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Response of Barley (*Hordium vugare* L.) to Different Sources of Phosphorus in Arid Region of Rajasthan

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ABSTRACT: A field experiment was conducted during *rabi* seasons of 2019-20 at Instructional Farm, College of Agriculture, Swami Keshwanand Rajasthan Agricultural University, Bikaner to study the response of Barley (*Hordium vulgare* L.) to different sources of phosphorus in Arid Region of Rajasthan The treatments comprising of 12 combinations of phosphorus sources *viz.,* PROM, DAP, SSP, PROM + DAP (1:1), PROM + SSP (1:1), DAP + SSP (1:1), PROM + DAP (2:1), PROM + SSP (2:1), DAP + SSP (2:1), PROM + DAP (1:2), PROM + SSP (1:2) and DAP + SSP (1:2). The experiment was laid out in randomized block design with three replications. The results revealed that application of PROM + DAP (2:1) recorded significantly higher plant height at 60 DAS and at harvest, dry matter accumulation at 30, 60, 90 DAS and at harvest, crop growth rate at 30-60 and 60-90 DAS, relative growth rate at 30-60 DAS and 60-90 DAS, total number of tillers m^{-1} row length, number of effective tiller m^{-1} row length, grains $spike^{-1}$, spike length, test weight grain, straw and biological yield, phosphorus content in grain and straw, nitrogen and phosphorus uptake by grain, straw and their total uptake but remained at par with PROM + SSP (2:1), PROM + DAP (1:1) and PROM + SSP (1:1). However, crop growth rate at 90 DAS-at harvest was higher with DAP + SSP (1:2). Highest net return (₹ 44273 ha^{-1}) with B:C ratio of 2.42 was also obtained under application of phosphorus as PROM + DAP (2:1).

Keywords: Barley, Phosphorus rich organic manure, Straw, Tillers, Yield.

INTRODUCTION

Barley is one of the most significant cereals and main resource of food of human beings living in cooler semi arid extent of the worldwide where wheat, rice, maize and other cereals are less adapted. It is more tolerant to saline and alkaline soils and drought resistant crop grown under adverse conditions than other cereals. It is an important staple food crop of India and commonly exploited as food for people and feed for animals and poultry birds (Singh *et al.,* 2012).

Due to the multifold uses and greater adaptability to diverse and adverse farming situations, area under barley is continuously increasing in north western 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 causes for expanding locality under this crop. Amongst mineral nutrients, phosphorus is an essential nutrient after nitrogen. Indian soils are weak to moderate in accessible phosphorus. Just regarding 30% of the applied phosphorus is in accessible for crops and outstanding portion modified into insolvable phosphorus (Sharma and Khurana 1997). Phosphorus is a most important component for plants as it helps the healthy development of root system and also hastens the maturity. For assembly away the necessity of phosphorus, different sources like, DAP, SSP, PROM, rock phosphate, phosphor gypsum, phosphor compost are used. Appropriate type of fertilizer can increase the yield of crops by 50% (Onasanya *et al*., 2009). The rock phosphate which is a cheaper source of phosphorus but cannot be applied directly into the soil therefore enrichment of organic manure with rock phosphate can solve the both problems of the deficiency of phosphorus and organic carbon content of the soil (Singh *et al.,* 2015). Now days, PROM has come out to be a better source of phosphorus. Phosphorous Rich Organic Manure (PROM) is an organic alternative and indigenous source of phosphatic fertilizer. This substance is more efficient source for adding phosphorous to soil as compared to chemical fertilizers like, DAP, MAP, SSP etc. Besides, PROM also supplies the phosphorus to the succeeding crops as efficiently as it nourishes the crop to which it has been applied.

MATERIALS AND METHODS

A field experiment was carried out during *rabi* season of 2019-20 at Instructional farm of Swami Keshwanand Rajasthan Agricultural University, Bikaner. Twelve treatments consists of phosphorus sources *viz.,* PROM,

DAP, SSP, PROM + DAP (1:1), PROM + SSP (1:1), DAP + SSP (1:1), PROM + DAP (2:1), PROM + SSP (2:1), DAP + SSP (2:1), PROM + DAP (1:2), PROM + SSP (1:2) and DAP + SSP (1:2) was laid out in a randomized block design with three replications. The soil of the experimental field was loamy sand with low in organic carbon (0.11%), available nitrogen (81.41 kg/ha), available phosphorus (32.4 kg/ha) and medium in available potassium (328 kg/ha) with pH 8.4. The barley variety "BH-959" was sown on 25 November 2019 with crop geometry of 20 cm × 10 cm under recommended package of practices. The total rainfall received during the season was 56 mm with 6 rainy days. Phosphorus was applied through DAP, SSP and PROM fertilizer as per treatments as basal application in furrows. PROM contains 0.4% N, 10.4% P, 7.9% OC. Standard methods were followed for crop and economics analysis.

RESULTS AND DISCUSSION

Growth attributes. The growth parameters *viz*. plant height at harvest, dry matter accumulation at harvest, crop growth rate between 30 to 60 DAS, 60 to 90 DAS and 90 DAS to harvest, relative growth rate between 30 to 60 DAS, 60 to 90 DAS and 90 DAS to harvest were influenced significantly due to different sources of phosphorus (Table 1). Application of PROM + DAP (2:1) recorded significantly highest plant height at harvest, dry matter accumulation at harvest, crop growth rate and relative growth rate which was at par with PROM + SSP (2:1), PROM + DAP (1:1) and PROM + SSP (1:1). Phosphorus is also associated with many vital functions and it contributes to better plant growth. The combination of PROM + DAP (1:1), PROM + SSP (1:1), PROM + DAP (2:1) and PROM + SSP (2:1) are most effective in increasing the growth parameters. The favorable effect of phosphorus through PROM with other fertilizer on growth parameters could be attributed to better availability of phosphorus for long duration which enhanced extensive root system. Intensive rooting thus encouraged effective utilization of nutrients.

Data in reference to comparative efficacy of phosphorus sources revealed that out of three phosphorus sources, PROM is most effective in increasing the growth parameters as compared to DAP and SSP. The favorable effect of phosphorus through PROM on growth parameters could be attributed to better availability of phosphorus for long duration which enhanced extensive root system. Intensive rooting thus encouraged effective utilization of nutrients. Further, PROM as a source of phosphorus contains organic matter as well as various essential nutrients prepared by organic manure and rock phosphate and serves as a rich source of energy for various micro-organisms. It also enhanced the performance of these micro-organisms for various beneficial functions in soil thus provided higher available phosphorus to plants (Singh *et al*., 2015). Several scientists reported the importance of phosphorus rich organic matter (high grade rock phosphate and fine size organic matter) in increasing the availability of P from PROM (Zayed & Motaal 2005). Similarly, Biswas and Narayanasamy (2006) have also documented the positive impact of phosphorus riche organic matter (PROM) as effective organic fertilizer for enhancement of growth and yield of plants. It is pertinent here to call into attention that increase phosphate solubilizing organism due to organic matter have been reported to solubilize inorganic forms of P by extracting organic acid that directly dissolves phosphatic material and/or chelate partners of the P ion in soil (Gour, 1990). The positive impact of composting is also reported by Nishanth and Biswas (2008) on wheat crop. The results of present investigation are in conformity with Phiri *et al.* (2010) in pigeon pea, Hellal *et al.* (2013) in maize and Sepat and Rai (2013) in maize and Bairwa *et al.* (2019) in wheat.

Table 1: Effect of phosphorus sources on growth attributes of barley.

Treatment	Plant height (cm) at harvest	Dry matter accumulation (g/m^2) at harvest	Crop growth rate (g/m^2/day)			Relative growth rate (mg/g/day)		
			30 - 60 DAS	60 - 90 DAS	90 DAS - Harvest	30 - 60 DAS	60 - 90 DAS	90 DAS - Harvest
PROM	98.28	788.53	8.72	8.01	5.99	41.05	17.01	8.52
DAP	92.03	769.07	8.42	7.83	5.89	40.85	16.68	8.88
SSP	87.34	726.80	8.29	7.90	4.59	40.79	17.03	7.10
PROM + DAP (1:1)	122.27	930.80	10.46	11.34	5.34	43.74	19.42	6.30
PROM + SSP (1:1)	117.73	925.20	10.19	11.28	5.50	43.06	19.62	6.57
DAP + SSP (1:1)	104.41	874.80	9.78	9.39	6.39	43.79	17.71	8.11
PROM + DAP (2:1)	129.93	972.13	10.91	11.76	5.76	44.28	19.44	6.54
PROM + SSP (2:1)	127.40	961.47	10.60	11.39	6.16	43.74	19.26	7.18
DAP + SSP (2:1)	102.29	867.20	9.74	9.44	6.17	43.96	17.86	8.01
PROM + DAP (1:2)	110.21	888.27	9.90	9.68	6.24	42.86	17.84	7.87
PROM + SSP (1:2)	107.16	874.27	9.84	9.75	5.86	43.34	18.09	7.44
DAP + SSP (1:2)	99.85	845.07	9.62	8.65	6.43	44.20	16.88	8.64
SEm±	5.61	26.47	0.36	0.34	0.30	0.76	0.68	0.27
CD (P=0.05%)	16.46	77.62	1.04	1.00	0.88	2.24	1.99	0.79

Yield attributes and yield. Application of PROM + DAP (2:1) significantly increased the number of total as well as effective tillers m^{-1} row length, numbers of grains spike^{-1}, spike length, test weight, grain and straw yield (Table 2) as compared to PROM, DAP, SSP, DAP + SSP (1:1), DAP + SSP (2:1), PROM + DAP (1:2), PROM + SSP (1:2), DAP + SSP (1:2) however it remained at par with PROM + DAP (1:1), PROM + SSP (1:1) and PROM + SSP (2:1). Lower dose of PROM application was probably not able to release adequate quantity of phosphorus in soil for crop growth as reported by Bairwa *et al.* (2019). Phosphorus has been recognized as essential nutrient for all living organisms and plays a very important role in conservation as well as transfer of energy in metabolic reactions of all living cells including biological energy transformation, root development and also in proliferation as it improve root nodule and biological nitrogen fixation by supplying assimilates to roots. P is the main constituent of various co-enzymes, ATP and ADP which serves as energy currency in plants. Phosphorus influences photosynthesis, phospholipids, synthesis of nucleic acids, membrane transport, cytoplasmic streaming and biosynthesis of proteins. Increased availability of P in the soil, improved the status of available nutrient resulting into a greater uptake. The uptake of available nutrients might have improved the photosynthetic synthesis and then translocations to the different parts for promoting the meristematic development in apical buds and inter calary meristems, ultimately increased the root and shoot development. This increase in yield and yield attributes by PROM may be due to an organic source of nutrition which contains organic matter and several essential nutrients with phosphorus and provide food for beneficial microorganism in field. The PROM application to soil might have increased the availability of nutrients due to increase in no. of micro fauna which bring out transformation of nutrients. Beneficial effect of PROM is also related to improvement in the soil physical properties as well as soil health. The ample availability of nutrients due to application of PROM might have increased yield attributes because nutrient supply favorably influenced the synthesis of chlorophyll and thus increased the carbohydrate metabolism. The favorable effect leads to increase in translocation of photosynthates towards seed, resulting in the formation of bold grains. The overall improvement in grain yield due to the application of PROM may be attributed to cumulative effect of growth parameters as well as yield attributes such as number effective tillers m^{-1} row length, number of grains $spike^{-1}$, spike length and test weight. Jain and Dahama (2006); Jat *et al.* (2007) also recorded significant improvement in wheat grain yield with increase in phosphorus levels. These results are in the conformity with findings of Singh *et al*. (2015); Yadav *et al.* (2017); Bairwa *et al.* (2019). The increase in straw yield significantly with phosphorus through PROM + DAP (2:1) could be attributed in increased vegetative growth as evident from dry matter (Table 2) possibly as a result of the effective uptake and utilization of nutrients absorbed through its extensive root system developed under phosphorus fertilization (Rathi and Singh 1976).

Nutrient content and uptake. PROM application in combination with PROM + DAP (1:1), PROM + SSP (1:1), PROM + DAP (2:1) and PROM + SSP (2:1) proved the most effective in increasing P content in grain and straw as well as nitrogen and phosphorus uptake (Table 3). Addition of PROM in soil improved the physico-chemical properties, nutritional status, and microbial population which resulted in the increased availability of these major nutrients and thus their uptake by crop. The increased availability of phosphorus in soil increased both macro and micro nutrient content with P fertilization might be attributed to balanced nutrient status of the soil. Uptake of N and P is a function of content of these nutrients in grain and straw and their yields. Thus increase in content of these nutrients in grain and straw and in yields have been resulted to increased uptake of N and P by crop. The results are in conformity with Imran *et al.* (2011) in maize, Zafar *et al.* (2011) in maize, Devi *et al.* (2012) in sorghum and Bairwa *et al.* (2019) in wheat.

Economics. Results showed (Table 3) that significantly higher net returns (Rs 44273 ha^{-1}) was fetched when barley crop fertilized with PROM + DAP (2:1) compared to PROM, DAP, SSP, DAP + SSP (1:1), DAP + SSP (2:1), PROM + DAP (1:2), PROM + SSP (1:2), DAP + SSP (1:2). As net returns is calculated by multiplying the grain and straw yields by their sale prices and subtracting the cost of cultivation including treatment cost. As the price of PROM is very low in comparison to the DAP and SSP, hence application of PROM + DAP (2:1) was found profitable over other treatments, therefore, led to the maximum returns as it provided a B:C ratio of 2.42.

Table 2: Effect of phosphorus sources on yield attributes and yields of barley.

Treatment	Total tillers/m row length	Effective tillers/m row length	Number of grains/spike	Spike length (cm)	Test weight (g)	Yields (kg/ha)	
						Grain	Straw
PROM	77.44	71.21	30.21	5.62	37.00	2999	4282
DAP	76.28	70.23	29.81	5.37	36.96	2896	4213
SSP	74.46	69.25	29.18	5.29	36.85	2778	4184
PROM + DAP (1:1)	88.53	81.89	34.52	7.13	40.27	3465	4852
PROM + SSP (1:1)	86.94	80.11	33.18	7.04	40.14	3410	4861
DAP + SSP (1:1)	82.46	74.23	32.19	6.61	38.16	3223	4586
PROM + DAP (2:1)	95.83	87.86	36.38	7.43	41.38	3621	5076
PROM + SSP (2:1)	91.59	84.63	35.61	7.23	40.09	3561	4910
DAP + SSP (2:1)	80.17	72.41	31.86	6.46	37.60	3167	4459
PROM + DAP (1:2)	86.05	76.02	33.01	6.84	39.16	3270	4546
PROM + SSP (1:2)	83.72	75.82	32.38	6.74	39.02	3249	4346
DAP + SSP (1:2)	77.98	72.08	31.32	6.44	37.57	3050	4338
SEm±	3.08	2.68	1.28	0.23	0.83	118	163
CD (P=0.05%)	9.05	7.87	3.75	0.68	2.44	346	479

Table 3: Effect of phosphorus sources on nutrient content, uptake and economics of barley.

Treatment	Nitrogen content (%)		Phosphorus content (%)		Nitrogen uptake (kg/ha)		Phosphorus uptake (kg/ha)		Net returns (₹ ha^{-1})	B:C ratio
	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw		
PROM	1.801	0.519	0.395	0.192	54.08	22.21	11.83	8.24	31937	2.04
DAP	1.789	0.515	0.387	0.175	51.70	21.72	11.21	7.40	29194	1.92
SSP	1.788	0.512	0.380	0.167	49.58	21.37	10.62	6.98	27236	1.86
PROM + DAP (1:1)	1.896	0.562	0.495	0.237	65.66	27.22	17.15	11.51	40853	2.31
PROM + SSP (1:1)	1.863	0.557	0.480	0.229	63.53	27.00	16.35	11.12	40035	2.28
DAP + SSP (1:1)	1.832	0.533	0.423	0.195	59.00	24.43	13.63	8.92	36094	2.16
PROM + DAP (2:1)	1.963	0.570	0.529	0.246	71.11	28.89	19.14	12.48	44273	2.42
PROM + SSP (2:1)	1.904	0.566	0.507	0.240	67.84	27.84	18.02	11.78	42680	2.37
DAP + SSP (2:1)	1.807	0.529	0.406	0.182	57.09	23.57	12.87	8.09	34279	2.08
PROM + DAP (1:2)	1.853	0.547	0.458	0.219	60.59	24.85	14.92	9.93	36513	2.16
PROM + SSP (1:2)	1.843	0.537	0.440	0.212	59.81	23.35	14.30	9.22	35369	2.13
DAP + SSP (1:2)	1.808	0.521	0.402	0.163	55.22	22.59	12.19	7.04	31999	2.01
SEm±	0.065	0.020	0.017	0.007	2.70	1.17	0.60	0.43	2070	0.07
CD (P=0.05%)	NS	NS	0.050	0.020	7.91	3.45	1.77	1.25	6070	0.19

CONCLUSIONS

Application of PROM + DAP (2:1) is remunerative in maximizing the yield of barley on loamy sand soils of Agro-climatic zone I-C. This treatment significantly provided the higher grain yield (3621 kg/ha) and net returns (₹ 44273/ha). However, these results are only indicative and it requires further experiment to arrive at good consistent as well as final conclusion.

Conflict of Interest. None.

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