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Effect of Nitrogen Levels and Zinc Fertilizer Scheduling on Economic of Wheat (*Triticum aestivum* L.) Production in Varanasi District of Uttar Pradesh

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Authors' contributions

This work was carried out as doctorate research work of author SKM. Authors SKP and MKS were guide and co-guide and helped in any critical stages of the research period as collection and analysis of data as well as thesis writing. All authors read and approved the final manuscript.

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ABSTRACT

A field investigation was carried out during winter (Rabi) season of 2012-2013 and 2013-2014 on sandy clay loam at Agricultural Research Farm, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi (25º 18' N and 83º 03' E) to evaluate the effect of nitrogen levels and zinc fertilization on economic of wheat production in Varanasi district of Uttar Pradesh.

The experiment was established using four levels of nitrogen (0, 90, 120 and 150 kg ha^{-1}) and four zinc fertilizer scheduling (Control, 5 kg Zn ha^{-1} basal + 0.5% spray at ear head initiation stage, 5 kg Zn ha^{-1} basal + 0.5% spray at flowering stage and 5 kg Zn ha^{-1} basal + 0.5% spray at milking stage) in randomized block design and replicated thrice.

Results from experimental findings revealed that considerably maximum yields (grain and straw), gross returns, net returns and benefit cost ratio was obtained with individual application of 150 kg N ha^{-1} and 5 kg Zn ha^{-1} + 0.5% $ZnSO_4$ spray at ear head initiation stage during both years of investigations. However, nitrogen and zinc fertilization interact significantly and maximum gross

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returns (INR. 100747.61 ha^{-1}) and net returns (INR. 68346.86 ha^{-1}) only during 2012-2013 and benefit cost ratio (2.11 and 2.67) during both years were recorded with $N_{150}\times Zn_1$ treatment. Based on experimentation it may be recommended that separately application of 150 kg N ha^{-1} and 5 kg Zn ha^{-1} + 0.5% $ZnSO_4$ spray at ear head initiation stage and combined $N_3\times Zn_1$ treatment was most effective for higher net returns and benefit cost ratio from wheat in Varanasi region of Uttar Pradesh.

Keywords: Nitrogen levels; zinc fertilizer scheduling; yield; economic; Triticum aestivum.

1. INTRODUCTION

Wheat (*Triticum aestivum* L.) is the second most important staple cultivated food crop of India after rice and consumed by nearly 65% of the population [1] and ranks first in dietary shares in northern India [2]. During the year 2013-2014, in India wheat was grown over an area of 31.19 million hectares and production of 95.91 million tonnes with an average productivity of 3075 kg ha^{-1}. In Uttar Pradesh, wheat was grown over an area of 9.96 million hectares with production of 30.25 million tonnes with average productivity of 3038 kg ha^{-1} during 2013-2014. The major area under wheat falls in the Indo-Gangetic Plains (IGP) which accounts for roughly 20 million hectares covering the states of Punjab, Haryana, Uttar Pradesh, Bihar and West Bengal [3].

Nitrogen is a vitally important and one of the universally deficient plant nutrients in most of the Indian soils and a component of many organic compounds viz, proteins, amino acids, nucleic acid, nucleotides, enzymes, protoplasm, vitamins, hormones, alkaloids etc. [4] and enhances the utilization of other nutrients [5]. There is a need to give a fresh look to nutrient requirement, especially of N for breaking the barrier in higher productivity of this crop. Nitrogen not only affects wheat productivity but also has a synergistic biofortification of food crops with Zn due to several physiological and molecular mechanisms which are under the influence of N nutritional status [6]. The highest grain yield was observed by application of 160 kg N ha^{-1} which increased yield by 29% as compared to without N application. While, application of 200 kg N ha^{-1} reduced grain yield by 6% as compared to 160 kg N ha^{-1}, however this reduction was not significant [7].

Zinc is important for various enzymatic and physiological activities and performs many catalytic functions in plants besides transformation of carbohydrates, chlorophyll, nitrogen metabolism, protein synthesis [8]. Recently, micronutrient deficiencies in plants are becoming increasingly important globally. Zinc deficiency not only reduces the crop production but also cause Zn deficiency in our diet [9]. About a half of the cereal-growing areas in the world contain low levels of plant available Zn in the soil and the plants grown in such areas suffer from Zn deficiency stress and contain low levels of Zn in the grain [10]. Generally, soil application of 25-50 kg zinc sulphate heptahydrate ha^{-1} is done to correct the deficiency, however, the availability of soil applied Zn is very poor and declines with time [11]. Foliar Zn application is a simple way for making quick correction of plant nutritional status in wheat and finally increased the grain [12].

Hence, keeping in the view, an experiment has been proposed to evaluate the effect of nitrogen levels and zinc fertilization through soil and as well as foliar fertilization on growth and yield of wheat.

2. MATERIALS AND METHODS

The field experiment was conducted at Agricultural Research Farm, Institute of Agricultural Sciences, Banaras Hindu University during 2012-2013 and 2013-2014. The soil of experimental site was sandy clay loam in texture and has low organic carbon (0.32% and 0.37%), available nitrogen (199.25 and 210.34 kg ha^{-1}), DTPA extractable zinc (0.43 and 0.47 mg kg^{-1}), medium available phosphorus (16.65 and 17.23 kg ha^{-1}) and available potassium (213.16 and 220.64 kg ha^{-1}) with optimum pH (7.20 and 7.40) during first and second year, respectively. The factorial experiment was established in randomized block design with four nitrogen levels (N_0, N_{90}, N_{120} and N_{150}, respectively, 0, 90, 120 and 150 kg N ha^{-1}) and four combinations of zinc application [Control (Zn_0), 5 kg Zn ha^{-1} at basal + 0.5% spray at ear head initiation stage (Zn_1), 5 kg Zn ha^{-1} at basal + 0.5% spray at flowering stage (Zn_2) and 5 kg Zn ha^{-1} at basal + 0.5% spray at milking stage (Zn_3)] and replicated thrice. Wheat variety HD 2733 was sown by using a seed rate of 125 kg ha^{-1} in well prepared soil by maintaining a row spacing of 22.5 cm and sown at depth of 3-4 cm on 3rd December and 7th December in 2012 and 2013, respectively. Recommended full dose of phosphorus and potassium (60 kg P_2O_5 and 60 kg K_2O ha^{-1}) were applied in all plots at the time of sowing through single super phosphate (SSP) and Muriate of Potash (MOP) during both years of investigation. The nitrogen and zinc fertilizers were applied as per treatment through urea and $ZnSO_4.7H_2O$ (heptahydrate) during both years. Foliar spray of 0.5% $ZnSO_4$ was done at different growth stages. Irrigation was applied depending upon requirements and other crop management practices were followed as per the recommendation of the area. The net plot (leaving 2 border rows on each side and 0.5 m from each side of the length) area was harvested and sun-dried and then the total biomass yield was recorded. After threshing, cleaning and drying the grain yield at 14% moisture and then converted into kg ha^{-1}.

The economics of different treatment was worked out separately by taking into account the existing price of various inputs and output, so that the most remunerative treatment could be recommended. The investment on fertilize, labour and power for performing different operations such as ploughing, weeding, irrigation, picking/harvesting (INR ha^{-1}) were considered as per rate prevalent at Research Farm, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi. The cost of cultivation was taken into account for calculating economics of treatments and to work out gross returns, net return and benefit cost ratio using the formula given below and expressed in rupees per hectare.

$$\text{Gross return (INR ha}^{-1}) = (\text{Grain yield} \times \text{Selling rate}) + (\text{Straw yield} \times \text{Selling rate}) \quad (1)$$

$$\text{Net return (INR ha}^{-1}) = \text{Gross return (INR ha}^{-1}) - \text{Cost of cultivation (INR ha}^{-1}) \quad (2)$$

$$\text{B : C ratio} = \frac{\text{Gross return (INR ha}^{-1})}{\text{Cost of cultivation (INR ha}^{-1})} \quad (3)$$

The data recorded were statistically analyzed using the F-test as per standard procedure suggested by Gomez and Gomez [13]. The least significant difference (LSD) value at p=0.05 was used to determine the significance of difference between treatment means.

3. RESULTS AND DISCUSSION

3.1 Grain Yield

Scrutiny of the data further (Fig. 1) indicated that grain yield of wheat markedly influenced due to increasing levels of nitrogen and zinc fertilizer scheduling during both years of experimentation. The magnitude of increase in grain yield of wheat with 150 kg N ha^{-1} was 47.72, 21.44 and 9.09% in 2012-2013 and 51.71, 23.12 and 10.82% in 2013-2014 over control, 90 and 120 kg N ha^{-1}, respectively. However, application of 90 and 120 kg N ha^{-1} significantly produced more yield compared to control during both years and registered an increase to the extent of 21.64 and 35.40% in 2012-2013 and 23.22 and 36.89% in 2013-2014, respectively. The positive increase in grain yield may be due to nitrogen being a major nutrient, affected all physic-chemical processes. Grain yield is an ultimate end product of many yield-contributing components, physiological and morphological processes taking place in plants during growth and development. Similar results were reported by Galieni et al. and Hasan et al. [14,15].

A marked variation on grain yield of wheat owing to application of different zinc fertilization treatments during both the year of study was recorded (Fig. 1). In 2012-2013, application of 5 kg Zn ha^{-1} + 0.5% $ZnSO_4$ spray at ear head initiation stage was on par to 5 kg Zn ha^{-1} + 0.5% $ZnSO_4$ spray at flowering stage and significantly produced more grain yield by10.26 and 30.26% over 5 kg Zn ha^{-1} + 0.5% $ZnSO_4$ spray at milking stage and control, respectively. However, application of 5 kg Zn ha^{-1} + 0.5% $ZnSO_4$ spray at flowering stage and 5 kg Zn ha^{-1} + 0.5% $ZnSO_4$ spray at milking stage was at par to each other significantly improved the grain yield by 21.82 and 18.14% over control, respectively. In 2013-2014, the magnitude of increase in grain yield due to 5 kg Zn ha^{-1} + 0.5% $ZnSO_4$ spray at ear head initiation stage was 10.0, 13.62 and 48.28% over 5 kg Zn ha^{-1} + 0.5% $ZnSO_4$ spray at flowering stage, 5 kg Zn ha^{-1} + 0.5% $ZnSO_4$ spray at milking stage and control, respectively. Though, the percent increase in grain yield owing to 5 kg Zn ha^{-1} + 0.5% $ZnSO_4$ spray at flowering stage and 5 kg Zn ha^{-1} + 0.5% $ZnSO_4$ spray at milking stage was 34.79 and 30.51% over control, respectively. Yield is a function of complex inter-relationships of its components, which are determined from the growth rhythms in vegetative phase and its subsequent reflection in reproduction phase of the plant. The increase in yield owing to application of zinc may be ascribed to improved growth and yield attributes and yield is directly related to these attributes. Gomez-Coronado et al. and Ram et al. [16,17] also reported such favourable effect of zinc on grain yield.

3.2 Straw Yield

The evaluation of data (Fig. 2) showed that straw yield was significantly influenced by different nitrogen levels and zinc fertilizer scheduling during both years of investigations.

During 2012-2013, significantly maximum straw yield of 7010.60 kg ha^{-1} was recorded with 150 kg N ha^{-1} which was 35.12 and 9.47% higher than control and 90 kg N ha^{-1} but at par with 120 kg N ha^{-1}. However, application of 90 kg N ha^{-1} gave higher yield than control. Similar trend was recorded during second year (2013-2014) of investigation. The magnitude of increase owing to 150 kg N ha^{-1} in straw yield was 46.32 and 14.34% over control and 90 kg N ha^{-1}. In comparison to 2012-2013, higher straw yield was recorded in second year (2013-2014) of experimentation. This might be better due to increase available nitrogen content in soil and it's efficient utilization by plants, which led to increase dry matter accumulation and photosynthetic rates that finally increased the straw yield of wheat. Similar results were reported by Suryawansi et al. and Meena et al. [18,19].

Different zinc fertilization treatments caused significant variation on straw yield of wheat during both years of investigations (Fig. 2). Maximum straw yield was recorded with 5 kg Zn ha^{-1} as basal + 0.5% $ZnSO_4$ spray at ear head initiation stage which was at par with 5 kg Zn ha^{-1} as basal + 0.5% $ZnSO_4$ spray at flowering stage and 5 kg Zn ha^{-1} as basal + 0.5% $ZnSO_4$ spray at milking stage and significant over control. Similar trend was recorded during second year of investigation. In comparison to first year, maximum straw yield was recorded in second year of experimentation. The favourable influence of soil and foliar applied zinc on straw yield is attributed to its catalytic or stimulatory effect on most of the physiological and metabolic processes of plants [20]. Participation of Zn in biosynthesis of indole acetic acid (IAA) and its role in initiation of primordial reproductive parts and partitioning of photosynthates towards sink are responsible for increased yields. These results are in agreement with finding of Gomez-Coronado et al. and Khattak et al. [16,21].

3.3 Economics

The economic analysis of data on gross returns, net return and benefit cost ratio furnished in Table 1 showed that gross returns, net returns and benefit cost ratio was increased with each increment in nitrogen levels during both years of investigation. Maximum gross return, net return and benefit cost ratio was obtained with 150 kg N ha^{-1} which was significant over rest of the levels during both years of investigations. However, lower levels of 90 and 120 kg N ha^{-1} significantly differed to each other enhanced the gross return, net return and benefit cost ratio over control during both years. This might be due better market price and more wheat production which led to proportionally higher gross return than cost of cultivation. These outcomes are in close conformity with Suryawansi et al. and Gangaiah and Ahlawat [18,22].

Further data revealed that zinc fertilizer scheduling improved the gross returns, net return and benefit cost ratio from crop during both years. Among different variants of zinc fertilization treatments, considerably maximum gross return, net return and benefit cost ratio were recorded when 5 kg Zn ha^{-1} + 0.5% $ZnSO_4$ spray at ear head initiation stage applied which was significant over control and 5 kg Zn ha^{-1} + 0.5% $ZnSO_4$ spray at milking stage during both years of investigation but at par with 5 kg Zn ha^{-1} + 0.5% $ZnSO_4$ spray at flowering stage. However, application of 5 kg Zn ha^{-1} + 0.5% $ZnSO_4$ spray at milking stage significantly increased the gross return, net return and benefit cost ration over control. This might be due to less cost of cultivation, better market price and more wheat yields production which led to proportionally higher gross return than cost of cultivation. These outcomes are in close conformity with Khattak et al., Chauhan et al. and Singh et al. [21,23,24].

Nitrogen levels and zinc fertilizer scheduling interact significantly in respect to gross return, net return and benefit cost ratio from wheat (Tables 2 & 3). In 2012-2013, significantly maximum gross returns (INR 100747.61 ha^{-1}) and net return (INR 67973.21 ha^{-1}) was obtained with N_{150}×Zn_1 which was higher than rest of treatment combinations and lowest gross returns (INR 43271.64 ha^{-1}) and net return (INR 14174.64 ha^{-1}) was obtained with N_0×Zn_0. The data further revealed that benefit cost ratio was significantly affected by combined application of nitrogen levels and zinc fertilizer scheduling during both years of investigation. Significantly maximum benefit cost ratio 2.07 and 2.63 was associated with N_{150}×Zn_1 treatment during 2012-2013 and 2013-2014, respectively, which was significant over rest of the treatments and lowest benefit cost ratio (0.49 and 0.48) was noted with N_0×Zn_0. The increases in gross return, net return and benefit cost ratio due to combined nitrogen and zinc fertilizer scheduling may be attributed to improvement in yield of wheat. Ahmadi and David [25] found that the treatment combination of N_{120}×Zn_3 provides highest net profit of INR 63395 ha^{-1} with benefit cost ratio of 1:2.77.

Table 1. Effect of nitrogen levels and zinc fertilizer scheduling on economical behaviors of wheat crop

Treatment	Cost of cultivation (INR. ha^{-1})		Gross return (INR. ha^{-1})		Net return (INR. ha^{-1})		Benefit cost ratio	
	2012-2013	2013-2014	2012-2013	2013-2014	2012-2013	2013-2014	2012-2013	2013-2014
Nitrogen levels (kg ha^{-1})								
N_0	30201.30	29459.30	61965.78	67614.58	31764.48	38155.28	1.04	1.29
N_{90}	31596.30	30854.30	75746.73	84393.79	44150.43	53539.49	1.40	1.73
N_{120}	32001.30	31259.30	83406.46	93500.20	51405.16	62240.90	1.61	1.99
N_{150}	32406.30	31664.30	88921.49	101355.05	56515.19	69690.75	1.74	2.20
SEm (±)	-	-	1541.89	2090.44	1148.35	2044.99	0.04	0.07
CD(P=0.05)	-	-	4453.31	6037.62	3316.68	5906.36	0.12	0.20
Zinc fertilizer scheduling								
Zn_0	30447.00	29705.00	67789.62	71588.97	37342.62	41883.97	1.21	1.39
Zn_1	31919.40	31177.40	84310.11	97191.17	52390.71	66013.77	1.63	2.11
Zn_2	31919.40	31177.40	79924.17	90396.73	48004.77	59219.33	1.50	1.89
Zn_3	31919.40	31177.40	78016.56	87686.75	46097.16	56509.35	1.44	1.81
SEm (±)	-	-	1541.89	2090.44	1148.35	2044.99	0.04	0.07
CD(P=0.05)	-	-	4453.31	6037.62	3316.68	5906.36	0.12	0.20
N × Zn	-	-	S*	NS**	S*	NS**	S*	NS**

**Significant*

*** Non-significant*

Table 2. Interactive effect of nitrogen levels and zinc fertilizer scheduling on gross and net returns (INR. ha^{-1}) of wheat crop during 2012-2013

Treatment	Gross return (INR. ha^{-1})				Net return (INR. ha^{-1})			
	Zn_0	**Zn_1**	**Zn_2**	**Zn_3**	**Zn_0**	**Zn_1**	**Zn_2**	**Zn_3**
N_0	43271.64	69845.85	67572.74	67172.89	14174.64	39276.45	37003.34	36603.49
N_{90}	68689.52	81269.70	78730.64	74297.07	38197.52	49305.30	46766.24	42332.67
N_{120}	78344.04	85377.27	86003.38	83901.14	47447.04	53007.87	53633.98	51531.74
N_{150}	80853.29	100747.61	87389.91	86695.16	49551.29	67973.21	54615.51	53920.76
	SEm (±)	3083.79	CD (*p=0.05*)	8906.62	SEm (±)	2296.71	CD (*p=0.05*)	6633.37

Table 3. Interactive effect of nitrogen levels and zinc fertilizer scheduling on benefit cost ratio of wheat crop

Treatment	2012-2013				2013-2014			
	Zn_0	**Zn_1**	**Zn_2**	**Zn_3**	**Zn_0**	**Zn_1**	**Zn_2**	**Zn_3**
N_0	0.49	1.28	1.21	1.20	0.48	1.62	1.55	1.48
N_{90}	1.25	1.54	1.46	1.32	1.29	2.03	1.80	1.80
N_{120}	1.54	1.64	1.66	1.59	1.80	2.15	2.11	1.90
N_{150}	1.58	2.07	1.67	1.65	2.00	2.63	2.12	2.05
	SEm (±)	0.08	CD (*p=0.05*)	0.24	SEm ±	0.14	CD (*p=0.05*)	0.39

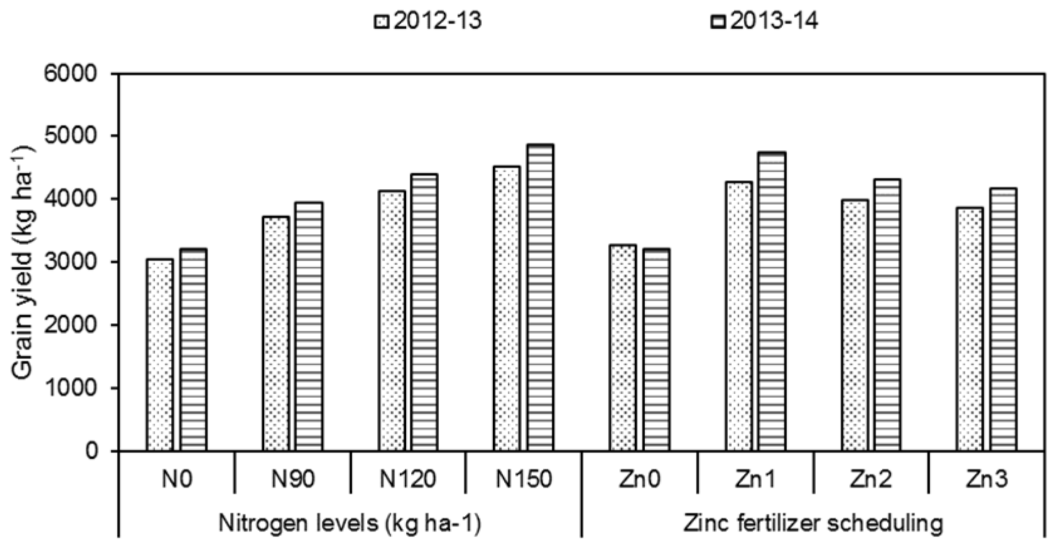

Fig. 1. Effect of nitrogen levels and zinc fertilizer scheduling on grain yield of wheat

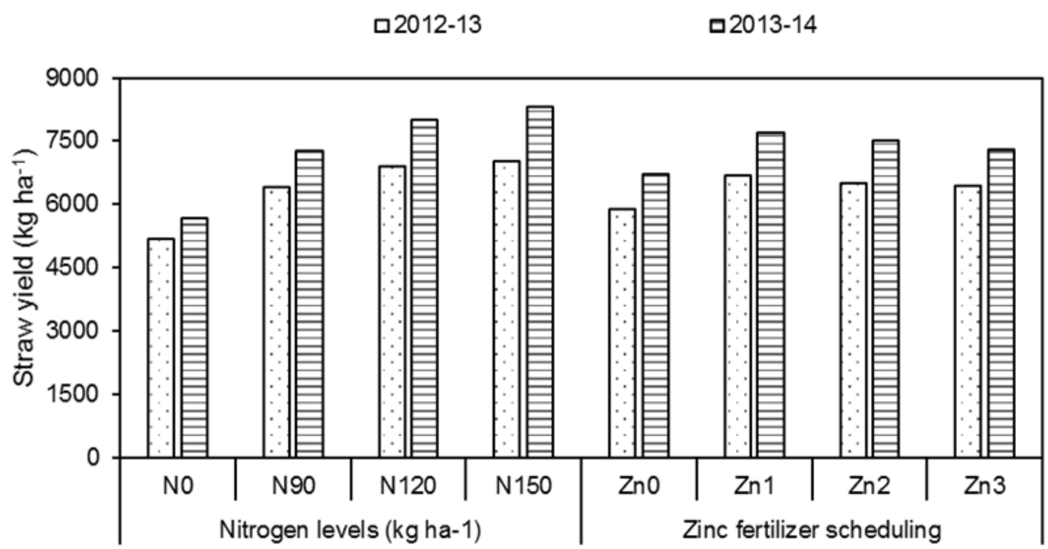

Fig. 2. Effect of nitrogen levels and zinc fertilizer scheduling on straw yield of wheat

4. CONCLUSION

Based on two consecutive year experimentation, it may be concluded that independent application of 150 kg N ha^{-1} and 5 kg Zn ha^{-1} + 0.5% $ZnSO_4$ spray at ear head initiation stage was more effective for higher yields, gross return, net return and benefit cost ratio from wheat crop. However, combined application of 150 kg N ha^{-1} + 5 kg Zn ha^{-1} + 0.5% $ZnSO_4$ spray at ear head initiation stage also was more remunerative for higher economics.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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