*Indian Journal of Weed Science* **52**(2): 116–122, 2020

Print ISSN 0253-8040 Online ISSN 0974-8164

# Herbicide combinations effect on weeds and yield of wheat in North-Eastern plain

**Dhiman Mukherjee**

*Department of Agronomy, Bidhan Chandra Krishi Vishwavidyalaya, Kalyani, West Bengal 741 235, India*
*Email: dhiman_mukherjee@yahoo.co.in*

**Article information**

**DOI:** 10.5958/0974-8164.2020.00021.0

**Type of article:** Research article

**Received** : 22 February 2020
**Revised** : 27 May 2020
**Accepted** : 29 May 2020

**Key words**
Herbicide

Microbial population

Weed

Wheat

Yield

**ABSTRACT**

A field experiment was conducted at District Seed Farm (AB Block), Kalyani under Bidhan Chandra Krishi Vishwavidyalaya during winter season of 2016-17 and 2017-18 in upland situation to evaluate the effect of various herbicides and it's combinations against different weed species and yield of wheat under new alluvial zone. The experiment was carried out in a randomized block design with eleven treatments in three replications. Total weed density at 30 days after spray, was recorded minimum with halauxifen-methyl-ester + florasulam + carfentrazone 10.21 + 20 g/ha and it was at par with the metsulfuron + carfentrazone 4 + 20 g/ha and considerably better than all other control measures except weed free situation. At 30 days after spray, least total weed biomass was observed with the 2,4-D E + carfentrazone 400 + 20 g/ha and showed parity with the halauxifen + florasulam + carfentrazone 10.21 + 20 g/ha, metsulfuron + carfentrazone 4 + 20 g/ha and halauxifen-methyl ester + florasulam 12.76 g/ha and statistically better than all other treatments except weed free situation. Amongst various herbicidal treatments, total weed density at 60 days after spray, lowest with halauxifen-methyl-ester + florasulam 12.76 g/ha and was at par with most of the treatments except 2,4-D Na 500 g/ha, 2,4-D Na + carfentrazone 400 + 20 g/ha and weedy check. This treatment also registered low weed biomass. The soil microbial population was significantly affected by weed control measures at 60 days after sowing.Higher grain yield of wheat was observed in weed free (4.80 t/ha) and was at par with metsulfuron + carfentrazone 4 + 20 g/ha (4.56 t/ha), halauxifen-methyl ester + florasulam + carfentrazone 10.21 + 20 g/ha (4.44 t/ha) and 2,4-D E + carfentrazone 400 + 20 g/ha (4.40 t/ha) and significantly better than other treatments. Total nutrient uptake by crop was highest in weed free and was at par with metsulfuron + carfentrazone 4 + 20 g/ha and significantly better to other treatments. From the study. It was concluded that use of metsulfuron + carfentrazone 4 + 20 g/ha resulted in maximum wheat yield followed by halauxifen-methyl ester + florasulam + carfentrazone 10.21 + 20 g/ha.

## INTRODUCTION

North eastern plain zone is not a traditional wheat (*Triticum aestivum* L.) growing area in India. However, at present, this crop became a staple food crop next to rice and its consumption is gradually increasing because of change in food habit and economic prosperity. In spite of a wide range of adoptability, little attention has been paid towards wheat production and maximization of yield potential of this crop in this state (West Bengal, Bihar, Jharkhand *etc*.) and its share to national production is less than 1%. Productivity of 2.8 t/ha is also far below the national average of 3.14 t/ha (Mukherjee 2018). The productivity of wheat in this zone is very low due to the continuous adoption of cereal-cereal (rice-wheat) cropping system, poor weed management, poor soil health and imbalance fertilizer use. Wheat is infested with diverse type of weed flora, as it is grown under diverse agro-climatic conditions, different cropping sequence, tillage and irrigation regimes (Meena *et al*. 2019). Weed infestation is one of the major biotic constraints in wheat production and weeds reduce wheat yield up to 60% if not controlled at the critical stages of crop (Yadav *et al.* 2019). Chemical weed control is a preferred practice due to unavailability of labour and high labour costs (Mukherjee *et al*. 2011). Also there is lesser feasibility of mechanical or manual weeding in wheat. Hence chemical weed control is a preferred practice due to scarce and costly labour as well as

lesser feasibility of mechanical or manual weeding (Mukherjee *et al*. 2011). The effect of herbicide application on soil health (microbial environment) is a great concern as it may affect the microbial growth (Kumar *et al.* 2014). Keeping all these in view, the present investigation was carried out to find out herbicidal effect on soil health and yield of wheat under new alluvial zone of West Bengal.

## MATERIALS AND METHODS

The field experiment was conducted at District Seed Farm (AB Block), Kalyani under Bidhan Chandra Krishi Viswavidyalaya during winter season of 2016-17 and 2017-18 in upland situation. The farm is situated at approximately 22° 56′ N latitude and 88° 32′ E longitude with an average altitude of 9.75 m above mean sea level (MSL). The soil of the experimental field was loamy in texture and almost neutral in reaction having pH 7.2, organic carbon 0.44%, available nitrogen 241.6 kg, available phosphorus 22.9 kg and available potassium 251.6 kg/ha. The aim of this research is to assess paradigm (new ready-mix broad-leaf weeds herbicide) combinations with other herbicides with different mode of action on both broad and narrow leaf weeds affecting wheat crops under new alluvial zone.

The experiment was carried out in a randomized block design, replicated thrice with eleven treatment namely halauxifen methyl-ester + florasulam 40.85 WG + surfactant polyglycol 26-2 N (12.76 + 750 ml/ ha), metsulfuron + surfactant (4 + 625 ml/ha), carfentrazone (20 g/ha), 2,4-D Na (500 g/ha), 2,4-D E (500 g/ha), metsulfuron + carfentrazone + surfactant (4.0 g + 20 g + 625 ml/ha), 2,4-D Na + carfentrazone (400 + 20 g/ha), 2,4-D E + carfentrazone (400 + 20 g/ha), halauxifen-methyl + florasulam + carfentrazone + surfactant (10.21 + 20 g + 750 ml/ha), weedy check and weed free. Wheat cultivar "*HD 2967*" was used for this experiment. The sowing of crop was done on 7th November, 2016 and 12th November, 2017 with recommended seed rate of 100 kg/ha using 150 kg N, 60 kg P and 40 kg K/ha. All herbicides were applied 28 days after sowing (DAS) with the help of knapsack sprayer fitted with flat fan nozzle at spray volume of 500 l/ha. Weed density and biomass were recorded at 30 and 60 days after spray (DASP) by placing a quadrate of 50 x 50 cm randomly at two spots in each plot. Data on weed density and biomass were subjected to square root transformation before statistical analysis. The experimental data were analysed statistically by applying the technique of analysis of variance (ANOVA) prescribed for the design to test the significance of overall difference among treatments by the F test and conclusions were drawn at 5% probability level (Gomez and Gomez 1984).

## RESULTS AND DISCUSSION

### Weed density

At 30 days after spray (DASP), post-emergence application of halauxifen-methyl ester + florasulam + carfentrazone 10.21 + 20 g/ha recorded the lowest density of *Eleusine indica* and was statistically better to other treatments (**Table 1**). Halauxifen-methyl is considered to mimic to plant growth hormone auxin, resulting in the disruption of growth processes in susceptible plants. Cellular effects include alterations in cell wall elasticity and gene expression. Additionally, non- productive tissue growth is induced, resulting in epinasty and phloem disruption, preventing the movement of photosynthates and causing death in days to weeks. Rest of the treatments are followed to these treatments. The results corroborate the findings of Mahmoud *et al*. (2016). Amongst broad-leaf weeds, minimum density of *Chenopodium album* and *Melilotus alba* was with the 2,4-D E + carfentrazone 400 + 20 g/ha and was at par with the halauxifen-methyl ester + florasulam + carfentrazone 10.21 + 20 g/ha for control of *Melilotus* species and significantly better to other treatments. This corroborate with the finding of Siveran *et al.* (2020). The density of *Vicia hirsuta* was completely checked with the halauxifen + florasulam + carfentrazone 10.21 + 20 g/ha, metsulfuron + carfentrazone 4 + 20 g/ha and halauxifen-methyl ester + florasulam 12.76 g/ha and was at par with the weed free situation. *Rumex spinosus* density was completely checked by 2,4-D E 500 g/ha and was at par with the weed free situation. The use of 2,4-D E + carfentrazone 400 + 20 g/ha and 2,4-D Na 500 g/ha produced less broad-leaf weed density and statistically better to other treatments except weed free situation. Similarly, effectiveness of carfentrazone and 2,4-D against various broad-leaf weeds has already been reported by Balyan and Malik (2000). Carfentrazone 20 g/ha was effective against *Cyperus difformis* and was at par with metsulfuron 4 g/ha and statistically superior to all the treatments except weed free situation.

At 60 days after spray, halauxifen-methyl ester + florasulam + carfentrazone 10.21 + 20 g/ha recorded lowest density of *Eleusine indica* and was statistically at par with 2,4-D E + carfentrazone 400 + 20 g/ha, 2,4-D Na + carfentrazone 400 + 20 g/ha and carfentrazone 20 g/ha and significantly better to other

herbicidal control measures (**Table 2**). Effect of halauxifen-methyl ester + florasulam on grassy weed was also reported by Mahmoud *et al.* (2016). Minimum density of *Chenopodium album* was observed with carfentrazone 20 g/ha and was at par only with metsulfuron + carfentrazone 4 + 20 g/ha and statistically better than all other treatments either in alone or mixed application of herbicides. The density of *Melilotus alba* was lowest with the halauxifen-methyl ester + florasulam 12.76 g/ha and was significantly better than all other herbicidal treatments (**Table 2**). Lowest density of *Vicia hirsuta* was observed with halauxifen-methyl ester + florasulam + carfentrazone 10.21 + 20 g/ha and was at par with 2,4-D Na 500 g/ha and halauxifen methyl-ester + florasulam 12.76 g/ha. and notably better than other. Significantly lower density of *Rumex spinosus* was observed with halauxifen-methyl ester + florasulam + carfentrazone 10.21 + 20 g/ha and was at par with the metsulfuron 4 g/ha. This corroborate with the earlier finding of Yadav *et al.* (2019).

**Weed biomass**

Weed biomass was significantly influenced by various treatments at 30 and 60 DASP (**Table 3** and **4**). Lowest weed biomass of *Eleusine indica* was observed in weed free and was at par with the the halauxifen-methyl ester + florasulam + carfentrazone 10.21 + 20 g/ha metsulfuron + carfentrazone 4 + 20 g/ha, carfentrazone 20 g/ha, halauxifen-methyl ester + florasulam 12.76 g/ha and metsulfuron 4 g/ha at 30 and 60 DASP (**Table 3**). The lowest weed biomass of *Cynodon dactylon* occurred with carfentrazone 20 g/ha and was significantly superior to all other treatments except weed free situation. The lowest biomass of *Chenopodium album* and *Melilotus alba* was observed with 2,4-D E + carfentrazone 400 + 20 g/ha and was at par with weed free situation and statistically superior to all other weed control measures except halauxifen-methyl ester + florasulam + carfentrazone 10.21 + 20 g/ha for *Melilotus alba.* Dry biomass of *Vicia hirsuta* was lowest in weed free at 30 DASP, and was at par with all other treatments except carfentrazone 20 g/ha and 2,4-D E 500 g/ha. However at 60 DASP, biomass of *Vicia hirsuta* was least with halauxifen-methyl ester + florasulam + carfentrazone 10.21 + 20 g/ha and was at par with halauxifen-methyl ester + florasulam 12.76 g/ha, 2,4-D Na 500 g/ha and metsulfuron + carfentrazone 4 + 20 g/ha and significantly better than all other herbicidal treatments. Significantly lower biomass of *Rumex spinosus* was observed with 2,4-D E 500 g/ha and was at par with the weed free at 30 DASP. Moreover at 60 DASP, low biomass of *Rumex*

**Table 1. The density (no./m$^2$) of major weed species at 30 days after herbicides spray (no./m$^2$) as affected by weed control treatments (pooled data of two years)**

| Treatment | Grasses | | Broad-leaf weeds | | | | | Sedges | |
|---|---|---|---|---|---|---|---|---|---|
| | *Eleusine indica* | *Cynodon dactylon* | *Chenopodium album* | *Melilotus alba* | *Vicia hirsuta* | *Rumex spinosus* | Other minor BLW | *Cyperus difformis* | *Cyperus iria* |
| Halauxifen-methyl + florasulam (12.76 g/ha) | 1.22 (1.00) | 2.42 (5.36) | 2.03 (6.33) | 1.81 (2.78) | 0.71 (0.00) | 2.19 (4.33) | 4.22 (17.36) | 2.71 (6.96) | 1.68 (2.33) |
| Metsulfuron (4 g/ha) | 2.63 (6.42) | 1.91 (3.13) | 4.26 (12.33) | 2.86 (7.66) | 1.36 (1.36) | 1.66 (2.27) | 2.78 (7.23) | 2.19 (4.33) | 2.61 (6.35) |
| Carfentrazone (20 g/ha) | 1.69 (2.36) | 1.43 (1.56) | 2.12 (4.00) | 3.03 (8.66) | 2.04 (3.65) | 1.41 (5.33) | 3.45 (11.44) | 1.95 (3.33) | 2.90 (7.91) |
| 2,4-D Na (500 g/ha) | 2.90 (7.89) | 2.04 (3.65) | 3.49 (11.66) | 2.86 (7.66) | 1.08 (0.66) | 1.76 (2.61) | 2.04 (3.65) | 3.02 (8.66) | 3.02 (8.63) |
| 2,4-D E (500 g/ha) | 3.03 (8.69) | 3.61 (12.54) | 3.34 (10.66) | 2.48 (5.66) | 1.26 (1.08) | 0.71 (0.00) | 2.59 (6.21) | 2.59 (10.00) | 3.10 (9.11) |
| Metsulfuron + carfentrazone (4 + 20 g/ha) | 1.31 (1.21) | 2.12 (4.02) | 1.68 (2.33) | 1.54 (1.87) | 0.71 (0.00) | 2.10 (3.91) | 2.57 (6.15) | 2.27 (4.66) | 2.52 (5.89) |
| 2,4-D Na + carfentrazone (400 + 20 g/ha) | 1.62 (2.12) | 2.47 (5.62) | 3.49 (11.66) | 1.68 (2.33) | 1.51 (1.78) | 2.27 (4.66) | 2.04 (3.65) | 3.09 (9.06) | 3.24 (10.00) |
| 2,4-D E + carfentrazone (400 + 20 g/ha) | 2.04 (3.65) | 2.16 (4.18) | 1.22 (1.00) | 1.08 (0.67) | 1.10 (0.71) | 1.26 (1.07) | 2.65 (6.55) | 2.72 (6.91) | 2.48 (5.69) |
| Halauxifen-methyl + florasulam + carfentrazone (10.21 + 20 g/ha) | 0.89 (0.30) | 2.03 (3.65) | 2.18 (4.25) | 1.22 (1.00) | 0.71 (0.00) | 1.65 (2.22) | 3.43 (11.33) | 2.04 (3.65) | 1.43 (1.56) |
| Weedy check | 3.61 (12.6) | 4.26 (17.65) | 3.98 (15.36) | 3.28 (10.23) | 2.40 (5.24) | 3.98 (15.36) | 5.08 (25.36) | 3.27 (10.23) | 3.61 (12.56) |
| Weed free | 0.71 (0.00) | 0.71 (0.00) | 0.71 (0.00) | 0.71 (0.00) | 0.71 (0.00) | 0.71 (0.00) | 0.71 (0.00) | 0.71 (0.00) | 0.71 (0.00) |
| LSD (p=0.05) | 0.23 | 0.35 | 0.32 | 0.19 | 0.30 | 0.22 | 0.32 | 0.26 | 0.30 |

Data analyzed after square root transformation ($\sqrt{x+0.5}$); Figures in parentheses are original values

**Table 2. The density (no. /m$^2$) of major weed species at 60 days after herbicides spray as affected by weed control treatments (pooled data of two years)**

| Treatment | Grasses | | Broad-leaf weeds | | | | | Sedges | |
|---|---|---|---|---|---|---|---|---|---|
| | *Eleusine indica* | *Cynodon dactylon* | *Cheno-podium album* | *Melilotus alba* | *Vicia hirsuta* | *Rumex spinosus* | Other minor BLW | *Cyperus difformis* | *Cyperus iria* |
| Halauxifen-methyl + florasulam (12.76 g/ha) | 1.98 (3.44) | 3.29 (10.36) | 3.58 (12.33) | 2.37 (5.11) | 1.98 (3.44) | 3.33 (10.64) | 5.56 (30.51) | 3.35 (10.76) | 3.71 (13.33) |
| Metsulfuron (4 g/ha) | 3.24 (10.00) | 3.55 (12.11) | 4.10 (16.33) | 3.21 (9.78) | 2.38 (5.16) | 2.74 (7.01) | 5.26 (27.23) | 3.39 (11.00) | 3.13 (9.35) |
| Carfentrazone (20 g/ha) | 3.04 (8.77) | 2.24 (4.56) | 2.55 (6.00) | 4.18 (17.00) | 2.92 (8.05) | 3.67 (13.00) | 5.14 (25.98) | 2.81 (7.43) | 4.30 (18.00) |
| 2,4-D Na (500 g/ha) | 3.39 (10.98) | 4.48 (19.65) | 5.02 (24.69) | 3.75 (13.54) | 1.87 (3.00) | 3.67 (12.98) | 6.64 (43.65) | 4.73 (21.89) | 5.19 (26.44) |
| 2,4-D E (500 g/ha) | 3.88 (14.58) | 4.47 (19.54) | 4.08 (16.11) | 3.17 (9.56) | 2.95 (8.18) | 3.14 (9.36) | 4.74 (22.01) | 4.18 (17.00) | 4.73 (21.88) |
| Metsulfuron + carfentrazone (4 + 20 g/ha) | 3.32 (10.55) | 3.56 (12.19) | 3.61 (12.53) | 4.42 (19.07) | 2.44 (5.44) | 3.72 (13.36) | 4.31 (18.15) | 4.45 (19.33) | 3.39 (11.00) |
| 2,4-D Na + carfentrazone (400 + 20 g/ha) | 2.92 (8.03) | 3.62 (12.61) | 4.68 (21.36) | 4.18 (17.00) | 3.14 (9.33) | 3.48 (11.66) | 5.84 (33.65) | 4.36 (18.55) | 4.10 (16.31) |
| 2,4-D E + carfentrazone (400 + 20 g/ha) | 2.77 (7.15) | 3.41 (11.18) | 3.14 (9.36) | 4.02 (15.69) | 3.72 (13.36) | 3.97 (15.33) | 5.36 (28.31) | 4.29 (17.92) | 3.25 (10.09) |
| Halauxifen-methyl + florasulam + carfentrazone (10.21 + 20 g/ha) | 2.61 (6.30) | 3.48 (11.65) | 3.88 (14.55) | 4.40 (18.87) | 1.68 (2.33) | 2.54 (5.95) | 4.88 (23.33) | 4.01 (15.65) | 4.22 (17.33) |
| Weedy check | 5.35 (28.16) | 6.41 (40.65) | 5.39 (35.11) | 4.44 (19.25) | 5.48 (29.56) | 6.46 (41.33) | 7.40 (54.36) | 5.66 (31.54) | 4.84 (22.96) |
| Weed free | 0.71 (0.00) | 0.71 (0.00) | 0.71 (0.00) | 0.71 (0.00) | 0.71 (0.00) | 0.71 (0.00) | 0.71 (0.00) | 0.71 (0.00) | 0.71 (0.00) |
| LSD (p=0.05) | 0.53 | 0.48 | 0.60 | 0.57 | 0.43 | 0.58 | 0.61 | 0.55 | 0.59 |

DASP – Days after spray; Data analyzed after square root transformation ($\sqrt{x+0.5}$); Figures in parentheses are original values

**Table 3. The weed biomass (g/m$^2$) of major weeds at 30 days after herbicides spray as affected by weed control treatments (pooled data of two years)**

| Treatment | Grassy weeds | | Broad-leaf weeds | | | | | Sedges | |
|---|---|---|---|---|---|---|---|---|---|
| | *Eleusine indica* | *Cynodon dactylon* | *Cheno-podium album* | *Melilotus alba* | *Vicia hirsuta* | *Rumex spinosus* | Other minor BLW | *Cyperus difformis* | *Cyperus iria* |
| Halauxifen-methyl + florasulam (12.76 g/ha) | 0.72 (0.02) | 1.54 (1.89) | 1.44 (1.56) | 1.17 (0.88) | 0.71 (0.00) | 1.42 (1.53) | 2.03 (3.65) | 1.35 (1.33) | 1.01 (0.53) |
| Metsulfuron (4 g/ha) | 0.91 (0.32) | 1.17 (0.87) | 2.12 (3.98) | 1.35 (1.32) | 0.94 (0.39) | 1.26 (1.10) | 1.68 (2.33) | 1.46 (1.65) | 1.56 (1.95) |
| Carfentrazone (20 g/ha) | 0.75 (0.06) | 0.85 (0.23) | 1.18 (0.89) | 1.62 (2.11) | 1.31 (1.22) | 1.42 (1.53) | 2.11 (3.98) | 1.07 (0.65) | 1.58 (2.01) |
| 2,4-D Na (500 g/ha) | 1.28 (1.13) | 1.23 (1.02) | 1.78 (2.66) | 1.47 (1.66) | 0.74 (0.05) | 1.18 (0.91) | 1.21 (0.98) | 1.68 (2.33) | 1.61 (2.11) |
| 2,4-D E (500 g/ha) | 1.31 (1.19) | 1.77 (2.65) | 2.15 (4.11) | 1.41 (1.48) | 1.08 (0.66) | 0.71 (0.00) | 1.57 (1.98) | 1.90 (3.11) | 1.87 (3.01) |
| Metsulfuron + carfentrazone (4 + 20 g/ha) | 0.90 (0.31) | 1.21 (0.98) | 1.17 (0.87) | 1.03 (0.56) | 0.71 (0.00) | 1.22 (0.99) | 1.62 (2.13) | 1.21 (0.98) | 1.52 (1.81) |
| 2,4-D Na + carfentrazone (400 + 20 g/ha) | 1.01 (0.53) | 1.35 (1.33) | 2.01 (3.56) | 1.17 (0.88) | 0.75 (0.06) | 1.20 (0.96) | 1.23 (1.02) | 1.69 (2.36) | 1.74 (2.54) |
| 2,4-D E + carfentrazone (400 + 20 g/ha) | 1.21 (0.97) | 1.31 (1.22) | 0.77 (0.09) | 0.77 (0.09) | 0.77 (0.09) | 0.92 (0.36) | 1.68 (2.33) | 1.38 (1.41) | 1.60 (2.09) |
| Halauxifen-methyl + florasulam + carfentrazone (10.21 + 20 g/ha) | 0.74 (0.05) | 1.19 (0.93) | 1.22 (0.98) | 0.93 (0.36) | 0.71 (0.00) | 1.09 (0.69) | 2.27 (4.66) | 1.22 (1.00) | 0.87 (0.26) |
| Weedy check | 1.85 (2.93) | 1.92 (3.22) | 2.04 (3.66) | 2.05 (3.69) | 1.54 (1.88) | 2.18 (4.22) | 2.86 (7.69) | 1.86 (2.98) | 1.82 (2.81) |
| Weed free | 0.71 (0.00) | 0.71 (0.00) | 0.71 (0.00) | 0.71 (0.00) | 0.71 (0.00) | 0.71 (0.00) | 0.71 (0.00) | 0.71 (0.00) | 0.71 (0.00) |
| LSD (p=0.05) | 0.25 | 0.22 | 0.24 | 0.28 | 0.23 | 0.19 | 0.31 | 0.32 | 0.29 |

Data analyzed after square root transformation ($\sqrt{x+0.5}$); Figures in parentheses are original values.

*spinosus* was observed with metsulfuron + carfentrazone 4 + 20 g/ha and was statistically similar with all other chemical treatments except carfentrazone 20 g/ha and 2,4-D E + carfentrazone 400 + 20 g/ha. *Cyperus difformis* biomass was least found free, however at 60 DASP, least biomass found with carfentrazone 20 g/ha and was at par with the metsulfuron 4 g/ha and halauxifen-methyl ester + florasulam 12.76 g/ha and significantly better to other treatments. *Cyperus iria* biomass was lowest in the weed free and was at par with halauxifen + florasulam + carfentrazone 10.21 + 20 g/ha.

At 30 and 60 DASP, lowest total weed density was observed registered with halauxifen-methyl ester + florasulam + carfentrazone 10.21 + 20 g/ha and it was at par with the metsulfuron + carfentrazone 4 + 20 g/ha and considerably better to all other control measures except weed free situation (**Table 5**). At 30 DAS, least total weed biomass was observed with

**Table 4. The weed biomass (g /m²) of major weed at 60 days after herbicides spray as affected by weed control treatments (pooled data of two years)**

| Treatment | Grassy weeds | | Broad-leaf weeds | | | | | Sedges | |
|---|---|---|---|---|---|---|---|---|---|
| | *Eleusine indica* | *Cynodon dactylon* | *Chenopodium album* | *Melilotus alba* | *Vicia hirsuta* | *Rumex spinosus* | Other minor BLW | *Cyperus difformis* | *Cyperus iria* |
| Halauxifen-methyl + florasulam (12.76 g/ha) | 1.56 (1.92) | 2.93 (8.09) | 3.32 (10.51) | 2.12 (3.98) | 1.77 (2.63) | 2.72 (6.92) | 4.70 (21.60) | 2.93 (8.13) | 3.57 (12.25) |
| Metsulfuron (4 g/ha) | 2.13 (4.02) | 2.37 (5.11) | 3.26 (10.16) | 2.77 (7.20) | 2.97 (8.33) | 2.69 (6.77) | 4.22 (17.36) | 2.74 (7.05) | 3.15 (9.45) |
| Carfentrazone (20 g/ha) | 1.96 (3.36) | 2.04 (3.66) | 3.11 (9.19) | 3.61 (12.54) | 3.40 11.05) | 3.94 (15.02) | 4.63 (20.98) | 2.37 (5.15) | 3.55 (12.12) |
| 2,4-D Na (500 g/ha) | 2.05 (3.69) | 3.52 (11.92) | 4.01 (15.61) | 3.19 (9.66) | 1.47 (1.65) | 3.32 (10.52) | 5.44 (29.11) | 3.75 (13.61) | 3.67 (12.98) |
| 2,4-D E (500 g/ha) | 2.33 (4.95) | 3.55 (12.11) | 3.19 (9.66) | 1.41 (1.48) | 2.04 (3.65) | 2.59 (6.23) | 3.47 (11.54) | 3.60 (12.51) | 4.69 (21.51) |
| Metsulfuron + carfentrazone (4 + 20 g/ha) | 2.00 (3.52) | 3.02 (8.66) | 2.89 (7.87) | 2.89 (7.83) | 1.69 (2.36) | 2.48 (5.68) | 3.38 (10.93) | 3.62 (12.65) | 3.36 (10.81) |
| 2,4-D Na + carfentrazone (400 + 20 g/ha) | 2.04 (3.66) | 3.47 (11.54) | 3.59 (12.36) | 3.58 (12.33) | 2.56 (6.06) | 2.90 (7.96) | 4.42 (19.11) | 3.85 (14.36) | 3.41 (11.03) |
| 2,4-D E + carfentrazone (400 + 20 g/ha) | 1.84 (2.88) | 2.69 (6.78) | 2.62 (6.34) | 3.01 (8.55) | 3.41 (11.11) | 3.55 (12.11) | 3.28 (10.31) | 3.27 (10.21) | 3.69 (13.14) |
| Halauxifen-methyl + florasulam + carfentrazone (10.21 + 20 g/ha) | 1.31 (1.21) | 2.82 (7.44) | 3.10 (9.08) | 4.08 (16.11) | 1.57 (1.98) | 2.80 (7.36) | 3.94 (15.06) | 2.93 (8.12) | 3.27 (10.26) |
| Weedy check | 4.75 (22.11) | 6.66 (43.89) | 5.75 (32.56) | 4.96 (24.11) | 4.48 19.55) | 3.08 (8.99) | 6.66 (43.98) | 4.76 (22.18) | 4.51 (19.81) |
| Weed free | 0.71 (0.00) | 0.71 (0.00) | 0.71 (0.00) | 0.71 (0.00) | 0.71 (0.00) | 0.71 (0.00) | 0.71 (0.00) | 0.71 (0.00) | 0.71 (0.00) |
| LSD (p=0.05) | 0.48 | 0.70 | 0.78 | 0.64 | 0.51 | 0.66 | 0.79 | 0.62 | 0.64 |

Data analyzed after square root transformation ($\sqrt{x+0.5}$); Figures in parentheses are original values

**Table 5. The total weed density, biomass, WCE and nutrient uptake by weeds as affected by weed control treatments (pooled data of two years)**

| Treatment | Weed density (at 30 DASP) (no./m²) | Weed density (at 60 DASP) (no./m²) | Weed biomass (at 30 DASP) (g/m²) | Weed biomass (at 60 DASP) (g/m²) | WCE (at 30 DASP) (%) | WCE (at 60 DASP) (%) | Nutrient uptake by weeds (kg/ha) | | | Total uptake by weeds (kg/ha) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | N | P | K | |
| Halauxifen-methyl + florasulam (12.76 g/ha) | 6.85(46.4) | 10.02(99.9) | 3.45(11.4) | 8.87(78.1) | 65.58 | 66.78 | 6.14 | 1.67 | 6.02 | 13.83 |
| Metsulfuron (4 g/ha) | 7.18(51.1) | 10.41(108.0) | 3.80(13.9) | 8.71(75.4) | 57.95 | 67.90 | 6.90 | 1.93 | 6.21 | 15.04 |
| Carfentrazone (20 g/ha) | 6.98(48.2) | 10.45(108.8) | 3.63(12.7) | 9.67(93.1) | 61.66 | 60.47 | 8.84 | 3.56 | 8.98 | 21.38 |
| 2,4-D Na (500 g/ha) | 7.45(55.1) | 13.32(176.8) | 3.64(12.7) | 10.50(108.7) | 61.45 | 53.74 | 9.94 | 5.04 | 10.78 | 25.76 |
| 2,4-D E (500 g/ha) | 8.03(63.9) | 11.78(138.2) | 4.32(18.2) | 9.17(83.6) | 45.01 | 64.42 | 8.02 | 3.11 | 8.42 | 19.55 |
| Metsulfuron + carfentrazone (4 + 20 g/ha) | 5.53(30.0) | 11.05(121.6) | 3.02(8.6) | 7.75(59.5) | 73.91 | 74.69 | 2.81 | 0.81 | 2.36 | 5.88 |
| 2,4-D Na + carfentrazone (400 + 20 g/ha) | 7.17(50.9) | 12.21(148.5) | 3.71(13.2) | 9.95(98.4) | 59.97 | 58.14 | 5.12 | 1.43 | 5.62 | 12.17 |
| 2,4-D E + carfentrazone (400 + 20 g/ha) | 5.56(30.4) | 11.35(128.4) | 3.02(8.6) | 9.05(81.4) | 73.85 | 65.36 | 3.98 | 1.13 | 4.98 | 10.09 |
| Halauxifen-methyl + florasulam + carfentrazone (10.21 + 20 g/ha) | 5.33(28.0) | 10.79(116.0) | 3.07(8.9) | 8.78(76.6) | 73.00 | 67.41 | 3.11 | 0.95 | 3.06 | 6.96 |
| Weedy check | 11.18(124.5) | 17.42(302.9) | 5.79(33.1) | 15.30(235.1) | - | - | 19.31 | 4.01 | 13.36 | 36.68 |
| Weed free | 0.71(0.0) | 0.71(0.0) | 0.71(0.0) | 0.71(0.0) | 100 | 100 | 0.00 | 0.00 | 0.00 | 0.00 |
| LSD (p=0.05) | 1.11 | 2.03 | 0.52 | 0.83 | - | - | 1.52 | 0.29 | 1.61 | 3.54 |

DASP – Days after spray; Data analyzed after square root transformation ($\sqrt{x+0.5}$); Figures in parentheses are original values

2,4-D E + carfentrazone 400 + 20 g/ha and was at par with halauxifen-methyl ester + florasulam + carfentrazone 10.21 + 20 g/ha, metsulfuron + carfentrazone 4 + 20 g/ha and halauxifen-methyl ester + florasulam 12.76 g/ha. The total weed biomass at 60 DASP was least with metsulfuron + carfentrazone 4 + 20 g/ha and was significantly superior to all other treatments except weed free situation. The weed control efficiency (WCE) was highest at 30 and 60 DASP with metsulfuron + carfentrazone 4 + 20 g/ha and was followed by 2,4-D E + carfentrazone 400 + 20 g/ha at 30 DASP, and metsulfuron 4 g/ha at 60 DASP. Nutrients uptake by weeds was minimum with the metsulfuron + carfentrazone 4 + 20 g/ha and was at par with the halauxifen-methyl ester + florasulam + carfentrazone 10.21 + 20 g/ha and 2,4-D E + carfentrazone 400 + 20 g/ha and notably better to other treatments.

**Soil microbial population**

The soil microbial population was significantly affected by various weed control measures at different stages (**Table 6**). However, after the crop harvest, there was no toxic effect on microbial population due to degradation of herbicides by micro-organism which resulted in improved microbial population. Among different weed control practices, weed free recorded maximum microbial population as reported by Kumar *et al.* (2014) and Singh *et al.* (2015).

**Yield**

The growth parameter was significantly affected by weed control treatments (**Table 7**), The results were in consistent with the findings of Singh *et al*. (2003) and Mukherjee (2012). Higher grain

**Table 6. The soil microbial population as affected by weed control treatments (pooled data of two years)**

| Treatment | Bacteria (CFU x $10^7$/ g soil) | | | Fungi (CFU x $10^3$ / g soil) | | | Actinomycetes (CFU x $10^4$ / g soil) | | |
|---|---|---|---|---|---|---|---|---|---|
| | Initial | 60 DAS | Harvest | Initial | 60 DAS | Harvest | Initial | 60 DAS | Harvest |
| Halauxifen-methyl + florasulam (12.76g/ha) | 6.21 | 8.33 | 12.32 | 3.15 | 4.77 | 7.32 | 8.98 | 5.23 | 10.26 |
| Metsulfuron (4 g/ha) | 6.87 | 4.95 | 13.36 | 3.64 | 5.65 | 8.36 | 8.33 | 5.36 | 12.33 |
| Carfentrazone (20 g/ha) | 6.11 | 4.68 | 13.14 | 4.16 | 3.37 | 8.32 | 9.17 | 6.32 | 9.22 |
| 2,4-D Na (500 g/ha) | 6.93 | 7.34 | 15.32 | 3.98 | 6.87 | 7.36 | 9.25 | 5.11 | 11.98 |
| 2,4-D E (500 g/ha) | 6.11 | 3.38 | 10.23 | 3.43 | 3.11 | 11.32 | 9.17 | 4.36 | 9.87 |
| Metsulfuron + carfentrazone (4 + 20 g/ha) | 6.13 | 11.92 | 16.32 | 4.46 | 7.27 | 8.69 | 8.94 | 5.69 | 9.63 |
| 2,4-D Na + carfentrazone (400 + 20 g/ha) | 6.91 | 10.46 | 14.25 | 4.99 | 6.73 | 9.65 | 8.25 | 3.65 | 15.46 |
| 2,4-D E + carfentrazone (400 + 20 g/ha) | 6.12 | 6.04 | 18.34 | 4.73 | 3.69 | 9.14 | 9.18 | 4.11 | 8.56 |
| Halauxifen-methyl + florasulam + carfentrazone (10.21 + 20 g/ha) | 6.66 | 5.45 | 12.44 | 4.33 | 5.11 | 8.58 | 8.95 | 4.02 | 10.02 |
| Weedy check | 6.65 | 8.36 | 15.36 | 4.25 | 3.66 | 7.59 | 9.05 | 8.31 | 8.96 |
| Weed free | 6.07 | 10.32 | 18.36 | 4.32 | 4.66 | 10.23 | 8.72 | 9.89 | 13.54 |
| LSD (p=0.05) | NS | 1.96 | 1.03 | NS | 1.73 | 0.98 | NS | 0.74 | 2.11 |

DAS – Days after crop sowing NS – Non-significant

**Table 7. The growth parameters, yield attributes and yield of wheat crop as affected by weed control treatments (pooled data of two years)**

| Treatment | Plant height (at 60 DAS) | LAI (at 60 DAS) | ET (no./ $m^2$) | DMA ($g/m^2$) (at 90 DAS) | Grain/ spike (no.) | Test weight (g) | Grain yield (t/ha) | | | Straw yield (t/ha) | | | Harvest index (%) | Nutrient uptake by crop (kg/ha) | | | Total uptake by crop (kg/ha) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | 2017 | 2018 | Pooled | 2017 | 2018 | Pooled | | N | P | K | |
| Halauxifen-methyl + florasulam (12.76 g/ha) | 94.6 | 3.19 | 313.5 | 498.1 | 34.24 | 38.22 | 3.85 | 4.31 | 4.08 | 5.24 | 7.52 | 6.38 | 39.0 | 550.1 | 13.0 | 46.1 | 109.2 |
| Metsulfuron (4 g/ha) | 94.4 | 3.15 | 286.6 | 418.2 | 34.83 | 37.89 | 4.20 | 3.83 | 4.02 | 7.06 | 7.56 | 7.31 | 35.4 | 448.9 | 12.6 | 43.2 | 104.7 |
| Carfentrazone (20 g/ha) | 100.1 | 3.09 | 275.5 | 314.1 | 31.01 | 38.19 | 3.09 | 3.72 | 3.40 | 5.64 | 6.68 | 6.16 | 35.6 | 637.1 | 10.3 | 35.8 | 83.3 |
| 2,4-D Na (500 g/ha) | 98.4 | 3.13 | 276.3 | 316.5 | 36.75 | 37.61 | 3.08 | 3.45 | 3.27 | 5.81 | 7.05 | 6.43 | 33.7 | 633.3 | 10.0 | 33.1 | 76.5 |
| 2,4-D E (500 g/ha) | 92.7 | 2.49 | 303.5 | 404.7 | 31.41 | 37.04 | 3.48 | 3.60 | 3.54 | 4.87 | 6.53 | 5.70 | 38.3 | 540.2 | 11.2 | 38.5 | 89.9 |
| Metsulfuron + carfentrazone (4 + 20 g/ha) | 99.1 | 3.41 | 307.0 | 516.7 | 37.11 | 40.31 | 3.99 | 5.12 | 4.56 | 6.70 | 7.72 | 7.21 | 38.7 | 772.2 | 17.3 | 60.2 | 149.8 |
| 2,4-D Na + carfentrazone (400 + 20 g/ha) | 74.4 | 3.01 | 301.5 | 318.3 | 29.12 | 38.91 | 3.95 | 4.26 | 4.11 | 6.35 | 6.18 | 6.26 | 39.6 | 559.2 | 14.3 | 51.3 | 124.8 |
| 2,4-D E + carfentrazone (400 + 20 g/ha) | 86.1 | 2.52 | 297.5 | 309.1 | 30.63 | 39.14 | 3.92 | 4.86 | 4.39 | 6.01 | 5.90 | 5.96 | 42.4 | 765.0 | 16.1 | 55.3 | 136.4 |
| Halauxifen-methyl + florasulam + carfentrazone (10.21 + 20 g/ha) | 98.2 | 3.11 | 274.4 | 487.2 | 33.65 | 38.55 | 4.95 | 3.87 | 4.41 | 6.69 | 6.98 | 6.84 | 38.2 | 767.6 | 17.1 | 58.3 | 142.9 |
| Weedy check | 90.0 | 2.05 | 225.9 | 235.1 | 17.23 | 36.61 | 1.87 | 1.36 | 1.61 | 3.05 | 2.23 | 2.64 | 37.9 | 519.6 | 9.1 | 25.4 | 53.1 |
| Weed free | 101.3 | 3.45 | 334.5 | 534.3 | 34.55 | 40.00 | 5.23 | 436 | 4.80 | 7.21 | 6.82 | 7.01 | 40.6 | 779.1 | 18.3 | 63.2 | 160.7 |
| LSD (p=0.05) | | 0.43 | 11.13 | 33.6 | 3.41 | 1.35 | 0.54 | 0.60 | 0.64 | 0.67 | 0.80 | 0.70 | 2.3 | 6.4 | 1.6 | 6.1 | 16.3 |

DAS – Days after crop sowing; ET- Effective tillers; DMA - Dry matter accumulation

yield of wheat was observed in weed free (4.80 t/ha) and was at par with metsulfuron + carfentrazone 4 + 20 g/ha (4.56 t/ha), halauxifen + florasulam + carfentrazone 10.21 + 20 g/ha. (4.44 t/ha), 2,4-D E + carfentrazone 400 + 20 g/ha (4.40 t/ha), confirming the findings of Kumar *et al*. (2014). Highest harvest index was registered with 2,4-D E + carfentrazone 400 + 20 g/ha and was at par with the weed free situation. Further observation revealed that, nutrient uptake by crop, was significantly influenced by various weed management practices (**Table 7**). Highest NPK uptake by wheat crop was registered with weed free and was at par with metsulfuron + carfentrazone 4 + 20 g/ha and halauxifen-methyl ester + florasulam + carfentrazone 10.21 + 20 g/ha. Total nutrient uptake by crop was highest registered with the weed free situation and was at par only with the metsulfuron + carfentrazone 4 + 20 g/ha. This might be due to inhibition of the enzyme acetolactate synthase (ALS) from metsulfuron, which acts as the catalyst in the first step of the biosynthesis of essential amino acids (valine, leucine and isoleucine). Better expression of yield attributes due to reduced weed infestation through these treatments might have helped the crop plants to accumulate more dry matter through greater nutrient uptake that might have provided more quantity of photosynthates to developing sink in crop plants produced more yield (Meena *et al*. 2019).

From the study, it may be concluded that use of metsulfuron + carfentrazone 4 + 20 g/ha and halauxifen-methyl ester + florasulam + carfentrazone 10.21 + 20 g/ha results in maximum wheat yield.

## REFERENCES


Balyan RS and Malik RK. 2000. New herbicides for jungali palak (*Rumex retroflexus* L.). *Indian Journal of Weed Science* **32**: 86–88.

Gomez KA and Gomez AA. 1984. *Statistical Procedures for Agricultural Research* John Willey and Sons, New York.

Kumar R, Jaidev, Singh RS, Singh SS and Tripathi SK. 2014. Effect of soil enzymes and beneficial soil micro-organism as influence by weed management practices under rice-wheat cropping system. *New Agriculture* **25**(1): 79–81.

Mahmoud S M, Soliman FS and Elsheik M. 2016.Combination of Halauxifen-methyl + florasulam with other grassy herbicides against complex weed flora in wheat. *Journal of Plant Protection and Pathology Mansoura University* **7**(5): 315–320.

Meena V, Kaushik MK, Dotaniya ML, Meena BP and Das H. 2019. Bio-efficacy of ready-mix herbicides on weeds and productivity in late-sown wheat. *Indian Journal of Weed Science* **51**(4): 344–351.

Mukherjee D. 2012. Resource conservation through indigenous farming system in hills of West Bengal. *Journal of Crop and Weed* **8**(1): 160–164.

Mukherjee D. 2018. Impact of improved technology for enhancing wheat productivity in West Bengal. *Journal of Experimental Biology and Agricultural Sciences* **6**(1): 258-263.

Mukherjee PK, Bhattacharya PM and Chowdhury AK.2011. Weed control in wheat (*Triticum aestivum* L.) under terai-agroecological region of West Bengal. *Journal of Wheat Research* **3**(2): 30–34.

Singh P, Sarathambal C, Kewat ML and Singh VP. 2015. Conservation tillage and weed management effect on soil microflora of soybean-wheat cropping system. *Indian Journal of Weed Science* **47**(4): 366–370.

Singh RP, Mukherjee D, Singh RK and Sinha AK. 2003. Bio-efficacy of herbicide in late sown wheat (*Triticum aestivum*). *Indian Journal of Agronomy* **48**(3): 196–198.

Sivran AC, Choudhary J and Sarita. 2020. Efficacy of herbicides on broad-leaved weed and yield of wheat (*Triticum aestivum* L.). *International Journal of Chemical Studies* **8**(2): 180–184.

Yadav HL, Gupta AK, Kumar S and Gupta S. 2019. Comparative efficacy of herbicides applied in wheat and their residual effect on the succeeding crops. *International Journal of Current Microbiology and Applied Sciences* **8**(4): 1866–1874.