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Study on yield maximization of wheat with equitable use of agri-inputs and weed management practices under restricted irrigation condition

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Abstract
The field experiment was entitled with "Study on yield maximization of wheat with equitable use of agri - inputs and weed management practices under restricted irrigation condition" was conducted during rabi 2021-22 and 2022-23, at student's Instructional farm, C.S.A. University of Agriculture and Technology, Kanpur Nagar (U.P.). The soil of the experimental plot was sandy loam in texture. The experiment was laid out in Factorial Randomized Block Design (RBD) with three replications, assigning 26 treatments combination, four fertility levels F_1- Absolut control, F_2- RDF (150:60:40 NPK Kg/ha), F_3- RDF (75:60:40 NPK Kg/ha) + 2 spray of Nano Urea (4ml/ litter), F_4- RDF (150:60:40 NPK Kg/ha) + 2 spray of Nano Urea (4ml/ litter) and five weed management practices W_1- Weedy check, W_2- Metsulfuran methyl 10% + Carfentrazone ethyl 40% DF @50g ha^{-1}, W_3-Pyromaxsulfuron 85% wc @ 800 ml ha^{-1}, W_4- Flumioxazin 50% sc @ 250 ml ha^{-1}, W_5- Two hand weeding at 20 and 40 DAS. The results of the experiment concluded that the there was no any effect of plant population on growth. Highest growth was recorded in RDF (150:60:40 NPK Kg/ha) + 2 spray of Nano Urea (4ml/ litter) (F_4) treatment and two hand weeding at 20 and 40 DAS (W_5) treatment. This is revealed by Relative growth rate highest growth was recorded at sowing to 30 DAS.

Keywords: Field experiment, yield maximization, wheat, agri-inputs

Introduction

The plant family Poaceae includes the self-pollinating crop wheat (Triticum aestivum L.), which has chromosome (2n = 42). It is a hexaploid, long-day, annual plant with a C3 nature that is mostly grown as a staple crop all over the world. With 106.84 million tons of grain produced annually and 13.33% of the global wheat production, wheat is India's most important winter food crop (Anonymous, 2022) [2]. To keep up with the expanding population, wheat production must increase; but, climate change poses a severe threat to this growth. With 70% carbohydrates, 10%-12% protein, 2.0% fat, minerals (1.8%), water (12%), crude fibers (2.2%), and trace levels of vitamins A, B, and thiamin, wheat is a nutrient-dense grain. (Britannica, 2021) [3]. Currently, weather fluctuations, unhealthy soil, and an increased risk of disease and insect-pest outbreaks limit the wheat farming method. All things considered, nitrogen is essential to wheat growth and development, and sustainable wheat production in India requires effective management techniques. (Lokendra *et el.*, 2024) [7]. On the other hand, nano-fertilizers are an important source of nutrients in agriculture that improve crop quality, productivity, and growth. They seem to be very successful in precision agriculture for accurate nutrient management since they increase nutrient usage efficiency and lower cultivation expenses. Nano fertilizers offer enhanced surface area for numerous metabolic reactions in plants, elevating photosynthesis rates, and therefore, boosting dry matter output and crop yield. (Qureshi *et al.*, 2018 and Rani *et al.*, 2024) [10, 11]. 11,000 field experiments conducted throughout India have shown that its small size and broad surface area improve nutrient availability, resulting in an 8% improvement in agricultural productivity. (Kumar *et al.*, 2020) [6]. One of the main causes for low wheat production, not only in India but globally as well, is weed infestation, which lowers wheat output by 37-50% (Waheed *et al.*, 2009) [15]. This can be reduced even more by implementing suitable weed control techniques.

There are numerous approaches to weed control, but none of them are infallible. In addition to being costly and time-consuming, manual weeding cannot be done until weeds exhibit enough vegetative growth. With the advent of herbicides, a variety of weeds in wheat can now be successfully controlled. Sulfosulfuron + Metsulfuron at 0.096 g ha^{-1} was the herbicide with the highest weed control efficacy, 82.27%. (Singh *et al.*, 2017) [14].

Materials and Methods

The experiment was conducted during *Rabi* season of 2021-22 and 2022-23 at student's Instructional farm, C.S.A. University of Agriculture and Technology, Kanpur Nagar (U.P.). The soil was sandy loam in texture, low in available OC, N, P and medium in K (kg ha^{-1}), pH (7.67, 7.68), EC (dsm^{-1}) 0.242, 0.244 respectively. The experiment was laid out in Factorial Randomized Block Design (RBD) with three replications, assigning 26 treatments combination, four fertility levels F_1- Absolut control, F_2- RDF (150:60:40 NPK Kg/ha), F_3- RDF (75:60:40 NPK Kg/ha) + 2 spray of Nano Urea (4ml/ litter), F_4- RDF (150:60:40 NPK Kg/ha) + 2 spray of Nano Urea (4ml/ litter) and five weed management practices W_1- Weedy check, W_2- Metsulfuran methyl 10% + carfentrazone ethyl 40% DF @50g ha^{-1}, W_3-Pyromaxsulfuron 85% wc @ 800 ml ha^{-1}, W_4-Flumioxazin 50% sc @ 250 ml ha^{-1}, W_5- Two hand weeding at 20 and 40 DAS. The experimental field was ploughed thoroughly to obtain fine seed bed. The fertilizers were applied as per treatment combination as basal dose and sprays. The Wheat seeds were sown at spacing of 22.5 cm with the seed rate of 100 kg/ha. Population count was taken on 30 DAS and at harvest. For this purpose, Plants were counted in one square meter area at two places in each net plot was earmarked by sticks randomly. The number of leaves per plants were counted of selected plant at 30, 60, 90 and 120 DAS and relative growth rate studied at 30, 60, and 90 days after sowing (DAS) and at harvest.

RGR was calculated by the formula given by Fisher (1921) as below

$$RGR = \frac{\text{loge W2} - \text{loge W1}}{\text{t2} - \text{t1}}$$

All agronomic practices were followed at all growth stages and the data was statistically analyzed using ANOVA technique.

Results and Discussion

Plant population

Table 1. Presents the effect of agricultural inputs and weed management practices on the plant population (plants per square meter) under different fertility levels showed non-significant variations in the year 2021 and 2022. In the year 2021, the initial plant populations ranged from 213.08 to 215.16 plants per m^2, with similar trends observed in 2022, ranging from 211.76 to 213.43 plants per m^2. At the final harvest stage, plant populations ranged from 359.86 to 368.01 plants per m^2 in 2021 and from 354.70 to 359.26 plants per m^2 in 2022. Similarly, the plant population non-significantly varied under different weed management practices. Initial plant populations ranged from 212.68 to 216.70 plants per m^2 in the year 2021 and from 211.28 to 213.53 plants per m^2 in the year 2022. At the final harvest stage, plant populations ranged from 360.88 to 367.92 plants per m^2 in the year 2021 and from 353.48 to 360.25 plants per m^2 in the year 2022. These results were enclosed close conformity with the finding of Hassan *et al.* (2021) in barely and Singh *et al.* (2022) [13] in wheat.

Table 1: Effect of agri-inputs and weed management practices on plant population of wheat

Treatment	Plant Population m^{-2}			
	Initial at 30 DAS		Final at harvest	
	2021	2022	2021	2021
Factor A: Fertility Level				
F_1	213.08	211.76	359.86	354.70
F_2	213.62	213.43	364.11	356.20
F_3	214.60	213.34	366.56	357.39
F_4	215.16	212.40	368.01	359.26
SEm±	4.24	4.26	6.85	7.20
CD @ 5%	NS	NS	NS	NS
Factor-B: Weed management practices				
W_1	213.66	211.28	360.88	353.48
W_2	212.68	212.40	362.98	355.67
W_3	213.30	212.99	364.70	356.93
W_4	214.25	213.53	366.68	358.11
W_5	216.70	213.47	367.92	360.25
SEm±	4.74	4.76	7.66	8.05
CD @ 5%	NS	NS	NS	NS

Number of Leaves per Plant

Significantly higher number of leaves per plant was observed with the RDF (150:60:40 NPK Kg/ha) + 2 spray of Nano Urea (4ml/ litter) (F_4) at all the stages of crop growth, during both of the years as compared to F_1 **(**Absolut control) at all the growth stages during 2021. In 2022 F_4 was significantly higher number of leaves as compared to F_1 **(**Absolut control) and F_2 (RDF (150:60:40 NPK Kg/ha)) at all the stages of crop growth except 30 DAS. At harvest stage, the treatment F_4 had the highest number of leaves per plant i.e., 20.38 and 21.10 in the year 2021 and 2022, respectively. While, the F_1 treatment had the lowest number of leaves at all the stages of crop growth in the year 2021 and 2022 i.e., 18.72 and 19.17, at harvest, respectively. Morsy *et al.*, (2021) [8] observed that foliar application of nano fertilizer with 500 ml ha^{-1} showed the highest mean values for number of leaves $plant^{-1}$ (19.3 and 19.2) and flag leaf area. Similarly, the significantly higher number of leaves per plant was observed with the treatment W_5 (Two hand weeding at 20 and 40 DAS) as compared to W_1 (Weedy check) and W_2 (Metsulfuran methyl 10% + carfentrazone ethyl 40% DF @50g ha^{-1}) at all the crop growth stages during both of the years except 30 DAS during both the years and at 60 DAS during 2022. At 30 DAS during both the years and at 60 DAS during 2022 W_5 was significantly higher number of leaves per plant as compared to W_1, W_2, and W_3. However, at the harvest stage, W_5 again revealed the highest leaf number per plant, noted 20.38 in 2021 and 21.36 in 2022, while W_1 showed the least with 19.03 in 2021 and 18.83 in 2022. The physiological stress imposed by weed competition in the untreated control (W_1) reduced leaf production, as the plants diverted energy toward survival rather than growth. These results were enclosed close conformity with the finding of Singh *et al.* (2022) [13] and Pal *et al.*, (2023) [9] in wheat.

Table 2: Effect of agri-inputs and weed management practices on number of leaves of wheat

Treatment	Number of leaves per plant							
	30 DAS		60 DAS		90 DAS		At harvest stage	
	2021	2022	2021	2021	2021	2021	2021	2022
Factor A: Fertility Level								
F_1	6.33	5.15	13.89	12.66	15.08	15.18	18.72	19.17
F_2	7.00	5.66	14.86	12.85	16.12	15.65	19.80	19.80
F_3	7.32	5.82	15.08	13.24	16.52	16.43	20.08	20.41
F_4	7.58	6.01	15.40	13.69	16.68	17.04	20.38	21.10
SEm±	0.20	0.17	0.25	0.21	0.23	0.28	0.24	0.39
CD @ 5%	0.58	0.49	0.71	0.60	0.65	0.79	0.70	1.13
Factor-B: Weed management practices								
W_1	6.17	5.11	13.19	11.92	14.78	14.94	19.03	18.83
W_2	6.40	5.34	14.53	12.64	15.98	15.80	19.43	19.35
W_3	7.03	5.64	15.05	13.16	16.43	16.18	19.78	20.13
W_4	7.61	6.03	15.45	13.60	16.60	16.50	20.13	20.94
W_5	8.08	6.20	15.83	14.26	16.73	16.96	20.38	21.36
SEm±	0.23	0.19	0.28	0.23	0.26	0.31	0.27	0.44
CD @ 5%	0.65	0.55	0.79	0.67	0.73	0.88	0.78	1.26

Table 3: Effect of agri-inputs and weed management practices on relative growth rate of wheat

Treatment	Relative growth rate (g/ g/ day)							
	30 DAS		60 DAS		90 DAS		At harvest stage	
	2021	2022	2021	2021	2021	2021	2021	2022
Factor A: Fertility Level								
F_1	20.64	20.57	14.58	14.53	2.51	2.46	2.46	2.37
F_2	21.93	21.82	14.80	14.69	2.74	2.67	2.85	2.70
F_3	22.22	22.10	14.97	14.83	2.85	2.77	2.99	2.87
F_4	22.24	22.57	15.12	15.03	2.89	2.83	3.11	2.96
SEm±	0.14	0.17	0.11	0.12	0.07	0.07	0.09	0.09
CD @ 5%	0.39	0.48	0.32	0.34	0.21	0.19	0.27	0.26
Factor-B: Weed management practices								
W_1	21.35	21.33	14.34	14.24	2.44	2.40	2.57	2.47
W_2	21.60	21.56	14.76	14.68	2.62	2.52	2.73	2.61
W_3	21.78	21.79	15.00	14.90	2.79	2.73	2.86	2.73
W_4	21.98	21.98	15.08	14.93	2.88	2.83	2.99	2.83
W_5	22.09	22.18	15.16	15.11	3.01	2.93	3.11	2.99
SEm±	0.15	0.19	0.13	0.13	0.08	0.07	0.10	0.10
CD @ 5%	0.44	0.53	0.36	0.38	0.23	0.21	0.30	0.29

Relative Growth Rate (RGR) Effect of Fertility Levels

Table 3 illustrated the impact of fertility levels on the relative growth rate at 30, 60, and 90 days after sowing (DAS) and at harvest, revealing significant differences at all growth stages. The significantly maximum relative growth rate was observed with treatment (F_4) RDF (150:60:40 NPK Kg/ha) + 2 spray of Nano (4ml/ liter) as compared to F_1 **(**Absolut control) at all the stages of crop growth during both of the years, except during 2022 at 30 DAS here F_4 RDF (150:60:40 NPK Kg/ha) + 2 spray of Nano (4ml/ liter) was significantly higher as compared to F_1 **(**Absolut control) and F_2 (RDF (150:60:40 NPK Kg/ha)) both the treatments. At harvest, F_4 recorded the highest relative growth rate of 3.11 g/g/day in 2021 and 2.96 g/g/day in 2022, whereas F_1 had the lowest relative growth rate at all the stages of crop growth, during both of the years i.e., 2.46 g/g/day in 2021 and 2.37 g/g/day in 2022 at harvest stage. Similar result reported by Rawat *et al*., (2022) [12] revealed that Nitrogen, a key driver of photosynthesis, accelerates carbon fixation, enabling faster growth. Similarly, the significantly higher relative growth rate per plant was observed with the treatment W_5 (Two hand weeding at 20 and 40 DAS) as compared to W_1 (Weedy check) and W_2 (Metsulfuran methyl 10% + carfentrazone ethyl 40% DF @50g ha^{-1}) at all the crop growth stages during both of the years. However, at the harvest stage, W_5 again showed the highest rate of 3.11 g/g/day in 2021 and 2.99 g/g/day in 2022, while W_1 had the lowest relative growth rate at all the stages of crop growth, during both of the years i.e., 2.57 g/g/day in 2021 and 2.47 g/g/day in 2022 at harvest stage. Same findings observed by Amare *et al*., (2014) [1], Yadav *et al*., (2019) [16], Singh *et al*. (2022) [13] and Dheer *et al*., (2024) [4] observed unchecked weeds in likely outcompeted wheat for light and nutrients, causing physiological limitations such as reduced photosynthesis, lower root development, and slower overall growth.

Conclusion

It is concluded from the above discussion that there was no any effect of plant population on growth. Highest growth (number of leaves and relative growth rate) was recorded in RDF (150:60:40 NPK Kg/ha) + 2 spray of Nano Urea (4ml/ litter) (F_4) treatment with two hand weeding at 20 and 40 DAS (W_5) treatment. This is revealed by Relative growth rate highest growth was recorded at sowing to 30 DAS.

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