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Effect of tillage method and weeding regime on soil weed seed bank status and yield performance of wheat

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Abstract

An experiment was conducted at the Agronomy Field Laboratory and net house of the Department of Agronomy, Bangladesh Agricultural University, Mymensingh from November 2012 to March 2014. Wheat (cv. *BARI Gom-26*) was sown with two tillage methods *viz.*, (i) conventional tillage and (ii) stale seedbed technique and nine weeding regimes *viz.,* (i) Unweeded (Control), (ii) Weed free, (iii) Hand weeding (HW) at 15 Days after sowing (DAS), (iv) HW at 15 and 45 DAS, (v) HW at 25 and 45 DAS (vi) HW at 25 DAS (vii) HW at 25 and 60 DAS (viii) 2,4-D amine at 15 DAS and (ix) 2,4-D amine at 15 DAS + HW at 60 DAS. The design was split-plot with three replications where tillage method was assigned to the main plots and weeding regime to the sub plots. Conventionally tilled plots were infested with 12 weed species of which the five most dominant weed species in descent order were *Polygonum coccineum* L, *Chenopodium album* L, *Cynodon dactylon* L., *Sonchus arvensis* L. and *Cyperus rotundus* L. In stale seedbed out of 15 weed species *Digitaria sanguinalis* L. and *Hedyotis corymbosa* (L.) Lamk. was dominant instead of *Chenopodium album* L. and *Sonchus arvensis* L. identified in conventional tillage. In soil weed seed bank study, 28 species were identified in conventional tillage and 30 in stale seedbed. Among them annuals were dominant over perennials and broadleaves over grasses and sedges. In conventional tillage, the five most dominant weed species in descent order were *Chenopodium album* L., *Hedyotis corymbosa* L., *Sonchus arvensis* L., *Polygonum coccineum* L. and *Rotala ramosior* L. while in stale seedbed, five dominant weeds were *Polygonum coccineum* L., *Chenopodium album L., Cynodon dactylon* L., *Lindernia procumbens* Krock. and *L. hyssopifolia* L. Except the number of spikelets spike^{-1}, rest of all other yield attributes and yield of wheat were affected significantly by the tillage methods. Stale seedbed technique yielded the higher grain (3.54 t ha^{-1}) and the conventional tillage yielded the lower (3.13 t ha^{-1}). The effect of weeding regime was significant on wheat except plant height and 1000-grain weight. The highest grain yield (3.85 t ha^{-1}) was recorded from weed free treatment followed by 2,4-D amine at 15 DAS and lowest (3.22 t ha^{-1}) from control. Interaction between the treatments was also. The highest grain yield (4.09 t ha^{-1}) was recorded from the stale seedbed technique kept weed free followed by 2,4-D amine at 15 DAS and lowest grain yield (3.04 t ha^{-1}) recorded from the conventional tillage retained unweeded.

Key words: Conventional tillage, stale seedbed technique, weeds seed bank, wheat, yield

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Introduction

Wheat (*Triticum aestivum* L.) is the most important cereal crop all over the world belonging to the family Poaceae. It ranks first in area (216.8 million hectares) and third in production (651.4 million metric tons) among the grain crops during 2009-10 in the world (FAO, 2012). In Bangladesh, the area under wheat cultivation during 2011-2012 was about 3.58 lakh ha producing 9.95 lakh tons of wheat with an average yield of 2.78 ton per hectare (BBS, 2012). Whereas, in Holland, UK, France and Norway, the average

yield of wheat yield are 7.50, 6.20, 5.90 and 4.80 t ha^{-1}, respectively (FAO, 2012). Though, wheat is an important cereal crop in Bangladesh, the average yield of wheat in Bangladesh is low compared to that of other wheat growing countries of the world due to lack of appropriate management practices. Among the management practices, lack of optimum seed rate, fertilizer management, irrigation, non-appropriate tillage of land and traditional weed management may be the cause of low production of wheat. To increase the yield of wheat appropriate weed and agronomic management practices are necessary.

Tillage has been used 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. Liebman and Davis (2000) 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 (Ball and Miller, 1993). 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.

Weed is one of the destructive integral pests in crop. It is the nutrient absorbing competitive plants which grows out of place spontaneously even under adverse condition. It is often said that "crop production is a fight against weeds". Weed grows in every piece of land of the world. The edaphic and climatic condition of Bangladesh favors the growth of weed. High competitive ability of weeds exerts a serious negative effect on crop production causing significant losses in crop yield. Many scientists from South Asia reported weed as the major constraint to wheat cultivation. 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).

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, numbers of panicles, grain weight etc. are affected by weed competition. Weed control treatments produced higher yield attributes, grain and straw yield (Pandey *et al.,* 2000). It was found that weeding at 20 and 40 days after sowing (DAS) gave the highest grain and straw yields. This can be achieved by removing the weeds through different weeding methods. (Tariful *et al*., 1998). The chemical weeding in different combinations can play an important role in reducing the early emergence of weeds along with the crop in the crop field. But due to the degradation of environment the chemical methods are discouraged in controlling weeds. Thus the best weeding regimes need to be adopted by the farmers with a view to reduce weeding infestation and maximize wheat yield.

On the other hand, soil weed seed bank reserves viable weed seeds present on the surface and in the soil. Generally, weed seed bank is the primary source of weed infestation in cultivated soil. Therefore, clean cultivation and use of stale seedbed technique can reduce the weed density. A stale seedbed is created when a field is prepared for planting and then left fallow for several weeks. Weeds are allowed to germinate during the fallow period. Irrigation can even be used to encourage germination in some situations. After a few weeks (usually two weeks or more) the emerged weeds are killed, buried seeds are not exposed to light and other stimuli that encourage germination, and emergence of new weed seedling is less likely to occur. This type of weed control option through weed seed bank depletion is very rare in our country. Therefore, the present study undertaken with the objectives to determine the method of tillage on the yield and yield contributing characters of

wheat; to observe the effect of weeding regime on the yield and yield contributing characters of wheat, and to evaluate the interaction effect of method of tillage and weeding regime on the yield and yield components of wheat.

Materials and Method

The experiment was conducted at the Agronomy Field Laboratory and net house of the Department of Agronomy, Bangladesh Agricultural University, Mymensingh from November 2012 to March 2014. Wheat (cv. *BARI Gom-26*) was sown with two tillage methods *viz.*, (i) conventional tillage and (ii) stale seedbed technique and nine weeding regimes *viz.,*(i) Unweeded (control), (ii) weed free, (iii) hand weeding (hw) at 15 Days after sowing (DAS), (iv) hw at 15 and 45 DAS, (v) hw at 25 and 45 DAS (vi) hw at 25 DAS (vii) hw at 25 and 60 DAS (viii) 2,4-D amine at 15 DAS and (ix) 2,4-D amine at 15 DAS + hw at 60 DAS. The experiment was laid out in a split-plot design with three replications where tillage method was assigned to the main plots and weeding regime to the sub plots. There were 54 plots having 4.0 m × 2.5 m area. The experimental land was opened with a tractor drawn disc plough 15 days before sowing and fertilized with the recommendation of BARI (2012). Weeding was done as per weeding regime treatment and other necessary intercultural operations were done in order to ensure and maintain the normal growth of the crop. Wheat was harvested at maturity on 12 March 2013. It was then carried to the threshing floor for processing. The crop was sun-dried for four days and then threshed and cleaned. Finally, all the data were recorded.

Soil samples were collected before and after wheat cultivation from the 54 experimental plots. Soil cores of 5 cm in diameter and 10 cm depth were sampled from each plot in a 'W' shaped pattern. Samples of 54 plots were placed on 54 plastic trays of 32 cm in diameter each. Each tray was filled with 1 kg soils. The samples were sprinkled daily with water as needed in order to maintain moisture level which is essential for the germination of weed seeds. Emerged seedlings of individual species were counted and removed at 3 weeks interval, throughout the germination period. Seedlings of questionable identity were transferred and grown until maturity to facilitate identification. After the removal of each batch of seedlings, soils were thoroughly mixed in order to expose the weed seeds to the upper layer of the soil and rewetted to permit further emergence and importance value (IV) for each weed species was calculated following the equation:

$$\text{IV (\%)} = \frac{\text{Number of each species in a community}}{\text{Total number of all species in a community}} \times 100$$

The recorded data were compiled and statistically analyzed for ANOVA with the computer package programme MSTAT-C (Russell, 1986) and mean differences were adjudged by DMRT (Gomez and Gomez, 1984).

Results and Discussion

Weed infestation in wheat field

Conventionally tilled plots kept unweeded were infested with 12 weed species belonging to seven families (Table 1). Among the total weed vegetation, annuals constituted 84.74% and perennial 15.26%. Broadleaves were dominated over grasses and sedges (Table 1). Five most dominant weed species ranked based on importance value were *Polygonum coccineum>Chenopodium album>Cynodon dactylon > Sonchus arvensis>Cyperus rotundus* (Figure 1).

The unweeded plots under stale seedbed technique, infested with 15 weed species belonging to eleven families (Table 2). Among the total weed vegetation annual and perennial weeds constituted 80.17% and 19.83%, respectively. Broadleaves were dominated over grasses and sedges (Table 2). Five most dominant weed species ranked based on importance value were *Polygonum coccineum>Cynodon dactylon>Digitaria sanguinalis>Cyperus rotundus> Hedyotis corymbosa* (Figure 2).

Sultana (2012) working with wheat identified thirteen weeds species in the Agronomy field laboratory belonging to nine families where *Chenopodium album* was the dominant followed by *Polygonum hydropiper.* Rahman (1985) observed *Chenopoduum album* was the dominant constituted 56.5% of the total weed vegetation. Sahu (1981) also found different weeds at different growth stages of

wheat while the most dominant species was *C. album.*

Table 1. Weed infestation in conventionally tilled unweed plots

Sl.	Local name	English name	Scientific name	Family	Weed type	Life cycle	IV (%)
1	Bathua	Lambs quarter	*Chenopodium album* L.	Chenopodiaceae	Broadleaf	Annual	15.38
2	Bantola	Field sow thistle	*Sonchus arvensis* L.	Compositae	Broadleaf	Annual	6.82
3	Ban copi	Jersy cudweed	*Gnaphalium affine* L.	Compositae	Broadleaf	Annual	1.34
4	Mutha	Purple nutsedge	*Cyperus rotundus* L.	Cyperaceae	Sedge	Perennial	5.38
5	Durba	Bermuda grass	*Cynodon dactylon* L.	Poaceae	Grass	Perennial	9.51
6	Angta	Joint grass	*Paspalum distichum* L.	Poaceae	Grass	Perennial	0.37
7	Khude shama	Barnyard grass	*Echinochloa colonum* L.	Poaceae	Grass	Annual	1.59
8	Angulee	Scrab grass	*Digitaria sanguinalis* L.	Poaceae	Grass	Annual	1.44
9	Chapra	Goose grass	*Eleusine indica* L.	Poaceae	Grass	Annual	2.82
10	Bishkatali	Swamp smart	*Polygonumcoccineum*L.	Polygonaceae	Broadleaf	Annual	53.97
11	Babui tulsi	Diamond flower	*Hedyotis corymbosa* L.	Rubiaceae	Broadleaf	Annual	3.99
12	Tita begun	Turkey berry	*Solanum torvum* Sw.	Solanaceae	Broadleaf	Annual	0.38

N.B., IV= Importance value

Table 2. Weed infestation in unweeded plots under stale seedbed technique method

Sl.	Local name	English name	Scientific name	Family	Weed type	Life cycle	IV (%)
1	Katanotey	Spiny pig weed	*Amaranthus spinosus* L.	Amaranthaceae	Broadleaf	Annual	0.99
2	Bathua	Lambs quarter	*Chenopodium album* L.	Chenopodiaceae	Broadleaf	Annual	3.49
3	Ban tola	Field sow thistle	*Sonchus arvensis* L.	Compositae	Broadleaf	Annual	4.21
4	Ban copi	Jersy cudweed	*Gnaphalium affine* L.	Compositae	Broadleaf	Annual	3.38
5	Fulkhari	Goat weed	*Ageratum conyzoides*	Compositae	Broadleaf	Perennial	0.95
6	Bansharisha	Wild mustard	*Rorippa dubia* L.	Cruciferae	Broadleaf	Annual	1.13
7	Mutha	Purple nutsedge	*Cyperus rotundus* L.	Cyperaceae	Sedge	Perennial	6.87
8	Durba	Bermuda grass	*Cynodon dactylon* L.	Poaceae	Grass	Perennial	12.01
9	Angulee	Scrab grass	*Digitaria sanguinalis* L.	Poaceae	Grass	Annual	10.61
10	Chapra	Goose grass	*Eleusine indica* L.	Poaceae	Grass	Annual	2.12
11	Amrul	Indian sorrd	*Oxalis europea* L.	Oxalidaceae	Broadleaf	Annual	0.79
12	Bish katali	Swamp smart	*Polygonum coccineum* L.	Polygonaceae	Broadleaf	Annual	40.30
13	Babui tulsi	Diamond flower	*Hedyotis corymbosa* L.	Rubiaceae	Broadleaf	Annual	5.42
14	Khet papri	False pimpernel	*Lindernia procumbens* Krock.	Scrophulariaceae	Broadleaf	Annual	2.89
15	Faskabegun	Ground chery	*Physalis heterophylla* L.	Solanaceae	Broadleaf	Annual	4.83

N.B., IV= Importance value

Islam (1987) and Gaffer (1987) concluded *Chenopoduum album* is the most important weed in wheat field. In this study *Polygonum coccineum* was the dominant over *Chenopoduum album* concluding *Chenopoduum album* might be replaced by *Polygonum coccineum.* Mamun (1993) investigated 73 weed species belongings to 24 families infesting wheat field in Old Brahmaputra Floodplain of which 53 were annuals and 20 perennials. But this study found the number of infesting weed species was only 10 belonging to 6 families. This difference indicates that weed vegetation changed from time to time, season to season and place to place.

Effect of tillage and weeding regime on soil weeds seed bank status

The soil weed seed bank was infested by different weed species under different families. There were 28 weed species belonging to 15 families identified in conventional tilled plot (Table 3). Five weed species belonged to the family Poaceae, four to Cyperaceae, three to Compositae and two to each of Polygonaceae, Rubiaceae, Scrophulariaceae,

Solanaceae and one each of the family Amaranthaceae, Asteraceae, Chenopodiaceae, Commelinaceae, Cruciferae, Leguminosae, Lythraceae and Oxalidaceae. Broadleaves were dominated over grasses and sedges. The five most dominant weed species in unweeded treatment based on importance value were *Chenopodium album> Hedyotis corymbosa> Sonchus arvensis> Polygonum coccineum>Rotala ramosior* (Figure 3) whereas a bit different five most dominant weed species found in weed free treatment were *Chenopodium album>Cynodon dactylon>Hedyotis corymbosa>Ageratum conyzoides> Polygonum coccineum* (Figure 4).

In stale seedbed technique, the soil weed seed bank was infested with 30 weed species belonging to seventeen families (Table 4).

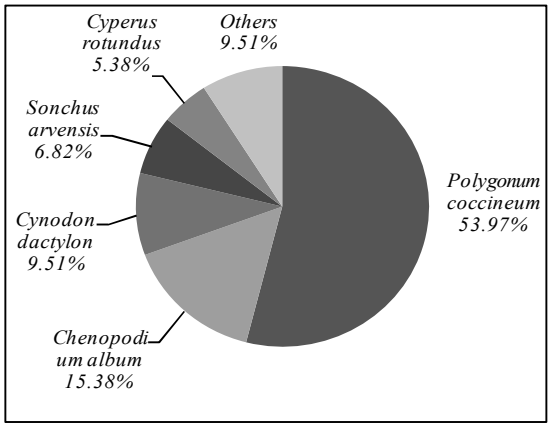

Figure 1. Five most dominant weeds found in conventionally tilled plots kept unweeded

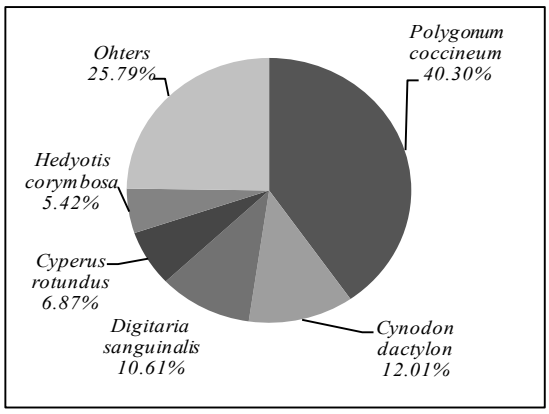

Figure 2. Five most dominant weeds in stale seedbed kept unweeded

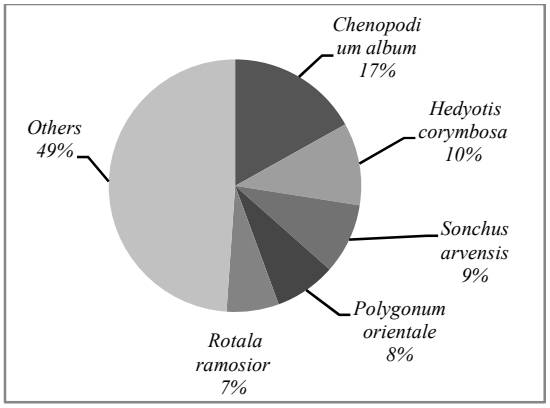

Figure 3. Five most dominant weed species in weed seed bank of conventional tillage kept unweeded

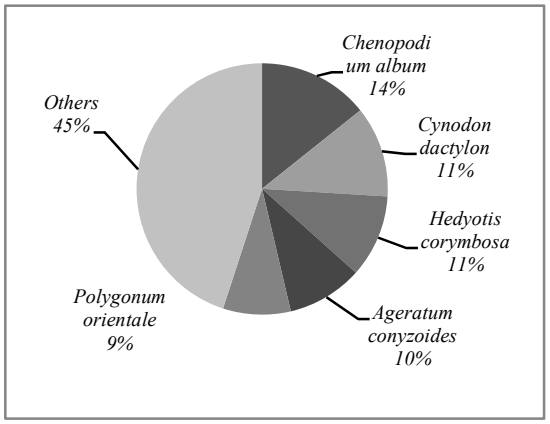

Figure 4. Five most dominant weed species in weed seed bank of conventional tillage kept weed free

Five weed species belonged to the family Poaceae, four to Cyperaceae, three to Compositae and two to each Polygonaceae, Rubiaceae, Scrophulariaceae, Solanaceae and one each to Amaranthaceae, Asteraceae, Chenopodia-ceae, Commelinaceae, Cruciferae, Leguminosae, Lythraceae, Onagraceae, Oxalidaceae and Umbelliferae. Broadleaves were dominated over grasses and sedges. The five most dominant weed species in unweeded treatment based on importance value were *Polygonum coccineum >Chenopodium album>Hedyotis corymbosa>Sonchus arvensis> Ageratum conyzoides* (Figure 5) where as a bit different dominant weed species was observed in weed free treatment such as *Polygonum coccineum>Chenopodium album>*

Cynodon dactylon>*Lindernia procumbens*> *Lindernia hyssopifolia* (Figure 6).

A large number of weed species was observed in soil weed seed bank than the aboveground weed flora of wheat field. There were 17 new weed species found in soil weed seed bank compared to the wheat field in both of the tillage systems (Table 1-Table 4). On the other hand, only *Gnaphalium affine* and *Physalis heterophylla* were found in wheat field as above ground weed flora and not found in soil seed bank in conventional tillage and stale seedbed technique, respectively (Table 1-Table 4).

Table 3. Weed species emerged in soil weed seed bank of net-house tray method in conventional tillage method

Sl.	Local name	English name	Scientific name	Family	Weed type	Life cycle
1	Katanotey	Spiny pig weed	*Amaranthus spinosus* L.	Amaranthaceae	Broadleaf	Annual
2	Halud nakful	Toothache plant	*Spilanthes iabadicensis* Moore.	Asteraceae	Broadleaf	Annual
3	Bathua	Lambs quarter	*Chenopodium album* L.	Chenopodiaceae	Broadleaf	Annual
4	Fulkhari	Goatweed	*Ageratum conyzoides* L.	Compositae	Broadleaf	Perennial
5	Bantula	Field sow thistle	*Sonchus arvensis* L.	Compositae	Broadleaf	Annual
6	Keshuti	White eclipta	*Eclipta alba* L.	Compositae	Broadleaf	Annual
7	Kanainola	Spreading day flower	*Murdania nudiflora* L.	Commelinaceae	Broadleaf	Annual
8	Bansharisha	Wild mustard	*Rorippa dubia* L.	Cruciferae	Broadleaf	Annual
9	Borochucha	Umbrella sedge	*Cyperus iria* L.	Cyperaceae	Grass	Annual
10	Mutha	Purple nutsedge	*Cyperus rotundus* L.	Cyperaceae	Sedge	Perennial
11	Joina	Grass like fimbry	*Fimbristylis miliaceae* Vahl.	Cyperaceae	Sedges	Annual
12	Panichaise	Spike sedges	*Eleocharis atropurpurea* Kunth.	Cyperaceae	Sedge	Annual
13	Durba	Bermuda grass	*Cynodon dactylon* L.	Poaceae	Grass	Perennial
14	Angta	Joint grass	*Paspalum scorbiculatum* L.	Poaceae	Grass	Perennial
15	Chapra	Goose grass	*Eleusine indica* L.	Poaceae	Grass	Annual
16	Khude shama	Jungle rice	*Echinochloa colonum* L.	Poaceae	Grass	Annual
17	Angulee ghash	Scrab grass	*Digitaria sanguinalis* L.	Poaceae	Grass	Annual
18	Banmasur	wild lentil	*Vicia sativa* L.	Leguminosae	Broadleaf	Annual
19	Acidghash	Low land rotala	*Rotala ramosior* (L.) Kochne	Lythraceae	Broadleaf	Annual
20	Amrul	Indian sorrd	*Oxalis europea* L.	Oxalidaceae	Broadleaf	Annual
21	Bishkatali	Swamp smart	*Polygonum coccineum* L.	Polygonaceae	Broadleaf	Annual
22	Gangpalong	Bitter dock	*Rumex maritimus* L.	Polygonaceae	Broadleaf	Annual
23	Babui tulsi	Diamond flower	*Hedyotis corymbosa* (L.) Lamk	Rubiaceae	Broadleaf	Annual
24	Hazardana	Corn spurge	*Dentella repens* L.	Rubiaceae	Broadleaf	Perennial
25	Panichaise	Spike sedges	*Lindernia dubia* L.	Scrophulariaceae	Broadleaf	Annual
26	Khet papri	False pimpernel	*Lindernia procumbens* Krock.	Scrophulariaceae	Broadleaf	Annual
27	Tita begun	Turkey berry	*Solanum torvum* Sw.	Solanaceae	Broadleaf	Annual
28	Ban tamak	Wild tobacco	*Nicotina plumbaginifolia* Viv.	Solanaceae	Broadleaf	Annual

In the soil seed bank study, the five most dominant weed species was almost similar between conventional tillage method and stale seedbed technique under unweeded treatment except *Rotala ramosior* in conventional tillage method instead of *Ageratum conyzoides* in stale seedbed technique (Figure 3 and Figure 4). However, the rank and order was different between these two tillage methods under unweeded treatment. But in case of weed-free treatment, among the five most dominant weeds, *Chenopodium album* and *Polygonum coccineum* were common for both of the tillage methods (Figure 5 and Figure 6). Moreover, in stale seedbed technique rest of the weed species constituted 56% whereas it was 45% in conventional tillage method. This result point out that, weed free condition

reduces seed storage in seed bank through reduction of seed setting of a dominant weed. Therefore, weed control practice may influence weed seed bank status by replacing one species to other species and once upon a time less dominant weed species appeared as a dominant species or dominant weed may disappeared based on weed management as well as the consequence of tillage practices. This statement is in agreement with Cussans (1975).

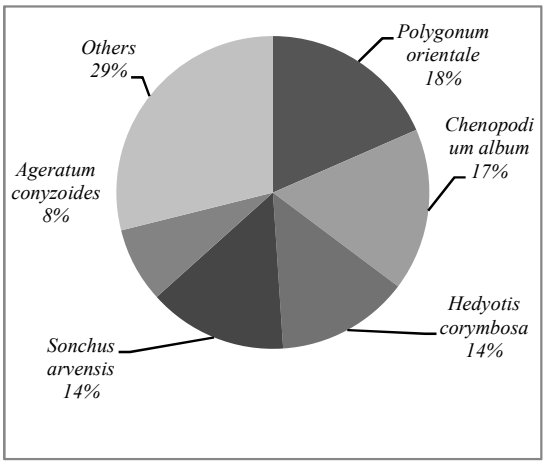

Figure 5. Five dominant weed in seed bank of stale seedbed kept unweeded

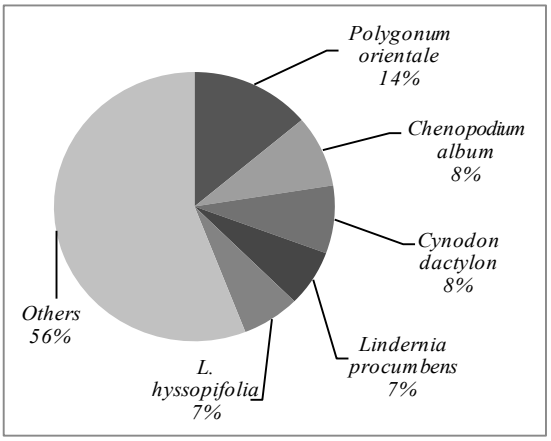

Figure 6. Five dominant weeds in weed seed bank of stale seedbed kept weed free

Effect of tillage methods on yield contributing characters and yield of wheat

Tillage methods exerted significant effect on all the plant characters of wheat except number of non-effective tillers hill^{-1}, spike length, number of spikelets spike^{-1}, straw yield, and biological yield (Table 5). Conventional tillage produced the taller plant (78.80 cm) and stale seedbed technique produced the shorter (75.57 cm). The higher total number of tillers hill^{-1} (5.46) was obtained from stale seedbed technique and the lower one (4.92) was obtained from conventional tillage method. The higher number of effective tillers hill^{-1} (4.37) was obtained from stale seedbed technique and the lower number of effective tillers hill^{-1} (3.90) was obtained from conventional tillage method. The higher weight of thousand-grain (46.12g) was obtained from stale seedbed technique compared to conventional tillage method. The higher grain yield (3.54 t ha $^{-1}$) was obtained from stale seedbed technique method and lower (3.13 t ha ^{1}) was obtained from conventional tillage method. The higher harvest index (44.47%) was obtained from stale seedbed technique compared to conventional tillage method.

Effect of weeding regime on yield and yield contributing characters of wheat

All the plant characters of wheat except plant height were affected significantly by the weeding regime (Table 6). The highest number of total tillers hill^{-1} (6.78) was produced by weed free treatment followed by 2,4-D amine at 15 DAS and 2, 4-D amine at 15 DAS + hand weeding at 60 DAS. The lowest number of total tillers hill^{-1} (4.50) was found in unweeded treatment. Okafor (1987) observed that total number of tillers hill^{-1}was increased by 45.68% in weed free and 11.73% in farmers weeding over unweeded. Similar findings were reported by Karim and Mamun (1988). The highest number of effective tillers hill^{-1} (5.81) was produced by weed free treatment followed by 2, 4-D amine at 15 DAS and 2, 4-D amine at 15 DAS + hand weeding at 60 DAS. The lowest number of effective tillers hill^{-1} (3.02) was found in unweeded treatment. Karim and Mamun (1988) also observed number of effective tillers was affected by weed competition. The highest number of non-effective tillers hill^{-1} (1.48) was produced by unweeded and the lowest number (0.91) was observed in 2, 4-D amine at 15 DAS + hand weeding at 60 DAS.The longest spike (12.22 cm) was recorded from 2,4-D amine at 15 DAS and the shortest spike (9.62 cm) was observed in Hand weeding at 25 DAS treatment. Singh and Singh

(1996) also observed reduction in spike length of wheat by 9.76% due to weed competition**.** The highest number of spikelets spike^{-1} (22.08) was recorded from weed free treatment followed 2,4-D at 15 DAS and the lowest one (19.03) was found in hand weeding at 15 DAS.

Table 4. Weed species emerged in soil weed seed bank of net-house tray method under stale seed bed technique

Sl.	Local name	English name	Scientific name	Family	Weed type	Life cycle
1	Kata notey	Spiny pig weed	*Amaranthus spinosus* L.	Amaranthaceae	Broadleaf	Annual
2	Halud nakful	Toothache plant	*Spilanthes iabadicensis* Moore.	Asteraceae	Broadleaf	Annual
3	Bathua	Lambs quarter	*Chenopodium album* L.	Chenopodiaceae	Broadleaf	Annual
4	Fulkhari	Goat weed	*Ageratum conyzoides* L.	Compositae	Broadleaf	Perennial
5	Bantula	Field sow thistle	*Sonchus arvensis*	Compositae	Broadleaf	Annual
6	Keshuti	White eclipta	*Eclipta alba* L.	Compositae	Broadleaf	Annual
7	Kanai nola	Spreading day flower	*Murdania nudiflora* L.	Commelinaceae	Broadleaf	Annual
8	Ban sharisha	Wild mustard	*Rorippa dubia* L.	Cruciferae	Broadleaf	Annual
9	Boro chucha	Umbrella sedge	*Cyperus iria* L.	Cyperaceae	Grass	Annual
10	Mutha	Purple nutsedge	*Cyperus rotundus* L.	Cyperaceae	Sedge	Perennial
11	Joina	Grass like fimbry	*Fimbristylis miliaceae* Vahl.	Cyperaceae	Sedges	Annual
12	Pani chaise	Spike sedges	*Eleocharis atropurpurea* Kunth.	Cyperaceae	Sedge	Annual
13	Durba	Bermuda grass	*Cynodon dactylon* L.	Poaceae	Grass	Perennial
14	Angta	Joint grass	*Paspalum scorbiculatum* L.	Poaceae	Grass	Perennial
15	Chapra	Goose grass	*Eleusine indica* L.	Poaceae	Grass	Annual
16	Khude shama	Jungle rice	*Echinochloa colonum* L.	Poaceae	Grass	Annual
17	Angulee	Scrab grass	*Digitaria sanguinalis* L.	Poaceae	Grass	Annual
18	Banmasur	wild lentil	*Vicia sativa* L.	Leguminosae	Broadleaf	Annual
19	Acid ghash	Low land rotala	*Rotala ramosior* (L.) Kochne	Lythraceae	Broadleaf	Annual
20	Pani long	Water prime rose	*Ludwigia prostrata*	Onagraceae	Broadleaf	Annual
21	Amrul	Indian sorrd	*Oxalis europea* L.	Oxalidaceae	Broadleaf	Annual
22	Bishkatali	Swamp smart	*Polygonum coccineum* L.	Polygonaceae	Broadleaf	Annual
23	Gang palong	Bitter dock	*Rumex maritimus* L.	Polygonaceae	Broadleaf	Annual
24	Babui tulsi	Diamond flower	*Hedyotis corymbosa* (L.) Lamk	Rubiaceae	Broadleaf	Annual
25	Hazardana	Corn spurge	*Dentella repens* L.	Rubiaceae	Broadleaf	Perennial
26	Pani marich		*Lindernia hyssopifolia* L.	Scrophulariaceae	Broadleaf	Annual
27	Khet papri	False pimpernel	*Lindernia procumbens* Krock.	Scrophulariaceae	Broadleaf	Annual
28	Tita begun	Turkey berry	*Solanum torvum* Sw.	Solanaceae	Broadleaf	Annual
29	Ban tamak	Wild tobacco	*Nicotina plumbaginifolia* Viv.	Solanaceae	Broadleaf	Annual
30	Khud manik	marsh pennywort	*Hydrocotyle sibthorpioides* Lam.	Umbelliferae	Broadleaf	Annual

The result was also in conformity with Okafor (1987) and Karim and Mamun (1988). Singh and Singh (1996) also observed that 40% reduction in number of spikelets spike^{-1} in wheat due to weed competition. The highest weight of 1000-grain (50.11g) was recorded from two hand weeding at 25 and 45 DAS and the lowest weight (36.92 g) was obtained from hand weeding at 15 DAS. Rahman (1985) recorded reduction in 1000-grain weight in wheat due to weed competition by 10.65%. The highest grain yield (3.85 t ha^{-1}) was obtained from weed free treatment followed by 2,4-D amine at 15 DAS and 2,4-D amine at 15 DAS + hand weeding at 60 DAS and lowest one (3.22 t ha^{-1}) was found from unweeded treatment. Hossain *et al.* (2001) reported that weed free condition gave higher grain yield of wheat. The highest straw yield (5.15 t ha^{-1}) was obtained from 2, 4-D amine at 15 DAS. The lowest straw yield (4.09 t ha^{-1}) was obtained from hand weeding at 25 DAS treatment. Rahman (1985), Mamun and Salim (1989) and Singh and Singh (1996) also observed reduction in straw yield in wheat due to weed competition**.**

Weed free treatment produced highest biological yield (8.99 t ha^{-1}) and lowest value (7.48 t ha^{-1}) was recorded from 2, 4-D amine at 15 DAS + hand weeding at 60 DAS. The highest harvest index (46.32%) was calculated from hand weeding at 25 DAS while the lowest value (39.71%) was from two hand weeding at 15 and 45 DAS.

Table 5. Effect of tillage methods on yield attributes and yields of wheat

Tillage method	Plant height (cm)	Tillers per $hill^{-1}$ (no.)	Effective tillers $hill^{-1}$ (no.)	Non-effective tillers $hill^{-1}$ (no.)	Spike length (cm)	Spikelet $spike^{-1}$ (no.)	1000 grain weight (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
CT	78.80a	4.92b	3.90b	1.03	10.40	19.30	41.01b	3.13b	4.95	8.08	38.73b
SS	75.57b	5.46a	4.37a	1.09	10.24	21.05	46.12a	3.54a	4.42	7.96	44.47a
$LSD_{(0.05)}$	2.19	0.39	0.41	3.12	4.34	3.85	2.93	0.058	4.09	3.27	4.44
LS	**	**	**	NS	NS	NS	**	*	NS	NS	**
CV (%)	6.34	4.17	3.06	4.09	4.21	3.72	11.69	12.69	13.69	14.69	15.69

CT= Conventional tillage, ST= Stale seed bed technique, LSD= Least significant difference, LS= Level of significance, CV= Coefficient of variance, * = Significant at 5% level of probability, ** = Significant at 1% level of probability, NS = Non significant

Table 6: Effect of weeding regime on yield attributes and yields of wheat

Weeding regime	Plant height (cm)	Tillers per $hill^{-1}$ (no.)	Effective tillers $hill^{-1}$ (no.)	Non-effective tillers $hill^{-1}$ (no.)	Spike length (cm)	Spikelet $spike^{-1}$ (no.)	1000 grain weight (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
W_1	79.80	4.50f	3.57e	0.94e	9.88cd	19.03d	36.92	3.28c	4.53b	7.81e	41.99g
W_2	77.69	4.77e	3.67de	1.10bc	9.86cd	19.09d	44.66	3.34c	5.07a	8.41b	39.71de
W_3	77.88	5.28c	4.13c	1.15b	10.49bc	20.20bcd	50.11	3.32c	4.54b	7.86c	42.23c
W_4	77.11	4.69e	3.78d	0.92e	9.62d	19.51cd	37.43	3.53b	4.09c	7.62e	46.32f
W_5	76.32	5.04d	4.01c	1.03cd	9.79cd	19.95bcd	44.18	3.29c	4.68b	7.97d	41.27e
W_6	77.18	5.61b	4.56b	1.05cd	12.22a	20.89b	47.43	3.53b	5.15a	8.68b	40.66d
W_7	77.17	5.57b	4.66b	0.91e	10.00cd	20.42bc	42.02	3.28c	4.69c	7.97d	41.15b
WF	77.57	6.78a	5.81a	0.97de	9.91cd	22.08a	43.86	3.85a	5.14a	8.99a	42.82a
UW	73.92	4.50f	3.02f	1.48a	11.09b	20.43bc	45.48	3.22c	4.26b	7.48e	43.04g
$LSD_{(0.05)}$	3.52	0.19	1.01	0.21	0.99	1.12	3.74	0.13	0.78	0.049	1.10
LS	NS	**	**	*	**	**	NS	**	**	**	**
CV (%)	6.34	4.17	3.06	4.09	4.21	3.72	11.69	12.69	13.69	14.69	15.69

UW = Unweeded, WF = Weed free, W_1 = Hand weeding at 15 DAS, W_2 = Two hand weeding at 15 and 45 DAS, W_3 = Two hand weeding at 25 and 45 DAS, W_4 = Hand weeding at 25 DAS, W_5 = Two hand weeding at 25 and 60 DAS, W_6 = 2,4-D amine at 15 DAS, W_7 = 2,4-D amine at 15 DAS+ hand weeding at 60 DAS, LSD= Least significant difference, LS= Level of significance, CV= Coefficient of variance, * = Significant at 5% level of probability, ** = Significant at 1% level of probability, NS = Non significant

Interaction effect of tillage method and weeding regime on yield attributes and yield of wheat

Interaction between tillage method and weeding had significant effect on all the plant characters of wheat except the number of non-effective tillers $hill^{-1}$and thousand grain weight (Table 7). The tallest plant (80.80cm) was obtained from conventional tillage method kept weed free while the shortest plant (68.65 cm) from stale seedbed technique with weedy check. The highest number of total tillers $hill^{-1}$ (7.07) was obtained in stale seedbed technique with weed free condition. The lowest number of total tillers $hill^{-1}$ (4.03) was obtained from conventional tillage method with unweeded condition. The highest number of effective tillers $hill^{-1}$ (6.12) was obtained

in stale seedbed technique with weed free condition. The lowest (2.97) was obtained from conventional tillage method retained unweeded.

The longest spike (13.22cm) was obtained from interaction of conventional tillage method and application of 2, 4-D amine at 15 DAS. The shortest spike (8.63 cm) was obtained from stale seedbed technique withhand weeding at 25 DAS.

Table 7. Interaction effect of tillage method and weeding regime on yield attributes and yield of wheat

Treatment interaction	Plant height (cm)	Tillers per hill^{-1} (no.)	Effective tillers hill^{-1} (no.)	Non-effective tillers hill^{-1} (no.)	Spike length (cm)	Spikelet spike^{-1} (no.)	1000-grain weight (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
CTW_1	80.60a	4.14k	3.30i	0.84	10.00de	19.70cde	33.39	3.28fg	4.65cd	7.93h	41.36g
CTW_2	76.40ab	4.58j	3.68gh	0.90	9.63de	19.63cde	42.80	3.34fg	5.60a	8.94c	37.36de
CTW_3	79.25ab	5.17fg	4.03ef	1.13	9.34ef	20.21cd	45.59	3.53de	5.44de	8.97h	39.35c
CTW_4	77.06ab	4.55j	3.52h	1.03	10.60cd	18.49def	34.08	3.32fg	4.33de	7.65e	43.39g
CTW_5	78.57ab	4.69ij	3.46hi	1.23	9.92de	19.33cde	41.15	3.29fg	5.20b	8.49cd	38.75d
CTW_6	78.60ab	5.01gh	3.88fg	1.13	13.22a	20.69bc	43.04	3.73bc	5.82a	9.55b	39.05de
CTW_7	78.69ab	5.66d	4.73d	0.92	9.83de	20.67bc	45.85	3.22fg	4.65g	7.87f	40.91a
CTWF	80.80a	6.49b	5.49b	1.00	9.48ef	18.50def	40.72	3.85b	5.14b	8.99b	42.82b
CTUW	79.19ab	4.03k	2.97j	1.07	11.56b	17.50f	42.48	3.04h	5.69a	8.73fg	34.82h
SSW_1	79.00ab	4.86hi	3.83fg	1.03	9.76de	18.35ef	40.45	3.17gh	4.42de	7.59h	41.76fg
SSW_2	78.98ab	4.96gh	3.66gh	1.30	10.09de	21.17bc	46.52	3.22fg	4.54cd	7.76e	41.49c
SSW_3	76.51ab	5.38ef	4.22e	1.17	11.64b	20.20cd	54.64	3.67bcd	4.84fg	8.51fg	43.12bc
SSW_4	77.17ab	4.84hi	4.03ef	0.80	8.63f	20.53c	40.78	3.55de	4.63cd	8.18de	43.39bc
SSW_5	74.07b	5.38ef	4.56d	0.83	9.67de	20.57c	47.21	3.28fg	5.16ef	8.44g	38.86e
SSW_6	75.77ab	6.20c	5.24c	0.96	11.22bc	22.34b	51.83	3.82b	4.47de	8.29e	46.07bc
SSW_7	75.64ab	5.48de	4.59d	0.89	10.17de	21.10bc	38.18	3.61cd	4.86bc	8.47cd	42.62c
SSWF	74.33b	7.07a	6.12a	0.95	10.34cde	24.53a	47.00	4.09a	5.13b	9.22a	44.36a
SSUW	68.65c	4.97gh	3.08j	1.89	10.61cd	19.70cde	48.48	3.38ef	4.69g	8.07i	41.88f
$LSD_{(0.05}$	3.98	0.35	0.41	2.32	1.17	1.02	3.79	0.19	0.40	0.18	1.10
LS	*	**	**	NS	**	*	NS	**	**	**	**
CV (%)	6.34	4.17	3.06	4.09	4.21	3.72	11.69	6.62	6.98	7.33	7.69

CT = Conventional tillage, LSD= Least significant difference, SS = Stale seedbed technique, UW = Un weeded, WF = Weed free W_1 = Hand weeding (HW) at 15 DAS, W_2 = HW at 15 and 45 DAS, W_3 = HW at 25 and 45 DAS, W_4 = HW at 25 DAS, W_5 = HW at 25 and 60 DAS, W_6 = 2,4-D amine at 15 DAS, W_7 = 2,4-D amine at 15 DAS+ HW at 60 DAS, LS= Level of significance, CV= Coefficient of variance, * = Significant at 5% level of probability, ** = Significant at 1% level of probability, NS = Non significant

The highest number of spikelets spike^{-1} (24.53) was obtained from stale seedbed kept weed free, while the lowest number of spikelet spike^{-1} (17.50) was obtained from conventional tillage with remained unweeded. The highest grain yield (4.09 t ha^{-1}) was obtained from weed free treatment in stale seedbed technique and lowest grain yield (3.04 t ha^{-1}) was observed from unweeded treatment in conventional tillage method due to the poor performance of yield contributing characters like number of tillers hill^{-1} and grain spike^{-1}. Because severe weed infestation occurred in the plots due to competition for moisture, nutrients between weed and wheat plants. The highest straw yield (5.82 t ha^{-1}) was observed in conventional tillage method with 2,4-D amine at 15 DAS, while the lowest straw yield (3.69 t ha^{-1}) was observed in stale seed bed technique kept unweeded. The highest biological yield (9.52t ha^{-1}) was found in stale seedbed technique retained weed free, while the lowest biological yield (7.59 t ha^{-1}) was produced by stale bed technique with hand weeding at 15 DAS. The highest harvest index (46.07%) was observed in

stale bed technique remained weed free and the lowest (36.56%) was calculated in conventional tillage kept weedy check.

Results showed a great variation in weed seed bank. *Chenopodium album, Hedyotis corymbosa, Sonchus arvensis, Polygonum coccineum, Rotala ramosior*, *Lindernia procumbens, Lindernia hyssopifolia* were the most frequently occurring and most abundant weed species. Results also reveal that the stale seedbed technique appears to be a promising technology to obtain 13% higher wheat yield over the conventional tillage. Stale seedbed sprayed 2, 4-D amine at 15 days after sowing controlled weed successfully and attributed the maximum outcome.

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