



## Response of barley (*Hordeum vulgare*) to phosphorus and zinc application under irrigated conditions of hyper arid plains of Rajasthan\*

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Due to the multifold uses and greater adaptability to diverse and adverse farming situations, area under barley (*Hordeum vulgare* L.) is continuously increasing in north-west part of Rajasthan. The loamy sand soils of the region are poor in fertility status having unfavourable salt balance with limited water availability but barley is capable of giving successful production under such conditions. Apart from this agronomic suitability of the crop in this region, low cost of production and fairly stable prices in recent years have also been the reasons for increasing area under this crop. P and Zn both have numerous vital roles in plants and their adequate supply is prerequisite for optimization of yield. In Rajasthan, 40% of soils are deficient in Zn (GOR 2001) but its deficiency is not necessarily accompanied with visual symptoms. P and Zn interaction affects the availability and utilization of both the nutrients (Sammauria and Yadav 2008). Though soil of experimental site was medium in available P but the information on conjunctive use of P and Zn in barley is severely lacking in the region. Considering these views present investigation was carried out.

Experiment was conducted during winter (*rabi*) season of 2005–06 at Instructional Farm, College of Agriculture, Bikaner. The soil was loamy sand, low in organic carbon (0.08%), available nitrogen (112.6 kg / ha), and DTPA extractable Zn (0.56 ppm) and medium in available P (12.5 kg P / ha) and high in potassium (199.59 kg K/ha). Treatments comprised four levels of P (0, 6.6, 13.1 and 19.7 kg P/ha) and four levels of Zn (0, 10, 20 and 30 kg ZnSO<sub>4</sub> / ha). The experiment was laid out in factorial randomized block design with three replications. Uniform basal doses of N (90 kg /

ha) and K (45 kg / ha) were applied. P and Zn were applied as per treatment and were drilled through diammonium phosphate and Zn sulphate, respectively. Rest of nitrogen was applied through urea and 45 kg nitrogen was applied as top-dressing in standing crop through urea 30 days after sowing. Potassium was applied through muriate of potash. Barley 'RD-2503' was sown at 22.5 cm apart on 15 November 2005 and harvested on 20 March 2006. Other package of practices was as per recommendations of the zone. For recording observation on growth and yield characters, five plants were selected randomly and average values were used for the purpose. Nutrient contents in grain and straw were estimated by following standard procedures and uptake of nutrients were worked out by multiplying nutrient contents and grain and straw yields. Cost of cultivation and gross returns for each treatment were computed on the basis of prevailing market prices of inputs and produce. For computation of net returns, cost of cultivation of each treatment was subtracted from the gross returns received from that particular treatment and B : C ratio was worked out by dividing gross returns with the total cost. In order to work out optimum doses of P and Zn, a regression analysis was done for grain yield of barley as a quadratic function of nutrients ( $Y = a + bx + cx^2$ ) by using following formula.

$$X_{opt} = \frac{P_x/P_y - b_1}{2b_2}$$

Where,  $P_x$  and  $P_y$  are the market prices for each kg of nutrient and grain yield, respectively and  $b_1$  and  $b_2$  are regression coefficients of linear and quadratic components of the production function.

Increasing levels of P significantly increased the plant height, total tillers / m row length recorded at 50 days after sowing and dry matter accumulation / m row length. Number of total tillers / m row length and dry matter accumulation at 60 and 120 days after sowing increased significantly up to application of 19.7 kg P / ha, however, plant height recorded at harvest increased only up to application of 13.1 kg P / ha

\*Short note

Based upon complete information of M Sc thesis of the first author

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(Table 1). Improvement in growth attributes due to phosphorous application may be ascribed to the effective utilization of nutrients through efficient root system developed by crop under increased supply of P. Similar results have also been reported by Jain and Dahama (2006) in wheat. Yield characters of barley also improved significantly with the increasing levels of P and number of effective tiller/m row length, ear length and number of grain/ear increased significantly up to application of 19.7 kg P/ha, however, test weight of barley did not affect. Significant improvements in growth and yield characters led to significant improvement in grain yield of barley with the application of P and the highest yield was obtained with the application of 19.7 kg P / ha that was 28.9% higher than control. However, harvest index remained non-significantly affected. Since P has definite role in development and energy transfer by playing a vital role in numerous metabolic processes, thus accumulated photosynthates diverted towards sink bringing significant improvement in the yield attributes and consequently in yield (Jain and Dahama 2006).

Increasing levels of P significantly influenced the nutrient and crude protein content in grain and straw. N and crude protein content in grain increased significantly up to application of 19.7 kg P/ha, whereas N content in straw and P content in grain increased up to 13.1 kg P / ha (Table 2). P content in straw increased only up to 6.6 kg P / ha. Increased content of N and P may be attributed to the further increase in availability of P in medium status soil that probably developed efficient root system augmenting uptake of P as well as of N. The highest total uptake of N and P was recorded with the application of 19.7 kg P/ha. No effect of P application was observed on K content in grain and straw

but total uptake of K increased significantly up to 13.1 kg P / ha. However, significant reduction in Zn content was noticed with the application of P indicating antagonistic relationship. Zn content in grain reduced up to 19.7 kg P / ha and up to 13.1 kg P / ha in straw. Decrease in Zn content at higher P level might be due to decrease in the available Zn in soil probably due to formation of complexes with excess P or probable interference in translocation (Sharma and Bapat 2000, Singh and Chauhan 2005). A characteristic pattern was noticed with regard to total uptake of Zn that increased significantly over control with the application of 6.6 kg P / ha but it decreased significantly with further increase in P levels. Total uptake of Zn was the lowest with the application of 19.7 kg P / ha that was at par with that of 13.1 kg P / ha but both of these were found significantly lower than control in this respect. The increase in total uptake of Zn with initial levels of P may be attributed to the increase in dry matter despite of decrease in content in grain and straw, however, with further increase in P levels reduction in contents was so great that increasing dry matter could not compensate it and significant reduction in total uptake was evident. Increased yields with the increasing P levels may be ascribed to the better nutritional environment in the rhizosphere by increasing availability of P and developing well developed root system enabling more uptakes of other nutrients. Application of P to barley was found as profitable as net returns increased with the increasing levels of P and the highest net returns (₹ 193 777/ha) and B: C ratio (3.17) was obtained with the application of 19.7 kg P / ha.

Plant height, number of tiller / m row length and dry matter accumulation recorded at 60 and 120 days after sowing increased significantly with the increasing levels of Zn and

Table 1 Effect of P and Zn application on growth and yield characters and yield of barley

Treatment	Growth character				Yield character					
	Tiller /m row length at 50 DAS (no)	Plant height (cm) at harvest	Dry matter accumulation (g / m row length)		Effective tiller/row length	Ear length	Grains/ ear	Test weight (g)	Yield (tonnes/ha)	Harvest index (%)
		60 DAS	120 DAS							
<i>P (kg / ha)</i>										
0	61.8	88.0	59.99	184.58	52.46	5.73	31.31	43.67	2.94	39.04
6.6	70.6	96.7	67.63	197.92	60.46	5.95	33.32	44.10	3.35	39.86
13.1	75.6	101.6	71.07	208.86	64.71	6.26	35.92	44.30	3.58	40.24
19.7	79.8	104.2	74.34	217.31	68.22	6.47	38.02	45.38	3.79	40.44
SEm±	1.2	1.6	1.04	2.80	1.05	0.07	0.65	1.05	0.070	0.40
CD (P=0.05)	3.4	4.6	2.99	8.08	3.03	0.20	1.89	NS	0.203	NS
<i>ZnSO<sub>4</sub> (kg / ha)</i>										
0	64.7	88.4	59.95	182.57	54.88	5.38	30.54	43.70	2.94	39.02
10	70.6	95.5	67.25	199.38	60.32	5.79	33.79	44.33	3.33	39.90
20	74.6	100.9	71.27	208.89	63.76	6.36	35.97	44.70	3.59	40.15
30	78.0	105.8	74.57	217.84	66.89	6.88	38.16	44.72	3.80	40.52
SEm±	1.2	1.6	1.04	2.80	1.05	0.07	0.65	1.05	0.070	0.40
CD (P=0.05)	3.4	4.6	2.99	8.08	3.03	0.20	1.89	NS	0.203	NS

DAS, Days after sowing

significant response for these growth characters could be obtained up to application up to 30 kg ZnSO<sub>4</sub> / ha (Table1). Zn has been reported to have key role in elevating the auxin concentration in plant that is growth promoting (Dewal and Pareek 2004).

Application of Zn significantly improved the yield characters and yield of barley. Application of 30 kg ZnSO<sub>4</sub> / ha resulted in the highest number of effective tillers/plant, ear length and grains / ear remaining significantly better over rest of the levels of applied Zn, however, test weight was not affected. Significant improvement in yield characters resulted in significant improvement in grain yield of barley and highest yield was obtained with the application of 30 kg ZnSO<sub>4</sub> / ha that was significantly better over rest of the levels and it was 29.5% higher than control. Zn has definite role in reproductive physiology, especially in initiation of reproductive primordial and favourable partitioning of photosynthates towards sink (Jain and Dahama 2006) that probably led to significant improvement in yield characters resulting significantly higher grain yield.

N and Zn content of grain and straw increased significantly with the application of increasing levels of Zn and the highest contents were recorded with the application of 30 kg ZnSO<sub>4</sub> / ha that was at par with the application of 20 kg ZnSO<sub>4</sub> / ha. Crude protein content of grain and straw also increased significantly with the application of 30 kg ZnSO<sub>4</sub> / ha. Increased availability of Zn in soil due to its application probably improved the content of grain and straw and probably improved functioning of physiological processes that might have helped in increased absorption of other nutrients also. But application of Zn brought significant reduction in P content of straw of barley and lowest content was recorded with the application of 30 kg ZnSO<sub>4</sub> / ha. Higher availability of Zn might have reduced the availability of P resulting in reduced content of P (Jain 2004, Sammauria and

yadav 2008). P content in grain and K content in grain and straw did not affect significantly with the application of any level of Zn. The highest total uptake of N and Zn was recorded with the application of 30 kg ZnSO<sub>4</sub> / ha, whereas total uptake of P and K increased up to application of 20 kg ZnSO<sub>4</sub> / ha. The highest net returns were also recorded with the application of 30 kg ZnSO<sub>4</sub> / ha but the highest value of B : C ratio was recorded with the application of 10 kg ZnSO<sub>4</sub> / ha and with further increase beyond this level there was constant decline in the B: C ratio and it was even lower than control with the application of 30 kg ZnSO<sub>4</sub> / ha.

Grain yield of barley was found highly positively correlated with the total uptake of P and Zn with the correlation coefficient (r) of 0.971 and 0.515, respectively. Simple regression equation (Y= a + bx) developed was also suggestive of increase in grain yield of barley due to total uptake of P and Zn. The relationship indicated that response of barley was linear to P and Zn application and the response equations are as below.

$$P : Y = 2.156 + 0.6028x$$

$$Zn : Y = 558.65 + 32.75x$$

On the basis of regression analysis, the optimum dose of P and Zn worked out to be 25.07 kg 35.11 kg ZnSO<sub>4</sub> / ha, respectively (Table 3). The corresponding expected grain yields were 3.85 and 3.87 tonnes/ha, respectively. The higher values of coefficient of determination for both the nutrients indicated very high degree of closeness between the predicted and observed values.

It may be concluded that application of 19.7 kg P/ha and 30 kg ZnSO<sub>4</sub> / ha increased grain yield of barley by 28.9 and 29.5%, respectively accompanied with the highest net returns.

## SUMMARY

Results of field experiment, conducted to study the effect of P and Zn application on growth, yield, and nutrient uptake

Table 2 Effect of P and Zn application on nutrient and protein content of barley

Treatment	N content (%)		P content (%)		K content (%)		Zn content (mg / kg)		Crude protein content (%)		Nutrient uptake (kg /ha)				Net returns (₹/ ha)	B:C ratio
	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw	N	P	K	Zn		
<i>P (kg / ha)</i>																
0	1.829	0.463	0.397	0.067	0.473	1.120	27.26	19.43	11.43	2.894	75.07	14.73	65.34	1.700	14 152	2.76
6.6	1.852	0.468	0.433	0.073	0.469	1.111	26.35	18.77	11.57	2.925	85.65	18.16	71.56	1.842	16 764	3.00
13.1	1.873	0.474	0.441	0.074	0.464	1.100	21.26	15.15	11.70	2.963	92.17	19.68	74.88	1.565	18 111	3.09
19.7	1.892	0.478	0.447	0.075	0.462	1.096	19.00	14.93	11.82	2.988	98.47	21.13	78.65	1.600	19 377	3.17
SEm±	0.006	0.001	0.005	0.001	0.004	0.010	0.15	0.16	0.036	0.006	1.67	0.38	1.52	0.030		
CD (P=0.05)	0.017	0.004	0.013	0.002	NS	NS	0.43	0.46	0.103	0.025	4.81	1.09	4.39	0.085		
<i>ZnSO<sub>4</sub> (kg / ha)</i>																
0	1.830	0.463	0.434	0.074	0.468	1.109	21.37	15.73	11.44	2.894	74.99	16.17	64.62	1.340	14 826	3.01
10	1.859	0.470	0.431	0.073	0.468	1.110	22.49	16.19	11.62	2.938	85.45	18.06	71.05	1.543	16 830	3.07
20	1.872	0.473	0.428	0.072	0.466	1.105	24.16	17.21	11.70	2.956	92.68	19.33	75.77	1.767	18 001	3.02
30	1.884	0.476	0.424	0.071	0.465	1.103	26.75	19.15	11.77	2.975	98.25	20.14	78.99	2.058	18 749	2.93
SEm±	0.006	0.001	0.005	0.001	0.004	0.010	0.149	0.160	0.04	0.006	1.67	0.38	1.52	0.030		
CD (P=0.05)	0.017	0.004	NS	0.002	NS	NS	0.43	0.46	0.10	0.025	4.81	1.09	4.39	0.085		

Table 3 Regression analysis of barley yield as a function of P and Zn fertilization

Study parameter	Value
Optimum level of P ( $P_{opt}$ )	25.07 kg P / ha
Yield at $P_{opt}$	3.85 tonnes/ha
a	2.95
b	0.428
c	-0.05
R <sup>2</sup> value	0.9967
Px / Py	0.008131
Optimum level of Zn ( $Zn_{opt}$ )	35.51 kg ZnSO <sub>4</sub> / ha
Yield at $Zn_{opt}$	3.87 tonnes/ha
a	2.94
b	0.4231
c	-0.0455
R <sup>2</sup> value	0.9995
Px / Py	0.01

of barley in loamy sand soils under irrigated conditions of hyper arid plains of Rajasthan, indicated that dry matter accumulation at different growth stages and number of tiller/m row length increased significantly up to 19.7 kg P/ha, however, plant height increased only up to 13.1 kg P<sub>2</sub>O<sub>5</sub>/ha. Yield attributes namely effective tillers/m row length, ear length and grains/ear increased significantly up to application of 19.7 kg P<sub>2</sub>O<sub>5</sub>/ha resulting in significantly higher grain that was 28.9% higher than control. N content in grain, crude protein content in grain total uptake of N and P and net returns and B : C ratio increased significantly up to application of 19.7 kg P/ha. N and protein content in straw, P content in grain and total uptake of K increased significantly up to application of 13.1 kg P/ha. Zn content in grain and straw and total Zn uptake decreased significantly with the P application. Application of 30 kg ZnSO<sub>4</sub>/ha significantly improved the growth and yield characters namely plant height, plant dry matter accumulation at different growth

stages and number of effective tillers/m row length, ear length and grains/ear and grain yield increased by 29.5% over control. N content in grain and straw, Zn content in grain and straw and total uptake of N and Zn and net returns increased up to application of 30 kg ZnSO<sub>4</sub> /ha. However, total uptake of P and K increased only up to 20 kg ZnSO<sub>4</sub> /ha. The highest B : C ratio was obtained with the application of 10 kg ZnSO<sub>4</sub> /ha. On the basis of regression analysis, the optimum dose of P and Zn were worked out to be as 25.07 kg P/ha and 35.11 kg ZnSO<sub>4</sub> /ha.

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