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Impact of nano-nitrogenous fertilization on productivity and profitability of Barley (*Hordeum vulgare* L.)

RAJVIR SINGH[1], SHUBHAM SINGH[2], VIRENDRA SINGH, HARISH KUMAR KULDIP SINGH[3], AND JITENDRA KUMAR

Ph.D. Research Scholar, Dept. of Agronomy, R.B.S. College, Bichpuri, Agra Afflited with, Dr. Bhimrao Ambedkar University, Agra

[*]***Corresponding Author Email:*** jkvbs1996@gmail.com

Abstract

*The present investigation entitled "Impact of nano-nitrogenous fertilization on productivity and profitability of Barley (*Hordeum vulgare *L.)" was carried out during* Rabi *season 2020-2021 under Department of Agronomy, R.B.S. College, Agriculture Research Farm Bichpuri, Agra (U.P.). The variables involved in this study viz. nano-nitrogen fertilizer [T_1, control (P+K only), T, (control (P+K only) +1000ml NN/ha at 30-35 and 60-65 DAS), T_3, (50%RDN+500 ml NN/ha at 30-35 and 60-65 DAS), T_4 (50%RDN+1000 ml NN/ha at 30-35 and 60-65 DAS), T_5 (75%RDN+500 ml NN/ha at 30-35 and 60-65 DAS), $\hat{O}_6$ (75%RDN+1000 ml NN/ha at 30-35 and 60-65 DAS), T_7, (100% RDN+500 ml NN/ha at 30-35 and 60-65 DAS), T_8, (100% RDN+1000ml NN/ha at 30-35 and 60-65 DAS)], thus in all 8 treatments were compared in Randomised Block Design (R.B.D.) with 3 replications. Reveled that barley crop fertilized with 100% RDN (60 kg ha¹) + foliar spray of nano-nirogen fertilizer @ 1000 ml ha¹ at 30-35 and 60-65 DAS (T_8) found maximum growth yield, grain yield (53.85 q ha¹), net return (79832.66) and B:C ratio (2.81) followed by treatment T_7- (100% RDN + foliar spray of nano-nitrogen fertilizer @ 500 ml/ha at 30-35 and 60-65 DAS).*

Key words: Barley, Foliar spray, Nano-fertilizer Nano-nitrogen, Yield

Introduction

Barley (*Hordeum vulgare* L.) is widely grown across a range of environments as a rain-fed or irrigated crop. It is considered as one of the most suitable cereal crops, which can survive and grow over a wide range of soils and under many adverse climatic conditions compared with many other cereal crops. The economically valuable product is grain, which is used for food and feed, but also for industrial processing. It ranks fourth after wheat, rice and maize in the world's cereal production with a share of 7% of the global cereal production (Pal *et al.,* 2012). It is usually used as food for human beings and feed for animals and poultry birds (Singh *et al.,* 2012). Almost 60 per cent of the total barley produced in India is consumed as cattle feed. In addition, to direct human consumption about 0.25 million tonnes of barley is used by the malting industries in the country for the production of beer, whisky and other products, viz. industrial alcohol and vinegar. Malt syrup is utilized in the preparation of candies, breakfast beverages and medicines. By- product of brewing and distilling industry, known as 'brewers' and 'distillers grain' is useful as cattle feed. Bold

[1]Professor,
[2]M.Sc. Student, Dept. of Agronomy, R.B.S. College, Bichpuri, Agra Afflited with, Dr. Bhimrao Ambedkar University, Agra
[5]Assistance Professor, [3]Dept. of Soil Conservation, N.D. College Shikohabad, Firozabad

and plump seeded barley varieties are suitable for manufacture of pearl barley and powder products which form the diet of the sick and convalescent people. Pearl barley is used for barley water, which is diuretic and is given to persons suffering from kidney disorders.

Nano-technology offers great potential to tailor fertilizer production with the desired chemical composition, higher nutrient use efficiency that may reduce environmental impact and boost the plant productivity. Nano- fertilizers are very effective for precise nutrient management in precision agriculture by matching with the crop growth stage for nutrient and by providing nutrient throughout the crop growth period. Nano-fertilizers are new generation of the synthetic fertilizers which contain readily available nutrients in nano scale range. Nano-fertilizers are preferred largely due to their efficiency and environment friendly nature compared to conventional chemical fertilizers. The nano-fertilizers deal with the elements in nano- meter dimensions (1-100 nm). When minimized to the nano-scale, these nutrients show some characteristics that differ from the presence of the nutrients in the macro scale, allowing unique applications. Nano-formulated fertilizers can release nutrients more slowly in cooperation with other fertilizers which may lead to improvement of nutrient use efficiency. Application of nano-fertilizers may improve solubility and dispersion of insoluble nutrients in soil, reduce nutrient immobilization and increase bio- availability (Naderi, Danesh- Shahraki, 2013). One of the advantages of using Nano-fertilizers is that application can be done in smaller amounts than when using common fertilizers (Subramanian *et al.,* 2015). Nano formulated fertilizers can be easily absorbed by plants and they may exhibit prolonged effective duration of nutrient supply in soil or on plant (Rameshaiah and Jpallavi, 2015). Nano-fertilizers have the potential to enhance nutrient use efficiency owing to higher nutrients uptake caused by smaller surface area of nano materials which increases nutrient-surface interaction.

Materials and Methods

The field experiment was carried out during *Rabi* season of 2021-21 at Agricultural Research Farm, Department of Agronomy, R.B.S. College, Bichpuri, Agra (U.P.). The experiment was laid out in 'randomized block design' having 8 treatments [T_1, control (P+K only), T, (control (P+K only) +1000ml NN/ha at 30-35 and 60-65 DAS), T_3, (50%RDN+500 ml NN/ha at 30-35 and 60-65 DAS), T_4 (50%RDN+1000ml NN/ha at 30-35 and 60-65 DAS), T_5 (75%RDN+500 ml NN/ha at 30-35 and 60-65 DAS), $\hat{O}_6$ (75%RDN+1000ml NN/ha at 30-35 and 60-65 DAS), T_7, (100% RDN+500 ml NN/ha at 30-35 and 60-65 DAS), T_8, (100% RDN+1000ml NN/ha at 30-35 and 60-65 DAS)], with three replications. The full dose of Nitrogen (60 kg ha^{-1}), P_2O_5 (30 kg ha^{-1}) and K, O (20 kg ha^1) as per treatment applied as basal dressing at the time of sowing through Urea (46% N), SSP (16%) and MOP (60% K_2O). Foliar application of different doses of nano-nitrogen fertilizers (500 & 1000ml ha^{-1}) was applied at 30-35 DAS and 60-65 DAS as per treatment.

Results and Discussion

Growth and Development

The data enumerated in Table-1 it is apparent that various treatments of RDN doses and nano-nitrogen fertilizer application exert significant effect of stand count metre², number of earhead m² and Length of spike. Maximum stand count m², number of earhead m² and Length of spike was observed with the application of 100% RDN with foliar spray of nano- nitrogen fertilizer @ 1000 ml ha^1 at 30-35 and 60-65 DAS stage (T_8) which was significantly higher over all other treatments by 1.88 to 17.70%, 2.21 to 20.14 % and 2.15 to 27.35. Treatment T_7 (100% RDN and 500 ml ha^1 nano-nitrogen fertilizer foliar spray at 30-35 and 60-65 DAS stage), T_6. (75% RDN and foliar spray of nano-nitrogen fertilizer @ 1000 ml ha^1 at 30-35 and 60-65 DAS stage) and T_5 (75% RDN and foliar spray of nano-nitrogen fertilizer @ 500 ml ha^{-1} at 30-35 and 60-65 DAS stage) were at par but these treatments had significantly higher stand count metre as compared to rest of the treatments. Treatment of T [Control (P+K only)] had the lowest stand count metre and proved its significant inferiority over all other treatments. Number of Spikelet's spike reveal that all the treatments had significant effect on number of spikelet's $spike^{-1}$. Application of 100% RDN and foliar spray of nano-nitrogen fertilizer @ 1000 ml ha

Table 1: Yield contributing characters of barley as influenced by various treatments

Treatments	Stand count (m^{-2})	Ear head/m^2	Length of spike (cm)	No. of spikelet's spike^{-1}	GrainWeight/ grains spike^{-1}(g)	No. of grains spike^{-1}	1000 grain weight (g)
T_1	299.50	280.50	5.96	40.73	1.39	38.20	36.10
T_2	305.66	288.50	6.18	41.55	1.48	39.43	37.05
T_3	312.25	294.25	6.30	42.66	1.54	40.72	37.46
T_4	326.66	310.50	6.50	43.83	1.60	42.26	37.95
T_5	338.33	320.66	6.90	44.06	1.65	42.50	38.60
T_6	341.16	323.66	7.14	44.26	1.67	42.85	38.95
T_7	346.00	329.70	7.43	44.96	1.75	43.50	39.18
T_8	352.50	337.00	7.59	45.61	1.80	44.35	40.18
SEm±	4.664	4.449	0.114	1.000	0.066	1.1140	10.081
CD (p=0.05)	14.285	13.626	0.349	3.063	0.201	3.492	NS

at 30-35 and 60-65 DAS stage (T_8) did not differ much with T_7.T_6, resulted in significantly higher number of spikelet's spike' by 1.45 to 12.00 per cent and treatment of T_5, T_4 and T_3 were at par among that but increased number of spikelet's spike" significantly over T, and T . Treatment T, [Control (P+K only)] found minimum number of spikelet's per spike. The similar results have also been reported by Abdel- Aziz *et al.,* (2016), Al-Juthery *et al.,* (2018), Abdel- Aziz *et al.,* (2018), Astaneh *et al.,* (2018) and Gomaa *et al.,* (2018).

The data presented in Table 1 it is apparent that effect of RDN and nano-nitrogen fertilizer application exert significant on grains weight spike. Maximum (1.80g) grains weight spike^{-1} was observed with the application of 100% RDN and foliar spray of nano-nitrogen fertilizer @1000 ml ha at 30-35 and 60-65 DAS stage (T_8) which was statistically at par with T_7, T_6, T_5 and T_4 produced significantly higher grain weight spike over rest of the treatments by 16.88 to 29.50 per cent. Minimum grain weight spike was noted with T [control (P+K only)]. The number of grains spike significantly influenced due to different doses of RDN and foliar spray of nano-nitrogen fertilizer. Treatment T_8 (100% RDN and foliar spray of nano-nitrogen fertilizer @ 1000 ml ha at 30-35 and 60-65 DAS stage) recorded significantly higher number of grains earhead over all other treatments except T_7. The magnitude of increase in number of grains spike^{-1} with treatment T_8 was to the tune of 3.50 to 16.10 per cent over all other treatments. Treatment T_7, treatment of T_6, treatment of T_5 and T_4 differed marginally among themselves but had significantly a greater number of grains spike when compared to rest of the treatments. Treatment T_1, [Control (P+K only)] was obtained minimum no. of grains (38.20) per spike. Treatment T_8 (100% RDN and foliar spray of nano-nitrogen fertilizer @ 1000 ml ha at 30-35 and 60-65 DAS stage) differed marginally with treatment T_7, resulted significantly higher 1000-grain weight by 3.93 to 12.13 per cent over all other treatments. Treatment T_8 significantly higher 1000-grain weight by 4.87 to 12.13 per cent over rest of the treatments. Treatment of T [Control (P+K only)] proved its significant inferiority over all other treatments with test weight of 36.10 gram.

Yield attributes

Effect of nano-nitrogen on yield parameters

The magnitude of the main effects of various doses of RDN and foliar spray of nano-nitrogen fertilizer @ 500 and 1000 ml ha at 30-35 and 60-65 DAS stage are summarized in Table 2. The observations recorded showed that biological yield, grain yield and straw was significantly higher (129.24 q ha^1, 53.85 q ha^1 and 75.39 qha^1) respectvelly with the treatment T_8 (100% RDN and foliar spray of nano-nitrogen fertilizer @ 1000 ml ha^1 at 30-35 and 60-65 DAS stage) which produced significantly higher biological yield, grain yield and straw over all the treatments except treatment T_7, (100% RDN and foliar spray of nano- nitrogen fertilizer @ 500 ml ha^1 at 30-35 and 60-65 DAS stage) and the magnitude of increase was 8.87 to 55.84, 10.24 to

Table 2: Influence by different treatments on yield and economics characters in barley

Treatments	Biological yield (q/ha)	GrainYield (q/ha)	StrawYield (q/ha)	Harvest index (%)	Cost of culti- vation (Rs.)	Gross income Income (Rs.)	Net income (Rs.)	B:C ratio
T_1	82.93	33.17	49.76	40.00	41757	77955	36198	1.86
T_2	90.89	36.80	54.09	40.48	43117	85926	41743	1.96
T_3	99.97	40.64	59.33	40.65	43023	94689	51666	2.19
T_4	109.51	44.70	64.81	40.42	43503	103926	60423	2.38
T_5	114.02	46.73	67.29	40.98	43216	108413	65197	2.50
T_6	118.70	48.85	69.85	41.15	43696	113085	69389	2.58
T_7	123.76	51.57	72.19	41.66	43409	118608	75199	2.72
T_8	129.24	53.85	75.39	41.67	43889	123855	79832	2.81
SEm+	2.301	0.939	1.361	0.005	NS	2183.19	2197.18	0.05
CD (p=0.05)	7.046	2.877	4.169	0.015	NS	6686.17	6729.02	0.16

62.35 and 4.43 to 51.51 per cent respectvelly. Minimum biological yield, grain yield and straw (82.93 q ha^{-1}, 33.17 q ha^{1} and 49.76 q ha^{-1}) was obtained with treatment of T [Control (P+K only)]. The next best treatment in this respect was T_7, (100% RDN and foliar spray of nano-nitrogen fertilizer @ 500 ml ha^{1} at 30-35 and 60-65 DAS stage) which was statistically with recorded appreciably higher grain yield (51.57 qha^{1}) over treatments T_1, T_2, T_3, T_4. Ts and T_6. The next best treatment was T_7 (100% RDN and foliar spray of nano-nitrogen fertilizer @500 ml ha^{1} at 30-35 and 60-65 DAS stage) which was statistically at par with T_8. Different doses of RDN and foliar spray of nano-nitrogen fertilizer @500 and 1000 ml ha^{-1} at 30-35 and 60-65 DAS did not exert significant effect on harvest index. However, maximum harvest index (41.67%) was found with treatment T_8 (100% RDN and foliar spray of nano-nitrogen fertilizer @1000 ml ha^{1} at 30-35 and 60-65 DAS stage) and minimum with T [Control (P+K only)] 40.00%.

Economic analysis of barley

A perusal of data presented in Table 2 reveals that there was considerable impact of various treatments on economics of the factors under study in relation to the other effects on yield and expenditure involved in various doses of RDN and application of nano-nitrogen fertilizer in barley. The cost of cultivation varied treatment 41757 ha to ^{1} 43889 under various dose of RDN and foliar spray of nano-nitrogen fertilizer @ 500ml and 1000 ml ha". The maximum cost of cultivation (^{1} 43889 ha) was incurred under 100% RDN and foliar spray of nano-nitrogen fertilizer @1000ml ha at 30-35 and 60-65 DAS. Whereas, minimum cost (41757 ha) was noted under T_1, [control (P+K only)]. The highest gross return of 123855 ha^{1} was recorded with treatment T_8 (100% RDN and foliar spray of nano-nitrogen fertilizer @1000 ml ha^{1} at 30-35 and 60-65 DAS stage) followed with T_7 (100% RDN and foliar spray of nano-nitrogen fertilizer @ 500 ml ha^{1} at 30-35 and 60-65 DAS stage) and significantly higher gross return over all other treatments by 4.42 and 58.88 per cent. The minimum (^{1} 77955.66 ha^{1}) gross return was found with T [control (P+K only)]. Indicates that the highest net return of 79832.66 ha^{1} was recorded with treatment T_8 (100% RDN and foliar spray of nano-nitrogen fertilizer @1000 ml ha^{1} at 30-35 and 60-65 DAS stage) followed with T_7, (100% RDN and foliar spray of nano-nitrogen fertilizer @ 500 ml ha^{-1} at 30-35 and 60-65 DAS stage) and significantly higher net return over all other treatments by 6.16 and 120.54 per cent. The minimum (36198 ha) net return was found with T [control (P+K only)]. However, maximum (2.81) B:C ratio was obtained with treatment T_8 (100% RDN and foliar spray of nano-nitrogen fertilizer @ 1000 ml ha^{1} at 30-35 and 60-65 DAS stage) followed by T_7 (100% RDN and foliar spray of nano-nitrogen fertilizer @ 500 ml ha^{1} at 30-35 and 60-65 DAS stage) i.e., 2.72 and minimum (1.86) with T [control(P+K only)]. These results are in corroboration with findings of Meena *et al.,* (2012) and Puniya *et al.*, (2015).

Conclusion

Based upon the results, barley crop fertilized with 100% RDN (60 kg ha^{-1}) + foliar spray of nano-nirogen fertilizer @ 1000 ml ha^{-1} at 30-35 and 60-65 DAS (T_8) found maximum growth yield, grain yield (53.85 q ha^{-1}), net return (79832.66) and B:C ratio (2.81) followed by treatment T_7- (100% RDN + foliar spray of nano-nitrogen fertilizer @ 500 ml/ha at 30-35 and 60-65 DAS).

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