WEED SUPPRESSION STUDY OF MULCH MATERIALS IN T. AMAN CULTIVATION

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CERTIFICATE

This is to certify that the thesis entitled "Weed Suppression study of mulch materials in Transplanted Aman Cultivation" submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of ***MASTER OF SCIENCE in AGRONOMY****, embodies the result of a piece of bona fide research work carried out by Sujan Majumder, Registration No.****07-02552*** *under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.*

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

Dated:
Dhaka, Bangladesh

Dr. H.M.M Tariq Hossain
Professor
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DEDICATED

TO

MY BELOVED PARENTS

LIST OF ABBREVIATED TERMS

FULL NAME	ABBREVIATION
Agro-Ecological Zone	AEZ
And others	*et al.*
Bangladesh Bureau of Statistics	BBS
Centimeter	cm
Degree Celsius	°C
Day After Sowing	DAS
Food and Agriculture Organization	FAO
Gram	gm
Hectare	ha
Kilogram	kg
Meter	m
Millimeter	mm
Muriate of Potash	MoP
Percent	%
Randomized Complete Block Design	RCBD
Sher-e-Bangla Agricultural University	SAU
Square meter	m^2
Triple Superphosphate	TSP
United Nations Development Program	UNDP

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The Author

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ABSTRACT

The study was conducted at the Agronomy Farm, Sher-e-Bangla Agricultural University, Dhaka-1207, Bangladesh, during the period from August to December 2013 to evaluate the weed suppression efficacies of six mulch materials applied with three rice varieties experimented in a randomized complete bock designed plots. The varieties under the trial were BRRI dhan33; BRRI dhan56 and BRRI dhan57 designated $V_{1,}$ V_2 and V_3 respectively. The mulch materials used were maize stover; mustard straw; rice straw; sesame straw; water smart weed (Bishkathali) and no mulch as also designated T_1, $T_{2,}$ $T_{3,}$ T_4, T_5 and T_6 respectively. The plant height was influenced significantly by rice varieties but mulch materials showed no effect on it. The highest plant height was observed in combination effect of BRRI dhan56 x mustard straw mulch (124.3cm) and that of the lowest was found in BRRI dhan57 with No mulch (97.2cm). At 80 DAT, the highest number of tillers hill^{-1}(23.88) was observed in BRRI dhan57. Moreover, the highest number of tillers hill^{-1} (25.33) was observed in BRRI dhan57 treated with maize stover. The plant dry matter was influenced significantly by rice varieties but effect of mulch materials was not significant. The highest grain yield (5.415 t ha^{-1}) was found in BRRI dhan33 which might have supported by higher panicle length(27.03cm) , number of filled grain panicle^{-1} (148.55) and thousand grain weight (28.41gm). Grain yield of rice did not differ significantly due to mulch materials. However, the highest grain yield (5.508 t ha^{-1}) was observed due to combined effect of BRRI dhan33 and rice straw while the lowest (3.717 t ha^{-1}) was estimated in BRRI dhan57 x no mulch combination. Mustard straw mulch reflected higher harvest index (50.02%) which is statistically similar with sesame stover (49.7%). BRRI dhan33 x mustard straw and BRRI dhan56 x water smart weed showed higher harvest index 53.81% and 53.11%, respectively while BRRI dhan57 x no mulch showed the lowest (43.2%).The highest and the lowest number of weeds at first weed collection was found in BRRI dhan56 (29.11) and BRRI dhan57 (11.72). respectively. Significant variation was recorded in number of weed production at second weed collection with the highest density at no mulch (15.88) and the lowest number (2.44) at water smart weed straw. The result indicated that mulch materials had influence on weed suppression. In interaction effect, BRRI dhan 56 x no mulch showed highest weeds while BRRI dhan 56 x water smart weed and BRRI dhan57 x water smart weed produce lowest (2) weed at 2nd weed collection.

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CHAPTER I

INTRODUCTION

Rice (*Oryza sativa L.*), the staple food crop for about half of the world population, is mainly grown in South and South-east Asia as well as in Bangladesh. The area and production of rice in Bangladesh are about 10.37 million hectares and 25.16 million tons, respectively with an average yield of only 2.43 t ha^{-1}. Rice is grown in three cropping seasons *Aus, Aman, Boro* in our country. Among the rice seasons, transplanted *Aman* (T. *Aman*) rice covers about 50.92% of total rice area and contributes to 39.03% of total rice production in the country (Anonymous, 2009). Weeds cause serious problems on yield reduction in rice production worldwide. Without weed management, rice yield may be reduced by 16 to 86%, or even 100% (Khanh *et al*., 2007). Worldwide more than 1000 weed species have been reported in rice (Baltaza and Dedatta, 1992). Weeds reduce crop productivity by interfering with crop growth. For example, in Nigeria uncontrolled weed reduce yield by about 40% in maize and 84% in upland rice (Akobundu, 1980), 31-70% in groundnut (Lagoke *et al.*, 1981), and 73-78% in cayenne pepper (Awodoyin and Ogunyemi, 2005). However, weed control requires more labours which limits the land area a farmer could cultivate (Chianu and Ak-intola, 2003). Weeds remain one of the most significant agronomic problems, especially on organic farm, because weed control can only be carried out without herbicides. Weed management based on organic standards and practices attempts to avoid the use of synthetic pesticides to increase plant productivity. The higher yields cannot be obtained without effective weed management even under ideal management practices (Awan, 1998). There is a strong interest in developing alternative methods of weed control in organic agriculture (Economou *et al*., 2002). Mulching as weed control method used in agriculture throughout the world (Gupta, 1991). Organic mulching are more popular in cropping systems, as they can suppress weeds, while at the same time reducing soil tillage for weed control, under any tillage system implemented (Bilalis *et al*., 2003). Residue of small grains has been shown inhibit weed emergence and growth in cropping systems by allelopathy (Putman *et al*., 1983; Blum et al., 1997). Since weed germination is affected by soil moisture and temperature, mulch not only suppresses weeds, but also maintain soil moisture at higher level compared with unmulched soil (Sharma and

Achraya, 2000; Edwards *et al*., 2000). Mulching improves soil moisture status and structure of soil (Muhammad *et al*., 2009), decreases salinity, controls weeds and soil erosion (Concord, 2009; Bu *et al*., 2002; Kumar and Lal, 2012), and increase the number of fertile tillers, and biomass production of wheat crop (Ahmed *et al*., 2009). Rice straw extract reduced the root length, shoot length, fresh biomass and dry biomass of the associated. Rice straw extract activity was due to the synergistic effects of various allelochemicals which inhibited/restricted the germination and growth of the test plants (Riaz*et et al*., 2013). Mustard straw is also considered as a suitable mulch material (Wilson *et al*., 2001). Several researches have studied and demonstrated the allelopathic ability of mustard in crop rotation (Williams *et al*., 1998; Reddy 2001; Shrestha *et al*., 2002). Allelopathy in maize has attracted less attention than allelopathy in rice or wheat. An important clue toward identifying the allelochemicals of maize is that the allelopathic potential of maize seedlings is enhanced by visible light.

Keeping above facts in view, the present study was, therefore, undertaken with the following objectives:

a) To observe the effectiveness of mulching materials on weed suppression.
b) To observe the interaction effect of mulch materials and rice varieties on yield and yield components of T. *aman* rice.

CHAPTER II

REVIEW OF LITERATURES

2.1 Effect of mulching on soil environment

Mulch provides a better soil environment, moderates soil temperature, increases soil porosity and water infiltration rate during intensive rain and controls runoff and erosion as well as suppresses weed growth (Bhatt and Kheral, 2006; Anikwe *et al.*, 2007; Sarkar and Singh, 2007; Glab and Kulig, 2008). Organic mulches perform additional functions of increasing soil organic matter content, and CEC, enhance biological activity, improve soil structure and increase plant nutrients after decomposition (Tian *et al.,* 1994; Lal, 1995).

Soil can be improved by the use of plant residue mulch. Mulch application increased the populations of earthworms, reduced leaching of nitrogen, and replaced lost organic matter in temperate agricultural fields (Schonbeck *et al.*, 1998). Mulvaney *et al*. (2010) found that the placement of plant residues on the soil surface maintained soil nitrogen levels longer than when residues were incorporated. Mulch-covered soil, even at low rates of mulch application, reduced soil erosion by 97% and reduced post-harvest N-leaching in organically grown potato plots (Doring*et al.,* 2005). Mary et al. (1996) determined that decomposition of both incorporated and surface residue plant material increased with the amount of available nitrogen within the soil.

Mulching improves biotic activity and adds nutrients to soil thereby improving soil fertility (Awodun and Ojeniyi, 1999; Ojeniyi and Adetoro, 1993). Hence mulching was found to increase yield of crops such as yam and cocoyam (Hulugalle *et al,* 1985, Igwillo, 2001), maize *(*Falade and Ojeniyi*;* 1997*,* and tomato (Agele *et al*, 1999a, 1999b).

Awodun and Ojeniyi, (1999) investigated the relative effect of *Pennisetumpurpurem, Aspiliaafricana, Panicum maximum, Chromolaenaodorata,* and *Ageratum conyzoides*mulches on soil properties and maize. The mulches increased soil organic matter N, K, Mg, Ca, leaf N, Ca, Mg and K, maize grain yield and fresh matter significantly. Chromolaena residue gave highest yield, soil and leaf nutrients content. Mexican sunflower recently became a widespread aggressive weed in southern Nigeria suppressing the growth of other weeds and crops.

Mulches, particularly organic mulches, can enhance sustainability by reducing chemical inputs and the use of fossil fuels to maintain healthy and aesthetically pleasing landscapes. The effects of mulches on environmental factors and landscape plant growth have been widely studied by Chalker-Scott (2007).

The effects of organic mulching methods on soil temperature depend upon the type of material, the depth of covering, the time of year when the mulch is applied, and the light-reflecting and heat-absorbing properties of the mulch (Allison, 1973). In general, soils that are mulched typically show less variation in temperature than bare soils during a day. Temperature differences due to mulching with organic materials have been frequently reported between 4-8 degrees Celsius, but as high as twice these values (Jacks *et al*, 1955). Hay increases the outgoing radiation from the soil, in contrast to black plastic which reduces outgoing radiation and results in greater net radiation (Shinde, 1997).

The increase of outgoing net radiation caused by hay results in cooler temperatures as compared to black plastic. Such an effect may be desirable in hot summer months. It has been shown that a thick layer of organic mulch can have great insulating effects. During certain times of the year, such properties may not be beneficial to plant growth. Even a thin layer of organic mulch in the spring can delay seed germination because the sun's rays cannot begin to warm the soil (Allison, 1973). The time of the year, the specific climate at a given location, and the temperature preference of the crop should be factors to consider when selecting a mulching method for the alteration of soil temperatures. Temperature and moisture in soil are very interdependent factors. Water content has an influence on soil temperature due to its higher heat capacity in relation the heat capacity of soil particles (Brady, 2008). A wetter soil will warm more slowly than a dry soil. The effect that mulch has on temperature can in turn affect the rate of evaporation of water out of the soil. Mulch is typically considered to preserve moisture in the soil. In actuality, mulches will not conserve much soil moisture during prolonged dry periods.

Organic mulches reduce evaporation when the soil just under the mulch is kept wet by frequent rains or irrigation, but has little or no effect when the upper soil dries out (Allison, 1973). In a scenario with regular wetting of the soil surface, mulch can reduce evaporation. The effects that organic mulches have on evaporation may be quantified in the calculation of crop evapotranspiration (ETc) by reducing the amount of soil water evaporation by 5% for each 10% of soil surface that is effectively covered by the mulch (Sadafi, 1991). A 50% decrease in soil evaporation can theoretically be achieved with an organic mulch on the soil surface. Properly maintained organic mulch installed to an adequate depth, and supplied with the right moisture, can increase crop stands and improve yields.

Sharma *et al*. (1998) in a study undertaken to assess the effects of levels and timings of incorporation of leucaena (*Leucaena leucocephala*) leaf mulch on soil-water use and performance of wheat grown on Dhoolkot silty clay loam soil in sub-mountain northwest India revealed that more moisture was available in mulched surface soil (0-15 cm) at the time of wheat sowing. Application of mulch increased moisture extraction, water use efficiency, grain and straw yield of wheat crop.

Rahman and Khattak (2002) applied crop residue in three ways as no residue, residue chopped at 10-15 cm length and spread on the surface and residue left as standing under rainfed conditions. Almost 12-30% more moisture and almost 25-47% higher yields were recorded in residue treated plots as compared to control.

Mulching is one of the management practices for increasing water use efficiency and weed control in crop fields (Unger and Jones, 1981). Different types of materials such as wheat straw, rice straw or husk, plastic film, grass, wood, sand, oil layer, etc. are used as mulch (Khurshid *et al.,* 2006; Seyfi and Rashidi, 2007).

A study by Li *et. a1*., (1999) explored the possibility of improving yields of spring wheat by using plastic film mulching. Field experiments compared three mulching treatments viz. 20 d, 40 d, and 60 d after sowing, with a non-mulch control. Mulching increased moisture in the upper 5 cm of soil, and shoots emerged 8 d earlier than in control. Mulching also increased number of tillers, length of the growing period, spikelets, grain numbers per spike and the duration from flowering to harvest.

Mulches provide an array of landscape benefits, including improving soil moisture (Fraedrich and Ham, 1982; Iles and Dosmann, 1999; Kraus, 1998; Litzow and Pellett 1993; Watson, 1988; Watson and Kupkowski, 1991), maintaining optimum soil temperatures (Fraedrich and Ham, 1982; Montague and Kjelgren, 2004), moderating energy budgets and reflected heat load (Montague *et al.,* 2007), improving soil nutrition (Greenly and Rakow, 1995), and improving landscape plant growth (Green and Watson, 1989; Greenly and Rakow, 1995; Lithow and Pellett, 1993).

2.2 Effect of mulching of yield and yield contributing characters

Chaudhry and Faizullah (1989) studied the effect of mulching on water conservation and growth of mung (*Vignaradiata*) on clay loam soil in Pakistan. They applied wheat straw @ 2, 4 and 6 Mg ha^{-1}] and found 35, 60 and 75 % increase in grain yield and 10, 25 and 30% more water conservation, respectively, as compared to unmulched soil.

The positive effects of mulches are repeatedly reported for crop parameters. Rehman *et al.,* (1999) observed significant variations in plant height, root length, total dry matter accumulation, leaf area index (LAI), crop growth rate CGR) and net assimilation rate (NAR) in onion. The mulching showed positive effect on growth attributes over the control.

Combined benefits of mulch and conservation tillage on maize were observed by Sharma and Acharya (2000) in north-west India. Mulching significantly increased maize yield during third cropping cycle.

Tariq *et al*. (2001) conducted a research study in NWFP, Pakistan with five varieties of sunflower and two types of mulches with two different rates. Results on yield and its component indicated that mulching had significant effect on all yield components. The maximum yield of 525 kg ha^{-1} was obtained in the plots covered by wheat straw at the rate of 5 Mg ha^{-1}.

The ability of the mulch to increase or decrease available nitrogen in the soil greatly depends upon the carbon-nitrogen ratio of the material. A preferable ratio is about 30 with an N content of 1.4 to 1.7%. Rye straw holds tightly to nitrogen as the material decays because it has a C/N ratio of 144 and comprises of only of 0.33% N (Bollen, 1953). A study in North Carolina showed that cereal rye yields about 6,000kg ha^{-1} on average and that such an amount would supply about 20kg N ha^{-1} after decomposition (Reberg-Horton *et al*, 2011). The residue of rye and other materials with high C/N ratios could reduce the growth of any plants in the mulched area by decreasing the available nitrogen level in the soil, especially if supplemental nitrogen is not applied (Carpenter & Watson, 1954). Care should be taken in the selection of organic mulches that materials with high C/N ratios are not used without additional nitrogen supplements. Some living plants are capable of producing nitrogen in the soil which could be beneficial when grown with crops. The use of a living mulch could well be an effective method for increasing nitrogen in soil. Studies have shown hairy vetch and crimson clover to average 4,900 and 5,500 kg ha^{-1} of biomass, respectively, resulting in 150 and 120kg N ha^{-1} (Reberg-Horton *et al*, 2011).

Awal and Khan (1999) observed the effects of sawdust, ash, rice straw and water hyacinth on growth, dry matter partitioning, earliness, yield attributes and yield of maize. Water hyacinth and rice straw mulches hastened the tasseling, milking and maturity time by 6, 8 and 8 days, respectively, and produced double the amount of biological and economic yield as compared to the control and sawdust. Significantly higher harvest index was also observed under water hyacinth and rice straw mulches.

Badaruddin *et al.*, (1999) reported that mulch increased yield in Sudan and Mexico, which are hot environments with low relative humidity, but not in hot, humid Bangladesh. In Mexico, extra inputs were more beneficial under hotter, spring-sown conditions than for winter sowings.

Yield contributing characters were significantly higher when water hyacinth mulch was used. The variety Ratan produced the highest (53.74 t/ha) fruit yield, while BARI tomato-3 showed the lowest (48.89 t/ha) fruit yield. The combination of mulching and variety exhibited significant variation in some yield components and yield. The combination of water hyacinth and Ratan produced the maximum yield (62.16 t/ha) and thus the experiment revealed that water hyacinth and straw mulches have potentiality to increase the yield of tomato (Kayum *et al.*, 2008).

A field experiment was done by Mohtisham *et al.,* (2013) to investigate the effect of different mulches on weed infestation in aerobic rice was conducted at Agronomic Research Area, University of Agriculture, Faisalabad, during the growing year 2010. The experiment was comprised of seven treatments *viz.*, weedy/controlled (no mulch), weed free (no mulch), wheat straw mulch, sugarcane trash mulch, maize residues mulch, polythene sheet mulch and biological mulch (Sesbania intercropped for 40 days). Crop mulches were used each at the rate of 5 t ha^{-1} while black polyethylene sheet was used as plastic mulch. Rice variety Super Basmati was used as a medium of trial. Densities of total weeds were reduced significantly by application of mulches and dry weight of weeds (broad and narrow leaf) was also significantly affected by the use of mulches. Different mulching techniques/material significantly improved the agronomic traits of aerobic rice over control. Plastic sheet mulching resulted in maximum paddy yield (4.18 t ha^{-1}) due to improvement in plant height (97.56 cm), number of panicle (25.73 cm) and 1000-grain weight (18.43 g).

Uwah and Iwo (2011) conducted a two-year field experiment to evaluate the effectiveness of organic mulch on the productivity of maize (*Zea mays* L.) and weed growth. Five mulch rates (0, 2, 4, 6, and 8 t/ha) were laid in a randomized complete block design with four replications. Soil moisture reserves were highest at the 8 t/ha mulch rate, followed by 6 t/ha rate. The unmulched control plots had the highest weed infestation, lowest soil moisture reserves, shortest plants and least number of leaves/plant. Weed infestation at the unmulched plots were higher by as much as more than 6 and 11 times those at 6 and 8 t/ha rates respectively. Plant height and number of leaves/plant were maximized at 8 t/ha rate, while dry stover yield, weight of grains/cob and grain yield/ha peaked at 6 t/ha rate. The grain yield obtained at 6 or 8 t/ha rates was more than double that of the unmulched control plots.

A significant increase in catnip yield was observed when treated with plant residue mulches (Duppong *et al.,* 2004). Leaf mulch contributed to increased pumpkin fruit size, fruit number, and number of orange fruits when compared to a no-mulch, bare soil treatment (Wyenandt *et al.,* 2008).

Mulches have a significant effect on plant height as reported by most of the researchers. Chakraborty (2000) studied the effect of rice straw mulch on growth;

yield and water use efficiency of chilli growing in a saline ecosystem and reported that plant height increased by 37.1% in rice straw that control. Similar results were also reported by Pramanik *et al*., (2002) in okara.

Correa *et al.,* (2003) conducted an experiment in Brazil to evaluate the effect of soil mulching on garlic and reported that soil mulch resulted in higher growth and yield that control (no mulching). Assi and Rayyan (2007) proved that plant height increased in mulches than bare land and the highest plant height was observed in black polythene than the other mulches (Transparent polythene mulch, straw mulch, and saw dust) in onion. Similar results were also reported in cauliflower by Sing *et al*., (1998). A field experiment was conducted by Pramanick *et al*., (2006) was five different coloured polythene mulch on onion crop with the objective to observe the effect of different coloured polythene mulches on weed management and growth and yield of bulb yield. The author found the highest plant height in off-white colour polythene mulch followed by blue and black coloured mulch and shortest was recorded in control.

A large number of research works on field crops and their response to different mulches have been evaluated. Halim (2006) evaluated the influence of different types of polythene mulches (Transparent, blue and black mulch) on growth, yield and yield attributes of chilli and reported that TDM production was greater in polythene mulch treated plants than the control one. Similar result was repoted by Asaduzzaman (2003) in tomato. Azam (2005) evaluated the effect of different mulches on growth and yield of onion and found that the heighest TDM production unider black plythene followed by transperant polythene mulch. Similar results were also reported by Ali (2002) in onion. Jamil *et al*., (2005) also reported that mulches generally increased TDM in field crop.

Total dry matter production and distribution in economically useful part that determines the crop yield (Watson *et al.,* 1958). Total dry matter of a crop depends on the size of leaves and on it's activity as well as the duration of its growth period during which photosynthesis continues (Watson 1958). Dry matter accumulation is positively correlated with leaf area. (Pandey, 1980) and increases with number of plants per unit area and crop duration (Gautom and Sharma, 1987). Dry matter production also depends on the NAR and LAI (Buttery, 1970; Tsuno, 1971). Dry matter and seed yields were significantly greater in mulched plants that in the unmulched plants (Barros and Hanks, 1993).

2.3 Effect of mulching on weed suppression

Soil coverage with organic mulches is one of the natural methods of preventing weed infestation. It can be achieved by using plant mulches and mulches from straw left after cereal grain harvest (Liebman and Davis 2000, Bàrberi 2002). A number of studies have documented that straw mulch is a good means of decreasing weed emergence and growth, reduce erosion and increase the biological activity of soil (Teasdale and Mohler 2000, Grassbaugh *et al*., 2004, Ramakrishna *et al*., 2006). This allows farmers to reduce an application of herbicides and tillage operations which disturb soil structure (Abdul-Baki *et al*., 1996). According to Jodaugienė *et al*., (2006), a positive effect of mulch is particularly visible in the period of intensive weed germination. In the study by Zagaroza (2003), how efficient the mulch was depended on the thickness of mulch layer on the soil surface.

According to Warren *et.al*., (2015)living mulch systems allow cover crops to be grown during periods of cash crop production, thereby extending the duration of cover crop growth and associated beneficial agroecosystem services. However, living mulches may also result in agroecosystem disservices such as reduced cash crop yields if the living mulch competes with the crop for limiting resources. We examined whether the effects of an Italian ryegrass [*Loliummultiflorum* (Lam.) Husnot]–white clover (*Trifoliumrepens* L., cv. New Zealand) living mulch on broccoli (*Brassica oleracea* L. var. italica) yield and yield components were dependent on fertilizer rate in field experiments conducted in Durham, NH, in 2011 (Expt. 1) and 2012 (Expt. 2). Drip-irrigated broccoli was grown under a range of organic fertilizer application rates in beds covered with plastic, with and without a living mulch growing in the uncovered, interbed space. Broccoli yields were similar in the living mulch and bare soil controls under the highest rates of fertilizer application in Expt. 1. In Expt. 2, living mulch reduced broccoli yields from 28% to 63%, depending on fertilizer rate. Differences in leaf SPAD values suggest that yield reductions were attributable, in part, to competition for nitrogen; however, other factors likely played a role in determining living mulch effects. Despite yield reductions, the living mulch reduced the prevalence of hollow stem in broccoli in Expt. 1. Organic fertilizer may have inconsistent effects on broccoli yields in living mulch systems.

Budelman(1989) says Organic mulches contain considerable quantities of plant nutrients. Increasing amounts of mulch improved the leaf nutrient contents of the yam crop and resulted in significantly higher tuber yields. Over a tuber yield range up to c. 15 tons ha^{-1} each additional ton DM *Gliricidia sepium* mulch applied resulted in a yield increment of about 2 ton yam tubers. A nutrient supply — nutrient extraction balance is discussed, comparing mulch applied and yam tubers harvested.

In order to improve legume productivity, use of rice straw mulch and various crop establishment methods Bunna *et al.,* (2011) examined in two series of mungbean experiments in Cambodia where soils were coarse and strongly compacted. In one set of experiments conducted at four locations in the first year the effect of straw mulch, planting method (manual vs seed drill) and tillage method (conventional vs no-till) was examined. Another set of experiments were conducted in the second year at three locations with four levels of mulch under two planting densities. On average in year 1, mulching of rice straw at 1.5 t/ha increased mungbean crop establishment from 72 to 83%, reduced weed biomass from 164 to 123 kg/ha and increased yield from 228 to 332 kg/ha. Mulch was effective in conserving soil moisture, and even at maturity the mulched area had on average 1% higher soil moisture content. The amount of mulch between 1 and 2 t/ha did not show consistent effects in year 2, partly because some mulch treatments resulted in excessive soil moisture content and were not effective. Rice straw mulch had a significant effect on mungbean yield in 6 out of the 7 experiments conducted in two years, and mean yield increase was 35%. This yield advantage was attributed to better crop establishment, improved growth and reduced weed pressure, but in some cases only one or two of these factors were effective. On the other hand, planting method, tillage method and planting density had only small effects on mungbean yield in most experiments. Only in one location out of four tested, the no-till treatment produced significantly higher yield than the conventional method. Seed drill produced similar mungbean establishment and grain yield to the manual planting suggesting that the planter can be used to save the labour cost which is increasing rapidly in the Mekong region. Maximum root depth varied little with mulch or planting density, and was shallow (<20 cm) in all three locations where this character was determined. It is concluded that while rice straw mulch increased yield of mungbean following rice, the inability of mungbean roots to penetrate the hard pan is a major constraint for development of a sound rice/mungbean cropping system in the lowlands with compacted soils.

De *et al*., (2015) conducted a two-year field experiment to study the efficacy of some mulching materials for soil moisture conservation and yield of groundnut (*Arachis hypogaea)* in summer under rainfed conditions. The mulches used were water hyacinth (WH), rice straw (RS), banana leaves covered with grass (BL), jute stick (JS) and white polythene sheet (PS). The groundnut cultivar AK-12-24 was sown by flat and ridge planting methods. The WH mulch conserved more soil moisture than the other mulches. The soil temperature at the root zone depth was also reduced with the use of WH mulch. The mulches used and the planting methods did not significantly affect the number of leaves and branches per plant. The mulches WH and RS manifested higher kernel yields of 0.67 and 0.61 t ha^{-1} respectively. The soil moisture content with ridge planting method was 8.4%, significantly higher than the flat planting method (7.3%). Soil temperature with flat (33.7°C) and ridge (33.2°C) planting method were statistically similar. The ridge method of planting produced higher kernel yield of groundnut (0.57 t ha^{-1}) than flat planting (0.42 t ha^{-1}).

Toxicity of garlic straw to *Melo idogyne incognita* under lab conditions and pots of tomato was studied by Gong *et al.,* (2013). Results indicated that the immobility and mortality of *M. incognita* juveniles were significantly increased with increasing water extract concentrations of 1%, 2% and 4% (w/v) raw garlic straw, and hatchability was significantly inhibited by application of the extract. 2% fermenting garlic straw increased mortality of *M. incognita* rate from 9.8% to 36.6% when compared with 2% raw garlic straw in different treatment time. While the effect of fermented garlic straw was greatly lower in toxic activity, about 11.4–49.4% lower in mortality of *M. incognita* in different treatment time. Pot trials also showed that *M. incognita* infestation of tomato roots was dramatically reduced with increasing volume of raw garlic straw application, however, higher concentration also inhibited the tomato plant growth, this might be due to the allelopathy compounds from garlic straw. Based on the analysis of above results, 2% raw garlic straw was chosen to combine with plastic film covering and rabbit manure, and it was obtained that the combinations of 2% raw garlic straw application before planting, animal manures and plastic film covering are an effective method in both inhibiting *M. incognita* incidence and increasing yield of tomato, which could decrease 72.39% in galling index (GI) and increase 72.64% in tomato yield when compared with control treatment. To make clear possible mechanism of garlic straw protecting tomato from *M. incognita* infestation, GC–MS were used to investigate the compounds constituents, and sulfur-containing compounds mainly accounted for the constituents and they might be responsible for the inhibition of *M. incognita*.

A field investigation by Goswami and Saha (2006) on elephant-foot yam (*Amorphophallus paeoniifolius* Blume) was carried out during the pre-rainy and rainy seasons (kharif) of 2001 and 2002 with various mulch materials, viz. transparent polythene, black polythene, wheat straw, paddy straw, banana leaf, water hyacinth (*Eichhornia crassipes*) and cowpea (*Vigna* sp.) as cover crop. Black polythene, paddy straw and water hyacinth recorded significantly higher yields (50.2–52.8 tones/ha), which was 7.1–28.8% more than that of no-mulch control. Black polythene recorded the highest weed-control efficiency (92.1%). Mulches conserved the soil moisture by 26.3 to 29.7% in the soil (0–30 cm). Organic and inorganic mulches were on a par with each other in maintaining the soil-moisture status. Higher benefit: cost (B:C) ratio (3.12–3.38) was observed under application of organic mulch compared with that of inorganic or synthetic mulches (1.88–2.09).

Experimental data indicate that as much as 85% of yield could be lost due to weeds (Smith, 1983). About 8000 species are said to behave as weeds in agriculture, out of which 250-300 are seriously harmful weed species and the rice losses attributed to them run into billions of dollars (Awan, 1998; Moody, 1991; Zhang, 1998).

Mulches work primarily by depriving young weed seedlings of vital sunlight. Mulching can decrease the occurrence of weeds by blocking light and release of allelopathic substance. Organic mulches are more popular in the cropping systems, as they can suppress weeds, while reducing soil tillage for weed control, under any tillage system implemented (Bilalis *et al.,* 2003). Residue of small grains has been shown to inhibit weed emergence and growth in cropping systems by allelopathy

(Putman *et al.,* 1983; Blum *et al.,* 1997). Since weed seed germination is affected by soil moisture and temperature, mulch does not only suppress weeds, but also maintains soil moisture at higher levels compared to unmulched soil (Edwards *et al.,* 2000; Sharm and Achraja, 2000).

Crop residues overspread on soil surface decrease soil temperature in the hot season and maintain it in autumn (Bristow, 1988; Duppong *et al.,* 2004). The reduction in paddy yield due to weed composition ranges from 9% to 51% (Mani *et al.,* 1968). Grain yield will be drastically reduced if paddy is not weeded out during early growth stages (Pande *et al.,* 1994).

According to Towa and Guo (2014) Mulching under RCCI (Rain-Catching and Controlled Irrigation) was an effective method to control weeds and reduce labor cost. In addition, mulching decreases the use of herbicides and the risk of pollution. On the other hand, mulching could improve yield and save water.

Ullah *et al.,* (1998) conducted experiments on various organic mulches for their effects on the yield components and seed yield of wheat. The unmulched plots produced the lowest seed yield. Maximum yields were recorded in cercanda mulched plot followed by rice straw. Similarly, Rahman *et al.,* (2005) observed that rice straw mulching had a significant effect on conserving initial soil moisture and reducing weed growth.

Straw has been reported to be a better option by Ramakrishna *et al.,* (2005) after conducting on-farm trials in northern Vietnam. The effect of three mulching materials (polythene, rice straw and chemical) on weed infestation, soil temperature, soil moisture and pod yield were studied. Use of straw as mulch proved to be an attractive and environment friendly option in Vietnam, as it is one of the largest rice growing countries with the least use of rice straw. Besides, it recycles plant nutrients effectively. Rice straw was also observed to improve the soil moisture conservation and grain yield by Bhatt and Khera (2005).

The experiment was carried out by Kosterna (2014) to investigate the effect of different kinds of straw and its dose applied to soil mulching on the amount and fresh mass of weeds and yield level of broccoli and tomato. The type of straw mulch applied to the soil mulching influenced number and fresh mass of weeds. This effect could be the result of the properties of the mulch (colour, structure, etc.) or the allelopathic effect on the germination and growth of individual weed species. The most efficient for limiting infestation was mulch from buckwheat and rye straw. Soil mulching, regardless of its kind, causes a decrease in the number and mass of weeds at the beginning of growing period of vegetables. The application of straw at a dose of 20 t ha^{-1}had higher weed-suppressing effect than at a dose of 10 t ha^{-1}. When assessing the infestation before harvest the influence of straw mulch was lower but still significant. The application in higher dose of rye and buckwheat straw in broccoli, corn and rape in tomato cultivation reduced a number of weeds compared to dose of 10 t ha^{-1}. The better yielding effect in both vegetable species had soil mulching with straw at a dose of 10 t ha^{-1}.

Studies carried out in Nigeria and elsewhere have shown that mulches not only conserved soil moisture and prevented erosion they also increased soil fauna and flora activities, suppressed weeds and maintained high crop yields (Kurshid *et al.,* 2006; Anikwe *et al.,* 2007; Seyfi and Rashidi, 2007; Essien*etal*., 2009).

Barman *et al.,* (2008) conducted a field experiment to study the feasibility of using water hyacinth mulch for weed control and increasing productivity of potato cv. Kufri, Chandramukhi. The weed control treatments consisted of control (no weed control measure), farmers practice (scrubbing the soil of inter rows space and earthing potato rows), water hyacinth mulch (HM), rice straw mulch (SM), metribuzin 250 g/ha as PE + HM, metribuzin 250 g/ha as PE + SM, metribuzin 500 g/ha as PE, and metribuzin 500 g/ha as PE + HM. Sprinkler irrigation was given immediately after planting, and flood irrigation was given during 3rd and 8th week after planting. Both rice straw and water hyacinth mulches controlled weed infestation throughout the growing period of potato, and no additional benefit of herbicide application in terms of weed control or tuber yield was noted in the mulched plots. The lowest tuber yield of 7.2 t/ha was recorded in control, it increased to 13.1, 20.8, 14.8, 21.1, 15.9, 13.0 and 21.4 t/ha respectively in the above mentioned treatments. It was concluded that water hyacinth mulch was superior to rice straw mulch in increasing potato yield in black cotton soil.

Mulching is an effective method of manipulating crop growing environment to increase yield and improve product quality by controlling weed growth, ameliorating soil temperature, conserving soil moisture, reducing soil erosion, improving soil structure and enhancing organic matter content (Opara-Nadi, 1993; Hochmuth *et al.*, 2001; Awodoyin and Ogunyemi, 2005). Awodoyin and Ogunyemi (2005) have reported that the weed control efficiency of different types of mulch in cayenne pepper production ranged from 27% to 97%.

Plant residues used as mulch can indirectly decrease weed seed bank inputs and future weed emergence by increasing the presence of seed predators (Pullaro *et al.*, 2006). Early establishment and late termination of cover crop species have been shown to increase weed suppression as well as decrease weed emergence in established plots (Mirsky *et al.*, 2011).

Field experiments were conducted by Awodoyin *et al.*, (2007) in the 1998 and 2004 cropping seasons to assess the impacts of different mulching materials on weed control, soil temperature, soil moisture depletion and performance of tomato (*Lycopersicones culentum* Mill.) in Ibadan, a rainforest-savanna transi-tion ecological zone of Nigeria. The crop growth and fruit yield were studied under plastic (grey-on-black), woodchip (Teak) and grass (*Pennisetum*) mulches, with handweeded and unweeded as controls in a randomized complete block design with three replicates. Also assessed were weed dry matter and species spectrum, soil temperatures at 5-cm and 15-cm depths, and soil moisture depletion. Compared to unweeded control that had the least total fruit yield (2.7 t/ha in 1998 and 4.2 t/ha in 2004), mulch types and handweeded treatments increased the fruit yield by 152-237% in 1998 and 188-202% in 2004. Compared to mean pooled fruit yield from all mulched plots, unweeded treatment reduced tomato fruit yield by about 65% and 66% in 1998 and 2004, respectively. The weed control efficiencies of the mulches ranged between 91% and 100%. Dicotyledon weed species dominated the plots in the two years accounting for 81.8% in 1998 and 90% in 2004. The number of low-growing weed species enumerated on the plots was 11 in 1998 and 18 in 2004. After four weeks of no rainfall in 1998, moisture loss was least (1.68±0.10%) under plastic mulch and highest (13.96±0.08%) on the unweeded plot. The differences between morning and afternoon soil temperatures at 5 cm depth were low under grass mulch, woodchip mulch and unweeded control (5.0-5.9oC) but high under plastic mulch and handweeded control (8.7-8.9oC). Mulches are effective in weed control and conservation of soil moisture, and the plant-based mulches are most effective in reducing soil temperature. These improvements of crop growing environment resulted in increased tomato growth and fruit yield.

Mulching conserve soil moisture through less evaporation losses and also improve the soil properties, thereby produce better fruit quality with less weeds, disease and pest etc. (Samedani and Rahimian, 2006).

In an experiment conducted by Jodaugiene *et al.,* (2006) reported that all organic mulches reduce weed germination. The positive effect of mulches was particularly obvious in the period of intensive germination of weeds. Straw, peat and wood chips had the strongest influence on the deceases of weed germination; however, it is important to make sure that mulches are not infected with weed seeds. Mulch of chopped grass is quick decomposed; therefore, repeated mulching is required to protect the crop from weeds.

Mulching is one method or practice that could be considered for the control of pests. Mulching may enhance the ability of the crop to compete for resources by making the system less suitable for the pests. Mulch should be considered for the successful control of weeds on Florida's mineral sands (Dittmar & Stall, 2013).

Mulches create a physical barrier to sunlight to work as a photosynthesis inhibitor to suppress weeds. Some mulch has been proven more effective than hand weeding and herbicides in several studies (Bond *et al.,* 2003).
Mulching could improve the crop stands and increase yield by providing an environment for optimal plant growth. Mulched and irrigated treatments have been shown to induce higher root growth in comparison with unmulched and rain fed treatments (Kumara and Dey, 2011).

The properties of some mulch may better benefit plant growth by preserving soil structure and acting as a barrier to the action of rainfall that can cause compaction and erosion. Less-compacted soil provides a better environment for seedling emergence and root growth (Kumara &Dey, 2011). Many other benefits to plant growth are associated with the altered conditions created by mulch. In addition to reducing competition from weeds, mulches are used to increase water infiltration, reduce evaporation, modify soil temperatures and increase crop yields (Allison, 1973). The color of a given material can have a range of influences on soil temperature. Soil temperature fluctuations are especially important since they impact physical, chemical and biological processes in the soil (Shinde, 1997).

Depending on properties of mulch, such as color and albedo, the mulch may result in either an increase or decrease soil maximum or minimum temperatures, but generally all mulches moderate soil temperature fluctuations (Allison, 1973). Some mulching materials can improve the structure and fertility as they are decomposed and incorporated into the soil. The selection of mulching materials must be undertaken carefully in organic production. Both natural and synthetic mulches are approved for the use in organic vegetable production under certain circumstances. Plastic mulches must be removed at the end of the growing season to coincide with standards of National Organic Program. Mulches of organic origin are biodegradable, but some synthetic mulches are designed to degrade through the growing season. The use of biodegradable plastics are not yet approved for organic production, but natural or organic biodegradable materials such as paper are allowed for use under current organic standards. Biodegradable forms of paper mulches have become quite popular in vegetable production, because labor costs for removal are foregone (Hochmuth, 1992). Proponents of organic farming may feel that utilizing living or dead plant material for mulching coincides more with their ideals and offers the same benefit of reduced labor and maintenance costs. For an organic mulch to be effective, it must be installed to a proper depth to inhibit the photosynthesis in weeds.

The effectiveness of water hyacinth, rice straw and dried grass mulches as suppressant of weed growth compared to the control was noted by Baten *et al.,* (1995). Control of broad leaf weeds due to the effect of oat mulch was reported in tobacco (Shiling *et al.,* 1986).

Nearly all annual weeds have trouble penetrating a thick mulch of organic material. Generally, better weed suppression is attained as the organic mulch is increased in depth. Mulches must be installed at a depth of 7.6 - 12.7cm after packing (Westerfield, 2013). Depths of 2.5cm, 7.6cm, and 15.2cm of chopped organic mulch from yard waste have been successfully used in citrus orchards in California for long-term control of weeds. Organic mulches are very useful in the management of perennial tree crops (Norris et al, 2003). A total of 76 weed species from 21 plant families were recorded growing in that experiment. Weed species such as spurge, groundsel, tall fescue, horseweed, purslane and scarlet pimpernel were at extremely low levels or non-existent in the mulched areas, but were very common in the unmulched plots (Sakovich, 2013). Such materials work primarily as photosynthesis inhibitors or physical barriers, but plant chemicals that are released during the decomposition of some materials may have additional benefits to weed suppression.

Another alternative for weed control is to use a living mulch to suppress weeds through allelopathy and competition. Allelopathy is an interaction between plants where compounds (i.e. tannins, alkaloids, phenolic acids) produced in one plant is released into the environment and inhibit, or stimulate, the growth of another plant (Gliessman, 2007). *Gliessman* acknowledged it is possible to utilize alleopathic interactions in farming as a cost effective alternative to using synthetic chemicals. The cover crop, winter rye (*Secalecereale*), suppresses weeds as it grows and as it decays when residues are incorporated into the soil. Other crops that can inhibit weeds include barley, beets, buckwheat, corn, cucumber, lupine, millet, oats, peas, rye, and wheat (Gliessman, 2007). With research advancements on the alleopathic properties of plants, farmers could manage fields with organic living mulches to reduce weeds, deter insect pests, attract beneficals and eliminate the need for pesticides.

Crutchfield (1984) conducted a research to determine the effect of wheat (*Triticumaestivum* L.) straw mulch level on weed control and corn growth in a winter wheat-ecofallow corn(*Zea mays*L.)fallow rotation.Wheat straw mulch was established at levels of 0, 1.68, 3.36, 5.04, and 6.72 t/ha in stubble fields after harvest (fall-adjusted) or the following spring (spring-adjusted).Atrazine{2-chloro-4-(ethylamino)-6-(isopropylamino)-s-triazine}concentration remained higher in unmulched soil than in soil with high levels of mulch for more than 9 months following application after wheat harvest due to interception of atrazine by the mulch. Metolachlor{2-chloro-N-(2-ethyl-6-methylphenyl)-N-(2-methoxy-1-methylethyl) acetamide} concentration remained higher in unmulched soil than in soil with high levels of mulch for more than 4 months after application at corn planting due to interception by the mulch. Even though the amount of atrazine and metolachlor in the soil was reduced by mulch in fall-adjusted experiments and the amount of metolachlor was reduced in spring-adjusted experiments, weed control was not reduced and usually increased with increasing mulch level. Thus increasing atrazine and metolachlor rate was not necessary to maintain adequate weed control in no-till wheat stubble since the mulch itself had an adverse effect on weed growth.

According to Budelman (1998) the performance of the leaf mulches of *Leucaena leucocephala, Gliricidia sepium* and *Flemingia macrophylla* in weed control has been tested in two trials. The length of the period during which a mulch layer yields significantly less weed biomass compared to the control plots is called the 'effective life-span' of the mulch. Of the three mulch materials only that of *F. macrophylla* shows promise in retarding weed development. In the second trial *F. macrophylla* leaf mulch was applied at rates of 3, 6 and 9 tons dry matter per ha. The effective lifespan of a mulch layer of 3 tons is between 12 and 13 weeks. The treatments 6 and 9 tons have effective life-spans of over 14 weeks. For moderate quantities (up to 5 tons of dry leaf mulch per ha) the effective life-span is estimated at about a 100 days. The value of mulching in weed control is limited to the control of weed species that multiply by seed. Regrowth originating from roots or stumps from former vegetation is unlikely to be checked by a mulch layer.

Monica *et al.,* (1994) conducted a field studies 1988/89 and 1989/90 at two locations to determine the effect of rye, wheat, and triticale cover crop mulches on weed emergence patterns, weed biomass, and soybean development. Redroot pigweed and common lamb squarters emergence patterns were not altered by mulches. Early in the season, mulches reduced weed biomass; however, the results were inconsistent between locations and years. Under weed-free conditions, the cover crop mulches had no detrimental effects on soybean development and yields were not different from bare soil controls.

Three years of field trials have been carried out by Anzalone *et al.,* (2011) in Zaragoza, Spain, using different biodegradable mulch materials in processing tomatoes. The aim was to evaluate weed control with several biodegradable mulches as alternatives to black polyethylene (PE) mulch. The treatments were rice straw, barley straw, maize harvest residue, absinth wormwood plants, black biodegradable plastic, brown kraft paper, PE, herbicide, manual weeding, and unweeded control. Assessments focused on weeds and on crop yield. A laboratory study showed that 1 kg/m² of organic mulch was sufficient to cover the soil for rice, barley straw and maize harvest residue. The most abundant weed species in the field were purple nutsedge, common purslane, common lambsquarters, and large crabgrass and a change in weed composition was observed between treatments and years. Most weed species were controlled by the mulching materials except that purple nutsedge was controlled only by paper mulch. The other species were well controlled by PE and biodegradable plastic and also by some of the organic mulch treatments. Best weed control and lowest weed biomass were achieved by paper followed by PE and biodegradable plastic. The best organic mulch was rice straw and the worst weed control was from absinth wormwood. Tomato yield was highest for PE followed by paper, manual weeding, biodegradable plastic, and rice straw and was clearly related to weed control. Paper, biodegradable plastic, and rice straw are potential substitutes for PE and herbicides.

El-S Hahawy *et al*., (2006) conducted a field trials were in two successive seasons (2003/ 2004) to study the allelopathic potential of rice straw residues at different rates and dates of application for controlling weeds in cucumber (*Cucumis sativa* L.). Mixing ground straw into the soil at different concentrations (125 - 500 g m-2) was consistently more effective in suppressing growth and development of a wide range of broad and narrow- leaved weeds than the intact straw, either applied simultaneously or three months prior to sowing of cucumber seeds. Applying the ground straw 3 months prior to sowing of crop seeds was the most effective treatment amongst others for controlling the weeds as well as increasing the cucumber productivity, irrespective of the rate of application. Eight phenolic acids were identified in the rice straw residues on TLC including cinnamic acid, salicylic acid, vanillic acid, p-hydroxybenzoic acid, 2, 5 dihydroxybenzoic acid, ferulic acid, o-coumaric acid and p-coumaric acid. It has been suggested that the phenolic acids might be considered the key factor of rice allelopathy against suppressing a wide range of mono-dicotyledonous weeds in different crops.

Devasinghe *et al.,* (2011) evaluated the effectiveness of rice straw mulch on managing weed populations and increasing yields of direct wet-seeded (DWSR) and direct dry-seeded rice (DDSR) in 2009 Yala (DS) and 2009/2010 Maha (WS) seasons in a principal rice growing region of Sri Lanka. The major weeds associated with DDSR in DS were *Cyperusrotundus*, *Isachneglobosa* and *Leptochloa chinensis*. In DWSR, the dominant species were *Cyperusro tundus, Echinochloa crus-galli* and *Isachne globosa*. The weed density was reduced in the WS and the major weeds were *Cyperusro tundus, Echinochloa crus-galli* and Isachne globosa. In both systems *Cyperus rotundus* was the most dominant weed species in all treatments based on the summed dominance ratio. The rice straw mulch was effective in weed management under DWSR, but not in DDSR. The grain yield was inversely correlated with increasing weed biomass and weed density in both systems. Compared to DWSR, chemical weeding which is the present practice in Sri Lanka, yield gains of 9.23% and 5.74% were achieved in DWSR with a straw mulch and a yield loss of 49.88% and 22.24% in the DDSR with the same treatment in DS and WS, respectively. The study indicated the possibility of suppressing weeds in direct wet-seeded land low rice with straw mulch in both seasons.

CHAPTER III

MATERIALS AND METHODS

This chapter describes the materials and methods which were used in the field to conduct the experiment during the period from August to December 2013. It comprises a short description of experimental site, soil and climate, variety, growing of the crops, experimental design and treatments and collection of data presented under the following headings:

3.1 Experimental site

The study was conducted at the Agronomy Farm, Sher-e-Bangla Agricultural University, Dhaka-1207, Bangladesh. Geographically the experimental area is located at $23^{0}41$ N latitude and $90^{0}22$ E longitudes at the elevation of 8.6 m above the sea level (FAO, 1988). The map showing the experimental site under the study is in Appendix III.

3.2 Characteristics of soil

Soil of the experimental field was silty loam in texture. The soil of the experimental area belongs to the Modhupur Tract (UNDP, 1988) under the AEZ No. 28. The land is above flood level and sufficient sunshine was available during experimental period (Appendix I).

3.3 Climate and weather

The climate of the experimental site was under the subtropical climate, characterized by three distinct seasons, winter season from November to February and the pre-monsoon or hot season from March to April and the monsoon period from May to October (Edris *et al*., 1979). Details of the meteorological data during the period of the experiment was collected from the Bangladesh Meteorological Department, Agargoan, Dhaka and presented in Appendix II.

3.4 Treatment of the experiment

There were two factors in the experiment as follows:

Factor-A: Three varieties of Rice

V_1= BRRI dhan33

V_2= BRRI dhan56

V_3= BRRI dhan57

Factor-B: Six types of mulch materials

T_1= Maize

T_2= Mustard

T_3= Rice

T_4= Till

T_5 = Water smartweed (Bishkathali).

T_6 = Control

3.5 Plating material

The rice varieties collected from Bangladesh Rice Research Institute (BRRI) namely BRRI dhan33, BRRI dhan56 and BRRI dhan57 were used as plating materials.

3.6 Design of the experiment

The two factorial experiments were laid out in a Randomized Complete Block Design (RCBD) with three replications.

3.7 Management of the Crop

The crop in each treatment was raised under same level of management practices. Th management practices followed in this experiment are described below:

3.7.1 Seed sprouting

The collected seeds were healthy. The seeds were immersed in a bucket filled with water for 24 hours. Then the seeds were taken out of water and kept thickly in gunny bags. The seeds started sprouting after 48 hours and were sown after 72 hours.

3.7.2 Preparation of seedling nursery and sowing of seeds

For raising rice seedlings a piece of high land was selected at the Agronomy Field Laboratory, Sher-e-Bangla Agricultural University, Dhaka. The land was puddled with mouldboard plough and leveled with ladder. Then the sprouted seeds were sown in the nursery beds on 17 July 2013. Weeds were removed and irrigation was given in the seedling nursery as and when necessary.

3.7.3 Preparation of experimental land

Tillage was given in the experimental land with a power tiller. Then the land was puddled thoroughly by repeated ploughing and cross ploughing with a mouldboard plough and subsequently leveled by laddering. Immediately after final land preparation the layout of experimental plot was made on 12 August 2013 according to experimental design. Weeds and stubbles were cleared off from individual plots and finally were levelled so properly by wooden plank that no water remained in the puddle field.

3.7.4 Fertilizer application

A fertilizer dose of 110-120-60-5 kg ha^{-1} of triple superphosphate, muriate of potash, gypsum and zinc sulphate respectively were applied at the time of final land preparation. Nitrogen (80kg N ha^{-1}) was applied in equal installments at 20 and 45 days after transplanting as top dressing.

3.7.5 Uprooting of seedlings

The seedlings were uprooted without causing any mechanical injury to the roots. Then the uprooted seedlings were transplanted in the main field.

3.7.6 Transplanting of seedlings

The seedlings were transplanted on 15 August 2013. Two to three seedlings were transplanted in each hill maintaining the spacing of 25 cm x 20 cm.

3.7.7 Application of mulching materials

All the mulch materials were chopped into small pieces (5 cm) and incorporated into the plot three days before seedling transplanting. Application rate of mulch materials were 2kg/6m^2.

3.8 Intercultural operations

3.8.1 Gap filling

Seedling in some hills died off and these were replaced by gap filling after one week of transplanting with seedlings from the same source.

3.8.2 Collection of weeds

The weed were collected before top dressing of urea. Weed collection were done twice in order to keep the crop weed free at 20 and 45 days after transplanting.

3.8.3 Water management

Water level was maintained at 3-5 cm depth to all the plots throughout the growing period.

3.8.4 Crop protection measures

No major disease incidence was observed. But, the crop was mildly attacked by green leaf hopper, brown plant hopper and stem borer at the vegetative growth stage. Diazinon (60 EC) was applied at the rate of 1.5 litre per hectare to control the insect pests.

3.9 Harvesting and processing

Five hills were selected randomly from each plot prior to harvesting. The plants were uprooted carefully for data collection. The crop of each experimental plot was harvested separately at full maturity on 15 December 2012. From the central (1m^2) area of each plot, the crop plants were harvested for collecting data on grain and straw yields. The harvested crop of each plot was bundled separately, tagged properly and brought to the clean threshing floor. The bundles were dried in sunshine, threshed and then grains were cleaned. After sun drying, the grain and straw weights were taken plot wise.

3.10 Collection of data at harvest

Experimental data on yield and yield contributing characters were recorded on the following parameters:

3.10.1 Plant height

Plant height was measured from the base of the plants to the tip of the panicle.

3.10.2 Total tillers hill^{-1}

Five hills plot^{-1} were selected and numbers of tillers were counted.

3.10.3 Effective fillers hill^{-1}

At least one grain containing panicles were considered as number of bearing tillers.

3.10.4 Non-effective fillers hill^{-1}

The panicles that contain no grain or the tiller without panicle were considered as number of non-bearing tillers.

3.10.5 Panicle length

Length of panicle was measured from the first node to the tip of the panicles and then the averages were expressed in cm.

3.10.6 Total grains panicle^{-1}

In each sample five panicles were randomly selected. Then total grains were counted and averages of 5 samples were taken.

3.10.7 Number of unfilled grains panicle^{-1}

Spikelets having unfilled endosperm were considered as unfilled grains and the numbers of such spikelets present on each panicle were counted.

3.10.8 Number of filled grains panicle^{-1}

Spikelets having food material inside were considered as filled grains and the numbers of such spikelets present on each panicle were counted.

3.10.9 Weight of 1000-grain

Thousand grains were randomly selected from each plot and then it was dried in an oven. Weight was taken in an electric balance.

3.10.10 Grain yield

Grains obtained from the central ($1m^2$) area of each plot were sun dried and weighed. Then dry weight of grains of each plot was converted to grain yield hectare^{-1}.

3.10.11 Straw yield

Straw yield obtained from the sampling area (central $1m^2$) of each plot was sun dried and weighed separately. Then the weight was converted to straw yield hectare^{-1}.

3.10.12 Biological yield

Grain yield and straw yield were altogether considered as biological yield. Biological yield was calculated with the following formula:

Biological yield (t ha^{-1}) = Grain yield (t ha^{-1}) + straw yield (t ha^{-1})

3.10.13 Harvest index (HI)

The ratio of grain yield to biological yield and was calculated with the following formula:

$$\text{Harvest index} = \frac{\text{Grain yield}}{\text{Biological yield}} \times 100$$

3.11 Statistical analysis

All the collected data were analyzed by following the analysis of variance (ANOVA) technique and mean differences were adjudged by Duncan's Multiple Range Test (DMRT) (Gomez and Gomez, 1984) using a computer operated programme named MSTAT-C.

CHAPTER IV
RESULTS AND DISCUSSION

The experiment was conducted to study the effective mulch material on weed control and yield of aman rice. The analysis of variance data on different crop and yield contributing characters as well as yield of rice as influenced by different mulch materials has been presented in this chapter.

Results of the study regarding varietal effect and mulch treatments with the interaction on yield and yield components of Transplant *Aman rice* have been presented and discussed under this section.

4.1 Yield and yield contributing characters at harvest

4.1.1 Plant height

4.1.1.1 Effect of varieties

Plant height varied significantly at 20 DAT (Appendix IV) with the highest value (40.9cm) by BRRI dhan56 which was statistically similar to that of BRRI dhan57 (40.89cm). The lowest was recorded in BRRI dhan33 (34.74cm). At 40 DAT, the plant height was significantly highest in BRRI dhan56 (93.23cm) and lowest in BRRI dhan33 (78.01). At 80 DAT BRRI dhan56 (123.9cm) was significantly highest and lowest BRRI dhan57 (98.6cm). Similar trend also found at 60 DAT (Table 1).

4.1.1.2 Effect of mulch materials

Singly Mulch materials did not affect significantly the plant height at 20 DAT, 40 DAT. 60 DAT and 80 DAT (Appendix IV). At 80 DAT, having the height range of 110.4cm - 112.4cm (Table 2).

4.1.1.3 Interaction effect of varieties and mulch materials

Interaction of varieties and mulch materials showed significant variations on plant height at 20 DAT, 40 DAT, 60 DAT and 80 DAT (Appendix IV). At 40 DAT, the highest plant height was recorded in BRRI dhan56 x no mulch (96.63cm) and the lowest in BRRI dhan33 x maize stover (81.73cm). At 60 DAT, the highest plant height (131.6cm) was found in BRRI dhan56 x no mulch while the lowest was found in BRRI dhan57 x mustard straw (99.13cm). At 20 DAT it ranged from 33.27cm to

42.73cm. But highest plant height (125.8cm) was found in BRRI dhan56 x no mulch and lowest (97.2cm) in BRRI dhan57 x no mulch interaction, at 80 DAT (Table 3).

4.1.2 Plant dry matter

4.1.2.1 Effect of varieties

Plant dry matter content varied significantly at 20 DAT (Appendix V) with the highest value (1.997gm) by BRRI dhan57 which was statistically similar to that of BRRI dhan56 (1.991gm). The lowest value was recorded in BRRI dhan33 (1.669gm). At 40 DAT, the plant dry matter did not varying significantly. But, it was significantly highest in BRRI dhan33 (49.47gm) and the lowest in BRRI dhan57 (41.60gm) at 60 DAT. The dry matter at 80 DAT BRRI dhan33 (59.19gm) was significantly highest which is statistically similar to BRRI dhan56 (57.55gm)(Table 1).

Table 1. Effect of varieties on plant height and dry matter of T. Aman rice at different growth durations

Varieties	Plant height (cm)				Plant dry matter (gm)			
	20 DAT	40 DAT	60 DAT	80 DAT	20 DAT	40 DAT	60 DAT	80 DAT
V_1	34.74b	78.01 b	113.8 b	110.9 b	1.669 b	22.96a	49.47a	59.19a
V_2	40.9 a	93.23 a	128.2 a	123.9 a	1.991 a	23.24a	49.89a	57.55a
V_3	40.89 a	79.38 b	100.6 c	98.6 c	1.997 a	25.75a	41.60b	48.65b
LSD value at 5 %	1.75	2.21	2.64	1.94	0.276	2.86	4.364	3.31
CV (%)	6.68	3.90	3.42	2.59	21.62	17.63	13.71	8.87

V_1=BRRI dhan 33, V_2= BRRI dhan 56, V_3= BRRI dhan 57

4.1.2.2 Effect of mulch materials

Mulch materials did not affect significantly the dry matter production at 20 DAT, 60 DAT and 80 DAT(Appendix V)..However, significant variation was observed in dry matter production at 40 DAT (Appendix II). The highest dry matter content (27.33gm) at 40 DAT was found in maize stover applied plants and the lowest was obtained in mustard straw treated plants (22.00gm) (Table 2).

Table 2. Effect of mulch materials on plant height and plant dry matter of rice at different growth durations

Treatments	Plant height (cm)				Plant dry matter (gm)			
	20 DAT	40 DAT	60 DAT	80 DAT	20 DAT	40 DAT	60 DAT	80 DAT
T_1	38.4 a	84.71a	115.0 a	112.0 a	1.807a	27.33 a	50.51 a	56.87a
T_2	38.44a	83.52a	113.6a	111.1a	2.033 a	22.00 b	46.25 a	53.57 a
T_3	37.71a	82.78a	114.7a	112.4a	1.675 a	22.11 b	44.55 a	57.10 a
T_4	39.42a	82.56a	113.8a	110.5a	2.010 a	23.74ab	48.64 a	53.65 a
T_5	40.11a	83.18a	113.5a	110.5a	1.938 a	25.05ab	46.97 a	56.41 a
T_6	38.98a	84.48a	114.5a	110.4a	1.851 a	23.66ab	45.00 a	53.15 a
LSD value at 5 %	2.48	3.12	3.74	2.75	0.3903	4.052	66.172	4.682
CV (%)	6.68	3.90	3.42	2.59	21.62	17.63	13.71	8.87

T_1=Maize stover, T_2= Mustard straw, T_3= Rice straw, T_4= Sesame stover, T_5= Water smart weed straw, T_6= No mulch

4.1.2.3 Interaction effect of varieties and mulch materials

Interaction of varieties and mulch materials showed significant variations in respect of dry matter production at 20 DAT, 40 DAT, 60 DAT and 80 DAT (Appendix V). At 40 DAT, the highest dry matter was recorded in BRRI dhan56 x maize straw mulch (28.41gm) and the lowest in BRRI dhan33 x no mulch (18.99gm). At 60 DAT, the highest dry matter (53.44gm) was found in BRRI dhan56 x sesame stover mulch while the lowest was found in BRRI dhan57 x rice straw mulch (38.19gm). At 20 DAT it ranged from 1.51gm to 2.43gm. But highest dry matter (64.89gm) was found in BRRI dhan33 x rice straw and lowest (44.70gm) in BRRI dhan57 x no mulch, at 80 DAT (Table 3).

Table 3. Combined effect of varieties and mulch materials on plant height and plant dry matterat different growth durations

Treatment Combinations	Plant Height				Plant dry matter (gm)			
	20 DAT	40 DAT	60 DAT	80 DAT	20 DAT	40 DAT	60 DAT	80 DAT
V_1T_1	35.40 cd	81.73 c	115.6 b	112.4 b	1.51 c	28.02 a	51.50 ab	59.65 a-d
V_1T_2	34.27 d	78.90 cd	113.7 b	111.0 b	1.84 abc	20.00 cde	45.88 a-e	55.20 b-f
V_1T_3	33.27 d	77.19 cd	114.4 b	112.7 b	1.53 c	22.47 a-e	46.00 a-e	64.89 a
V_1T_4	34.53 d	76.03 d	116.0 b	111.4 b	1.71 bc	20.71 b-e	52.78 a	56.07 b-f
V_1T_5	37.0 bcd	78.15 cd	112.0 b	109.5 b	1.83 abc	27.55 ab	52.76 a	61.01 ab
V_1T_6	34.0 d	76.06 d	111.1 b	108.2 b	1.60 c	18.99 e	47.99 a-e	58.31 a-d
V_2T_1	40.60 ab	94.57 ab	127.9 a	123.8 a	2.14 abc	28.41 a	51.19 abc	58.72 a-d
V_2T_2	39.67 abc	92.20 ab	127.9 a	124.3 a	1.83 abc	19.87 cde	50.92 abc	56.83 a-d
V_2T_3	39.13 abc	90.70 b	126.3 a	123.1 a	1.66 c	19.25 de	49.47 a-d	60.18 a-c
V_2T_4	42.40 a	93.33 ab	126.4 a	122.5 a	2.17 abc	23.36 a-e	53.44 a	56.65 b-e
V_2T_5	42.73a	91.93 ab	128.8 a	124.1 a	2.34 ab	22.07 a-e	48.06 a-e	56.44 b-e
V_2T_6	40.87 ab	96.63 a	131.6 a	125.8 a	1.81 abc	26.46 abc	46.26 a-e	56.44 b-e
V_3T_1	39.20 abc	77.83 cd	101.4 c	99.61 c	1.77 abc	25.55 a-e	48.82 a-e	52.24 c-g
V_3T_2	41.40 a	79.46 cd	99.13 c	97.87 c	2.43 a	26.14 a-d	41.94 b-e	48.68 e-g
V_3T_3	40.73 ab	80.47 cd	103.3 c	101.3 c	1.84 abc	24.62 a-e	38.19 e	46.24 g
V_3T_4	41.33 a	78.30 cd	98.91 c	97.65 c	2.15 abc	27.15 ab	39.70 de	48.22 fg
V_3T_5	40.60 ab	79.46 cd	99.83 c	98.0 c	1.65 c	25.52 a-e	40.19 de	51.80 d-g
V_3T_6	42.07 a	80.74 cd	100.9 c	97.20 c	2.14 abc	25.53 a-e	40.75 cde	44.70 g
LSD value at 5 %	4.30	5.41	6.47	4.77	0.6761	7.018	10.69	8.11
CV (%)	6.68	3.90	3.42	2.59	21.6%	17.63	13.71	8.87

V_1=BRRI dhan 33, V_2= BRRI dhan 56, V_3= BRRI dhan 57, T_1=Maize stover, T_2= Mustard straw, T_3= Rice straw, T_4=Sesame stover, T_5= Water smart weed, T_6= No mulch

4.1. 3. Number of tillers hill^{-1} at 20 DAT

4.1.3.1 Effect of varieties

Varieties showed significant effect on producing tillers hill^{-1}at 20 DAT (Appendix VI).The highest number of tillers hill^{-1} (12.11) was obtained from BRRI dhan56 and that of the lowest (9.0) in BRRI dhan33 (Figure 1).

4.1.3.2 Effect of mulch materials

It was observed that mulch materials also differed significantly in producing tillers hill^{-1} 20 DAT (Appendix VI). The highest number of tillers hill^{-1} (11.66) was obtained from the mulch water smart weed mulch. The lowest number of tillers hill^{-1} (9.11) was obtained in maize straw mulch (Table 4).

4.1.3.3 Interaction effect of varieties and mulch materials

Interaction effect of varieties and mulch materials showed significant effect on number of tillers hill^{-1}(Appendix VI). Result showed that the highest number of tillers hill^{-1} (14.0) was produced by BRRI dhan57 with water smart weed mulch materials and that of the lowest (6.33) was obtained from the combination of BRRI dhan33 x Maize stover mulch (Table 5).

4.1.4 Number of tillers hill^{-1} at 40 DAT

4.1.4.1 Effect of varieties

Varieties showed significant effect on the production of tillers hill^{-1}(Appendix VI). The highest number of tillers hill^{-1} (24.72)was obtained from BRRI dhan57 and the lowest number of tillers hill^{-1} (19.0) was found from BRRI dhan56 which was statistically similar to that of BRRI dhan33 (19.33) at 40 DAT (Figure 1).

4.1.4.2 Effect of mulch materials

It was observed that different plant mulch materials had significant effect on the number of tillers hill^{-1}(Appendix VI). The highest number of tillers hill^{-1} (23.55) was from maize stover mulch. The lowest number of tillers hill (16.88)was found in no mulch treated plots.(Table 4).

4.1.4.3 Effect of interaction varieties and mulch materials

The interaction effect between rate of varieties and mulch materials was significant on the number of tillers hill^{-1} 40 DAT (Appendix VI). Results showed the highest number of tillers hill^{-1} (28.33) was obtained from BRRI dhan57 x water smart weed mulch materials and the lowest number of tillers hill^{-1} (15) was found from BRRIdhan33 x no mulch treatment (Table 5).

4.1.5 Number of tillers hill^{-1} at 60 DAT

4.1.5.1 Effect of varieties

Varieties had significant effect on the number of tillers hill^{-1} 60 DAT (Appendix VI). The highest number of tillers hill^{-1} (24.77) was obtained from BRRI dhan57. The lowest number of tillers hill^{-1} (17.44) was found in BRRI dhan33 which was statistically similar to that of BRRI dhan56 (18.38) (Figure 1).

4.1.5.2 Effect of mulch materials

The tillers hill^{-1} was not significantly influenced by different mulch treatments 60 DAT (Appendix VI). However, the highest number of tillers hill^{-1} (21.11) was obtained from maize mulch materials and the lowest by no mulch materials (Table 4).

4.1.5.3 Effect of interaction of varieties and plant mulch materials at 60 DAT

Number of tillers hill^{-1} was significantly influenced by varieties and mulch materials 60 DAT (Appendix VI). The highest number of tillers hill^{-1} (26.67) was obtained from the combined effect of BRRI dhan57 with water smart weed mulch material which was statically similar to the other 5 combinations of BRRI dhan57. Non significant variations were found in the interaction effects of the result of the varieties with mulch materials under study (Table 5).

4.1.6 Number of tillers hill^{-1} at 80 DAT

4.1.6.1 Effect of varieties

At 80 DAT, significantly(Appendix VI) the highest number of tillers hill^{-1} (23.88) was observed in the variety BRRI dhan57 while it was found lowest in BRRI dhan33 (17.33) (Figure 1).

4.1.6.2 Effect of mulch materials

Single effect of mulch materials showed insignificant variations among the six mulch materials used under the study at 80 DAT in respect of number of tiller hill^{-1}(Appendix VI). It ranged from 18.44 to 20.44(Table 4).

4.1.6.3 Interaction effect of varieties and mulch materials

A significant difference was observed in the combined effect of rice variety and mulch materials in respect of number tillers hill^{-1} at 80 DAT(Appendix VI). The highest number of tillers hill^{-1} was recorded in BRRI dhan57 x maize straw mulch combination (25.33) followed by BRRI dhan57 x water smart weed (24.33), BRRI dhan57 x sesame stover (24.0) and BRRI dhan57 x no mulch (Table 5).

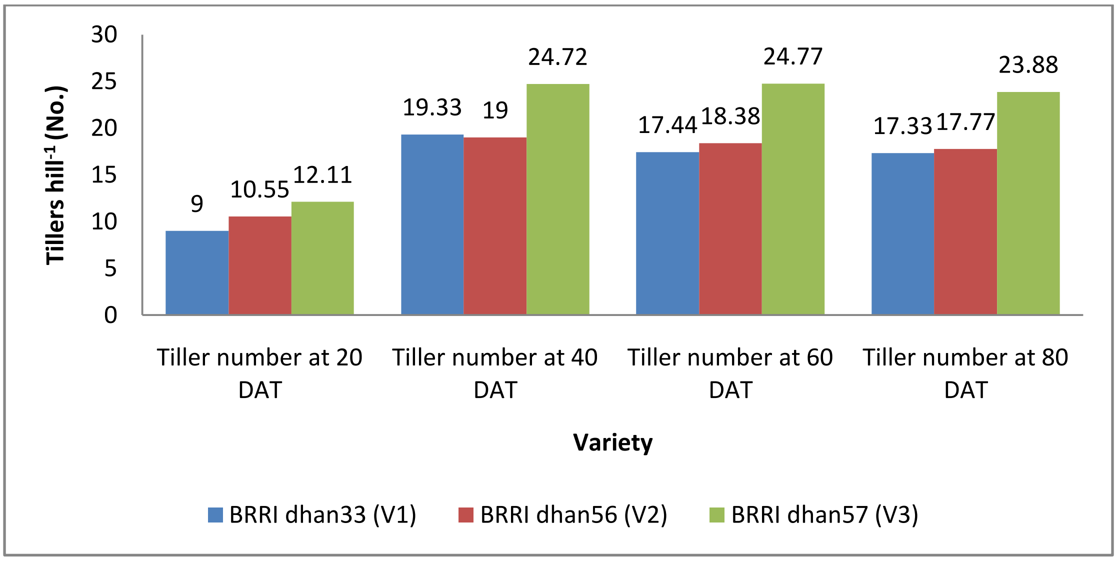

Figure 1. Effect of variety on tiller number of rice at different growth duration ($LSD_{0.05}$ = 1.222, 1.722, 1.500 and 1.717 for 20 DAT, 40 DAT, 60 DAT and 80 DAT respectively)

Table 4. Effect of mulch materials on tiller number of rice at different growth durations

Treatments	Number of tillers $hill^{-1}$			
	20 DAT	40 DAT	60 DAT	80 DAT
T_1	9.11 c	23.55 a	21.11 a	20.44 a
T_2	11.33 ab	21.33 ab	19.77 a	19.88 a
T_3	9.77 bc	21.22 ab	20.0 a	19.66 a
T_4	10.44 abc	21.11 b	20.33 a	19.77 a
T_5	11.66 a	22.0 ab	20.55 a	19.77 a
T_6	11.0 ab	16.88 c	19.44 a	18.444 a
LSD value at 5 %	1.72	2.43	2.12	2.42
CV (%)	17.08	12.09	10.96	12.89

T_1=Maize stover, T_2= Mustard straw, T_3= Rice straw, T_4= Sesame stover,T_5= Water smartweed, T_6= No mulch

Table 5. Combined effect of varieties and mulch materials on number of tillers $hill^{-1}$ at different growth durations

Treatment Combinations	Number of tillers $hill^{-1}$			
	20DAT	40DAT	60DAT	80DAT
V_1T_1	6.333 f	22.33 c-f	18.0 b	18.0 d
V_1T_2	10.33 de	19.67 fg	17.67 b	17.0 d
V_1T_3	9.0 ef	20.33 d-g	17.33 b	17.0 d
V_1T_4	9.33 de	19.33 fg	18.33 b	18.67 cd
V_1T_5	9.0 ef	19.33 fg	17.33 b	17.67 d
V_1T_6	10.0 de	15.0 h	16.0 b	15.67 d
V_2T_1	10.33 de	21.33 def	19.67 b	18.0 d
V_2T_2	10.33 de	18.67 fgh	17.67 b	19.33 bcd
V_2T_3	10.33 de	19.0 fgh	19.0 b	19.33 bcd
V_2T_4	11.0 b-e	20.0 efg	18.67 b	16.67 d
V_2T_5	12.0 a-d	18.33 fgh	17.67 b	17.33 d
V_2T_6	9.33 de	16.67 gh	17.67 b	16.0 d
V_3T_1	10.67 cde	27.0 ab	25.67 a	25.33 a
V_3T_2	13.33 abc	25.67 abc	24.0 a	23.33 ab
V_3T_3	10.0 de	24.33 a-d	23.67 a	22.67 abc
V_3T_4	11.0 b-e	24.0 b-e	24.0 a	24.0 a
V_3T_5	14.0 a	28.33 a	26.67 a	24.33 a
V_3T_6	13.67 ab	19.0 fgh	24.67 a	23.67 a
LSD value at 5 %	2.99	4.21	3.67	4.20
CV (%)	17.08	12.09	10.96	12.89

V_1=BRRI dhan 33, V_2= BRRI dhan 56, V_3= BRRI dhan 57, T_1=Maize stover, T_2= Mustard straw, T_3= Rice straw, T_4=Sesame stover, T_5= Water smart weed, T_6= No mulch.

4.1.7 Number of effective tillers hill^{-1}

4.1.7.1 Effect of varieties

Significant difference in respect of number of effective tillers hill^{-1} was observed due to the mean effect of variety (Appendix VII). The highest number of effective tillers hill^{-1} (21.72) was found in BRRI dhan57 whereas the lowest value (15.0) was recorded from BRRI dhan56 which was statistically similar with that of BRRI dhan33 (16.11) (Figure 2).

4.1.7.2 Effect of mulch materials

Mean effect of mulch materials on effective no. of tillers hill^{-1} did not show any statistical difference (Appendix VII). It ranged from 16.66 to 18.55 (Table 6).

4.1.7.3 Interaction effect of varieties and mulch materials

The combined effect of varieties and mulch materials showed statistically dissimilar effect on in number of tillers hill^{-1}(Appendix VII). The highest (23.33) was recorded in both BRRI dhan57x maize stover followed by BRRI dhan57x water smart weed straw (22.0), BRRI dhan57x Sesame stover (22.0) and BRRI dhan57 x Rice straw (21.67). The lowest value was obtained from both BRRI dhan56 x water smart weed (15.0) and BRRI dhan56 x No mulch (15.0) (Table 7).

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

4.1.8.1 Effect of varieties

The effect of varieties on number of non-effective tiller hill^{-1} differed significantly (Appendix VII). The highest number of non-effective tillers hill^{-1} was found in the variety BRRI dhan57 (2.16) and lowest was obtained from BRRI dhan33 (1.33). It indicates that BRRI dhan33 is best among the varieties because it produced less number of non-effective tillers hill^{-1}. (Figure 2)

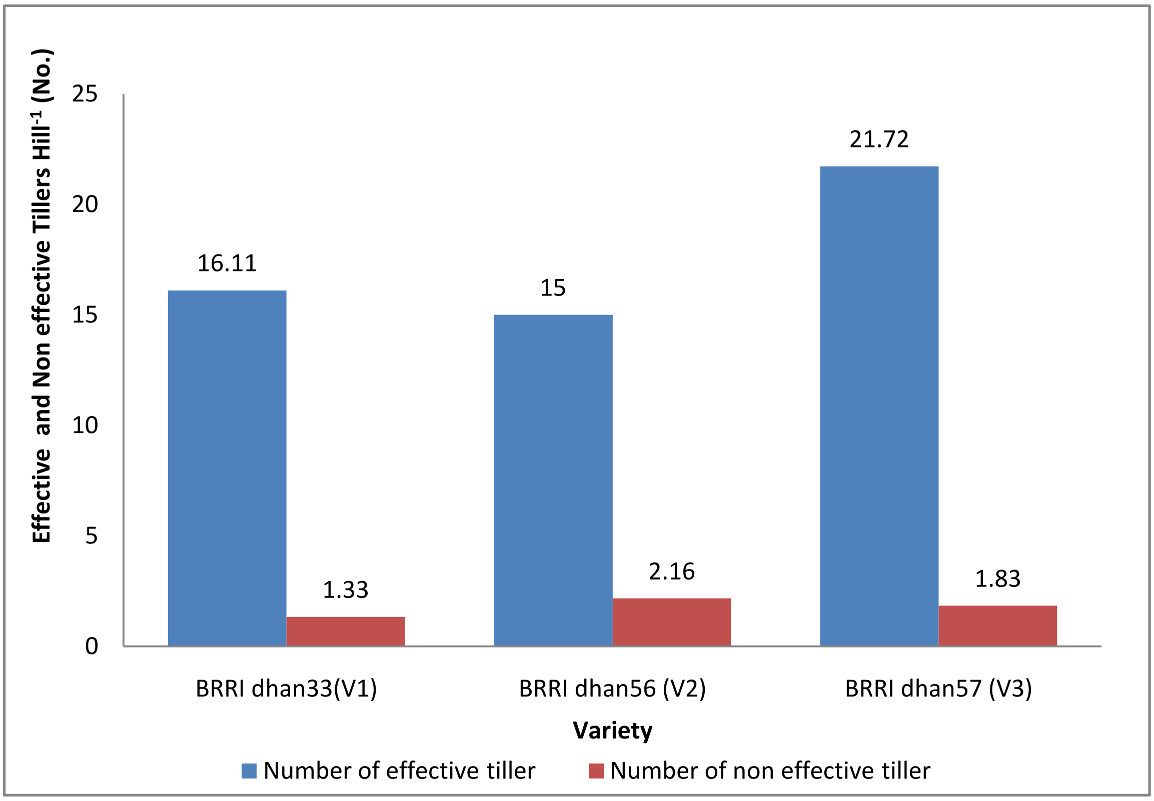

Figure 2. Effect of varieties on number of effective and non effective tiller ($LSD_{0.05}$ = 1.535 and 0.5051 for effective and non effective tillers respectively)

4.1.8.2 Effect of mulch materials

Statistically significant variation was observed among the mean effect of the mulch treatments used (Appendix VII). The highest contribution of mulch materials in respect of number of non-effective tillers was found in mustard straw (2.2) and the lowest was obtained from rice straw (1.44) (Table 6).

4.1.8.3 Interaction effect of varieties and mulch materials

Interaction of rice varieties and mulch materials caused significant difference among the combinations in respect of number of non-effective tillers hill^{-1}(Appendix VII). The highest value was found from BRRI dhan56 x mustard straw (3.33) while the lowest was produced by the combination of BRRI dhan33 x rice Straw (1.0), BRRI dhan56 x no mulch (1.0) and BRRI dhan57 x rice straw (1.0). It indicated that rice straw mulch had tremendous effect on reduction of non-effective tiller hill^{-1} (Table 7).

Table 6. Effect of mulch materials on number of effective tiller and non-effective tillers hill^{-1}

Treatments	Number of effective tiller hill^{-1}	Number of non-effective tiller hill^{-1}
T_1	18.55 a	1.66 ab
T_2	17.55 a	2.22 a
T_3	18.22 a	1.44 b
T_4	17.88 a	2.0 ab
T_5	17.77 a	1.66 ab
T_6	16.66 a	1.66 ab
LSD value at 5 %	2.17	0.71
CV (%)	12.75	41.93

T_1=Maize stover, T_2= Mustard straw, T_3= Rice straw, T_4= Sesame stover, T_5= Water smartweed starw, T_6= No mulch

Table 7. Combination effect of varieties and mulch materials on number of effective and non-effective tillers hill^{-1}

Treatment Combination	Number of effective tiller hill^{-1}	Number of non effective tiller hill^{-1}
V_1T_1	16.67 c	1.33 cd
V_1T_2	15.67c	1.33 cd
V_1T_3	16.33c	1.0 d
V_1T_4	17.33 bc	1.66 bcd
V_1T_5	16.33c	1.33 cd
V_1T_6	14.33c	1.33 cd
V_2T_1	15.67c	2.0 bcd
V_2T_2	16.33c	3.33 a
V_2T_3	16.67c	2.33 abc
V_2T_4	14.33c	2.33 abc
V_2T_5	15.0 c	2.0 bcd
V_2T_6	15.0 c	1.0 d
V_3T_1	23.33a	1.66 bcd
V_3T_2	20.67ab	2.0 bcd
V_3T_3	21.67a	1.0 d
V_3T_4	22.0 a	2.0 bcd
V_3T_5	22.0 a	1.66 bcd
V_3T_6	20.67 ab	2.66 ab
LSD value at 5 %	3.76	1.23
CV (%)	12.75	41.93

V_1=BRRI dhan 33, V_2= BRRI dhan 56, V_3= BRRI dhan 57, T_1=Maize stover, T_2= Mustard straw, T_3= Rice straw, T_4= Sesame stover, T_5= Water smartweed starw, T_6= No mulch.

4.1.9 Panicle length

4.1.12.1 Effect of varieties

Mean length of panicle was found to differ significantly with the varieties used (Appendix VII). The highest panicle length was contributed by BRRI dhan33 (27.03cm) followed by BRRI dhan56 (26.5cm) and the lowest was observed in BRRI dhan57 (23.07cm) (Figure 3).

4.1.9.2 Effect of mulch materials

It was observed that mulch materials had significant effect on panicle length (Appendix VII). The highest panicle length (25.84cm) was found in both mustard straw and water smart weed mulch followed by maize stover mulch and the shortest panicle length (24.77cm) was observed in no mulch (Figure 4).

4.1.9.3 Interaction effect of varieties and mulch materials

The experimental results showed that the interaction effect of varieties and plant mulch materials was significant on panicle length (Appendix VII). The longest panicle was obtained from BRRI dhan33 x mustard straw (27.57cm) followed by BRRI dhan33 x maize stover (27.55cm) and BRRI dhan56 x water smart weed mulch (27.50cm) whereas the shortest panicle was (22.25 cm) obtained from the BRRI dhan57 x no mulch (22.0cm)(Table 8).

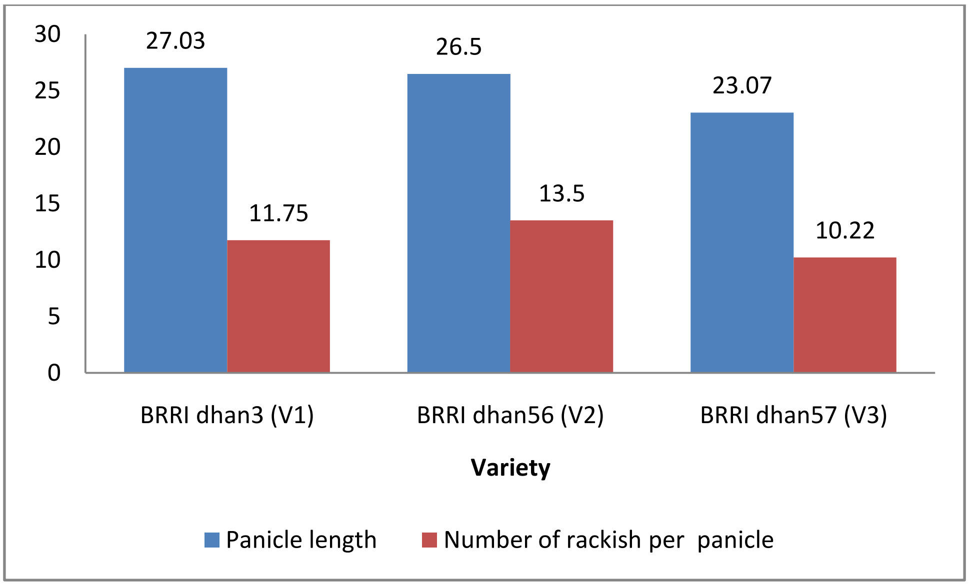

Figure 3. Effect of varities on panicle length and number of rakish panicle^{-1} (LSD$_{0.05}$ = 0.7118 and 0.5839 for panicle length and rakish panicle^{-1}respectively)

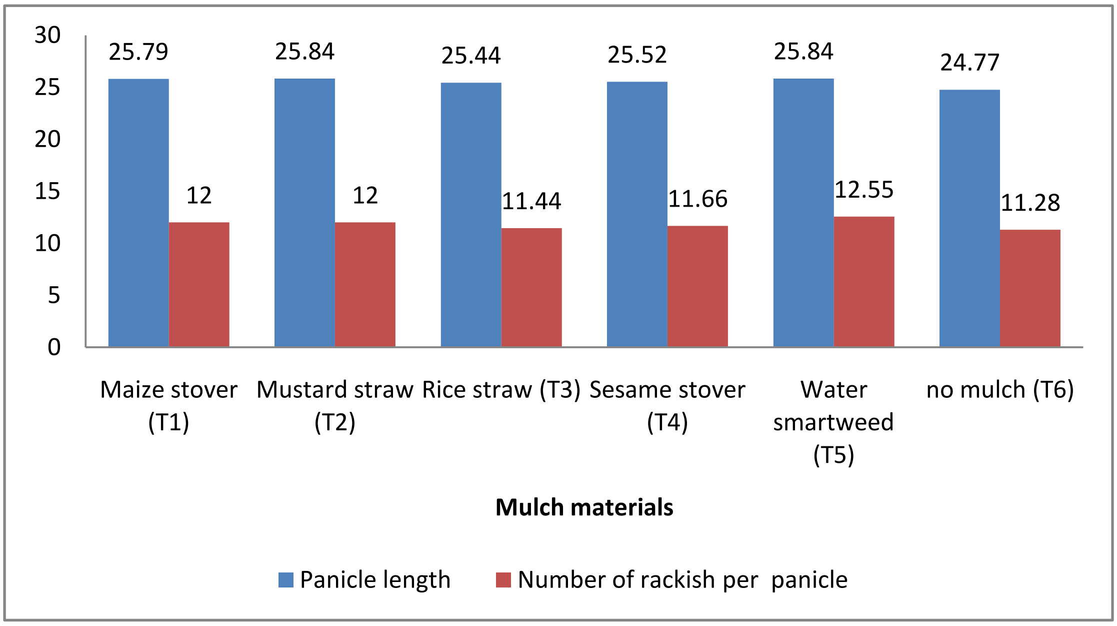

Figure 4.Effect of mulch materials on panicle length, number of rakish panicle^{-1} (LSD$_{0.05}$ = 1.007 and 0.8258 for panicle length and rakish panicle^{-1} respectively)

4.1.10 Number of rakish panicle^{-1}

4.1.10.1 Effect of varieties

Singly number of rakish panicle^{-1} varied significantly with the varieties (Appendix VII). The highest number of rakish panicle^{-1} (13.5) was found in BRRI dhan56 whereas the lowest was observed in BRRI dhan57 (10.22) (Figure 3).

4.1.10.2 Effect of mulch materials

Mean effect of mulch materials had significant effect on the production of number of rakish panicle^{-1} of T-Aman rice (Appendix VII). Water smart weed mulch contributed the highest (12.55) number of rakish panicle^{-1}, while the lowest (11.28) was obtained from no mulch materials. It clearly indicates that mulching had positive effect on number of rakish panicle^{-1}(Figure 4).

4.1.10.3 Interaction effect of varieties and mulch materials

The interaction of varieties and mulch materials showed significant variations among the treatment combinations in respect of number of rakish panicle^{-1} production (Appendix VII). Considering number of rakish panicle, BRRI dhan56 x water smart weed mulch produces the highest (14.67) number of rakish panicle^{-1} while the lowest was contributed by BRRI dhan57x no mulch (10.0), BRRI dhan57xsesame mulch

(10.0) and BRRI dhan57 x maize stover (10.0). It clearly indicated that combination of BRRI dhan57 with any mulch materials showed the lowest effect on rakis panicle^{-1} (Table 8).

Table 8. Combination effect of varieties and mulch materials on panicle length and number of rakish panicle^{-1}

Treatment Combination	Panicle length (cm)	Number of rakish panicle^{-1}
V_1T_1	27.55 a	12.33 cd
V_1T_2	27.57 a	11.67 de
V_1T_3	26.97 ab	11.67 de
V_1T_4	26.54 ab	11.67 de
V_1T_5	27.28 ab	12.33 cd
V_1T_6	26.32 ab	10.87 ef
V_2T_1	26.21 ab	13.67 abc
V_2T_2	26.80 ab	14.0 ab
V_2T_3	25.55 b	12.33 cd
V_2T_4	26.97 ab	13.33 abc
V_2T_5	27.50 a	14.67 a
V_2T_6	26.01 ab	13.0 bcd
V_3T_1	23.63 cd	10.0 f
V_3T_2	23.17 cd	10.33 ef
V_3T_3	23.80 c	10.33 ef
V_3T_4	23.07 cd	10.0 f
V_3T_5	22.77 cd	10.67 ef
V_3T_6	22.00 d	10.0 f
LSD value at 5 %	1.74	1.43
CV (%)	4.11	7.29

V_1=BRRI dhan 33, V_2= BRRI dhan 56, V_3= BRRI dhan 57, T_1=Maize stover, T_2= Mustard straw, T_3= Rice straw, T_4= Sesame stover, T_5= Water smartweed starw, T_6= No mulch.

4.1.11Number of filled grains panicle^{-1}

4.1.11.1 Effect of varieties

Varieties had significant effect on number of filled grains panicle^{-1}(Appendix VII).The highest number of filled grains panicle^{-1}(148.55) was obtained from and BRRI dhan33. The lowest number of filled grains panicle^{-1} (105.11) was recorded from the variety BRRI dhan57 (Figure 5**).**

4.1.11.2 Effect of mulch materials

Mulch materials showed non-significant (Appendix VII) effect on number of filled grains panicle^{-1} ranging from 124.66 to 131.44.(Figure 6**).**

4.1.11.3 Interaction effect of varieties and mulch materials

Interaction of varieties and mulch materials showed significant variation on the number of filled grains panicle^{-1}(Appendix VII).The highest number of filled grains panicle^{-1} (155.0) was recorded in the interaction of BRRI dhan33 with rice straw mulch materials and the lowest one (98.33) was observed from the combination of BRRI dhan57 with rice straw mulch treatment (98.33) which was statistically as par with that of BRRI dhan57 x mustard straw (98.67) (Table 9).

4.1.12 Number of unfilled grains panicle^{-1}

4.1.12.1 Effect of varieties

Varieties had significant effect on the number of unfilled grains panicle^{-1}(Appendix VII). The maximum number of unfilled grains panicle^{-1} (29.83) was recorded from BRRI dhan56 followed by and BRRI dhan57 (28.72). The minimum number of unfilled grains panicle^{-1} (21.94) was found in BRRI dhan33. This indicated that the variety BRRI dhan33 was better compared to other two varieties in respect of number of unfilled grains panicle (Figure 5**).**

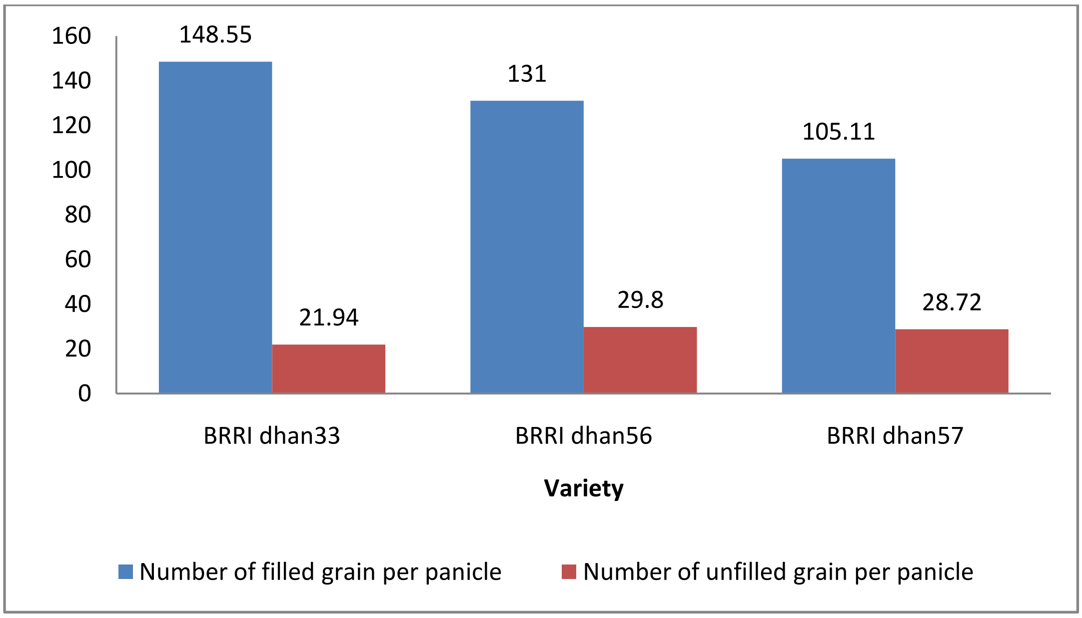

Figure 5. Effect of varities on filled grain panicle^{-1} and unfilled grain panicle^{-1} ($LSD_{0.05}$ = 8.946 and 5.045 for filled and unfilled grain panicle^{-1} respectively)

4.1.12.2 Effect of mulch materials

Number of unfilled grains was significantly influenced by mulch materials used (Appendix VII). Rice straw mulch materials produced significantly the highest number of unfilled grains panicle^{-1} (31.22) and the lowest one (22.0) was produced by sesame straw mulch materials (Figure 6**).**

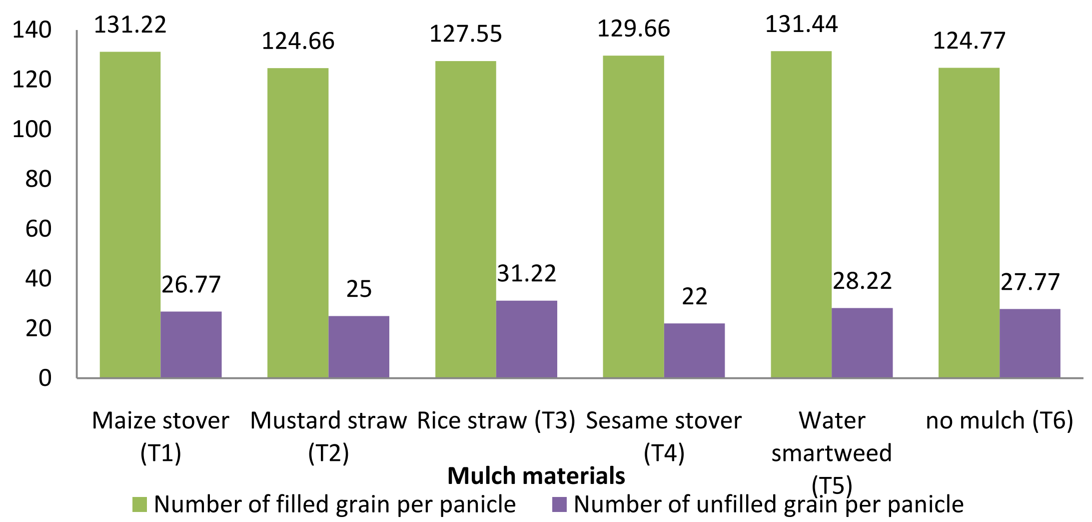

Figure 6. Effect of mulch materials on filled grain panicle^{-1} and unfilled grain panicle^{-1} (LSD$_{0.05}$ = 12.65 and 7.135 for filled and unfilled grain panicle^{-1} respectively)

4.1.12.3 Interaction effect of varieties and mulch materials

Number of unfilled grains panicle was significantly influenced by the interaction between varieties and mulch treatment (Appendix VII). Numerically the highest number of unfilled grains panicle^{-1} (41.67) was recorded in BRRI dhan56 x no mulch materials and the lowest one (16.0) was obtained from BRRI dhan33x mustard straw treatment (Table 9). It indicates that mulch materials has tremendous effect on grain filling in rice (Table 9).

4.1.13 1000-grain weight

4.1.13.1 Effect of varieties

The effect of varieties on 1000-grain weight was found significant (Appendix VII). Apparently the highest (28.41g) 1000-grain weight was found in BRRI dhan33. The lowest 1000-grain weight was found from BRRI dhan57 (16.17g). The result indicated that the varieties are affected to produce different size grain (Figure 7).

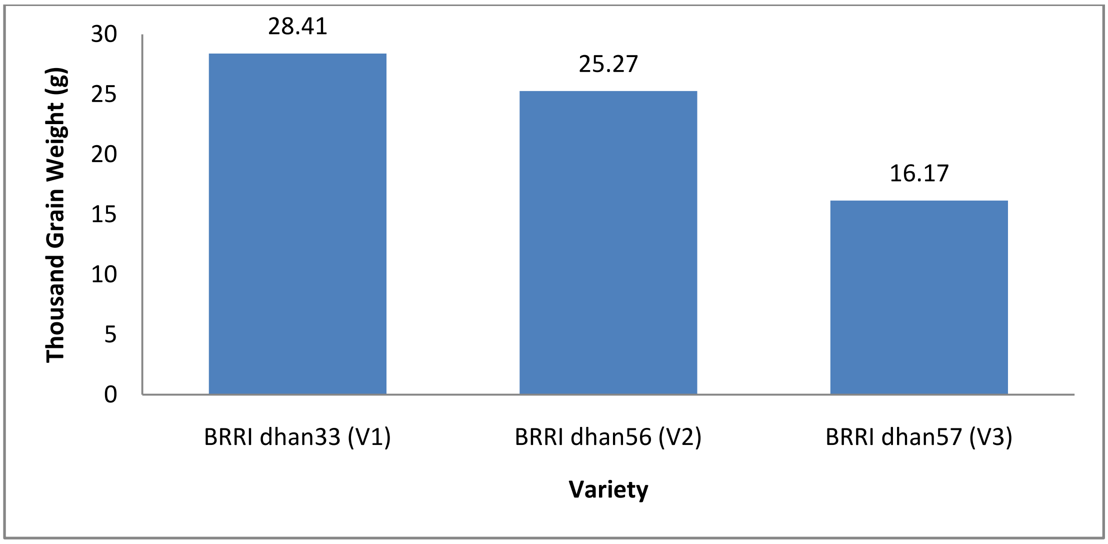

Figure 7. Effect of varieties on thousand grain weights ($LSD_{0.05}$ = 0.08015)

4.1.13.2 Effect of mulch materials

The effect of mulch materials on 1000-grain weight was found significant (Appendix VII). The results indicated that the highest 1000-gram weight was found from rice straw mulch (23.84) and the lowest (22.79) was found in plots with no mulch. Thus, it indicated that addition of mulch materials increase the seed grain size, which might be due to the addition of more nutrient to the plant. (Figure 8).

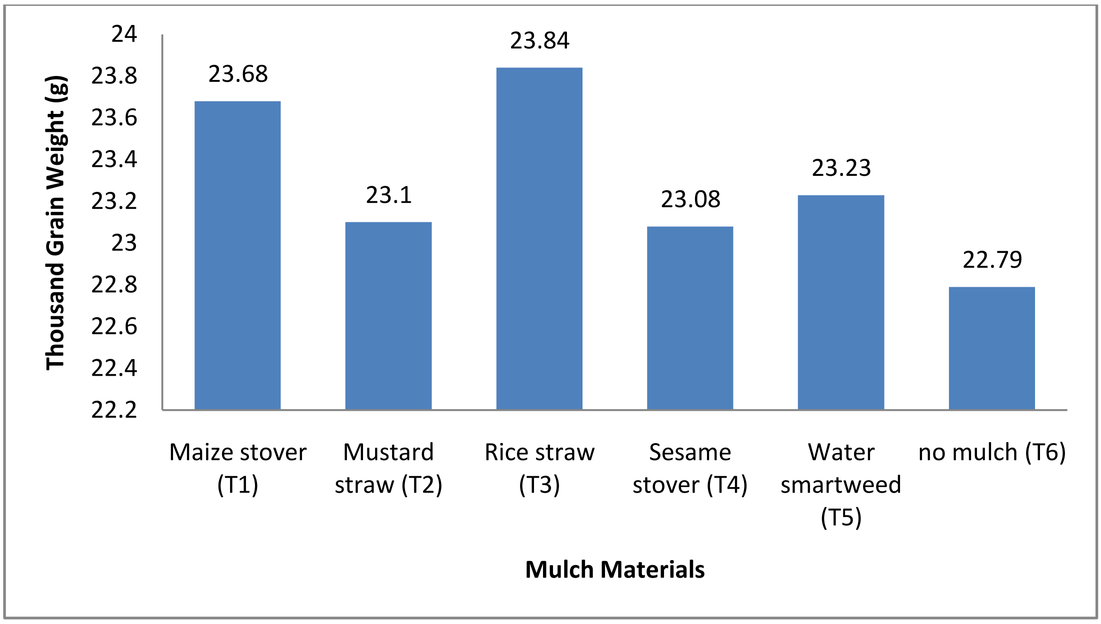

Figure 8. Effect of mulch materials on thousand grain weights ($LSD_{0.05}$ = 0.1134)

4.1.13.3 Interaction effect of varieties and mulch materials

The interaction effect of different varieties and mulch materials was significant in respect of 1000-gram weight (Appendix VII). The 1000-grain weight ranged from 14.93g to 28.97g. The highest (28.97g) 1000-grain weight was obtained from the combination of BRRI dhan33 x sesame stover mulch and the lowest (14.93g) was obtained from BRRI dhan57 x sesame stover mulch (Table 9).

Table 9. Effect of varieties and mulch materials combination on filled grain, unfilled grain panicle^{-1} and thousand grain weight

Treatment Combination	Number of filled grain panicle^{-1}	Number of unfilled grain panicle^{-1}	1000- grain weight (gm)
V_1T_1	147.7 ab	22.33 b-e	28.27 d
V_1T_2	146.3 ab	16.0 e	28.0 e
V_1T_3	155.0 a	28.33 b-e	28.70 b
V_1T_4	147.0 ab	19.0 de	28.97 a
V_1T_5	149.3 ab	24.67 b-e	28.47 c
V_1T_6	146.0 ab	21.33 b-e	28.07 e
V_2T_1	133.7 a-d	25.0 b-e	25.67 f
V_2T_2	129.0 b-e	27.67 b-e	25.47 g
V_2T_3	129.3 b-e	33.0 ab	25.77 f
V_2T_4	138.7 abc	20.33 cde	25.33 g
V_2T_5	133.3 a-e	31.33 a-d	24.60 i
V_2T_6	122.0 c-f	41.67 a	24.83 h
V_3T_1	112.3 d-g	33.0 ab	17.10 j
V_3T_2	98.67 g	31.33 a-d	15.83 l
V_3T_3	98.33 g	32.33 abc	17.07 j
V_3T_4	103.3 fg	26.67 b-e	14.93 n
V_3T_5	111.7 efg	28.67 bcd	16.63 k
V_3T_6	106.3 fg	20.33 cde	15.47 m
LSD value at 5 %	21.91	12.36	0.19
CV (%)	10.30	27.76	0.51

V_1=BRRI dhan 33, V_2= BRRI dhan 56, V_3= BRRI dhan 57, T_1=Maize stover, T_2= Mustard straw, T_3= Rice straw, T_4= Sesame stover, T_5= Water smart weed starw, T_6= No mulch.

4.1.14 Grain yield

4.1.14.1 Effect of varieties

Grain yield differed significantly with varieties (Appendix VIII). The highest grain yield (5.41 t ha^{-1}) was estimated in BRRI dhan33 and the lowest (4.09 t ha^{-1}) was obtained from BRRI dhan57. The higher and lower yield might be due to the genetic potentiality of the respective varieties (Table 10).

4.1.14.2 Effect of mulch materials

Grain yield affected significantly due to mulch materials (Appendix VIII). Grain yield ranged from 4.486 t ha^{-1} to 5.026 t ha^{-1}. However, it was found better improvement over the control treatments (Table 11).

4.1.14.3 Interaction effect of varieties and mulch materials

A significant variation was observed among the combined treatments of varieties and mulch materials in respect of dry grain production per hectare (Appendix VIII). The highest (5.508 t ha^{-1}) grain yield was observed in the treatment combination of BRRI dhan56 x rice straw while the lowest was estimated in the combination of BRRI dhan57 x no mulch (3.717 t ha^{-1}). It was observed that BRRI dhan57 in combination with all the mulch treatments contributed less grain yield production. But increase in grain yield was observed with addition of mulch materials in each and every combination (Table 12).

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

4.1.15.1 Effect of varieties

The effect of varieties showed significant effect on straw yield (Appendix VIII). The highest straw yield (5.74t ha^{-1}) was observed in BRRI dhan33. The lowest straw yield (4.88 t ha^{-1}) was produced by BRRI dhan57 which was statistically at par with that of BRRI dhan56 (5.18 t ha^{-1}) (Table 10).

4.1.15.2 Effect of mulch materials

The effect of mulch materials was significant in respect of straw yield (Appendix VIII). The results showed that the highest straw yield (5.75t ha^{-1}) was found in maize straw mulch which was statistically identical with no mulch (5.48t ha^{-1}) and rice mulch materials (5.41 t ha^{-1}) (Table. 11).

4.1.15.3 Interaction effect of varieties and mulch materials

Interaction of varieties and mulch materials significantly influenced straw yield (Appendix VIII). The highest straw yield (6.34 t ha^{-1}) was recorded from BRRI dhan33 with no mulch materials and the lowest straw yield (4.53 t ha^{-1}) was obtained from

BRRI dhan56 x water smart weed mulch which was statistically similar to that of BRRI dhan57 x sesame straw mulch (4.55 t ha^{-1}) (Table 12).

4.1.16 Harvest index

4.1.16.1 Effect of varieties

The effect of varieties was significant in terms of harvest index (Appendix VIII). The highest harvest index (48.76%) was observed in the variety BRRI dhan33 which was statistically similar with BRRI dhan56 (50.20%). The lowest harvest index (45.69%) was found from BRRI dhan57 (Table 10).

4.1.16.2 Effect of mulch materials

The effect of mulch materials was significant in respect of harvest index (Appendix VIII). The results showed that the highest harvest index (50.02%) was found in mustard straw mulch and sesame stover (49.70%) which was statistically similar with rice straw (48.44%) and water smartweed (49.47%) where no mulching showed lowest(45.03%) harvest index (Table 11).

4.1.16.3 Interaction effect of varieties and mulch materials

Interaction of varieties and mulch materials showed significant variation on harvest index of rice crop (Appendix VIII). The highest harvest index was recorded from BRRI dhan33 with mustard straw(53.81%) and BRRI dhan56 with water smartweed (53.11%) which was similar with BRRI dhan33 x maize stover (49.51%), BRRI dhan33 x sesame stover (48.85%), BRRI dhan56 x mustard straw (51.52%), BRRI dhan56 x rice straw (49.80%), BRRI dhan56 x sesame stover (52.30%)and the lowest harvest index (43.20%) was found from BRRI dhan57 with no mulch (Table 12).

Table 10. Effect of varieties yield and harvest index of T. Aman rice

Varieties	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Harvest Index (%)
V_1	5.415 a	5.74 a	48.76 a
V_2	5.161 b	5.18 b	50.20 a
V_3	4.095 c	4.88 b	45.69 b
LSD value at 5 %	0.153	0.47	2.129
CV (%)	4.63	13.21	6.52

V_1=BRRI dhan 33, V_2= BRRI dhan 56 and V_3= BRRI dhan 57

Table 11. Effect of mulch materials on yield and harvest index of T. Aman rice

Treatments	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Harvest index (%)
T_1	5.026 a	5.75 a	46.62 bc
T_2	4.890 a	4.86 b	50.02 a
T_3	5.101 a	5.41 ab	48.44 ab
T_4	4.920 a	5.01 b	49.70 a
T_5	4.920 a	5.08 b	49.47 ab
T_6	4.486 b	5.48 ab	45.03 c
LSD value at 5 %	0.2163	0.66	3.01
CV (%)	4.63	13.21	6.52

T_1=Maize stover, T_2= Mustard straw, T_3= Rice straw, T_4= Sesame stover, T_5= Water smartweed starwand T_6= No mulch.

Table 12. Effect of varieties and mulch materials combination on yield and harvest index of T. Aman rice

Treatment Combination	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Harvest index (%)
V_1T_1	5.50 ab	5.87 abc	48.42 b-e
V_1T_2	5.467 ab	4.74 cde	53.81 a
V_1T_3	5.508 a	5.63 a-e	49.51 a-d
V_1T_4	5.463 ab	5.73 a-d	48.85 a-e
V_1T_5	5.403 ab	6.11 ab	47.09 b-f
V_1T_6	5.148 ab	6.34 a	44.85 d-f
V_2T_1	5.421 ab	6.08 ab	47.22 b-f
V_2T_2	5.212 ab	4.99 b-e	51.12 a-c
V_2T_3	5.464 ab	5.51 a-e	49.80 a-d
V_2T_4	5.130 b	4.74 cde	52.30 ab
V_2T_5	5.147 ab	4.53 e	53.11 a
V_2T_6	4.592 c	5.21 a-e	47.04 c-f
V_3T_1	4.156 d	5.31 a-e	44.23 ef
V_3T_2	3.992 de	4.86 cde	45.13 d-f
V_3T_3	4.330 cd	5.08 b-e	46.01 c-f
V_3T_4	4.167 d	4.55 e	47.95 b-f
V_3T_5	4.210 d	4.61 de	47.62 b-f
V_3T_6	3.717 e	4.91 cde	43.20 f
LSD value at 5 %	0.3747	1.15	5.214
CV (%)	4.63	13.21	6.52

V_1=BRRI dhan 33, V_2= BRRI dhan 56, V_3= BRRI dhan 57, T_1=Maize stover, T_2= Mustard straw, T_3= Rice straw, T_4= Sesame stover, T_5= Water smartweed starw, T_6= No mulch.

4.1.17 Number of weeds at 20 DAT and 40 DAT weed collection

4.1.17.1 Effect of varieties

Variety effected significantly on production of number of weeds at first collection of weed. (Appendix IX). The highest number of weeds at first weeding was found in BRRI dhan56 (29.11) and the lowest from BRRI dhan57 (11.72). At second collection time, insignificant effect was observed in producing number of weeds and it ranged from 6.0 to 7.16. But in the case of total number of weeds, highest number (36.26) of weeds were found in BRRI dhan56 and the lowest (17.89) in BRRI dhan57 which is statically similar with BRRI dhan33 (Table 13).

4.1.17.2 Effect of mulch materials

Mean effect of mulch materials did not differ significantly in terms of number of weed produced at first weed collection (Appendix IX). Again significant variation was recorded in number of weed population at second collection having the highest population in no mulch (15.88) and that of lowest was in water smartweed straw (2.44). The result indicated that mulch materials affected on weed suppression (Table 14).

4.1.17.3 Interaction effect of varieties and mulch materials

At first weed collection, the highest number of weeds were recorded in BRRI dhan33 x sesame straw (43.67) while the lowest were BRRI dhan33 X mustard straw (9), BRRI dhan33 x no mulch (9), BRRI dhan57 X sesame straw (8.9), BRRI dhan57 x water smart weed (8.33) and BRRI dhan57 x no mulch. At second collection, the highest number of weeds were counted in BRRI dhan56 x no mulch (20.67) and the lowest was found in both BRRI dhan57 x water smart weed (2.0) and BRRI dhan56 x water smart weed (2.0). It clearly indicated that water smart weed along with BRRI dhan56 and BRRI dhan57 could contributed weed suppression.

Considering the number of total weeds, it was observed that BRRI dhan56 x no mulch contributed significantly the highest number of weed (57.0) production (Appendix VI). On the contrary the lowest (10.33) was recorded both from the combination of BRRI dhan57 x Water smart weed and BRRI dhan57 x Sesame stover mulch (Table 15).

4.1.18 Weed dry matter at 20 DAT and 40 DAT weed collection

4.1.18.1 Effect of varieties

Varietal effect on weed dry matter content varied significantly at 1st weed collection (Appendix IX). The highest weed dry matter at 1st collection was recorded in BRRI dhan56 (18.28gm) whereas the lowest was found in BRRI dhan57 (7.65gm) followed by BRRI dhan33 (10.81). Weed dry matter at 2nd collection varied from 1.06 to 1.30.However, total weed dry matter was found highest (19.59gm) in BRRI dhan56 and the lowest (8.38gm) in BRRI dhan57 (Table 13).

4.1.18.2 Effect of mulch materials

Mean effect of mulch materials on dry matter production varied significantly at 1st and 2nd weed collection (Appendix IX). Significantly the highest dry matter content at 1st collection was found from rice straw mulch treated plot (20.67gm) whereas it was lowest in the weeds of mustard mulch treated plot (8.14gm). Considering weed dry matter at 2nd collection, the highest (2.93gm) was recorded in control treatments and the lowest (0.49gm) was obtained from water smart weed mulched plot which were statistically similar with those of the other mulch material applied plots. However, in the case of total weed dry matter the highest (21.60gm) was recorded in rice straw which was similar to no mulch (Table 14).

4.1.18.3 Interaction effect of varieties and mulch materials

Interaction of varieties and mulch materials differ significantly at 20 DAT and 40 DAT weed collection (Appendix IX). At first collection, the highest weed dry matter (25.07gm)was recorded in BRRI dhan56 x maize straw mulch treated plot followed by BRRI dhan56 x no mulch (22.70gm) and the lowest was observed in BRRI dhan56 x sesame straw (3.68gm) which is statistically similar to that of BRRI dhan56 x no mulch (4.35gm), BRRI dhan57 x water smart weed (5.87gm), BRRI dhan57 x mustard straw (5.61gm), BRRI dhan57 x maize straw (6.01gm) and BRRI dhan33 x mustard straw (6.02gm). At second weeding, dry matter content ranged from 0.39gm to 3.36gm. In the case of total weed dry matter the highest weight (26.22gm) was recorded in BRRI dhan56 x maize straw which was similar to BRRI dhan56 x no mulch and the lowest eight (4.47gm) was found in BRRI dhan57 x sesame straw mulch which was statistically similar to those of BBRI dhan57 x mustard straw mulch and BRRI dhan x water smart weed mulch (Table 15).

Table 13. Effect of T. Aman rice varieties on weed number and weed dry matter in different weeding

Varieties	Number of weeds			Weeds dry matter (gm)		
	1st collection (20DAT)	2nd collection (40DAT)	Total	1st collection (20DAT)	2nd collection (40DAT)	Total
V_1	19.55 ab	6 .0 a	25.56 b	10.81 b	1.06 a	11.87 b
V_2	29.11 a	7.16 a	36.28 a	18.28 a	1.30 a	19.59 a
V_3	11.72 b	6.16 a	17.89 b	7.65 b	1.18 a	8.38 b
LSD value at 5 %	9.69	1.78	10.33	5.64	0.64	5.738
CV (%)	71.10	40.93	57.36	67.96	79.90	63.06

V_1=BRRI dhan 33, V_2= BRRI dhan 56, V_3= BRRI dhan57

Table 14. Effect of mulch materials on number of weed and weed dry matter in different weeding

Treatments	Number of weeds			Weeds dry matter (gm)		
	1st collection (20DAT)	2nd collection (40DAT)	Total	1st collection (20DAT)	2nd collection (40DAT)	Total
T_1	19.77 a	6 b	25.78 a	12.96 ab	1.10 b	14.07 ab
T_2	15.33 a	5 b	20.33 a	8.14 b	0.88 b	9.03 b
T_3	26.11 a	5.77 b	31.89 a	20.67 a	0.96 b	21.63 a
T_4	24.66 a	3.55 bc	28.22 a	10.48 b	0.72 b	11.21 b
T_5	17.44 a	2.44 c	19.89 a	9.39 b	0.49 b	9.88 b
T_6	17.44 a	15.88 a	33.33 a	11.85 b	2.93 a	14.78 ab
LSD value at 5 %	13.71	2.51	14.60	7.97	0.90	8.11
CV (%)	71.10	40.93	57.36	67.96	79.90	63.06

T_1=Maize straw, T_2= Mustard straw, T_3= Rice straw, T_4= Sesame straw, T_5= Water smartweed starw, T_6= No mulch

Table 15. Effect of varieties and mulch materials combination on weed number in different weeding

Treatment Combinations	Number of weeds			Weeds dry matter (gm)`		
	1st collection	2nd collection	Total	1st collection	2nd collection	Total
V_1T_1	11.0 cd	6.0 cde	17.00 cd	7.81 bc	1.01 cd	8.82 b-e
V_1T_2	9.0d	4.67cde	13.67 d	6.02 c	0.86 d	6.88 de
V_1T_3	26.33 a-d	4.67 cde	31.00 b-d	20.27 ab	0.64 d	20.92 a-d
V_1T_4	43.67 a	3.33 de	47.00 ab	14.20 abc	0.72 d	14.92 a-e
V_1T_5	18.33 bcd	3.33 de	21.67 cd	8.05 bc	0.63 d	8.68 c-e
V_1T_6	9.0 d	14.0 b	23.00 b-d	8.50 bc	2.51 abc	11.01 b-e
V_2T_1	35.0 ab	5.0 cde	40.00 a-c	25.07 a	1.15 cd	26.22 a
V_2T_2	21.67 a-d	3.67 de	25.33 b-d	12.78 abc	0.74 d	13.52 a-e
V_2T_3	33.67 abc	8.33 c	42.00 a-c	21.35 ab	1.46 bcd	22.81 ab
V_2T_4	22.33 a-d	3.33 de	25.67 b-d	13.57 abc	0.66 d	14.23 a-e
V_2T_5	25.67 a-d	2.0 e	27.67 b-d	14.24 abc	0.47 d	14.71 a-e
V_2T_6	36.33 ab	20.67 a	57.00 a	22.70 a	3.36 a	26.06 a
V_3T_1	13.33 bcd	7.0 cd	20.33 cd	6.01 c	1.16 cd	7.16 c-e
V_3T_2	15.33 bcd	6.67 cd	22.00 b-d	5.617 c	1.06 cd	6.68 e
V_3T_3	18.33 bcd	4.33cde	22.67 b-d	20.40 ab	0.78 d	21.18 a-c
V_3T_4	8.0 d	4.0 cde	12.00 d	3.68 c	0.78 d	4.47 e
V_3T_5	8.33 d	2.0 e	10.33 d	5.87 c	0.39 d	6.267 e
V_3T_6	7.0 d	13.0 b	20.00 cd	4.35 c	2.92 ab	7.28 c-e
LSD value at 5 %	23.75	4.36	25.29	13.82	1.57	14.06
CV (%)	71.10	40.93	57.36	67.96	79.90	63.06

V_1=BRRI dhan 33, V_2= BRRI dhan 56, V_3= BRRI dhan 57, T_1=Maize straw, T_2= Mustard straw, T_3= Rice straw, T_4= Sesame straw, T_5= Water smartweed starw, T_6= No mulch

CHAPTER V

SUMMARY AND CONCLUSION

The experiment was conducted at the Agronomy research field, Sher-e- bangle Agriculture University, Dhaka to find out the weed suppression efficiency of mulch materials in T. *Aman* rice cultivation. The experiment treatments included three varieties *viz.* BRRI dhan33(V_1), BRRI dhan56(V_2) and BRRI dhan57(V_3) and six mulch materials maize stover (T_1); mustard straw(T_2); rice straw(T_3), sesame stover(T_4), water smartweed(T_5) and no mulch (T_6). The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. The total number of unit plots were 54 and the unit plot size was 3m x 2m = 6m^2. Rice seedlings were transplanted on 15 August, 2012.

Observations were made on rice as weed population, dry weight of weed, dry weight of rice plant, plant height, tiller number hill^{-1}, number of effective tillers hill^{-1}, number of non effective tillers hill^{-1}, panicle length, number of rakish panicle^{-1}, number of filled grain panicle^{-1}, number of non filled panicle^{-1}, weight of 1000 grains, grain yield, straw yield and harvest index. One square meter area were randomly selected from each unit plot for taking data on weed population and dry weights of weed at 20 and 40 days after transplanting. Five hills were randomly selected per plot for taking plant height, tiller number hill^{-1}, number of effective tillers hill^{-1} , number of non effective tillers hill^{-1} , panicle length, number of rakish panicle^{-1}, number of filled grain panicle^{-1}and number of non filled panicle^{-1} at harvest. Thousand grains weight was measured from sampled seed. An area of 1m^2 from each plot was harvested for grain yield and straw yield. Harvest index was calculated from grain yield and straw yield.

The findings reflected mean plant height of T. Aman rice varieties under study did not affected significantly but interaction with mulch materials on the plant height varied from 108.2 cm to 125.8 cm.

The highest dry matter was found from BRRI dhan33 x rice straw (64.89gm) and that of the lowest in BRRI dhan33 x no mulch (44.70gm).

The highest number of tillers hill^{-1} (11.66) was obtained from the mulch water smart weed materials with this mulch material BRRI dhan57 produced the highest number (14) of tiller hill^{-1}.

Significant difference in respect of number of effective tillers hill^{-1} was observed in the mean effect of variety. The highest number of effective tille (23.33) was recorded in BRRI dhan57x maize straw followed by BRRI dhan57x water smart weed straw (22.0), BRRI dhan57x sesame straw (22.0) and BRRI dhan57 x rice straw (21.67). On the other hand the highest number of non-effective tillers hill^{-1} was found in variety BRRI dhan57 (2.16) and that of the lowest was obtained from BRRI dhan33 (1.33).The highest number of non-effective tillers hill^{-1}was obtained from BRRI dhan56 x mustard straw (3.33).

The longest panicle was obtained from BRRI dhan33 x mustard straw (27.57cm) followed by BRRI dhan33 x maize straw (27.55cm) and BRRI dhan56 x water smart weed mulch (27.50cm). The highest number of grains panicle^{-1}(148.55) was obtained from and BRRI dhan33. The highest number of filled grains panicle^{-1} (155.0) was recorded in the interaction of BRRI dhan33 with rice straw mulch materials.

The highest grain yield (5.101 t ha^{-1}) was obtained from rice straw mulch materials followed by maize st over (5.66 t ha^{-1}), water smart weed and sesame stover (4.92 t ha^{-1}) and mustard straw (4.89 t ha^{-1}). The highest grain yield (5.508 t ha^{-1}) was found BRRI dhan33 x rice straw mulch materials followed by BRRI dhan33 x maize stover mulch (5.5 t ha^{-1}), BRRI dhan33 x mustard straw mulch (5.467 t ha^{-1}), BRRI dhan56 x rice straw (5.464 t ha$^{-1),}$), BRRI dhan33 x sesame stover (5.463 t ha^{-1}), BRRI dhan x maize stover (5.421 t ha^{-1}), BRRI dhan56 x mustard straw (5.212 t ha^{-1}), BRRI dhan33 x no mulch (5.148 t ha^{-1}),BRRI dhan56 x water smartweed (5.147 t ha^{-1}).

Grain yield changed significantly with change of varieties. Grain yield of rice did not differ significantly as influenced by mulch materials except the absolute control. The higher and lower yield might be due to the genetic potentiality of the respective varieties. Increment was observed with the addition of any mulch materials in each and every combination. The highest (5.08 t ha^{-1}) grain yield was observed in the treatment combination of BRRI dhan56 x rice straw mulch while the lowest was estimated in the combination of BRRI dhan57 x no mulch (3.717 t ha^{-1}). The effect of varieties was significant in terms of straw yield. . The results showed that the highest straw yield (5.75t ha^{-1}) was found in maize straw mulch which was statistically identical with no mulch (5.48t ha^{-1}). The highest straw yield (6.34 t ha^{-1}) was recorded from BRRI dhan33 with no mulch materials and the lowest straw yield (4.53 t ha^{-1}) was obtained from BRRI dhan56 x water smart weed mulch which was statistically similar to that of BRRI dhan57 x sesame straw mulch (4.55 t ha^{-1}).

The highest number of weeds at first weed collection was found in BRRI dhan56 (29.11) and lowest from BRRI dhan57 (11.72). The result indicated that mulch materials had influence on weed suppression. At first collection of weed, the more weeds were found in the combination of BRRI dhan33 x sesame straw (43.67) while the lowest weeds were found in BRRI dhan33 X mustard straw (9), BRRI dhan33 x no mulch (9), BRRI dhan57 X sesame straw (8.9), BRRI dhan57 x water smart weed (8.33) and BRRI dhan57 x no mulch. Again, at second weed collection the highest number of weeds was counted in BRRI dhan56 x no mulch (20.67). Weed dry matter at 2nd weed collection varied insignificantly and ranged from 1.06gm to 1.30gm considering weed dry matter at 2nd weed collection, the highest (2.93gm) was recorded in control treatments and lowest (0.49) was obtained from water smart weed mulched plot. At second weed collection, dry matter content ranged from 0.39gm to 3.36gm.

It may be concluded that BRRI dhan33 with rice straw encourage growth and yield of rice. Rice straw also able to reduce the growth of weeds while other treated materials like maize stover , mustard straw, sesame stover, water samart weed was positive to control weed.

However, to reach a specific conclusion and recommendation, more research work is needed with additional mulch materialson weed management and yield of T. Aman rice over different Agro-ecological zones of Bangladesh.

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APPENDICES

Appendix I. Analytical data of soil sample of the experimental plot

A. Morphological Characteristics

Morphological features	characteristics
Location	Agricultural Farm, SAU, Dhaka
AEZ	Modhupur Tract (28)
General Soil Type	Shallow red brown terrace soil
Land Type	Medium high land
Soil Series	Tejgaon
Topography	Fairly leveled
Flood Level	Above flood level
Drainage	Well drained

B. Mechanical analysis

Constituents	Percent
Sand	27
Silt	43
Clay	30

C. Chemical analysis

Soil properties	Amount
Soil pH	5.8
Organic carbon (%)	0.45
Total nitrogen (%)	0.03
Available P (ppm)	20
Exchangeable K (%)	0.1
Available S (ppm)	45

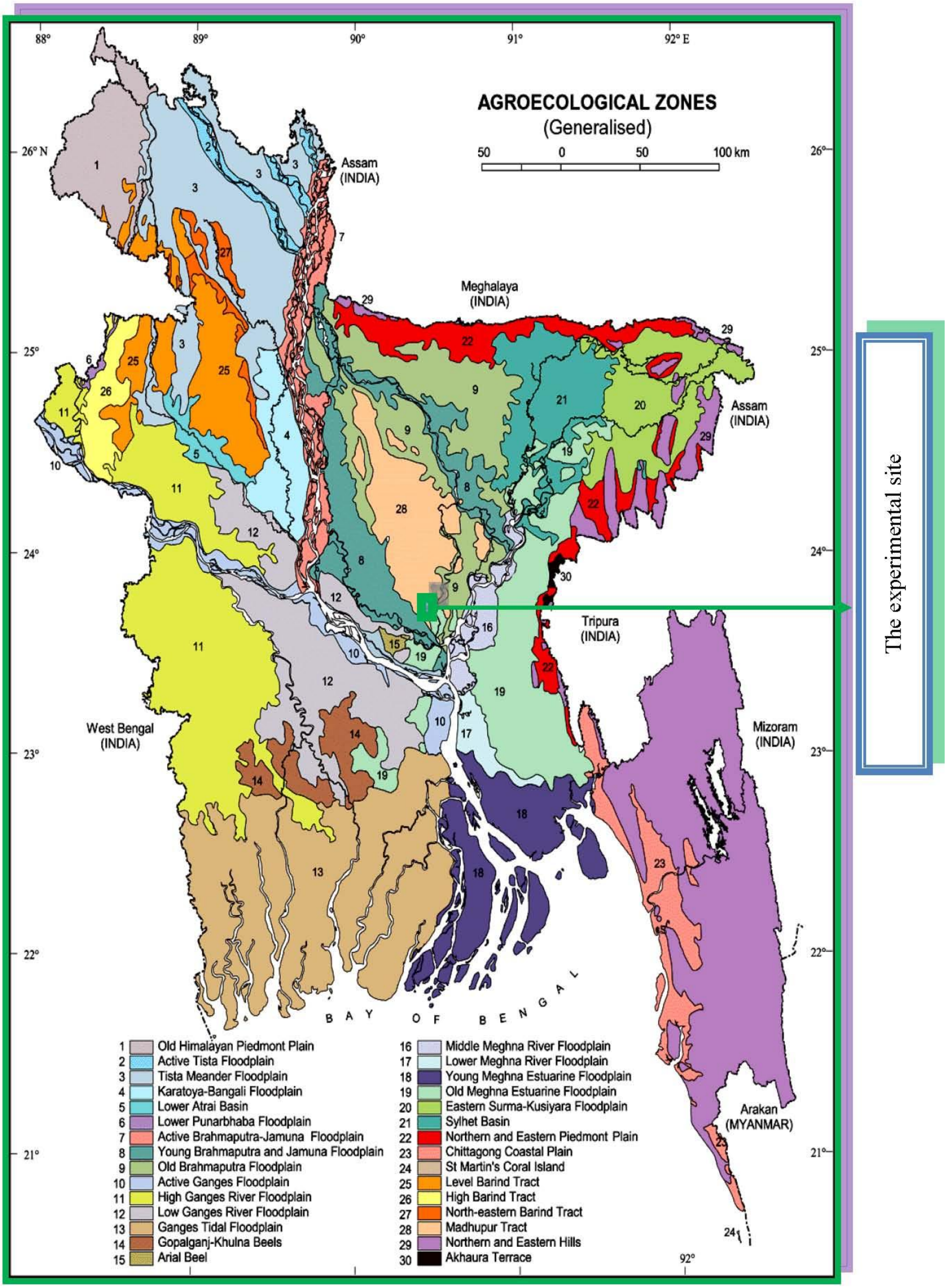
Appendix II. Monthly records of air temperature, relative humidity, rainfall and sunshine during the period from August to December 2013

Year	Month	** Air temperature (0C)		**Relative humidity (%)	*Rainfall (mm)	**Sunshine (Hours)
		Maximum	Minimum			
2013	August	33.5	26.7	80	514	4.7
2013	September	31	24.4	79	183	3.6
2013	October	31.3	22.8	78	341	4.9
2013	November	28.6	18.9	73	107	5.8
2013	December	23.2	16.6	69	0	5

***Monthly total, ** Monthly average**

Source: Bangladesh Meteorological Department (Climate & weather division) Agargoan, Dhaka, Bangladesh

Appendix III. Map showing the experimental site



Appendix IV. Anova table for plant height at 20, 40, 60, 80 DAT

Source of variation	Degree of freedom	Mean square			
		at 20 DAT	at 40 DAT	at 60 DAT	at 80 DAT
Replication	2	0.669 NS	5.200 NS	0.179 NS	6.266 NS
Factor A	2	226.936**	1275.781 **	3423.933 **	2890.044**
Factor B	5	6.4769**	7.055 NS	3.535 NS	6.418 NS
Factor AB	10	3.865NS	12.123 NS	13.670 NS	9.938 NS
Error	34	6.728	10.641	15.241	8.270

* = Significant at P 0.05. ** = Significant at P 0.01. NS = Not significant.

Appendix V. Anova table for Plant dry matter at 20, 40, 60 DAT

Source of variation	Degree of freedom	Mean square			
		at 20 DAT	at 40 DAT	at 60 DAT	at 80 DAT
Replication	2	1.403NS	161.709 NS	428.142 NS	55.115 NS
Factor A	2	2.544*	170.614 NS	1570.795*	578.856*
Factor B	5	0.661 NS	143.420 NS	183.806 NS	30.85 NS
Factor AB	10	0.725 NS	103.276 NS	93.743 NS	20.253 NS
Error	34	0.665	71.542	166.026	23.899

* = Significant at P 0.05. ** = Significant at P 0.01. NS = Not significant

Appendix VI. Anova table for Tiller Number at 20, 40, 60, 80 DAT

Source of variation	Degree of freedom	Mean square			
		at 20 DAT	at 40 DAT	at 60 DAT	at 80 DAT
Replication	2	31.056**	27.185 NS	33.019*	9.722 NS
Factor A	2	43.556**	185.685**	286.463**	241.556**
Factor B	5	8.533*	44.285**	3.174 NS	3.911 NS
Factor AB	10	4.489 NS	6.019 NS	2.530NS	3.733 NS
Error	34	3.252	6.460	4.901	6.428

* = Significant at P 0.05. ** = Significant at P 0.01. NS = Not significant.

Appendix VII. Anova table for Thousand grain weight, no. of effective tiller, no. of non effective tiller, panicle length, no of rackish, no. of filled grain and no of unfilled grain

Source of variation	Degree of freedom	Mean square						
		thousand grain weight	no. of effective tiller	no. of non effective tiller	panicle length	no. of rackish	no. of filled grain	no. of unfilled grain
Replication	2	0.017 NS	7.389 NS	0.222 NS	2.747 NS	0.414 NS	75.500 NS	9.389 NS
Factor A	2	727.558**	211.722**	3.167*	83.420**	48.414**	8597.556**	328.222*
Factor B	5	1.428**	3.778 NS	0.711 NS	1.522 NS	1.894 NS	83.556 NS	87.856 NS
Factor AB	10	1.029**	2.367 NS	1.011 NS	1.041 NS	0.592 NS	79.178 NS	98.911 NS
Error	34	0.014	5.134	0.556	1.104	0.743	174.402	55.467

* = Significant at P 0.05. ** = Significant at P 0.01. NS = Not significant.

Appendix VIII. Anova table for grain yield, straw yield and harvest index.

Source of variation	Degree of freedom	Mean square		
		Grain yield	straw yield	Harvest index
Replication	2	0.076 NS	0.785 NS	11.023 NS
Factor A	2	8.827**	3.364*	95.362**
Factor B	5	0.411**	1.022 NS	35.581*
Factor AB	10	0.038 NS	0.54 NS	11.716 NS
Error	34	0.051	0.485	9.783

* = Significant at P 0.05. ** = Significant at P 0.01. NS = Not significant.

Appendix IX. Anova table for number of weed and weed dry matter content at 1st & 2nd weed collection

Source of variation	Degree of freedom	Mean square					
		weed no. at 1st weed Collection	weed no. at 2nd weed collection	Total weed no. at 1st & 2nd weed collection	DM at 1st weed collection	DM at 2nd weed collection	Total DM at 1st & 2nd weed collection
Replication	2	54.574 NS	2.056 NS	39.019 NS	175.775 NS	2.464 NS	137.586 NS
Factor A	2	1365.130*	7.167 NS	1535..685*	536.267**	0.271 NS	553.331*
Factor B	5	169.041 NS	209.289**	289.663 NS	179.636*	6.999**	191.627 NS
Factor AB	10	291.263 NS	14.389 NS	350.219 NS	56.797 NS	0.201 NS	57.087 NS
Error	34	204.489	6.958	232.332	69.232	0.895	71.765

* = Significant at P 0.05. ** = Significant at P 0.01. NS = Not significant.

Plate 1: Uprooting of rice seedling at nursery seedbed.

Plate 2: Field layout for transplanting of rice seedling

Plate 3: Maize stover incorporated in experimental plot

Plate 4: Mustard straw incorporated in experimental plot

Plate 5: Transplanting of rice seedling in main experimental field

Plate 6: Experimental field at tillering stage

Plate 7: Weed collection from experimental field

Plate 8: Drying of collected weed for weighing of dry matter

Plate 9: Experimental field at flowering stage