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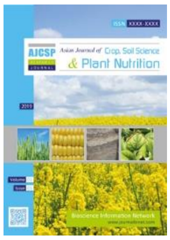

# Effect of herbicides on weed control and performance of wheat

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***ABSTRACT***

*An experiment was conducted to evaluate the weed control efficiency and wheat performance as affected by different types of herbicides at the Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh from November 2016 to March 2017. The experiment was laid out in a randomized complete block design and consists of four replications and eleven treatments viz. no weeding ($T_0$), L–Quat 20 SL as pre-emergence herbicide at 2 DAS ($T_1$), Affinity 50.75 WP as post-emergence herbicide at 23 DAS ($T_2$), $T_1$ + $T_2$ ($T_3$), $T_3$ + hand weeding at 40 DAS ($T_4$), Panida 33 EC as pre–emergence herbicide at 2 DAS ($T_5$), U–46D fluid as post-emergence herbicide at 23 DAS ($T_6$), $T_5$ + $T_6$ ($T_7$), $T_7$ + hand weeding at 40 DAS ($T_8$), $T_5$ + $T_1$ + $T_5$ + $T_6$ ($T_9$), $T_5$ + $T_2$ ($T_{10}$). Fourteen weed species namely Echinochloa cruss–galli, Echinochloa colona Cynodon dactylon, Digitaria sanguinalis, Paspalum distichum, Parapholis incurva, Cyperus rotundus, Chenopodium album, Polygonum hydropiper, Alternanthera sessilis, Oldenlandia corymbosa, Vicia sativa, Physalis heterophylla and Commelina diffusa were infested the experimental field belonging to 9 families where six were grasses, one was sedge and seven were broadleaves. Five most dominant weed species based on importance value in unweeded conditions at 15 DAS were Polygonum hydropiper > Cyperus rotundus > Echinochloa colona > Chenopodium album > Cynodon dactylon. But at 40 DAS and harvest the rank and order of above mentioned five most dominant weed species was differed and Commelina diffusa and Echinochloa cruss–galli were found at 40 DAS and at harvest, respectively instead of Chenopodium album. Both the weed density and dry weight were lowest in $T_8$ treatment followed by $T_4$ treatment at 15 DAS, 40 DAS and harvest. In case of weed control efficiency, these treatments along with $T_3$, $T_4$, $T_7$, $T_8$, $T_9$ and $T_{10}$ treatments produced the best result as "good control" in comparison to others which produce "fair control" efficiency at 40 DAS. But at harvest, only $T_4$ and $T_8$ produced as "good control" efficiency. The yield and yield components of BARI Gom 24 (Prodip) were statistically significant except the number of non–effective tillers hill$^{-1}$. The highest grain yield (5 t ha$^{-1}$) was recorded in the treatment $T_8$ which was statistically identical to the treatment $T_4$ due to having higher number of effective tillers hill$^{-1}$, higher number of spikelets spike$^{-1}$, higher number of filled grains spike$^{-1}$ and 1000-grain weight. The lowest grain yield (2.9 t ha$^{-1}$) was observed from the control (no weeding) treatment. The highest net returns (61473tk) and BCR (1.64) were obtained under the weed control $T_8$ treatment. It can be concluded that the treatment $T_8$ (Panida 33EC pre-emergence + U 46 D Fluid post–emergence + hand weeding once at 40 DAS) could be applied as the promising practice in wheat cultivation in terms of effective weed control, highest yield, highest economic returns and highest BCR.*

***Key Words:*** *Herbicide, IVW, WCE, Weed infestation, Weed density, Wheat and Yield*

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## I. Introduction

Wheat (*Triticum aestivum* L.) is considered as the second most important cereal crop because of its easier cultivation, higher nutrient content and ecological suitability in Bangladesh. From a nutritional point of view, wheat grain is rich in food value containing 12% protein, 1.72% fat, 69.60% carbohydrate and 27.20% minerals (BARI, 2004). Now-a-days, to ensure food security through only on rice production is a burning issue in Bangladesh, as there are many limitation in rice production. In such a condition, increasing wheat production can play a vital role. But there are many factors responsible for low yield of wheat where weed infestation is the major cause. Weeds belonging to the family Poaceae, Portulacaceae, Chenopodiaceae and Cyperaceae are the most common in the wheat field and cause yield loss of about 29–50% (Singh and Gosh, 1992). Wheat yield decreased could be as much as 30% under medium high and high weed infestation whereas yield loss may reach as much as 90% under very high weed infestation (TÓTH, 1999). Earlier only traditional method (land tillage, hand weeding and raking) was followed to control weed which was time-consuming, laborious as well as costly (Chowdhury et al., 1995) Later on, farmers got more benefits introducing herbicides in crop fields for controlling weeds as they respond quickly as well as less time consuming and cost-effective.

Statistics showed that the total use of herbicides was 5049.38 tons in Bangladesh in the year 2016 (BBS, 2018) compared to only 108 ton in 1989 (BBS, 1991) and the growth is almost exponential. Chemical weed control was proved to control weeds effectively, thus produced higher grain yield of wheat than hand weeding and may be increased about 37% (Shah and Habibullah, 2005; Baluch, 1993). In addition, Ahmed et al. (2000) reported that herbicidal weed control methods are more cost effective offering an advantage to save labour and cost of production of wheat in Bangladesh while Shamsi et al. (2001) indicated that the herbicides are the most effective formulation, reducing weed density and dry matter accumulation, giving the highest grain yield of wheat. However, single herbicide is not capable of controlling all the weeds at a time, so that the combination of herbicide may allow for field weed suppression to reducing the potential herbicide injury to crops. The combination of herbicides resulted in improved weed control over single application (Uddin et al., 2010). Mixtures of herbicides are often used to enhance efficiency and reduce selectivity (Green et al., 1995). From the above scenario, the study was conducted to find out the effective herbicide or their combination along with hand weeding for the control of weeds in wheat fields and to assess the cost effectiveness of different weed control methods.

## II. Materials and Methods

The experiment was conducted to evaluate the effect of herbicides on weed control and performance of wheat cv. Prodip at the Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh, during the period from November 2016 to March 2017. The experimental field was a high land belonging to the Old Brahmaputra Floodplain Agro Ecological Zone (AEZ) (UNDP and FAO, 1988). The soil of the experimental field was silty clay loam having pH 6.8. The experiment laid out in Randomized Complete Block Design (RCBD) and consisted of eleven treatments viz. no weeding, L-Quat 20 SL as pre-emergence herbicide at 2 DAS ($T_1$), Affinity 50.75 WP as post-emergence herbicide at 23 DAS ($T_2$), L-Quat 20 SL as pre-emergence at 2 DAS followed by Affinity 50.75 WP as post-emergence herbicide at 23 DAS ($T_3$) , L-Quat 20 SL as pre-emergence at 2 DAS followed by Affinity 50.75 WP as post-emergence herbicide at 23 DAS + Hand weeding at 40 DAS ($T_4$), Panida 33 EC as pre-emergence herbicide at 2 DAS ($T_5$), U-46D fluid as post emergence herbicide at 23 DAS ($T_6$), Panida 33 EC as pre-emergence herbicide at 2 DAS followed by U-46D fluid as post emergence herbicide at 23 DAS ($T_7$), Panida 33 EC as pre-emergence herbicide at 2 DAS followed by U-46D fluid as post emergence herbicide at 23 DAS + Hand weeding at 40 DAS ($T_8$), L-Quat 20 SL as pre-emergence herbicide at 2 DAS followed by U-46D fluid as post emergence herbicide at 23 DAS ($T_9$), Panida 33 EC as pre-emergence herbicide at 2 DAS followed by Affinity 50.75 WP as post emergence herbicide at 23 DAS ($T_{10}$).

The size of each unit plot was 10 m2 (2.5 m × 2 m) having 50 cm distance between two adjacent plots as well as 1 m distance between two replications. The land was prepared by using power tiller. The plots were fertilized with urea, triple super phosphate (TSP), muriate of potash (MoP), gypsum and boric acid at the rate of 220, 180, 50, 120, 6 kg ha$^{-1}$, respectively. A full dose of triple super phosphate, muriate of potash, gypsum, and boric acid were applied at final land preparation. And urea was applied in two equal splits– Two–third of urea was applied at land preparation and one–third of the urea was applied at 17 DAS after giving irrigation. Seeds were collected from Bangladesh Agriculture Development Corporation (BADC) marketing office Khagdohor, Mymensingh and sown in line on 20 November 2016 maintained 3–5 cm depth. Seed was covered with soil immediately after sowing to protect the seeds and seedlings from birds up to 20 DAS. Weeding operation was done as per experimental treatments where weeds were allowed to grow in the control plots throughout the growing season. The crop was irrigated once at the crown root initiation stage following flood irrigation at 20 DAS. Plant protection measures were not required, as the crop was free from insect and disease attack. The crop was harvested at full maturity on 20 March 2017. The data of weed parameters were collected at 15 and 40 DAS and at harvest. Weed parameters such as weed density (no. m$^{-2}$), weed dry weight (g m$^{-2}$), importance value of weed (%) and weed control efficiency (%) were recorded. Yield and yield contributing characters such as plant height, no. of total tillers hill$^{-1}$, no. of non–effective tillers hill$^{-1}$, no. of effective tillers hill$^{-1}$, spike length, no. of spikelets spike$^{-1}$, no. of filled grains spike$^{-1}$, no, of unfilled grains spike$^{-1}$ and thousand seed weight were collected and collected data were analyzed statistically using the “analysis of variance” technique and mean differences were adjudged by Duncan’s Multiple Range Test (DMRT) at 5% level (Gomez and Gomez, 1984).

## III. Results and Discussion

**Floristic composition of weeds:** A total of 14 weed species belonging to nine families infested the experimental crops of which six from Poaceae and one from each of the family: Cyperaceae, Chenopodiaceae, Polygonaceae, Amaranthaceae, Rubiaceae, Leguminosae, Solanaceae and Commelinaceae and annual outnumbered the perennial. Local names, English name, scientific name, family, morphological type, life cycle of these weeds have been presented in Table 01. Results showed that eight species were the most dominant viz. *Polygonum hydropiper, Chenopodium album, Cyperus rotundus, Cynodon dactylon, Physalis heterophylla, Echinochloa colona, Panicum repens* and *Alternanthera sessilis* which was most effective during the study. But other six species were not present in all the growing season. *Oldenlandia corymbosa* was present at 40 DAS and at harvest and *Digitaria sanguinalis*, *Vicia sativa, Echinochloa cruss–galli* and *Parapholis incurea* appeared at harvest. Only one weed, *Commelina diffusa*, was present at 40 DAS (Table 01).

**Infested weed species with their importance value at 15, 40 DAS and harvest**: At 15 DAS eight weed species belonging to six families were observed under different herbicidal weed control practices. The five most dominant weed species based on importance value were *Polygonum hydropiper* > *Cyperus rotundus* > *Echinochloa colonum* > *Chenopodium album* > *Cynodon dactylon* were present in ($T_0$, $T_2$, $T_3$, $T_4$, $T_6$, $T_7$, $T_8$, $T_9$, $T_{10}$) treatments. In case of $T_1$ and $T_5$ treatments, the rank and order of the five most dominant weed species differed and *Paspalum distichum* was found instead of *Cyperus rotundus* and *Cynodon dactylon* in $T_1$ and $T_5$ treatment, respectively. At 40 DAS five most important weed species were *Polygonum hydropiper* > *Cyperus rotundus* > *Commelina diffusa* > *Echinochloa colonum* > *Chenopodium album* was the dominant weed in $T_1$, $T_2$, $T_6$, $T_7$, $T_9$. In case of $T_3$–$T_5$, $T_8$ and $T_{10}$ treatment, the rank and order of the five most dominant weed species differed and in $T_3$ treatment *Cynodon dactylon* was found instead of *Commelina diffusa. Paspalum distichum* was found in $T_4$ and $T_5$ treatments and *Cynodon dactylon* in $T_8$ and $T_{10}$ instead of *Chenopodium album.* At harvest, the five most important weed species were *Polygonum hydropiper* > *Echinochloa cruss–galli* > *Cyperus rotundus* > *Cynodon dactylon* > *Echinochloa colonum* were the dominant weed species in $T_1$–$T_7$, $T_9$ and $T_0$ (Table 02 and Figure 01). The rank and order of the five most dominant weed species differed in $T_8$ and $T_{10}$ treatment. *Digitaria sanguinalis* was found in $T_{10}$ instead of *Echinochloa colonum*. In case of $T_8$ treatment, *Digitaria sanguinalis* and *Physalis heterophylla* were found instead of *Cyperus rotundus* and *Echinochloa colonum*. Kabir (2009) was experimented the Agronomy Field Laboratory, Bangladesh

Agricultural University; reported that *Cynodon dactylon, Polygonum hydropiper, Cyperus rotundus, Digitaria sanguinalis, Physalis heterophylla,* were the most important weed species in Wheat of the same site.

In unweeded conditions, the five most dominant weed species at 15 DAS based on importance value were *Polygonum hydropiper* > *Cyperus rotundus* > *Echinochloa colonum* > *Chenopodium album* > *Cynodon dactylon*. In case of 40 DAS and harvest the rank and order of five most dominant weed species differed and *Commelina diffusa* and *Echinochloa cruss–galli* were found at 40 DAS and harvest, respectively, instead of *Chenopodium album* (Table 02).

**Table 01. Floristic composition of the weeds in the experimental field at different days after sowing**

| Sl. no. | Local name | English name | Scientific name | Family name | Morpho–logical Types | Life cycle | Weeds at different DAS | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | 15 | 40 | Harvest |
| 1 | Boro Shama | Benyard grass | *Echinochloa cruss–galli* L. | Poaceae | Grass | Annual | _ | _ | + |
| 2 | Khude Shama | Jungle rice | *Echinochloa colonum* (L.) Link. | Poaceae | Grass | Annual | + | + | + |
| 3 | Durba | Bermuda grass | *Cynodon dactylon* (L.) Pers. | Poaceae | Grass | Perennial | + | + | + |
| 4 | Anguli | Scrab grass | *Digitaria sanguinalis* (L.) Scop. | Poaceae | Grass | Annual | _ | _ | + |
| 5 | Angta | Quack grass | *Paspalum distichum* L. | Poaceae | Grass | Perennial | + | + | + |
| 6 | Chela | Sheand weed | *Parapholis incurea* (L.) C.E.Hubb. | Poaceae | Grass | Annual | _ | _ | + |
| 7 | Mutha | Nut grass | *Cyperus rotundus* L. | Cyperaceae | Sedge | Perennial | + | + | + |
| 8 | Bathua | Lambs quarter | *Chenopodium album* L. | Chenopodiaceae | Broadleaved | Annual | + | + | + |
| 9 | Bishkataly | Smart weed | *Polygonum hydropiper* L. | Polygonaceae | Broadleaved | Annual | + | + | + |
| 10 | Chanchi | Chanchi | *Alternanthera sessilis* L. (R. Bn) | Amaranthaceae | Broadleaved | Perennial | + | + | + |
| 11 | Khetpapri | Lindernia | *Oldenlandia corymbosa* (L.) Lamk | Rubiaceae | Broadleaved | Annual | _ | + | + |
| 12 | Bon mosur | Wild lentil | *Vicia sativa* Lamk. | Liguminosae | Broadleaved | Annual | _ | _ | + |
| 13 | Foska Begun | Clammy ground–cherry | *Physalis heterophylla* L. | Solanaceae | Broadleaved | Annual | + | + | + |
| 14 | Monayna | Climbing dayflower | *Commelina diffusa* Burn. F. | Commelinaceae | Broadleaved | Perennial | _ | + | _ |

**Weed density**
Weed density ($m^{-2}$) was significantly influenced by weed control practices. The highest weed population (55.75 $m^{-2}$, 120.5 $m^{-2}$, 151.5 $m^{-2}$) was found in $T_0$ (no weeding) at 15 DAS, 40 DAS and harvesting, respectively (Table 03). At 15 DAS the lowest weed population (30 $m^{-2}$) was found in $T_5$ as Panida 33EC pre-emergence herbicide which was statistically identical to another $T_1$ and $T_8$ treatment. At 40 DAS the lowest population (15.5 $m^{-2}$) was found in ($T_8$). After that at harvesting, the lowest weed population (25.5 $m^{-2}$) was observed in $T_8$. A similar research finding was also reported by Rekha et al. (2002) who opined that weed density was lower in all weed control practices compared to the unweeded plot.

**Table 02. Infested weed species in the experimental field with their importance value (%) at 15 and 40 DAS and harvest**

| Times | Treatments | Khude Shama | Durba | Angta | Mutha | Bishkatali | Bathua | Foska Begun | Chanchi | Khetpapri | Monaayna | Boro shama | Anguli | Chela | Bon Mosur |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 15 DAS | $T_0$ | 8.16 | 1.78 | 0.89 | 28.51 | 55.01 | 4.56 | 0.40 | 0.69 | | | | | | |
| | $T_1$ | 20.11 | 3.74 | 3.03 | – | 60.05 | 11.06 | – | 2.01 | | | | | | |
| | $T_2$ | 9.30 | 1.95 | 1.85 | 32.25 | 44.82 | 7.03 | 1.11 | 1.69 | | | | | | |
| | $T_3$ | 12.10 | 3.36 | 1.44 | 22.01 | 50.50 | 10.35 | – | 0.24 | | | | | | |
| | $T_4$ | 9.39 | 3.47 | 1.73 | 32.26 | 47.63 | 5.63 | – | – | | | | | | |
| | $T_5$ | 11.76 | – | 2.33 | 21.39 | 59.94 | 4.58 | – | – | | | | | | |
| | $T_6$ | 13.54 | 2.05 | 1.23 | 34.48 | 60.96 | 6.82 | 1.07 | – | | | | | | |
| | $T_7$ | 13.96 | 3.37 | 2.41 | 41.27 | 44.02 | 6.31 | – | – | | | | | | |
| | $T_8$ | 8.69 | 1.44 | – | 42.75 | 51.68 | 3.03 | 1.30 | – | | | | | | |
| | $T_9$ | 15.37 | 2.84 | 2.07 | 21.74 | 47.74 | 8. 79 | 1.55 | – | | | | | | |
| | $T_{10}$ | 8.89 | 4.18 | 1.47 | 28.47 | 48.20 | 7.85 | 1.29 | – | | | | | | |
| 45 DAS | $T_0$ | 12.03 | 7.36 | 2.67 | 9.85 | 44.67 | 3.46 | 0.75 | | 1.23 | 17.98 | | | | |
| | $T_1$ | 9.45 | 2.32 | 3.01 | 21.80 | 43.57 | 5.11 | 0.90 | | 2.50 | 11.34 | | | | |
| | $T_2$ | 8.51 | 3.29 | 5.17 | 18.43 | 45.29 | 8.19 | – | | 1.45 | 9.67 | | | | |
| | $T_3$ | 11.07 | 3.36 | 1.98 | 23.28 | 55.40 | 3.73 | 1.18 | | – | – | | | | |
| | $T_4$ | 9.62 | 2.45 | 2.52 | 19.13 | 50.50 | 1.19 | 1.47 | | 1.85 | 10.77 | | | | |
| | $T_5$ | 8.88 | 2.91 | 3.88 | 18.78 | 47.95 | | 1.61 | | 2.45 | 13.54 | | | | |
| | $T_6$ | 8.89 | 4.08 | 4.17 | 13.09 | 46.32 | 8.31 | 2.52 | | 0.90 | 11.72 | | | | |
| | $T_7$ | 7.49 | 5.59 | 4.35 | 20.23 | 40.86 | 6.17 | 1.23 | | – | 14.08 | | | | |
| | $T_8$ | 8.21 | 4.70 | 3.42 | 20.19 | 42.27 | – | 3.08 | | 2.59 | 15.54 | | | | |
| | $T_9$ | 7.47 | 4.65 | 1.93 | 19.43 | 46.62 | 5.70 | 3.07 | | – | 12.13 | | | | |
| | $T_{10}$ | 10.54 | 4.34 | – | 20.26 | 49.01 | – | 1.52 | | – | 13.94 | | | | |
| At harvest | $T_0$ | 9.70 | 9.83 | 0.90 | 11.91 | 50.50 | 3.06 | 0.37 | 1.07 | 0.74 | | 10.82 | 0.38 | 0.69 | 0.64 |
| | $T_1$ | 6.93 | 8.40 | 4.82 | 10.84 | 41.45 | 6.69 | 2.04 | – | 4.19 | | 12.91 | 1.73 | – | – |
| | $T_2$ | 8.48 | 9.47 | 7.80 | 10.43 | 40.32 | 6.83 | – | – | 3.09 | | 13.27 | 2.31 | – | – |
| | $T_3$ | 5.37 | 7.89 | 4.65 | 9.46 | 41.75 | 5.30 | – | 2.31 | 2.05 | | 10.50 | 2.92 | 1.09 | 1.16 |
| | $T_4$ | 9.08 | 9.54 | 5.90 | 10.95 | 40.38 | 7.19 | – | 3.54 | 2.34 | | 15.12 | 4.96 | – | – |
| | $T_5$ | 7.80 | 9.04 | 3.29 | 9.60 | 40.92 | 6.23 | 2.15 | – | 5.30 | | 13.30 | 2.37 | – | – |
| | $T_6$ | 7.35 | 8.71 | 3.33 | 11.53 | 40.50 | 6.01 | 1.83 | – | 2.06 | | 15.38 | 2.68 | 0.62 | – |
| | $T_7$ | 7.32 | 8.10 | 3.60 | 10.81 | 40.72 | 5.76 | 2.50 | – | 2.48 | | 16.04 | 1.64 | 1.03 | – |
| | $T_8$ | – | 17.08 | 4.38 | – | 56.32 | – | 5.58 | – | 1.24 | | 8.32 | 7.35 | – | – |
| | $T_9$ | 6.15 | 7.47 | 3.05 | 10.62 | 48.60 | 3.15 | 3.34 | 2.47 | – | | 13.12 | 3.03 | – | – |
| | $T_{10}$ | 5.85 | 9.00 | 4.56 | 11.20 | 42.97 | – | – | – | 4.33 | | 15.01 | 7.08 | – | – |

$T_0$: No weeding, $T_1$: L–Quat 20 SL as pre–emergence herbicide at 2 DAS, $T_2$: Affinity 50.75 WP as post–emergence herbicide at 23 DAS, $T_3$: $T_1$ + $T_2$, $T_4$: $T_3$ + hand weeding at 40 DAS, $T_5$: Panida 33 EC as pre–emergence herbicide at 2 DAS, $T_6$: U–46D fluid as post emergence herbicide at 23 DAS, $T_7$: $T_5$ + $T_6$, $T_8$: $T_7$ + hand weeding at 40 DAS, $T_9$: $T_5$ + $T_1$ + $T_5$ + $T_6$, $T_{10}$: $T_2$ + $T_5$.

## Weed dry weight

The highest weed dry weight (72.85 g m$^{-2}$, 150.8 g m$^{-2}$, 204.90 g m$^{-2}$) of weed was found in $T_0$ ( no weeding ) at 15 DAS, 40 DAS and harvesting, respectively (Table 04). Similar to weed density the lowest dry weight (17.2 g m$^{-2}$) of weed was recorded in ($T_5$) at 15 DAS. At 40 DAS the lowest weed dry weight (25.54 g. m$^{-2}$) was found in ($T_8$). After that at harvesting the lowest dry weight (34.25 g. m$^{-2}$) was also observed in $T_8$ (Table 03).

## Weed control efficiency (%)

The grading of weed control efficiency varied with different weed control practices (Table 03). It is important to mention here that the treatments pre-emergence followed by post-emergence herbicides like $T_3$, $T_4$, T7 - T9 and $T_{10}$ gave the best result as "good control" (70.02-86.07%) in comparison to other at 40 DAS. The four other treatments $T_1$, $T_2$, $T_5$ and $T_6$ which were single application of herbicide either pre-emergence or post-emergence had "fair control" (57.73-64.07%) efficiency (Table 03). At harvest, the effect of both pre-emergence followed by post-emergence herbicide + hand weeding, like $T_8$ and $T_4$ the most effective for controlling weed in comparison to others which provided "good control" (75.21-83.28%). On the other hand, the treatments $T_3$, $T_7$, $T_9$ and $T_{10}$ in which pre-emergence herbicide followed by post-emergence herbicides were used, had "fair control" efficiency. Among the single application of herbicide either pre-emergence or post-emergence produce "poor control" efficiency except for $T_5$ treatment where Panida 33EC was used and $T_5$ treatment produce "fair control" efficiency (Table 03).

From the result, it is showed that weed control efficiency at harvest was lower than the weed control efficiency at 40 DAS except $T_4$ and $T_8$ where hand weeding was applied at 40 DAS. This is because of that the herbicides used singly or in combination gradually lost their control efficiency over weed. Besides this new weeds emerged throughout the growing season. But in case of $T_4$ and $T_8$ manual weeding practice was used along with the herbicidal application. Ravisankar et al., (2013) found a similar result concluding the highest weed control efficiency of chemicals with manual hand weeding.

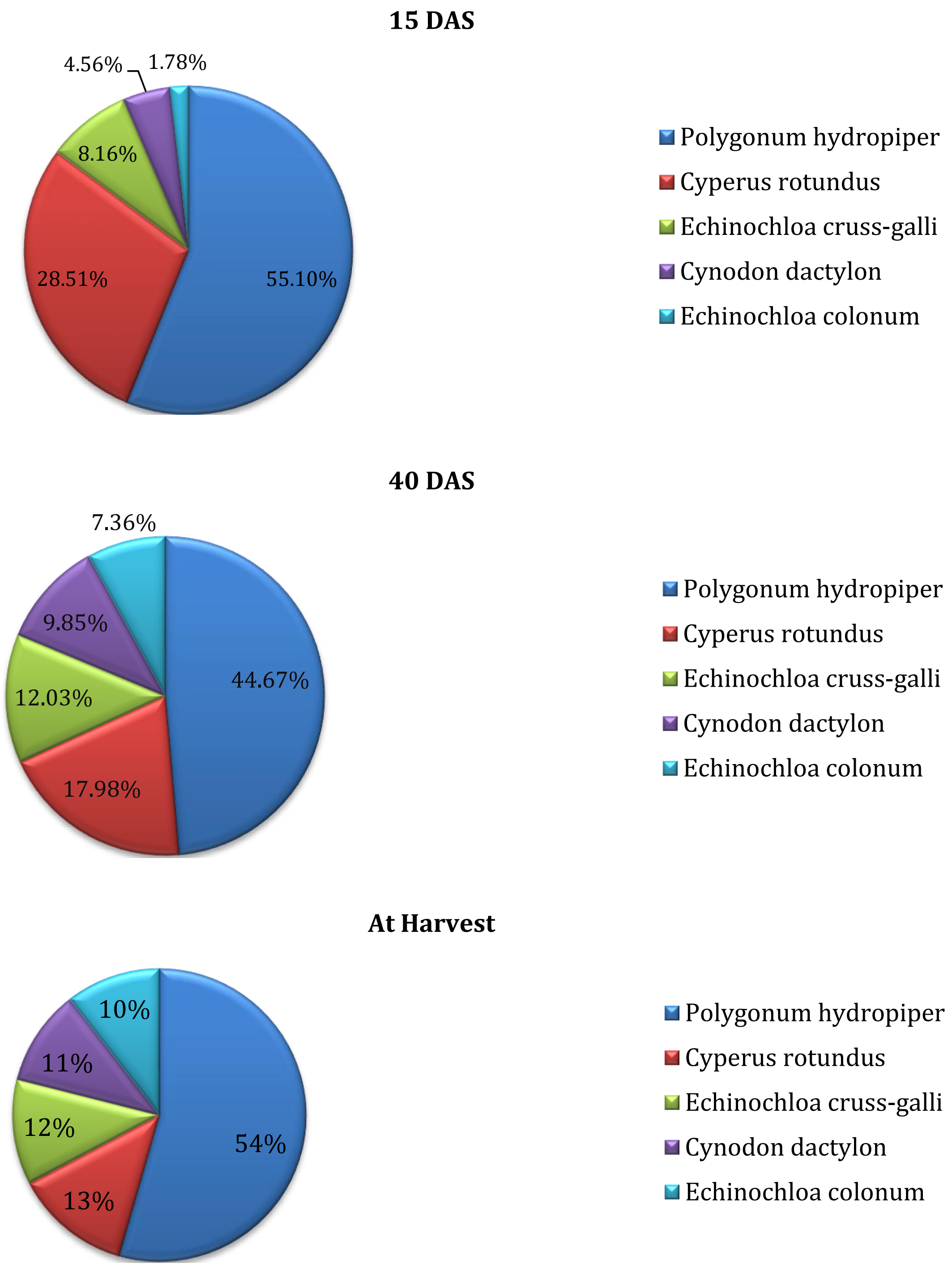


**Figure 01. Five most important weed at 15, 40 DAS and at harvest based on importance value of weed**

**Table 03. Effect of treatments on weed density, dry weight and weed control efficiency at different days after sowing**

| Treatments | Weed density at different DAS | | | Weed dry weight (gm$^{-2}$) at different DAS | | | Weed control efficiency at | |
|---|---|---|---|---|---|---|---|---|
| | 15 | 40 | Harvest | 15 | 40 | Harvest | 40 | Harvest |
| Unweeded ($T_0$) | 55.75a | 120.5a | 151.5a | 72.85a | 150.8a | 204.90a | 0.00 NC | 0.00 |
| L–Quat 20SL as pre–emergence ($T_1$) | 30.50d | 45.25c | 80.25d | 17.40d | 58.23bc | 124.50c | 61.37 FC | 39.03 PC |
| Affinity 50.75WP as post–emergence ($T_2$) | 41.50b | 52.75b | 96.75b | 23.66b | 63.75b | 130.60b | 57.73 FC | 36.24 PC |
| L–Quat 20SL+ Affinity 50.75WP= ($T_3$) | 36.50c | 29.50ef | 64.00f | 20.81c | 44.28d | 86.40e | 70.64 GC | 57.82 FC |
| L–Quat 20SL+Affinity 50.75WP+Hand weeding ($T_4$) | 35.25c | 20.50g | 47.25i | 20.20c | 35.73e | 50.78h | 76.31 GC | 75.21 GC |
| Panida 33EC as pre–emergence ($T_5$) | 30.00d | 40.25d | 73.00e | 17.20d | 54.18c | 98.55d | 64.07 FC | 51.89 FC |
| U 46 D Fluid as post–emergence ($T_6$) | 42.75b | 48.75bc | 86.25c | 24.36b | 58.79bc | 127.40bc | 61.01 FC | 37.16 PC |
| Panida 33EC+U 46 D Fluid ($T_7$) | 36.25c | 28.50ef | 56.75g | 20.78c | 42.53d | 76.61f | 72.10 GC | 62.60 FC |
| Panida 33EC+U 46 D Fluid+Hand weeding ($T_8$) | 30.25d | 15.50h | 25.50j | 17.34d | 25.54f | 34.25i | 86.06 GC | 83.28 GC |
| L–Quat 20SL+U 46 D Fluid ($T_9$) | 33.75c | 31.25e | 66.00f | 19.35cd | 45.20d | 89.10e | 70.02 GC | 40.57 FC |
| Panida 33EC+Affinity 50.75WP ($T_{10}$) | 35.50c | 25.75f | 52.75h | 20.35c | 40.37de | 71.21g | 73.23 GC | 65.24 FC |
| $LSD_{0.05}$ | 2.73 | 4.01 | 3.21 | 2.41 | 5.47 | 4.48 | – | – |
| Sx | 0.943 | 1.39 | 1.11 | 0.834 | 1.89 | 1.55 | – | – |
| Level of significance | ** | ** | ** | ** | ** | ** | – | – |
| CV (%) | 5.09 | 6.66 | 3.06 | 6.70 | 6.73 | 3.12 | – | – |

In a column, mean values with same letter (s) or without letter do not differ significantly whereas mean values with dissimilar letter differ significantly (as per DMRT); ** =Significant at 1% level of probability
CC= Complete control (100%), EC= Excellent control (90–99%), GC= Good control (70–89%), FC= Fair control (40–69%), PC= Poor control (20–39%), SC= Slightly control (1–19%) and NC= No control (0%)

### Yield and yield Contributing Characters of wheat

**Plant height:** It was found that the highest plant height was observed in $T_8$ which was identical to $T_4$. The lowest plant height (78.80 cm) was recorded under no weeding treatments which were identical to $T_1$ and $T_2$ (Figure 02). Hasan (2008) observed that plant height of wheat reduced due to competition of weeds.

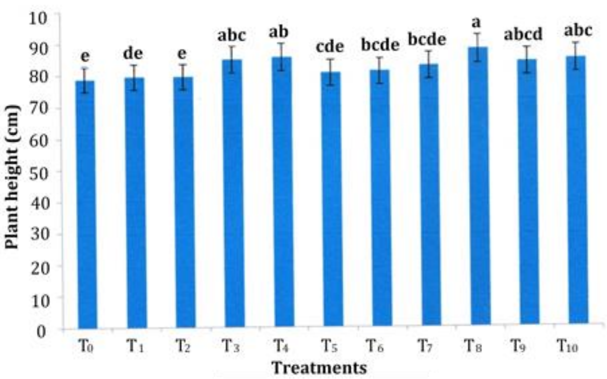


**Figure 02. Effect of herbicidal weed control practices on plant height of wheat**

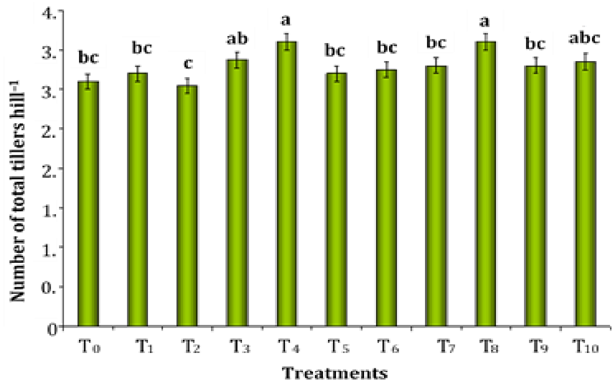


**Figure 03. Effect of herbicidal weed control practices on number of total tillers hill$^{-1}$ of wheat**

$T_0$: No weeding, $T_1$: L–Quat 20 SL as pre–emergence herbicide at 2 DAS, $T_2$: Affinity 50.75 WP as post–emergence herbicide at 23 DAS, $T_3$: $T_1$ + $T_2$, $T_4$: $T_3$ + hand weeding at 40 DAS, $T_5$: Panida 33 EC as pre–emergence herbicide at 2 DAS, $T_6$: U–46D fluid as post-emergence herbicide at 23 DAS, $T_7$: $T_5$ + $T_6$, $T_8$: $T_7$ + hand weeding at 40 DAS, $T_9$: $T_5$ + $T_1$ + $T_5$ + $T_6$, $T_{10}$: $T_5$ + $T_2$

**Number of total tillers hill$^{-1}$**: The highest number of tillers hill$^{-1}$ (3.6) was observed in $T_8$ (Panida 33EC as pre-emergence + U-46 D Fluid as post-emergence and hand weeding at 40 DAS) which was statistically identical to $T_4$. The lowest number of tillers hill$^{-1}$ (3.05) was observed at no weeding ($T_0$) treatment which was identical to $T_2$ (Figure 03). Sharma et al. (2005) reported that different weed management treatments reduced weed population and thereby decreased weed-crop competition during the entire growth stage. Thus increases tillers and other yield attributes.

**Number of effective tillers hill$^{-1}$ and non-effective tillers hill$^{-1}$:** Similar to total tiller hill$^{-1}$ the highest number of effective tillers hill$^{-1}$ (3.27) was produced from the treatment $T_8$ which was statistically identical to $T_4$ (Table 04). The lowest number of effective tillers hill$^{-1}$ (2.57) was observed from no weeding treatment (Table 04). Similar result was reported by (Nahar, 2014) as weed infestation decreased the number of effective tillers hill$^{-1}$. The effect of herbicidal weed control treatment on the number of non-effective tillers hill$^{-1}$ was non-significant.

**Number of spikelets spike$^{-1}$:** The number of spikelets spike$^{-1}$ was different ($p>0.01$) as different weed control treatments ranged from (11.15- 13.23) (Table 04). The highest number of spikelets spike$^{-1}$ (13.23) was observed in chemical weed control $T_8$ which was statistically similar to $T_4$ and the treatment $T_{10}$ at 40 DAS. Crop weed competition was higher in unweeded plot and hence the lowest number of spikelets spike$^{-1}$ was produced (Table 04). A similar research finding was also reported by Parvez et al. (2013) for *T. aman* rice.

**Table 04. Effect of weed control practices on yield and yield contributing characters of wheat including percentage of yield grain**

| Treatments | No. of effective tillers hill$^{-1}$ | No. of spikelets spike$^{-1}$ | No. of filled grains spike$^{-1}$ | No. of sterile spikelets spike$^{-1}$ | 1000 seed weight (g) | Grain yield (t ha$^{-1}$) | Yield gain (%) |
|---|---|---|---|---|---|---|---|
| $T_0$ | 2.57 c | 11.15 c | 25.77 e | 1.25a | 40.78 e | 2.90 d | 00.00 |
| $T_1$ | 2.75 bc | 11.82 bc | 25.98 de | 1.00 bc | 42.53 de | 3.45 c | 18.97 |
| $T_2$ | 2.75 bc | 11.24 c | 25.89 de | 1.08 ab | 43.66 cd | 3.27 c | 12.76 |
| $T_3$ | 2.85 b | 12.57 ab | 29.39ab | 0.85 cd | 45.66 ab | 4.50 b | 55.17 |
| $T_4$ | 3.15 a | 13.22 a | 30.52 a | 0.81 cd | 46.67 a | 4.80 a | 65.52 |
| $T_5$ | 2.75 bc | 12.44 ab | 27.15 de | 0.94 bcd | 44.56 bc | 3.50 c | 20.69 |
| $T_6$ | 2.75 bc | 11.86 bc | 27.80 cd | 0.91 bcd | 41.15 e | 3.30 c | 13.79 |
| $T_7$ | 2.90 b | 12.72 ab | 29.67 ab | 0.90 bcd | 46.10 ab | 4.72 ab | 62.76 |
| $T_8$ | 3.27a | 13.23 a | 30.76 a | 0.77 d | 47.00 a | 5.00 a | 72.41 |
| $T_9$ | 2.85 b | 12.46 ab | 28.15 bc | 0.85 cd | 44.99abc | 4.30 b | 48.28 |
| $T_{10}$ | 2.95 b | 12.98 a | 29.73 ab | 0.82 cd | 46.33 ab | 4.7 ab | 63.79 |
| $LSD_{0.05}$ | 0.188 | 0.937 | 2.10 | 0.182 | 1.83 | 0.223 | – |
| Sx | 0.065 | 0.324 | 0.726 | 0.063 | 0.634 | 0.077 | – |
| Level of sig. | ** | ** | ** | ** | ** | ** | – |
| CV (%) | 4.49 | 5.26 | 5.14 | 13.48 | 2.85 | 3.75 | – |

$T_0$: No weeding, $T_1$: L–Quat 20 SL as pre-emergence herbicide at 2 DAS, $T_2$: Affinity 50.75 WP as post-emergence herbicide at 23 DAS, $T_3$: $T_1$ + $T_2$, $T_4$: $T_3$ + hand weeding at 40 DAS, $T_5$: Panida 33 EC as pre-emergence herbicide at 2 DAS, $T_6$: U–46D fluid as post-emergence herbicide at 23 DAS, $T_7$: $T_5$ + $T_6$, $T_8$: $T_7$ + hand weeding at 40 DAS, $T_9$: $T_5$ + $T_1$ + $T_5$ + $T_6$, $T_{10}$: $T_5$ + $T_2$ In a column, mean values with same letter (s) or without letter do not differ significantly whereas mean values with dissimilar letter differ significantly (as per DMRT); ** =Significant at 1% level of probability

**Spike length**

The longest spike (15.79 cm) was recorded from treatment $T_8$ (Panida 33EC followed by U-46 D Fluid + hand weeding) and the shortest spike (9.52 cm) was recorded from no weeding treatment (Figure 04). A similar result was also found by Karim and Mamun (1988) and Okafor (1987) who reported that spike length was reduced due to the competitive stress of weeds.

**Number of filled grains spike$^{-1}$**

Significantly, the highest filled grains spike$^{-1}$ (30.76) was produced by the treatment $T_8$ which was statistically similar to the treatment $T_4$ (Table 04). The lowest number (25.77) of filled grains spike$^{-1}$ was recorded by no weeding (control) treatment).

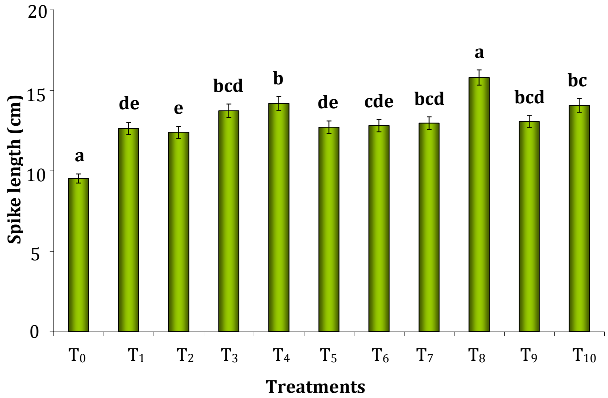


**Figure. 04. Effect of herbicidal weed control practices on spike length (cm) of wheat**

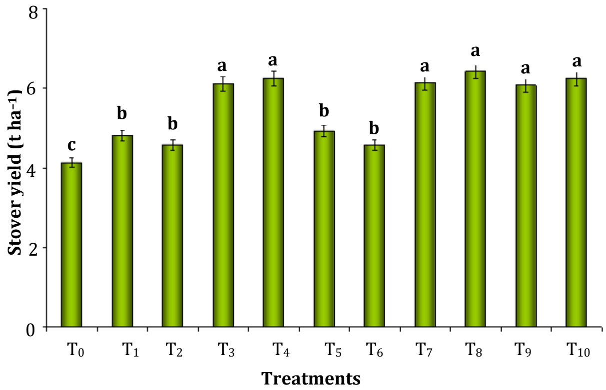


**Figure 05. Effect of herbicidal weed control practices on stover yield of wheat**

$T_0$: No weeding, $T_1$: L–Quat 20 SL as pre–emergence herbicide at 2 DAS, $T_2$: Affinity 50.75 WP as post–emergence herbicide at 23 DAS, $T_3$: $T_1 + T_2$, $T_4$: $T_3$ + hand weeding at 40 DAS, $T_5$: Panida 33 EC as pre–emergence herbicide at 2 DAS, $T_6$: U–46D fluid as post emergence herbicide at 23 DAS, $T_7$: $T_5 + T_6$, $T_8$: $T_7$ + hand weeding at 40 DAS, $T_9$: $T_5 + T_1 + T_5 + T_6$, $T_{10}$: $T_5 + T_2$

**Number of sterile spikelets spike$^{-1}$**

The lowest (0.77) unfilled grains spike$^{-1}$ were recorded from the treatment $T_8$ at 40 DAS. The highest number of unfilled grains spike$^{-1}$ (1.25) was recorded in no weeding treatments.(Table 04). The results showed that unfilled grains spike$^{-1}$ decreased with the increasing frequency of weeding treatments. Similar results were also reported by Okafor (1987) and Karim and Mamun (1988).

**1000-grain weight**

The highest 1000-grain weight (47.00 g) was recorded in treatment $T_8$ which was statistically identical to the treatment $T_4$ at 40 DAS (Table 04). Mamun and Salim (1989) and Singh and Singh (1996) also recorded a reduction in 1000 grain weight due to weed competition.

**Grain yield:** The highest grain yield (5 t ha$^{-1}$) was obtained from the treatment ($T_8$), which was statistically identical to another weed control treatment $T_4$. Pre-emergence followed by post-emergence herbicidal treatment showed moderate grain yield viz. $T_{10}$ and $T_7$. The lowest grain yield (2.90 t ha$^{-1}$) was obtained from no weeding treatment (Table 04). The highest grain yield in treatment $T_8$ and $T_4$ might be resulted due to the highest number of effective tillers hill$^{-1}$, nubmer of spikelets spike$^{-1}$, nubmer of filled grains spike$^{-1}$ and 1000-grain weight. Rahman (1985), Mamun and Salim (1989), Phogat et al. (1991) and Malik et al. (1992) also observed a reduction in grain yield in wheat due to weed competition, by 28.96%, 46.97% 25.01% and 28.08%, respectively.

**Straw yield:** The maximum straw yield (6.42 t ha$^{-1}$) was produced under both treatment $T_8$ at 40 DAS which was statistically identical to the treatment $T_3$, $T_4$, $T_7$, $T_9$ and $T_{10}$ where both pre and post-emergence herbicide were applied (Figure 05). The lowest straw yield (4.13 t ha$^{-1}$) was produced by no weed control treatment received (Figure 05). Rahman (1985), Mamun and Salim (1989) and Singh and Singh (1996) also observed a reduction in straw yield in wheat due to weed competition, respectively by 31.90%, 31.74%, 44.10%.

**Harvest index (%):** The highest (43.78%) harvest index was obtained from the treatment $T_8$ (Panida 33EC + U-46 D Fluid + hand weeding at 40 DAS). The lowest harvest index (41.25%) was obtained from no weeding treatment (Figure 06). A similar research finding was also reported by Salek (2014) who observed that weed management practices showed the highest harvest index compared with unweeded condition.

**Percent Yield Gain in Wheat over Weed Control:** Percent yield gain varied with different weed control practices was given Table 05. The highest yield gain 72.41% was recorded under $T_8$ treatment (pre-emergence as Panida 33EC + post-emergence as U-46 D Fluid + hand weeding at 40 DAS) followed by the treatment $T_4$, $T_{10}$, $T_7$, $T_3$ and $T_9$ (Table 05). The lowest yield gain (0.00%) was recorded in the control condition.

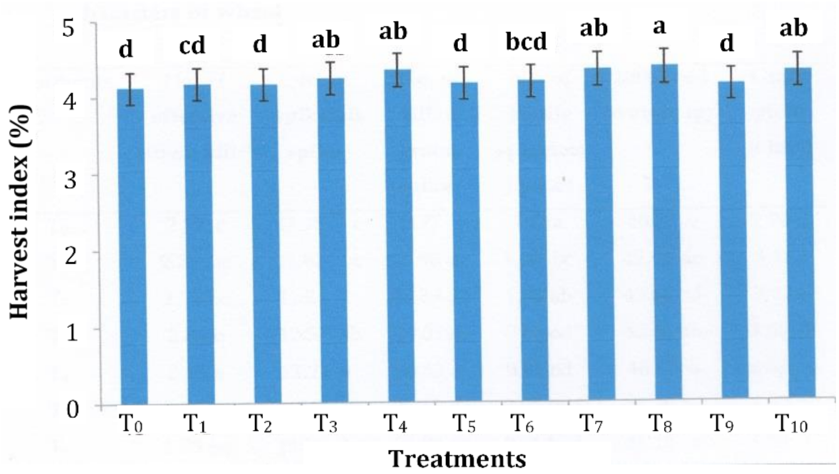


**Figure 06. Effect of herbicidal weed control practices on Harvest index (%) of wheat**

$T_0$: No weeding, $T_1$: L–Quat 20 SL as pre-emergence herbicide at 2 DAS, $T_2$: Affinity 50.75 WP as post-emergence herbicide at 23 DAS, $T_3$: $T_1$ + $T_2$, $T_4$: $T_3$ + hand weeding at 40 DAS, $T_5$: Panida 33 EC as pre-emergence herbicide at 2 DAS, $T_6$: U–46D fluid as post-emergence herbicide at 23 DAS, $T_7$: $T_5$ + $T_6$, $T_8$: $T_7$ + hand weeding at 40 DAS, $T_9$: $T_5$ + $T_1$ + $T_5$ + $T_6$, $T_{10}$: $T_5$ + $T_2$

**Table 05. Grain yield and percent yield gain in wheat due to herbicidal weed control**

| Weed control practices | BARI Gom 24 (Prodip) | |
|---|---|---|
| | Grain yield ( t ha$^{-1}$) | Yield gain (%) |
| $T_0$ | 2.90d | 00.00 |
| $T_1$ | 3.45c | 18.97 |
| $T_2$ | 3.27c | 12.76 |
| $T_3$ | 4.50b | 55.17 |
| $T_4$ | 4.80a | 65.52 |
| $T_5$ | 3.50c | 20.69 |
| $T_6$ | 3.30c | 13.79 |
| $T_7$ | 4.72ab | 62.76 |
| $T_8$ | 5.00a | 72.41 |
| $T_9$ | 4.30b | 48.28 |
| $T_{10}$ | 4.75ab | 63.79 |

**Economics of treatments**

**Net returns:** It is obvious from the data (Table 06) that a net return from wheat was influenced to a great extent by different weed control treatments. The treatment $T_8$ provided the highest net return of 61473 tk ha$^{-1}$, which excelled in the rest of the treatments. The other treatment such as $T_4$, $T_{10}$, $T_7$, $T_3$, $T_9$, $T_5$, $T_1$, $T_6$, $T_2$ and unweeded condition ($T_0$) provided additional net returns of taka 55454, 46818, 45783, 40835, 39800, 17813, 10948, 8628, 6663, 4982 ha$^{-1}$ respectively. The highest mean B:C ratio of 1.64 was recorded with the treatment $T_8$ (Panida 33EC as pre-emergence + U 46 D Fluid as post-emergence + hand weeding at 40 DAS) that was significantly higher followed by $T_4$, $T_{10}$, $T_7$, $T_3$, $T_9$, $T_5$, $T_1$, $T_6$, $T_2$ and $T_0$ with the B:C values 1.59, 1.57, 1.55, 1.54, 1.46, 1.24, 1.23, 1.17, 1.16, 1.06, respectively (Table 06). From this experiment, it can be concluded that application of Panida 33EC @ 2.5 L ha$^{-1}$ + U 46 D Fluid 3 L ha$^{-1}$ + hand weeding once at 40 DAS is the best treatment in terms of economic returns and BCR for controlling weeds and having considerable yield increase in wheat

**Table 06. Net returns and B: C ratio in wheat due to herbicidal weed control**

| Treatments | Net returns (Taka ha$^{-1}$) | B:C ratio |
|---|---|---|
| $T_0$ = Unweeded | 6019 | 1.06 |
| $T_1$= L–Quat 20SL as pre–emergence | 20638 | 1.23 |
| $T_2$ =Affinity 50.75WP as post–emergence | 14655 | 1.16 |
| $T_3$= L–Quat 20SL+ Affinity 50.75WP | 50525 | 1.54 |
| $T_4$ = L–Quat 20SL+ Affinity 50.75WP+Hand weeding | 56491 | 1.59 |
| $T_5$=Panida 33EC as pre–emergence | 21673 | 1.24 |
| $T_6$ =U 46 D Fluid as post–emergence | 15690 | 1.17 |
| $T_7$= Panida 33EC+ U 46 D Fluid | 52845 | 1.55 |
| $T_8$ = Panida 33EC+ U 46 D Fluid +Hand weeding | 61473 | 1.64 |
| $T_9$= L–Quat 20SL+ U 46 D Fluid | 43660 | 1.46 |
| $T_{10}$ = Panida 33EC+ Affinity 50.75WP | 54810 | 1.57 |

## V. Conclusion

Finally, it can be concluded that pre-emergence Panida 33EC + post-emergence U 46 D Fluid + hand weeding at 40 DAS could be applied as the promising practice in wheat cultivation in terms of weed control, yield and economic returns. However, further studies would be necessary to confirm this result to evaluate the effectiveness and potentiality of this weed management practice for successful weed control, better yield and economic returns in wheat.

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