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Shweta
Department of Agriculture, Maharishi Markandeshwar (Deemed to be University) Mullana, Ambala, Haryana, India

Ishwar Singh
Department of Agriculture, Maharishi Markandeshwar (Deemed to be University) Mullana, Ambala, Haryana, India

RK Behl
Department of Agriculture, Maharishi Markandeshwar (Deemed to be University) Mullana, Ambala, Haryana, India

Devi Singh
Department of Agriculture, Maharishi Markandeshwar (Deemed to be University) Mullana, Ambala, Haryana, India

OP Mehla
Department of Agriculture, Maharishi Markandeshwar (Deemed to be University) Mullana, Ambala, Haryana, India

Gajraj Yadav
Department of Agriculture, Maharishi Markandeshwar (Deemed to be University) Mullana, Ambala, Haryana, India

Corresponding Author:
Shweta
Department of Agriculture, Maharishi Markandeshwar (Deemed to be University) Mullana, Ambala, Haryana, India

Effect of enhanced doses of phosphatic and zinc fertilizers over recommended doses of fertilizers (RDF) on grain yield and its attributes in wheat (*Triticum aestivum* L.)

Shweta, Ishwar Singh, RK Behl, Devi Singh, OP Mehla and Gajraj Yadav

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Abstract
A field experiment was conducted at the Research farm of the Department of Agriculture, Maharishi Markandeshwar University, Mullana, Ambala during *Rabi* season of 2023 to determine the "Effect of enhanced doses of Phosphatic and Zinc fertilizers over recommended doses of fertilizers (RDF) on grain yield and its attributes in wheat (*Triticum aestivum* L.)". The experiment was laid out in a Factorial Randomized Block Design (FRBD) with three replications and four treatments applied to three wheat varieties DBW187, HD3226 and WH1270. The treatments were control (T_1), (T_2) 100% RDF (recommended doses of fertilizers) *i.e*., Nitrogen-150 kg/ha through Urea (50% basal dose + urea 25% at after 25 days of sowing + 25% at pre flowering), Phosphorus- 60 kg/ha through SSP (100% basal dose), Potassium- 60 kg/ha through Muriate of Potash (100% as basal dose) and $ZnSo_4$-25 kg/ha, (T_3) 25% higher $ZnSo_4$ + RDF, (T_4) 25% higher P_2O_5 + RDF. The data was recorded on plant growth parameters, grain yield and its components namely plant height, dry weight accumulation per meter row length, total no. of tillers per running meter row length, number of spikes per meter row length, number of grains per spike, 1000 grains weight, grain yield, straw yield and biological yield. Indices namely harvest index, cost of cultivation, gross return, net return and benefit cost ratio were computed. The comparative evaluation of various treatments revealed that 25% enhanced doses of phosphatic and zinc fertilizers gave good response and higher yield as compared to RDF. The increase in yield due to application of 25% higher phosphorous (56.02 q/ha) as well as zinc (54.54 q/ha) was significantly higher over RDF (52.11 q/ha) and control (30.74 q/ha). Treatment T_4 showed highest gross returns (Rs.162055.5/ha) and net returns (Rs. 95,238/ha) as well as higher benefit cost ratio (2.42).

Keywords: Wheat, *Triticum aestivum*, grain yield, phosphorous, zinc

Introduction
Wheat (*Triticum aestivum* L.) a member of Poaceae family, is India's prime most staple food crop after rice. It is known as the "king of cereals". The earliest cultivated species are hulled wheat and comprise all three polyploidy levels known in *Triticum* spp., diploid, tetraploid and hexaploid (Sousa *et al*., 2021) [13]. There are mainly three species of wheat that are grown in India and *Triticum aestivum* or bread wheat being the most commonly grown one. It is produced in almost all the wheat cultivating states of India, *i.e*. Uttar Pradesh, Punjab, Haryana, Rajasthan, Bihar, West Bengal, Assam *etc*. Wheat is typically traded based on specific properties such as grain protein content and hardness. Wheat is consumed globally by billions of people. Wheat is a food that contains human nutrition, especially in the least developed countries where wheat products are major food. It is used as flour that is used in different types of food variety and baked products. It contains minerals, fat and vitamins, which are source of micronutrients and dietary fiber. It contains 78% carbohydrate, 14% protein, 2% fat and vitamins such as thiamine and vitamin B as well as minerals such as zinc and iron etc.
In 2021- 2022, wheat occupied 304.69 lakh hectare area with production of 106.84 million tonnes and average yield of 3507 kg/ha in India (GOI Annual Report, 2022- 2023). Approximately 14% of the nation's cultivated land is dedicated to growing wheat.

India contributes approximately 12% of the total wheat production of world. In Haryana, wheat is cultivated on 2533 thousand hectare with 11876 thousand tonnes production with average yield as 4678 kg/ha (Swati, 2024) [14]. Nutrient use efficiency through inorganic fertilizer by the crops vary from 30-50% in case of N, 15-20% in case of P and less than 5% in case of micronutrients. Among the fertilizers, nitrogen (N) is the most important nutrient for wheat and it improves yield and quality of grain. Plants contain more N than any other nutrients obtained from the soil. N fertilization increases Zn acquisition in cereal crops. Phosphorous is the second essential macronutrient required for plant growth and development alongside nitrogen (Bechtaoui *et al*., 2021) [4]. It is an essential nutrient needed for normal plant growth and development. As an important nutrient, P is present less in the soil and cannot be replenished without external sources (Arsad *et al.,* 2022.) [2]. The major attention given to nitrogen and phosphorous fertilization than potassium. After N, potassium (K) is absorbed in large amount than any other element and plays an important role in improving the quality of crop and enhancing crop resistance. It activates the photosynthetic enzymes and assimilates translocation.

During the recent years, in developing countries, the deficiency of micronutrient creating a problem of malnutrition. This deficiency is due to minimum uptake of Zn by plants because soils are rich in carbonates and bicarbonates and calcium which bind with P and Zn thus form a complex that is not absorbed by plants. Zinc supplementation is a typical way to correct zinc deficiency. Zinc is an important micronutrient for plants since it is involved in many fundamental cellular functions including metabolic and physiological processes, enzyme activation, and ion homeostatis (Saleem *et al*., 2022) [12].

The alkaline soil has a higher concentration of salt ions, which limit the crop growth in terms of nutrient availability. Thus, substantial amount of applied nutrients is lost through various pathways, more so in light texture alkaline soils. It is therefore, imperative to evaluate effect of enhanced doses of nutrients in such soils to optimise sustainable wheat production. In light of the above facts, the present study is designed with the following objectives.

Objectives

1. To determine effect of enhanced doses of phosphatic and zinc fertilizers over RDF (recommended dose of fertilizers) on plant growth, grain and straw yield and their attributes.
2. To work out the economics of different fertilizer treatments.

Materials and Methods

The field experiment entitled **"**Effect of enhanced doses of Phosphatic and Zinc fertilizers over RDF on grain yield and its attributes in wheat (*Triticum aestivum* L.)" was conducted at research farm of Department of Agriculture, Maharishi Markandeshwar (Deemed to be University), Mullana, Ambala, Haryana through *Rabi* season of 2022-2023. The research plot was composed of sandy loam soil. The soil was moderately alkaline, contained less organic matter and had medium quantities of accessible phosphate and potassium. The experiment was conducted in FRBD (Factorial Randomized Block Design). Factor A consisted three wheat varieties (DBW187, HD3226 and WH1270) and Factor B consisted four treatments each replicated thrice. The treatments were control (T_1), 100% RDF (T_2) i.e., Nitrogen- 150 kg/ha through Urea, Phosphorous- 60 kg/ha through SSP, Potassium- 60 kg/ha through MOP, $ZnSo_4$- 25 kg/ha, 25% higher $ZnSo_4$ + RDF (T_3), 25% higher P_2O_5 + RDF (T_4). Data on growth, yield attributes, yield and economics were subjected to statistically analysed by means of the variances partition (ANOVA) method as stated by Panse and Sukhatme (1985) [10].

Results and Discussions

Growth Parameters

The information about growth parameters is presented in Table 1. Among treatments, T_4 (25% higher P_2O_5 + RDF) observed the highest plant height (103.40 cm), dry matter accumulation per meter row length (253.27 g), total number of tillers per running meter row length (60.32) which was statistically higher than T_3 followed by T_2 and the lowest growth parameters were observed in T_1 control. Among varieties, WH1270 recorded the highest plant height (99.70 cm), dry matter accumulation per meter row length (240.17 g), total number of tillers per running meter row length (62.55) followed by HD3226 and the lowest was observed in DBW187. The greatest growth characters of wheat may be due to P which increased the absorption of nutrients by roots and have better proliferation of roots (Yadav *et al*. 2017) [15]. This was also in findings of Noonari *et al*. (2016) [9]. There was significant increase in growth rate with increase of Zn rate with recommended doses of fertilizers over control. Similar findings were also reported by Arshad *et al.* (2016) [3]. The significantly poor growth characters were observed under control (T_1) mainly due to unavailability of required nutrients in sufficient quantity for growth and development of wheat crop. The similar findings were also reported by Jat *et al*. (2020) [6].

Yield and Yield Attributes

The data regarding yield and yield attributes is presented in Table 2. Among treatments, T_4 (25% higher P_2O_5 + RDF) observed the highest total number of spikes per meter row length (74.57), number of grains per spike (50.60), 1000- grain weight (43.31 g) and grain yield (56.02 q/ha), straw yield (68.73 q/ha), biological yield (125.58 q/ha), harvest index (45.03%) which was statistically higher than T_3 followed by T_2 and the lowest yield and yield attributes were observed in T_1 control. Among varieties, WH1270 recorded the highest total number of spikes per meter row length (69.03), number of grains per spike (45.87), 1000- grain weight (42.21 g) and grain yield (54.24 q/ha), straw yield (67.67 q/ha), biological yield (121.99 q/ha), harvest index (44.26%) followed by HD3226 and the lowest was observed in DBW187. Effects of application of Zn in crop growth could be due to the reason that Zn plays a vital role in synthesis of auxin hormone in plants and in inititation of primordia for reproductive parts. Similar results were also reported by Prajapati *et al*. (2022) [11]. Also similar results were reported by Jat *et al.* (2018) [7], Yadav *et al.* (2017) [15], Arif *et al.* (2017) [1] and Mishra *et al.* (2017) [8]. The highest grain yield due to 25% higher phosphorous fertilizer in addition to RDF was observed. This significant increase in grain yield may be due to increased biological yield. The increase in biological yield could be attributed to better source and sink relationships. Biological yield has two components *i.e.* grain yield and straw yield therefore, 25% higher phosphorous application in addition to RDF resulted in higher grain yield as well as straw yield. Similar results were observed in findings of Jat *et al*. (2018) [7]. The application of higher P fertilizers meets the levels of P in soil as soils are alkaline (Arshad *et al.* 2016) [3]. The significantly poor yield and yield attributes were observed under control (T_1) mainly due to unavailability of required nutrients in sufficient quantity for growth and development of wheat crop. The similar findings were also reported by Jat *et al*. (2020) [6].

Economics

The data regarding economics of wheat varieties affected by treatments and their interactions are reported in Table 3. Among treatments, T_4 (25% higher P_2O_5 + RDF) showed the highest cost of cultivation (Rs. 66,818/ha), gross return (Rs. 162055.5/ha), net return (Rs. 95,238/ha) and benefit cost ratio (2.42) and the lowest was observed in T_1 (control) where no fertilizers were used. Within varieties, all three varieties had the same cost of cultivation (Rs.57,300/ha). The maximum gross return (Rs. 157196/ha), net return (Rs. 99,896/ha) and benefit cost ratio (2.74) was observed in WH1270 followed by HD3226 and the lowest was observed in DBW187. The highest gross return and net return was increased with increasing supply of phosphorous. This was also in the findings of Mishra *et al.* (2017) [8].

Interaction Effect

The significant variety and treatment interactions for some characters namely total number of tillers per running meter row length at 90 DAS and at harvest, grain yield, straw yield and biological yield revealed that different varieties responded differently to fertiliser treatments.

Table 1: Effect of enhanced doses of Phosphatic and Zinc fertilizers over recommended doses of fertilizers (RDF) on growth parameters in wheat (*Triticum aestivum* L.)

Treatments	Plant Height (cm)				Dry matter accumulation per meter row length (g)				Number of tillers per running meter row length			
	30 DAS	60 DAS	90 DAS	At Harvest	30 DAS	60 DAS	90 DAS	At Harvest	30 DAS	60 DAS	90 DAS	At Harvest
Varieties												
V_1-DBW187	17.29	44.84	89.30	95.94	6.62	57.68	101.39	236.06	20.93	36.13	44.56	41.79
V_2- HD3226	18.11	46.55	90.97	97.89	7.58	59.58	103.69	238.20	22.11	38.25	57.24	54.63
V_3-WH1270	19.33	48.34	92.86	99.70	8.20	62.27	106.34	240.17	23.01	40.50	64.37	62.55
SEm±	0.22	0.49	0.50	0.55	0.15	0.37	0.53	0.65	0.21	0.22	0.37	0.46
C.D at 5%	0.65	1.44	1.48	1.62	0.46	1.09	1.58	1.91	0.61	0.64	1.11	1.36
Fertility levels												
T_1	13.93	38.59	84.04	89.08	4.86	38.36	91.09	200.66	17.38	33.50	45.03	42.28
T_2	18.66	45.53	90.81	97.82	7.23	62.21	104.89	247.84	22.25	37.81	55.72	53.31
T_3	19.59	50.09	93.70	101.08	8.31	68.60	108.64	250.81	23.23	39.62	58.32	56.05
T_4	20.80	52.09	95.62	103.40	9.47	70.19	110.64	253.27	25.22	42.24	62.49	60.32
SEm±	0.25	0.56	0.58	0.63	0.18	0.42	0.62	0.75	0.24	0.25	0.43	0.53
C.D at 5%	0.75	1.67	1.71	1.87	0.53	1.26	1.82	2.21	0.70	0.74	1.28	1.58
V×F Interactions												
SEm±	0.44	0.97	1.00	1.10	0.31	0.74	1.07	1.29	0.41	0.43	0.75	0.92
C.D at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	2.21	2.73

Note

T_1- Control
T_2- 100% RDF (recommended doses of fertilizers)
T_3- 25% higher $ZnSO_4$ + RDF
T_4- 25% higher P_2O_5 + RDF

Table 2: Effect of enhanced doses of phosphatic and zinc fertilizers over recommended doses of fertilizers (RDF) on yield and yield attributes in wheat (*Triticum aestivum* L.)

Treatments	Total number of spike per meter row length	Number of grains per spike	Test weight (g)	Grain yield (q/ha)	Straw yield (q/ha)	Biological yield (q/ha)	Harvest index (%)
Varieties							
V_1-DBW187	65.66	42.30	40.51	41.67	56.42	97.58	42.42
V_2- HD3226	67.33	44.03	41.51	49.16	64.54	113.73	43.30
V_3- WH1270	69.03	45.87	42.21	54.24	67.67	121.99	44.26
SEm±	0.50	0.47	0.23	0.43	0.47	0.71	0.18
C.D at 5%	1.49	1.38	0.68	1.28	1.38	2.10	0.53
Fertility levels							
T_1	55.41	34.60	38.41	30.74	45.48	76.33	40.25
T_2	66.77	42.26	41.40	52.11	66.84	119.40	43.68
T_3	72.63	48.82	42.51	54.54	68.73	123.10	44.35
T_4	74.57	50.60	43.31	56.02	70.44	125.58	45.03
SEm±	0.58	0.54	0.26	0.49	0.54	0.82	0.21
C.D at 5%	1.72	1.59	0.78	1.47	1.59	2.43	0.61
V×F Interactions							
SEm±	1.01	0.93	0.46	0.86	0.94	1.42	0.36
C.D at 5%	NS	NS	NS	2.55	2.76	4.20	NS

Note:

T_1- Control
T_2- 100% RDF (recommended doses of fertilizers)
T_3- 25% higher $ZnSO_4$ + RDF
T_4- 25% higher P_2O_5 + RDF

Table 3: Effect of enhanced doses of phosphatic and zinc fertilizers over recommended dose of fertilizers (RDF) on economics in wheat (*Triticum aestivum* L.)

Treatments	Cost of cultivation (Rs./ha)	Gross return (Rs./ha)	Net return (Rs./ha)	Benefit: Cost ratio
Varieties				
V_1- DBW187	57,300	122424.25	65,124	2.13
V_2- HD3226	57,300	143944	86,644	2.51
V_3- WH1270	57,300	157196	99,896	2.74
Fertility levels				
T_1- Control	57,300	92673.5	35,374	1.61
T_2- 100% RDF	65,918	151970.25	86,053	2.30
T_3- 25% higher $ZnSo_4$ over RDF	65,964	158058.5	92,095	2.39
T_4- 25% higher P_2O_5 over RDF	66,818	162055.5	95,238	2.42

Conclusion

Therefore, from the result of the present investigation it is concluded that farmers may adopt 25% higher P and Zn application especially in calcareous soils of north east Haryana rich in carbonates and bicarbonates. Both P and Zn bind with Ca to form a complex and both these nutrients become non available. Therefore, in such soils application of higher doses of P and Zn may compensate some of the nutrients fixed in complex form so that the crop may not manifest P and Zn deficiency. The economic analysis also confirms that application of higher doses of P and Zn are economically viable and farmers can follow recommendation of using 25% higher P and Zn over and above recommended doses of fertilizers.

Among varieties WH1270 significantly out yielded other varieties HD3226 and DBW187 and recorded highest straw yield, grain yield, harvest index and biological yield as (67.67 q/ha), (54.24 q/ha), (44.26%) and (121.99 q/ha) respectively.

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