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Determining the Effect of Nutrient Management and Weed Control Practices on Weed Dynamics in Wheat (*Triticum aestivum* L.)

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

An experiment was carried out at Agronomy Research Farm of Acharya Narendra Deva University of Agriculture and Technology, Kumarganj, Ayodhya (Uttar Pradesh) during Rabi season (2022-23 & 2023-24) to investigate the effect of nutrient management and weed control practices on dynamics of weed in different treatments in wheat crop. Split plot design was used in the experimental field with three nutrient levels in main plot and six weed control practices in sup plot

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and replicated thrice. Among the nutrient management treatments 75% RDF + 10 t ha^{-1} FYM + one spray of nano-urea @ 4ml/lit was found to be more effective for controlling weed density, weed dry weight, weed control efficiency (%), and weed index (%) during both years of experimentation. Sequential spray of Clodinofop + Metsulfuron (60 + 4 g a.i. ha^{-1}) reduced the density and dry weight of weeds, however recorded highest weed control efficiency (89.57% & 90.77%) and minimum weed index (1.99 & 1.96) during 2022-23 and 2023-24 respectively. The better control of weeds and higher uptake of nutrient in this treatment resulted in higher yield. Thus it might be concluded that application of 75% RDF +10 t ha^{-1} FYM + one spray of nano-urea @ 4ml/lit with the spraying of Clodinofop + Metsulfuron (60 + 4 g a.i. ha^{-1}) found to be more effective in reducing weed infestation in wheat crop.

Keywords: Nutrient; herbicide; nano-urea; dynamics; wheat.

1. INTRODUCTION

"Wheat (*Triticum aestivum* L.) is one of the most important cereal crop that grown widely among cereal crops of the world. It is a selfpollinated crop that have (2n = 42) chromosome number this cereal is belong to Poaceae family. The anatomy of this crop is C3 with annual, hexaploid, long day plant and grown largely as a staple food crop in the globe" (Choudhary *et al.*2023). "wheat crop is the most important staple food of about 2 billion people (36 % of the world population) globally. It is cultivated with an area of 215.9 million hectares, production 771.78 million tonnes and productivity of 3.53 tonnes per hectare. In India, it is grown in an area of 31.61 million hectares, production 109.52 million tonnes with a productivity of 3464 kg per hectare and Uttar Pradesh having first rank in respect to both area (9.85 million hectare) and production (31.16 million tonnes) with a productivity of 3664 kg per hectare" [1]. It is currently the most widely produced, consumed, and traded cereal grain worldwide [2]. Therefore, the development of intensive cereal management strategies has been prompted by the desire to maximize winter wheat yields. To optimize the grain yield of wheat crop these integrate practices are very important like, management of weed and nutrient, seeding dates and rates, row spacing, soil fertility, insects diseases, and lodging [3].

Among the various management practices, management of nutrient is very important in crop nutrition in order to produce larger yield [4]. Expectation for nutrient application in agricultural system in future is to be increasing to produce more food, feed and fiber from lesser land area. Efficient utilization of applied nutrients will be the key to sustainability in such high input-high output systems. From both economic and environmental point of view efficient fertilization is crucial. It involves minimizing nutrient losses to the environment, while optimizing crop yields. It is crucial to note that effective nutrient use is fundamentally a result of prudent management decisions and balanced fertilizer application.

Raising the production capacity of wheat is mostly dependent on balanced nutrition because the wheat crop is extremely responsive to applied nutrient through numerous sources. Among various nutrients, nitrogen is required by wheat crop in large amount and usually supplied through outside sources like fertilizer and manures as most of the soil in wheat growing areas are deficient in nitrogen availability. Nitrogen fertilization always result in increase in above ground dry matter and root biomass production which result in to higher productivity as well as higher residues left in the soil after the crop harvest which helps in improving the fertility of the soil other nutrients like P and K are also required to be applied through manures and fertilizers. Fertilizer application alone has a negative impact on soil health and crop productivity; thus, integrating different sources of nitrogenous (organic and inorganic) fertilizer is more appropriate because it lowers the need for chemical fertilizer application and cultivation costs. In addition to being an environmentally friendly approach, this method also shows that FYM in combination with chemical fertilizer has a positive effect on wheat [5,6].

In agriculture nano-fertilizers are very important tools to improve crop growth, yield and quality parameters with increase nutrient use efficiency, reduce wastage of fertilizers and cost of cultivation. In precision agriculture, nano-fertilizers are the most efficient way to precisely regulate crop nutrients. They can supply nutrients at any point during the crop's growth phase by matching the crop's stage of development. Up to the ideal dosage, nano-fertilizers boost crop growth Qureshi et al. [7].

Additional concentration increases may impede crop growth because of nutrient toxicity.

Among numerous factors answerable for weeds infestation, low yield and their management are very important factors. Weed reduces crop yield by 20–50% because it competes with crop plants [8]. Common methods for eliminating weeds include cultural, mechanical, and chemical approaches. The unavailability of labor during peak season and adverse weather conditions prevent timely weed control. Thus, control of weeds by mechanical methods and manual or hand weeding alone is not feasible. Therefore, the control of weeds by chemical approach is a crucial substitute. Weed killers are a very useful and efficient way to keep weeds under control in wheat crop because of their effectiveness and efficiency [9].

2. MATERIALS AND METHODS

The experiment was carried out during Rabi season 2022-23 and 2023-24 at Agronomy Research farm, Acharya Narendra Deva University of Agriculture and Technology, Kumarganj, Ayodhya (U.P.). The experimental field's soil was "silty loam," saline in texture, low in organic carbon and accessible nitrogen, medium in phosphorous, and rich in potassium. The experimental site is geographically located in the sub-tropical Indo-Gangatic Plains (IGP), which have alluvial calcareous soil. The treatment consisted of three different nutrient levels viz., 100% RDF (150:60:40 kg ha^{-1}), 75% RDF + 10 t ha^{-1} FYM + one spray of nano-urea @ 4ml/lit and 50% RDF + 15 t ha^{-1} FYM + one spray of nano-urea @ 4ml/lit and six weed control practices Sulfosulfuron + Metsulfuron (30 + 2 g a.i. ha^{-1}), Clodinofop + Metsulfuron (60 + 4 g a.i. ha^{-1}), Sulfosulfuron + Carfentrazone (25 + 20g a.i. ha^{-1}), Sulfosulfuron + Carfentrazone (25 + 20g a.i. ha^{-1}), Clodinofop + Carfentrazone (60 + 20g a.i. ha^{-1}), Weed free (two hand weeding at 20 and 45 DAS), Weedy check. In all, there were 18 treatment combinations included in the experiment. The experiment field was laid out in Split Plot Design (SPD) and replicated thrice. The wheat variety HD-2967 was sown manually at distance of 20 cm in rows with the seed rate of 100 kg ha^{-1} on 20th November 2022-23 and 25November 2023-24. The herbicides were dissolved in water and applied 35 days after sowing, and spray of nono-urea was done at 45 DAS with 315 liter water solution ha^{-1} using knapsack sprayer fitted with flat- fan nozzle. The experimental field was divided into 54 plots. Each gross plot size was 4.0 m x 5.0 m and net plot size was 3.6m x 4.0m and row to row distance was maintained 20 cm. As per the treatments FYM was applied and incorporated into the soil before the sowing of wheat crop.

Weeds counting was taking for dominated weed species *viz*.; *Melilotus indica, Phalaris minor*, *Chenopodium album*, *Avena ludoviciana* and other weeds individual in each plots. Weeds which are except these were counted as other weeds. Weed count was taken in 30, 60, 90 DAS and harvest stage of crop growth and reported as number of weeds m^{-2}. The data on number of weeds were subjected to square-root transformation using ($\sqrt{x + 0.5}$).

For dry matter of weeds all the weeds inside the quadrate were cut close to the ground level in each plot and collected for the dry matter accumulation. The samples were first dried in sun to remove the moisture and then kept in oven at 70°C ± 2°C for 48 hours to remove remaining moisture as till a constant weight was achieved. The weight of dried samples were taken and expressed in gram per square meter.

Following formula was used to determine the weed control efficiency:

$$\mathbf{WCE}\ (\%) = \frac{DWc - DWt}{DWc} \times 100$$

Where,
WCE = Weed control efficiency (%)
DWc = Dry weight of weeds (g m^{-2}) in weedy check
DWt = Dry weight of weeds (g m^{-2}) in treated plot whose efficiency was calculated.
Weed index was determined by following formula:

$$W.I. = \frac{Y_{wf} - Y_t}{Y_{wf}} \times 100$$

Where,
Y_{wf} = Grain yield of weed free plot
Y_t = Grain yield of treated plot

3. RESULTS AND DISCUSSION

Effect on weed density (no. m^{-2}) and dry weight of weeds (g m^{-2}): In the experimental field the major weed flora comprised grasses, *viz. Avena fatua* and *Phalaris minor*; broad-leaf weeds, *viz*. *Melilotus alba, Chenopodium album* and *Anagallis arvensis*; and other weeds.

Table 1. density of total weeds (No. m^{-2}) and dry weight of weed as influenced by nutrient and weed management practices

Treatment	Density of total weeds						Weed dry weight (gm^{-2})					
	30 DAS		60 DAS		90 DAS		30 DAS		60 DAS		90 DAS	
	2022-23	2023-24	2022-23	2023-24	2022-23	2023-24	2022-23	2023-24	2022-23	2023-24	2022-23	2023-24
A. Main plot (Nutrient Management)												
F_1 :100% RDF (150:60:40 kg ha^{-1})	6.93 (55.13)	6.78 (52.70)	5.54 (37.88)	5.43 (36.52)	5.33 (35.48)	5.23 (34.22)	3.29 (11.60)	3.22 (11.08)	4.50 (24.62)	4.42 (23.74)	4.27 (24.42)	3.73 (18.55)
F_2 :75% RDF + 10 t ha^{-1}FYM + one spray of nano-urea @ 4ml/lit	7.48 (64.63)	7.32 (61.80)	5.06 (31.25)	5.01 (30.75)	4.88 (29.33)	4.80 (28.62)	3.53 (13.57)	3.46 (12.97)	4.12 (20.32)	4.04 (19.55)	3.63 (17.85)	3.15 (13.33)
F_3 :50% RDF + 15 t ha^{-1}FYM + one spray of nano-urea @ 4ml/lit	7.85 (71.37)	7.68 (68.30)	5.94 (43.55)	5.83 (42.02)	5.73 (40.80)	5.62 (39.37)	3.70 (14.98)	3.63 (14.37)	4.83 (28.30)	4.74 (27.31)	4.56 (27.81)	3.94 (20.75)
SEm±	0.160	0.230	0.129	0.121	0.123	0.114	0.107	0.086	0.100	0.102	0.097	0.098
C.D. at 5%	0.628	0.902	0.507	0.473	0.485	0.446	NS	NS	0.391	0.400	0.381	0.385
B. Sub plot (Weed Management)												
W_1 : Sulfosulfuron + Metsulfuron (30 + 2 g a.i. ha^{-1})	8.67 (74.93)	8.46 (71.20)	5.37 (28.43)	5.27 (27.37)	5.10 (25.60)	4.97 (24.30)	4.02 (15.73)	3.93 (14.97)	4.34 (18.47)	4.24 (17.57)	3.48 (11.85)	2.98 (8.50)
W_2 : Clodinofop + Metsulfuron (60 + 4 g a.i. ha^{-1})	8.58 (73.33)	8.37 (69.70)	5.10 (25.67)	5.01 (24.73)	4.85 (23.13)	4.73 (21.97)	3.98 (15.40)	3.89 (14.63)	4.13 (16.67)	4.03 (15.86)	3.08 (9.21)	2.57 (6.28)
W_3 : Sulfosulfuron+ Carfentrazone (25 + 20g a.i. ha^{-1})	8.77 (76.57)	8.55 (72.77)	5.77 (32.97)	5.66 (31.63)	5.48 (29.70)	5.34 (28.20)	4.07 (16.10)	3.97 (15.30)	4.67 (21.43)	4.55 (20.35)	3.90 (14.89)	3.37 (11.02)
W_4 : Clodinofop + Carfentrazone (60 + 20g a.i. ha^{-1})	8.85 (77.70)	8.63 (73.83)	5.95 (34.50)	5.80 (33.10)	5.65 (31.07)	5.51 (29.57)	4.11 (16.33)	4.01 (15.53)	4.81 (22.43)	4.69 (21.30)	4.46 (18.04)	3.87 (13.33)
W_5 : Weed free (two hand weeding at 20 and 45 DAS)	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)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)
W_6 : Weedy check	8.95 (79.73)	8.85 (78.10)	10.20 (103.80)	10.09 (101.73)	10.09 (101.73)	10.03 (100.37)	4.15 (16.73)	4.11 (16.40)	8.23 (67.47)	8.15 (66.13)	9.29 (86.17)	8.15 (66.13)
SEm±	0.181	0.199	0.139	0.130	0.133	0.124	0.095	0.095	0.107	0.110	0.102	0.097
C.D. at 5%	0.523	0.574	0.402	0.374	0.384	0.358	0.276	0.275	0.309	0.319	0.294	0.279
Interaction	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Data subjected to square root ($\sqrt{x+0.5}$) transformation and original values are given in parentheses

Table 2. Weed control efficiency (%) and weed index (%) as influenced by various nutrient and weeds management practices

Treatment		Weed control efficiency (%)		Weed index (%)	
		90 DAS			
		2022-23	2023-24	2022-23	2023-24
A. Main plot (Nutrient Management)					
F_1	100% RDF (150:60:40 kg ha^{-1})	71.80	72.32	11.75	11.54
F_2	75% RDF + 10 t ha^{-1}FYM + one spray of nano-urea @ 4ml/lit	75.82	76.37	11.75	11.54
F_3	50% RDF + 15 t ha^{-1}FYM + one spray of nano-urea @ 4ml/lit	71.65	72.33	11.75	11.55
B. Sub plot (Weed Management)					
W_1	Sulfosulfuron + Metsulfuron (30 + 2 g a.i. ha^{-1})	86.50	87.37	3.78	3.72
W_2	Clodinofop + Metsulfuron (60 + 4 g a.i. ha^{-1})	89.57	90.77	1.99	1.96
W_3	Sulfosulfuron + Carfentrazone (25 + 20g a.i. ha^{-1})	82.93	83.57	14.14	13.89
W_4	Clodinofop + Carfentrazone (60 + 20g a.i. ha^{-1})	79.53	80.33	19.13	18.79
W_5	Weed free (two hand weeding at 20 and 45 DAS)	100.00	100.00	0.00	0.00
W_6	Weedy check	0.00	0.00	31.47	30.92

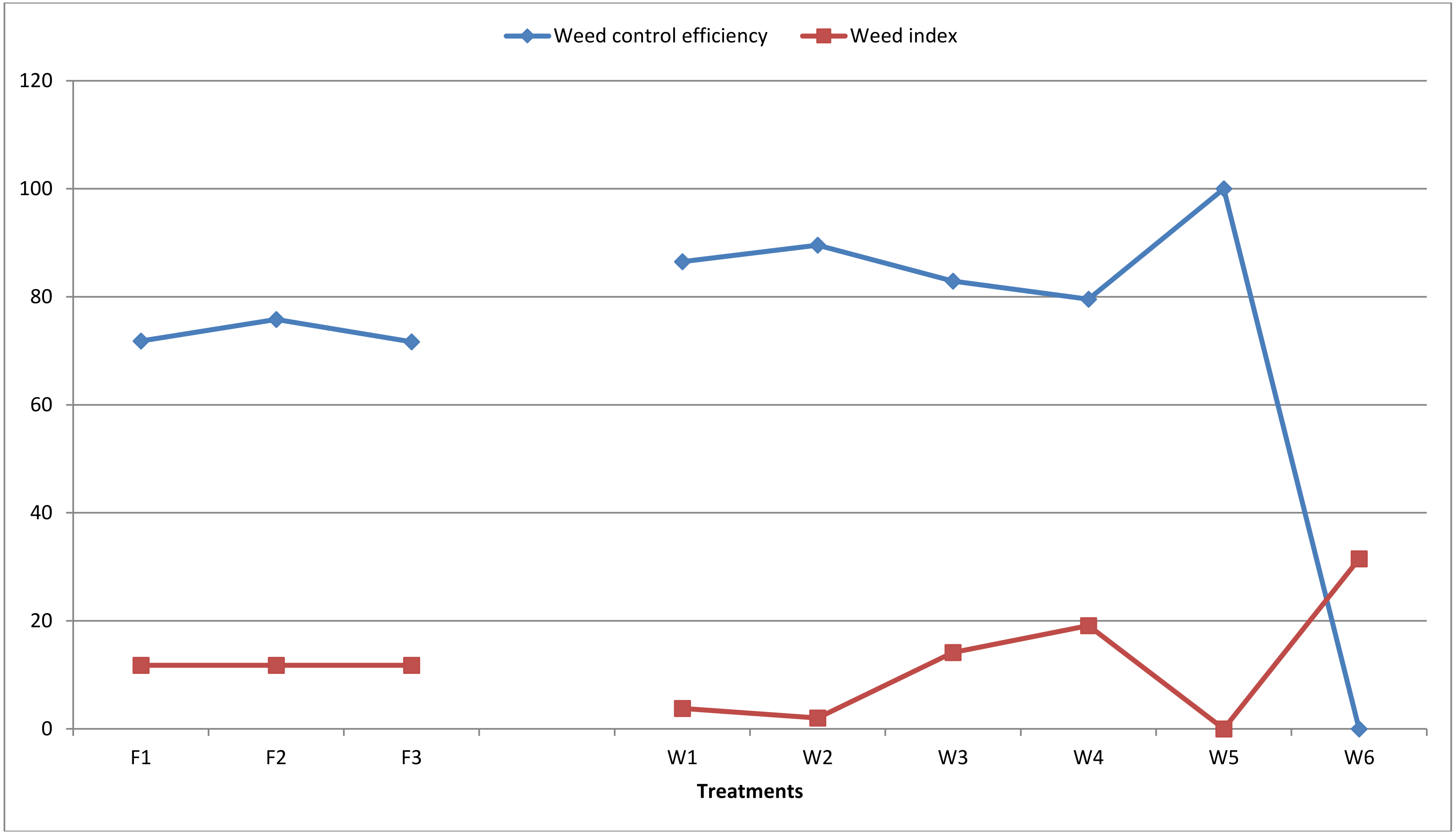

Fig. 1a. Weed control efficiency (%) and weed index (%) as influenced by various nutrient and weeds management practices during 2022-23

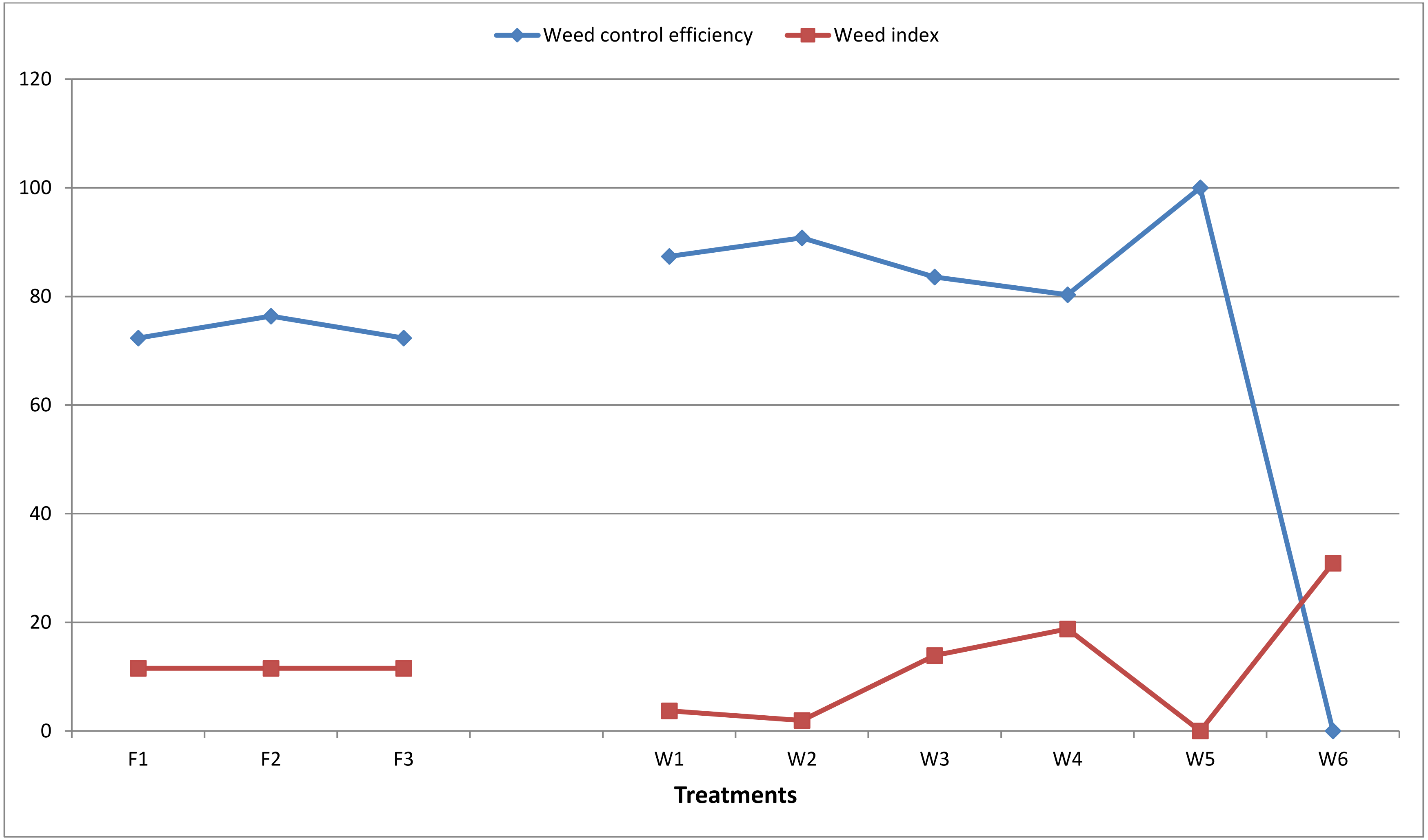

Fig. 1b. Weed control efficiency (%) and weed index (%) as influenced by various nutrient and weeds management practices during 2023-24

Fig. 2. Collecting and counting of weed flora from experimental field

Different nutrient management and weed control practices was significantly effective to minimize the density and dry weight of weeds as compared to weedy check during both year of experimentation. Density of weeds (no. m^{-2}) and dry weight of weeds (g m^{-2}) under different nutrient management and weed control practices is presented in (Table 1). In case of nutrient management application of 75% RDF + 10 t ha^{-1} FYM + one spray of nano-urea @ 4ml/lit recorded significantly minimum weed density and dry weight of weeds as compared to rest of the nutrient levels at each stages of crop growth, except 30 DAS. Among the herbicidal treatments, post- emergence application of Clodinofop + Metsulfuron (60 + 4 g a.i. ha^{-1}) recorded the minimum density and dry weight of grassy and broad leaved weeds. The highest dry matter accumulation of weeds were recorded in weedy check at 60 and 90 DAS, while the lowest weed dry weight recorded with weed free which was significantly lesser than the rest of the weed control practices. This might be due to more luxuriant growth of crop plant causes critical period of crop weed competition, application of higher rate of nutrients shift the competitive advantage in favor of crop and also help in smothering of weed and poor germination of weeds and the above mentioned herbicide is more effective in reducing density of weeds as compared to other herbicides. The reduced weed density under this treatment might result less weed dry weight. The similar findings have been reported by Deen *et al.* [10], Jain *et al*. [11], Kumar *et al*. [12].

Interaction effect between fertility levels and weed management practices on density and dry weight of weed were found non-significant at all stages of crop growth.

Effect on weed control efficiency (%): The data of weed control efficiency under various nutrient management and weed control practices is presented in Table 2 and depicted in Fig. (1a, 1b). In case of nutrient levels the maximum weed control efficiency was recorded with the application of 75% RDF + 10 t ha^{-1} FYM + one spray of nano-urea @ 4ml/lit (75.82% , 76.37%). In term of weed control practices, the maximum weed control efficiency was found with weed free (100%) followed by Clodinofop + Metsulfuron (60 + 4 g a.i. ha^{-1}) (89.57%, 90.77), Sulfosulfuron + Metsulfuron (30 + 2 g a.i. ha^{-1}) (86.50%, 87.37) during both years of experimentation respectively. It might be due to effectively control of broad leaved weeds and narrow weeds as well as which is directly related to increase weed control efficiency. Similar findings reported by Mishra *et al*. [13] and Paighan *et al*. [14].

Effect on Weed Index (%): The weed index, also referred to as the competition index. It indicates the reduction of yield due to competition offered by weeds and is expressed in percentage (%).

Data pertaining to the weed index is presented in Table 2 and Fig. (1a, 1b), revealed that the lowest yield reduction in wheat was observed in Clodinofop + Metsulfuron (60 + 4 g a.i. ha^{-1}) (1.99%, 1.96%), whereas, maximum yield reduction (31.47%, 30.92%) was recorded under weedy check during 2022-23 and 2023-24 respectively. Minimum yield reduction recorded with Clodinofop + Metsulfuron (60 + 4 g a.i. ha^{-1}) might be due to effective control of weeds which is inversely related to weed index (%). Similar findings reported by Pandey *et al*. [15] and Paswan *et al.* [16].

4. CONCLUSION

From the overall studies, it can be concluded that application of 75% RDF + 10 t ha^{-1} FYM + one spray of nano-urea @ 4ml/lit with the spraying of herbicide Clodinofop + Metsulfuron (60 + 4 g a.i. ha^{-1}) found superior for effective control of weeds, weed control efficiency and less yield reduction(weed index) in such treatments.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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