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Effect of nutrient and weed management practices on crop growth and productivity of wheat (*Triticum aestivum* L.) under rice-wheat cropping system in typic ustochrept soils

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Abstract
An experiment was carried out during winter (*rabi)* seasons in 2018-19 and 2019-20 at CRC farm of sardar Vallabhbhai Patel University of Agricultural& Technology, Meerut, Uttar Pradesh to evaluate the various nutrient and weed management practices on crop growth and productivity of wheat (*Triticum aestivum* L.). The treatments comprised of four nutrient management options, *viz.*, Control (No NPK) (T_1), 100% NPK (T_2), 100% NPK + Bio-stimulant-G@ 25kg/ha (soil application) (T_3) and 100% NPK + Bio-stimulant-L @ 625 ml/ha foliar spray each at 55&70 DAS(T_4) and four weed management practices weedy check (W_1), Two hand weeding (W_2), Sulfosulfuron+ Metsulfuron Methyl @ 20 + 4 g a.i. ha^{-1} (W_3), Carfentrazone-ethyl + Sulfosulfuron @ 20 + 25 g a.i. ha^{-1} (W_4) in Factorial Randomized block design and replicated thrice. Results indicated that highest plant height, number of tillers and maximum dry matter (433.6 & 447.1, 308.7 & 318.4 and 301.7 & 305.3), and highest reduction in weed density and weed dry matter accumulation was with an application of 100% NPK + Bio-stimulant-L. Among the herbicides Sulfosulfuron + Metsulfuron Methyl @ 20 + 4 g a.i. ha^{-1} gave best control of density of total weeds and dry matter accumulation at all the stages. Among the nutrient management options 100% NPK + Bio-stimulant-L @ 625 ml/ha foliar spray each at 55&70 DAS(T_4) and Sulfosulfuron+ Metsulfuron Methyl @ 20 + 4 g a.i. ha^{-1} (W_3) weed management may be recommended for better growth and higher yield of the wheat crop.

Keywords: Nutrient management practices, weed management practices, growth, productivity

Introduction
After China, India (*Triticum aestivum* L.) is the world's second largest wheat grower, accounting for 13.5 percent of worldwide wheat production. Wheat is the world's most extensively produced staple food crop, contributing significantly to global food security by providing food to billions of people, accounting about half of the all dietary protein (Deshmukh *et al*. 2020) [4]. The total area under wheat in India is about 314.51lakh ha with production of 1075.92 lakh tones and average productivity of 3421 kg ha^{-1} (DAC&FW). Imbalanced application of nutrients is one of the major barrier responsible for low productivity of wheat. This can be accomplished by utilizing all available nutrient sources, both organic and inorganic. The basic line is that any mismatch between nutrient input and output that depletes the soil is harmful. If an imbalance occurs, it will have a negative impact. Since the mid-1980s, yield of wheat in India has either declined or stagnated (Sinha *et al*., 1998; Duxbury *et al*., 2000) [11, 5]. One of the key problems is traditional blanket fertilizer recommendations, which result in fertilizer use that is unbalanced. As well as a reduction in fertilizer efficiency Agricultural properties in India is a widely fragmented country with erratic nutrient supplies both in terms of spatial and temporal capacity.

Biostimulants are currently gaining popularity in crop production, particularly in the rice-wheat cropping system as a companion of inorganic fertilizers. These products have the potential to improve agricultural sustainability by allowing for more production with less environmental impact. Algal biostimulants are rich in micro- and macronutrients, particularly nitrogen (N), phosphorus (P), and potassium (K), and might be used as an organic slow-release fertilizer (Ronga *et al*., 2019). Also microalgal extracts contained phytohormones such as auxins, cytokinins, abscisic acid, ethylene, and gibberellins, which are known to influence plant growth and development (Stirk *et al*., 2013) [12].

Chemical weed management is preferred in wheat because labor is limited and expensive, and mechanical or manual weeding is impractical. There are numerous good ready-mix herbicide combinations utilized for weed management in wheat these days, and they have been found to be successful in controlling broad spectrum weeds in wheat. Sulfosulfuron plus metsulfuron, Carfentrazone-ethyl plus Sulfosulfuronhave been demonstrated to be effective against complex weed flora. In this case, a proper combination of broad-spectrum herbicides is required. The use of two or more herbicides in a pre-mix combination to control a diversified weed flora is beneficial. As a result, an attempt was undertaken to evaluate the efficacy of various post-emergence herbicide combinations on weed flora, wheat growth, and yield.

Materials and Method

The field experiment was conducted at CRC farm of the Sardar Vallabhbhai Patel University of Agriculture & Technology, Meerut located in Indo-Gangetic plains of Western Uttar Pradesh. The soil of experimental site was sandy loam in texture, low in available nitrogen and organic carbon, medium in available phosphorus and potassium and slightly alkaline in reaction. The predominant soil at the experimental site is classified as Typic Ustochrept with sandy loam texture having pH 7.4, bulk density 1.49 g/cm3, low organic carbon content (0.42%), Soil samples for 0–15 cm depth at the site were collected and tested prior to applying treatments and the basic properties were low available nitrogen, low organic carbon, available phosphorus, available potassium medium and alkali in reaction. The experiment was laid out in a factorial randomized block design with two factors treatments consists of four nutrient management practices and four weed management practices and were replicated thrice. The treatments combination include four nutrient management options, *viz*., Control (No NPK) (T_1), 100% NPK (T_2), 100% NPK + Bio-stimulant-G@ 25kg/ha (soil application) (T_3) and 100% NPK + Bio-stimulant-L @ 625 ml/ha foliar spray each at 55&70 DAS (T_4) as first factor and four weed management practices weedy check (W_1), Two hand weeding (W_2), Sulfosulfuron+ Metsulfuron Methyl @ 20 + 4 g a.i. ha^{-1} (W_3), Carfentrazone-ethyl + Sulfosulfuron @ 20 + 25 g a.i. ha^{-1} (W_4) as second factor respectively. Wheat variety 'DBW-71' was sown on 10 December, 2018 and 9 December, 2019 with 100 kg seed/ha, keeping row-to-row distance of 20 cm during both the year of experimentation. The experimental field was provided with proper irrigation channels and the individual plots were demarcated by bunds. The growth and yield characters were recorded such as plant height at harvest (cm), number of total tillers $plant^{-1,}$ grain yield (t ha^{-1}), straw yield (t ha^{-1}). The data was analyzed statistically. Five plants will be tagged randomly in each net plot and their individual height will be recorded in centimeters with the help of meter scale from the ground surface to the tip of fully expanded leaves. Height of all the five plants will be summed and averaged to express plant height in centimeters.

Number of tillers will be recorded by using 0.25m-2 row lengths from three places in each plot and average of three places will be taken for analysis. The plant samples for dry matter accumulation well be taken at 30, 60, 90 DAS and at harvest after sowing from 0.25 m row length selected randomly from each plot. The samples were sun dried and then dried in oven at 72ºC ± 0.5ºC for 72 hours or till the constant were achieved. The dry matter was expressed in gram per meter row length. Grain yield recorded in kg/plot was finally converted into grain yield in kg/ha. The crop from each unit plot was harvested at full maturity to record the data on grain and straw yields. All data obtained from the experiment, conducted under factorial randomized block design were statistically analyzed using the F-test as per the procedure given by Gomez and Gomez (1984). Critical differences (CD) values at P = 0.05 were used to determine the significance of difference between treatment means. Treatment differences that were non-significant were denoted by NS. The growth and yield data were recorded, analyzed and tabulated after statistical test.

Results and Discussion

Effect on Wheat growth and yield parameters

a. Plant Height

The highest plant height of wheat was recorded with application of 100% NPK + Bio-stimulant-L @ 625 ml/ha foliar spray each at 55&70 DAS (88.1cm), which was at par with 100% NPK + Bio-stimulant-G @ 25kg/ha (soil application)(86.55cm) but significantly superior over application of 100% NPK alone (84cm). It indicates that application of biostimulant foliarly along with 100% NPK proved beneficial in increasing the plant height of wheat over 100% NPK alone (Table 1). Such a higher growth characters in this treatments can be linked with foliar application of nutrients which are absorbed by the leaf epidermis and easily transferred to the developing parts through the phloem. These results are in conformity with findings of Shah *et al*. (2013) [10]; Nelson and Staden (1986) [9].

Among the herbicides Sulfosulfuron + Metsulfuron Methyl @ 20 + 4 g a.i. ha^{-1} was recorded the best treatment for weed control during both years which resulted in maximum availability of moisture, nutrient, light and space to the crop. The lowest plant height was recorded with unweeded control (76.85cm) at all stages of crop growth and this might be due to heavy competition offered by weeds that resulted in reduced uptake of nutrients there by reducing the growth. Similar results were also reported by Deshmukh *et al*. (2020) [4].

b. Number of Tillers (No. m^{-2})

Highest number of tillers m^{-2} was observed with application of 100% NPK + Bio-stimulant-L @ 625 ml/ha foliar spray each at 55&70 DAS, which was at par with 100% NPK + Bio-stimulant-G @ 25kg/ha (soil application) (299.1 m^{-2}) but significantly superior over control (223 no. m^{-2}) (Table 1). Lowest numbers of tillers m^{-2} were recorded in unweeded control (215.45 m^{-2}) and the highest number for tillers were in two hand weeding treatment (320.4 m^{-2}) which was at par with treatment receiving Sulfosulfuron + Metsulfuron Methyl @ 20 + 4 g a.i. ha-1 (313.4 m^{-2}). These results are in conformity with Deshmukh *et al*. (2020) [4]. It might be due to less crop-weed competition and better resources utilization at the time of active growth as the weeds were properly controlled under these treatments.

Table 1: Effect of different nutrient and weed management practices on plant height (cm), tillers (No. m^{-2}) and dry matter accumulation (gm^{-2}) of wheat crop

Treatments	Plant height (cm)	Number of tillers m^{-2})	Dry matter accumulation (gm^{-2})
Nutrient management			
Control	76.85	223	837.7
100% NPK	84	286.1	1026.5
100% NPK + Bio-stimulant-G @ 25kg/ha (soil application)	86.55	299.1	1147.05
100% NPK + Bio-stimulant-L @ 625 ml/ha foliar spray each at 55&70 DAS	88.1	303.5	1172.8
C.D (P=0.05)	3.82	8.75	29.05
Weed management practices			
Weedy check	75.4	215.45	851.6
Two hand weeding	90.25	320.4	1181.25
Sulfosulfuron + Metsulfuron Methyl @ 20 + 4 g a.i. ha^{-1}	87.35	313.4	1133.25
Carfentrazone-ethyl + Sulfosulfuron @ 20 + 25 g a.i. ha^{-1}	85.35	298.85	1022
C.D (P=0.05)	4.17	16.1	44.9

c. Dry matter accumulation (g m^{-2})

The highest dry matter accumulated was in crop grown with application of 100% NPK + Bio-stimulant-L @ 625 ml/ha foliar spray each at 55&70 DAS (1172.8 g m^{-2}) (Table 3) which was at par with100% NPK + Bio-stimulant-G @ 25kg/ha (soil application) (1147.05 g m^{-2}) but significantly superior over control.

Sulfosulfuron + Metsulfuron Methyl @ 20 + 4 g a.i. ha^{-1}(1133.25 g m^{-2})was the best treatment for weed control during both years which resulted in maximum availability of moisture, nutrient, light and space to the crop. The lowest dry matter accumulation was recorded with unweeded control treatment (851.6g m^{-2})at all stages of crop growth and this might be due to heavy competition offered by weeds that resulted in reduced uptake of nutrients there by reducing the growth. Similar results were also reported by Deshmukh *et al.* (2020) [4] and Meena *et al.* (2020) [8].

d. Productivity

The highest grain and straw yields were recorded with application of 100% NPK + Bio-stimulant-L @ 625 ml/ha foliar spray each at 55&70 DAS which was at par with 100% NPK + Bio-stimulant-G @ 25kg/ha (soil application) but significantly superior over application of 100% NPK alone. This result is in corroboration with the findings of Szczepanek *et al.* (2106 & 2018) [14, 13].

The yield was significantly higher in two hand weeding (44.7 and 45.2) followed by Sulfosulfuron + Metsulfuron Methyl @ 20 + 4 g a.i. ha-1 which was significantly superior to Carfentrazone-ethyl + Sulfosulfuron @ 20 + 25 g a.i. ha-1. The better performance of these treatments in terms of yield could be attributed to better expression of their yield attributes due to reduction in crop weed competition. These results were in accordance with the results reported by Choudhary *et al.* (2021) [2], Barla *et al.* (2017) [1].

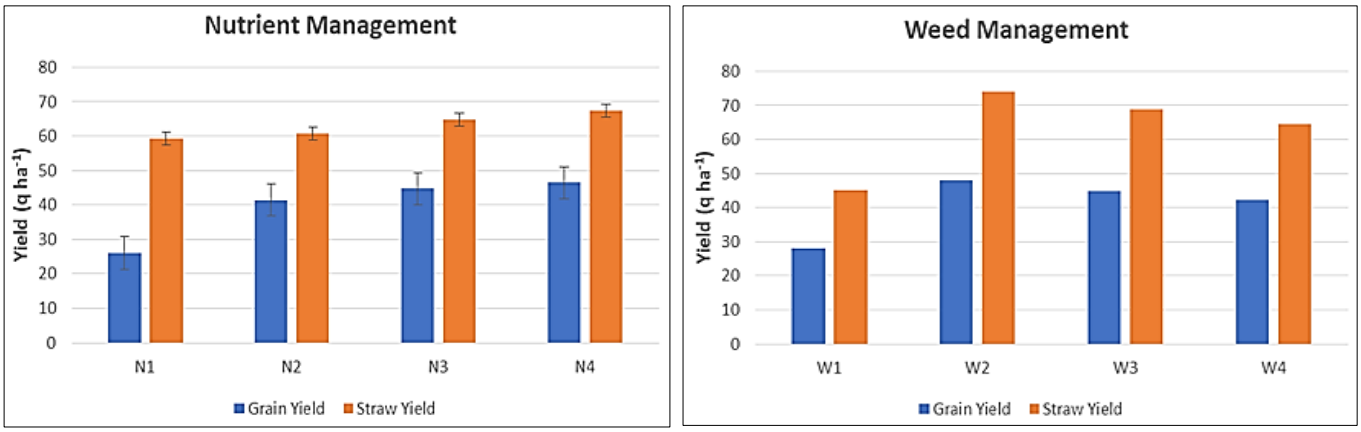

Fig 1: Effect of different nutrient and weed management practices on grain and straw yield of wheat crop

Weed studies

Pooled analysis of data revealed significant reduction in all weed control treatments with respect to weed density (m^{-2}) and dry weed biomass (g m^{-2}) over unweeded control as indicated in (Table 2). Highest reduction in weed density(m^{-2}) and dry matter of weeds (g m^{-2}) were recorded under two hand weeding at 30, 60 and 90 DAS due to complete removal of the weeds among the herbicides, Sulfosulfuron + Metsulfuron Methyl @ 20 + 4 g a.i. ha-1 (6.8 m^{-2} and 5.95 g m^{-2}) was found to be more superior in curtailing the weed population and dry weight of weeds followed by Carfentrazone-ethyl + Sulfosulfuron @ 20 + 25 g a.i. ha^{-1} (8.5 m^{-2} and 7.25 g m^{-2}) as compared to unweeded control (9 m^{-2} and 10.9 g m^{-2}).

Two hand weeding gave most effective control which reduced mean dry matter accumulation of total weeds by 76.15, 90.0 and 87.21 per cent over control at 30, 60 and 90 DAS respectively (Table 2 and 3).

Total weed population was reduced significantly due to various weed control treatments. This might be due to the herbicidal application alone and in combination which were effective in timely reducing total weed population. Lekh Chand and Punia (2017) [17] and Chaudhary *et al.* (2017) also reported similar results.

Table 2: Density of total weeds (m^2) as influenced by different nutrient and weed management practices

Treatment	Total weeds density (m^{-2})		
	30 DAS	60 DAS	90 DAS
Nutrient Management			
Control	12.2(156.25)	9.6(99.3)	9(88.1)
100% NPK	12.3(151.2)	9(88.6)	8.35(78)
100% NPK + Bio-stimulant-G @ 25kg/ha (soil application)	12.05(144.5)	8.4(78.65)	7.65(67.3)
100% NPK + Bio-stimulant-L @ 625 ml/ha foliar spray each at 55&70 DAS	11.65(135.2)	7.65(67.3)	6.8(55.75)
C.D. (P=0.05)	NS	0.51	0.515
Weed Management			
Weedy check	14.35(205.9)	13.55(183.3)	12.85(164.95)
Two hand weeding	6.85(47.65)	4.85(24)	3.95(16.3)
Sulfosulfuron + Metsulfuron Methyl @ 20 + 4 g a.i. ha^{-1}	13.75(187.55)	7.45(56.3)	6.75(46.45)
Carfentrazone-ethyl + Sulfosulfuron @ 20 + 25 g a.i. ha^{-1}	14.05(197.5)	9(82)	8.45(72.1)
C.D. (P=0.05)	0.55	0.57	0.585

Original values is parentheses and data subjected to square root (√x+1) transformation

Table 3: Total weeds dry matter accumulation (g m^{-2}) as influenced by different nutrient and weed management practices

Treatment	Total dry weight of weeds (g m^{-2})		
	30 DAS	60 DAS	90 DAS
Nutrient management			
Control	5(25.5)	7.15(55.85)	7.6(62.05)
100% NPK	4.85(24.15)	6.85(51.75)	7.25(57.05)
100% NPK + Bio-stimulant-G @ 25kg/ha (soil application)	4.7(22.55)	6.85(51.75)	6.85(50.95)
100% NPK + Bio-stimulant-L @ 625 ml/ha foliar spray each at 55&70 DAS	4.6(21.45)	5.65(37.35)	6.2(43.6)
C.D. (P=0.05)	NS	0.25	0.25
Weed management practices			
Weedy check	5.85(33.55)	10.35(107.55)	10.9(118.1)
Two hand weeding	2.95(8)	3.3(10.75)	3.95(15.1)
Sulfosulfuron + Metsulfuron Methyl @ 20 + 4 g a.i. ha^{-1}	5.2(26.05)	5.55(30.45)	5.95(35.55)
Carfentrazone-ethyl + Sulfosulfuron @ 20 + 25 g a.i. ha^{-1}	5.35(28.05)	6.95(47.9)	7.25(52.4)
C.D. (P=0.05)	0.43	0.28	0.28

Original values is parentheses and data subjected to square root (√x+1) transformation

Conclusion

Based on the findings of the present investigation, it can be inferred that the adoption 100% NPK + Bio-stimulant-L @ 625 ml/ha foliar spray each at 55 &70 DAS with Sulfosulfuron + Metsulfuron Methyl @ 20 + 4 g a.i. ha^{-1} proved in significantly enhancing the growth attributes and yield. Form the present study it was observed that 100% NPK + Bio-stimulant-L @ 625 ml/ha foliar spray each at 55 &70 DAS significantly improved the growth and yield of wheat crop. Among the weed control practices Sulfosulfuron + Metsulfuron Methyl @ 20 + 4 g a.i. ha^{-1} improved the different growth parameters and yield of wheat crop over the control.

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