Plant Archives Vol. 25, Supplement 1, 2025 pp. 1613-1626 e-ISSN:2581-6063 (online), ISSN:0972-5210

Plant Archives

Journal homepage: http://www.plantarchives.org
DOI Url : https://doi.org/10.51470/PLANTARCHIVES.2025.v25.supplement-1.223

EFFECT OF DIFFERENT WEED MANAGEMENT MEASURES ON WEED POPULATION, CROP YIELD AND PRODUCTION ECONOMICS OF COMMON BREAD WHEAT (*TRITICUM AESTIVUM* L.) GROWN IN NEW ALLUVIAL ZONE OF WEST BENGAL INDIA

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(Date of Receiving : 29-10-2024; Date of Acceptance : 31-12-2024)

ABSTRACT

A field experiment was carried out to examine the effect of different weed management measures on weed population, crop yield and production economics of common bread wheat during rabi season of 2021-22 (November-March) at D block farm, B.C.K.V., Kalyani, Nadia, West Bengal. The number of treatments was 13, which was replicated four times in a randomized complete block design (RCBD). It was observed that among the treatments, maximum yield parameters, weed control efficiency was recorded in T_1 (weeding at 10 days interval) throughout the growing period of the plant but B:C value for this treatment was lowest due to high labour cost. The highest B:C value was observed in T_{10} (Carfentrazone ethyl 40% DF 20 g/ha as PoE application at 25 DAS followed by hoeing at 40 DAS). Among the herbicide applied treatments, the highest weed control efficiency was also observed in T_{10} (Carfentrazone ethyl 40% DF 20 g/ha as PoE application at 25 DAS followed by hoeing at 40 DAS) (79.64%) and lowest in T_7 (2,4D Na- Salt 20% WP 500 g/ha as PoE application at 25 DAS) (59.58%) at 45 DAS. So, due the highest B:C value and higher weed control efficiency as well as yield than other herbicide applied treatments, T_{10} can be considered as the best weed management measure for common bread wheat grown in new alluvial zone of West Bengal.

Keywords **:** wheat, weed management, weed control efficiency, herbicide, yield parameters.

Introduction

Wheat is a cereal grain which is a worldwide staple food. The many species of wheat together make up the genus Triticum; the most widely grown is common bread wheat (T. aestivum). The archaeological record suggests that wheat was first cultivated in the regions of the Fertile Crescent around 9600 BCE. Botanically, the wheat kernel is a type of fruit called caryopsis. Wheat is the second most important and widely grown food crop in India and in world, it is the highest grown food crop. Wheat is called as the "king of cereals". Wheat is very rich in its nutritional quality. It has a high starch content 60-75% (Sramkovaa, 2009).

There are so many reasons for low productivity of wheat. But one of the important factors is reduction in yield due to weeds. Weeds, perhaps may be considered as single limiting factor of low yield due to the fact that weeds compete with crop plants for nutrients, light, moisture and space. Moreover, they increase production cost, decrease the yield of crop, harbors insect and plant diseases, decrease quality of the farm produce and reduces the values of land. Depending upon the weed intensity, 18.6% yield loss happens in wheat (Singh *et al.*, 2018). The prominent weeds that are present in the wheat field in Rabi season in north India are- *Chenopodium album, Asphodelus tenufolias, Anagallis arvensis*, *Fumaria parviflora*. A few grassy weeds like *Phalaris minor, Avena fatua* have come up in aggressive competition with wheat crop in Punjab,

Haryana, western UP and Rajasthan. Introduction of high yielding dwarf wheat variety changed the spectrum of weed flora from dominance of broad leaf weeds in 1960s to mixed flora of broadleaf and grassy weeds in early 1970s and then the dominance of grassy weeds especially, *Phalaris minor* in late 1970s. Hence, the chemical weed control became necessary in late 1970s. Herbicides were introduced in 1970-80. Weed flora changed in favour of complex weed species in late 1980s and then again in favour of *Phalaris minor* during early 90s with evolution of herbicide resistance of this weed to isoproturon (Malik and Singh, 1995). Herbicide resistance is a major cause of yield loss as continuous use of herbicides at the same site of action resulted in multiple herbicide resistance. The indiscriminate and continuous use of isoproturon for more than a decade with an unbroken rice-wheat cropping pattern accentuated by poor application rates, spray techniques and timing, led to resistance in *Phalaris minor* (Singh *et al*., 2019). Wheat is infested by both grassy and broad leaf weeds and effective weed management require an integrated approach using both chemical and non-chemical approaches. The best approach is integrated weed management in which all suitable methods of weed control are used in a compatible manner to reduce weed population and maintain them at levels below the threshold causing economic injury. Plant density, time of sowing, variety, seed rate, spacing, tillage practices, quantity and time of fertilizer and irrigation water are some of important factors, which influence the weed-crop competition. Regulation of these factors should be such that they give the competitive edge to crop over weeds (Chhoker *et al*., 2012). Herbicide mixtures may be an alternative for management or delay of cross resistance development against these herbicides (Dhawan *et al*., 2009).

Until recently the conventional method of controlling weeds, there was the age-old practice of hand weeding. This cultural method of weed management i.e., hand weeding is becoming more expensive due to steep rise in labour wages and non-availability of labourer at the critical period of weed control. Hence the herbicidal method of weed control is gaining importance which is less expensive than the hand weeding.

Materials and Methods

The experiment was conducted in Rabi season of 2021-22 at D block farm, Kalyani, Nadia under BCKV, West Bengal. The farm is located at latitude 22.58°N (North) and longitude 88.25°E (East) and altitude 9 m above MSL (Mean Sea Level). The experiment was conducted in new alluvial zone of West Bengal under medium land situation with good drainage facility. The soil samples were collected at random from various places of the experimental field and after proper mixing, kept for shade drying for preparing soil sample for analyzing physico chemical properties of the soil. The soil of the experimental field was Sandy loam in nature with medium organic carbon and low nitrogen status. Available phosphorus was high with medium potassium and low amount of zinc. The soil reaction was neutral. The soil test results are presented in table number 1. The experimental site comes under sub-tropical humid climate where temperature is moderate. The onset of monsoon is generally in the month of June and ends in September. The crop was grown during the Rabi season of 2021-22. From the meteorological data during the period of experiment, the maximum and minimum temperatures ranged from 23.32^{0}C to 31.81^{0}C and 11.99^{0}C to 17.61^{0}C respectively. The maximum and minimum relative humidity ranged from 89.2% to 95.19% and 47.10% to 62.58% respectively. The total rainfall during the period of experiment (November 2021 to March 2022) was 226.2 mm. The variety that is used in this experiment is HD2824 (Poorva). It is tolerant to rusts and leaf blight. The experimental design was randomized complete block design (RCBD). Field was prepared with standard method and layout was done as per planning for the experiment. Each plot size was 5m x 4m. Number of treatments was 13 (treatment details have been given in table 2) and number of replications was 4, total number of plots was 52. Seeds were sown @100 kg/ha at an interval of 25 cm x 10 cm. On the day of sowing, each plot received a half dose of 150 kg N/ha, full dose of 60 kg P2O5/ha, and half dose of 60 kg K_2O/ha, which were administered via urea, single super phosphate, and muriate of potash, respectively, to all the treatments. the rest of nitrogen and potash were applied at crown root initiation stage and 35 DAS through the previous fertilizers. Before land preparation, one flood irrigation was given to bring the soil for proper tillage condition. Five subsequent irrigations were given at crown root initiation, maximum tillering, flowering, soft dough and lastly at hard dough stages. No weed management measures were adopted except treatment imposition. The amount of herbicide required for each plot was calculated by using the formula: Q = 10RA/P, where Q= Quantity of herbicide required for each plot in g / ml, R= Rate of application in kg a.i./ha, A= Area in square meter, P= percentage of active ingredient in the herbicide formulation. The required amount of commercial herbicide was properly weighed and mixed with water. After that they were sprayed in each plot with sprayer. Weed control efficiency was calculated with

the formula: WCE (%) = (Weed dry weight in the treated plot - weed dry weight in the untreated plot/ Dry weight of the weeds in the untreated plot) x 100. For analysis purposes, the final weed data (weed count and weed dry weight) were transformed using the formula $(X+0.5)^{0.5}$. Data of all the yield attributing character was taken at harvest. Grains and straw obtained from each plot were sun dried and weighed carefully to record the grain and straw yield per plot. It was converted into tone/ha. Harvest index is the ratio between economical yield and biological yield and it was expressed in %. Weed index (%) was calculated by the formula: (Yield from the treated plot - the yield from the weed free plot / Yield from the weed free plot) x 100. For economic viability analysis the economics of various treatments were determined using the field trial results and current market rates. Fisher's "Analysis of Variance" (ANOVA) approach, as described by Panse and Sukhatme, was used to analyse the experimental data. P = 0.05 was the level of significance utilized in the "F" and "t" tests. The critical difference values were calculated at 5% probability level where F test was found significant.

Table 1: Physico-chemical properties of the experimental soil

A. Physical properties		Values		Methods used
1. Mechanical composition	Sand (%)	55.91		International pipette method (Piper, 1966)
	Silt (%)	25.01		
	Clay (%)	19.08		
B. Chemical properties		Values	Rating	Methods used
1. Organic carbon (%)		0.63	Medium	Walkey and Black Method (1934)
2. Available Nitrogen (kg/ha)		203.6	Low	Macro-Kjeldahl method (Jackson, 1973)
3. Available P2O5 (kg /ha)		30.2	High	Olsen's Method (Olsen *et al*., 1954)
4. Available K2O (kg /ha)		184.2	Medium	Flame photometer method (Jackson, 1973)
5. Zinc (ppm)		0.53	Low	DTPA extraction method
6. Soil pH		7.37	Neutral	Beckman's pH meter method (Jackson, 1973)

Table 2: Details of the treatments

Treatment	Treatment details
T1	Hand weeding at 10 days interval
T2	Metsulfuron methyl 20% WG 4 g/ha + Carfentrazone ethyl 40% DF 20 g/ha as PoE application at 30 DAS
T3	2,4 DE 38% EC 500 ml/ha + carfentrazone ethyl 40% DF 20 g/ha as PoE application at 30 DAS
T4	2,4 D Ester 38% EC 500 ml /ha as PoE application at 30 DAS
T5	2,4 DE 38% EC 500 ml/ha as PoE application at 30 DAS followed by hoeing at 40 DAS
T6	2,4 D Na- Salt 20% WP 500 g/ha + Carfentrazone ethyl 40% DF 20g/ha as PoE application at 30 DAS
T7	2,4 D Na- Salt 20% WP 500 g/ha as PoE application at 30 DAS
T8	2,4 D Na- Salt 20% WP 500 gm/ha as PoE application at 30 DAS followed by hoeing at 40 DAS
T9	Carfentrazone ethyl 40% DF 20 g/ha as PoE application at 30 DAS
T10	Carfentrazone ethyl 40% DF 20 g/ha as PoE application at 30 DAS followed by hoeing at 40 DAS
T11	Metsulfuron methyl 20% WG 4 g/ha as PoE application at 30 DAS
T12	Weedy check
T13	Two hoeings at 20 DAS and 40 DAS, respectively

Result and Discussions

Density of grass weeds as affected by different weed management measures in the field of wheat crop (no/sq m):

Results presented in table 3 showed the grass weed density at 30, 45, 75 DAS and at harvest in the experiment.

At 45 DAS, grass weed density recorded the lowest value at T1 (hand weeding at 10 days interval). Among the herbicidal treatment ($0.71/m^2$), T10 (Carfentrazone ethyl 40% DF 20 g/ha as PoE application at 30 DAS followed by hoeing at 40 DAS) showed the lowest grass weed density whose value is found to be statistically at par with other treatments T2 (Metsulfuron methyl 20% WG 4 g/ha + Carfentrazone ethyl 40% DF 20 g/ha as PoE application at 30 DAS), T3 (2,4 DE 38% EC 500 ml/ha + carfentrazone ethyl 40% DF 20 g/ha as PoE application at 30 DAS), T5 (2,4 DE 38% EC 500 ml/ha as PoE application at 30 DAS followed by hoeing at 40 DAS), T6 (2,4 D Na-Salt 20% WP 500 g/ha + Carfentrazone ethyl 40% DF 20g/ha as PoE application at 30 DAS), T8 (2,4 D Na-Salt 20% WP 500 gm/ha as PoE application at 30 DAS

followed by hoeing at 40 DAS) and T13 (Two hoeings at 20 DAS and 40 DAS, respectively). The grass weed density was highest in T12 (Weedy check) (4.78/m^2). Among herbicidal treatments, highest grass weed density was observed in T7 (2,4 D Na- Salt 20% WP 500 g/ha as PoE application at 30 DAS).

At 75 DAS, among all the treatments, T1 (Hand weeding at 10 days interval) has given the lowest grass weed density (1.35/m^2). The highest grass weed density was observed in weedy check (8.97/m^2). Among the herbicidal treatment, T7 has shown the highest grass weed population. Among the herbicidal treatments T10 (Carfentrazone ethyl 40% DF 20 g/ha as PoE application at 30 DAS followed by hoeing at 40 DAS) recorded the lowest grass weed population and its value is statistically at par with T3(2,4 DE 38% EC 500 ml/ha + carfentrazone ethyl 40% DF 20 g/ha as PoE application at 30 DAS), T5, T6(2,4 D Na- Salt 20% WP 500 g/ha + Carfentrazone ethyl 40% DF 20g/ha as PoE application at 30 DAS), and T13.

At harvest, the highest grass weed density (14.84/m^2) was recorded in the weedy check (T12). Among the herbicidal treatments, T7 (2,4 D Na- Salt 20% WP 500 g/ha as PoE application at 30 DAS) has shown the highest grass weed density. Among all the treatments, T1 (Hand weeding at 10 days interval) has shown the best performance (2.34/m^2) with lowest grass weed density and among the herbicidal treatments, T6 (2,4 D Na- Salt 20% WP 500 g/ha + Carfentrazone ethyl 40% DF 20g/ha as PoE application at 30 DAS) recorded the lowest value which is statistically at par with T10(Carfentrazone ethyl 40% DF 20 g/ha as PoE application at 30 DAS followed by hoeing at 40 DAS), T13, T8, T5, T3(2,4 DE 38% EC 500 ml/ha + carfentrazone ethyl 40% DF 20 g/ha as PoE application at 30 DAS) and T2 (Metsulfuron methyl 20% WG 4 g/ha + Carfentrazone ethyl 40% DF 20 g/ha as PoE application at 30 DAS).

The cause of least grass weed density in T1 (Hand weeding at 10 days interval) is due to regular hand weeding. It kept the plots almost weeds free. The weedy check plot has highest grass weed density as it has not received any weed control measures throughout the crop period in the experiment. As the herbicidal treatments were imposed at 30 DAS, no significant differences were observed among the treatments except T1 (Hand weeding at 10 days interval) and T13 (Two hoeings at 20 DAS and 40 DAS, respectively) which was obvious (Ahuja and Yaduraju, 1989). This finding was also in the line of conclusions of several other workers from their research in the field of weed management in cropped fields (Anderson and Barrett, 1985).

Table 3: Density of grass weeds as affected by different weed management measures in the field of wheat crop (no/sq m)

Treatment	Density of grass weeds (no./sq. m)			
	30 DAS	**45DAS**	**75DAS**	**Harvest**
T1 (Hand weeding at 10 days interval)	1.17 (0.86)	0.71 (0.04)	1.35 (1.32)	2.34 (4.97)
T2 (Metsulfuron methyl 20% WG 4 g/ha + Carfentrazone ethyl 40% DF 20 g/ha as PoE application at 30 DAS)	2.23 (4.47)	1.39 (1.43)	2.64 (6.46)	4.47 (19.4)
T3 (2,4 DE 38% EC 500 ml/ha + carfentrazone ethyl 40% DF 20 g/ha as PoE application at 30 DAS)	1.49 (1.72)	0.98 (0.46)	1.86 (2.95)	2.98 (8.38)
T4 (2,4 D Ester 38% EC 500 ml /ha as PoE application at 30 DAS)	3.49 (11.68)	2.13 (4.03)	4.05 (15.90)	6.89 (46.97)
T5 (2,4 DE 38% EC 500 ml/ha as PoE application at 30 DAS followed by hoeing at 40 DAS)	1.94 (3.26)	1.28 (1.13)	2.43 (5.40)	3.89 (14.63)
T6 (2,4 D Na- Salt 20% WP 500 g/ha + Carfentrazone ethyl 40% DF 20g/ha as PoE application at 30 DAS)	1.40 (1.46)	0.96 (0.42)	1.85 (2.92)	2.80 (7.34)
T7 (2,4 D Na- Salt 20% WP 500 g/ha as PoE application at 30 DAS)	4.39 (18.77)	2.93 (8.08)	5.59 (30.74)	8.79 (76.76)
T8 (2,4 D Na- Salt 20% WP 500 gm/ha as PoE application at 30 DAS followed by hoeing at 40 DAS)	2.23 (4.47)	1.49 (1.72)	2.95 (8.20)	4.47 (19.48)
T9 (Carfentrazone ethyl 40% DF 20 g/ha as PoE application at 30 DAS)	3.87 (14.47)	2.57 (6.10)	4.88 (23.31)	7.74 (59.40)

T10 (Carfentrazone ethyl 40% DF 20 g/ha as PoE application at 30 DAS followed by hoeing at 40 DAS)	1.88 (3.03)	0.92 (0.34)	1.87 (2.99)	3.76 (13.63)
T11 (Metsulfuron methyl 20% WG 4 g/ha as PoE application at 30 DAS)	2.98 (8.38)	1.92 (3.18)	3.72 (13.33)	5.96 (35.02)
T12 (Weedy check)	7.42 (54.55)	4.78 (22.34)	8.97 (79.96)	14.84 (219.72
T13 (Two hoeings at 20 DAS and 40 DAS, respectively)	1.49 (1.72)	0.98 (0.46)	2.25 (4.56)	2.99 (8.44)
SEm +	**-**	**0.23**	**0.41**	**0.65**
CD(p=0.05)	**-**	**0.67**	**1.22**	**2.03**

*Data in the parenthesis is the original one which has been transformed by taking square root after adding 0.5 with it before statistical analysis.

Effect of weed control measures on broadleaf weed density

The results depicted in Table 4 show the density of broadleaf weeds at 30, 45, 75 DAS and at harvest.

At 45 DAS, among all the treatments, T1 (Hand weeding at 10 days interval) recorded the lowest broadleaf weed density (2.4 weeds/square meter). Among the herbicidal treatments, T10 (Carfentrazone ethyl 40% DF 20 g/ha as PoE application at 30 DAS followed by hoeing at 40 DAS) has shown the lowest broadleaf weed density (5.7 weeds/square meter) whose value is statistically at par with T6 (2,4 D Na- Salt 20% WP 500 g/ha + Carfentrazone ethyl 40% DF 20g/ha as PoE application at 30 DAS) and T3 (2,4 DE 38% EC 500 ml/ha + carfentrazone ethyl 40% DF 20 g/ha as PoE application at 30 DAS).

At 75 DAS, T1 (Hand weeding at 10 days interval) has recorded the lowest broadleaf weed density. Among the chemical treatments (4.5/m^2), T10 (Carfentrazone ethyl 40% DF 20 g/ha as PoE application at 30 DAS followed by hoeing at 40 DAS) has shown the lowest broad leaf weed density (8.4/m^2) whose value did not differ significantly from the treatments, T6 (2,4 D Na- Salt 20% WP 500 g/ha + Carfentrazone ethyl 40% DF 20g/ha as PoE application at 30 DAS), T3 (2,4 DE 38% EC 500 ml/ha + carfentrazone ethyl 40% DF 20 g/ha as PoE application at 30 DAS) and T2 (Metsulfuron methyl 20% WG 4 g/ha + Carfentrazone ethyl 40% DF 20 g/ha as PoE application at 30 DAS).

At harvest, among all the treatments, T12 (weedy check) has shown the highest broadleaf weed density (18.6/m^2). Among the herbicidal treatments, T10 (Carfentrazone ethyl 40% DF 20 g/ha as PoE application at 30 DAS followed by hoeing at 40 DAS) showed the lowest broadleaf weed density (10.8/m^2) which is statistically at par with T6 (2,4 D Na- Salt 20% WP 500 g/ha + Carfentrazone ethyl 40% DF 20g/ha as PoE application at 30 DAS), T3 (2,4 DE 38% EC 500 ml/ha + carfentrazone ethyl 40% DF 20 g/ha as PoE application at 30 DAS) and T2 (Metsulfuron methyl 20% WG 4 g/ha + Carfentrazone ethyl 40% DF 20 g/ha as PoE application at 30 DAS).

From the above finding, it is clear that hand weeding at 10 days interval showed the lowest broadleaf weed density and it is highest in weedy check plots. Among the herbicidal treatments, T10 (Carfentrazone ethyl 40% DF 20 g/ha as PoE application at 30 DAS followed by hoeing at 40 DAS) showed the best results expressing very low performance of broad leaf weeds.

It has been revealed from the results that performance of broad leaf weeds in respect of density of weeds followed the similar pattern as found in case of grass weeds. Treatment T1 (Hand weeding at 10 days interval) attained very poor population of weeds in all the stages whereas treatment T12 (weedy check) showed the maximum weed density among all the treatments and it was quite possible due to absence of any weed control measure in this treatment during the entire crop growing period. Similar conclusions were drawn by V. M. Bhan and his co-workers (1976), Banga, *et. al.* (1997) Anderson (2005), Anderson and Beck (2007) and many more researchers.

Table 4: Density of broad leaf weeds (BLW) as affected by different weed management measures in the field of wheat crop (no./sq. m)

Treatment	Density of broad leaf weeds (no./sq. m)			
	30 DAS	**45DAS**	**75DAS**	**Harvest**
T1(Hand weeding at 10 days interval)	2.95 (8.20)	2.4 (5.26)	4.5 (19.75)	5.9 (34.31)
T2 (Metsulfuron methyl 20% WG 4 g/ha + Carfentrazone ethyl 40% DF 20 g/ha as PoE application at 30 DAS)	5.9 (34.31)	10.7 (113.99)	10.1 (101.51)	11.8 (138.74)
T3 (2,4 DE 38% EC 500 ml/ha + carfentrazone ethyl 40% DF 20 g/ha as PoE application at 30 DAS)	5.5 (29.75)	7.6 (57.26)	9.8 (95.54)	11.0 (120.5)
T4 (2,4 D Ester 38% EC 500 ml /ha as PoE application at 30 DAS)	7.35 (53.52)	12.6 (158.26)	13.9 (192.71)	14.7 (215.59)
T5 (2,4 DE 38% EC 500 ml/ha as PoE application at 30 DAS followed by hoeing at 40 DAS)	6.15 (37.32)	9.6 (91.66)	11.2 (124.94)	12.3 (150.79)
T6 (2,4 D Na- Salt 20% WP 500 g/ha + Carfentrazone ethyl 40% DF 20g/ha as PoE application at 30 DAS)	5.4 (28.66)	6.9 (47.11)	9.2 (84.14)	10.8 (116.14)
T7 (2,4 D Na- Salt 20% WP 500 g/ha as PoE application at 30 DAS)	8.55 (72.60)	14.1 (198.31)	16.3 (265.19)	17.1 (291.91)
T8 (2,4 D Na- Salt 20% WP 500 gm/ha as PoE application at 30 DAS followed by hoeing at 40 DAS)	6.55 (42.40)	10.8 (116.14)	12.7 (160.79)	13.1 (171.11)
T9 (Carfentrazone ethyl 40% DF 20 g/ha as PoE application at 30 DAS)	8.1 (65.11)	13.2 (173.74)	14.9 (221.51)	16.2 (261.94)
T10 (Carfentrazone ethyl 40% DF 20 g/ha as PoE application at 30 DAS followed by hoeing at 40 DAS)	5.4 (28.66)	5.7 (31.99)	8.4 (70.06)	10.8 (116.14)
T11(Metsulfuron methyl 20% WG 4 g/ha as PoE application at 30 DAS)	7.45 (55.00)	11.1 (122.71)	13.5 (181.75)	14.9 (221.51)
T12 (Weedy check)	9.3 (85.99)	14.3 (203.99)	17.1 (291.91)	18.6 (345.46)
T13 (Two hoeings at 20 DAS and 40 DAS, respectively)	6.25 (38.56)	8.8 (76.94)	10.9 (118.31)	12.5 (155.75)
SEm +	**-**	**0.66**	**0.49**	**0.69**
CD(p=0.05)	**-**	**1.98**	**2.5**	**1.11**

*Data in the parenthesis is the original one which has been transformed by taking square root after adding 0.5 with it before statistical analysis

Effect of weed control measures on sedge weed density:

Table 5 shows the sedge weed density at 30,45,75 DAS and at harvest.

At, 30 DAS, sedge weed density recorded its lowest value in the hand weeded plot followed by T13 (hoeing at 20 and 40 DAS). As no other treatment is applied, so they showed non-significant value. At 45 DAS, weed density was much lower due to treatment imposition at 30 DAS. Sedge weed density was maximum in T12 (weedy check). Among the herbicide treated plots, T7 treated plots showed the highest sedge weed density. Among the other treatments, T1 (Hand weeding at 10 days interval), T6 (2,4 D Na- Salt 20% WP 500 g/ha + Carfentrazone ethyl 40% DF 20g/ha as PoE application at 30 DAS), T3 (2,4 D Na- Salt 20% WP 500 g/ha as PoE application at 30 DAS) and T10 (Carfentrazone ethyl 40% DF 20 g/ha as PoE application at 30 DAS followed by hoeing at 40 DAS) performed the best. Their values statistically differed from rest of the treatments.

At 75 DAS, there was a trend of increasing sedge weed density from 45 DAS. Among all the treatments, highest sedge weed density was observed in T12 (weedy check) and among the herbicidal treatment, highest sedge weed density was observed in T7 (2,4 D Na- Salt 20% WP 500 g/ha as PoE application at 30 DAS). The lowest sedge weed density was observed in the hand weeded plots (T1) and among the chemically treated plots, T10 (Carfentrazone ethyl 40% DF 20 g/ha as PoE application at 30 DAS followed by hoeing at 40 DAS) showed the best results with least sedge weed density which is statistically significant to other treatments.

At harvest, the sedge weed density was increased than 75 DAS. Among all the treatments, T1 (Hand weeding at 10 days interval) showed the best results which is statistically differed from rest of the treatments. Among the chemical treatments T10 (Carfentrazone ethyl 40% DF 20 g/ha as PoE

application at 30 DAS followed by hoeing at 40 DAS) showed the best results to control sedge weed population. T6 (2,4 D Na- Salt 20% WP 500 g/ha + Carfentrazone ethyl 40% DF 20g/ha as PoE application at 30 DAS) also showed similar results as T10 (Carfentrazone ethyl 40% DF 20 g/ha as PoE application at 30 DAS followed by hoeing at 40 DAS), they are statistically at per. But they differed from rest of the treatments.

So, it can be concluded that, among all the treatments, T1(Hand weeding at 10 days interval) has recorded the best results to control sedge weed population followed by T10 (Carfentrazone ethyl 40% DF 20 g/ha as PoE application at 30 DAS followed by hoeing at 40 DAS) which is a herbicidal treatment. Among all the treatments, the weedy check plots showed the maximum sedge weed density and among all the herbicidal treatments, T7 (2,4 D Na- Salt 20% WP 500 g/ha as PoE application at 30 DAS) recorded the highest density of sedge weeds.

Table 5: Density of sedge weeds as affected by different weed control measures (number per square meter)

Treatments	Density of sedge weed (no./ sq. m.)			
	30DAS	**45DAS**	**75DAS**	**At harvest**
T1(Hand weeding at 10 days interval)	2.35 (5.02)	0.95 (0.40)	1.41 (1.48)	4.71 (21.68)
T2 (Metsulfuron methyl 20% WG 4 g/ha + Carfentrazone ethyl 40% DF 20 g/ha as PoE application at 30 DAS)	4.9 (23.51)	1.06 (0.62)	4.70 (21.59)	9.80 (95.54)
T3 (2,4 DE 38% EC 500 ml/ha + carfentrazone ethyl 40% DF 20 g/ha as PoE application at 30 DAS)	4.8 (22.54)	0.95 (0.40)	3.91 (14.78)	9.60 (91.66)
T4 (2,4 D Ester 38% EC 500 ml /ha as PoE application at 30 DAS)	6.75 (45.06)	1.34 (1.46)	6.10 (36.71)	13.50 (181.75
T5 (2,4 DE 38% EC 500 ml/ha as PoE application at 30 DAS followed by hoeing at 40 DAS)	5.45 (29.20)	1.08 (0.66)	4.21 (17.22)	10.91 (118.52
T6 (2,4 D Na- Salt 20% WP 500 g/ha + Carfentrazone ethyl 40% DF 20g/ha as PoE application at 30 DAS)	4.52 (19.93)	0.92 (0.34)	3.52 (11.89)	9.05 (81.40)
T7 (2,4 D Na- Salt 20% WP 500 g/ha as PoE application at 30 DAS)	7.45 (55.00)	1.56 (1.93)	6.80 (45.74)	14.91 (221.80
T8 (2,4 D Na- Salt 20% WP 500 gm/ha as PoE application at 30 DAS followed by hoeing at 40 DAS)	6.28 (38.93)	1.11 (0.72)	5.10 (25.51)	12.56 (157.25
T9 (Carfentrazone ethyl 40% DF 20 g/ha as PoE application at 30 DAS)	7.16 (50.76)	1.46 (1.63)	6.80 (45.74)	14.32 (204.56)
T10 (Carfentrazone ethyl 40% DF 20 g/ha as PoE application at 30 DAS followed by hoeing at 40 DAS)	3.95 (15.10)	0.94 (0.38)	2.61 (6.31)	7.91 (62.06)
T11(Metsulfuron methyl 20% WG 4 g/ha as PoE application at 30 DAS)	6.56 (42.53)	1.25 (1.40)	5.33 (27.90)	13.13 (171.89
T12 (Weedy check)	8.00 (63.5)	3.19 (9.67)	6.90 (46.11)	16.01 (255.82
T13 (Two hoeings at 20 DAS and 40 DAS, respectively)	5.22 (26.74)	0.97 (0.44)	4.34 (18.33)	10.45 (108.70
SEm +	**-**	**0.12**	**0.29**	**0.57**
CD(p=0.05)	**-**	**0.37**	**0.91**	**1.81**

*Data in the parenthesis is the original one which has been transformed by taking square root after adding 0.5 with it before statistical analysis

Total weed density as affected by different weed management measures in the field of wheat crop (no/ sq m):

Total weed density is recorded at 30, 45, 75 DAS and at harvest and it is presented in table 6.

At 30 DAS, total weed density recorded its lowest value in the hand weeded plot followed by T13 (Two hoeing at 20 DAS and 40 DAS, respectively). As no other treatment was applied, so they showed non-significant value.

At 45 DAS, the total weed density was lower compared to 30 DAS. The reason behind it may be treatment imposition at 30 DAS. The highest weed density was observed in weedy check plots (T12). Among the herbicidal treatments, T7 (2,4 D Na- Salt 20% WP 500 g/ha as PoE application at 30 DAS) showed the highest weed density. T1 (Hand weeding at 10 days interval) performed the best in controlling total weed density. Herbicidal treatments T10 (Carfentrazone ethyl 40% DF 20 g/ha as PoE application at 30 DAS followed by hoeing at 40 DAS),

T6 (2,4 D Na- Salt 20% WP 500 g/ha + Carfentrazone ethyl 40% DF 20g/ha as PoE application at 30 DAS) and T3 showed better results than rest of the treatments with close enough values. But they differed statistically from the other treatments.

At 75 DAS, T1 (Hand weeding at 10 days interval) recorded the lowest total weed density and the highest total weed density was in T12 (Weedy check). Among the herbicidal treatments, total weed density was recorded the least in T10 (Carfentrazone ethyl 40% DF 20 g/ha as PoE application at 30 DAS followed by hoeing at 40 DAS) whose value is statistically at par with T3 (2,4 DE 38% EC 500 ml/ha + carfentrazone ethyl 40% DF 20 g/ha as PoE application at 30 DAS) and T6 (2,4 D Na- Salt 20% WP 500 g/ha + Carfentrazone ethyl 40% DF 20g/ha as PoE application at 30 DAS).

At harvest, following the previous trend, lowest total weed density was observed in the hand weeded plots which differed significantly from rest of the treatments. Among the herbicidal treatments, T10 (Carfentrazone ethyl 40% DF 20 g/ha as PoE application at 30 DAS followed by hoeing at 40 DAS) and T6 (2,4 D Na- Salt 20% WP 500 g/ha + Carfentrazone ethyl 40% DF 20g/ha as PoE application at 30 DAS) have performed the best. Their values are statistically at par with T3 (2,4 DE 38% EC 500 ml/ha + carfentrazone ethyl 40% DF 20 g/ha as PoE application at 30 DAS), T13 (Two hoeings at 20 DAS and 40 DAS, respectively), T5 and T2.

From the findings, it can be concluded that among all the treatments, hand weeding at 10 days interval showed the least total weed density in all crop growth stages. So, hand weeding is an effective means of weed control. This has been also opined by many researchers like Amare (2014). Among the herbicidal treatments, T10 (Carfentrazone ethyl 40% DF 20 g/ha as PoE application at 30 DAS followed by hoeing at 40 DAS), T6 (2,4 D Na- Salt 20% WP 500 g/ha + Carfentrazone ethyl 40% DF 20g/ha as PoE application at 30 DAS) and T3 (2,4 DE 38% EC 500 ml/ha + carfentrazone ethyl 40% DF 20 g/ha as PoE application at 30 DAS) performed the best which can be supported by the findings of Baghestani (2007) and Kundu *et al* (2020).

Table 6: Total weed density as affected by different weed management measures in the field of wheat crop (no/ sq m)

Treatment	Total weed density (no./ sq. meter)			
	30 DAS	**45 DAS**	**75 DAS**	**Harvest**
T1(Hand weeding at 10 days interval)	6.37 (40.07)	4.06 (15.98)	7.26 (52.20)	12.95 (167.20)
T2 (Metsulfuron methyl 20% WG 4 g/ha + Carfentrazone ethyl 40% DF 20 g/ha as PoE application at 30 DAS)	13.65 (185.82)	13.15 (172.42)	17.44 (303.65)	26.07 (679.14)
T3 (2,4 DE 38% EC 500 ml/ha + carfentrazone ethyl 40% DF 20 g/ha as PoE application at 30 DAS)	13.65 (185.82)	9.53 (90.32)	15.57 (241.92)	23.58 (555.51)
T4 (2,4 D Ester 38% EC 500 ml /ha as PoE application at 30 DAS)	13.65 (185.82)	16.07 (257.74)	24.05 (577.90)	35.09 (1230.80
T5 (2,4 DE 38% EC 500 ml/ha as PoE application at 30 DAS followed by hoeing at 40 DAS)	13.65 (185.82)	11.96 (142.54)	17.84 (317.76)	27.01 (729.04)
T6 (2,4 D Na- Salt 20% WP 500 g/ha + Carfentrazone ethyl 40% DF 20g/ha as PoE application at 30 DAS)	13.65 (185.82)	8.78 (76.58)	14.57 (211.78)	22.65 (512.52)
T7 (2,4 D Na- Salt 20% WP 500 g/ha as PoE application at 30 DAS)	13.65 (185.82)	18.59 (345.08)	28.69 (822.61)	40.80 (1664.14)
T8 (2,4 D Na- Salt 20% WP 500 gm/ha as PoE application at 30 DAS followed by hoeing at 40 DAS)	13.65 (185.82)	13.4 (179.06)	20.75 (430.06)	30.13 (907.31)
T9 (Carfentrazone ethyl 40% DF 20 g/ha as PoE application at 30 DAS)	13.65 (185.82)	17.23 (296.37)	26.60 (707.06)	38.26 (1463.32)
T10 (Carfentrazone ethyl 40% DF 20 g/ha as PoE application at 30 DAS followed by hoeing at 40 DAS)	13.65 (185.82)	7.56 (56.65)	17.17 (294.30)	22.47 (504.40)
T11(Metsulfuron methyl 20% WG 4 g/ha as PoE application at 30 DAS)	13.65 (185.82)	14.27 (203.13)	11.01 (120.72)	33.99 (1154.82)
T12 (Weedy check)	13.65 (185.82)	22.27 (495.45)	32.87 (1079.93)	49.45 (2444.80)
T13 (Two hoeings at 20 DAS and 40 DAS, respectively)	11.24 (125.83)	10.75 (115.06)	17.49 (305.40)	25.94 (672.38)
SEm +		**1.01**	**1.41**	**1.96**
CD(p=0.05)		**3.03**	**4.27**	**5.95**

*Data in the parenthesis is the original one which has been transformed by taking square root after adding 0.5 with it before statistical analysis

Effect of weed control treatments on weed control efficiency:

Weed control efficiency at 45,75 DAS and at harvest are presented in table 7.

At 45 DAS, weed control efficiency was highest (93.76%) in T1(Hand weeding at 10 days interval). Among the chemical treatments, T10 (Carfentrazone ethyl 40% DF 20 g/ha as PoE application at 30 DAS followed by hoeing at 40 DAS) recorded the highest weed control efficiency (79.64%) followed by T6 (2,4 D Na- Salt 20% WP 500 g/ha + Carfentrazone ethyl 40% DF 20g/ha as PoE application at 30 DAS),T3 (2,4 DE 38% EC 500 ml/ha + carfentrazone ethyl 40% DF 20 g/ha as PoE application at 30 DAS) and T13 (Two hoeing at 20 DAS and 40 DAS, respectively). The lowest weed control efficiency is observed in the weedy check treatment as there was no weed control measures applied.

At 75 DAS, following the similar trend, weed control efficiency was highest (84.61%) in T1 (Hand weeding at 10 days interval). Among the chemical treatments, T10 (Carfentrazone ethyl 40% DF 20 g/ha as PoE application at 30 DAS followed by hoeing at 40 DAS) recorded the highest weed control efficiency (70.31%) followed by T6 (2,4 D Na- Salt 20% WP 500 g/ha + Carfentrazone ethyl 40% DF 20g/ha as PoE application at 30 DAS), T3 (2,4 DE 38% EC 500 ml/ha + carfentrazone ethyl 40% DF 20 g/ha as PoE application at 30 DAS) and T13 (Two hoeing at 20 DAS and 40 DAS, respectively). The lowest weed control efficiency is observed in the weedy check treatment (0%). Among the herbicidal treatment T7 (2,4 D Na- Salt 20% WP 500 g/ha as PoE application at 30 DAS) showed the lowest weed control efficiency.

At harvest, weed control efficiency was highest (84.42%) in T1(Hand weeding at 10 days interval). Among the chemical treatments, T10 (Carfentrazone ethyl 40% DF 20 g/ha as PoE application at 30 DAS followed by hoeing at 40 DAS) recorded the highest weed control efficiency (69.74) followed by T6 (2,4 D Na- Salt 20% WP 500 g/ha + Carfentrazone ethyl 40% DF 20g/ha as PoE application at 30 DAS), T3 (2,4 DE 38% EC 500 ml/ha + carfentrazone ethyl 40% DF 20 g/ha as PoE application at 30 DAS) and T13 (Two hoeing at 20 DAS and 40 DAS, respectively). The lowest weed control efficiency is observed in the weedy check treatment. Among the herbicidal treatment T7 (2,4 D Na- Salt 20% WP 500 g/ha as PoE application at 30 DAS) showed the lowest weed control efficiency.

From the findings of the table 7, it is clear that hand weeding is the best measure to get high weed control efficiency. It showed similar results with the findings of Amare *et al.* (2014). The weed control efficiency gradually declined from 45 DAS to 75 DAS and at harvest may be due to more regeneration of weeds as no weed control measure is applied after the treatment imposition at 30DAS. In all growth stages of the wheat crop, weed control efficiency was lowest in T12 (weedy check) as no weed control treatment was applied. Among the herbicidal treatments, T10 (Carfentrazone ethyl 40% DF 20 g/ha as PoE application at 30 DAS followed by hoeing at 40 DAS) recorded the highest weed control efficiency which is also opined by Mustari *et al.* (2016).

Table 7: Weed control efficiency (%) on influenced by various weed control measures in wheat crop

Treatment	Weed control efficiency (%)		
	45DAS	75DAS	Harvest
T1(Hand weeding at 10 days interval)	93.76	84.61	84.42
T2 (Metsulfuron methyl 20% WG 4 g/ha + Carfentrazone ethyl 40% DF 20 g/ha as PoE application at 30 DAS)	67.88	59.65	58.95
T3 (2,4 DE 38% EC 500 ml/ha + carfentrazone ethyl 40% DF 20 g/ha as PoE application at 30 DAS)	76.34	67.23	66.46
T4 (2,4 D Ester 38% EC 500 ml /ha as PoE application at 30 DAS)	63.13	55.26	54.49
T5 (2,4 DE 38% EC 500 ml/ha as PoE application at 30 DAS followed by hoeing at 40 DAS)	69.53	61.15	60.48
T6 (2,4 D Na- Salt 20% WP 500 g/ha + Carfentrazone ethyl 40% DF 20g/ha as PoE application at 30 DAS)	77.74	68.39	67.86
T7 (2,4 D Na- Salt 20% WP 500 g/ha as PoE application at 30 DAS)	59.58	52.06	50.91
T8 (2,4 D Na- Salt 20% WP 500 gm/ha as PoE application at 30 DAS followed by hoeing at 40 DAS)	64.45	56.46	55.54
T9 (Carfentrazone ethyl 40% DF 20 g/ha as PoE application at 30 DAS)	62.22	54.39	53.48

T10 (Carfentrazone ethyl 40% DF 20 g/ha as PoE application at 30 DAS followed by hoeing at 40 DAS)	79.64	70.31	69.74
T11(Metsulfuron methyl 20% WG 4 g/ha as PoE application at 30 DAS)	67.13	58.89	58.12
T12(Weedy check)	00.00	00.00	00.00
T13(Two hoeing at 20 DAS and 40 DAS, respectively)	75.80	66.78	65.89

Effect of weed control treatments on yield attributes of Wheat crop:

Table 8 shows the values of grain weight per ear head, filled grain per ear and 1000 grain weight and number of effective tillers per square meter.

Grain weight per ear(g):

In case of grain weight per ear head, T1(Hand weeding at 10 days interval) showed the maximum value (2.88 g). Among the chemical treatments, T10 (Carfentrazone ethyl 40% DF 20 g/ha as PoE application at 30 DAS followed by hoeing at 40 DAS) showed the best results (2.76g) which is at par with T1(Hand weeding at 10 days interval), T6 (2,4 D Na- Salt 20% WP 500 g/ha + Carfentrazone ethyl 40% DF 20g/ha as PoE application at 30 DAS) and T3 (2,4 DE 38% EC 500 ml/ha + carfentrazone ethyl 40% DF 20 g/ha as PoE application at 30 DAS). The lowest value was recorded in the weedy check plot followed by T7 (2,4 D Na- Salt 20% WP 500 g/ha as PoE application at 30 DAS) which is a herbicidal treatment.

Number of filled grains/ear head:

In case of number of filled grains per ear head, T1 (Hand weeding at 10 days interval) recorded the best results (40.39). Among the herbicidal treatments, T10 (Carfentrazone ethyl 40% DF 20 g/ha as PoE application at 30 DAS followed by hoeing at 40 DAS) showed the best results (40.06) which is at par with T1(Hand weeding at 10 days interval), T6 (2,4 D Na- Salt 20% WP 500 g/ha + Carfentrazone ethyl 40% DF 20g/ha as PoE application at 30 DAS) and T3 (2,4 DE 38% EC 500 ml/ha + carfentrazone ethyl 40% DF 20 g/ha as PoE application at 30 DAS). The lowest value was recorded in the weedy check pots followed by T7 (2,4 D Na- Salt 20% WP 500 g/ha as PoE application at 30 DAS) which is a herbicidal treatment. It is presented in figure17.

1000 grains weight (g):

In case of 1000 grain weight (g) the results followed the same trend. T1(Hand weeding at 10 days interval) showed the maximum 1000 test weight (41.33g) which significantly differed from other treatments. Among the herbicidal treatments, T10 (Carfentrazone ethyl 40% DF 20 g/ha as PoE application at 30 DAS followed by hoeing at 40 DAS) showed the best results (40.54g) which is statistically at par with T6 (2,4 D Na- Salt 20% WP 500 g/ha + Carfentrazone ethyl 40% DF 20g/ha as PoE application at 30 DAS) and T3(2,4 DE 38% EC 500 ml/ha + carfentrazone ethyl 40% DF 20 g/ha as PoE application at 30 DAS).

Number of effective tillers/m^2:

In case of effective tillers per square meter, T1(Hand weeding at 10 days interval) recorded the maximum value (310.96/m^2). Among the herbicidal treatments, T10 (Carfentrazone ethyl 40% DF 20 g/ha as PoE application at 30 DAS followed by hoeing at 40 DAS) showed the best results (303.58/m^2) and it is statistically at par with T1(Hand weeding at 10 days interval), T6 (2,4 D Na- Salt 20% WP 500 g/ha + Carfentrazone ethyl 40% DF 20g/ha as PoE application at 30 DAS), T3 (2,4 DE 38% EC 500 ml/ha + carfentrazone ethyl 40% DF 20 g/ha as PoE application at 30 DAS) and T13.

Ear length(cm):

Maximum ear length (9.09 cm) was recorded with T1(Hand weeding at 10 days interval). Among the herbicidal treatments, T10 showed the maximum (9.01cm) ear length. The value of T10 (Carfentrazone ethyl 40% DF 20 g/ha as PoE application at 30 DAS followed by hoeing at 40 DAS) showed statistically at par value with T1(Hand weeding at 10 days interval), T6 (2,4 D Na- Salt 20% WP 500 g/ha + Carfentrazone ethyl 40% DF 20g/ha as PoE application at 30 DAS) and T3 (2,4 DE 38% EC 500 ml/ha + carfentrazone ethyl 40% DF 20 g/ha as PoE application at 30 DAS).

In all the observations, lowest values were recorded in the weedy check treatments and among the herbicidal treatments T7 (2,4 D Na- Salt 20% WP 500 g/ha as PoE application at 30 DAS) showed the lowest values.

From the finding, it is clear that, hand weeding resulted the highest values in case of all yield attributes. It may be due to more dry matter accumulation by the crop than the weed as the plots were kept weed free throughout the growth period. So, it did not face any competition for inputs like light, space, nutrients and water. The finding is similar to the findings of Amare and Sharma (2014). Among the herbicidal treatments, T10 (Carfentrazone ethyl 40% DF 20 g/ha as PoE

application at 30 DAS followed by hoeing at 40 DAS) showed the best results. Similar finding was observed by Mukherjee (2011). The weedy check treatments showed the minimum value of yield attributes due to highest competition for resources between crop and weed.

Table 8: Effect of different weed control measures on yield attributes of wheat crop

Treatments	Grain weight/ earhead (g)	Number of filled grains per ear	1000 grains weight (g)	Number of effective tillers per m^2	Ear length(cm)
T1(Hand weeding at 10 days interval)	2.88	40.39	41.33	310.96	9.09
T2 (Metsulfuron methyl 20% WG 4 g/ha + Carfentrazone ethyl 40% DF 20 g/ha as PoE application at 30 DAS)	2.09	35.06	38.98	249.12	8.04
T3 (2,4 DE 38% EC 500 ml/ha + carfentrazone ethyl 40% DF 20 g/ha as PoE application at 30 DAS)	2.65	37.47	40.33	286.45	8.80
T4 (2,4 D Ester 38% EC 500 ml /ha as PoE application at 30 DAS)	1.38	29.52	37.51	165.64	7.22
T5 (2,4 DE 38% EC 500 ml/ha as PoE application at 30 DAS followed by hoeing at 40 DAS)	2.39	35.32	39.01	262.31	8.33
T6 (2,4 D Na- Salt 20% WP 500 g/ha + Carfentrazone ethyl 40% DF 20g/ha as PoE application at 30 DAS)	2.79	38.14	40.22	293.16	8.88
T7 (2,4 D Na- Salt 20% WP 500 g/ha as PoE application at 30 DAS)	1.18	26.73	37.24	151.29	7.17
T8 (2,4 D Na- Salt 20% WP 500 gm/ha as PoE application at 30 DAS followed by hoeing at 40 DAS)	1.78	33.21	39.21	232.98	7.99
T9 (Carfentrazone ethyl 40% DF 20 g/ha as PoE application at 30 DAS)	1.29	29.78	37.25	155.37	7.18
T10 (Carfentrazone ethyl 40% DF 20 g/ha as PoE application at 30 DAS followed by hoeing at 40 DAS)	2.76	40.06	40.54	303.58	9.01
T11(Metsulfuron methyl 20% WG 4 g/ha as PoE application at 30 DAS)	1.58	31.03	38.19	217.89	7.80
T12 (Weedy check)	1.01	21.86	37.01	139.31	7.12
T13 (Two hoeings at 20 DAS and 40 DAS, respectively)	2.50	36.35	39.74	278.23	8.43
SEm +	**0.10**	**1.03**	**0.23**	**9.53**	**0.10**
CD(p=0.05)	**0.31**	**3.09**	**0.72**	**28.61**	**0.33**

Effect of different weed control measures on grain yield, straw yield, weed index and harvest index of Wheat crop:

Table 9 shows the data recorded on grain yield, straw yield, weed index and harvest index of the wheat crop.

Grain yield(t/ha):

In case of grain yield, T1 (Hand weeding at 10 days interval) recorded the maximum value (4.5t/ha). Among the chemical treatment, T10 (Carfentrazone ethyl 40% DF 20 g/ha as PoE application at 30 DAS followed by hoeing at 40 DAS) showed the highest grain yield (4.3t/ha) and it is statistically at par with T1(Hand weeding at 10 days interval). But they varied statistically from rest of the treatments. The lowest grain yield was recorded in T12 (Weedy check) (2.3t/ha) and among the herbicidal treatments, T7 (2,4 D Na- Salt 20% WP 500 g/ha as PoE application at 30 DAS) (3.11t/ha) showed the minimum value.

Straw yield(t/ha):

In case of straw yield, T13 (hoeing at 20 and 40 DAS) showed the maximum value (6.21t/ha). Among the herbicidal treatments, T6 (5.93t/ha) showed the best value. The minimum value was recorded by the weedy check treatment and among the herbicidal treatments, T7 (2,4 D Na- Salt 20% WP 500 g/ha as PoE application at 30 DAS) showed the minimum value.

Weed Index (%):

In case of weed index, T12 (Weedy check) recorded the maximum value (48.88%) as no weed control measures were applied. Among the herbicidal treatments, T7 (2,4 D Na- Salt 20% WP 500 g/ha as PoE application at 30 DAS) showed the maximum value (30.12%) of weed index. T1(Hand weeding at 10

days interval) recorded the minimum value (00%). In this case, among the rest treatments, T10 (Carfentrazone ethyl 40% DF 20 g/ha as PoE application at 30 DAS followed by hoeing at 40 DAS) showed the minimum value (4.44%).

Harvest Index (%):

Harvest index recorded its maximum value (44.95%) in case of T1(Hand weeding at 10 days interval). Among the herbicidal treatments, T10 (Carfentrazone ethyl 40% DF 20 g/ha as PoE application at 30 DAS followed by hoeing at 40 DAS) recorded the maximum value (44.47%) and it is statistically at par with T1(Hand weeding at 10 days interval). The lowest harvest index was recorded with T9 (Carfentrazone ethyl 40% DF 20 g/ha as PoE application at 30 DAS) recorded the minimum (40.25%) harvest index value.

From all the above findings, the performance of T1(Hand weeding at 10 days interval) is best in case of grain yield and harvest index due to less competition for resources between crop and weed and high source to sink transfer of assimilates than the other treatments as they faced crop weed competition. The herbicidal treatment T10 (Carfentrazone ethyl 40% DF 20 g/ha as PoE application at 30 DAS followed by hoeing at 40 DAS) showed similar results as T1(Hand weeding at 10 days interval) as weed management was effective. The findings can be supported by the works and conclusions drawn by Hussain *et al.* (2008) and Mukherjee (2019). The minimum value in case of grain yield was recorded in T12 due to highest crop weed competition and poor source to sink transfer of assimilates. The source to sink transfer was also reduced in T7 (2,4 D Na- Salt 20% WP 500 g/ha as PoE application at 30 DAS) which recorded the minimum grain yield among the chemical treatments.

Table 9: Effect of various weed control treatments on biomass production weed index and harvest index in wheat crop

Treatment	Grain yield (t/ha)	Straw yield (t/ha)	Weed index (%)	Harvest index (%)
T1(Hand weeding at 10 days interval)	4.5	5.51	00.00	44.95
T2 (Metsulfuron methyl 20% WG 4 g/ha + Carfentrazone ethyl 40% DF 20 g/ha as PoE application at 30 DAS)	3.51	5.10	22.00	40.69
T3 (2,4 DE 38% EC 500 ml/ha + carfentrazone ethyl 40% DF 20 g/ha as PoE application at 30 DAS)	4.02	5.68	10.66	41.32
T4 (2,4 D Ester 38% EC 500 ml /ha as PoE application at 30 DAS)	3.32	4.71	30.12	41.34
T5(2,4 DE 38% EC 500 ml/ha as PoE application at 30 DAS fb hoeing at 40 DAS)	3.60	5.18	20.00	41.00
T6 (2,4 D Na- Salt 20% WP 500 g/ha + Carfentrazone ethyl 40% DF 20g/ha as PoE application at 30 DAS)	4.10	5.93	8.88	40.88
T7 (2,4 D Na- Salt 20% WP 500 g/ha as PoE application at 30 DAS)	3.11	4.49	30.88	40.84
T8 (2,4 D Na- Salt 20% WP 500 gm/ha as PoE application at 30 DAS fb hoeing at 40 DAS)	3.40	4.83	24.44	41.31
T9 (Carfentrazone ethyl 40% DF 20 g/ha as PoE application at 30 DAS)	3.20	4.75	28.88	40.25
T10 (Carfentrazone ethyl 40% DF 20 g/ha as PoE application at 30 DAS followed by hoeing at 40 DAS)	4.30	5.37	4.44	44.47
T11 (Metsulfuron methyl 20% WG 4 g/ha as PoE application at 30 DAS)	3.52	5.04	21.77	40.98
T12 (Weedy check)	2.30	3.40	48.88	40.35
T13 (Two hoeing at 20 DAS and 40 DAS, respectively)	3.90	6.21	13.33	38.58
SEm +	**0.12**	**0.16**		**0.34**
CD(p=0.05)	**0.37**	**0.46**		**1.06**

Economic analysis of different weed control treatments on wheat crop:

Any weed control method could effectively be recommended only when it becomes economically viable and environmentally sustainable. Cost of cultivation was determined treatment wise on the basis of present market price of various common and variable cost of agri-inputs which were used in this experiment. The data on economic analysis had been presented in table 10.

Cost of cultivation (Rs/ha):

From table 10, the highest cost of cultivation (Rs. 83581) had been recorded in T1(Hand weeding at 10 days interval) because of a greater number of labour and high labour wages. Whereas, lowest cost of cultivation (Rs.40285) was observed in weedy check. Among the herbicidal treatments, T5 (Rs. 46390) showed the lowest cost of cultivation. Whereas, the highest cost was involved in the herbicidal treatment T4 (2,4 D Ester 38% EC 500 ml /ha as PoE application at 30 DAS) (Rs.49880). The second highest cost of cultivation, next to T1 (Hand weeding at 10 days interval) was recorded in T13 (Two hoeings at 20 DAS and 40 DAS, respectively) (Rs.52360).

Gross return (Rs/ha):

The gross return was higher in T1(Hand weeding at 10 days interval) (Rs.90675) than all other treatments. Weedy check plots showed the lowest gross return. Among herbicidal treatments, highest gross return was observed in T6 (2,4 D Na- Salt 20% WP 5oo g/ha + Carfentrazone ethyl 40% DF 20g/ha as PoE application at 30 DAS) (Rs.89019).

Net return (RS/ha):

Among all the treatments, the highest net return (Rs41816) was recorded in T10 (Carfentrazone ethyl 40% DF 20 g/ha as PoE application at 30 DAS followed by hoeing at 40 DAS). Among the other treatments, T12 (Weedy check) showed the lowest value.

Benefit cost ratio:

Among all the treatments, highest B:C value was recorded in T10 (Carfentrazone ethyl 40% DF 20 g/ha as PoE application at 30 DAS followed by hoeing at 40 DAS) (1.89) followed by T6 (2,4 D Na- Salt 20% WP 500 g/ha + Carfentrazone ethyl 40% DF 20g/ha as PoE application at 30 DAS) (1.86). Among all the treatments, weedy check recorded the lowest B:C value followed by hand weeding (1.08). This was because of high labor cost for weed control which ultimately increased the total cost of cultivation in T1(Hand weeding at 10 days interval) and resulted in lower B:C value. So, it is clear that application of post emergence herbicide followed by hoeing is the most economically viable treatment. It was matched with the findings of Mukherjee, 2019 and Amare *et al*., 2015.

Table 10: Economics of different weed control treatment on Wheat crop

Treatment	Common Cost of cultivation (Rs./ha)	Variable Cost of cultivation (Rs./ha)	Total Cost of cultivation (Rs./ha)	Gross return (Rs./ha)	Net return (Rs./ha)	Benefit-cost ratio
T_1(Hand weeding at 10 days interval)	40285	43296	83581	90675	7094	1.08
T_2 (Metsulfuron methyl 20% WG 4 g/ha + Carfentrazone ethyl 40% DF 20 g/ha as PoE application at 30 DAS)	40285	8085	48370	84163	35793	1.74
T_3(2,4 DE 38% EC 500 ml/ha + carfentrazone ethyl 40% DF 20 g/ha as PoE application at 30 DAS)	40285	7705	47990	86382	38392	1.80
T_4(2,4 D Ester 38% EC 500 ml /ha as PoE application at 30 DAS)	40285	9595	49880	80306	30426	1.61
T_5(2,4 DE 38% EC 500 ml/ha as PoE application at 30 DAS fb hoeing at 40 DAS)	40285	6105	46390	83038	36648	1.79
T_6(2,4 D Na- Salt 20% WP 500 g/ha + Carfentrazone ethyl 40% DF 20g/ha as PoE application at 30 DAS)	40285	7575	47860	89019	41159	1.86
T_7 (2,4 D Na- Salt 20% WP 500 g/ha as PoE application at 30 DAS)	40285	9365	49650	78943	29293	1.59
T_8 (2,4 D Na- Salt 20% WP 500 gm/ha as PoE application at 30 DAS followed by hoeing at 40 DAS)	40285	8585	48870	82590	33720	1.69
T_9 (Carfentrazone ethyl 40% DF 20 g/ha as PoE application at 30 DAS)	40285	8815	49100	78560	29460	1.60
T_{10}(Carfentrazone ethyl 40% DF 20 g/ha as PoE application at 30 DAS followed by hoeing at 40 DAS)	40285	6700	46985	88801	41816	1.89
T_{11}(Metsulfuron methyl 20% WG 4 g/ha as PoE application at 30 DAS)	40285	8665	48950	79788	30838	1.63
T_{12}(Weedy check)	40285	0.00	40285	37465	……..	0.93
T_{13}(Two hoeings at 20 DAS and 40 DAS, respectively)	40285	12075	52360	73827	21467	1.41

Conclusion

So, from the above findings, it can be concluded that laborious time consuming and costly hand weeding treatment can easily be replaced by application of Carfentrazone ethyl 40% DF 20 g/ha as PoE application at 30 DAS followed by hoeing at 40 DAS for managing the weed population and ultimately increasing economic return of wheat grown in new alluvial zone of west Bengal

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