EFFECT OF TILLAGE DEPTH AND MULCH MATERIALS ON WEED MANAGEMENT, YIELD ATTRIBUTES AND YIELD OF WHEAT

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DECEMBER, 2014

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REG. NO. : 08-03150

A Thesis
Submitted to the Faculty of Agriculture,
Sher-e-Bangla Agricultural University, Dhaka,
in partial fulfilment of the requirements
for the degree of

MASTER OF SCIENCE (MS)
IN
AGRONOMY

SEMESTER: JULY-DECEMBER, 2014

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CERTIFICATE

This is to certify that the thesis entitled **'Effect of Tillage Depth and Mulch Materials on Weed Management, Yield Attributes and Yield of Wheat'** submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfilment of the requirements for the degree of **Master of Science** in **Agronomy**, embodies the result of a piece of *bonafide* research work carried out by **Salina Afroz Urmee**, Registration number: **08-03150** 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 duly been acknowledged.

Dated:
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DEDICATED

TO

MY BELOVED PARENTS

ACKNOWLEDGEMENTS

The author first wants to articulate her enormous wisdom of kindness to the Almighty Allah for His never ending blessing, protection, regulation, perception and assent to successfully complete of research and prepare thesis.

The author feels proud to express her heartiest gratitude, sincere appreciation and immense indebtedness to her supervisor Dr. H. M. M. Tariq Hossain, Professor, Department of Agronomy, Sher-e-Bangla Agricultural University (SAU), Dhaka, Bangladesh for his continuous scholastic and intellectual guidance, cooperation, constructive criticism and suggestions in carrying out the research work and preparation of thesis, without his intense co-operation this work would not have been possible.

The author feels proud to express her deepest respect, sincere appreciation and immense indebtedness to her co-supervisor Dr. Parimal Kanti Biswas, Professor, Department of Agronomy, SAU, Dhaka, for his scholastic and continuous guidance, constructive criticism and valuable suggestions during the entire period of course and research work and preparation of this thesis.

The author expresses her sincere respect and gratitude to Dr. Md. Fazlul Karim, Professor and Chairman, Departement of Agronomy, SAU, Dhaka for his valuable suggestions and cooperation during the study period. The author also expresses her heartfelt thanks to all the teachers of the Department of Agronomy, SAU, for their valuable teaching, suggestions and encouragement during the period of the study.

The author expresses her sincere appreciation to her brothers, sister, relatives, well wishers and friends for their inspiration, help and encouragement throughout the study.

The Author

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ABSTRACT

The experiment were conducted during the period from November 2013 to March 2014 in the experimental field of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka to find out the effect of tillage depth and mulch materials on weed management, yield attributes and yield of wheat. The experiment comprised of two factors; Factor A: Tillage depth (4 levels)- T_0: Control, T_1: $3^{//}$ depth, T_2: $6^{//}$ depth and T_3: $9^{//}$ depth and Factor B: Mulch materials (3 types)- M_0: Control (no mulch), M_1: Rice straw and M_2: Black polythene. The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. *Cyperous rotundus, Eleusine indica, Cynodon dactylon, Digitaria sanguinalis, Echinochloa colonum, Chenopodium album* were found with major population among the 10 weed species in the experimental field. In the case of tillage depth, at 20 DAS the maximum number of weed population m^{-2} were recorded in T_0 (14.00), while the minimum number in T_3 (7.44). At 30, 40, 50, 60 DAS and at harvest, the longest plants were found from T_3 (34.15, 55.60, 69.29, 91.67 and 106.76 cm, respectively), whereas the shortest plants from T_0 (24.59, 37.50, 52.60, 75.96 and 92.94 cm, respectively). The highest grain yield were recorded from T_3 (3.47 t ha^{-1}), whereas the lowest from T_0 (2.15 t ha^{-1}). The highest straw yield were recorded from T_2 (4.98 t ha^{-1}), whereas the lowest from T_0 (3.56 t ha^{-1}). For mulch materials, at 20 DAS, the maximum numbers of weed population m^{-2} were found in M_0 (13.50), while the minimum number in M_2 (8.33). At 30, 40, 50, 60 DAS and at harvest, the longest plants were observed from M_2 (32.99, 52.89, 65.93, 88.89 and 105.69 cm, respectively), while the shortest plants from M_0 (27.90, 45.21, 60.11, 79.62 and 97.04 cm, respectively). The highest grain yield were found from M_2 (3.25 t ha^{-1}), while the lowest from M_0 (2.81 t ha^{-1}). The highest straw yield were found from M_2 (4.69 t ha^{-1}), while the lowest from M_0 (4.22t ha^{-1}). Due to the interaction effect of tillage depth and mulch materials, at 20 DAS, the maximum number of weed population m^{-2} (16.33) were found from T_0M_0, while the minimum number (4.33) from T_3M_2 treatment combination. At 30, 40, 50, 60 DAS and at harvest, the longest plants were observed from T_3M_2 (37.29, 60.46, 73.75, 96.60 and 111.50 cm, respectively) and the shortest plants from T_0M_0 (23.18, 35.38, 51.36, 70.19 and 89.40 cm, respectively). The highest grain yield were found from T_3M_2 (3.95 t ha^{-1}) and the lowest from T_0M_0 (2.07 t ha^{-1}). The highest straw yield were found from T_3M_2 (5.39 t ha^{-1}) and the lowest from T_0M_0 (3.43 t ha^{-1}). It were revealed that $9^{//}$ depth of tillage with Black polythene mulch were found the best for weed management, yield attributes and yield of wheat.

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CHAPTER I

INTRODUCTION

Wheat (*Triticum aestivum* L.) primarily grown across the exceptionally diverse range of environments is an important food crop (WRC, 2009). The largest area of wheat cultivation in the warmer climates exists in the South-East Asia including Bangladesh, India and Nepal (Dubin and Ginkel, 1991). Importance of wheat crop may be understood from the fact that it covers about 42% of total cropped area in rice-wheat system in South Asia (Iqbal *et al.,* 2002). It contributes to the national economy by reducing the volume of import of cereals for fulfilling the food requirements of the country (Razzaque *et al.*, 1992). In Bangladesh, wheat is the second most important cereal crop (FAO, 1997). It occupies above 4% of the total cropped area and 11% of the area cropped in *rabi* and contributes 7% to the total output of food cereals (Anon., 2008). Generally, wheat supplies carbohydrate (69.60%), protein (12%), fat (1.72%), minerals (16.20%) and also other necessary nutrients in trace amount (BARI, 1997).

Bangladesh had become highly dependent on wheat imports while dietary preferences were changing such that wheat was becoming a highly desirable food supplement to rice. Domestic wheat production rose to more than 1 million tons per year, but was still only 7-9% of total food grain production (BARI, 2010). Wheat cultivation has been increased manifolds to meet up the food shortage in the country. But, in spite of its importance, the yield of the crop in the context of our country is low (2.2 t ha^{-1}) in comparison to other wheat growing countries of the world (FAO, 1997). The area, production and yield of wheat have been increasing dramatically based on the demand of over increasing population of Bangladesh during the last two decades, but its present yield is too low in comparison to some developed countries like Japan, France, Germany and UK producing 3.76, 7.12, 7.28, and 8.00 t ha^{-1}, respectively (FAO, 2000). At present about 706.33 thousand hectares of land in Bangladesh is covered by wheat with the annual production of 1,592 thousand tons (BBS, 2012).

Yield of wheat is very low in Bangladesh and the low yield of wheat however is not an indication of low yielding potentiality of this crop, but may be attributed to a number of reasons viz. unavailability of quality seeds of high yielding varieties, delayed sowing after the harvest of transplanted aman rice, fertilizer management, disease and insect infestation and improper or limited irrigation facilities or no use of mulch materials. Major constraints to wheat grain yield in this region are inadequate rainfall and high temperatures during grain filling at the end of the season (Radmehr *et al*., 2003; Andarzian *et al*., 2008). Weed is one of the destructive integral pests in crop. It is the nutrient absorbing competitive plants which grow out of place spontaneously even under adverse condition. It is often said that "crop production is a fight against weeds" (Cardina *et al*., 2002; Mohler *et al*., 2006). Weed grows in every piece of land of the world. The edaphic and climatic condition of Bangladesh favours the growth of weed. High competitive ability of weeds exerts a serious negative effect on crop production causing significant losses in crop yield (Mishra *et al.*, 2005). Many scientists from South Asia reported weed as the major constraint to wheat cultivation (Qureshi and Bhatti, 2001; Singh *et al.*, 2003). It is reported that weeds reduced wheat yield up to 25-30% in Pakistan (Nayyar *et al*., 1994) 20-40% in India (Mishra, 1997) and up to 50% in Nepal (Ranjit, 2002). The number of weed species reported vary from country to country, 90 species from India (Rao, 2000), 73 species from Bangladesh (Begum *et al.*, 2003) and 30 species from IAAS, Nepal (Dangol and Chaudhary, 1993). It has been reported that most of the plant parameters of wheat are affected by weed competition (Karim and Mamun, 1988). Karim (1987) estimated that weeds caused a loss of 33% of total yield in Bangladesh, where most of the plant parameters including plant height, number of tillers, number of panicles, grain weight etc. are affected by weed competition.

Tillage has been used for millennia to prepare the soil prior to sowing many of the annual grain crops. It involves applying power to break up and rearrange the entire top soil structure. It has the primary aim of destroying weeds and pests but is also important for incorporating, redistributing or releasing nutrients and making the soil texture suitable for seed sowing, seed germination and for easy penetration of seedling roots. Ball and Miller (1993) suggested that a possible solution for weed problems would be the combination of different soil tillage systems to avoid the establishment of predominant weed species. Changes in tillage practices can lead to shifts in weed species composition of the agricultural community. In general, weed emergence is often related to tillage i.e. soil disturbance, temperature, rainfall, soil moisture and radiant energy. Zimdahl *et al.* (1988) observed that tillage caused weed emergence regardless of the time that it occurred.

Dhima *et al.* (2006) also reported allelopathic potential of the winter cereal extracts when used as mulch materials. Soil incorporation of sunflower residues significantly reduced the weeds by 66% compared to the control (Ata and Jamil, 2001). So the use of mulch materials with soil to control weeds is simple and easy technique and as well as improves the soil organic matter content. Rapeseed and mustard contain high amounts of glucosinolates is one of the most useful allelopathic cover crop that reduced total weed biomass in soybean by 40-49% (Krishnan *et al.*, 1998). Weed suppression is effective when crop residues left undisturbed on the soil surface but the effect is lost when tilled into the soil (Sheila, 1986). Yenish and Worsham (1993) also reported the highest weed control by rye application in the field for the commencing crop.

Considering the present context, the experiment was therefore, designed with the following objectives:

- To identify the different weed species grown due to different tillage depth and mulch materials.
- To compare the growth and yield of wheat due to tillage depth and use of mulch materials.
- To find out the interaction effect of tillage depth and mulch materials on weed population, growth and yield of wheat.

CHAPTER II

REVIEW OF LITERATURE

Weed is the integral part of crops. It reduces wheat yield. Selection of tillage method and use of mulch materials are an important investigation to suppress weed growth and thus give the best performance with regard to quantity and quality of wheat. In Bangladesh research work related to weed management through tillage and mulch are scarce. To justify the present study attempts have been made to incorporate some of the important findings of renowned scientists and research work in this country and in other countries have been reviewed under the following headings:

2.1 Weed vegetation in wheat

The weed vegetation of a particular area is determined not only by the environment but also by biological factors. Weed vegetation in crops field is the result of cropping system, cropping season, topography of land and management practices like time and degree of land preparation, type of cultivar, time of planting, planting rate, fertilizer management, weeding method and intensities and so on practiced by the farmers at different times during the crop cycle.

Rahman (1974) observed that the infesting species of weed in wheat crop were *Chenopodium album, Cynodon dactylon, Eleusine indica, Cyperus rotundus* and a few legume species. *Chenopodium album* constituted 56.5% of the total weed vegetation.

Rahman (1985) observed a more wide range of weed flora in wheat crop which included *Chenopodium album, Paspalum distichum, Gnaphalium luteo-album, Vicia sativa, Dactyloctenium aegyptium, Cyperus rotundus, Hydrocotyle asiatica, Marsilea quadrifolia* and *Eclipta prostrata. Chenopodium album* ranked top the list in respect of intensity of infestation.

Nesterove and Chukanova (1981) recorded the deduction in grain yield of wheat caused by different populations of weeds and greatest reduction was found by the presence of *Convolvulus arvensis* and *Amaranthus retrotlexus*. Jalis (1987) studied the predominating influence of *Phalaris minor* and *Avena fauta* in wheat.

Sahu (1981) observed that, the prominent infesting species of weeds in wheat crop were *Chenopodium album, Digitaria sanguinalis, Eragrastic diarrhna, Lathyrus sativus* and *Medicago denticulata.*

Mamun *et al.* (1986) observed that wheat fields were infested with 16 species of weeds including *Avena fatua, Phalaris minor, Lolium temulenturn* and *Cynodon dactylon.* As per Roder *et al.* (1982) the main weeds of wheat field in the Dresden area of German Democratic Republic were *Apera spiceventi, Lolium anplexicanle, Lolium purpuream, Cynodon dactylon, Cyperus rotundus, Matriecaria chamomillia, Setaria medico, Veromica henderofolia, Viola arvensis, Lipia nudiflora, Melilotus indica, Launca pinnatifida, Cannabis sativa, Nicotina plumbginifolia, Spergula arvensis, Phalaris minor.*

Gaffer (1987) observed that the prominent infesting species of weeds in wheat crop were *Bonnaya brachiata, Chenopodium album*, *Vicia hirsuta, G. luteoalbum, Cynodon dactylon, Cyperus rotundus, Solanum nigram, Physalis heterophylla* and *Amaranthus viridis*. Among the infesting species of weeds *Chenopodium album* and *Cyperus rotundus* recorded the first and second position in respect of intensity of infestation.

Islam (1987) noticed that weed flora in a wheat crop were five grass species *Digitaria aegyptium, Echinochloa crussgalli, Cynodon dactylon, Parapholis incurva* and *Leersia hexandra*, seven broadleaf species *Chenopodium album, Vicia sativa, Amaranthus viridis, Physalis heterophylla, Solanum torvum, E. prastrata and Gnaphalium luteo-album*, one sedge, *Cyperus rotundus* and a few other species of weeds. The cumulative relative density of the broadleaf weeds was 70.81% against 22.37% of the grass weeds and 6.8% of the sedge. Among the infesting species, *Chenopodium album* was the principal weed having about 57.05% of the total weed vegetation followed by the grass weed, *Dactyloctenium aegyptium*, the sedge, *Cyperus rotundus* and the broadleaf weed, *Vicia sativa*. Similar vegetation of weed association has also been reported by Khan *et al.* (1980) in wheat field at the same location.

Mamun and Salim (1989) reported that, eight weed species infested wheat crop at the Bangladesh Agricultural University Farm. Among them the heirerchical positions of five most dominant species were *Chenopodium album, Vicia sativa, Cynodon dactylon, Cyperus rotundus* and *Parapholis incurva*.

From a weed survey conducted by Ahmed (1993) revealed that 51 weed species were present in wheat fields in Riwat area; of these 84% were dicotyledonous and nearly 79% were annuals. On the basis of an index of importance 5 most dominant species were *Convolvulus arvensis, Anagallis arvensis, Fumaria indica, Oxalis corniculata* and *Taraxacum officinale*.

Hosmani (1995) observed that the common weeds observed in wheat in Karnataka include *Dinebra retrotlexa, Brachiaria isachne, Chrozophora rotteri, Portulaca spp., Trianthama portulacastrum, Amaranthus spp. Parthenium hysterophorus* and *Digera arvensis.*

Kushwaha and Singh (2000) reported infestation of wheat with *Cinnivera dinnatifida, Phalaris minor, Cyperus rotundus, Cynodon dacty]on, Anagallis arvensis, Chenopodium album, Fumaria parviflora, Portulaca oleracea, Avena fatua, Mililotus indica* and *Panicum spp. at* Haridwar, Uttar Pradesh.

Tiwari and Parihar (1993) and Malik *et al.* (1995) observed *Chenopodium album, Me]ilotus indica* and *Vicia sativa* as major weed flora in wheat field at Hissar and Sarkanda, Bilaspur (Madhya Pradesh).

Qureshi and Bhatti (2001) showed that upto 45 weeds species have been reported in wheat field in different wheat-growing areas in Pakistan. *Phalaris minor,* *Rumex dentatus, Coronopus didymus, Medicago denticulata, Chenopodium album,* and *Poa annua* have been reported as the frequently occurring and densely populated weeds of wheat in Pakistan (Siddiqui and Bajwa, 2001).

Shad (1991) observed that the grain yield of wheat declined with the increase in weed density under both rainfed as well as irrigated conditions. Singh *et al.* (2003) studied effects of *Ageratum conyzoides* on wheat. They found that effects of soil previously infested with this weed, amended soils, residues of leaves and their extracts were inhibitory, compared to respective control; on root/shoot length and seedling dry weight of wheat. It was concluded that leaves residue of *Ageratum conyzoides* are phytotoxic to wheat by releasing phenolics into soil.

Singh *et al.* (2004) observed *Chenopodium album, Melilotus abla, Me]ilotus indica, Medicago denticu]ata, Lathyrus aphaca, Vicia sativa, Vicia hirsuta, Fumaria parvitlora, Anallis arvensis* and *Coronopus didymus* in wheat field.

Mishra *et al.* (2005) reported that wheat field was infested mainly with *Chenopodium album* (88.6%) and *Physalis minima* (8.5%). Hossain *et al.* (2010a) observed that the major weeds affecting the wheat crop in Bangladesh are *Oxalis europaea*, *Cynodon dactylon*, *Eleusine indica*, *Digitaria sanguinalis, Cyperus rotundus*, *Chenopodium album, Physalis heterophylla, Vicia hirsuta*, *Hedyotis corymbosa* and *Stellarla media*. Hossain *et al.* (2010) from a field study noted that wheat fields are normally infested by between 18 and 22 types of weed species belonging to 11-12 families. Among them, *Oxalis* spp. was the most important, accounting for 27-33% of the total weed vegetation.

Haque (2011) identified, seventeen weed species belonging to nine families in wheat crop at the Bangladesh Agricultural University Farm. Among them *Chenopodium album, Vicia sativa, Cynodon dactylon, Cyperus rotundus, Eclipta alba and Lindernia procumbens* were dominant.

2.2 Effect of tillage on growth and yield of wheat

Vita *et al.* (2007) reported that higher yield was obtained with NT (no- tillage) than CT (conventional tillage) in the first two years at Foggia. In contrast, mean yield and quality parameters at Vasto were similar for the two treatments, except in the third year in which CT produced more than NT (4.6 mg ha^{-1} versus 2.9 mg ha^{-1}).

Ranjan *et al.* (2006) observed that wheat yield were higher in conventionally tilled plots than zero-tilled plots. Grove (2006) found that the tillage management had a significant effect on the average yield of wheat following soybean residues. The more recent the chisel tillage, the greater the wheat yield. Wheat yield reduced with greater duration of no-tillage. There was a large average response to fertilizer (N), with yields increasing up to a total fertilizer N rate of 80 lb N $acre^{-1}$. There was no statistically significant interaction between tillage and fertilizer nitrogen rate. There was a trend for no-till wheat to require more nitrogen (between 80 and 120 lb N $acre^{-1}$) to optimize yield than did the chisel plough wheat (between 40 and 80 lb N $acre^{-1}$). The more modest nitrogen response of tilled wheat was likely to be due to greater mineralization of nitrogen from organic matter. Lodging was observed in the chisel plough wheat at the highest fertilizer nitrogen rate.

Mohler *et al.* (2006) used ceramic beads as seed surrogates to get a more complete picture of the affects of tillage types on vertical seed distribution. They found that chisel, disk, and rotary tillage buried at least 70% of seeds below 2 cm, but caused little effect below 10 cm. Tillage with a moldboard plow showed inversion of the soil, but burial of seeds was greater than movement of buried seeds towards the surface. In no-tillage and moldboard plow treatments, an upward movement of seeds by natural processes was observed below 14 cm.

Ranjan *et al*. (2006) reported that wheat yield were higher in conventionally tilled plots than zero tilled plots. Ogbodo (2005) stated that crop growth and yield significantly increased with tilled soil than untilled soil.

Ahuja *et al*. (2004) obseved Abhilash (IET-5882) produced the maximum grain yield, gross income and net income with minimum tillage. Maecka and Blecharezyk (2002) reported cereal yields were greater under ploughing system than reduced tillage.

Ardell *et al*. (2001) mentioned that grain yields by tillage systems were in the order of CT >MT>NT with respective yield to 2227, 2167 and 2101 kg ha^{-1}. Basunia (2000) investigated that maximum plant height was found by country plough with four passes. The tillage depth had significant effects on wheat yield. Momirovinc *et al*. (1999) revealed that mulch tillage gave the highest yield, which was significantly higher than no-tillage systems.

Panjab *et al*. (1998) concluded that conventional tillage resulted in taller plants, longer and heavier spikes, more grain $spike^{-1}$ higher grain than no tillage. Conventional tillage also decreased the population of monocot weeds, while soil fertility was generally not significantly affected by tillage.

Brovo and Florentino (1997) studied to compare the effects of conventional tillage and minimum tillage in Venezuela, statistically significant differences were not found between two tillage systems in terms of cotton yield. However, the tendency was conventional tillage > minimum tillage.

Machul *et al*. (1997) viewed that maize cultivation under conventional tillage was most profitable. The biggest grain yield and biggest direct surplus were obtained under this system. Rahman (1997) reported that highest grain and straw yields were found under power tiller treatment.

Rezaul Ahmed (1997) found that the highest grain yield was produced when the land was prepared with two plowing followed by two laddering and the lowest yield was obtained in the plots with no land preparation.

Hur *et al*. (1996) carried out an experiment in the field and reported that mean grain yields for no-tillage, power tiller and tractor cultivation were 5.64 t ha^{-1}, 5.98 t ha^{-1} and 6.25 t ha^{-1} respectively.

Singh and Singh (1996) found that grain yield of wheat were higher with no tillage in relation to other tillage systems. Mohammad *et al*. (1995) reported that the moldboard plough plus disc harrow gave the highest grain yield of 447g m^{-2} in relation to the other tillage equipment used in the experiment.

Matin and Uddin (1994) found that significant highest grain straw yields of wheat in power tiller treatments over country plough treatments.

Munir *et al*. (1994) mentioned that direct drilling of wheat after wheat yield harvest produced 24% higher yield than wheat sown with conventional tillage.

Negussie et al. (1994) carried out an experiment to study the effect of minimum tillage on durum wheat. The grain yield obtained with minimum tillage was almost 50 percent lower than that of conventional tillage when minimum tillage was practiced continuously on the same piece of land.

Ahmed and Haffar (1993) concluded that crop yield was not significantly affected by different tillage system.

Lee and Jung (1993) reported that growth and nutrient content of wheat was poorer in the no-tillage treatment with the tradition of- 0, 2 tillage or rotary plow with alone. Yield was also lower with no-tillage due to low panicle and numbers and low ripening and milling rate.

Razzaq *et al*. (1993) stated that the higher yield increase of 19.91% in wheat yield was obtained with the use of disc harrow once followed chisel plough twice and mouldboard plough once followed by disc harrow once the conventional practice.

The different tillage systems can influence the composition of weed species of agricultural plant communities. Changes from traditional tillage to a conservation tillage system can lead to shifts in weed species composition (Ball and Miller, 1993).

Barberi and Lo Cascio (2001) described an inverse relation between diversity of weed species and the environment alteration. Otherwise, conservation tillage system is believed to worsen weed problems by higher weed emergence promoted by concentration of seed in soil and shifts of the weed community towards increased abundance of troublesome species, e.g. grasses and perennials.

Several researchers have observed that changes on weed species composition could occur by adoption of conservation tillage system (Ball and Miller, 1993). The change from a traditional to a conservation tillage system alters the disturbance regime, which can lead to shifts in weed species composition. Many researchers have described predominant weeds of different tillage systems, like *Lolium spp.* in the minimum tillage system. These species shifts generally result in the emergence of species tolerant to existing weed management practices (Wrucke and Arnold, 1985; Radosevich and Holt, 1984)

The higher content of organic matter and crop residues, in reduced or no-tillage system decreases herbicide efficacy (Pal, 2000). In these systems, annual options Medit146 erraneennes, Serie A, Numero 69 grasses and perennial weeds could cause great problems; however, short-living weeds are favoured. Annual dicotyledons producing seeds with high longevity will decline with reduced tillage systems. Annual grasses remain a problem in these conditions.

One negative factor associated with the shift to conservation tillage systems is the likely need for increased herbicide inputs to prevent infestation increases. Therefore, a no-tillage system seems to be difficult to carry out over a long period without a very intense herbicide use (Berti and Sattin, 1994). Twenty-three weed species have been identified in their piece of research study. An analysis of variance on the relative density of weeds confirmed that there were four main weed species which differed significantly between tillage systems. These weed species were the following: *Cardaria draba*, *Hypecoum procumbens*, *Lolium rigidum* and *Lamium amplexicaule.*

Field management practices affect weed seedling emergence patterns (Mohler and Galford, 1997; Bond *et al*., 1998; Spandl *et al*., 1998; Spandl *et al*., 1999; Cardina *et al*., 2002; Bullied *et al*., 2003; Van Acker *et al*., 2004), weed seedbank diversity, seed dormancy and viability (Mohler and Galford, 1997; Davis and Liebman, 2003), and seed placement (Cardina *et al*., 2002; Mohler *et al*., 2006).

Tillage can change weed seed dormancy status by exposing seeds to short pulses of light needed as germination triggers (Carroll and Mullinix, 1995). This can cause a flush of emergence after tillage and has been used as a control measure with preparation of a stale seedbed to deplete the weed seedbank (Juroszek and Gerhards, 2004; Rasmussen, 2004). In this case, a field is tilled and the flush of weed seedlings is managed before planting of the crop (Swanton and Booth, 2004).

In a review of night-time tillage trials, Juroszek and Gerhards (2004) found a wide range of efficacy. This ranged from a 97.5% reduction in weed cover to an 80% increase in weed seedling emergence. A number of factors caused this range of variability, including the type of tillage implement used, the light sensitivity of the weed species, the variation in soil water content, and the dormancy status of the weed seeds.

In a study conducted by Cardina *et al.* (2002) found that in no tillage systems, seed bank density tends to be higher that in tilled systems with most of the seeds concentrated near the soil surface.

2.3 Influence of mulch materials on growth and yield of wheat

Ashrafi *et al.* (2007) reported that Barley [*Hordeum vulgare* (L.) Koch.] contains water soluble allelochemicals that inhibit the germination and growth of other species. Growth of wild barley, as indicated by plant height and weight, was significantly reduced when grown in soil previously cropped to Barley compared with that cropped to wild barley. In bioassays, Barley extracts reduced wild barley hypocotyl length, hypocotyl weight, radicle weight, seed germination, and radicle length by as much as 44, 578, 61, 686 and 79%, respectively, when compared with water control. Increasing the water extract concentrations from 4 to 20 g per 100 ml of water of all Barley parts significantly increased the inhibition of wild barley germination, seedling length and weight. Based on 8-day-old wild barley radicle length, averaged across all extract concentrations, the degree of toxicity of different Barley plant parts can be ranked in the following order of inhibition: leaves > flowers > mixture of all plant parts > stems > roots.

Dhima *et al.* (2006) conducted a study to measure the effect of two barley (*Hordeum vulgare* L.) and six triticale (*xTriticosecale*) cultivars and three rye (*Secale cereale* L.) populations, used as cover crops, on the emergence and growth of barnyard grass [*Echinochloa crus-galli* (L.) P. Beauv.], bristly foxtail [*Setaria verticillata* (L.) P. Beauv.], large crabgrass [*Digitaria sanguinalis* (L.) Scop.], and sugarbeet (*Beta vulgaris* subsp. *vulgaris*). In the field, barnyard grass, bristly foxtail, and large crabgrass emergence in mulched plots was 39 to 69%, 0 to 34%, and 0 to 78% lower, respectively, as compared with that in mulch-free plots. They also suggest that Athinaida barley and the rye from Albania could be used as cover crops for annual grass weed suppression in sugarbeet.

Maiksteniene and Arlauskiene (2006) designed an experiment to identify the effects of legume pre-crops and intercrops as well as the impact of their biomass incorporated as green manure on the weed incidence in succeeding cereals. Under sown intercrops (*Trifolium pratense* L., *Lolium multiflorum* Lam., *Dactylis glomerata* L.), reduced the number of weeds in cereals (on average 13.9%). During the cereal post-harvest period red clover performed best at suppressing weeds, and its positive effect persisted in the year following incorporation of intercrops biomass.

Chaichi and Edalati-Fard (2005) studied the allelopathic effects of chickpea root extracts on germination and early growth of crops in rotation. Seed germination rate, germination percent, plant height, shoot dry weight and shoot/root ratio of crops were affected by different treatments. Seed germination rate of crops after chickpea line 5436 was significantly reduced after four weeks. Seed germination percentage increased as the crops were sown two weeks after chickpea physiological ripening. The crop height followed an increasing trend as they were sown later after physiological ripening of chickpea lines. The root extracts of line 4488 significantly reduced soybean biomass production. However, under the same conditions it enhanced biomass production of sorghum. The severity of chickpea root extracts inhibitory effects on crops was dependent on chickpea cultivar as well as the genetic characteristics of crops in rotation.

Xuan *et al.* (2005) found that incorporation of the allelopathic plants to rice fields at 1-5 days after transplanting gave the greatest weed reduction. The selective impacts of these plants on major noxious paddy weeds (such as *Echinochloa crus-galli*, *Monochoria vaginalis, Rotala indica, Eleocharis acicularis, Scirpus juncoides, Doparium juncencum, Lindernia pyxidaria,* and *Cyperus difformis*) were demonstrated. Some species (*Alpinia zerumbet, Ageratum conyzoides, Azadirachta indica, Piper methysticum, Leucaena leucocephala,* and *Melia azedarach*) showed strong inhibition on major plant pathogens (such as *Corticium rolfsii*, *Fusarium solani, Pyricularia grisea, Pythium spp., Rhizopus stolonifer, Taphrina deformans,* and *Thanatephorus cucumeris*) and they may become effective tools in reducing plant pathogens and weeds. Numerous growth inhibitors (alkaloids, phenolics, fatty acids, lactones, and flavonoids) identified from these allelopathic plants are responsible for their allelopathic properties.

Gallandt and Haramoto (2004) showed allelopathic potential has been well documented for cover crops such as cereal rye (*Secale cereale* L.), hairy vetch

(*Vicia villosa* Roth) and red clover (*Trifolium pratense* L.). They discussed unique attributes of Brassicas that make them promising options for pest management, as well as generally beneficial cover crops. From controlled settings on the effects of Brassicas, Brassica extracts and isolated compounds contained therein on seed germination, seedling emergence and establishment, and seedling growth—effects that, combined or taken alone, could contribute to reducing the density and vigor of weed communities in the field.

Riley *et al*. (2004) reported that mulching vegetables with chopped plant material both supplies nutrients and suppress weeds. Highly significant yield effects were found in both vegetable crops. Relative to the control treatment, beet yields were 135% and 123% after mulching, with and without hand-weeding, respectively, whilst cabbage yields were 124% and 118%. Yields after inter-row harrowing were 79% for beet and 83% for cabbage, relative to hand-weeding. Weed control on mulched plots was satisfactory throughout the growing season, probably due to the slow decay of the grass. This study showed that chopped plant material prevents weed growth as well as supplying nutrients

Norsworthy (2003) evaluated the allelopathic potential of wild radish was in controlled environments Germination and radical growth of all species were reduced by the extract compared with distilled water. However, topical applications of the aqueous extract failed to induce injury on any species by 7 d after treatment. Emergence and shoot fresh weight of the bioassay plants were reduced by wild radish residue incorporated into soil, with the level of suppression dependent on the quantity of residue incorporated. Sickle pod and prickly sida were extremely sensitive to incorporated wild radish residues, with > 95% fresh weight reduction at 0.5% (wt/wt) residue, compared with an untreated control. Conversely, yellow nutsedge showed a high degree of tolerance in all trials. Of the crops evaluated, cotton emergence and growth were most sensitive to incorporated wild radish residues.

Turk and Tawaha (2003) reported that black mustard (*Brassica nigra* L.) contains water-soluble substances that inhibited the germination and seedling growth of wild oat (*Avena fatua* L.). Aqueous extracts of *B. nigra* leaf, stem, flower and root plant part were made to determine their effects on germination and dry weights of hypocotyl and radicle length of 8-d old *A. fatua* L. seedlings over a range of extract concentrations. Increasing the aqueous extract concentrations of separated *B. nigra* L., plant parts significantly inhibited *A. fatua* L. germination, seedling length and weight. Radicle length was more sensitive to extract source than seed germination or hypocotyl length. Soil incorporation of fresh *B. nigra* roots only or both roots and shoots reduced *A. fatua* emergence, plant height, and dry weight per plant.

Brandsaeter and Riley (2002) showed that the winter annual legume Hairy Vetch (*Vicia villosa* Roth.) and the biennial legume Yellow Sweet Clover (*Melilotus officinalis* (L.) Pall.) are probably the most promising species. Preliminary results, from experiments in which cauliflower was transplanted into a mulch of mown Hairy Vetch, showed that the green manure effect of this species was better when incorporated into the soil than when used as surface mulch. The use of clover/grass material as a surface mulch in carrots, red beet and white cabbage has given good control of annual weeds, but not of perennials. It is difficult to quantify the amount of clover material needed for sufficient weed control in different vegetables. However, 6, 9 and 12 tonnes DM ha^{-1} for white cabbage, red beet and carrots, respectively. From a holistic point of view; the use of clover material has also given promising control of pests, especially in carrots, as well as having substantial nutritional value when used as either green manure or mulch.

Barker and Bhowmik (2001) reported that crop residues have many potential uses in cropping systems, among which are imparting weed control. In one experiment, residues were imported to the vegetable plots and applied as surface mulches or incorporated shallowly into the ground. In another experiment, the residues were grown on site as cover crops in the year preceding vegetable production and disked into the plots. Application of imported residues was more effective in weed control and yield enhancement than the cover crop residues. Imported residues were effective in control of early emerging weeds, whereas with the cover crops supplemental weed management was required for early weed control. Weed control did not differ substantially with species of residue, but control increased as amount of incorporated residues increased from 6 to 24 ton/ha. Weed control with residue incorporation at 6 ton/ha was as effective as a mulch of 24 ton/ha. If weed control was imparted by the residues, crop yields with any residue treatment were equivalent to those from plots kept relatively weed-free by tillage. Yields did not vary with amounts of residues applied.

Daimon and Kotoura (2000) stated that *Crotalaria spectabilis* incorporation significantly increased wheat dry weight and nitrogen uptake. However, values for HD plant incorporation were significantly lower than those for LD and MD plant incorporation at 80 and 120 days after seeding. A reduction of the dry weight and total root length of wheat grown with aqueous extracts of HD plants was found in a growth pouch experiment.

Ohno *et al.* (2000) reported that there was a 20% reduction of radicle growth in the green manure treatment in comparison with the wheat stubble treatment, but only at the first sample date after residue incorporation (8 DAI). The radicle growth reduction had the highest correlation with the concentration of soluble phenolics in the soil: water extracts. The close agreement of the predicted and observed root growth reduction at 8 DAI further supports clover residue as the source of the phytotoxicity. Their study demonstrates that the potential exists for using legume green manures to reduce the amounts of synthetic herbicides needed for weed control.

Cheema *et al.* (1997) reported that use foliar sprays of different allelopathic water extracts for inhibiting weeds in field crops reduce weed biomass by 33-53% and increase in wheat yield (7-14%) by application of sorghum (*Sorghum bicolor*) and sunflower (*Helianthus annuus*) water extracts.

Moyer and Huan (1996) observed that extracts of lentil (*Lens culinaris* Medic), oat (*Avena sativa* L.), canola (*Brassica napus* L.), and barley (*Hordeum vulgare* L.) were more toxic to flixweed (*Descurainia sophia* L. Webb), stinkweed (*Thlaspi arvense* L.), and downy brome (*Bromus tectorum* L.) than extract of canola was to wheat. The greater toxicity of these crop residues to flixweed, stinkweed, and downy brome than to wheat may permit selective management of these weeds in wheat. Flixweed, stinkweed, and downy brome are major winter annual weeds in winter wheat and usually require late fall or early spring herbicide treatments in no-tillage systems. Therefore, residues of canola, lentil, oat and barley have potential for reducing herbicide use in winter wheat production and in no-tillage direct seeding farming systems. Crop extracts were not toxic enough to affect the growth in the field of seven other weeds.

Boydstone and Hang (1995) evaluated fall-planted rapeseed and sudangrass for weed control in potato during a two-year study. Rapeseed incorporated in the spring in a loamy sand soil reduced weed density 85 and 73% in 1992 and 1993, respectively, and reduced weed biomass 96 and 50% in 1992 and 1993, respectively. Potato following rapeseed yielded 25% and 17% more total tuber weight than potato following sudangrass in 1992 and fellow in 1993, respectively. Similarly, white mustard tissue added at 20g fresh per 400g dry soil reduced biomass of hairy nightshade and green foxtail by 83 and 70%, respectively.

Friedman *et al.* (1995) examined five cover crop species on nitrogen production and weed suppression in Sacramento Valley Farming Systems and found that the Lana vetch mixes and the Lana vetch provided more effective weed control than the purple vetch in both years. In 1993-94, weeds were negligible in all Lana vetch treatments, while the weeds in the purple vetch treatment made up almost 35% of the total biomass. In 1994-95, the Lana vetch and fava/Lana vetch treatments were considerably more effective at choking out weeds than the purple vetch, although the cowpea/Lana vetch treatment was not more effective. However, the vetch in mix was unable to compete effectively with the heavy weed growth.

Daar (1986) said that rye residue contains generous amounts of allelopathic chemicals. When rye is killed in place and left undisturbed on the soil surface, these chemicals leach out and prevent germination of small-seeded weeds. Weed suppression is effective for about 30–60 days.

Rose *et al.* (1984) experimented on 280 soybean cultivars and found soybean cultivars of later maturity tended to compete more effectively with weeds. Twenty soybean cultivars of varying competitive ability were selected and grown in the greenhouse during 1981 and 1982 to determine the importance of allelopathy in competing with weeds. Exudates from roots of soybean cultivars grown in sand reduced the dry weight of 4-week-old velvetleaf plants an average of 15%, but foxtail millet was not inhibited. Incorporation of 1% ground soybean dry matter into Sharpsburg silty clay loam inhibited germination and dry weight of greenhouse grown velvetleaf an average of 46% each. Foxtail millet germination and dry weights were reduced an average of 82 and 65%, respectively. Undiluted soybean plant extracts of all cultivars tested slowed the germination and dry weight accumulation of 6-day-old velvetleaf and foxtail millet, but dilution of the extracts caused quite variable responses.

CHAPTER III

MATERIALS AND METHODS

The experiment was conducted to find out the effect of tillage depth and mulch materials on weed management, yield attributes and yield in wheat. The details of the materials and methods i.e. location of experimental site, soil and climate condition of the experimental plot, materials used, design of the experiment, data collection and procedure of data analysis those were used or followed in this experiment have been presented below under the following headings:

3.1 Description of the experimental site

3.1.1 Experimental period

The experiment was conducted during the *Rabi* season from the period of November 2013 to March 2014.

3.1.2 Site description

The present piece of research work was conducted in the experimental field of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka. The location of the site is $23^{0}74^{/}$N latitude and $90^{0}35^{/}$E longitude with an elevation of 8.2 meter from sea level.

3.1.3 Climatic condition

The geographical location of the experimental site was under the subtropical climate and its climatic conditions is characterized by three distinct seasons, namely winter season from the month of November to February and the pre-monsoon period or hot season from the month of March to April and monsoon period from the month of May to October (Edris *et al*., 1979). Details of the meteorological data of air temperature, relative humidity, rainfall and sunshine hour during the period of the experiment was collected from the Weather Station of Bangladesh, Sher-e-Bangla Nagar, Dhaka and details has been presented in Appendix I.

3.1.4 Soil characteristics of the experimental plot

The soil belongs to "The Modhupur Tract", AEZ-28 (FAO, 1988). Top soil was silty clay in texture, olive-gray with common fine to medium distinct dark yellowish brown mottles. Soil pH was 6.2 and had organic carbon 0.45%. The experimental area was flat having available irrigation and drainage system and above flood level. The selected plot was medium high land. The details have been presented in Appendix II.

3.2 Experimental details

3.2.1 Treatment of the experiment

The experiment comprised of two factors

Factor A: Tillage depth (4 types)

i) T_0: Control

ii) T_1: $3^{//}$ depth

iii) T_2: $6^{//}$ depth

v) T_3: $9^{//}$ depth

Factor B: Mulch materials (3 types)

i) M_0: Control (no mulch)

ii) M_1: Rice straw

iii) M_2: Black polythene

There were in total 12 (4×3) treatment combinations such as T_0M_0, T_0M_1, T_0M_2, T_1M_0, T_1M_1, T_1M_2, T_2M_0, T_2M_1, T_2M_2, T_3M_0, T_3M_1 and T_3M_2.

3.2.2 Experimental design and layout

The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. The experimental area was divided into three equal blocks. Each block contained 12 plots where 12 treatments combination were allotted at random. There were 36 unit plot altogether in the experiment. The size of each plot was 2.5 m × 1.5 m. The distance maintained between two blocks and two plots were 1.0 m and 0.5 m, respectively. The layout of the experiment is shown in Figure 1.

3.3 Growing of crops

3.3.1 Seed collection

The seeds of wheat variety 'BARI Gom 26' were collected from Bangladesh Agricultural Research Institute (BARI), Joydevpur, Gazipur**.** It was released in 2010 (BARI, 2012).

3.3.2 Preparation of the main field

The piece of land selected for the experiment was opened in the 12th November 2013 with a spade as per the treatment of tillage depth. Different tillage depth i.e. 3, 6 and 9 inches depth was maintained with measuring a meter scale and in case of control treatment only crust the surface soil using hand pressure. Finally, the land was ploughed and cross-ploughed several times by a spade followed by laddering to obtain a good tilth following the treatment of tillage depth. Weeds and stubble were removed and finally a desirable tilth of soil was obtained for sowing of wheat seeds. Fertilizers and manures as indicated below in 3.3.4 were mixed with the soil of plot.

3.3.3 Seeds sowing

Furrows were made for sowing the wheat seeds when the land was in proper joe condition and seeds were sown at 20 November, 2013. Seeds were sown continuously maintaining 20 cm line to line distance and plant to plant 5 cm. After sowing, seeds were covered with soil and slightly pressed by hand.

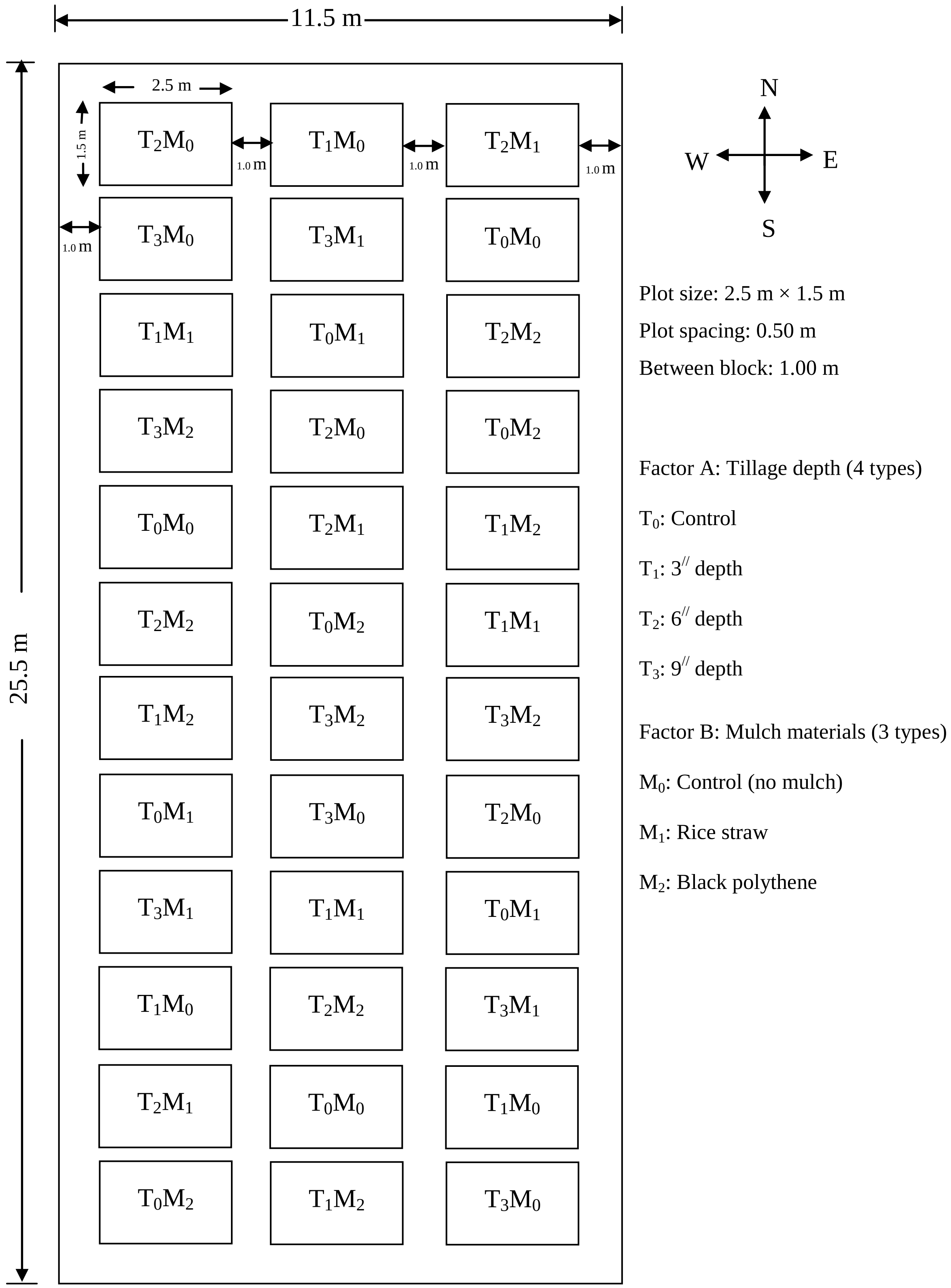


Figure 1. Layout of the experimental plot

3.3.4 Application of fertilizers and manure

The fertilizers N, P, K and S in the form of Urea, TSP, MP and Gypsum, respectively were applied. Cowdung was applied @ 10 t ha^{-1} 15 days before seeds sowing in the field. The entire amount of TSP, MP and Gypsum and 1/3rd of urea were applied during the final preparation of land. Rest of urea was top dressed after first irrigation at 20 DAS (BARI, 2011). The dose and method of application of fertilizers are presented below in Table 1.

Table 1. Doses and method of application of fertilizers in wheat field

Fertilizers	Dose (per ha)	Application (%)	
		Basal	1st installment
Urea	220 kg	33.33	66.67
TSP	180 kg	100	--
MP	50 kg	100	--
Gypsum	120 kg	100	--
Cowdung	10 ton	100	--

Source: BARI, 2011, Krishi Projukti Hatboi, Joydebpur, Gazipur

3.3.5 After care

After the germination of seeds, various intercultural operations such as irrigation, weeding, top dressing of fertilizer and plant protection measures were accomplished for better growth and development of the wheat seedlings.

3.3.5.1 Irrigation and drainage

Two flood irrigations at 20 and 40 DAS were provided. Proper drainage system was also developed for draining out excess water.

3.3.5.2 Weeding

Weedings were done to keep the plots free from weeds to facilitate better growth and development of wheat seedlings. The newly weeds were uprooted carefully and identified as per plots. Weeder was used at 20 and 40 DAS to remove weeds from the experimental plot.

3.3.5.3 Plant protection

The crop was attacked by different kinds of insects during the growing period. Triel-20 ml was applied on 05 January, 2014 and sumithion-40 ml/20 litre of water was applied on 30 January as plant protection measure. During the entire growing period the crop was observed carefully to take protection measures.

3.4 Harvesting, threshing and cleaning

The crop was harvested manually depending upon the maturity starting from 103 DAS. The harvested crop of each plot was bundled separately, properly tagged and brought to threshing floor. Enough care was taken during threshing and cleaning period of wheat grain. Fresh weight of wheat grain and straw were recorded plot wise from 1 m^2 area. The grains were dried, cleaned and weighed for individual plot. The weight was adjusted to a moisture content of 12%. Yields of wheat grain and straw m^{-2} were recorded and converted to t ha^{-1}.

3.5 Data collection

3.5.1 Plant height

The height of plant was recorded in centimeter (cm) at 30, 40, 50 and 60 DAS (Days After Sowing) and at harvest as the average of 10 plants selected at random from the inner rows of each plot that were tagged earlier. The height was measured from the ground level to the tip of the plant by a meter scale.

3.5.2 Tillers $plant^{-1}$

The number of tillers $plant^{-1}$ was recorded at the time of 30, 40, 50 and 60 DAS. Data were recorded by counting tillers from each plant and as the average of 10 plants selected at random from the inner rows of each plot.

3.5.3 Dry matter content $plant^{-1}$

Data from ten sample plants of each plot were collected after harvest and gently washed with tap water, thereafter soaked with paper towel. Then fresh weight was taken immediately after soaking by paper towel. After taking fresh weight, the sample was oven dried at 70^0C for 72 hours. Then oven-dried samples were transferred into a desiccator and allowed to cool down to room temperature, thereafter dry weight of stem was taken and expressed in gram. As per the above procedure dry matter content plant^{-1} was recorded at 30, 40, 50 and 60 DAS.

3.5.4 Days from sowing to spike emergence

Days from sowing to starting of spike emergence was recorded by calculating the number of days from sowing to starting of spike emergence by keen observation of the experimental plots during the experimental period.

3.5.5 Days from sowing to maturity

Days from sowing to maturity to maturity was recorded by calculating the number of days from sowing to starting of maturity as spikes become brown color by keen observation of the experimental plot.

3.5.6 Number of spikes plant^{-1}

The total number of spikes plant^{-1} was recorded by calculating spikes plant^{-1}. Data on number of spikes plant^{-1} were counted from 10 selected plant at harvest and average value was recorded.

3.5.7 Number of spikelets spike^{-1}

The total number of spikelets spike^{-1} was counted as the number of spikelets from 10 randomly selected spikes from each plot and average value was recorded.

3.5.8 Ear length

The length of ear was measured with a meter scale from 10 selected panicles and the average value was recorded.

3.5.9 Grains spike^{-1}

The total number of grains spike^{-1} was counted as the number of grains from 10 randomly selected spikes from each plot and average value was recorded.

3.5.10 Unfilled spikelets spike^{-1}

The total number of unfilled spikelets spike^{-1} was counted as the number of unfilled spikelets from 10 randomly selected spikes from each plot and average value was recorded.

3.5.11 Total spikelets spike^{-1}

The total number of spikelets spike^{-1} was counted by adding the number of filled and unfilled spikelets from 10 randomly selected spike from each plot and average value was recorded.

3.5.12 Weight of 1000 seeds

One thousand seeds were counted randomly from the total cleaned harvested seeds of each individual plot and then weighed in grams and recorded.

3.5.13 Grain yield

Grains obtained from 1.0 m^2 area of each unit plot were sun-dried and weighed carefully. The dry weight of grains of central 1.0 m^2 area was used to record grain yield m^{-2} and this was converted into t ha^{-1}.

3.5.14 Straw yield

Straw obtained from 1.0 m^2 area of each unit plot were sun-dried and weighed carefully. The dry weight of straws of central 1.0 m^2 area was used to record straw yield m^{-2} and was converted into t ha^{-1}.

3.5.15 Biological yield

Grain yield and straw yield together were regarded as biological yield of wheat. The biological yield was calculated with the following formula:

Biological yield = Grain yield + Straw yield.

3.5.16 Harvest index

Harvest index was calculated from per hectare grain and straw yield that were obtained from each unit plot and expressed in percentage.

$$HI = \frac{\text{Economic yield (grain weight)}}{\text{Biological yield (Total dry weight)}} \times 100$$

3.6 Statistical Analysis

The data obtained for different characters were statistically analyzed to observe the significant difference among the tillage depth and mulch materials and their interaction. The mean values of all the characters were calculated and analysis of variance was performed. The significance of the difference among the treatment means was judged by the Duncan Multiple Range Test (DMRT) at 5% level of probability (Gomez and Gomez, 1984).

CHAPTER IV

RESULTS AND DISCUSSION

The results of the experiment have been presented with the help of table and graphs and possible interpretations have been given under the following headings:

4.1 Weed control

4.1.1 Weed species in the experimental field

It is a common phenomenon that plants compete with numerous weeds under favourable condition. Plant-weed competition increased when the density of weeds increases. Ten weed species belongs to 6 families were found infested in the treated plot. Among them 5 species were under the family of Gramineae and there were only one weed species for each of the family of Cyperaceae Leguminose, Chenopodiaceae, Solanaeae and Labiatae. *Cyperous rotundus, Eleusine indica, Cynodon dactylon, Digitaria sanguinalis, Echinochloa colonum, Chenopodium album* were found with major population among the 10 weed species. Among the weed population 3 were perennial and rest 7 were annual as per their life cycle. There were five species of grass, two were sedge and three under broad leaved category (Table 2). Rahman (1985) observed a more wide range of weed flora in wheat crop field which included *Chenopodium album, Paspalum distichum, Gnaphalium luteo-album, Vicia sativa, Dactyloctenium aegyptium, Cyperus rotundus, Hydrocotyle asiatica, Marsilea quadrifolia* and *Eclipta prostrata.*

In the experimental area, the major 10 weed population were recorded such as *Cyperus rotundus* (5.67 m^{-2}), *Eleusine indica* (7.33 m^{-2}), *Cynodon dactylon* (4.33 m^{-2}), *Digitaria sanguinalis* (2.33 m^{-2}), *Vicia sativa* (1.67 m^{-2}), *Echinochloa colonum* (5.67 m^{-2}), *Chenopodium album* (3.33 m^{-2}), *Solanum torvum* (1.33 m^{-2}), *Leucas aspera* (1.33 m^{-2}) and *Panicum repens* (1.33 m^{-2}).

Table 2. List of weeds with common name, scientific name, family, life cycle and type that were observed in the experimental plot and their average number in each m^2 of area during the growing period

Sl. No.	Local name	Common name	Scientific name	Family	Life cycle	Population (No/ m^{-2})
1.	Mutha	Nut sedge	*Cyperus rotundus*	Cyperaceae	Annual	5.67
2.	Chapra	Goose grass	*Eleusine indica*	Gramineae	Perennial	7.33
3.	Durba	Bermuda grass	*Cynodon dactylon*	Gramineae	Perennial	4.33
4.	Anguli ghas	Scrab grass	*Digitaria sanguinalis*	Gramineae	Annual	2.33
5.	Bon Mosur	Wild lentil	*Vicia sativa*	Leguminosae	Annual	1.67
6.	Choto Shama	Jungle rice	*Echinochloa colonum*	Gramineae	Annual	5.67
7.	Bathua	Lambsquarters	*Chenopodium album*	Chenopodiaceae	Annual	3.33
8.	Tita Begun	Tita Begun	*Solanum torvum*	Solanaceae	Annual	1.33
9.	Shetodron	Leucas	*Leucas aspera*	Labiatae	Annual	1.33
10.	Bon China	Torpado grass	*Panicum repens*	Gramineae	Perennial	1.33

4.1.2 Weed Population

Weed population m^{-2} at 20 and 40 DAS varied significantly due to different tillage depth (Appendix III). At 20 DAS, the maximum numbers of weed population m^{-2} (14.00) were recorded in T_0 (control), while the minimum number of weed population m^{-2} (7.44) were observed in T_3 ($9^{//}$ tillage depth) treatment which were statistically similar (8.11 and 8.67) to T_2 ($6^{//}$ tillage depth) and T_1 ($3^{//}$ tillage depth) (Table 3). At 40 DAS, the maximum numbers of weed population m^{-2} were recorded in T_0 (21.89), while the minimum number in T_3 (10.00) treatment which were statistically similar by T_2 (10.55) and T_1 (11.44), respectively, Haque (2011) reported that *Chenopodium album, Vicia sativa, Cynodon dactylon, Cyperus rotundus, Eclipta alba and Lindernia procumbens* were dominant weed species in wheat crop field.

Statistically significant variation were recorded in terms of weed population m^{-2} at 20 and 40 DAS for different mulch materials (Appendix III). Data revealed that at 20 DAS, the maximum numbers of weed population m^{-2} (13.50) were found in M_0 (no mulch i.e. control), while the minimum number of weed population (8.33) in M_2 (polythene mulch) which were statistically similar (8.58) to M_1 (rice straw mulch (Table 3). At 40 DAS, the maximum numbers of weed population m^{-2} were recorded in M_0 (20.33), while the minimum number in M_2 (10.42) which were statistically similar to M_1 (10.75) treatment.

Interaction effect of different tillage depth and mulch materials showed significant differences on weed population m^{-2} at 20 and 40 DAS (Appendix III). At 20 DAS, the maximum number of weed population m^{-2} were found from T_0M_0 (16.33), while the minimum number were recorded from T_3M_2 (4.33) treatment combination (Table 4). At 40 DAS, the maximum number of weed population m^{-2} were found from T_0M_0 (28.33), while the minimum number were recorded from T_2M_2 (6.00) treatment combination.

4.1.3 Dry weight of weed biomass

Different tillage depth showed statistically significant variation in terms of dry weight of weed biomass m^{-2} at 20 and 40 DAS (Appendix III). At 20 DAS, the highest dry weight of weed biomass m^{-2} were observed in T_0 (6.04 g), while the lowest dry weight of weed biomass m^{-2} were found in T_3 (4.093 g) treatment which were statistically similar to T_2 (4.10 g) and T_1 (4.21 g), respectively (Table 3). At 40 DAS, the highest dry weight of weed biomass m^{-2} were recorded in T_0 (8.43 g), whereas the lowest dry weight of weed biomass m^{-2} were found in T_3 (6.23 g) treatment which were statistically similar to T_2 (6.51 g) and T_1 (6.70 g), respectively.

Dry weight of weed biomass m^{-2} at 20 and 40 DAS varied significantly due to different mulch materials (Appendix III). At 20 DAS, the highest dry weights of weed biomass m-2 were recorded in M_0 (5.95 g), while the lowest dry weights of weed biomass m-2 were found in M_2 (3.93 g) which were statistically similar to M_1 (3.95 g) (Table 3). At 40 DAS, the highest dry weights of weed biomass m-2 were observed in M_0 (7.68 g), while the lowest dry weights of weed biomass m-2 were found in M_2 (6.72 g) which were statistically similar to M_1 (6.73 g).

Statistically significant variation were recorded due to the interaction effect of different tillage depth and mulch materials in terms of dry weight of weed biomass m^{-2} at 20 and 40 DAS (Appendix III). At 20 DAS, the highest dry weight of weed biomass m^{-2} were recorded from T_0M_0 (6.81 g), while the lowest dry weight of weed biomass m^{-2} were found from T_3M_2 (3.10 g) treatment combination (Table 4). At 40 DAS, the highest dry weight of weed biomass m^{-2} were observed from T_0M_0 (8.65 g), whereas the lowest dry weight of weed biomass m^{-2} were attained from T_2M_2 (5.72 g) treatment combination.

Table 3. Effect of tillage depth and mulch materials on weed population and dry weight of weed

Treatments	Weeds population (No.) at		Dry weight of weed biomass (gm^{-2})	
	20 DAS	**40 DAS**	**20 DAS**	**40 DAS**
Tillage depth				
T_0	14.00 a	21.89 a	6.04 a	8.43 a
T_1	8.67 b	11.44 b	4.21 b	6.70 b
T_2	8.11 b	10.55 b	4.10 b	6.51 b
T_3	7.44 b	10.00 b	4.09 b	6.23 b
SE	**0.142**	**0.108**	**0.029**	**0.024**
Level of significance	**0.01**	**0.01**	**0.01**	**0.01**
Mulch materials				
M_0	13.50 a	20.33 a	5.95 a	7.68 a
M_1	8.58 b	10.75 b	3.95 b	6.73 b
M_2	8.33 b	10.42 b	3.93 b	6.72 b
SE	**0.158**	**0.219**	**0.040**	**0.048**
Level of significance	**0.01**	**0.01**	**0.01**	**0.01**
CV(%)	**8.00**	**5.98**	**6.92**	**5.61**

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

T_0: Control

T_1: 3// tillage depth

T_2: 6// tillage depth

T_3: 9// tillage depth

M_0: Control (no mulch)

M_1: Rice straw

M_2: Black ploythene

Table 4. Interaction effect of tillage depth and mulch materials on weed population and dry weight of weed

Treatments	Weeds population (No.) at		Dry weight of weed biomass (g m^{-2})	
	20 DAS	40 DAS	20 DAS	40 DAS
T_0M_0	16.33 a	28.33 a	6.81 a	8.65 a
T_0M_1	13.33 b	19.33 b	5.69 b	8.34 a
T_0M_2	12.33 b	18.00 b	5.62 b	8.30 a
T_1M_0	13.67 b	19.33 b	5.58 b	7.82 b
T_1M_1	7.33 c	8.33 c	3.58 d	6.28 cd
T_1M_2	5.00 cd	6.67 c	3.46 d	6.00 cd
T_2M_0	12.67 b	17.33 b	5.44 c	7.15 b
T_2M_1	7.00 c	8.00 c	3.34 d	6.39 cd
T_2M_2	4.67 cd	6.33 c	3.29 d	5.98 cd
T_3M_0	11.33 b	16.33 b	5.98 c	7.08 b
T_3M_1	6.67 cd	7.33 c	3.19 d	5.90 cd
T_3M_2	4.33 d	6.00 c	3.10 d	5.72 d
SE	**0.922**	**0.438**	**0.080**	**0.097**
Level of significance	**0.05**	**0.05**	**0.01**	**0.01**
CV(%)	**8.00**	**5.98**	**6.92**	**5.61**

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

T_0: Control — M_0: Control (no mulch)

T_1: 3// tillage depth — M_1: Rice straw

T_2: 6// tillage depth — M_2: Black ploythene

T_3: 9// tillage depth

4.2 Crop Growth Characters

4.2.1 Plant height

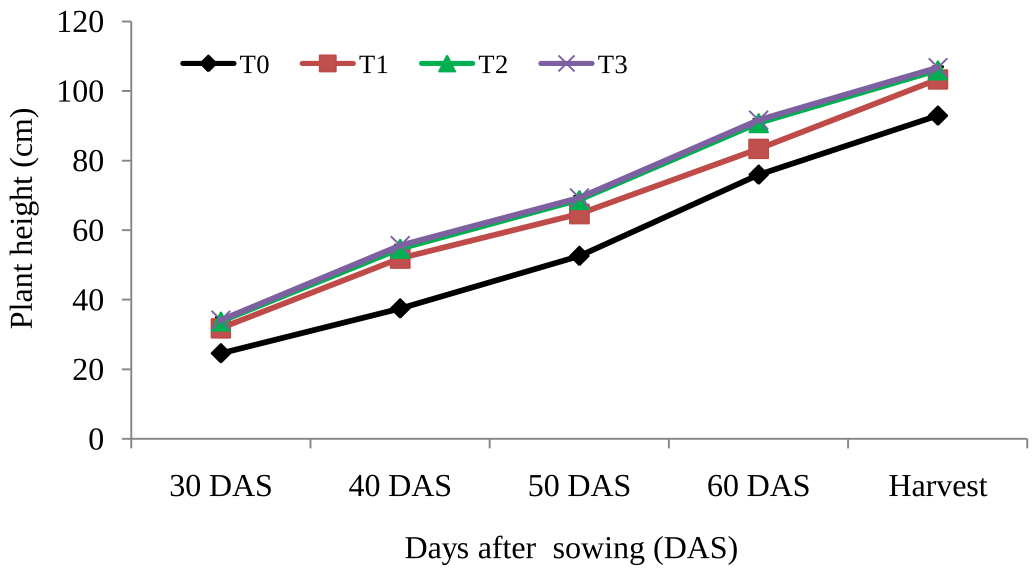
Plant height of wheat at 30, 40, 50, 60 DAS and harvest showed statistically significant difference due to different tillage depth (Figure 2). At 30, 40, 50, 60 DAS and at harvest, the longest plant were found from T_3 (34.15, 55.60, 69.29, 91.67 and 106.76 cm, respectively) which were statistically similar to T_2 (33.81, 54.71, 68.72, 90.82 and 105.98 cm, respectively) and by T_1 followed (31.82, 51.89, 64.68, 83.38 and 103.00 cm, respectively), whereas the shortest plant were recorded from T_0 (24.59, 37.50, 52.60, 75.96 and 92.94 cm, respectively).

Different mulch materials showed significantly effect in terms of plant height of wheat at 30, 40, 50, 60 DAS and at harvest (Figure 3). At 30, 40, 50, 60 DAS and harvest, the longest plant were observed from M_2 (32.99, 52.89, 65.93, 88.89 and 105.69 cm, respectively) which were statistically similar to M_1 (32.39, 51.67, 65.43, 87.86 and 104.04 cm, respectively), while the shortest plant were found from M_0 (27.90, 45.21, 60.11, 79.62 and 97.04 cm, respectively).

Interaction effect of tillage depth and mulch materials showed significant differences on plant height at 30, 40, 50, 60 DAS and at harvest (Table 5). At 30, 40, 50, 60 DAS and harvest, the longest plant were observed from T_3M_2 (37.29, 60.46, 73.75, 96.60 and 111.50 cm, respectively) and the shortest plant were found from the treatment combination of T_0M_0 (23.18, 35.38, 51.36, 70.19 and 89.40 cm, respectively).

4.2.2 Number of tillers plant^{-1}

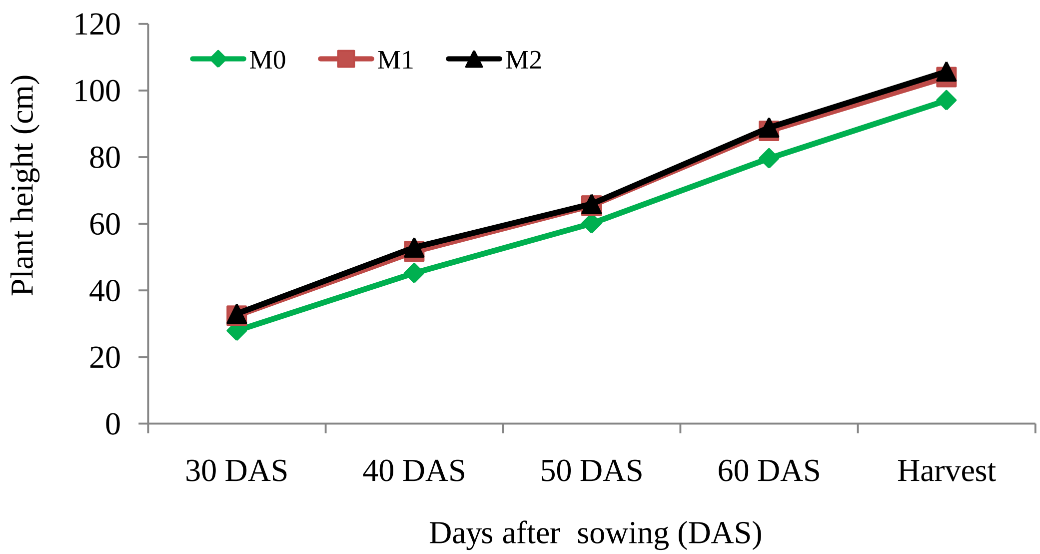
Number of tillers plant^{-1} of wheat at 30, 40, 50 and 60 DAS showed statistically significant difference due to different tillage depth (Figure 4). At 30, 40, 50 and 60 DAS, the highest number of tillers plant^{-1} were found from T_3 (3.50, 4.41, 5.62 and 6.58, respectively) which were statistically similar to T_2 (3.39, 4.48, 5.58 and 6.46, respectively) followed by T_1 (2.90, 4.42, 5.46 and 5.63, respectively), whereas the lowest number of tillers plant^{-1} were recorded from T_0 (2.44, 3.66, 5.11 and 5.24 respectively).



T_0: Control T_1: 3// tillage depth

T_2: 6// tillage depth T_3: 9// tillage depth

Figure 2. Effect of different tillage depth on plant height of wheat. (SE = 0.610, 0.812, 0.842, 0.915 and 1.083)



M_0: Control (no mulch) M_1: Rice straw

M_2: Black ploythene

Figure 3. Effect of different mulch materials on plant height of wheat (SE = 0.529, 0.703, 0.730, 0.792 and 0.938)

Table 5. Interaction effect of tillage depth and mulch materials on plant height of wheat at different days after sowing and harvest

Treatments	Plant height (cm) at				
	30 DAS	**40 DAS**	**50 DAS**	**60 DAS**	**Harvest**
T_0M_0	23.18 e	35.38 d	51.36 g	70.19 e	89.40 f
T_0M_1	26.05 de	39.65 d	55.53 fg	80.43 cd	96.37 de
T_0M_2	24.55 e	37.48 d	50.91 g	77.25 d	93.05 ef
T_1M_0	28.04 cd	46.35 c	60.36 ef	78.55 d	97.84 de
T_1M_1	33.68 b	54.59 b	67.16 b-d	85.65 b	104.70 bc
T_1M_2	33.74 b	54.73 b	66.52 cd	85.94 b	107.49 ab
T_2M_0	30.10 c	48.82 c	63.79 de	84.55 bc	99.95 cd
T_2M_1	34.94 ab	56.40 ab	69.82 a-c	92.15 a	107.26 ab
T_2M_2	36.39 ab	58.90 ab	72.54 ab	95.77 a	110.72ab
T_3M_0	30.27 c	50.28 c	64.93 c-e	85.21 bc	100.95 cd
T_3M_1	34.89 ab	56.04 ab	69.19 a-d	93.20 a	107.81 ab
T_3M_2	37.29 a	60.46 a	73.75 a	96.60 a	111.50 a
SE(±)	**1.057**	**1.407**	**1.459**	**1.584**	**1.876**
Level of significance	**0.05**	**0.05**	**0.05**	**0.05**	**0.05**
CV(%)	**5.53**	**4.88**	**5.96**	**4.64**	**6.95**

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

T_0: Control
T_1: 3// tillage depth
T_2: 6// tillage depth
T_3: 9// tillage depth

M_0: Control (no mulch)
M_1: Rice straw
M_2: Black ploythene

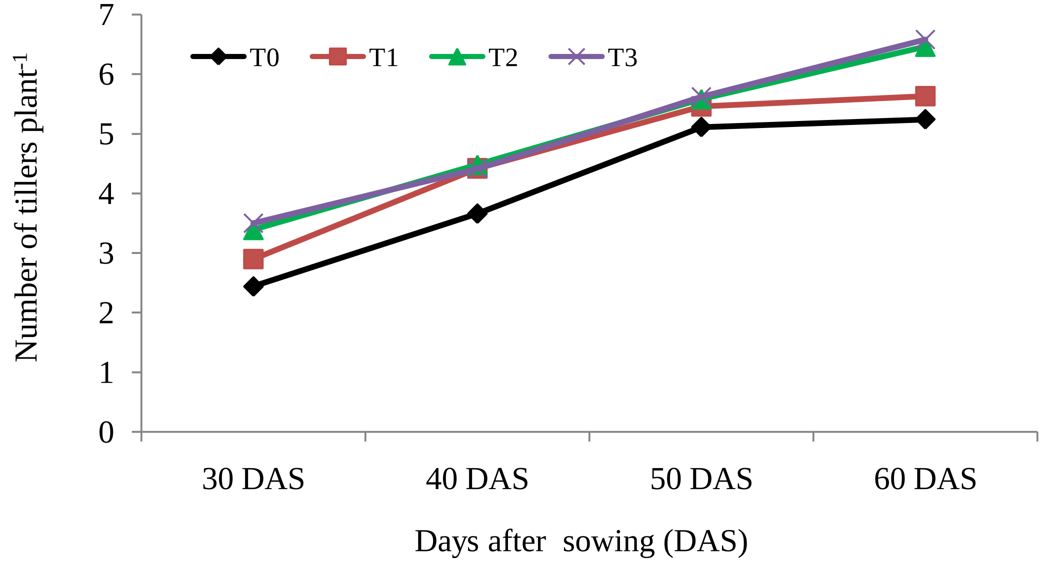
Different mulch materials showed significant effect in terms of number of tillers plant^{-1} of wheat at 30, 40, 50 and 60 DAS (Figure 5). At 30, 40, 50 and 60 DAS, the highest number of tillers plant^{-1} were observed from M_2 (3.42, 4.46, 5.96 and 6.71, respectively) which were statistically similar to M_1 (3.28, 4.28, 5.45 and 6.15, respectively), while the lowest number of tillers plant^{-1} were found from M_0 (2.47, 3.98, 4.92 and 5.07, respectively).

Interaction effect of tillage depth and mulch materials showed significant differences on number of tillers plant^{-1} at 30, 40, 50 and 60 DAS (Table 6). At 30, 40, 50 and 60 DAS, the highest number of tillers plant^{-1} were observed from T_3M_2 (3.90, 4.87, 6.52 and 7.33, respectively) and the lowest number of tillers plant^{-1} were found from the treatment combination of T_0M_0 (2.10, 3.43, 4.50 and 4.33, respectively).

4.2.3 Dry matter accumulation plant^{-1}

Dry matter accumulation plant^{-1} of wheat at 30, 40, 50 and 60 DAS showed statistically significant difference due to different tillage depth (Figure 6). At 30, 40, 50 and 60 DAS, the highest dry matter accumulation plant^{-1} were found from T_3 (2.18, 4.00, 4.96 and 5.82 g, respectively) which were statistically similar to T_2 (2.33, 4.11, 5.20 and 6.11 g, respectively) followed by T_1 (2.22, 3.87, 4.76 and 5.82 g, respectively), whereas the lowest dry matter accumulation plant^{-1} were recorded from T_0 (1.13, 3.31, 4.00 and 4.98 g, respectively).

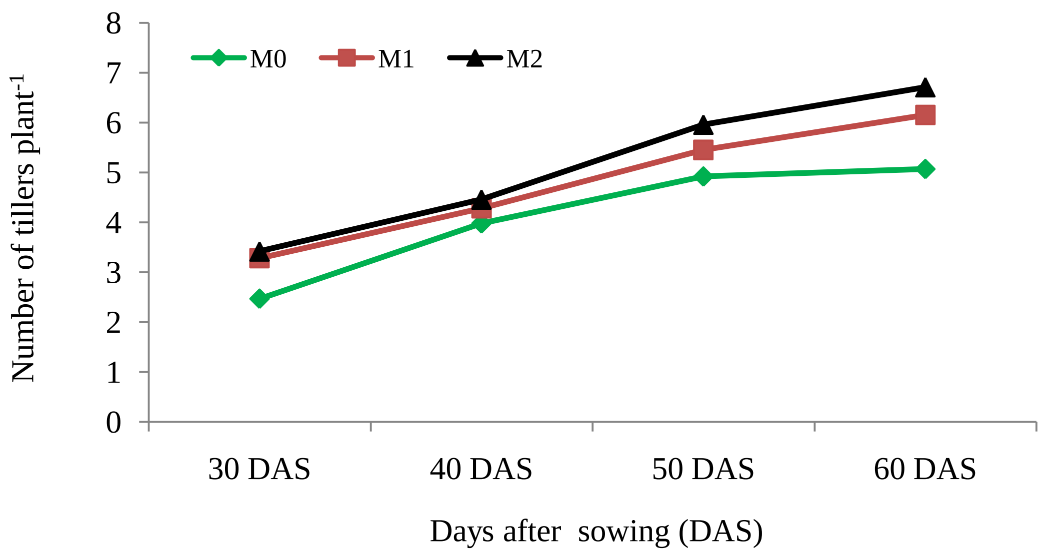
Different mulch materials showed significant effect in terms of dry matter accumulation plant^{-1} of wheat at 30, 40, 50 and 60 DAS (Figure 7). At 30, 40, 50 and 60 DAS, the highest dry matter accumulation plant^{-1} were observed from M_2 (2.28, 4.10, 4.97 and 5.75 g, respectively) which were statistically similar to M_1 (2.07, 3.85, 4.77 and 5.47 g, respectively), while the lowest dry matter accumulation plant^{-1} were observed from M_0 (1.55, 3.52, 4.45 and 5.83 g, respectively).



T_0: Control T_1: 3// tillage depth

T_2: 6// tillage depth T_3: 9// tillage depth

Figure 4. Effect of different tillage depth on number of tillers plant^{-1} of wheat (SE= 0.061, 0.063, 0.126 and 0.158)



M_0: Control (no mulch) M_1: Rice straw

M_2: Black ploythene

Table 6. Interaction effect of tillage depth and mulch materials on number of tillers plant^{-1} of wheat at different days after sowing

Treatments	Number of tillers plant^{-1}			
	30 DAS	40 DAS	50 DAS	60 DAS
T_0M_0	2.10 e	3.43 d	4.50 e	4.33 h
T_0M_1	2.43 d	3.63 cd	5.23 cd	5.20 f-h
T_0M_2	2.80 c	3.90 c	5.60 bc	6.20 b-e
T_1M_0	2.37 de	4.37 b	5.24 cd	5.03 gh
T_1M_1	3.17 b	4.50 b	5.47 b-d	5.87 d-g
T_1M_2	3.17 b	4.40 b	5.67 bc	6.00 c-f
T_2M_0	2.63 cd	4.33 b	5.17 c-e	5.77 e-g
T_2M_1	3.70 a	4.43 b	5.53 bc	6.67 b-d
T_2M_2	3.83 a	4.67 ab	6.03 ab	6.93 ab
T_3M_0	2.77 c	3.80 c	4.79 de	5.17 f-h
T_3M_1	3.83 a	4.57 ab	5.55 bc	6.87 a-c
T_3M_2	3.90 a	4.87 a	6.52 a	7.33 a
SE(±)	0.106	0.108	0.217	0.274
Level of significance	0.05	0.01	0.05	0.05
CV(%)	6.02	4.42	6.92	6.79

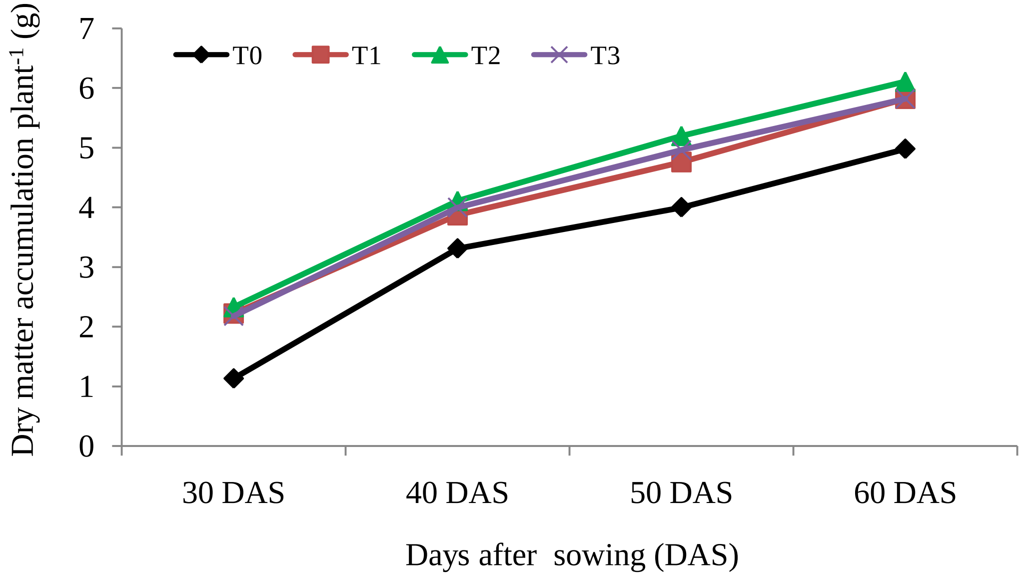
In a column means having similar letter(s) are statistically similar and those having dissimilar letter (s) differ significantly at 0.05 level of probability

T_0: Control — M_0: Control (no mulch)

T_1: 3$^{//}$ tillage depth — M_1: Rice straw

T_2: 6$^{//}$ tillage depth — M_2: Black ploythene

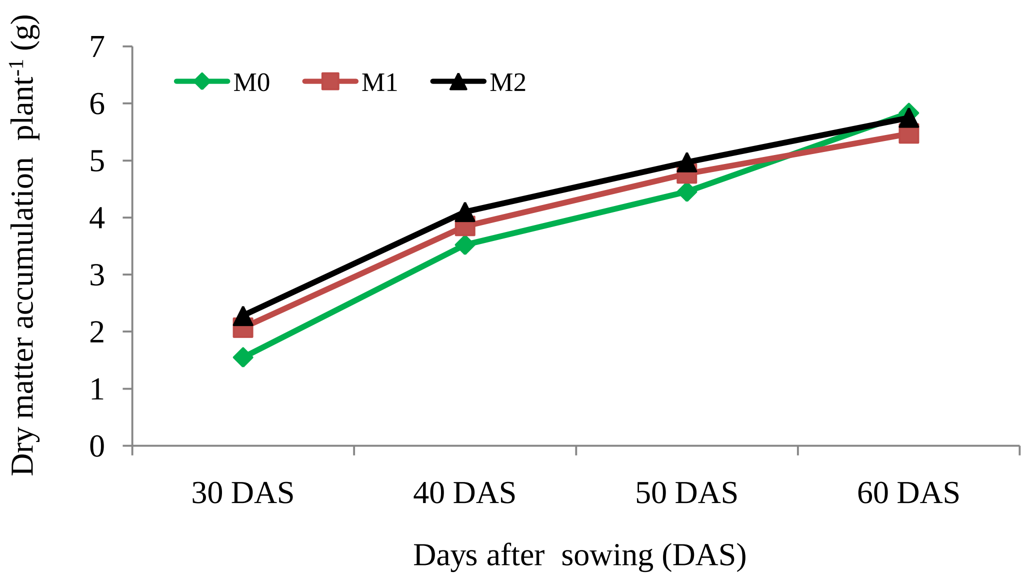
T_3: 9$^{//}$ tillage depth



T_0: Control T_1: 3// tillage depth

T_2: 6// tillage depth T_3: 9// tillage depth

Figure 6. Effect of different tillage depth on dry matter accumulation plant^{-1} of wheat (SE = 0.124, 0.097, 0.060 and 0.088)



M_0: Control (no mulch) M_1: Rice straw

M_2: Black ploythene

Figure 7. Effect of different mulch materials on dry matter accumulation plant^{-1} of wheat. (SE = 0.107, 0.084, 0.052 and 0.076)

Interaction effect of tillage depth and mulch materials showed significant differences on dry matter accumulation plant^{-1} at 30, 40, 50 and 60 DAS (Table 7). At 30, 40, 50 and 60 DAS, the highest dry matter accumulation plant^{-1} were observed from T_3M_2 (2.20, 4.27, 5.20 and 5.87 g, respectively) and the lowest dry matter accumulation plant^{-1} were found from the treatment combination T_0M_0 (1.00, 3.07, 3.67 and 4.93 g, respectively).

4.2.4 Days from sowing to spike emergence

Days from sowing to spike emergence showed statistically significant difference due to different tillage depth (Table 8). The maximum number of days from sowing to spike emergence were recorded from T_0 (66.78) which were statistically similar to T_1 (63.33) followed by T_2 (62.11), whereas the minimum number of days from sowing to spike emergence were observed from T_3 (61.00).

Different mulch materials showed significant effect in terms of days from sowing to spike emergence of wheat (Table 8). The maximum number of days from sowing to spike emergence were found from M_0 (64.83) which were statistically similar to M_1 (63.50), while the minimum number of days from sowing to spike emergence were recorded from M_2 (61.58).

Interaction effect of tillage depth and mulch materials showed significant differences on days from sowing to spike emergence (Table 9). The maximum number of days from sowing to spike emergence were found from T_0M_0 (68.67) and the minimum number of days from sowing to spike emergence were recorded from the treatment combination T_2M_2 (56.33).

4.2.5 Days from sowing to maturity

Days from sowing to maturity showed statistically significant difference due to different tillage depth (Table 8). The maximum number of days from sowing to maturity were recorded from T_0 (114.67), which were statistically similar to T_1 (113.44) followed by T_3 (112.44), whereas the minimum number of days from sowing to maturity were observed from T_2 (109.56).

Table 7. Interaction effect of tillage depth and mulch materials on dry matter accumulation plant^{-1} of wheat at different days after sowing

Treatments	Dry matter content plant^{-1} (g) at			
	30 DAS	40 DAS	50 DAS	60 DAS
T_0M_0	1.00 e	3.07 f	3.67 g	4.93 de
T_0M_1	1.33 e	3.27 ef	4.07 f	4.73 e
T_0M_2	1.07 e	3.60 d-f	4.27ef	5.27 cd
T_1M_0	1.47 de	3.67 c-e	4.53 de	6.60 a
T_1M_1	2.33 bc	3.80 b-e	4.73 cd	5.07 de
T_1M_2	2.87 ab	4.13 a-d	5.00 bc	5.80 b
T_2M_0	1.67 c-e	3.73 b-e	4.93 bc	6.13 b
T_2M_1	2.33 bc	4.20 a-c	5.27 ab	6.13 b
T_2M_2	3.00 a	4.40 a	5.40 a	6.07 b
T_3M_0	2.07 cd	3.60 d-f	4.67 cd	5.67bc
T_3M_1	2.27 bc	4.13 a-d	5.00 bc	5.93 b
T_3M_2	2.20 bc	4.27 ab	5.20 ab	5.87 b
SE(±)	0.214	0.168	0.104	0.152
Level of significance	0.05	0.05	0.05	0.01
CV(%)	12.49	7.62	5.82	4.62

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

T_0: Control	M_0: Control (no mulch)
T_1: 3// tillage depth	M_1: Rice straw
T_2: 6// tillage depth	M_2: Black ploythene
T_3: 9// tillage depth	

Different mulch materials showed significant effect in terms of days from sowing to maturity (Table 8). The maximum number of days from sowing to maturity were found from M_0 (114.17) which were statistically similar to M_2 (112.67), while the minimum number were observed from M_1 (110.75).

Interaction effect of tillage depth and mulch materials showed significant differences on days from sowing to maturity (Table 9). The maximum number of days from sowing to maturity were recorded from T_0M_0 (119.00) and the minimum number of days from sowing to maturity were found from the treatment combination of T_2M_2 (103.00).

4.2.6 Number of spikes plant^{-1}

Number of spikes plant^{-1} showed statistically significant difference due to different tillage depth (Table 8). The highest number of spikes plant^{-1} were recorded from T_3 (4.50) which were statistically similar to T_2 (4.34) followed by T_1 (4.08), whereas the lowest number of spikes plant $^{-1}$ were observed from T_0 (3.59).

Different mulch materials showed significant effect in terms of number of spikes plant^{-1} of wheat (Table 8). The highest number of spikes plant^{-1} were found from M_2 (4.63) which were statistically similar to M_1 (4.30), while the lowest number of spikes plant^{-1} were recorded from M_0 (3.46).

Interaction effect of tillage depth and mulch materials showed significant differences on number of spikes plant^{-1} (Table 9). The highest number of spikes plant^{-1} were found from T_3M_2 (5.33) and the lowest number of spikes plant^{-1} were recorded from the treatment combination of T_0M_0 (3.20).

4.2.7 Number of spikelets spike^{-1}

Number of spikelets spike^{-1} showed statistically significant difference due to different tillage depth (Table 8). The highest number of spikelets spike^{-1} were recorded from T_3 (25.97) which were statistically similar to T_2 (25.57) followed by T_1 (24.94), whereas the lowest number were observed from T_0 (23.27).

Different mulch materials showed significant effect in terms of number of spikelets spike^{-1} of wheat (Table 8). The highest number of spikelets spike^{-1} were found from M_2 (26.67) which were statistically similar to M_1 (25.74), while the lowest number of spikelets spike^{-1} were recorded from M_0 (22.39).

Interaction effect of tillage depth and mulch materials showed significant differences on number of spikelets spike^{-1} (Table 9). The highest number of spikelets spike^{-1} were found from T_3M_2 (28.73) and the lowest number of spikelets spike^{-1} were recorded from the treatment combination of T_0M_0 (20.47).

Table 8. Effect of tillage depth and mulch materials on days to spike emergence, days to maturity, number of spikes plant^{-1} and number of spikelets spike^{-1} of wheat

Treatments	Days from sowing to spike emergence	Days from sowing to maturity	Number of spikes plant^{-1}	Number of spikelets spike^{-1}
Tillage depth				
T_0	66.78 a	114.67 a	3.59 c	23.27 b
T_1	63.33 b	113.44 ab	4.08 b	24.94 a
T_2	62.11 b	109.56 c	4.34 ab	25.57 a
T_3	61.00 b	112.44 b	4.50 a	25.97 a
SE(±)	0.911	1.023	0.01	0.420
Level of significance	0.01	0.01	0.126	0.10
Mulch materials				
M_0	64.83 a	114.17 a	3.46 c	22.39 b
M_1	63.50 ab	110.75 b	4.30 b	25.74 a
M_2	61.58 b	112.67 a	4.63 a	26.67 a
SE(±)	0.789	1.312	0.109	0.364
Level of significance	0.05	0.01	0.01	0.01
CV(%)	5.73	5.81	5.29	5.05

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

T_0: Control
T_1: 3// tillage depth
T_2: 6// tillage depth
T_3: 9// tillage depth

M_0: Control (no mulch)
M_1: Rice straw
M_2: Black ploythene

Table 9. Interaction effect of tillage depth and mulch materials on days to spike emergence, days to maturity, number of spikes plant^{-1} and number of spikelets spike^{-1} of wheat

Treatments	Days from sowing to spike emergence	Days from sowing to maturity	Number of spikes plant^{-1}	Number of spikelets spike^{-1}
T_0M_0	68.67 a	119.00 a	3.20 f	20.47 e
T_0M_1	64.67 a-d	116.00 a-c	3.63 d-f	24.27 cd
T_0M_2	67.00 a-c	109.00 f	3.93 c-e	25.07 cd
T_1M_0	67.67 ab	108.67 f	3.57 d-f	23.80 d
T_1M_1	62.00 cd	111.33 c-e	4.07 cd	24.60 cd
T_1M_2	60.33 de	118.33 a	4.60 bc	26.43 bc
T_2M_0	63.00 b-d	114.33 b-d	3.77 d-f	23.83 d
T_2M_1	67.00 a-c	111.33 d-f	4.63 bc	26.40 bc
T_2M_2	56.33 e	103.00 g	4.63 bc	26.47 bc
T_3M_0	62.67 b-d	117.67 ab	3.30 ef	21.47 e
T_3M_1	60.33 de	109.33 f	4.87 ab	27.70 ab
T_3M_2	60.00 de	110.33 ef	5.33 a	28.73 a
SE(±)	1.578	2.622	0.218	0.727
Level of significance	0.01	0.01	0.05	0.01
CV(%)	5.73	5.81	5.29	5.05

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

T_0: Control — M_0: Control (no mulch)

T_1: 3$^{//}$ tillage depth — M_1: Rice straw

T_2: 6$^{//}$ tillage depth — M_2: Black ploythene

T_3: 9$^{//}$ tillage depth

4.2.8 Ear length

Ear length showed statistically significant difference due to different tillage depth (Table 10). The highest ear length were recorded from T_3 (17.12 cm) which were statistically similar to T_2 (16.49 cm) followed by T_1 (16.26 cm), whereas the lowest ear length were observed from T_0 (15.58 cm).

Different mulch materials showed significant effect in terms of ear length of wheat (Table 10). The highest ear length were found from M_2 (16.82 cm) which were statistically similar to M_1 (16.58 cm), while the lowest ear length were recorded from M_0 (15.69 cm).

Interaction effect of tillage depth and mulch materials showed significant differences on ear length (Table 11). The highest ear length were found from T_3M_2 (18.67 cm) and the lowest ear length were recorded from the treatment combination of T_0M_0 (14.58 cm).

4.2.9 Grains spike^{-1}

Grains spike^{-1} showed statistically significant difference due to different tillage depth (Table 10). The highest grains spike^{-1} were recorded from T_3 (32.57) which were statistically similar to T_2 (31.78) followed by T_1 (30.44), whereas the lowest grains spike^{-1} were observed from T_0 (27.22).

Different mulch materials showed significant effect in terms of grains spike^{-1} of wheat (Table 10). The highest grains spike^{-1} were found from M_2 (32.54) which were statistically similar to M_1 (31.83), while the lowest grains spike^{-1} were recorded from M_0 (25.33).

Interaction effect of tillage depth and mulch materials showed significant differences on grains spike^{-1} (Table 11). The highest grains spike^{-1} were found from T_3M_2 (35.83) and the lowest grains spike^{-1} were recorded from the treatment combination of T_0M_0 (25.33).

4.2.10 Unfilled spikelets spike^{-1}

Unfilled spikelets spike^{-1} showed statistically significant difference due to different tillage depth (Table 10). The highest unfilled spikelets spike^{-1} were recorded from T_0 (3.62) which were statistically similar to T_1 (2.94) followed by T_2 (2.61), whereas the lowest unfilled spikelets spike^{-1} were observed from T_3 (1.99).

Different mulch materials showed significant effect in terms of unfilled spikelets spike^{-1} of wheat (Table 10). The highest unfilled spikelets spike^{-1} were found from M_0 (3.22) which were statistically similar to M_1 (2.70), while the lowest unfilled spikelets spike^{-1} were recorded from M_2 (2.45).

Interaction effect of tillage depth and mulch materials showed significant differences on unfilled spikelets spike^{-1} (Table 11). The highest unfilled spikelets spike^{-1} were found from T_0M_1 (4.03) and the lowest unfilled spikelets spike^{-1} were recorded from the treatment combination of T_3M_2 (1.50).

4.2.11 Total spikelets spike^{-1}

Total spikelets spike^{-1} showed statistically significant difference due to different tillage depth (Table 10). The highest total spikelets spike^{-1} were recorded from T_3 (34.56) which were statistically similar to T_2 (34.39) followed by T_1 (33.39), whereas the lowest total spikelets spike^{-1} were observed from T_0 (30.84).

Different mulch materials showed significant effect in terms of total spikelets spike^{-1} of wheat (Table 10). The highest total spikelets spike^{-1} were found from M_2 (34.99) which were statistically similar to M_1 (34.53), while the lowest total spikelets spike^{-1} were recorded from M_0 (28.56).

Interaction effect of tillage depth and mulch materials showed significant differences on total spikelets spike^{-1} (Table 11). The highest total spikelets spike^{-1} were found from T_3M_2 (37.33) and the lowest total spikelets spike^{-1} were recorded from the treatment combination of T_0M_0 (28.40).

4.2.12 Weight of 1000-grains

Weight of 1000-grains showed statistically significant difference due to different tillage depth (Table 10). The highest weight of 1000-grains were recorded from T_3 (44.46 g) which were statistically similar to T_2 (44.05 g) and followed by T_1 (42.67 g), whereas the lowest weight of 1000-grains were observed from T_0 (39.51 g).

Different mulch materials showed significant effect in terms of weight of 1000-grains of wheat (Table 10). The highest weight of 1000-grains were found from M_2 (43.41 g) which were statistically similar to M_1 (42.72 g), while the lowest weight of 1000-grains were recorded from M_0 (40.40 g).

Interaction effect of tillage depth and mulch materials showed significant differences on weight of 1000-grains (Table 11). The highest weight of 1000-grains were found from T_3M_2 (48.19 g) and the lowest weight of 1000-grains were recorded from the treatment combination of T_0M_0 (37.33 g).

Table 10. Effect of tillage depth and mulch materials on ear length, grains spike, unfilled and total spikelets spike^{-1} and weight of 1000 grains of wheat

Treatments	Ear length (cm)	Grains spike^{-1}	Unfilled spikelets spike^{-1}	Total spikelets spike^{-1}	Weight of 1000-grain (g)
Tillage depth					
T_0	15.58 c	27.22 c	3.62 a	30.84 b	39.51 b
T_1	16.26 bc	30.44 ab	2.94 b	33.39 a	42.67 a
T_2	16.49 ab	31.78 b	2.61 c	34.39 ab	44.05 a
T_3	17.12 a	32.57 a	1.99 d	34.56 a	44.46 a
SE(±)	**0.273**	**0.630**	**0.078**	**0.680**	**0.342**
Level of significance	**0.01**	**0.01**	**0.01**	**0.05**	**0.05**
Mulch materials					
M_0	15.69 b	25.33 b	3.22 a	28.56 b	40.40 b
M_1	16.58 a	31.83 a	2.70 b	34.53 a	42.72 a
M_2	16.82 a	32.54 a	2.45 c	34.99 a	43.41 a
SE(±)	**0.236**	**0.558**	**0.061**	**0.578**	**0.311**
Level of significance	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**
CV(%)	**5.00**	**4.55**	**6.68**	**7.62**	**6.31**

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

T_0: Control

T_1: 3$^{//}$ tillage depth

T_2: 6$^{//}$ tillage depth

T_3: 9$^{//}$ tillage depth

M_0: Control (no mulch)

M_1: Rice straw

M_2: Black ploythene

Table 11. Interaction effect of tillage depth and mulch materials on ear length, grains spike, unfilled and total spikelets spike^{-1} and weight of 1000 grains of wheat

Treatments	Ear length (cm)	Grains spike^{-1}	Unfilled spikelets spike^{-1}	Total spikelets spike^{-1}	Weight of 1000-grain (g)
T_0M_0	14.58 d	25.33 e	3.07 c	28.40 e	37.33 f
T_0M_1	16.14 bc	29.83 cd	4.03 a	33.87 a-c	40.70 c-f
T_0M_2	16.03 b-d	26.50 de	3.77 ab	30.27 c-e	40.52 d-f
T_1M_0	16.25 bc	26.33 de	3.60 b	29.93 de	44.65 b
T_1M_1	16.14 bc	30.33 c	2.83 c	33.17 b-d	41.66 b-e
T_1M_2	16.39 bc	34.67 ab	2.40 de	37.07 a	41.70 b-e
T_2M_0	16.53 bc	24.33 e	3.53 b	27.87 e	38.48 ef
T_2M_1	16.76 bc	31.83 bc	2.17 e	34.00 a-c	44.44 bc
T_2M_2	16.18 bc	33.17 a-c	2.13 e	35.30 ab	43.23 b-d
T_3M_0	15.41 cd	25.33 e	2.70 cd	28.03 e	41.14 b-e
T_3M_1	17.29 b	35.33 ab	1.77 f	37.10 a	44.05 b-d
T_3M_2	18.67 a	35.83 a	1.50 f	37.33 a	48.19 a
SE(±)	**0.473**	**1.115**	**0.123**	**1.115**	**0.621**
Level of significance	**0.05**	**0.01**	**0.01**	**0.05**	**0.01**
CV(%)	**5.00**	**4.55**	**6.68**	**7.62**	**6.31**

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

T_0: Control | M_0: Control (no mulch)

T_1: 3// tillage depth | M_1: Rice straw

T_2: 6// tillage depth | M_2: Black ploythene

T_3: 9// tillage depth

4.3 Yield

4.3.1 Grain yield

Grain yield showed statistically significant difference due to different tillage depth (Table 12). The highest grain yield were recorded from T_3 (3.47 t ha^{-1}) which were statistically similar to T_2 (3.56 t ha^{-1}) followed by T_1 (3.15 t ha^{-1}), whereas the lowest grain yield were observed from T_0 (2.15 t ha^{-1}). Ranjan *et al*. (2006) reported that wheat yield were higher in conventionally tilled plots than zero tilled plots. Ogbodo (2005) stated that crop growth and yield significantly increased with tilled soil than untilled soil.

Different mulch materials showed significant effect in terms of grain yield of wheat (Table 12). The highest grain yield were found from M_2 (3.25 t ha^{-1}) which were statistically similar to M_1 (3.18 t ha^{-1}), while the lowest grain yield were recorded from M_0 (2.81 t ha^{-1}).

Interaction effect of tillage depth and mulch materials showed significant differences on grain yield (Table 13). The highest grain yield were found from T_3M_2 (3.95 t ha^{-1}) and the lowest grain yield were recorded from the treatment combination of T_0M_0 (2.07 t ha^{-1}).

4.3.2 Straw yield

Straw yield showed statistically significant difference due to different tillage depth (Table 12). The highest straw yield were recorded from T_2 (4.98 t ha^{-1}) which were statistically similar to T_3 (4.96 t ha^{-1}) followed by T_1 (4.57 t ha^{-1}), whereas the lowest straw yield were observed from T_0 (3.56 t ha^{-1}).

Different mulch materials showed significant effect in terms of straw yield of wheat (Table 12). The highest straw yield were found from M_2 (4.69 t ha^{-1}) which were statistically similar to M_1 (4.64 t ha^{-1}), while the lowest straw yield were recorded from M_0 (4.22 t ha^{-1}).

Interaction effect of tillage depth and mulch materials showed significant differences on straw yield (Table 13). The highest straw yield were found from

T_3M_2 (5.39 t ha^{-1}) and the lowest straw yield were recorded from the treatment combination of T_0M_0 (3.43 t ha^{-1}).

4.3.3 Biological yield

Biological yield showed statistically significant difference due to different tillage depth (Table 12). The highest biological yield were recorded from T_2 (8.54 t ha^{-1}) which were statistically similar to T_3 (8.43 t ha^{-1}) followed by T_1 (7.72 t ha^{-1}), while the lowest biological yield were observed from T_0 (5.71 t ha^{-1}).

Different mulch materials showed significant effect in terms of biological yield of wheat (Table 12). The highest biological yield were found from M_2 (7.94 t ha^{-1}) which were statistically similar to M_1 (7.82 t ha^{-1}), whereas the lowest biological yield were recorded from M_0 (7.03 t ha^{-1}).

Interaction effect of tillage depth and mulch materials showed significant differences on biological yield (Table 13). The highest biological yield were found from T_3M_2 (9.34 t ha^{-1}) and the lowest biological yield were recorded from the treatment combination of T_0M_0 (5.50 t ha^{-1}).

4.3.4 Harvest index

Harvest index showed statistically significant difference due to different tillage depth (Table 12). The highest harvest index were recorded from T_2 (41.55%) which were statistically similar to T_3 (41.07%) followed by T_1 (40.78%), whereas the lowest harvest index were observed from T_0 (37.59%).

Different mulch materials showed significant effect in terms of harvest index of wheat (Table 12). The highest harvest index were found from M_2 (40.62%) which were statistically similar to M_1 (40.35%), while the lowest from M_0 (39.75%).

Interaction effect of tillage depth and mulch materials showed significant differences on harvest index (Table 13). The highest harvest index were found from T_3M_2 (42.24%) and the lowest harvest index were recorded from the treatment combination of T_0M_0 (37.62%).

Table 12. Effect of tillage depth and mulch materials on grain, straw and biological yield and harvest index of wheat

Treatments	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
Tillage depth				
T_0	2.15 c	3.56 c	5.71 c	37.59 b
T_1	3.15 b	4.57 b	7.72 b	40.78 a
T_2	3.56 a	4.98 a	8.54 a	41.55 a
T_3	3.47 a	4.96 a	8.43 a	41.07 a
SE(±)	**0.083**	**0.080**	**0.143**	**0.559**
Level of significance	**0.01**	**0.01**	**0.01**	**0.01**
Mulch materials				
M_0	2.81 b	4.22 b	7.03 b	39.75
M_1	3.18 a	4.64 a	7.82 a	40.35
M_2	3.25 a	4.69 a	7.94 a	40.63
SE(±)	**0.072**	**0.070**	**0.124**	**0.484**
Level of significance	**0.01**	**0.01**	**0.01**	**NS**
CV(%)	**8.11**	**5.33**	**5.66**	**4.17**

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

T_0: Control
T_1: 3// tillage depth
T_2: 6// tillage depth
T_3: 9// tillage depth

M_0: Control (no mulch)
M_1: Rice straw
M_2: Black ploythene

Table 13. Interaction effect of tillage depth and mulch materials on grain, straw and biological yield and harvest index of wheat

Treatments	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
T_0M_0	2.07 e	3.43 e	5.50 f	37.62 cd
T_0M_1	2.14 e	3.63 e	5.76 f	37.05 d
T_0M_2	2.23 e	3.63 e	5.86 f	38.08 b-d
T_1M_0	2.96 cd	4.36 cd	7.31 de	40.47 a-c
T_1M_1	3.21 b-d	4.61 b-d	7.82 c-e	40.98 ab
T_1M_2	3.28 b-d	4.74 bc	8.03 cd	40.90 ab
T_2M_0	2.86 d	4.22 d	7.08 e	40.35 a-c
T_2M_1	3.87 a	5.33 a	9.20 ab	42.05 a
T_2M_2	3.52 ab	5.01 ab	8.53 bc	41.30 ab
T_3M_0	3.37 bc	4.87 b	8.24 c	40.58 a-c
T_3M_1	3.51 ab	5.00 ab	8.52 bc	41.32 ab
T_3M_2	3.95 a	5.39 a	9.34 a	42.24 a
SE(±)	**0.144**	**0.139**	**0.248**	**0.969**
Level of significance	**0.05**	**0.01**	**0.01**	**0.05**
CV(%)	**8.11**	**5.33**	**5.66**	**4.17**

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

T_0: Control
T_1: 3// tillage depth
T_2: 6// tillage depth
T_3: 9// tillage depth

M_0: Control (no mulch)
M_1: Rice straw
M_2: Black ploythene

CHAPTER V

SUMMARY AND CONCLUSION

The experiment were conducted during the period from November 2013 to March 2014 in the experimental field of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka to find out the effect of tillage depth and mulch materials on weed management, yield attributes and yield of wheat. The experiment comprised of two factors; Factor A: Tillage depth (4 types)- T_0: Control, T_1: $3^{//}$ depth, T_2: $6^{//}$ depth andT_3: $9^{//}$ depth and Factor B: Mulch materials (3 types)- M_0: Control (no mulch), M_1: Rice straw and M_2: Black polythene. The experiment were laid out in a Randomized Complete Block Design (RCBD) with three replications.

Cyperous rotundus, Eleusine indica, Cynodon dactylon, Digitaria sanguinalis, Echinochloa colonum, Chenopodium album were found with major population among the 10 weed species in the experimental field. In case of tillage depth, at 20 DAS, the maximum number of weed population m^{-2} were recorded in T_0 (14.00), while the minimum number were observed in T_3 (7.44). At 40 DAS, the maximum numbers of weed population m^{-2} were recorded in T_0 (21.89), while the minimum numbers in T_3 (10.00) treatment. At 20 DAS, the highest dry weight of weed biomass m^{-2} were observed in T_0 (6.04 g), while the lowest dry weight were found in T_3 (4.093 g) treatment. At 40 DAS, the highest dry weight of weed biomass m^{-2} were recorded in T_0 (8.43 g), whereas the lowest dry weight were found in T_3 (6.23 g) treatment.

At 30, 40, 50, 60 DAS and harvest, the longest plant were found from T_3 (34.15, 55.60, 69.29, 91.67 and 106.76 cm, respectively), whereas the shortest plant were recorded from T_0 (24.59, 37.50, 52.60, 75.96 and 92.94 cm, respectively). At 30, 40, 50 and 60 DAS, the highest numbers of tillers $plant^{-1}$ were found from T_3 (3.50, 4.41, 5.62 and 6.58 respectively), whereas the lowest numbers were recorded from T_0 (2.44, 3.66, 5.11 and 5.24 cm, respectively). At 30, 40, 50 and 60 DAS, the highest dry matter accumulation $plant^{-1}$ were found from T_3 (2.18, 4.00, 4.96 and 5.82 g, respectively), whereas the lowest were recorded from T_0 (1.13, 3.31, 4.00 and 4.98 g, respectively). The highest days from sowing to spike initiation were recorded from T_0 (66.78), whereas the lowest days were observed from T_3 (61.00). The highest days from sowing to maturity were recorded from T_0 (114.67), whereas the lowest days from sowing to maturity were observed from T_2 (109.56). The highest number of spikes plant^{-1} were recorded from T_3 (4.50), whereas the lowest number were observed from T_0 (3.59). The highest number of spikelets spike^{-1} were recorded from T_3 (25.97), whereas the lowest number were observed from T_0 (23.27). The highest ear length were recorded from T_3 (17.12 cm), whereas the lowest were observed from T_0 (15.58 cm). The highest grains spike^{-1} were recorded from T_3 (32.57), whereas the lowest from T_0 (27.22). The highest unfilled spikelets spike^{-1} were recorded from T_0 (3.62), whereas the lowest from T_3 (1.99). The highest total spikelets spike^{-1} were recorded from T_3 (34.56), whereas the lowest were observed from T_0 (30.84). The highest weight of 1000-grains were recorded from T_3 (44.46 g), whereas the lowest were observed from T_0 (39.51 g). The highest grain yield were recorded from T_3 (3.47 t ha^{-1}), whereas the lowest were observed from T_0 (2.15 t ha^{-1}). The highest straw yield were recorded from T_2 (4.98 t ha^{-1}), whereas the lowest were observed from T_0 (3.56 t ha^{-1}). The highest biological yield were recorded from T_2 (8.54 t ha^{-1}), whereas the lowest were observed from T_0 (5.71 t ha^{-1}). The highest harvest index were recorded from T_2 (41.55%), whereas the lowest from T_0 (37.59%).

For mulch materials, at 20 DAS, the maximum numbers of weed population m^{-2} were found in M_0 (13.50), while the minimum number of weed population in M_2 (8.33). At 40 DAS, the maximum numbers of weed population m^{-2} were recorded in M_0 (20.33), while the minimum number in M_2 (10.42). At 20 DAS, the highest dry weight of weed biomass m^{-2} were recorded in M_0 (5.95 g), while the lowest were found in M_2 (3.93 g). At 40 DAS, the highest dry weight of weed biomass m^{-2} were observed in M_0 (7.68 g), while the lowest dry weight of weed biomass m^{-2} were found in M_2 (6.72 g).

At 30, 40, 50, 60 DAS and harvest, the longest plant were observed from M_2 (32.99, 52.89, 65.93, 88.89 and 105.69 cm, respectively), while the shortest plant were found from M_0 (27.90, 45.21, 60.11, 79.62 and 97.04 cm, respectively). At 30, 40, 50 and 60 DAS, the highest number of tillers plant^{-1} were observed from M_2 (3.42, 4.46, 5.96 and 6.71 respectively), while the lowest number were found in M_0 (2.47, 3.98, 4.92 and 5.07 respectively). At 30, 40, 50 and 60 DAS, the highest dry matter accumulation plant^{-1} were observed from M_2 (2.28, 4.10, 4.97 and 5.75 g, respectively), while the lowest from M_0 (1.55, 3.52, 4.45 and 5.83 g, respectively). The highest days from sowing to spike initiation were found from M_0 (64.83), while the lowest days were recorded from M_2 (61.58). The highest days from sowing to maturity were found from M_0 (114.17), while the lowest days from sowing to maturity were recorded from M_1 (110.75). The highest number of spikes hill^{-1} were found from M_2 (4.63), while the lowest number from M_0 (3.46). The highest number of spikelets spike^{-1} were found from M_2 (26.67), while the lowest number from M_0 (22.39). The highest ear length were found from M_2 (16.82 cm), while the lowest ear length from M_0 (15.69 cm). The highest grains spike^{-1} were found from M_2 (32.54), while the lowest from M_0 (25.33). The highest unfilled spikelets spike^{-1} were found from M_0 (3.22), while the lowest from M_2 (2.45). The highest total spikelets spike^{-1} were found from M_2 (34.99), while the lowest from M_0 (28.56). The highest weight of 1000-grains were found from M_2 (43.41 g), while the lowest weight from M_0 (40.40 g). The highest grain yield were found from M_2 (3.25 t ha^{-1}), while the lowest from M_0 (2.81 t ha^{-1}). The highest straw yield were found from M_2 (4.69 t ha^{-1}), while the lowest straw yield from M_0 (4.22 t ha^{-1}). The highest biological yield were found from M_2 (7.94 t ha^{-1}), while the lowest biological yield were recorded from M_0 (7.03t ha^{-1}). The highest harvest index were found from M_2 (40.62%), while the lowest harvest index were recorded from M_0 (39.75%).

Due to the interaction effect of tillage depth and mulch materials, at 20 DAS, the maximum number of weed population m^{-2} were found from T_0M_0 (16.33), while the minimum number were recorded from T_3M_2 (4.33) treatment combination. At

40 DAS, the maximum number of weed population m^{-2} were found from T_0M_0 (28.33), while the minimum number from T_2M_2 (6.00) treatment combination. At 20 DAS, the highest dry weight of weed biomass m^{-2} were recorded from T_0M_0 (6.81 g), while the lowest from T_3M_2 (3.10 g) treatment combination. At 40 DAS, the highest dry weight of weed biomass m^{-2} were observed from T_0M_0 (8.65 g), whereas the lowest from T_2M_2 (5.72 g) treatment combination.

At 30, 40, 50, 60 DAS and harvest, the longest plant were observed from T_3M_2 (37.29, 60.46, 73.75, 96.60 and 111.50 cm, respectively) and the shortest plant were found from the treatment combination of T_0M_0 (23.18, 35.38, 51.36, 70.19 and 89.40 cm, respectively). At 30, 40, 50 and 60 DAS, the highest number of tillers plant^{-1} were observed from T_3M_2 (3.90, 4.87, 6.52 and 7.33 respectively) and the lowest number of tillers plant^{-1} were found from the treatment combination of T_0M_0 (2.10, 3.43, 4.50 and 4.33 respectively). At 30, 40, 50 and 60 DAS, the highest dry matter accumulation plant^{-1} were observed from T_3M_2 (2.20, 4.27, 5.20 and 5.87 g, respectively) and the lowest were found from the treatment combination of T_0M_0 (1.00, 3.07, 3.67 and 4.93 g, respectively). The highest days from sowing to spike initiation were found from T_0M_0 (68.67) and the lowest days were recorded from the treatment combination of T_2M_2 (56.33). The highest days from sowing to maturity were found from T_0M_0 (119.00) and the lowest days were recorded from the treatment combination of T_2M_2 (103.00). The highest number of spikes hill^{-1} were found from T_3M_2 (5.33) and the lowest number from the treatment combination of T_0M_0 (3.20). The highest number of spikelets spike^{-1} were found from T_3M_2 (28.73) and the lowest number o from the treatment combination of T_0M_0 (20.47). The highest ear length were found from T_3M_2 (18.67 cm) and the lowest ear length were recorded from the treatment combination of T_0M_0 (14.58 cm). The highest grains spike^{-1} were found from T_3M_2 (35.83) and the lowest from the treatment combination of T_0M_0 (25.33). The highest unfilled spikelets spike^{-1} were found from T_0M_1 (4.03) and the lowest from the treatment combination of T_3M_2 (1.50). The highest total spikelets spike^{-1} were found from T_3M_2 (37.33) and the lowest from the treatment combination of

T_0M_0 (28.40). The highest weight of 1000-grains were found from T_3M_2 (48.19 g) and the lowest from the treatment combination of T_0M_0 (37.33 g). The highest grain yield were found from T_3M_2 (3.95 t ha^{-1}) and the lowest grain yield were recorded from the treatment combination of T_0M_0 (2.07 t ha^{-1}). The highest straw yield were found from T_3M_2 (5.39 t ha^{-1}) and the lowest from the treatment combination of T_0M_0 (3.43 t ha^{-1}). The highest biological yield were found from T_3M_2 (9.34 t ha^{-1}) and the lowest biological yield from the treatment combination of T_0M_0 (5.50 t ha^{-1}). The highest harvest index (were found from T_3M_2 42.24%) and the lowest harvest index were recorded from the treatment combination of T_0M_0 (37.62%).

Conclusion:

Considering the above discussion it may be concluded that

- In the experiment, $9^{//}$ depth of tillage was more effective than the others;
- Black polythene mulch gave better performance;
- During the investigation, $9^{//}$ depth of tillage with Black polythene mulch was found the best for weed management, yield attributes and yield of wheat;

Considering the results of the present research, further studies may be carried out in different agro-ecological zones (AEZ) of Bangladesh for regional compliance including more management practices to achieve maximum yield of wheat.

REFERENCES

Ahmed, M. H. and Haffar, I. (1993). Comparison of five tillage system for cotton production in rahad scheme. *Suan Agricultural Mechanism, Asia, Africa and Latin America*. **24**(2): 17-20.

Ahmed, S. (1993). Quantitative studies on the weeds of wheat fields of Riwat area, Islamabad. *Pakistan J. Sci. Indian Res.*, **36**(1): 31-34.

Ahuja, J. K., Patil, U. C. and Guptan, V. (2004). Effect of conservation tillage on productivity and economies of rice. *JNKVV Res. J.*, **38**(1): 78-79.

Andarzian, B., Bakhshandeh, A.M., Bannayan, M., Eman, Y., Fathia, G., Alami Saeed, K. (2008). Wheat Pot: a simple model for spring wheat yield potential using monthly weather data. *Biosyst. Eng*., **99**: 487–495.

Anonymous. (2008). Statistical year book of Bangladesh-2006. Bangladesh Bureau of Statistics, Planning Division, Ministry of Planning, Government of the People's Republic of Bangladesh. www.bbs.gov.bd (4 November 2012).

Ardell, D., Halvorson, A. L., Black, J. N., Krupingley, S. D., Merril, B., Wienhold, J. and Tonaka, K. I. (2001). Spring wheat response to tillage system and nitrogen fertilization within crop fallow system. *Agron. J.*, **92**: 151.

Ashrafi, Z. Y., Sadeghi, S. and Mashhadi, H. R. (2007). Allelopathic Effects of Barley (*Hordeum vulgare*) on Germination and Growth of Wild Barley (*H. spontaneum*). *Pak J. Weed Sci. Res*., **13**(1-2): 99-112.

Ata, Z. D. and Jamil, M. (2001). Allelopathic Suppression of Weeds: A New Field in Need of Attention. DAWN internet edition. DAWN Group of Newspapers (http://www.dawn.com/2001/12/31/index.htm).

Ball, A. and Miller, N. (1993). Influence of time of transplanting on the performance of scented rice in Andra Pradesh. *J. Res., ANGRAU*, **29**(222-3): 98- 101.

Barberi, L. and Cascio, L. (2001). Bio-efficiency of new promising herbicides for weed management in summer rice. *Indian J. Weed Sci.*, **32**(1&2) 35-38.

BARI (Bangladesh Agricultural Research Institute) 1997: Increase wheat cultivation and Decrease Irrigation Cost (A folder in Bangla). Wheat Research Centre, Bangladesh Agricultural Research Institute, Nashipur, Dinajpur-5200.

BARI (Bangladesh Agricultural Research Institute). (2010). Wheat production in Bangladesh: a success story. ttp://www.bari.gov. bd/index. php? Option = com simplest forum & view = post list & topic = true & forum Id=1& parented = 288 (4 November 2012).

BARI (Bangladesh Agricultural Research Institute). (2011). Krishi Projukti Hat Boi. BARI. Joydevpur, Gazipur. p. 18.

BARI (Bangladesh Agricultural Research Institute). (2012). Wheat varieties released by Bangladesh Agricultural Research Institute. 861, 862, 863 (4 November 2012).

Barker, A. V. and Bhowmik, P. C. (2001). Weed Control with Crop Residues in Vegetable Cropping Systems. *J. Crop Prod*., **4**(2): 163-183.

Basunia MSH 2000: Effect of land tilling by country plough and power tiller on some soil properties and yield of transplant Aman rice (C.V.BRII). M.S.(Agronomy),Thesis, Department of Agronomy, BAU, Mymensingh.

BBS (Bangladesh Bureau of Statistics). (2012). Statistical Year Book of Bangladesh. Bangladesh Bureau of Statistics. Statistics Division.

Ministry of Planning. Government of the Peoples Republic of Bangladesh. Dhaka.

Begum, M., Iqbal, M. Z., Rezaul Karim, S. M. and Mamun, A. A. (2003). Weed flora of wheat, mustard and lentil grown in old Brahmaputra floodplain soils of Bangladesh. *Bangladesh J. Agril. Sci.,* **30**(1): 129-134.

Berti, M., Sattin, R. K, Pal, D. (1994). Bio-efficiency of new promising herbicides for weed management in summer rice. *Indian J. Weed Sci.,* **23**(2): 23-29.

Bond, W., Moore, H. C., Atkinson, R. J. and Bevan, J. R., Lennartsson, M. E. K. (1998). Changes in the weed seedbank following different weeding treatments in drilled salad onion and carrot crops grown in organic and conventional systems. *Biological Agric. Hort*., **16**: 203-215.

Boydstone, Y. P. and Hang, P. K. (1995). fall-planted rapeseed and sudangrass for weed control in potato. *Indian J. Agron*., **41**(1): 123-129.

Brandsaeter L. O. and Riley, H. (2002). Cover Crops and Mulches for Weed Control in Organically Grown Vegetables. 5th EWRS Workshop on Physical Weed Control. Pisa, Italy, 11-13 March. p.174

Brovo, S. K. and Florentino, Y. T. (1997). Compare the effects of conventional tillage and minimum tillage. *Sarhad J. Agric.*, **13**(2): 35-42.

Bullied, W. J., Marginet, A. M., Van Acker, R. C. (2003). Conventional- and conservationtillage systems influence emergence periodicity of annual weed species in canola. *Weed Sci.,* **51:** 886-897.

Cardina, J., Herms, C. P. and Doohan, D. J. (2002). Crop rotation and tillage system effects on weed seedbanks. *Weed Sci,*. **50:** 448-460.

Carroll, J. W. and Mullinix, B. G. (1995). Weed management in peanut using stale seedbed techniques. *Weed Sci.,* **43**: 293-297.

Chaichi, M. R. and Edalati-Fard, L. (2005). Evaluation of Allelopathic Effects of Chickpea Root Extracts on Germination and Early Growth of Sorghum (*Sorghum halepense*), Soybean (*Glycine max* L.) and Sunflower (*Helianthus annus*). Allelopathy Congress.

Cheema, Z. A., Luqman, M. and Khaliq, A. (1997). Use of Allelopathic Extracts of Sorghum and Sunflower Herbage for Weed Control in Wheat. *J. Animal Plant Sci.*, **7**:91-93.

Daar, S. (1986). Update: Suppressing Weeds with Allelopathic Mulches. The IPM Practitioner. April. p. 1-4.

Daimon, H. and Kotoura, S. (2000). Incorporation of *Crotalaria spectabilis* Grown at a High Seeding Rate Inhibits the Growth of the Succeeding Wheat Crop. *J. Agron. Crop Sci*., **185**(2): 137-144.

Dangol, D. R. and Chaudhary, N. K. (1993). Wheat-weed interactions at Rampur, Chitwan. In: F. P. Neupane (ed.). IAAS Research Reports (1992-1993), pp. 19-37.

Davis, A. S. and Liebman, M. (2003). Cropping system effects on giant foxtail (Setaria faberi) demography: I. Green manure and tillage timing. *Weed Sci.*, **51**: 919-929.

Dhima, K. V., Basilakoglou, I. B., Eleftherohorinos, I. G. and Lithourgidis, A. S. (2006). Allelopathic Potential of Winter Cereal Cover Crop Mulches on Grass Weed Suppression and Sugarbeed Development. *Crop Sci.*, **46**: 1682-1691.

Dubin, Y. P. and Ginkel, P. M. (1991). Wheat cultivation in the warmer climates exists in the South-East Asia including Bangladesh. *Indian J. Agril. Sci*., **58**(1): 131-135.

Edris, K. M., Islam, A. T. M. T., Chowdhury, M. S. and Haque, A. K. M. M. (1979). Detailed Soil Survey of Bangladesh, Dept. Soil Survey, Govt. People's Republic of Bangladesh. p. 118.

FAO (Food and Agriculture Organization) (1997) Production Yearbook. Food and Agriculture Organization, Rome, Italy. **41** 116-117.

FAO. (1988). Production Year Book. Food and Agricultural Organization of the United Nations Rome, Italy. **42**: 190-193.

FAO. (2000). Production Year Book. Food and Agricultural Organization of the United Nations Rome, Italy. **54**: 176-186.

Friedman, D., Gristina, L., Volat, M., Temple, S., Shennan, C. and Stewart, D. (1995). Evaluation of Five Cover Crop Species or Mixes for Nitrogen Production and Weed Suppression. In Sacramento Valley Farming Systems. Sustainable Agriculture Research and Agriculture Program. University of California. [http://www.sarep.ucdavis.edu/]

Gaffer, M. A. (1987). Studies on infestation of weeds in wheat grown under irrigated condition. Ann. Rep. on "A comprehensive study on weeds and their infestation in the arable land of Bangladesh". Department of Agronomy, Bangladesh Agricultural University, Mymensingh. pp. 53-55.

Gaffer, M. A., Khan, E. A., Alam, M. S. and Adhikary, S. K. (1997). Influence of planting density and time of weeding on weed infestation and yield performance in wheat. *Indian J. Agron.*, **32**(1): 30-34.

Gallandt, E. R. and Haramoto, E. R. (2004). Brassica cover cropping for weed management: A review. *Renewable Agric. Food Sys*., **19**: 187-198.

Gawronska, H., Bernat, W., Janowiak, F., Gawronski, S. W. (2004). Comparative Studies on Wheat and Mustard Responses to Allelochemicals of Sunflower Origin. Abstract of Second European Allelopathy Symposium. p. 28

Gomez, K. A. and Gomez, A. A. (1984). Statistical Procedure for Agricultural Research (2nd edn.). Int. Rice Res. Inst., A Willey Int. Sci., pp. 28-192.

Grove JH 2006: Tillage, previous tillage and the nitrogen requirement of wheat following full season soybean. 0Thttp://www. Agronomy. org./cca/exam pdf/11. pdf

Haque N 2011: Effect of seed rate and weeding regime on the yield performance of wheat. M. Sc. (Ag.) Thesis, Department of Agronomy, Bangladesh Agricultural University, Mymensingh. pp. 38 .

Hosmani MM 1995: Weed management in field crops. In: Integrated Weed Management in Field Crops. pp. 113-145.

Hossain A, Chowdhury MAS, Jahan T, Sarker MAI, Akhter MM 2010: Competitive ability of wheat cultivars against weeds. *Bangladesh Journal of Weed Sci.*, **1**(1) 65-72.

Hur BK, BK Yun, KS Choi 1996: Effect of tillage methods of paddy field on yearly change of rice yield and soil properties. Korean Journal Crop Science 44 (1) 109-114. Iqbal M., Khan M.A., Anwar. M.Z. (2002). Zero-tillage technology and farm profits: a case study of wheat growers in the rice zone of Punjab. *Pakistan Dev. Rev.*, **41**: 665-682.

Islam MA 1987: Infestation and performance of wheat as affected by seed rate and duration of weed competition. M. Sc. (Ag.) Thesis, Department Agronomy, Bangladesh Agricultural University, Mymensingh. pp. 17-27.

Jalis A 1987: Weed problems in wheat. Progress. Farming, **7:** 20-30.

Juroszek P, Gerhards R 2004: Photocontrol of weeds. *J. Agron. Crop Sci.*, **190:** 402-415.

Karim, S. M. R. (1987). Estimate of crop losses due to weeds in Bangladesh. Abstract 2nd Annual Conference Bangladesh Society of Agronomy, Bangladesh Rice Research Institute, Joydebpur, Gazipur. pp. 13-20.

Karim, S. M. R. and Mamun, A. A. (1988). Crop weed competition Analysis of some perspectives. *Bangladesh J. Agril. Sci.*, **15**(1) 65-73.

Khan, N. H., Bhuian, M. S. U. and Islam, M. Z. (1980). Effect of land tilling and weeding on the yield of Mexican wheat. *Bangladesh J. Agric*., **5**(2): 107-112

Krishnan, G., Holshouser, D. L. and Nissen, S. J. (1998). Weed control in Soybean (Glycine max) with green manure crops. *Weed Tech*., **12**(1): 97-102.

Kushwaha, B. L. and Singh, P. K. (2000). Comparative efficacy and economics of mechanical and chemical weed control in wheat. *Annals Plant Protec. Sci.*, **8**(1): 71-75.

Lee, J. S. and Jung, Y. T. (1993). Rice growth and soil properties as affected by tillage methods on direct sown rice RDA. *J. Agril. Sci. Soil Fert*., **35**: (1) 264-269.

Machul, M., Krasowicz, S. and Szeleznak, E. (1997). Effect of tillage methods on the economics of grain production of maize grown in monoculture. Fragmenta Agronomica (Poland) **2**: 435-438.

Maecka, J. and Blecharezyk, A. (2002). Effect of tillage system on cereal yield and soil properties. *Prace. Z-zakresu nuk-Rolniczych*, **93**: 79-87.

Maiksteniene, S. and Arlauskiene, A. (2006). The Effect of Agricultural Management Systems on the Weed Incidence in Cereals. *Agron*. *Res*., **4**(Special issue): 281–285.

Malik, R. S., Yadav, S. K. and Malik, R. K. (1995). Nutrient uptake by wheat and associated weeds as influenced by herbicides. *Indian J. Weed Sci.*, **27**(1 & 2): 63-66.

Mamun, A. A. and Salim, M. (1989). Evaluation of isoproturan, a selective herbicide, for weed control in wheat. *Bangladesh J. Agril. Sci.,* **16**(1): 93-99.

Mamun, A. A., Jerjak, J. A. and Kadir, H. H. (1986). Crop production in Iraq with special emphasis on weeds and their control. *Bangladesh J. Agril. Sci.,* **13**(2) 19-29.

Matin, M. A. and Uddin, M. S. (1994). Effect of two tillage systems on soil physical properties, root growth and the yield of rice and maize. *Pakistan J. Sci. Indus Res*., **37**(5) 201-203.

Mishra, J. S. (1997). Critical period of weed competition and losses due to weeds in major field crops. *Farmers and Parliament*. **23** 19-20.

Mishra, J. S., Singh, V. P. and Yaduraju, N. T. (2005). Effect of tillage as weed control methods on weeds and wheat in vertisols. *Indian J. Weed Sci.,* **37**(1&2): 96-97.

Mohammad, A. K., Mansoor, K. K. and Massod, U. R. (1995). Effect of different tillage operation on emergence and yield of wheat. *Agri. Mechanism Asia, Africa and Latin America.* **26**: (2) 62-64.

Mohler, C. L. and Galford, A. E. (1997). Weed seedling emergence and seed survival: separating the effects of seed position and soil modification by tillage. *Weed Res.*, **37:** 147-155.

Mohler, C. L., Frisch, J. C. and McCulloch, C. E. (2006). Vertical movement of weed seed surrogates by tillage implements and natural processes. *Soil Tillage Res*., **86:** 110-122.

Momirovic, R., Stankovic, N., Skrbic, B Somzar, P. and Dakie, L. (1999). Effect of tillage system and herbicide application on weediness and yield of maize under continuous cropping variability of maize grain yield effect on tillage system and herbicide application. *Pesticidilyugoslania.* **14**(2): 189-196.

Moyer, J. R. and Huan, H. C. (1996). Effect of Aqueous Extracts of Crop Residues on Germination and Seedling Growth of Ten Weed Species. *Bot. Bull. Acad. Sci*., **38**: 131-139.

Munir, A., Khan, A. S. and Muslim, A. Z. (1994). Development and adaption of No-tillage technology of sowing wheat. *Agril. Mechanism Asia, Africa and Latin America.* **25**(4): 24-28.

Nayyar, M. M., Shafi, M., Shah, M. M. and Mahmood, T. (1994). Weed eradication studies in wheat. Abstract. 4th Pakistan Weed Science, Conference, UAF.

Negussie, T., Ahmed, S. and Hulluka, M. (1994). The effect of tillage on yield of durum wheat in Central Ethiopia, Addis Ababa. CIMMYT 241-246.

Nesterove, Q. N. and Chukanova, C. V. (1981). The harmfulness, predominant weed species in wheat. *Field Crops Abst.*, **38:** 3332-3332.

Norsworthy, J. K. (2003). Allelopathic Potential of Wild Radish (*Raphanus raphanistrum*). *Weed Tech*., **17**(2): 307-313.

Ogbodo, E. B. N. (2005). Effect of depth of tillage on soil physical conditions, growth and yield of sweet potato in an ultisol at Abakaliki, Southeastern Nigeria. *J. Agric. Social Res*., **5**(1) 41-47.

Ohno, T., Doolan, K., Zibilske, L. M., Liebman, M., Gallandt, E. R. and Berube, C. (2000). Phytotoxic Effects of Red Clover Amended Soils on Wild Mustard Seedling Growth. *Agric. Ecosys. Env.*, **78**(2): 187-192.

Pal, N. C. (2000). The higher content of organic matter and crop residues, in reduced or no-tillage system decreases herbicide efficacy. *Bangladesh J. Agric. Sci*., **27**(1): 123-129.

Panjab, S., Aipe, K. C., Prashed, R. Sharma, S. N., Singh, S. and Singh, P. (1998). Division of Agronomy. India Agricultural Research Institute, New Delhi-012, India. *Indian J. Agron*., **43**(2) 204-207.

Qureshi, R and Bhatti, G. R. (2001). Determination of weed communities in wheat field of district Sukhur. *Pakistan J. Bot.,* **33:** 109-115.

Radmehr, M., Ayeneh, G.A. and Mamghani, R., (2003). Responses of late, medium and early maturity bread wheat genotypes to different sowing date. I. Effect of sowing date on phonological, morphological, and grain yield of four breed wheat genotypes. *Iran. J. Seed. Sapling*, **21**(2): 175–189

Radosevich, S. R. and Holt, J. S. (1984). *Weed Ecology: Implications for Vegetation Management*. John Wiley & Sons. New York. p. 265.

Rahman MS 1997: Different tillage methods on soil properties, root growth and yield of BRRI dhan29. MS Thesis Department of Soil Science, BAU, Mymensingh.

Rahman, M. M. (1985). Duration of weed competition on the performance of wheat. M. Sc. (Ag.) Thesis, Department of Agronomy, Bangladesh Agricultural University, Mymensingh. pp. 18-26.

Rahman, M. S. (1974). Study on the effect of methabenzthiazuron as chemical weed killer in winter wheat *(Triticum aestivum).* M. Sc. (Ag.) Thesis, Department of Agronomy, Bangladesh Agricultural University, Mymensingh. pp. 16-31.

Ranjan, B., Singh, R. D., Chandra, S., Kundu, S. and Gupta, H. S. (2006). Effect of tillage and irrigation on yield and soil properties under rice (*Oryza* *sativa*), wheat (*Triticum aestivum*) system on a sandy clay loam soil of Uttaranchal. *Indian J. Agric. Sci*., **76**(7): 405-409.

Ranjit, J. D. (2002). Response of wheat weeds to straw mulch in mid plants. Proceedings of International Seminar on Mountains- Kathmandu, March 6-8, 2002, pp. 372-377.

Rao, V. S. (2000). Principles of Weed Science (2nd ed.). Oxford and IBH Publishing Co. Pvt. Ltd. New Delhi, India.

Rasmussen, I. A. (2004). The effect of sowing date, stale seedbed, row width and mechanical weed control on weeds and yields of organic winter wheat. *Weed Res.*, **44** 12-20.

Razzaq, A., Karim, A. and Sabir, B. A. (1993). Appropriate tillage package for wheat production after in rice tract. *Agril. Mechanism Asia, Africa and Latin America*. **24**(3): 23-26.

Razzaque, A., Das, N. and Roy, S. (1992). Wheat is the most important cereal crop that contributes to the national economy. *Indian J. Agron*., **26**(1): 35-39.

Rezaul, S. M. K. and Ahmed, S. (1997). Effect of degree of land preparation and spacing on weed growth and yield of transplant Aman rice. *Bangladesh J. Agril. Sci*., **24**(1): 40-42.

Riley, H., Brandsæter, L. O. and Danielsberg, G. (2004). Mulching compared to physical weed control measures in organically grown vegetables. 6th EWRS Workshop on Physical and Cultural Weed Control Lillehammer, Norway, 8-10 March 2004 p. 39.

Roder, W., Reinsch, B., Eggert, H. and Kahnus, A. (1982). Two years results on the influence of stand density (ear m-2) of cereal on gra:n yield and weed infestation under commercial conditions. *DDR*. **36**(12): 235-237.

Rose, S. J., Burnside, O. C., Specht, J. E and Swisher, B. A. (1984). Competition and Allelopathy between Soybeans and Weeds. *Agron. J.*, **76**: 523-528.

Sahu, T. R. (1981). Weed Flora of wheat crop in Madhya Pradesh. *Indian J. Weed Sci.*, **13**(2) 154-155.

Shad, R. A. and Siddiqui, S. S. (1991). Interference of various densities of Indian sweet clover *Melilotus indica* Linn. in wheat. *Pakistani J. Weed Sci. Soc.*, **49:** 69-75.

Sheila, D. (1986). Update: Suppressing weeds with allelopathic mulches. The IPM Practitioner. April. p. 14.

Siddiqui, I. and Bajwa, R. (2001). Variation in weed composition in wheat fields of Lahore and Gujranwala divisions. *Pakistani J Biol. Sci.*, **4:** 492-504.

Singh, H. P., Batish, D. R., Kaur, S. and Kohli, R. K. (2003). Phytotoxic interference of Ageratum conyzoides with wheat (*Triticum aestivum*). *J. Agron. Crop Sci.*, **189:** 341-346.

Singh, K. M. and Singh, R. N. (1996). Effect of boron fertilization and weed control methods on yield and yield attributes of wheat. *Indian J. Agron.*, **39**(3): 365- 370.

Singh, U. P., Singh, Y. and Kumar, V. (2004). Effect of weed management and cultivars on wheat (*Triticum aestivum*) and weeds. *Indian J. Weed Sci.,* **36**(1&2): 57-59.

Spandl, E., Durgan, B. R. and Forcella, F. (1998). Tillage and planting date influence foxtail (*Setaria* spp.) emergence in continuous spring Wheat (*Triticum aestivum*). *Weed Tech.,* **12:** 223-229.

Spandl, E., Durgan, B. R. and Forcella, F. (1999) Foxtail (*Setaria* spp.) seedling dynamics in spring wheat (*Triticum aestivum*) are influenced by seeding date and tillage regime. *Weed Sci.,* **47:** 156-160.

Swanton, C. J. and Booth, B. D. (2004). Management of weed seedbanks in the context of populations and communities. *Weed Tech.,* **18:** 1496-1502.

Tiwari, R. B. and Parihar, S. S. (1993). Weed management studies in wheat. *Indian Journal of Weed Sci.,* **25**(3 & 4): 88-90.

Turk, M. A. and Tawaha, A. M. (2003). Allelopathic Effect of Black Mustard (*Brassica nigra* L.) on Germination and Growth of Wild Oat (*Avena fatua* L.). *Crop Protec*., **22**(4): 673-677.

Van Acker, R. C., Bullied, W. J. and Sissons, M. (2004). Tillage index predicts weed seedling recruitment depth. *Canadian J. Plant Sci.,* **84:** 319-326.

VitaPDe, E., Paolo, D., Fecondo, G., Fonzo, N. D. and Pisante, M. (2007). No-tillage and conventional tillage effects on durum wheat yield, grain shallow red brown terrace soils of Bangladesh. *Sarhad J Agric*., **21**(4): 655-665.

WRC (Wheat Research Center). (2009). Annual Report, 2008–09. Wheat Research Center, Nashipur, Dinajpur, Bangladesh, p. 181.

Wrucke, A. (1985). Photosynthetic characteristics and dry matter accumulation **23**(1): 82-88.

Xuan, T. D., Hong, N. H., Khanh, . D., Eiji, T., Tawata, S and Fukuta, M. (2005). Utilization of plant allelopathy for biological control of weeds and plant pathogens in rice. Allelopathy Congress. 2005.

Zimdahl, R. L., Moody, K., Lubigan, R. T. and Castin, E. M. (1988). Patterns of weed emergence in tropical soil. *Weed Sci.*, **36:** 603-608.

APPENDICES

Appendix I. Monthly record of air temperature, rainfall, relative humidity and sunshine of the experimental site during the period from November 2013 to March 2014

Month	*Air temperature (^{o}C)		*Relative humidity (%)	*Total rainfall (mm)
	Maximum	Minimum		
November, 2013	25.8	16.0	78	00
December, 2013	22.4	13.5	74	00
January, 2014	25.2	12.8	69	00
February, 2014	27.3	16.9	66	39
March, 2014	31.7	19.2	57	23

* Monthly average,

Source: Bangladesh Meteorological Department (Climate & weather division) Agargoan, Dhaka-1212

Appendix II. Characteristics of experimenatl field soil (the soil is analyzed by Soil Resources Development Institute (SRDI), Farmgate, Dhaka)

A. Morphological characteristics of the experimental field

Morphological features	Characteristics
Location	Central Farm , SAU, Dhaka
AEZ	Madhupur Tract (28)
General Soil Type	Shallow red brown terrace soil
Land type	High land
Soil series	Tejgaon
Topography	Fairly leveled
Flood level	Above flood level
Drainage	Well drained

B. Physical and chemical properties of the initial soil

Characteristics	Value
% Sand	27
% Silt	43
% Clay	30
Textural class	Silty-clay
pH	6.2
Organic carbon (%)	0.45
Organic matter (%)	0.78
Total N (%)	0.03
Available P (ppm)	20.00
Exchangeable K (me/100 g soil)	0.10
Available S (ppm)	45

Source: SRDI

Appendix III. Analysis of variance of the data on plant height of wheat at different days after sowing (DAS) and harvest as influenced by tillage depth and mulch materials

Source of variation	Degrees of freedom	Mean square			
		Weeds population (No.) at		Dry weight of weed biomass (g m^{-2})	
		20 DAS	40 DAS	20 DAS	40 DAS
Replication	2	0.021	0.000	0.003	0.002
Tillage depth (A)	3	5.389**	12.576**	0.234**	0.355**
Mulch materials (B)	2	440.611**	1040.076**	2.718**	11.546**
Interaction (A×B)	6	0.667*	1.299*	0.061**	0.105**
Error	22	0.299	0.576	0.019	0.028

**: Significant at 0.01 level of probability; *: Significant at 0.05 level of probability

Appendix IV. Analysis of variance of the data on plant height of wheat at different days after sowing (DAS) and harvest as influenced by tillage depth and mulch materials

Source of variation	Degrees of freedom	Mean square				
		Plant height (cm) at				
		30 DAS	40 DAS	50 DAS	60 DAS	Harvest
Replication	2	1.417	0.617	11.453	6.764	3.722
Tillage depth (A)	3	178.527**	639.517**	541.692**	486.061**	366.086**
Mulch materials (B)	2	92.973**	204.629**	124.728**	309.538**	253.296**
Interaction (A×B)	6	5.377*	13.018*	18.522*	8.833*	11.269*
Error	22	3.353	5.937	6.386	7.531	10.559

**: Significant at 0.01 level of probability; *: Significant at 0.05 level of probability

Appendix V. Analysis of variance of the data on number of tillers plant^{-1} of wheat at different days after sowing (DAS) and harvest as influenced by tillage depth and mulch materials

Source of variation	Degrees of freedom	Mean square			
		Number of tillers plant^{-1}			
		30 DAS	40 DAS	50 DAS	60 DAS
Replication	2	0.013	0.001	0.136	0.337
Tillage depth (A)	3	2.119**	1.383**	0.480*	3.734**
Mulch materials (B)	2	3.211**	0.695**	3.204**	8.270**
Interaction (A×B)	6	0.103*	0.160**	0.237*	0.431*
Error	22	0.034	0.035	0.142	0.225

**: Significant at 0.01 level of probability; *: Significant at 0.05 level of probability

Appendix VI. Analysis of variance of the data on dry matter accumulation plant^{-1} of wheat at different days after sowing (DAS) as influenced by tillage depth and mulch materials

Source of variation	Degrees of freedom	Mean square			
		Dry matter accumulation plant^{-1} (g) at			
		25 DAS	45 DAS	60 DAS	75 DAS
Replication	2	0.010	0.001	0.028	0.013
Tillage depth (A)	3	2.816**	1.135**	2.416**	2.158**
Mulch materials (B)	2	1.703**	1.028**	0.814**	0.443**
Interaction (A×B)	6	0.417*	1.029**	0.607*	0.534*
Error	22	0.137	0.085	0.033	0.069

**: Significant at 0.01 level of probability; *: Significant at 0.05 level of probability

Appendix VII. Analysis of variance of the data on days to spike initiation, days to maturity, number of spikes plant^{-1} and number of spikelets spike^{-1} of wheat as influenced by tillage depth and mulch materials

Source of variation	Degrees of freedom	Mean square			
		Days from sowing to spike emergence	Days from sowing to maturity	Number of spikes plant^{-1}	Number of spikelets spike^{-1}
Replication	2	0.194	0.014	0.014	1.120
Tillage depth (A)	3	56.398**	1.435**	1.435**	12.740**
Mulch materials (B)	2	32.028*	4.350**	4.350**	60.881**
Interaction (A×B)	6	39.287**	0.338*	0.338*	5.278**
Error	22	7.467	0.142	0.142	1.587

**: Significant at 0.01 level of probability; *: Significant at 0.05 level of probability

Appendix VIII. Analysis of variance of the data on ear length, grains spike^{-1}, unfilled and total spikelets spike^{-1} and weight of 1000-grains of wheat as influenced by tillage depth and mulch materials

Source of variation	Degrees of freedom	Mean square				
		Ear length (cm)	Grains spike^{-1}	Unfilled spikelets spike^{-1}	Total spikelets spike^{-1}	Weight of 1000-grain (g)
Replication	2	0.461	1.382	0.051	1.608	3.231
Tillage depth (A)	3	3.626**	37.859**	4.171**	18.399*	37.716*
Mulch materials (B)	2	4.230**	189.424**	1.877**	154.597**	29.823**
Interaction (A×B)	6	2.139*	17.442**	1.028**	12.832*	19.092**
Error	22	0.670	3.729	0.045	4.004	3.735

**: Significant at 0.01 level of probability; *: Significant at 0.05 level of probability

Appendix IX. Analysis of variance of the data on weight of 1000 grains, grain, straw & biological yield and harvest index as influenced by tillage depth and mulch materials

Source of variation	Degrees of freedom	Mean square			
		Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
Replication	2	0.000	0.033	0.035	0.429
Tillage depth (A)	3	3.762**	4.002**	15.516**	29.186**
Mulch materials (B)	2	0.651**	0.806**	2.904**	2.404
Interaction (A×B)	6	0.194*	0.221**	0.827*	0.803*
Error	22	0.062	0.058	0.185	2.816

**: Significant at 0.01 level of probability; *: Significant at 0.05 level of probability