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Effect of organic and inorganic sources of fertilizers on growth and yield of irrigated wheat (*Triticum aestivum* L.)

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Abstract
An experiment comprising 9 treatments *viz*., 75% RDF (T_1), 100% RDF (T_2), 125% RDF (T_3), 75% RDF + 5 t ha^{-1} FYM (T_4), 75% RDF + 5 t ha^{-1} Vermicompost (T_5), 100% RDF s+ 5 t ha^{-1} FYM (T_6), 100% RDF + 5 t ha^{-1} Vermicompost (T_7), 125% RDF + 5 t ha^{-1} FYM (T_8), 125% RDF + 5 t ha^{-1} Vermicompost (T_9) were tested on a wheat crop of the variety K-1317 at the university's research farm during Rabi 2022–2023 using a randomized block design with three replications. 125% RDF + 5 t ha^{-1} Vermicompost (T_9) was found to be most effective treatment on growth parameters *viz*., initial plant population (138), plant height 23.33, 54.23, 89.74 and 93.51 cm, number of tillers per m^{-2} 276, 368, 414 and 460 at 30, 60, 90 DAS and harvest, leaf area index 1.5, 4.58 and 6.81, dry matter accumulation 10.18, 59.42, 68.96 at 30, 60, 90 DAS respectively and yield attributes i.e., spike length (9.23 cm), number of spikes per m^{-2} (346.78), Number of Spikelet's ear^{-1} (17.47), No. of grain per spike (44.77) and test weight (42.66 g). maximum biological yield (107.57 q ha^{-1}), grain yield (46.17 q ha^{-1}) and straw yield (61.40 q ha^{-1}) and maximum harvest index (42.92%) are also recorded with 125% RDF + 5 t ha^{-1} Vermicompost (T_9). Maximum net return 77,439.71 Rs. Ha^{-1} was observed with 125% RDF + 5 t ha^{-1} FYM (T_8) and in case of B:C ratio treatment 100% RDF (T_2) was recorded highest B:C ratio (1.88).

Keywords: Wheat, FYM, vermicompost

Introduction
Particularly in developing nations where a cereal-based agricultural system is the sole significant source of nutrition and calorie intake, cereals are crucial to meeting the expanding population's worldwide food need (Sendhil *et al.*, 2020) [8]. The nutrient-rich cereal is produced in a variety of conditions; worldwide, wheat covers about 220 million hectares (ha), ranking first among all crops in terms of acreage with an annual yield of roughly 764.4 million tons and an average productivity of 3.53 tons/ha in 2019–20 (USDA, 2020) [11]. One of the most significant cereal crops farmed worldwide and a staple food for almost 2.5 billion people worldwide is wheat (*Triticum aestivum* L.). Given its diversified agro-ecological conditions, which it has been blessed with, India is the world's second-largest producer of wheat, providing food and nutrition security to the majority of its population through production and consistent supply, notably in recent years. With a record average productivity of 3.53 tons/ha, the crop has been under cultivation for around 29.32 years (14% of the world's land), producing 103.6 million tonnes of wheat (13.92% of the world's production) (USDA, 2020) [11]. Wheat is widely procured by the government and distributed to a majority of the population; it ensures not only food security but also nutrition security. Wheat has a significant share in consumption of food basket with a 36% share in the total food grains produced from India. Area growth is primarily to blame for this increase in production, with a small gain in productivity following. (Singh *et al*., 2019 and Sangwan *et al.*, 2019) [6, 7].

In India, the Rabi season is when wheat is grown. Typically, it is planted in November and harvested in March or April. From 2018-19 to 2019-20, the area planted with wheat increased, with a net gain in area of 1.5 million ha (5%) over the two years. With 9.75 million hectares (32% of the total), Uttar Pradesh has the greatest area share, followed by Madhya Pradesh (18.75%), Punjab (11.48%), Rajasthan (9.74%), Haryana (8.36%), and Bihar (6.82%). However, states like Jharkhand (51%), Madhya Pradesh (27%) and Rajasthan (13%), had a significant increase in wheat area. It is farmed in the state of Uttar Pradesh on an area of roughly 9.86 million ha, producing 38.04 million tonnes and yielding 3.86 tonnes per hectare.

The considerable rise in the minimum support price and the government's purchase are the two key forces that led to the significant growth in the area that is dedicated to wheat cultivation. (Sendhil *et al*., 2020) [8].

The soils of UP and India frequently lack at least seven nutrients (N, P, K, S, Zn, Fe, and B). India's population is growing quickly, and as a result, modern agriculture has become increasingly demanding on the soil's nutrients over time. However, the availability of artificial nutrient sources for plant growth and development, particularly the usage of synthetic nitrogen fertilizer, was one of the key initiating causes behind the dramatically improved wheat yield. In addition to nitrogen fertilizer, other important nutrients for wheat's growth, development, and production are potash and phosphorus fertilizer. In addition to these major (macro) nutrients, some other nutrients are also necessary for the growth of wheat but are only required in very little (micro) amounts. Boron (B), zinc (Zn), iron (Fe), copper (Cu), manganese (Mn), and chlorine (Cl) are among those known to affect wheat's yield of both grain and straw.

In an area of India where crops are grown intensively, high yearly crop output causes significant nutrient losses, which are then not adequately replenished by chemical fertilizers and manures, leading to poor soil health. It has been stated that production factors are rising while yields are declining. To sustain output, growers have started applying larger dosages of fertilizer. These new trends of indiscriminate fertilizer usage without the use of organic nutrient sources are also to blame for the decline in soil health. The imbalanced use of fertilizers has left soils lacking in multiple nutrients. Because of the variety of restrictions that result from poor soil quality, soils eventually have low functional capacity.

A balanced fertilization schedule employing organic manures is seen to be a beneficial agricultural approach to preserve output, improve fertilizer use effectiveness, and restore soil fertility. The fast-releasing fertilizer nutrient pool and the slow-releasing organic nutrient pool, respectively, in the combined usage system, enable it to address both the short- and long-term nutrient needs of crops. The integrated nutrient supply, which includes the use of chemical fertilizers, organic manures like FYM, and bio-fertilizers, helps close the gap between the removal and addition of nutrients while also ensuring a balanced nutrient ratio and increasing wheat productivity. Organic matter serves as the substrate for a variety of beneficial organisms that are vital to the health of the plant in the soil. (Kumar *et al.*, 2015) [4].

Material and Methods

The present experiment comprising 9 treatments viz., 75% RDF (T_1), 100% RDF (T_2), 125% RDF (T_3), 75% RDF + 5 t ha^{-1} FYM (T_4), 75% RDF + 5 t ha^{-1} Vermicompost (T_5), 100% RDF + 5 t ha^{-1} FYM (T_6), 100% RDF + 5 t ha^{-1} Vermicompost (T_7), 125% RDF + 5 t ha^{-1} FYM (T_8), 125% RDF + 5 t ha^{-1} Vermicompost (T_9) They were placed through randomized block design with three replications on wheat crop cv. K-1317 at the university's research farm during Rabi 2022–2023, with the following spacing of 20 cm x 5 cm in plot size of 5.0 m × 4.0 m. The experimental site is situated at an altitude of 126 m above mean sea level and at a latitude of roughly 26.57° North, 80.21° East, and longitude of roughly. The experimental soil was sandy loam in composition and had the following characteristics: 7.3 pH, 0.44 dSm^{-1} EC, 0.52% organic carbon, 139.2 kg ha^{-1} available nitrogen, 13.75 kg ha-1 available P2O5, and 205.7 kg ha^{-1} available K_2O. The experimental field was well-prepared for effective germination. Prior to sowing, fertilizers @ 120 kg N, 60 kg P_2O_5, and 40 kg K_2O ha^{-1} were sprayed. On November 18, 2022, 100 kg ha^{-1} of high-quality seed of the cultivar K-1317 was sowed. Knapsack sprayers with flat fan nozzles and 500 liters of water per acre were used to apply pre-emergence herbicides. To grow the optimal crop, many other agronomic and plant protection methods were periodically employed.

Five plants were chosen at random from each plot, and those plants were tagged. We took measurements at 30, 60, and 90 days after sowing (DAS), as well as at maturity, to determine the height (cm), the number of tillers per plant, and the leaf area index. It was decided to compute the mean values. It was recorded how many days it took for each treatment's wheat plant to flower for fifty percent after the seed was sown. The number of days was tallied, and the results were represented as the average number of days till flowering reached 50%. From the tagged plants in each plot, the following yield attributes were recorded: spike length, number of spikes per m^{-2}, number of spikelet's $ears^{-1}$, number of grains per spike, and test weight. The biological yield, grain yield, straw yield, and harvest index were all determined with the help of Donald's (1962) as Economic yield/ Biological yield x 100. These values were recorded from the net plot area of each plot individually.

Results and Discussion

Initial plant population (m^{-2}): The experimental data on IPP is shown in Table-1. The remarkable effect on IPP were shown with the use of rhizobium, iron and zinc solubilizers. The maximum IPP i.e., 138 was recorded in the treatment T_9- 125% RDF + 5 t/ha Vermicompost followed by 135.6 in T_8- 125% RDF + 5 t/ha FYM. The minimum IPP (121.20) was observed in T_1- 75% RDF treatment.

Plant height (cm): Wheat plant height was measured at 30, 60, and 90 days after sowing as well as during harvest stage. Table-1 contains the results of the presentation of the data. After 30–90 days after being sown, the plant will have reached its full height. The plants exhibited almost little sign of growth either when they reached maturity or when they were already mature. Significantly maximum plant height of 23.33, 54.23, 89.74 and 93.51 cm at 30, 60, 90 DAS and at harvest stage followed by 125% RDF + 5 t/ha FYM. The significantly lowest height 17.53, 43.66, 70.92 and 75.93 cm was observed in 75% RDF. The result of plant height was following the result of Suryawanshi *et al*., (2018) and Yadav *et al*., (2014) [10, 13]

Number of tillers (m-2): At 30, 60, and 90 DAS, as well as at harvest, the number of tillers per square meter of wheat was counted. The results of these counts are depicted in Table-1. The data collected during the wheat growth period revealed that the growth was at its highest between 30 and 90 DAS. When plants reached maturity, the number of tillers barely increased. It was significantly noticed that T_9- 125% RDF + 5 t/ha Vermicompost was most effective treatment recorded maximum number of tillers 276.00, 368, 414 and 460 at 30, 60, 90 DAS and at harvest stage followed by T_8- 125% RDF + 5 t/ha FYM. The significantly lowest tillers 242.40, 323.20, 363.60 and 404 was observed in T_1- 75% RDF. The result of number of tillers m^{-1} was also revealed by Singh *et al*., (2019) [9].

Leaf area index: The Leaf area index was recorded at 30,60 and 90 DAS and data have been depicted in Table-1. The data recorded during the growth phase of chickpea showed that the growth was maximum during 30 DAS to 90 DAS. It was significantly noticed that T_9-125% RDF + 5 t/ha Vermicompost was most effective treatment recorded maximum Leaf area index 1.56, 4.60 and 6.81 at 30, 60 and 90 DAS stage followed by T_8-125% RDF + 5 t/ha FYM. The significantly lowest height 0.73, 3.84 and 5.76 was observed in T_1-75% RDF. The result on leaf area index was also revealed by Kumar *et al.,* (2022) [5].

Dry matter accumulation per plant: At 30, 60, and 90 days after sowing, data was gathered on the amount of dry matter that had accumulated on each wheat plant. Table-1. contains the results that have been obtained. The data of dry matter accumulation of growth phase of wheat showed that accumulation was maximum between 30 DAS to 90 DAS. It was significantly noticed that T_9-125% RDF + 5 t/ha Vermicompost was most effective treatment recorded maximum Leaf area index 10.18, 59.42 and 68.96 g at 30, 60 and 90 DAS stage followed by T_8-125% RDF + 5 t/ha FYM. The significantly lowest height 8.54, 43.35 and 52.27 g was observed in T_1-75% RDF. The other treatments produced significantly higher plant height than T_1 treatment. Choudhary *et al.,* (2022) [2] found that the consequence of dry matter accumulation per plant was noticed by them likewise.

Number of spike (m^{-2}): The table-2 clearly depicted that the experimental data of the Number of spike (m^{-2}) were significantly affected due to different nutrient combinations. It was significantly noticed that T_9-125% RDF + 5 t/ha Vermicompost was most effective treatment recorded maximum Number of spike (346.78) followed by T_8-125% RDF + 5 t/ha FYM. The significantly lowest Number of spike (176.76) was observed in T_1-75% RDF. The result of Number of spike (m^{-2}) was also find by Singh *et al.,* (2019) [9].

Spike length (cm): The results of the experiment given in table-2 showed quite clearly that the length of the spike, measured in cm, was greatly affected by the different nutritional combinations. It was significantly noticed that T_9-125% RDF + 5 t/ha Vermicompost was most effective treatment recorded maximum Spike length (9.67 cm) followed by T_8-125% RDF + 5 t/ha FYM. The significantly lowest Spike length (7.94 cm) was observed in T_1-75% RDF.

Number of Spikelet ear^{-1}: The experimental data of Number of Spikelet ear^{-1} have been shown in Table-2. The Number of Spikelet ear^{-1} were significantly affected due to various combinations. Data noticed that T_9-125% RDF + 5 t/ha Vermicompost was most effective treatment recorded maximum Number of Spikelet ear^{-1} (18.47) followed by T_8-125% RDF + 5 t/ha FYM. The significantly lowest Number of Spikelet ear^{-1} (15.47) was observed in T_1-75% RDF. The result of grains per pod was also find by Sangawan *et al.,* (2019) [7].

Number of grains per spike: The experimental data of Number of grains per spike have been depicted in Table-2. The application of vermicompost and FYM affect the grains per spike. It was significantly noticed that T_9-125% RDF + 5 t/ha Vermicompost was most effective treatment recorded maximum Number of grain per spike (45.77) followed by T_8-125% RDF + 5 t/ha FYM. The significantly lowest Number of grains per spike (19.23) was observed in T_1- 75% RDF. The result of pod length was also found by Kumar *et al.,* (2016) [14].

Test weight (g): The data of test weight have been presented in Table-2. The test weight in present investigation found from 39.88 g to 48.66 g. The nutrient supply by RDF, Vermicompost and FYM produces healthy and bold seeds. The maximum test weight 48.66 g was recorded in the treatment T_9-125% RDF + 5 t/ha Vermicompost which was followed by T_8-125% RDF + 5 t/ha FYM. The minimum test weight 39.88 g was found in T_1- 75% RDF. The result of test weight was also found by Yadav *et al.,* (2014) [13].

Grain yield (kg/ ha): Table-2 contains the results of the calculations on the amount of grain produced per hectare. It was found that the treatment with T_9-125% RDF + 5 t/ha Vermicompost was the most effective one, recording a maximum grain yield of 4617 kg ha^{-1} when the crop was harvested, followed by the treatment with T_7-100% RDF + 5 t/ha Vermicompost. This was a noteworthy finding. During the course of the experiment, the T_1-75% RDF treatment produced a significantly minimum grain production of 3814 kg ha^{-1}. Yadav *et al.,* (2018) [12] likewise came to the conclusion that grain yield was a significant factor.

Harvest index (%): The experimental data of harvest index (%) have been shown in Table-2. The maximum harvest index 42.92% was in the treatment T_9-125% RDF + 5 t/ha Vermicompost followed by T_9-125% RDF + 5 t/ha Vermicompost. The lowest harvest index of 40.28 was found in T_1-75% RDF. The result of harvest index was also found by Yadav *et al.,* (2018) [12].

Net monitory return (Rs ha^{-1}): The data regarding the net monetary return that is provided in Table-2. It was significantly noticed that T_8-125% RDF + 5 t/ha FYM was recorded maximum Net monitory return 77,439.71 Rs ha^{-1} followed by T_6-100% RDF +5 t/ha FYM. Under the experiment significant minimum Net monitory return 58,025.50 Rs ha^{-1} of T_1-75% RDF treatment.

B: C ratio: The information that pertains to the B:C Ratio is shown in Table-2. It was significantly noticed that T_2-100% RDF was recorded maximum B:C Ratio 1.88 followed by T_3-125% RDF. Under the experiment significant minimum B:C Ratio 1.32 of T_9-125% RDF + 5 t/ha Vermicompost treatment.

Table 1: Effect of organic and inorganic sources of fertilizers on growth of wheat

Treatments	Initial Plant Population	Plant height (cm)				No. of tillers m^{-2}				Leaf area index at 90 DAS	Dry matter accumulation g per plant		
		30 DAS	60 DAS	90 DAS	At harvest	30 DAS	60 DAS	90 DAS	At harvest		30 DAS	60 DAS	90 DAS
T_1	121.2	17.53	43.66	70.92	75.93	242.40	323.2	363.6	404	5.76	8.54	43.35	52.27
T_2	123	17.72	47.96	72.43	77.61	246.00	328	369	410	5.99	8.82	51.56	57.99
T_3	124.2	18.37	49.78	74.52	79.71	248.40	331.2	372.6	414	6.01	9.01	52.23	59.65
T_4	127.2	18.51	50.21	76.81	81.68	254.40	339.2	381.6	424	6.24	9.11	54.76	61.57
T_5	131.4	21.67	52.95	78.68	83.46	262.80	350.4	394.2	438	6.32	9.39	56.68	64.26
T_6	129.6	19.67	51.45	77.94	82.61	259.20	345.6	388.8	432	6.38	9.24	56.31	64.02
T_7	132.6	19.57	46.92	80.21	85.42	265.20	353.6	397.8	442	6.59	9.54	57.12	62.6
T_8	135.6	22.46	48.76	85.82	90.65	271.20	361.6	406.8	452	6.56	9.85	58.36	65.26
T_9	138	23.33	54.23	89.74	93.51	276.00	368	414	460	6.81	10.18	59.42	68.96
SE(m)	3.36	0.51	1.29	2.03	2.17	6.71	8.96	10.07	11.19	0.16	0.24	1.41	1.60
C.D.	10.15	NS	1.179	1.148	0.971	20.30	27.08	30.46	33.84	0.49	0.73	4.28	4.85

Table 2: Effect of organic and inorganic sources of fertilizers on yield and yield attributes of wheat

Treatments	Spike length (cm)	No. of spike (m^{-2})	Number of Spikelet ear^{-1}	No. of grain per spike	Test weight (g)	Harvest index (%)	Net return Rs. Ha^{-1}	B:C ratio
T_1	7.94	176.76	15.47	19.23	39.88	40.28	66,179.38	1.77
T_2	8.56	213.63	15.86	41.77	40.77	41.57	73,189.08	1.88
T_3	8.67	247.02	16.08	42.32	41.35	41.75	73,700.22	1.82
T_4	8.86	256.56	16.24	42.63	41.66	41.93	73,271.11	1.79
T_5	9.15	330.64	17.21	44.77	42.49	42.35	71,449.01	1.43
T_6	9.09	328.75	17.17	44.56	42.33	42.21	73,944.32	1.74
T_7	9.19	342.75	17.67	43.92	42.61	42.64	70,946.08	1.38
T_8	9.17	333.96	17.24	44.82	42.53	42.46	77,439.71	1.76
T_9	9.23	346.78	17.47	44.77	42.66	42.92	69,707.14	1.32
SE(m)	0.23	6.89	0.43	1.08	1.15	1.10	-	-
C.D.	0.70	20.84	1.30	3.28	3.47	NS	-	-

Conclusion

Based on the results presented above, it is recommended that in the *Rabi* season of 2022-23. the treatment T_9-125% RDF + 5 t/ha Vermicompost could be exploited in order to best to growth, yield attributes and harvest the maximum grain yield 4617 kg ha^{-1}, revenue generation (net return Rs. 77,439.71 ha^{-1}) with T_8-125% RDF + 5 t/ha FYM treatment and B:C ratio (1.88) with T_2-100% RDF in wheat cultivation.

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