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Gurudev Singh

Scientist (Agronomy)

Department of Genetics and

Plant Breeding College of

Agriculture CSKHPKV,

Palampur, Himachal Pradesh,

India

Sandeep Manuja

Department of Agronomy

College of Agriculture

CSKHPKV, Palampur,

Himachal Pradesh, India

DK Parmar

Hill Agricultural Research &

Extension Centre Bajaura,

Kullu, Himachal Pradesh, India

Dhanbir Singh

Department of Soil Science

College of Agriculture

CSKHPKV, Palampur,

Himachal Pradesh, India

Corresponding Author:**Gurudev Singh**

Scientist (Agronomy)

Department of Genetics and

Plant Breeding College of

Agriculture CSKHPKV,

Palampur, Himachal Pradesh,

India

Response of rainfed barley (*Hordeum vulgare* L.) to phosphorus and potassium application

Gurudev Singh, Sandeep Manuja, DK Parmar and Dhanbir Singh

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Abstract

A field experiment was carried out during the *rabi* seasons of three years (2012-13 to 2014-15) at the Experimental Farm of Hill Agricultural Research and Extension Centre, Bajaura, Kullu (H.P.) with the objective of studying the impact of phosphorus and potassium application in rainfed barley (*Hordeum vulgare* L.). The trial was laid out in split plot design, replicated thrice, with four phosphorus levels (0, 20, 30 and 40 kg P₂O₅ / ha) in main plot and three potassium levels (0, 20 and 40 K₂O / ha) in subplot. Barley variety VLB 118 was used in the present investigation which was raised using recommended package of practices except for the treatments. Application of higher dose of phosphorus hastened the flowering by about a week as compared to no phosphorus application. Significantly highest grain yield was recorded with the application of 40 kg P₂O₅ / ha followed by application of 30 kg / ha, 20 kg / ha and control in that order, each treatment differing significantly from one other. The higher yield recorded with the application of 40 kg P₂O₅ / ha was due to the higher values of yield attributes *viz.*, number of grains / spike and 1000 – grain weight recorded with its application. Straw yield also followed the similar trend with the exception that the difference between the application of 30 and 40 kg P₂O₅ / ha was not significant. Potassium application also increased the grain and straw yield of barley with each level bringing about significant increase with highest value recorded with the application of 40 kg K₂O / ha. Higher values of all the economic indices (gross return, net return and benefit: cost ratio (B:C ratio) were also recorded with the application of highest doses of phosphorus and potassium. The present study proved the importance of phosphorus and potassium application for obtaining higher yield and profitability of rainfed barley cultivated in North Western Himalayan region.

Keywords: Barley, phosphorus, potassium, yield, economics

Introduction

Barley (*Hordeum vulgare* L) is one of the most important cereal crops in the world after rice, wheat and maize. It is also one of the ancient crops that were domesticated during the pre-Harappan era. It is believed that this crop originated in the Middle East, from where it has spread all over the world with major area under this crop falling in the temperate region though it is also cultivated under the subtropical conditions. It is the most widely adapted crop among the cereals, and it suitably withstands the vagaries of nature, like scarcity of water and an extreme of temperature stress and hence is a preferred crop for areas where wheat cultivation is restricted because of the above factors. During the ancient time barley was cultivated for human consumption but with the changing preferences of the populace, the use of this crop as a food crop has declined with only about 3% of the total production being used as food (Newman and Newman, 2008) [9] while remaining production being used as animal feed (60%), malt (30%) or seed (7%). Contrary to this it is still a staple food crop for people in number of countries including Tibet, Nepal and Bhutan as well as many other temperate regions of the world. However with the growing awareness about the health benefits of this crop, being considered as the best food for health by nutritionists, the interest in its cultivation is increasing rapidly. With the water availability for agriculture reducing at an alarming rate this crop has emerged as a popular substitute for wheat as its water requirement is considerably lower than the water requirement of wheat and can be grown in areas having limited water availability. This is a very dynamic cereal in hills as it fulfils the demand of hill people for food and animal feed / fodder besides being used for the production of traditional alcoholic beverages, in traditional system of medicine as well as in various religious rituals.

During 2018 – 19 this crop was cultivated on an area of 5.76 lakh hectare in India with the total production of 16.33 lakh tonnes and average productivity of 28.4 q/ ha while in the North-western Himalayas (Uttarakhand and Himachal Pradesh) this crop was cultivated on an area of 0.44 lakh hectare with the total production of 0.69 lakh tonnes with the productivity of

15.97 q / ha (ICAR-IIWBR, 2020) [6]. This lower productivity of barley in the hilly regions of the country can be attributed to its cultivation being restricted to marginal lands in rainfed areas and non – adoption of improved agronomic practices, particularly imbalanced fertilizer use. The farmers in hilly regions are generally resource poor and are hesitant to use costly phosphatic and potassic fertilizers with focus more on the use of nitrogenous fertilizers. Also little work has been done to study the effect of phosphorus and potassium application on the productivity of barley in hilly regions of our country. Keeping these in mind a field investigation was carried out to find out the most economical dose of phosphorus and potassium for barley grown in hilly areas of North – western Himalayas.

Materials and Methods

A field experiment was carried out at the Experimental Farm of Hill Agricultural Research and Extension Centre, Bajaura, Kullu (H.P.) during *rabi* seasons of 2012-13 to 2014-15 to study the effect of graded doses of phosphorus and potassium on the yield attributing characters, yield and economics of barley raised under rainfed conditions. The site is characterized by subtropical highland climate with warm summers, relatively cold winters and a high diurnal temperature variation. The mean maximum and minimum temperatures during the crop seasons varied between 12.4 °C to 29.6 °C and -1.1 °C to 12.6 °C, respectively while the site received an average rainfall of 515.3 mm during the crop seasons. The soil of the experimental site was silty loam in texture, neutral in reaction (pH 6.8), medium in available nitrogen (302 kg / ha) and available potassium (276 kg / ha) and high in available phosphorus (33.2 kg / ha). The treatments comprised of four phosphorus levels (0, 20, 30 and 40 kg / ha) and three potassium levels (0, 20, 40 kg / ha) which were replicated thrice in split plot design with phosphorus levels in main plot and potassium levels in subplot. The barley variety VLB 118 was sown in the first week of November in all the three years at row spacing of 23 cm using seed rate of 100 kg/ha. The crop was fertilized with 60 kg N / ha which was applied in two equal splits at the time of sowing and after first rainfall

while the entire quantities of phosphorus and potassium, as per the treatments, were applied at the time of sowing. The crop was raised as per the standard package of practices. The data on development stage (days taken to 50% flowering) as well as on yield attributes and yield was recorded with standard procedures and was subjected to analysis of variance by method given by Gomez and Gomez (1984) [5]. The treatment means were compared at 5% level of probability. The expenses incurred for all the cultivation operations from preparatory tillage to harvesting including the cost of fixed and variable inputs *viz.* seed, fertilizers, pesticides etc. applied to each treatment was calculated on the basis of prevailing local market prices. The gross realization in terms of rupee per hectare was worked out taking into consideration the grain and straw yields from each treatment. Net returns of each treatment were calculated by deducting the total cost of cultivation from the gross returns. The benefit: cost ratio (B:C) was calculated by dividing gross returns with cost of cultivation.

Results and Discussion

Days to 50% flowering

Days to 50% flowering was significantly influenced by phosphorus application while potassium application had no significant influence on this parameter (Table 1). Significantly lowest number of days to 50% flowering was recorded with the application of 30 kg P₂O₅ / ha though this treatment was at par with the application of kg P₂O₅ / ha. This advancement of flowering in barley by one week with the application of higher dose of phosphorus can be attributed to the role played by phosphorus in the dry matter distribution which facilitates the plant development. Phosphorus is also actively involved in the various key physiological processes in plants including photosynthesis, energy transfer, transformation of sugars and starches as well as nutrient movement within the plant. Also phosphorus is concentrated more in fast growing parts of plant and hence it reduces the time taken to reach a particular development stage (Ahn, 1993) [1]. Similar results showing hastened flowering and maturity with the higher phosphorus application has been reported by Ottman (2009) [10] and Tigre *et al* (2014) [15].

Table 1: Effect of phosphorus and potassium application on yield attributes of grain barley (Pooled data of three years)

Treatment	Days to 50% Flowering	No. of spikes / m ²	Grains / spike	1000 grain weight (g)	Grain yield (q / ha)	Straw yield (q / ha)	Harvest Index
Phosphorus levels (kg / ha)							
0	145.3	297	34.05	44.26	34.17	56.04	0.379
20	141.3	324	36.63	46.44	40.53	62.01	0.395
30	137.2	359	37.85	46.83	46.58	67.08	0.410
40	138.2	358	41.11	47.77	50.69	69.95	0.420
CD (P=0.05)	2.5	14	1.59	0.93	1.43	2.91	0.020
Potassium levels (kg / ha)							
0	141.3	320	35.91	45.32	38.80	59.58	0.394
20	140.3	340	37.61	46.35	43.70	63.80	0.407
40	139.4	344	38.71	47.30	46.49	67.93	0.406
CD (P=0.05)	NS	12	1.38	0.81	1.36	2.39	NS

Yield attributes and yield

The yield attributes as well as grain and straw yield was significantly impacted by both the phosphorus and potassium application (Table 1) though the interaction between these two nutrients was not found significant for any of the parameters studied. Number of spikes / m² increased with increasing phosphorus application with significantly higher value recorded with the application of 30 P₂O₅ / ha while significantly lowest value of this parameter was recorded in control treatment where no phosphorus was applied. Similarly the number of grains / spike and 1000 – grain weight also

increased with increasing phosphorus application with significantly highest values of both these parameters recorded with the application of highest dose of 40 P₂O₅ / ha. Phosphorus plays an important role in the metabolism of the plant and is involved in cellular energy transfer, respiration and photosynthesis besides being structural component of the nucleic acids, coenzymes, phosphoproteins and phospholipids (Ozanne, 1980) [11]. It also plays an important role in the translocation of photosynthates to the grain ensuring better source – sink relationship. Also adequate supply of this nutrient is required from the earliest stages of crop growth,

which if not available can severely restrict initial growth, from which plant will not recover even when this nutrient is supplied in adequate quantities at a later stage. Since the entire quantity of phosphorus is applied at the time of sowing, adequate availability due to its application at a higher dose resulted in better root and shoot development which resulted in better photosynthetic activity and robust initial growth which led to improved tillering and consequently higher number of effective tillers per unit area. This better initial growth due to adequate phosphorus supply also resulted in increased leaf area and hence higher photosynthetic activity at a later stages along with better translocation of assimilates to the economic part and ultimately resulted in higher number of grains / spike as well as 1000 – grain weight.

The beneficial effect of higher dose of phosphorus on different yield attributes was reflected in the grain and straw yield of barley which also increased with increasing doses of this nutrient with significantly highest yields recorded with the application of highest dose of 40 P₂O₅ / ha though this dose was at par with the application of 30 P₂O₅ / ha for straw yield. Significantly lowest grain and straw yield was recorded in control where no phosphorus was applied indicating the need to apply adequate quantity of phosphorus even in soils which are already rich in this nutrient. Similar results showing beneficial effect of phosphorus application on yield attributes and yield of barley have been reported by Sharma *et al.* (2011) [12], Devraja and Hegde (2006) [3] and Singh and Singh (2018) [14]. Significantly higher values of harvest index was also recorded with the higher phosphorus application with highest value recorded with 40 P₂O₅ / ha which may be attributed to the better translocation of photosynthates to the grains.

Significantly higher number of spikes / m² was recorded with the application of 40 kg K₂O / ha though this treatment was at par with the application of 20 kg K₂O / ha with the control treatment where no potassium was applied recording lowest number of spikes / m². Number of grains also followed the similar trend with highest value recorded with the application of 40 kg K₂O / ha while lowest value recorded with no potassium application. The 1000 – grain weight of barley increased with increasing potassium application from no potassium application to 40 kg K₂O / ha with each successive level bringing significant increase in 1000 – grain weight. Potassium application resulted in increased root and shoot growth which resulted in improved resource capture and higher photosynthetic rate during the early part of plant growth (Drew, 1975) [4]. This higher photosynthetic activity during the initial growth stage results in more availability of assimilates which plays an important role in increasing the number of spikes / m². Also application of higher dose of potassium results in higher leaf area duration which prolongs the period leaves are able to supply assimilates to filling

grains (Brennan and Jayasena 2007) [2] resulting in higher number of grains / spike and higher 1000 – grain weight. Also the higher availability of assimilates at the flowering stage reduces the number of aborting grains in the spike resulting in higher number of grains / spike (Kirby, 1988) [7]. Similar results showing beneficial effect of potassium application on yield attributes of barley have also been reported by Makela *et al.* (2012) [8] and Shekhawat *et al.* (2013) [13].

The grain yield of any crop is a function of various yield attributes and the beneficial effect of potassium application on different yield attributes was further reflected in the grain yield of barley which increased with increasing potassium dose. Significantly lowest grain yield was recorded in control which increased significantly with the application of 20 kg K₂O / ha. Further increase in potassium application to 40 kg K₂O / ha also brought about significant increase in grain yield which was about 20% higher than the yield obtained when no potassium was applied. Straw yield of barley also followed the similar trend with each successive increase in potassium application from 0 kg to 40 kg K₂O / ha bringing about significant increase in straw yield. Shekhawat *et al.* (2013) [13], has also reported significant response of potassium on grain yield of barley in loamy sand soils of Rajasthan.

Economics

The adaptability of any technology among the farmers depends on its economic viability. The effect of application of graded doses of phosphorus and potassium on the economics of barley production has been presented in Table 2. Highest values of gross return was recorded with the application of highest doses of both phosphorus and potassium (40 P₂O₅ / ha and 40 kg K₂O / ha) while the lowest values were obtained in the control treatment where these nutrients were not added to the crop. The higher values of gross return obtained with the application of these nutrients was due to the higher grain and straw yield recorded. A close perusal of the data revealed that net return as well as B:C ratio also followed the similar trend with these values increasing with increasing application of phosphorus and potassium. Application of 40 kg P₂O₅ / ha increased the net returns by 64.4% over no phosphorus application though the increase in net return was 24.7% and 49.0% higher when the phosphorus was applied at 20 and 30 kg P₂O₅ / ha, respectively. Similarly the increase in net return from potassium application was 17.4% and 27.8% with the application of 20 and 40 kg K₂O / ha, respectively over no potassium application. These results can be explained on the basis of the fact that the additional return obtained with the application of these nutrients was much higher than the cost of application of these nutrients. Highest B:C ratio of 2.99 was recorded with the application of 40 kg P₂O₅ / ha while it was 2.84 when the potassium was applied at the highest rate of 40 kg K₂O / ha.

Table 2: Effect of phosphorus and potassium application on economics of barley production (Pooled data of three years)

Treatment	Cost of cultivation (Rs / ha)	Gross return* (Rs / ha)	Net return (Rs/ha)	B:C Ratio
Phosphorus levels (kg / ha)				
0	28,855	66,837	37,982	2.32
20	30,143	77,493	47,350	2.57
30	30,787	87,386	56,599	2.84
40	31,430	93,877	62,447	2.99
Potassium levels (kg / ha)				
0	29,771	74,184	44,413	2.49
20	30,304	82,330	52,026	2.72
40	30,838	87,589	56,751	2.84

* Price of grains: Rs 1300 / quintal; Straw: Rs. 400 / quintal

From the present study it can be concluded that application of both phosphorus and potassium is essential for obtaining higher productivity of barley with the crop responding up to the application rates of 40 kg P₂O₅/ ha as well as 40 kg K₂O/ ha. However for the resource poor farmers who cannot afford higher application rates of these nutrients can go in for the application of lower doses of 30 kg P₂O₅/ ha as well as 20 kg K₂O/ ha.

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