +K, Biofertilizer, Biofertilizer + N + P + K and Bio-fertilizer + P + K. and three varieties BARI Mung-5, BARI Mung-6 and BINA mung 5 were also used as experimental variables. The experiment was laid out in Randomized Block Design with fifteen treatments where each treatment was replicated three times. Results showed that most of the growth and yield component of mungbean viz. plant height, branch plant^{-1}, number of nodules plant^{-1}, total dry matter plant^{-1}, pods plant^{-1}, seed plant^{-1}, seed pod^{-1}, weight of 1000-seeds, seed yield and straw yield were significantly influence by the bio-fertilizer (Bradyrhyzobium inoculums) treatment except number of leaves and dry weight of nodule. These are influenced by chemical fertilizer and biofertilizer also. All the parameters performed better in case of Bradyrhyzobium inoculums. BARI Mung-6 obtained highest number of nodule plant^{-1} and higher dry weight of nodule.

It also obtained highest number of pod plant^{-1}, seed plant^{-1}, 1000 seed weight and seed yield. Interaction effect of variety and bio-fertilizer (Bradyrhyzobium) inoculation was significant of all the parameters. BARI mung 6 with Bradyrhyzobium inoculums produced the highest number of nodule and pod plant^{-1}. It also showed the highest seed yield, Stover yield and 1000-seed weight.

Wang and Daun (2004) reported that, protein content was used as an indicator of environmental conditions for a study on varietal and environmental variation in proximate composition, minerals, amino acids and certain antinutrients of field peas. Four field pea varieties, each with three levels of protein content, were selected. Crude protein content overall ranged from 20.2 to 26.7%. Analysis of variance showed that both variety and environmental conditions had a significant effect on starch, acid detergent fibre (ADF), neutral detergent fibre (NDF) and fat content, but ash content was only affected by variety. Significant varietal and environmental differences in potassium (K), manganese (Mn) and phosphorus (P) were noted. Calcium (Ca) and copper (Cu) showed significant varietal differences, while iron (Fe), magnesium (Mg) and zinc (Zn) had significant environmental differences. Environmental conditions showed significant effects on alanine, glycine, isoleucine, lysine and threonine content. Variety had a significant effect on sucrose, raffinose and phytic acid content, whereas environmental conditions had an influence on trypsin inhibitor activity (TIA). The major pea components protein and starch were inversely correlated. ADF, NDF, Fe, Mg, Zn and the amino acid arginine were positively correlated with protein content. The amino acids glycine, histidine, isoleucine, lysine and threonine were negatively correlated with protein content. It was found that tryptophan was the most deficient amino acid and the sulphur-containing amino acids were the second limiting amino acids in peas. Raffinose was positively correlated with sucrose but negatively correlated with verbascose. There were significant correlations between mineral contents and some of the proximate components.

Sarkar *et al.* (2004) was carried out an experiment to study the effect of planting date and plant density on the yield and yield attributes of five varieties of mungbean. The experiment comprised of four planting dates viz. 03 February,18 February, 05 March and 20 March, five varieties viz. BARI Mung-2, BARI Mung-3, BARI Mung-4, BARI Mung-5 and BINA Mung-2 and three planting densities viz., 20x20 cm, 30x10 cm and 40x30 cm.

The experiment was laid out in a split-split plot design with three replications. It was observed that early planted (03 and 18 February) crops produced higher yield as compared to late planted (05 and 20 March) crops. Variety BARI Mung-2, BARI Mung-3 and BARI Mung-4 produced higher seed yield as compared to variety BARI Mung-5 and BINA Mung-2.The 30x10 cm plant density always showed the highest yield performance. Variety BINA Mung-2 produced the highest branches plant^{-1}when planted on 03 February at a spacing of 40x30 cm. The highest pods plant^{-1} was found in the variety BARI Mung-3 when planted at a density of 30x10 cm and planted on 18 February. Pod length was the highest in variety BARI Mung-5 planted on 05 March with a plant density of 20x20 cm. The highest 1000- seed weight was obtained in case of variety BARI Mung-5 planted on 03 February at densities of 20x20 cm and 30x10 cm. Variety BARI Mung-2 planted on 3 February at plant density of 30x10 cm significantly produced the highest seed yield and harvest index and the lowest seed yield and harvest index were found in the variety BARI Mung-3 planted on 20 March at a plant density of 40x30 cm.

CHAPTER III

MATERIALS AND METHODS

The experiment was conducted at the Agronomy field, Sher-e-Bangla Agricultural University, Dhaka-1207 during the period from March to June, 2017. Detailed of the experimental materials and methods followed in the study are presented in this chapter. The experiment was conducted to study the growth and yield performance of mungbean (*Vigna radiata* L.) under the application of different herbicides.

3.1 Site description

3.1.1 Geographical location

The experimental area was situated at 23°77′N latitude and 90°33′E longitude at an altitude of 8.6 meter above the sea level (Anon., 2004).

3.1.2 Agro-ecological region

The experimental field belongs to the Agro-ecological zone of "The Modhupur Tract", AEZ-28 (Anon., 1988a). This was a region of complex relief and soils developed over the Modhupur clay, where flood plain sediments buried the dissected edges of the Modhupur Tract leaving small hillocks of red soils as 'islands' surrounded by floodplain (Anon., 1988b).

3.1.3 Climate

The area has sub-tropical climate, characterized by high temperature, high relative humidity and heavy rainfall with occasional gusty winds in Kharif season (April-September) and scanty rainfall associated with moderately low temperature during the Rabi season (October-March). Weather information regarding temperature, relative humidity and rainfall prevailed at the experimental site during the study period were presented in Appendix I.

3.1.4 Soil

The soil of the experimental site belongs to the general soil type, Shallow Red Brown Terrace Soils under Tejgaon Series. Top soils were clay loam in texture, olive-gray with common fine to medium distinct dark yellowish brown mottles.

Soil pH ranged from 5.6-6.5 and had organic matter 1.10-1.99%. The experimental area was flat having available irrigation and drainage system and above flood level. Soil samples from 0-15 cm depths were collected from experimental field. The analyses were done by Soil Resource and Development Institute (SRDI), Dhaka. The physical and chemical properties of the soil were presented in Appendix II.

3.2 Details of the experiment

3.2.1 Treatments

The experiment consisted of 2 factors:

Factors A: Variety (3)

(a) V_1 = BARI Mung-5
(b) V_2 = BARI Mung-6
(c) V_3= BARI Mung-4

Factors B: Herbicide (4)

(a) T_1= Whipsuper (Fenoxaprop-p-ethyl) @ 1.5 ml L^{-1}
(b) T_2 = Panida 33 EC (Pendimethalion) @ 2.0 ml L^{-1}
(c) T_3 = Paraxon (27.6% WV paraquat dichloride salt) @ 2.0 ml L^{-1}
(d) T_4 = Topstar 40 WP (40% oxadiargyl) @ 1.0 g L^{-1}

3.2.2 Experimental design and layout

The experiment was laid out in a factorial RCBD design with three replications. There were 12 treatment combinations. The total numbers of unit plots were 36. The size of unit plot was 3.50 m × 1.50 m. The distances between plot to plot and replication to replication were 0.75 m and 1.0 m, respectively.

3.3 Crop/Planting Material

As per the treatment, BARI Mung-4, BARI Mung-5 and BARI Mung-6 were used as planting material.

3.3.1 Description of crop

Variety (BARI Mung-4)

This variety was developed at 1996 from local cross (BMX 841121). Plant height: 52-57 cm. Resistant to YMV and CLS. Photo Insensitive. Protein: 23.1%, CHO: 51.32%. Head dhal Yield: 68%. Cooking Time: 17 min. 1000-seed weight: 31.9g. Seed Yield: 1.1-1.3t/ha. Duration: 60-65 days (BARI, 2013).

Variety (BARI Mung-5)

This variety was introduced (1997) from AVRDC (NM- 92). Plant height: 41-46 cm. Resistant to YMV and CLS. Photo Insensitive. Protein: 20.93%, CHO: 49.46%. Head dhal Yield: 68%. Cooking Time: 18 min. Quite Synchrony in maturity. 1000-seed weight: 41.9g. Seed yield: 1.40-1.45 t ha^{-1}. Duration: 58-60 days (BARI, 2013).

Variety (BARI Mung-6)

The seeds of BARI Mung-6, a modern mungbean variety was used as experimental material. BARI Mung-6 was developed by Bangladesh Agricultural Research Institute (BARI). The plants life cycle lasts for 55-58 days and synchronous type. The plants are erect, stiff and less branched. Each plant contains 15-20 pods. Each pod is around 10 cm long and contains 8-10 seeds. Seeds are large and green in color and drum shaped. The seed yield of BARI Mung-6 range from 1.4-1.5 t ha^{-1}(BARI, 2013).

3.3.2 Description of recommended chemical fertilizer

The recommended chemical fertilizer dose was 50, 100, 55 and 1 kg ha^{-1} of Urea, TSP (triple super phosphate), MoP (muriate of potash) and BA (boric acid) respectively ((BARI, 2013)). All the fertilizers along with half of urea were applied by broadcasting and was mixed with soil thoroughly at the time of final land preparation after making plot.

3.4 Crop management

3.4.1 Seed collection

Seeds of BARI Mung-4, BARI Mung-5 and BARI Mung-6 were collected from Pulse Seed Section, BARI, Joydebpur, Gazipur, Bangladesh.

3.4.2 Seed sowing

The seeds of BARI Mung-6, BARI Mung-5 and BARI Mung-4 were sown by hand in 30 cm apart from lines with continuous spacing at about 3 cm depth at the rate of 40 g $plot^{-1}$.

3.4.3 Collection and preparation of initial soil sample

The soil sample of the experimental field was collected before fertilizer application. The initial soil samples were collected before land preparation from a 0-15 cm soil depth. The samples were collected by an auger from different location covering the whole experimental plot and mixed thoroughly to make a composite sample. After collection of soil samples, the plant roots, leaves etc. were removed. Then the samples were air-dried and sieved through a 10-mesh sieve and stored in a clean plastic container for physical and chemical analysis.

3.4.4 Preparation of experimental land

A pre- sowing irrigation was given on 15March, 2017. The land was open with the help of a tractor drawn disc harrow on 25March, 2017, then ploughed with rotary plough twice followed by laddering to achieve a medium tilth required for the crop under consideration. All weeds and other plant residues of previous crop were removed from the field. Immediately after final land preparation, the field layout was made on March 28, 2017 according to experimental specification. Individual plots were cleaned and finally prepared the plot.

3.4.5 Fertilizer application

The specific plots area was fertilized @ 50, 100, 55 and 1 kg ha^{-1} of Urea, TSP, MoP, BA and 10 t ha^{-1}cowdung respectively. The entire amounts of triple super phosphate (TSP), boric acid (BA) and cowdung were applied as basal dose at final land preparation.

3.4.6 Intercultural operations

3.4.6.1 Thinning

The plots were thinned out on 15 days after sowing to maintain a uniform plant stand.

3.4.6.2 Weeding

The crop was infested with weeds during the early stage of crop establishment. To control weeds, herbicide was used as per the treatment.

3.4.6.3 Application of irrigation water

Irrigation water was added to each plot, first irrigation was done as pre-sowing and other one was given 2-3 days before weeding.

3.4.6.4 Drainage

There was a heavy rainfall during the experimental period. Drainage channel were properly prepared to easy and quick drained out of excess water.

3.4.6.5 Plant protection measures

The crop was infested by insects and diseases, those were effectively and timely controlled by applying recommended insecticides and fungicides. Black ant controlled by sevin-5at 30 DAS.

3.4.7 Harvesting and post-harvest operation

Maturity of crop was determined when 80-90% of the pods become blackish in color. The harvesting of BARI Mung-6, BARI Mung-5and BARI Mung-4 were done up to 14June, 2017. Five pre-selected plants per plot from which different yield attributing data were collected and 1.0 m^2 areas from middle portion of each plot was separately harvested and bundled, properly tagged and then brought to the threshing floor for recording grain and straw yield. 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 determined and converted to kg ha^{-1}.

3.4.8 Recording of data

Emergence of plants were counted from starting to a constant number of plants m^{-2} area of each plot. Experimental data were determined from 15 days of growth duration and continued until harvest. Dry weights of plant were collected by harvesting respective number of plants at different specific dates from the inner rows leaving border rows and harvest area for grain. The following data were recorded during the experimentation.

A. Crop growth characters

i. Plant height (cm)

ii. Leaves plant^{-1}(No.)

iii. Branches plant $^{-1}$(No.)

iv. Plant dry weight (g)

v. Nodules plant^{-1}(No.)

vi. Dry weight of nodules plant^{-1}(g)

B. Yield and other crop characters

i. Pods plant^{-1}(No.)

ii. Seeds pod^{-1}(No.)

iii. Weight of 1000-seed (g)

iv. Pod yield (kg ha^{-1})

v. Seed yield (kg ha^{-1})

vi. Harvest index (%)

C. Weed Data

i. Dry weight of weed

3.4.9 Detailed procedures of recording data

A brief outline of the data recording procedure followed during the study given below:

A. Crop growth characters

3.4.9.1 Plant height

Plant height of 5 selected plants from each plot was measured at 30, 60 days after sowing (DAS) and at harvest. The height of the plant was determined by measuring the distance from the soil surface to the tip of the leaf of main shoot.

3.4.9.2 Leaves plant^{-1}(No.)

Leaves plant^{-1} of 5 selected plants from each plot was measured at 30, 60 days after sowing (DAS) and at harvest. The number of leaves plant^{-1} was determined and average together.

3.4.9.3 Dry weight of plant

The sub-samples of 5 plant plot^{-1} uprooted from second line were oven dried until a constant leveled, from which the weights of above ground dry matter were recorded at 30 days intervals and at harvest.

3.4.9.4 Nodules (No.)

The 5 plants plot^{-1} from second line was uprooted with the help of spade. The roots of the sample plants were washed gently and total number of nodules from five plants was counted at 20, 35 and 50 DAS and the mean value determined.

3.4.9.5 Nodules dry weight

Nodules were oven dried and then dry weight of nodules was measured in milligram.

B. Yield and other crop characters

3.4.9.6 Branches plant^{-1}(No.)

Branches number was counted from ten pre-selected plants and the mean value was determined.

3.4.9.7 Pods plant^{-1}

Pods of ten selected plants were counted and the average pods for each plant was determined.

3.4.9.8 Seeds pod^{-1}

Pods from each of ten plants plot^{-1} were separated from which ten pods were selected randomly. The number of seeds pod^{-1} was counted and average number of seeds pod^{-1} was determined.

3.4.9.9 Weight of 1000-seed

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 were expressed in gram.

3.4.9.10 Pod yield

Pod yield was determined from the central 1 m^2 area of each plot. After separation of pods, the sub-samples were oven dried to a constant weight and finally converted to kg ha^{-1}.

3.4.9.11 Seed yield

Grain yield was determined from the central 1 m^2 area of each plot and expressed as t ha^{-1} and adjusted with 12% moisture basis. Moisture content was measured by using a digital moisture tester.

3.4.9.12 Harvest index

Harvest index denotes the ratio of economic yield (seed yield) to biological yield and was calculated with following formula (Donald, 1963; Gardner *et al*., 1985).

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

3.4.9.13 Weeds dry weight

Weeding was done from 1 m^{-2} each plot and keep in oven. After that oven dry weight of weeds was measured in g.

3.4.11 Statistical analysis

All the collected data were analyzed following the analysis of variance (ANOVA) technique using a statistical computer software Statistix 10 and the means were adjusted by DMRT(Duncan's Multiple Range Test) test at 5% level of significance.

CHAPTER IV

RESULTS AND DISCUSSION

This chapter represent the result and discussions of the present study entitled growth and yield performance of mungbean (*Vigna radiata L.*) under application of different herbicides. Summary of mean square values at different parameters are also given in the appendices. Tables and figures have been presented on where required.

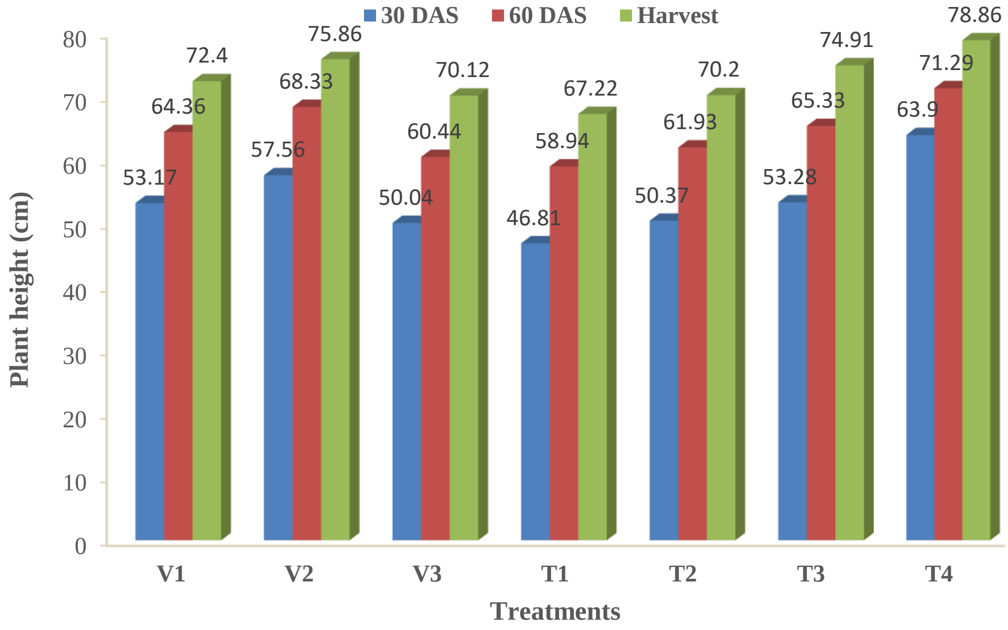
4.1 Plant height

4.1.1 Influence of varieties

Plant height of mungbean is positively affected by the varieties and showed statistically significant variation (Fig. 1 and Appendix III). The tallest mungbean plant (57.56 cm, 68.33 cm and 75.86 cm at 30 DAS, 60 DAS and at harvest, respectively) was found in V_2 and shortest plant (50.04 cm, 60.44 cm and 70.12 cm at 30 DAS, 60 DAS and at harvest, respectively) was recorded in V_3. The plant height is directly associated with the varieties of mungbean. The finding is close conformity of finding Lertmongkol *et al*. (2011).

4.1.2 Influence of herbicides

Application of different herbicides had positively significant impact on plant height of mungbean (Fig. 1 and Appendix III). The plant height range was 46.81 cm to 78 cm from 30 DAS to harvest time. The tallest plant (63.9 cm, 71.29 cm and 78.86 cm at 30 DAS, 60 DAS and harvest time respectively) was recorded in T_4 and shortest plant (46.81 cm, 58.94 cm and 67.22 cm at 30 DAS, 60 DAS and harvest time respectively) was found in T_1. Our finding agreed with the finding of Sumalapao *et al*. (2018), Marchioretto and Dal Magro (2017), Aktar *et al*. (2016), Bibi *et al*. (2016), Chaudhari *et al*. (2016).



DAS= Day after sowing; V_1 = BARI Mung-5, V_2 = BARI Mung-6, V_3= BARI Mung-4; T_1 = Whipsuper, T_2 = Panida 33 EC, T_3 = Paraxon, T_4 = Topstar 40 WP

Fig. 1. Influence of varieties and herbicide on plant height of mungbean

4.1.3 Combine effect of varieties and herbicides

Combine effect of varieties and herbicides produced positively significant plant height only at harvest (Table 1 and appendix IV).The tallest plant (68.79 cm, 77.26 cm and 81.86 cm at 30 DAS, 60 DAS and at harvest times, respectively) was found in V_2T_4 combine compared to others combinations. The shortest plant was produced by V_3T_1 (45.49 cm and 57.79 cm at 30 DAS and 60 DAS) and V_1T_1 (64.96 cm at harvest).

Table 1. Combine effect of varieties and herbicide on plant height of mungbean

Treatments	Plant height (cm) at		
	30 DAS	**60 DAS**	**Harvest**
V_1T_1	46.22	59.09	64.96 f
V_1T_2	49.48	60.50	68.23 ef
V_1T_3	52.92	65.29	77.73 a-c
V_1T_4	65.62	73.86	79.99 ab
V_2T_1	49.89	60.93	71.33 de
V_2T_2	55.29	66.53	75.29 b-d
V_2T_3	57.82	69.89	76.33 a-d
V_2T_4	68.79	77.26	81.86 a
V_3T_1	45.49	57.79	66.36 ef
V_3T_2	47.52	59.76	68.06 ef
V_3T_3	50.26	61.79	71.66 c-e
V_3T_4	58.46	63.73	75.69 a-d
SE (±)	**NS**	**NS**	**1.246**
CV (%)	**3.49**	**4.14**	**2.90**

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

DAS= Day after sowing; V_1 = BARI Mung 5, V_2 = BARI Mung 6, V_3= BARI Mung 4; T_1 = Whipsuper, T_2 = Panida 33 EC, T_3 = Paraxon, T_4 = Topstar 40 WP

4.2 Number of leaves

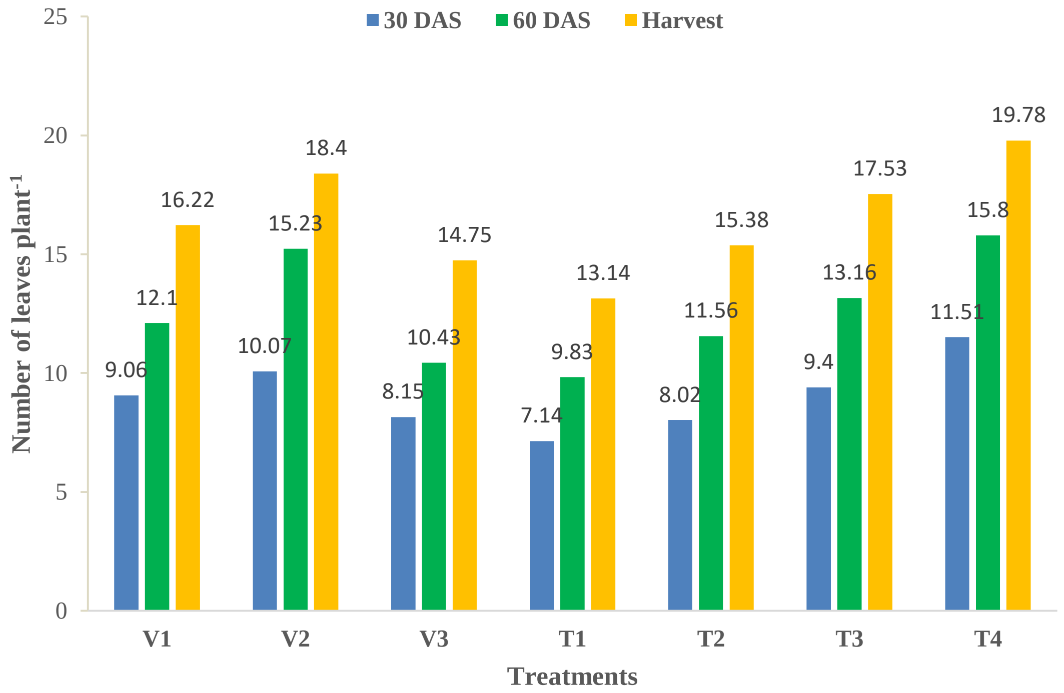
4.2.1 Influences of varieties

Mungbean varieties produced positively significant values of number of leaves plant^{-1} (Fig. 2 and Appendix V). The maximum number of leaves was found in V2 treatment and minimum number of leaves was recorded in V_3 treatment. The values of leaves number in V_2 treatments was 10.07, 15.23 and 18.4 at 30 DAS, 60 DAS and at harvest times, respectively. The values of leaves number in V_3 treatments was 8.15, 10.43 and 14.75 at 30 DAS, 60 DAS and harvest times, respectively. This might be due to less competition among the plants and weeds in V_2 treatment. Probably, V_2 variety had allelopathic effect to control weeds. The finding is close conformity of finding Lertmongkol *et al*. (2011).

4.2.2 Influences of herbicides

Application of herbicides showed positively significant effects on number of leaves mungbean (Fig. 2 and Appendix V). The maximum number of leaves plant^{-1} (11.51, 15.80 and 19.78 at 30 DAS, 60 DAS and at harvest times, respectively) was recorded in T_4 treatment while minimum number of leaves plant^{-1} (7.14, 9.83 and 13.14 at 30 DAS, 60 DAS and harvest times, respectively) was found in T_1 treatments.

This might be due to less competition among weeds and mungbean plants. Because less number of weeds and weeds dry weight was recorded in T_4 treatment and highest number of weeds and weeds dry weight was found in T_1 treatment. Our finding agreed with the finding of Khan *et al*. (2011), Ali *et al*. (2011), Kundu *et al*. (2009), Chattha *et al*. (2007), Reddy *et al*. (2007), Machado *et al*. (2006).



DAS= Day after sowing; V_1 = BARI Mung-5, V_2 = BARI Mung-6, V_3= BARI Mung-4; T_1 = Whipsuper, T_2 = Panida 33 EC, T_3 = Paraxon, T_4 = Topstar 40 WP

Fig. 2. Influence of varieties and herbicide on number of leaves of mungbean

4.2.3 Combine effects of varieties and herbicides

Combine effect of mungbean varieties and herbicides showed non-significant effect on number of leaves plant^{-1} (Table 2 and Appendix V). Although having non-significant effect, the maximum number of leaves was recorded in V_2T_4 (13.63, 18.58 and 22.57 at 30 DAS, 60 DAS and at harvest times, respectively) treatments and minimum number of leaves was found in V_3T_1 (6.83, 8.51 and 11.74 at 30 DAS, 60 DAS and harvest times, respectively).

Table 2. Combine effect of varieties and herbicide on number of leaves

Treatments	Number of leaves plant^{-1} at		
	30 DAS	60 DAS	Harvest
V_1T_1	7.69	9.18	13.39
V_1T_2	8.49	11.17	15.81
V_1T_3	9.50	13.18	17.41
V_1T_4	11.86	15.71	19.11
V_2T_1	7.89	12.44	14.91
V_2T_2	9.13	14.48	17.04
V_2T_3	10.96	16.24	19.91
V_2T_4	13.63	18.58	22.57
V_3T_1	6.83	8.51	11.74
V_3T_2	7.43	9.64	13.91
V_3T_3	8.73	10.68	15.91
V_3T_4	10.93	13.74	18.28
SE (±)	**NS**	**NS**	**NS**
CV (%)	**6.93**	**4.85**	**3.84**

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

DAS= Day after sowing; V_1 = BARI Mung 5, V_2 = BARI Mung 6, V_3= BARI Mung 4;
T_1 = Whipsuper, T_2 = Panida 33 EC, T_3 = Paraxon, T_4 = Topstar 40 WP

4.3 Number of branches plant^{-1}

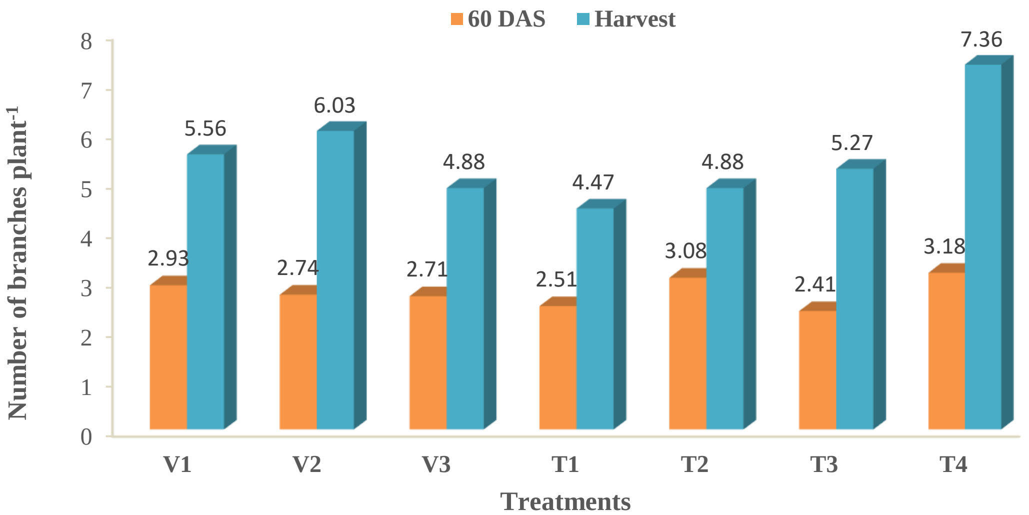
4.3.1 Influence of varieties

Number of branches plant^{-1} of mungbean is not positively affected by the varieties at 60 DAS. It showed statistically significant variation only at harvest (Fig. 3 and Appendix V).

The maximum number of branches of mungbean plant was found in V_1 (2.93) at 60 DAS and V_2 (6.03) at Harvest. The minimum number of branches of mungbean plant was recorded in V_3 (2.71 and 4.88 at 60 DAS and at harvest time, respectively). This might be due to allelopathic effect of V_2 variety that confirmed minimum number of weeds or no weeds in around V_2 variety. The finding is close conformity of finding Lertmongkol *et al*. (2011).

4.3.2 Influence of herbicides

Application of different herbicides had positively significant impact only at harvest on number of branches plant^{-1} of mungbean (Fig. 3 and Appendix V). The number of branches plant^{-1} of mungbean range was 2.51 to 7.36 cm from 60 DAS to harvest time. The maximum number of branches was recorded in T_4 and minimum number of branches was found in T_1. The values of plant height in T_4 treatment was 3.18 and 7.36 at 60 DAS and at harvest time, respectively. The values of plant height in T_1 treatment was 2.51 and 4.47 at 60 DAS and at harvest time, respectively. This might be due to less competition among weeds and mungbean plants. Because less number of weeds and weeds dry weight was recorded in T_4 treatment and highest number of weeds and weeds dry weight was found in T_1 treatment. Our finding agreed with the finding of Ali *et al*. (2011), Kundu *et al*. (2009), Chattha *et al*. (2007), Reddy *et al*. (2007), Machado *et al*. (2006).



DAS= Day after sowing; V_1 = BARI Mung-5, V_2 = BARI Mung-6, V_3= BARI Mung-4; T_1 = Whipsuper, T_2 = Panida 33 EC, T_3 = Paraxon, T_4 = Topstar 40 WP

Fig. 3. Influence of varieties and herbicide on number of branches plant^{-1} of mungbean

4.3.3 Combine effect of varieties and herbicides

Combine effect of varieties and herbicides did not produce positively significant number of branches of mungbean (Table 2 and appendix V).

Although, the maximum number of branches (4.41 at 60 DAS and 8.51 at harvest times, respectively) was found in V_3T_4 and V_2T_4combine, respectively compared to others combinations. The minimum number of branches was produced by V_3T_1 (1.88 at 60 DAS) and V_3T_1 (4.41 at harvest).

Table 3. Combine effect of varieties and herbicide on number of branches

Treatments	Number of branches at	
	60 DAS	**Harvest**
V_1T_1	3.21	4.54
V_1T_2	4.01	5.24
V_1T_3	1.88	5.74
V_1T_4	3.44	7.58
V_2T_1	2.74	5.08
V_2T_2	3.64	5.28
V_2T_3	3.11	6.08
V_2T_4	2.31	8.51
V_3T_1	2.21	4.41
V_3T_2	2.21	4.74
V_3T_3	2.87	4.61
V_3T_4	4.41	6.61
SE (±)	**NS**	**NS**
CV (%)	**43.02**	**13.18**

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

DAS= Day after sowing; V_1 = BARI Mung-5, V_2 = BARI Mung-6, V_3= BARI Mung-4; T_1 = Whipsuper, T_2 = Panida 33 EC, T_3 = Paraxon, T_4 = Topstar 40 WP

4.4 Plant dry weight

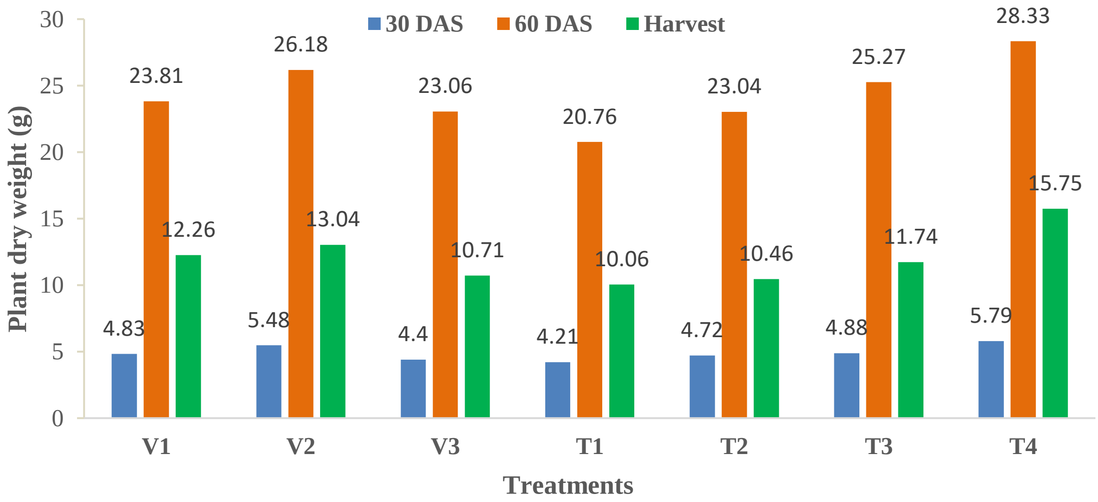
4.4.1 Influences of varieties

Mungbean varieties produced positively significant values of plant dry weight (Fig. 4 and Appendix VI).

The highest values of plant dry weight were found in V_2 treatment and lowest value of plant dry weight was recorded in V_3 treatment. The values of plant dry weight in V_2 treatments was 5.44 g, 26.18 g and 13.04 g at 30 DAS, 60 DAS and harvest times, respectively. The values of plant dry weight in V_3 treatments was 4.40 g, 23.06 g and 10.71 g at 30 DAS, 60 DAS and at harvest times, respectively. Probably, V_2 variety had allelopathic effect to control weeds. As a result, less competition was among the plants and weeds in V_2 treatment. The finding is close conformity of finding Lertmongkol *et al*. (2011).

4.4.2 Influences of herbicides

Application of herbicides showed positively significant effects on plant dry weight of mungbean (Fig. 4 and Appendix VI). The highest plant dry weight (5.79 g, 28.33g and 15.75 g at 30 DAS, 60 DAS and harvest times, respectively) was recorded in T_4 treatment while lowest plant dry weight (4.21 g, 20.76 g and 10.06 g at 30 DAS, 60 DAS and harvest times, respectively) was found in T_1 treatments. This might be due to less competition among weeds and mungbean plants. Because less number of weeds and weeds dry weight was recorded in T_4 treatment and highest number of weeds and weeds dry weight was found in T_1 treatment. Our finding agreed with the finding of Sumalapao *et al*. (2018), Marchioretto and Dal Magro (2017), Khan *et al*. (2011), Ali *et al*. (2011), Kundu *et al*. (2009), Chattha *et al*. (2007), Reddy *et al*. (2007), Machado *et al*. (2006).



DAS= Day after sowing; V_1 = BARI Mung-5, V_2 = BARI Mung-6, V_3= BARI Mung-4; T_1 = Whipsuper, T_2 = Panida 33 EC, T_3 = Paraxon, T_4 = Topstar 40 WP

Fig. 4. Influence of varieties and herbicide on plant dry weight of mungbean

4.4.3 Combine effects of varieties and herbicides

Combine effect of mungbean varieties and herbicides showed significant effect on plant dry weight at all sampling dates except at 30 DAS (Table 4 and Appendix VI). The highest plant dry weight was recorded in V_2T_4 (6.67 g, 29.74 g and 17.76 g at 30 DAS, 60 DAS and harvest times, respectively) treatments and minimum number of leaves was found in V_3T_1 (3.91 g, 19.00 g and 9.46 g at 30 DAS, 60 DAS and harvest times, respectively).

Table 4.Combine effect of varieties and herbicide on plant dry weight

Treatments	Plant dry weight (g) at		
	30 DAS	**60 DAS**	**Harvest**
V_1T_1	4.31	19.49 f	10.18 fg
V_1T_2	4.87	22.64 e	10.36 fg
V_1T_3	4.93	25.42 cd	12.60 d
V_1T_4	6.03	28.51 b	15.96 b
V_2T_1	5.05	24.41 d	10.59 f
V_2T_2	5.40	25.36 cd	11.33 e
V_2T_3	5.63	26.03 c	12.56 d
V_2T_4	6.67	29.74 a	17.76 a
V_3T_1	3.91	19.00 f	9.46 h
V_3T_2	4.52	21.74 e	9.76 gh
V_3T_3	4.71	24.99 cd	10.10 fg
V_3T_4	5.32	27.35 b	13.60 c
SE (±)	**NS**	**0.227**	**0.120**
CV (%)	**7.50**	**1.65**	**1.79**

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

DAS= Day after sowing; V_1 = BARI Mung 5, V_2 = BARI Mung 6, V_3= BARI Mung 4; T_1 = Whipsuper, T_2 = Panida 33 EC, T_3 = Paraxon, T_4 = Topstar 40 WP

4.5 Number of leaves

4.5.1 Influences of varieties

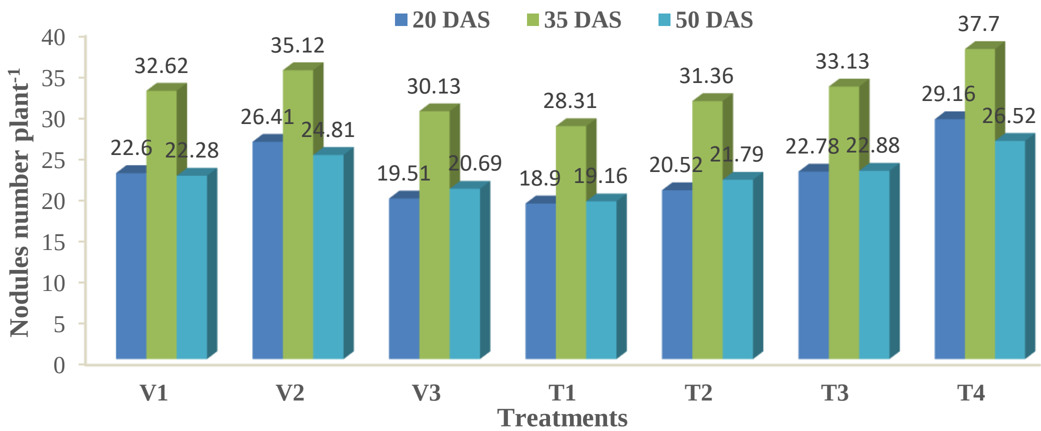
Mungbean varieties produced positively significant values of number of nodules plant^{-1}at all sampling dates (Fig. 5 and Appendix VII).

The maximum number of nodules was found in V_2 treatment and minimum number of nodules was recorded in V_3 treatment. The values of nodules number in V_2 treatments was 26.41, 35.12 and 24.81 at 20 DAS, 35 DAS and 50 DAS, respectively.

The values of nodules number in V_3 treatments was 19.51, 30.13 and 20.69 at 20 DAS, 35 DAS and 50 DAS, respectively. This might be due to less competition among the plants and weeds in V_2 treatment. Probably, V_2 variety had allelopathic effect to control weeds. The finding is close conformity of finding Lertmongkol *et al*. (2011).

4.5.2 Influences of herbicides

Application of herbicides showed positively significant effects on number of nodules mungbean (Fig. 5 and Appendix VII). The maximum number of nodules plant^{-1} (29.16, 37.70 and 26.52 at 20 DAS, 30 DAS and 55 DAS, respectively) was recorded in T_4 treatment while minimum number of nodules plant^{-1} (18.90, 28.31 and 19.16 at 20 DAS, 35 DAS and 50 DAS, respectively) was found in T_1 treatments. This might be due to less competition among weeds and mungbean plants. Because less number of weeds and weeds dry weight was recorded in T_4 treatment and highest number of weeds and weeds dry weight was found in T_1 treatment. Our finding agreed with the finding of Bibi *et al*. (2016), Chaudhari *et al*. (2016), Tamang *et al*. (2015), Shakibapour and Saeedipour (2015), Soltani *et al*. (2013), Khaliq *et al*. (2012), Ali *et al*. (2011), Kundu *et al*. (2009), Chattha*et al*. (2007), Reddy *et al*. (2007), Machado *et al*. (2006).



DAS= Day after sowing; V_1 = BARI Mung-5, V_2 = BARI Mung-6, V_3= BARI Mung-4; T_1 = Whipsuper, T_2 = Panida 33 EC, T_3 = Paraxon, T_4 = Topstar 40 WP

Fig. 5. Influence of varieties and herbicide on number of nodules plant^{-1}

4.5.3 Combine effects of varieties and herbicides

Combine effect of mungbean varieties and herbicides showed significant effect on number of nodule plant^{-1}except at 55 DAS (Table 5 and Appendix VII). Although having non-significant effect, the maximum number of nodule was recorded in V_2T_4 (36.14, 39.62 and 28.34 at 20 DAS, 35 DAS and 50 DAS, respectively) treatments and minimum number of nodule was found in V_3T_1 (15.91, 24.28 and 16.54 at 20 DAS, 35 DAS and 50 DAS, respectively).

Table 5. Combine effect of varieties and herbicide on number of nodules plant^{-1}

Treatments	Number of nodules at		
	20 DAS	**35 DAS**	**50 DAS**
V_1T_1	19.78 ef	29.18 g	19.88
V_1T_2	20.67 d-f	31.22 e-g	21.08
V_1T_3	23.61 cd	33.01 c-f	22.78
V_1T_4	27.18 b	37.91 ab	26.24
V_2T_1	21.65 c-e	32.10 d-g	21.70
V_2T_2	23.64 cd	34.01 c-e	24.49
V_2T_3	25.04 bc	35.60 b-d	25.53
V_2T_4	36.14 a	39.62 a	28.34
V_3T_1	15.91 g	24.28 h	16.54
V_3T_2	17.88 fg	29.49 fg	20.44
V_3T_3	20.31 d-f	31.41 e-g	20.98
V_3T_4	24.78 bc	36.19 a-c	25.62
SE (±)	**0.696**	**0.742**	**NS**
CV (%)	**5.11**	**3.63**	**6.48**

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

DAS= Day after sowing; V_1 = BARI Mung-5, V_2 = BARI Mung-6, V_3= BARI Mung-4; T_1 = Whipsuper, T_2 = Panida 33 EC, T_3 = Paraxon, T_4 = Topstar 40 WP

4.6 Nodules dry weight

4.6.1 Influence of varieties

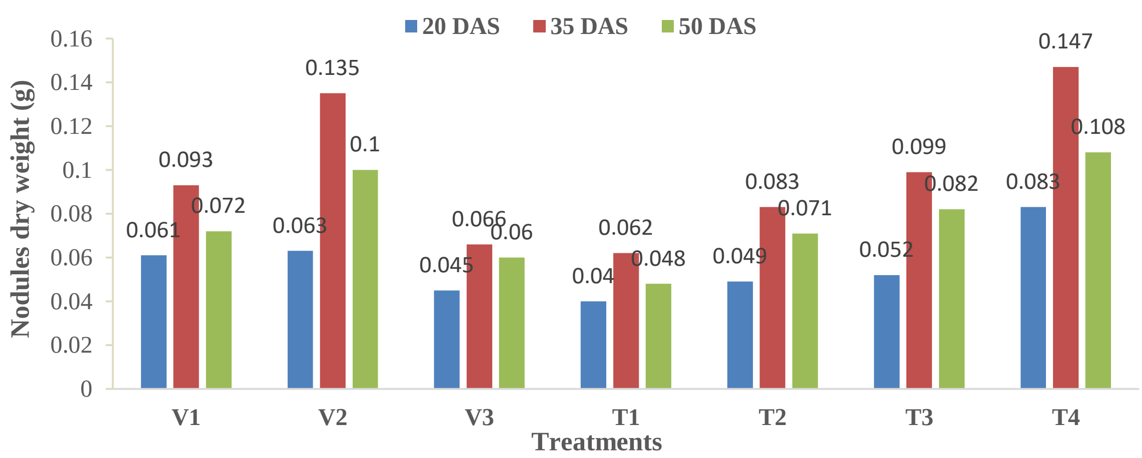
Nodules dry weight of mungbean is positively affected by the varieties and showed statistically significant variation (Fig. 6 and Appendix VIII).

The highest nodules dry weight (0.063 g, 0.135 g and 0.100 g at 20 DAS, 35 DAS and 50 DAS, respectively) was found in V_2 and lowest nodules dry weight (0.045 g, 0.066 g and 0.06 g at 20 DAS, 35 DAS and 50 DAS, respectively) was recorded in V_3. The nodules dry weight is directly associated with the varieties of mungbean. This might be due to allelopathic effect of V_2 variety. The finding is close conformity of finding Lertmongkol *et al*. (2011).

4.6.2 Influence of herbicides

Application of different herbicides had positively significant impact on nodules dry weight of mungbean (Fig. 6 and Appendix VIII). The nodules dry weight range was 0.04 g to 0.147 g at 20 to 50 DAS. The highest nodules dry weight was recorded in T_4 and lowest nodules dry weight was found in T_1.The values of nodules dry weight in T_4 treatment was 0.083 g, 0.147 g and 0.108g at 20 DAS, 35 DAS and 50 DAS, respectively. The values of nodules dry weight in T_1 treatment was 0.04 g, 0.062 g and 0.048 g at 20 DAS, 35 DAS and 50 DAS, respectively.

This might be due to less competition among weeds and mungbean plants. Because less number of weeds and weeds dry weight was recorded in T_4 treatment and highest number of weeds and weeds dry weight was found in T_1 treatment. Our finding agreed with the finding of Shakibapour and Saeedipour (2015), Soltani *et al*. (2013), Khaliq *et al*. (2012), Khan *et al*. (2011), Ali *et al*. (2011), Kundu *et al*. (2009), Chattha *et al*. (2007), Reddy *et al*. (2007).



DAS= Day after sowing; V_1 = BARI Mung-5, V_2 = BARI Mung-6, V_3= BARI Mung-4; T_1 = Whipsuper, T_2 = Panida 33 EC, T_3 = Paraxon, T_4 = Topstar 40 WP

Fig. 6. Influence of varieties and herbicide on nodules dry weight of mungbean

4.6.3 Combine effect of varieties and herbicides

Combine effect of varieties and herbicides did not produce positively significant nodules dry weight (Table 6 and appendix VIII). The highest nodules dry weight (0.100 g, 0.200 g and 0.123 g at 30 DAS, 35 DAS and 50 DAS, respectively) was found in V_2T_4combine compared to others combinations. The lowest nodules dry weight was produced by V_3T_1 (0.040 g, 0.040 g at 20 DAS and 35 DAS) and V_1T_1 (0.027 g at 50 DAS).

Table 6. Combine effect of varieties and herbicide on nodules dry weight

Treatments	Nodules dry weight (g) at		
	20 DAS	**35 DAS**	**50 DAS**
V_1T_1	0.040	0.047	0.027
V_1T_2	0.053	0.090	0.070
V_1T_3	0.060	0.100	0.080
V_1T_4	0.090	0.133	0.110
V_2T_1	0.040	0.100	0.080
V_2T_2	0.053	0.110	0.093
V_2T_3	0.057	0.130	0.103
V_2T_4	0.100	0.200	0.123
V_3T_1	0.040	0.040	0.037
V_3T_2	0.040	0.050	0.050
V_3T_3	0.040	0.067	0.063
V_3T_4	0.060	0.107	0.090
SE (±)	**NS**	**NS**	**NS**
CV (%)	**15.49**	**14.09**	**20.46**

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

DAS= Day after sowing; V_1 = BARI Mung-5, V_2 = BARI Mung-6, V_3= BARI Mung-4; T_1 = Whipsuper, T_2 = Panida 33 EC, T_3 = Paraxon, T_4 = Topstar 40 WP

4.7 Number of pods

4.7.1 Influences of varieties

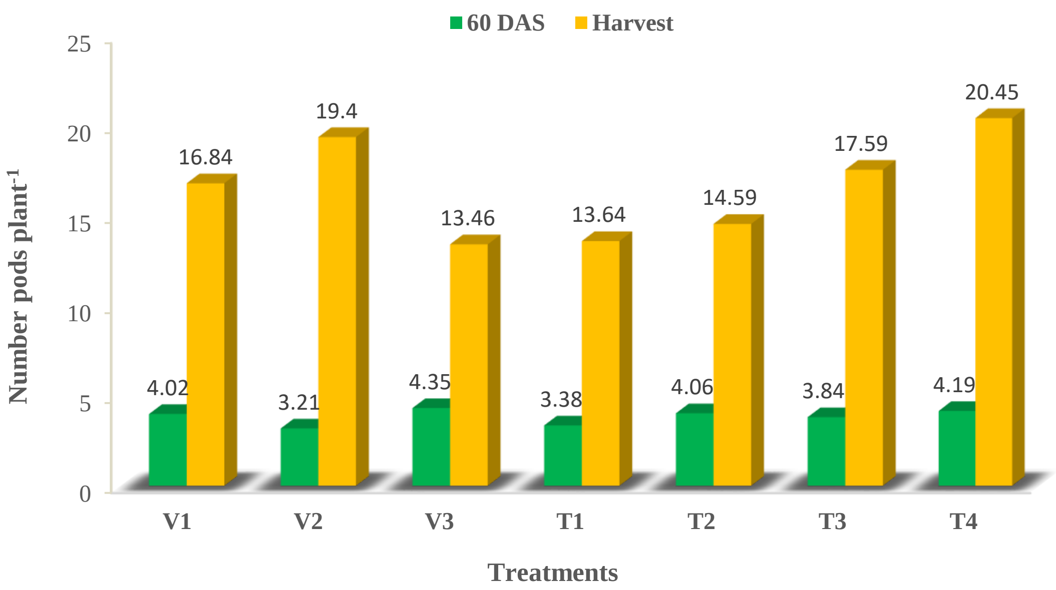
Mungbean varieties produced positively significant values on number of pods plant^{-1}only at harvest (Fig. 7 and Appendix IX). The maximum number of pods was found in V_2 treatment and minimum number of pods was recorded in V_3 treatment.

The values of pods number in V_3 and V_2 treatments was 4.35 and 19.60 at 60 DAS and at harvest times, respectively. The values of pods number in V_2 and V_3 treatments was 3.21 and 13.46 at 60 DAS and harvest times, respectively.

This might be due to less competition among the plants and weeds in V_2 treatment. Probably, V_2 variety had allelopathic effect to control weeds. The finding is close conformity of finding Lertmongkol *et al*. (2011).

4.7.2 Influences of herbicides

Application of herbicides showed positively significant effects on number of pods in mungbean only at harvest (Fig. 7 and Appendix IX). The maximum number of pods plant^{-1} (4.19 and 20.45 at 60 DAS and harvest times, respectively) was recorded in T_4 treatment while minimum number of pods plant^{-1} (3.38 and 43.64 at 60 DAS and harvest times, respectively) was found in T_1 treatments. This might be due to less competition among weeds and mungbean plants. Because less number of weeds and weeds dry weight was recorded in T_4 treatment and highest number of weeds and weeds dry weight was found in T_1 treatment. Our finding agreed with the finding of Soltani *et al*. (2013), Khaliq *et al*. (2012), Khan *et al*. (2011), Ali *et al*. (2011), Kundu *et al*. (2009).



DAS= Day after sowing; V_1 = BARI Mung-5, V_2 = BARI Mung-6, V_3= BARI Mung-4; T_1 = Whipsuper, T_2 = Panida 33 EC, T_3 = Paraxon, T_4 = Topstar 40 WP

Fig. 7. Influence of varieties and herbicide on number of pods plant^{-1}

4.7.3 Combine effects of varieties and herbicides

Combine effect of mungbean varieties and herbicides showed significant effect on number of leaves plant^{-1}only at harvest (Table 7 and Appendix IX). The maximum number of pods was recorded in V_3T_3 (6.11 at 60 DAS) and V_2T_4 (23.44 at harvest) treatments and minimum number of leaves was found in V_3T_1 (2.64 and 9.84 at 60 DAS and harvest times, respectively).

Table 7. Combine effect of varieties and herbicide on number of pods

Treatments	Number of pods at	
	60 DAS	Harvest
V_1T_1	5.28	15.18 e
V_1T_2	3.61	15.88 de
V_1T_3	3.18	17.24 c-e
V_1T_4	4.84	19.92 bc
V_2T_1	2.84	16.54 de
V_2T_2	4.31	17.54 c-e
V_2T_3	2.88	20.91 ab
V_2T_4	3.64	23.44 a
V_3T_1	2.64	09.84 f
V_3T_2	4.87	10.97 f
V_3T_3	6.11	15.24 e
V_3T_4	4.71	18.62 b-d
SE (±)	**NS**	**0.585**
CV (%)	**49.56**	**5.64**

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

DAS= Day after sowing; V_1 = BARI Mung-5, V_2 = BARI Mung-6, V_3= BARI Mung-4; T_1 = Whipsuper, T_2 = Panida 33 EC, T_3 = Paraxon, T_4 = Topstar 40 WP

4.8 Number of seeds pod^{-1}

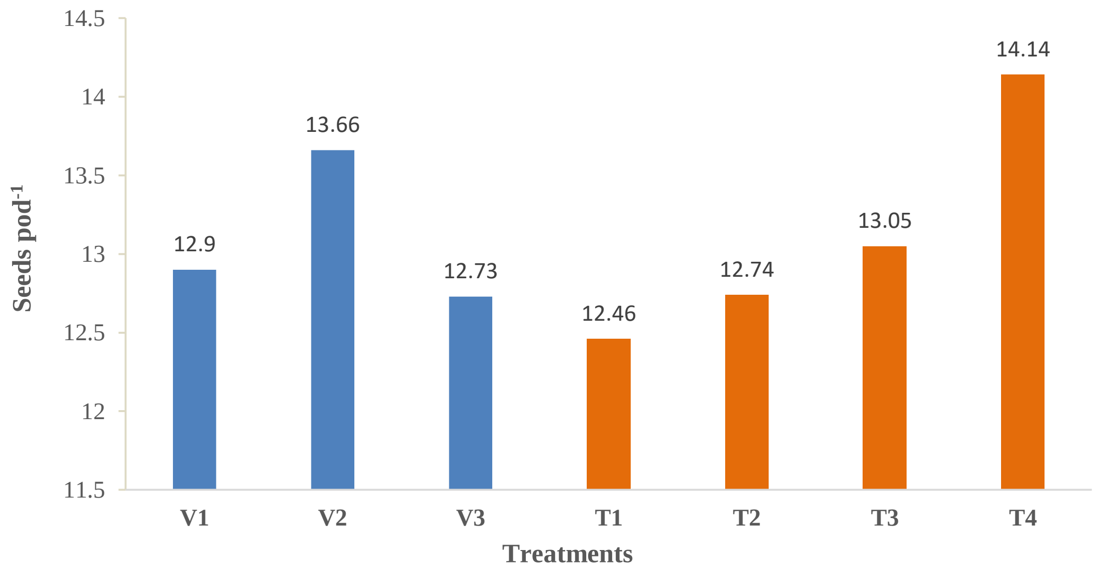
4.8.1 Influences of varieties

Mungbean varieties produced positively significant values of number of seeds pod^{-1} (Fig. 8 and Appendix X). The maximum number of seeds pod^{-1}was found in V_2 treatment and minimum number of seeds pod^{-1}was recorded in V_3 treatment. The values of seeds pod^{-1} number in V_2 treatments was 13.66.

The values of number of seeds pod^{-1}in V_3 treatments was 12.73. This might be due to less competition among the plants and weeds in V_2 treatment. Probably, V_2 variety had allelopathic effect to control weeds. The finding is close conformity of finding Lertmongkol *et al*. (2011).

4.8.2 Influences of herbicides

Application of herbicides showed positively significant effects on number of seeds pod^{-1}(Fig. 8 and Appendix X). The maximum number of seeds pod^{-1}(14.14) was recorded in T_4 treatment while minimum number of seeds pod^{-1}(12.46) was found in T_1 treatments. This might be due to less competition among weeds and mungbean plants. Because less number of weeds and weeds dry weight was recorded in T_4 treatment and highest number of weeds and weeds dry weight was found in T_1 treatment. Our finding agreed with the finding of Aktar *et al*. (2016), Bibi *et al*. (2016), Chaudhari *et al*. (2016), Soltani *et al*. (2013), Khaliq *et al*. (2012), Khan *et al*. (2011), Ali *et al*. (2011), Chattha *et al*. (2007), Reddy *et al*. (2007), Machado *et al*. (2006).



V_1 = BARI Mung-5, V_2 = BARI Mung-6, V_3= BARI Mung-4; T_1 = Whipsuper, T_2 = Panida 33 EC, T_3 = Paraxon, T_4 = Topstar 40 WP

Fig. 8. Influence of varieties and herbicide on number of seeds pod^{-1}

4.8.3 Combine effects of varieties and herbicides

Combine effect of mungbean varieties and herbicides showed non-significant effect on number of seeds pod^{-1}(Table 8 and Appendix X). Although having non-significant effect, the maximum number of seeds pod^{-1}was recorded in V_2T_4 (15.41) treatments and minimum number of seeds pod^{-1}was found in V_3T_1 (12.36).

Table 8. Combine effect of varieties and herbicide on number of seeds pod^{-1}

Treatments	Number of seeds pod^{-1}
V_1T_1	12.63
V_1T_2	12.79
V_1T_3	13.04
V_1T_4	13.99
V_2T_1	13.03
V_2T_2	13.33
V_2T_3	13.72
V_2T_4	15.41
V_3T_1	12.36
V_3T_2	12.73
V_3T_3	1301
V_3T_4	13.66
SE (±)	**NS**
CV (%)	**3.43**

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

V_1 = BARI Mung 5, V_2 = BARI Mung 6, V_3= BARI Mung 4; T_1 = Whipsuper, T_2 = Panida 33 EC, T_3 = Paraxon, T_4 = Topstar 40 WP

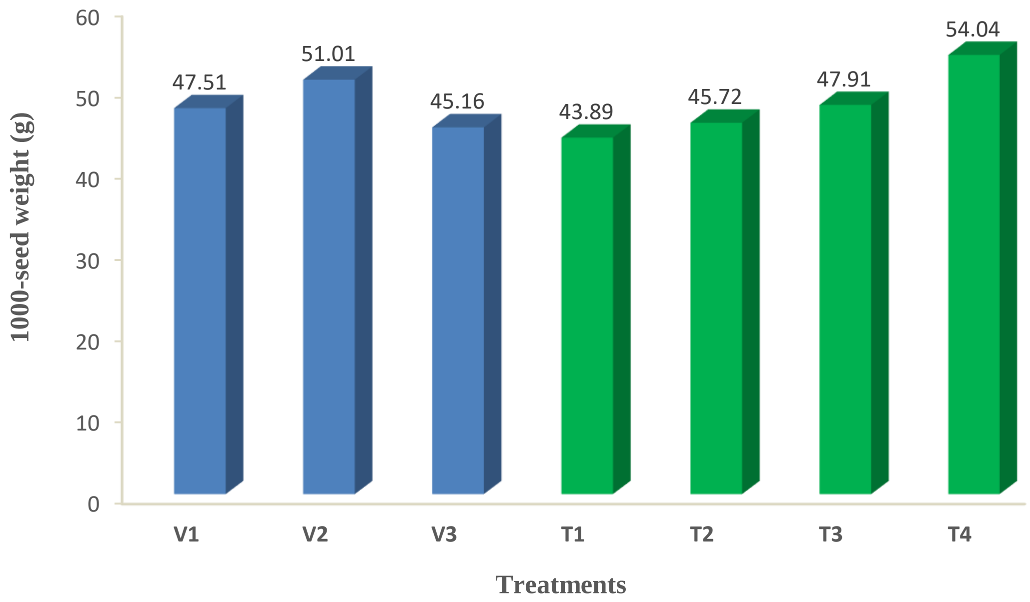
4.9 Weight of 1000 seeds

4.9.1 Influence of varieties

Weight of 1000 seeds of mungbean is positively affected by the varieties and showed statistically significant variation (Fig. 9 and Appendix X). The highest weight of 1000 seeds (51.01 g) was found in V_2 and lowest 1000 seeds weight (45.16) was recorded in V_3. The 1000 seeds weight is directly associated with the varieties of mungbean. This might be due to allelopathic effect of V_2 variety. The finding is close conformity of finding Lertmongkol *et al*. (2011).

4.9.2 Influence of herbicides

Application of different herbicides had positively significant impact on 1000-seed weight of mungbean (Fig. 9 and Appendix X). The 1000-seed weight range was 43.89 g to 54.04 g. The highest 1000-seed weight was recorded in T_4 and lowest 1000-seed weight was found in T_1. The values of plant height in T_4 treatment was 54.04 g. The values of 1000-seed weight in T_1 treatment was 43.89 g. This might be due to less competition among weeds and mungbean plants. Because less number of weeds and weeds dry weight was recorded in T_4 treatment and highest number of weeds and weeds dry weight was found in T_1 treatment. Our finding agreed with the finding of Khaliq *et al*. (2012), Khan *et al*. (2011), Ali *et al*. (2011), Kundu *et al*. (2009), Chattha *et al*. (2007).



V_1 = BARI Mung-5, V_2 = BARI Mung-6, V_3= BARI Mung-4; T_1 = Whipsuper, T_2 = Panida 33 EC, T_3 = Paraxon, T_4 = Topstar 40 WP

Fig. 9. Influence of varieties and herbicide on 1000 seeds weight of mungbean

4.9.3 Combine effect of varieties and herbicides

Combine effect of varieties and herbicides produced positively significant effect on 1000-seed weight of mungbean (Table 9 and appendix X).

The highest 1000 seeds weight (545.41 g) was found in V_2T_4 combine compared to others combinations. The lowest plant was produced by V_3T_1 (414.01 g).

Table 9. Combine effect of varieties and herbicide on 1000-seed weight

Treatments	1000-seed weight (g)
V_1T_1	44.66e
V_1T_2	45.06 e
V_1T_3	46.43 d
V_1T_4	53.95 a
V_2T_1	46.32 d
V_2T_2	50.75 c
V_2T_3	52.52 b
V_2T_4	54.54 a
V_3T_1	40.75 f
V_3T_2	41.40 f
V_3T_3	44.85 e
V_3T_4	53.69 a
SE (±)	**1.861**
CV (%)	**4.12**

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

V_1 = BARI Mung-5, V_2 = BARI Mung-6, V_3= BARI Mung-4; T_1 = Whipsuper, T_2 = Panida 33 EC, T_3 = Paraxon, T_4 = Topstar 40 WP

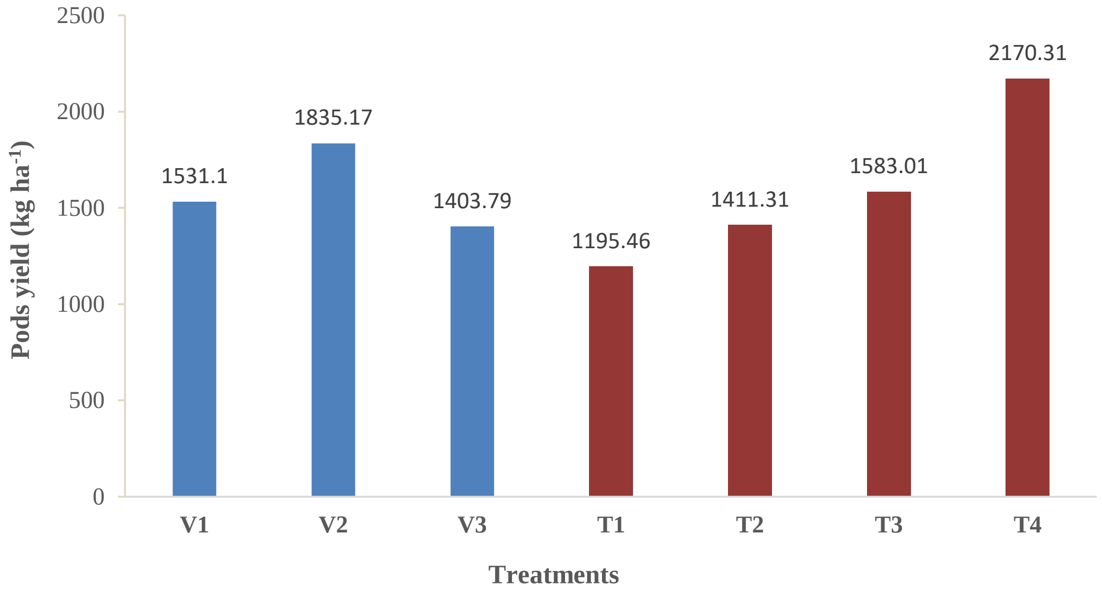
4.10 Pods yield

4.10.1 Influences of varieties

Mungbean varieties produced positively significant values of pods yield (Fig. 10 and Appendix X). The highest pods yield was found in V_2 treatment and lowest pods yield was recorded in V_3 treatment. The values of pods yield in V_2 treatments was 1835.5 kg ha^{-1}. The values of pods yield in V_3 treatments was 1403.8 kg ha^{-1}. This might be due to less competition among the plants and weeds in V_2 treatment. Probably, V_2 variety had allelopathic effect to control weeds. The finding is close conformity of finding Lertmongkol *et al*. (2011).

4.10.2 Influences of herbicides

Application of herbicides showed positively significant effects on pods yield of mungbean (Fig. 10 and Appendix X). The highest pods yield was recorded in T_4 treatment (2170.3 kg ha^{-1}) while lowest pods yield was found in T_1 treatments (1195.5 kg hs^{-1}). This might be due to less competition among weeds and mungbean plants. Because less number of weeds and weeds dry weight was recorded in T_4 treatment and highest number of weeds and weeds dry weight was found in T_1 treatment. Our finding agreed with the finding of Bibi *et al*. (2016), Chaudhari *et al*. (2016), Tamang *et al*. (2015), Shakibapour and Saeedipour (2015), Soltani *et al*. (2013), Khaliq *et al*. (2012).



V_1 = BARI Mung-5, V_2 = BARI Mung-6, V_3= BARI Mung-4; T_1 = Whipsuper, T_2 = Panida 33 EC, T_3 = Paraxon, T_4 = Topstar 40 WP

Fig. 10. Influence of varieties and herbicide on pods yield of mungbean

4.10.3 Combine effects of varieties and herbicides

Combine effect of mungbean varieties and herbicides showed significant effect on pods yield (Table 10 and Appendix X). The highest pods yield in V_2T_4 treatment (2827.63 kg ha^{-1}) and lowest pods yield was found in V_3T_1 (1065.77 kg ha^{-1}).

Table 10. Combine effect of varieties and herbicide on pods yield of mungbean

Treatments	Pods yield (kg ha^{-1})
V_1T_1	1203.43 gh
V_1T_2	1352.51 e-h
V_1T_3	1673.91 b-d
V_1T_4	1895.41 b
V_2T_1	1317.81 f-h
V_2T_2	1540.94 c-f
V_2T_3	1655.14 b-e
V_2T_4	2827.63 a
V_3T_1	1065.77 h
V_3T_2	1341.11 e-h
V_3T_3	1420.61 d-g
V_3T_4	1788.51 bc
SE (±)	**61.162**
CV (%)	**6.71**

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

V_1 = BARI Mung-5, V_2 = BARI Mung-6, V_3= BARI Mung-4; T_1 = Whipsuper, T_2 = Panida 33 EC, T_3 = Paraxon, T_4 = Topstar 40 WP

4.11 Seeds yield

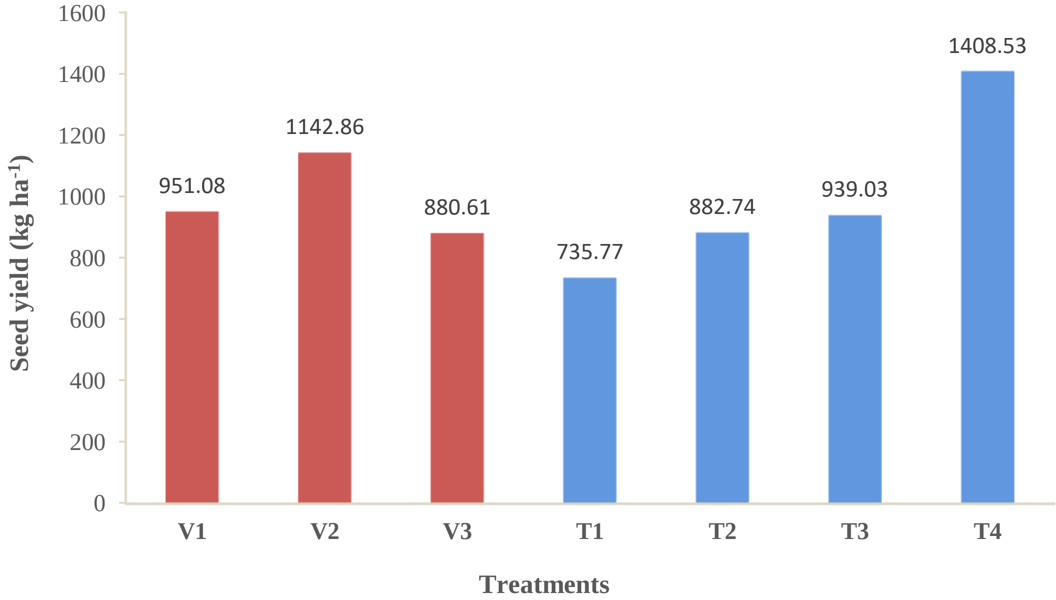
4.11.1 Influence of varieties

Seeds yield of mungbean is positively affected by the varieties and showed statistically significant variation (Fig. 11 and Appendix X). The highest seeds yield (1142.90 kg ha^{-1}) was found in V_2 and lowest seeds yield (880.61 kg ha^{-1}) was recorded in V_3. The seeds yield is directly associated with the varieties of mungbean. This might be due to allelopathic effect of V_2 variety. The finding is close conformity of finding Lertmongkol *et al*. (2011).

4.11.2 Influence of herbicides

Application of different herbicides had positively significant impact on seeds yield of mungbean (Fig. 11 and Appendix X). The seeds yield range was 735.77 kg ha^{-1} to 1408.50 kg ha^{-1}. The highest seeds yield was recorded in T_4 and lowest seeds yield was found in T_1. The values of seeds yield in T_4 treatment was 1408.50 kg ha^{-1}.

The values of seeds yield in T_1 treatment was 735.77 kg ha^{-1}. This might be due to less competition among weeds and mungbean plants. Because less number of weeds and weeds dry weight was recorded in T_4 treatment and highest number of weeds and weeds dry weight was found in T_1 treatment. Our finding agreed with the finding of Sumalapao *et al*. (2018), Ali *et al*. (2011), Kundu *et al*. (2009), Chattha*et al*. (2007), Machado *et al*. (2006).



V_1 = BARI Mung-5, V_2 = BARI Mung-6, V_3= BARI Mung-4; T_1 = Whipsuper, T_2 = Panida 33 EC, T_3 = Paraxon, T_4 = Topstar 40 WP

Fig. 11. Influence of varieties and herbicide on seeds yield of mungbean

4.11.3 Combine effect of varieties and herbicides

Combine effect of varieties and herbicides produced positively significant seeds yield (Table 11 and appendix X). The highest seeds yield (1982.99 kg ha^{-1}) was found in V_2T_4 combine compared to others combinations. The lowest plant was produced by V_3T_1 (685.62 kg ha^{-1}).

Table 11. Combine effect of varieties and herbicide on seeds yield of mungbean

Treatments	Seeds yield (kg ha^{-1})
V_1T_1	765.27 cd
V_1T_2	857.04 b-d
V_1T_3	1046.92 bc
V_1T_4	1136.39 b
V_2T_1	757.37 cd
V_2T_2	924.72 b-d
V_2T_3	907.63 b-d
V_2T_4	1982.99 a
V_3T_1	685.62 d
V_3T_2	867.44 b-d
V_3T_3	863.49 b-d
V_3T_4	1107.17 b
SE (±)	**59.267**
CV (%)	**10.77**

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

V_1 = BARI Mung-5, V_2 = BARI Mung-6, V_3= BARI Mung-4; T_1 = Whipsuper, T_2 = Panida 33 EC, T_3 = Paraxon, T_4 = Topstar 40 WP

4.12 Harvest index

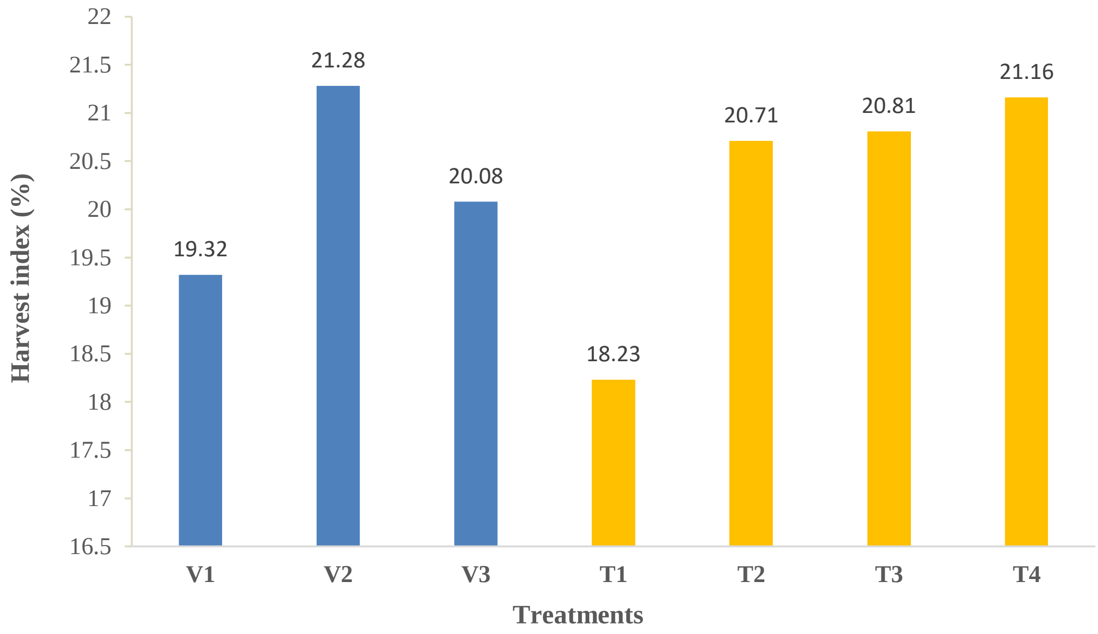
4.12.1 Influences of varieties

Mungbean varieties produced positively significant values of harvest index of mungbean (Fig. 12 and Appendix XI). The highest harvest index was found in V_2 treatment and lowest harvest index was recorded in V_1 treatment. The values of harvest index in V_2 treatments was 21.28%. The values of harvest index in V_1 treatments was 19.32. This might be due to less competition among the plants and weeds in V_2 treatment. Probably, V_2 variety had allelopathic effect to control weeds. The finding is close conformity of finding Lertmongkol *et al*. (2011).

4.12.2 Influences of herbicides

Application of herbicides showed positively significant effects on harvest index of mungbean (Fig. 12 and Appendix XI). The highest harvest index (21.16%) was recorded in T_4 treatment while lowest harvest index (18.23%) was found in T_1 treatments. This might be due to less competition among weeds and mungbean plants.

Because less number of weeds and weeds dry weight was recorded in T_4 treatment and highest number of weeds and weeds dry weight was found in T_1 treatment. Our finding agreed with the finding of Tamang *et al*. (2015), Soltani *et al*. (2013), Khaliq *et al*. (2012), Khan *et al*. (2011), Ali *et al*. (2011), Kundu *et al*. (2009), Chattha *et al*. (2007).



V_1 = BARI Mung-5, V_2 = BARI Mung-6, V_3= BARI Mung-4; T_1 = Whipsuper, T_2 = Panida 33 EC, T_3 = Paraxon, T_4 = Topstar 40 WP

Fig. 12. Influence of varieties and herbicide on harvest index of mungbean

4.12.3 Combine effects of varieties and herbicides

Combine effect of mungbean varieties and herbicides showed positively significant impact on harvest index (Table 12 and Appendix XI). The highest harvest index recorded in V_2T_4 (24.98%) treatments and the lowest harvest index was found in V_3T_1 (17.64%).

Table 12. Combine effect of varieties and herbicide on harvest index in mungbean

Treatments	Harvest index (%)
V_1T_1	18.52 b
V_1T_2	20.40 ab
V_1T_3	20.83 ab
V_1T_4	18.79 b
V_2T_1	19.48 b
V_2T_2	21.27 ab
V_2T_3	20.67 ab
V_2T_4	24.98 a
V_3T_1	17.64 b
V_3T_2	21.42 ab
V_3T_3	21.89 ab
V_3T_4	20.66 ab
SE (±)	**0.884**
CV (%)	**7.52**

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

V_1 = BARI Mung-5, V_2 = BARI Mung-6, V_3= BARI Mung-4; T_1 = Whipsuper, T_2 = Panida 33 EC, T_3 = Paraxon, T_4 = Topstar 40 WP

4.13 Weeds dry weight

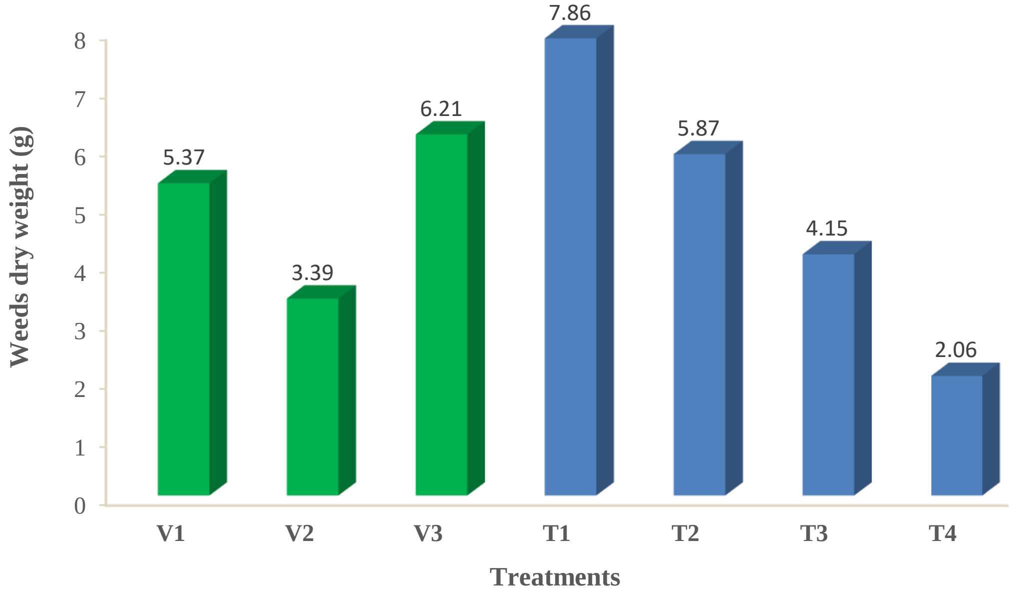
4.13.1 Influence of varieties

Weeds dry weight of mungbean is positively affected by the varieties and showed statistically significant variation (Fig. 13 and Appendix XI). The highest weeds dry weight (6.21 g) was found in V_3 and lowest weeds dry weight (3.39 g) was recorded in V_2. This might be due to allelopathic effect of V_2 variety. The finding is close conformity of finding Lertmongkol *et al*. (2011).

4.13.2 Influence of herbicides

Application of different herbicides had positively significant impact on weeds dry weight (Fig. 13 and Appendix XI). The weeds dry weight range was 2.06 g to 7.86 g. The highest weeds dry weight was recorded in T_1 and lowest weeds dry weight was found in T_4. The values of weeds dry weight in T_4 treatment was 2.06 g. The values of weeds dry weight in T_1 treatment was 7.86 g.

This might be due to positive impact of herbicides. Our finding agreed with the finding of Bibi *et al*. (2016), Chaudhari *et al*. (2016), Tamang *et al*. (2015), Shakibapour and Saeedipour (2015), Soltani *et al*. (2013), Khaliq *et al*. (2012), Khan *et al*. (2011), Ali *et al*. (2011).



V_1 = BARI Mung-5, V_2 = BARI Mung-6, V_3= BARI Mung-4; T_1 = Whipsuper,
T_2 = Panida 33 EC, T_3 = Paraxon, T_4 = Topstar 40 WP

Fig. 13. Influence of varieties and herbicide on weeds dry weight $m^{-2}$of mungbean

4.13.3 Combine effect of varieties and herbicides

Combine effect of varieties and herbicides produced positively significant weeds dry weight (Table 13 and appendix XI). The highest weeds dry weight (10.33 g) was found in V_3T_1combine compared to others combinations. The lowest weeds dry weight was produced by V_2T_4 (1.03 g).

Table 13. Combine effect of varieties and herbicide on weeds dry weight m^{-2} of mungbean

Treatments	Weeds dry weight (g)
V_1T_1	8.08 b
V_1T_2	6.20 d
V_1T_3	4.15 f
V_1T_4	3.03 g
V_2T_1	5.20 e
V_2T_2	4.20 f
V_2T_3	3.12 g
V_2T_4	1.03 i
V_3T_1	10.33 a
V_3T_2	7.21 c
V_3T_3	5.17 e
V_3T_4	2.11 h
SE (±)	**0.098**
CV (%)	**2.23**

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

V_1 = BARI Mung-5, V_2 = BARI Mung-6, V_3= BARI Mung-4; T_1 = Whipsuper, T_2 = Panida 33 EC, T_3 = Paraxon, T_4 = Topstar 40 WP

CHAPTER V

SUMMARY AND CONCLUSION

The investigation was conducted at the Agronomy field, Sher-e-Bangla Agricultural University to study the growth and yield performance of mungbean (*Vigna radiata*) under the application of different herbicide during the period from March to June, 2017. For this purpose, 3 selected BARI Mung-4, BARI Mung-5, and BARI Mung-6 were used as a test crops This chapter represents the summery and conclusion of the research.

The tallest mungbean plant (57.56 cm, 68.33 cm and 75.86 cm at 30 DAS, 60 DAS and harvest, respectively) was found in V_2 and shortest plant (50.04 cm, 60.44 cm and 70.12 cm at 30 DAS, 60 DAS and harvest, respectively) was recorded in V_3. The values of plant height in T_4 treatment was 63.9 cm, 71.29 cm and 78.86 cm at 30 DAS, 60 DAS and harvest time respectively. The values of plant height in T_1 treatment was 46.81 cm, 58.94 cm and 67.22 cm at 30 DAS, 60 DAS and harvest time, respectively. The tallest plant (68.79 cm, 77.26 cm and 81.86 cm at 30 DAS, 60 DAS and harvest times, respectively) was found in V_2T_4 interaction compared to others combinations. The shortest plant was produced by V_3T_1 (45.49 cm and 57.79 cm at 30 DAS and 60 DAS) and V_1T_1 (64.96 cm at harvest).

The values of leaves number in V_2 treatments was 10.07, 15.23 and 18.4 at 30 DAS, 60 DAS and harvest times, respectively. The values of leaves number in V_3 treatments was 8.15, 10.43 and 14.75 at 30 DAS, 60 DAS and harvest times, respectively. The maximum number of leaves plant^{-1} (11.51, 15.80 and 19.78 at 30 DAS, 60 DAS and harvest times, respectively) was recorded in T_4 treatment while minimum number of leaves plant^{-1} (7.14, 9.83 and 13.14 at 30 DAS, 60 DAS and harvest times, respectively) was found in T_1 treatments. The maximum number of leaves was recorded in V_2T_4 (13.63, 18.58 and 22.57 at 30 DAS, 60 DAS and harvest times, respectively) treatments and minimum number of leaves was found in V_3T_1 (6.83, 8.51 and 11.74 at 30 DAS, 60 DAS and harvest times, respectively).

The maximum number of branches of mungbean plant was found in V_1 (2.93) at 60 DAS and V_2 (6.03) at Harvest. The minimum number of branches of mungbean plant was recorded in V_3 (2.71 and 4.88 at 60 DAS and harvest time, respectively).

The maximum number of branches was recorded in T_4 and minimum number of branches was found in T_1. The values of plant height in T_4 treatment was 3.18 and 7.36 at 60 DAS and harvest time respectively. The values of plant height in T_1 treatment was 2.51 and 4.47 at 60 DAS and harvest time, respectively. The maximum number of branches (4.41 at 60 DAS and 8.51 at harvest times, respectively) was found in V_3T_4 and V_2T_4 interaction, respectively compared to others combinations. The minimum number of branches was produced by V_3T_1 (1.88 at 60 DAS) and V_3T_1 (4.41 at harvest).

The values of plant dry weight in V_2 treatments was 5.44 g, 26.18 g and 13.04 g at 30 DAS, 60 DAS and harvest times, respectively. The values of plant dry weight in V_3 treatments was 4.40 g, 23.06 g and 10.71 g at 30 DAS, 60 DAS and harvest times, respectively. The highest plant dry weight (5.79 g, 28.33g and 15.75 g at 30 DAS, 60 DAS and harvest times, respectively) was recorded in T_4treatment while lowest plant dry weight (4.21 g, 20.76 g and 10.06 g at 30 DAS, 60 DAS and harvest times, respectively) was found in T_1 treatments. The highest plant dry weight was recorded in V_2T_4 (6.67 g, 29.74 g and 17.76 g at 30 DAS, 60 DAS and harvest times, respectively) treatments and minimum number of leaves was found in V_3T_1 (3.91 g, 19.00 g and 9.46 g at 30 DAS, 60 DAS and harvest times, respectively).

The values of nodules number in V_2 treatments was 26.41, 35.12 and 24.81 at 20 DAS, 35 DAS and 50 DAS, respectively. The values of nodules number in V_3 treatments was 19.51, 30.13 and 20.69 at 20 DAS, 35 DAS and 50 DAS, respectively. The maximum number of nodules plant^{-1} (29.16, 37.70 and 26.52 at 20 DAS, 30 DAS and 55 DAS, respectively) was recorded in T_4 treatment while minimum number of nodules plant^{-1} (18.90, 28.31 and 19.16 at 20 DAS, 35 DAS and 50 DAS, respectively) was found in T_1 treatments. The maximum number of nodule was recorded in V_2T_4 (36.14, 39.62 and 28.34 at 20 DAS, 35 DAS and 50 DAS, respectively, respectively) treatments and minimum number of nodule was found in V_3T_1 (15.91, 24.28 and 16.54 at 20 DAS, 35 DAS and 50 DAS, respectively).

The highest nodules dry weight (0.063 g, 0.135 g and 0.100 g at 20 DAS, 35 DAS and 50 DAS, respectively) was found in V_2 and lowest nodules dry weight (0.045 g, 0.066 g and 0.06 g at 20 DAS, 35 DAS and 50 DAS, respectively) was recorded in V_3. The values of nodules dry weight in T_4 treatment was 0.083 g, 0.147 g and 0.108 g at 20 DAS, 35 DAS and 50 DAS, respectively.

The values of nodules dry weight in T_1 treatment was 0.04 g, 0.062 g and 0.048 g at 20 DAS, 35 DAS and 50 DAS, respectively. The highest nodules dry weight (0.100 g, 0.200 g and 0.123 g at 30 DAS, 35 DAS and 50 DAS, respectively) was found in V_2T_4 interaction compared to others combinations. The lowest nodules dry weight was produced by V_3T_1 (0.040 g, 0.040 g at 20 DAS and 35 DAS) and V_1T_1 (0.027 g at 50 DAS).

The values of pods number in V_3 and V_2 treatments was 4.35 and 19.60 at 60 DAS and harvest times, respectively. The values of pods number in V_2 and V_3 treatments was 3.21 and 13.46 at 60 DAS and harvest times, respectively.

The maximum number of pods plant^{-1} (4.19 and 20.45 at 60 DAS and harvest times, respectively) was recorded in T_4 treatment while minimum number of pods plant^{-1} (3.38 and 43.64 at 60 DAS and harvest times, respectively) was found in T_1 treatments. The maximum number of pods was recorded in V_3T_3 (6.11 at 60 DAS) and V_2T_4 (23.44 at harvest) treatments and minimum number of leaves was found in V_3T_1 (2.64 and 9.84 at 60 DAS and harvest times, respectively).

The values of seeds pod^{-1} number in V_2 treatments was 13.66. The values of number of seeds pod^{-1} in V_3 treatments was 12.73. The maximum number of seeds pod^{-1} (14.14) was recorded in T_4 treatment while minimum number of seeds pod^{-1} (12.46) was found in T_1 treatments. The maximum number of seeds pod^{-1} was recorded in V_2T_4 (15.41) treatments and minimum number of seeds pod^{-1} was found in V_3T_1 (12.36).

The highest weight of 1000 seeds (51.01 g) was found in V_2 and lowest 1000 seeds weight (45.16) was recorded in V_3. The 1000 seeds weight range was 43.89 g to 54.04 g. The highest 1000 seeds weight was recorded in T_4 and lowest 1000 seeds weight was found in T_1. The values of plant height in T_4 treatment was 54.04 g. The values of 1000 seeds weight in T_1 treatment was 43.89 g. The highest 1000 seeds weight (545.41 g) was found in V_2T_4 interaction compared to others combinations. The lowest plant was produced by V_3T_1 (414.01 g).

The values of pods yield in V_2 treatments was 1835.5 kg ha^{-1}. The values of pods yield in V_3 treatments was 1403.8 kg ha^{-1}. The highest pods yield was recorded in T_4 treatment (2170.3 kg ha^{-1}) while lowest pods yield was found in T_1 treatments (1195.5 kg hs^{-1}). The highest pods yield in V_2T_4 treatment (2827.63 kg ha^{-1}) and lowest pods yield was found in V_3T_1 (1065.77 kg ha^{-1}).

The highest seeds yield (1142.90 kg ha^{-1}) was found in V_2 and lowest seeds yield (880.61 kg ha^{-1}) was recorded in V_3. The seeds yield range was 735.77 kg ha^{-1} to 1408.50 kg ha^{-1}. The highest seeds yield was recorded in T_4 and lowest seeds yield was found in T_1. The values of seeds yield in T_4 treatment was 1408.50 kg ha^{-1}. The values of seeds yield in T_1 treatment was 735.77 kg ha^{-1}. The highest seeds yield (1982.99 kg ha^{-1}) was found in V_2T_4 interaction compared to others combinations. The lowest plant was produced by V_3T_1 (685.62 kg ha^{-1}).

The values of harvest index in V_2 treatments was 21.28%. The values of harvest index in V_1 treatments was 19.32. The highest harvest index (21.16%) was recorded in T_4 treatment while lowest harvest index (18.23%) was found in T_1 treatments. The highest harvest index recorded in V_2T_4 (24.98%) treatments and the lowest harvest index was found in V_3T_1 (17.64%).

The highest weeds dry weight (6.21 g) was found in V_3 and lowest weeds dry weight (3.39 g) was recorded in V_2. The weeds dry weight range was 2.06 g to 7.86 g. The highest weeds dry weight was recorded in T_1 and lowest weeds dry weight was found in T_4. The values of weeds dry weight in T_4 treatment was 2.06 g. The values of weeds dry weight in T_1 treatment was 7.86 g. The highest weeds dry weight (10.33 g) was found in V_3T_1 interaction compared to others combinations. The lowest weeds dry weight was produced by V_2T_4 (1.03 g).

The highest values of yield and yield contributing character i.e. number of pods $plant^{-1}$ (23.44), number of seeds per pod (15.41), 1000 seeds weight (54.51 g), pod yield (2827.63 kg ha^{-1}), seed yield (1892.99 kg ha^{-1}), and harvest index (24.98%) were highest in V_2T_4 combination. Therefore, the combine effect V_2T_4 could be used to cultivate mungbean for increasing production.

Recommendation

This study was carried out only for one location even for one season. So, it is not possible to recommend this finding for farmer’s level. Therefore, more research should have carried out in different agro-ecological zone with same treatment and also changing the treatment. Thus, it can be concluded that, this experiment should carry out in different locations of Bangladesh in different season.

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APPENDIX

Appendix. Monthly recorded the average air temperature, rainfall, relative humidity and sunshine of the experimental site during the period from March to June2017

Month	Air temperature (^{0}C)		Relative humidity (%)		Rainfall (mm) (total)
	Maximum	Minimum	Maximum	Minimum	
March, 2017	38.32	21.12	81.22	33.54	10.70
April, 2017	40.39	20.32	82.32	40.62	75.90
May, 2017	39.31	20.98	90.35	41.35	208.36
June, 2017	38.64	18.39	89.64	45.83	295.38
July, 2017	36.95	19.82	88.23	56.56	110.98

Source: SAU mini weather station, Sher-e-Bangla Agricultural University, Dhaka-1207, Bangladesh

Appendix II. Physical characteristics and chemical composition of soil of the experimental plot

Soil characteristics	Analytical results
Agrological Zone	Madhupur Tract
pH	6.00-6.65
Organic matter	0.86
Total N (%)	0.49
Available phosphorous	18.2ppm
Exchangeable K	0.41meq/100gsoil
S	15.23 µg/g soil
Boron	0.29
Ca	6.30meq/100g soil

Source: Soil Resources Development Institute (SRDI), Dhaka

Appendix III. **ANOVA of influence of herbicide on plant height of mungbean**

Sources of variation	Degrees of freedom	Mean square		
		Plant height (cm) at		
		30 DAS	60 DAS	Harvest
Replication	2	1.180	37.541	6.277
Variety	2	171.105	186.443	100.895
Herbicide	3	488.210	252.519	236.994
Variety*Herbicide	6	7.627	20.187	14.700
Error	22	3.558	7.171	4.512

Appendix IV. **ANOVA of influence of herbicide on number of leaves**

Sources of variation	Degrees of freedom	Mean square		
		Number of leaves at		
		30 DAS	60 DAS	Harvest
Replication	2	0.5503	0.6953	1.3362
Variety	2	11.1286	71.0069	40.4669
Herbicide	3	37.2774	57.8795	73.0598
Variety*Herbicide	6	0.5182	0.5440	0.7948
Error	22	0.4263	0.3853	0.4103

Appendix V. **ANOVA of influence of herbicide on number of branches**

Sources of variation	Degrees of freedom	Mean square	
		Number of branches at	
		60 DAS	Harvest
Replication	2	1.13861	0.3558
Variety	2	0.15528	3.9608
Herbicide	3	1.36333	14.8566
Variety*Herbicide	6	2.63750	0.3871
Error	22	1.67073	0.5646

Appendix VI. ANOVA of influence of herbicide on plant dry weight

Sources of variation	Degrees of freedom	Mean square		
		Plant dry weight (g) at		
		30 DAS	60 DAS	Harvest
Replication	2	0.08536	0.0603	0.79
Variety	2	3.51326	31.7869	1681.35
Herbicide	3	3.90245	93.8100	6089.25
Variety*Herbicide	6	0.05057	3.6246	173.36
Error	22	0.14709	0.1635	4.64

Appendix VII. ANOVA of influence of herbicide on number of nodules

Sources of variation	Degrees of freedom	Mean square		
		Number of nodules at		
		20 DAS	35 DAS	60 DAS
Replication	2	2.207	4.219	2.4180
Variety	2	143.446	74.726	51.8200
Herbicide	3	182.363	138.741	83.8245
Variety*Herbicide	6	10.848	3.331	1.6092
Error	22	1.386	1.417	2.1822

Appendix VIII. ANOVA of influence of herbicide on nodules dry weight

Sources of variation	Degrees of freedom	Mean square		
		Nodules dry weight (g) at		
		20 DAS	35 DAS	60 DAS
Replication	2	3.694E-04	0.00034	5.278E-05
Variety	2	1.119E-03	0.01460	5.078E-03
Herbicide	3	3.204E-03	0.01159	5.589E-03
Variety*Herbicide	6	2.343E-04	0.00046	2.667E-04
Error	22	7.551E-05	0.00019	2.497E-04

Appendix IX. **ANOVA of influence of herbicide on number of pods**

Sources of variation	Degrees of freedom	Mean square	
		Number of pods at	
		60 DAS	Harvest
Replication	2	2.61083	2.479
Variety	2	4.28583	106.534
Herbicide	3	1.13704	85.761
Variety*Herbicide	6	4.74731	3.171
Error	22	4.08235	0.896

AppendixX. **ANOVA of influence of herbicide on pods characters and yield**

Sources of variation	Degrees of freedom	Mean square			
		Seeds pod^{-1}	1000 seeds weight (g)	Pods yield (kg ha^{-1})	Seeds yield (kg ha^{-1})
Replication	2	0.11174	0.7	9375	10396
Variety	2	2.95361	10432.9	589511	221035
Herbicide	3	4.89581	17554.5	1573207	761682
Variety*Herbicide	6	0.26324	1219.9	178649	186181
Error	22	0.20863	11.3	11390	11416

Appendix XI. **ANOVA of influence of herbicide on Harvest index and dry weight of weeds**

Sources of variation	Degrees of freedom	Mean square	
		Harvest index (%)	Weeds dry weight (g)
Replication	2	1.8767	0.2120
Variety	2	11.7686	25.1454
Herbicide	3	16.3304	55.1461
Variety*Herbicide	6	7.7410	2.6331
Error	22	2.3879	0.0124

Appendix XII. Lists of some weeds found in experimental field

Sl. No.	Common name	English name	Scientific name
1	Hatishur	Indian helitrope	*Heliotropiun indicum*
2	Mutha	Purple nutsedge	*Cyperus rotundus*
3	Holdemutha	Yellow nutsedge	*Cyperus esculentus*
4	Chotoshema	Jungle rice	*Echinochloa colonum*
5	Dhurba	Bermuda grass	*Cynodon dactylon*
6	Malancha	Alligator weed	*Alternanthera philoxeroides*
7	Helencha	Marsk herb	*Enhydra fluctuans*
8	Bon pat	Wild jute	*Corchorus acutangulus*