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OPTIMIZING PHOSPHORUS USE AND GENOTYPE SELECTION FOR SUSTAINABLE BERSEEM (*TRIFOLIUM ALEXANDRINUM* L.) PRODUCTION IN HARYANA

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SUMMARY

A field experiment was conducted at Forage Research Farm, Department of Genetics and Plant Breeding, CCS Haryana Agricultural University, Hisar (India) during winter season (*Rabi*) of 2022-23 to study the response of different phosphorus levels on the fodder yield, quality and economics of berseem (*Trifolium alexandrinum* L.) genotypes. The experiment was laid out in split plot design with six promising berseem genotypes (JB-08-17, JHB-20-1, JHB-20-2, PC-114, BB-2 and Wardan) in main plot and three phosphorus levels in sub plot (60, 80 and 100 kg P_2O_5/ha) and replicated thrice. Among genotypes, highest total green fodder and dry matter yield (799.3 and 114.3 q/ha, respectively) were recorded with the genotype JHB-20-2, which were at par with JHB-20-1 and BB-2. Maximum gross returns (Rs. 1,59,865/ha), net returns (Rs. 86,072/ha) and B:C (2.16) were fetched with JHB-20-2. Maximum mean crude protein content (21.34%) was estimated in BB-2 which was at par with JHB-20-1 and JHB-20-2. Among different P levels, highest green fodder and dry matter yield (776.6 and 109.3 q/ha, respectively) were recorded with the application of 100 kg P_2O_5/ha which were significantly superior over 80 and 60 kg P_2O_5/ha. Highest mean crude protein content (21.96%) was estimated with the application of 100 kg P_2O_5/ha which was significantly superior over the lower levels of phosphorus. Similar trend was also observed in crude protein yield. Maximum BC ratio (2.08) fetched with the application of 100 kg P_2O_5/ha but it was on a par with 80 kg P_2O_5/ha (2.03).

Key words: Berseem, green fodder yield, dry matter, phosphorus level, crude protein content

Berseem (*Trifolium alexandrinum* L.) is one of the most important leguminous fodders of subtropical countries. It was introduced in India from Egypt in 1904; started cultivation as a rotational crop at government cattle farm, since 1910 its cultivation was taken up by cultivators (Das Gupta, 1943). This crop crop is popularly known as 'king of fodder crops' and occupies about 54% (1.9 mha) of the total cultivated *rabi* fodder cropped area (Wasnik *et al.*, 2020). In northern India, this crop is grown as multi-cut fodder annual and has a maturity period of about six months. Berseem forms a major part of the animal diet from November to May in the central and northern-western parts of India. It is highly nutritious fodder contains 15.8-26.7% crude protein, 14.9-28.3% crude fiber, 1.4-3.0% ether extract, 1.40-2.58% calcium and 2.52-4.25% nitrogen content and about 0.14-0.20% phosphorus content on dry weight basis. Berseem is now a much popular and established fodder crop due to its multi-cut nature (4-8 cuts), providing fodder for a long duration (November to May), very high green fodder yield with better quality and high palatability (Singh *et al.*, 2019). Apart from providing high quality green fodder, it also acts as soil cover and prevents soil erosion also (Akshit *et al.*, 2022). Owing to its high demand in milk shed areas and it has wider adaptability, high regeneration capacity, quick growth, high out turn of green fodder, high palatability, easy digestibility and easy cultivation practices, the economic return of this crop are more than other fodder crops. The varietals improvement in this crop however, could get a slow momentum (Shukla and Patil, 1985).

Phosphorus (P), an essential macronutrient, plays a pivotal role in the growth and development of plants. However, the limited availability of P in soil presents significant challenges for crop productivity, especially when plants are subjected to abiotic stresses such as drought, salinity and extreme temperatures (Khan *et al.*, 2023). P stands next to N which is required for the root growth and also helps in

absorption of different plant nutrients (Devi and Satpal, 2019). Berseem, being a leguminous crop, requires sufficient phosphorus in free form for better nodulation. Also, phosphorus plays a fundamental role in number of enzymatic reactions and protein synthesis. It plays a major role in energy transfer system. Thus, phosphorus is essential for a numerous metabolic processes. Research work has been conducted on P fertilization of berseem in different part of country, which proved that application of P has produced tremendous effect on fodder yield, quality and economics of berseem. Providing soluble P to plants during their growth cycle is a commonly recommended approach. This can be achieved by applying phosphorus pentoxide (P_2O_5) as a fertilizer (Bindraban, *et al*., 2020). Also, several workers (Rana *et al.*, 1992; Mani and Singh, 1997 and Godara *et.al.* 2016) reported that increasing phosphorus fertilization levels caused increases in tillering, plant height, regeneration, fodder yield of Berseem. However, the present study was carried out to evaluate the performance of six berseem genotypes at three phosphorus levels to work out the optimum and economic P dose.

MATERIALS AND METHODS

The study was conducted during winter season (*rabi*) of 2022-23 at Forage Section Research Farm area of CCS Haryana Agricultural University, Hisar (Haryana), India (29° 10′ N of 75° 46′ E, at an average elevation of 215.2 m above mean sea level). The soil of the experimental site was sandy loam having pH 7.7, EC 0.32 dS/m, organic carbon 0.48 per cent and available N, P and K were 138.0, 12.5 and 252.5 kg/ha, respectively. The weekly weather parameters during the crop season are given in Fig. 1. The treatments were six multi-cut entries of berseem (JB-08-17, JHB-20-1, JHB-20-2, PC-114, BB-2 and Wardan) in main plot and three phosphorus levels (60, 80 and 100 kg/ha) in sub plot and replicated thrice in split plot design. In the experiment, four test genotypes JB-08-17 (Jawahar Berseem 08-17), JHB-20-1, JHB-20-2, PC-114, were compared with Wardan (North-Central Zonal Checks) and BB-2 (Zonal check for North-West and Central zone). The gross plot size was 4m × 3m. The calculated quantity of P fertilizer doses as per treatments and 20 kg/ha N as basal dose were applied in the respective plots according to the design and mixed with the soil at the time of sowing and seed was sown by broadcasting with irrigation. The sowing was done on November 15, 2022. Next

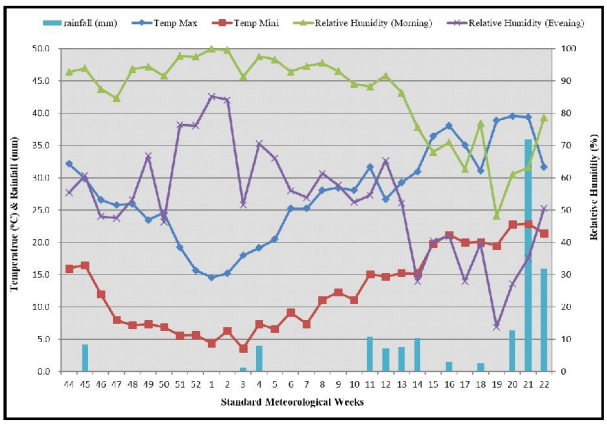

Fig. 1. Weekly weather parameters during the crop season (*Rabi* 2022-23).

irrigations were applied as and when requirement of irrigation rises after seedling establishment. Plant population was recorded by counting the tillers number per square meter putting quadrate from three random spots in all 54 plots at each cut. Plant height was also taken of three randomly selected plants at every harvesting time. For green fodder, crop was harvested first at 60 days after sowing (DAS) and thereafter 30-40 days' interval. Total five cuts were taken in 190-day crop duration. Total rainfall received during the crop duration was 67.9 mm. The crop was harvested from each net plot area individually and weighed. Thus green fodder yield was recorded and converted in q/ha. Dry matter yield (q/ha) was taken from fresh 500 g sample of green fodder after complete drying. Plant samples were also analyzed in lab for quality analysis. The crude protein content was calculated by multiplying the nitrogen percentage with 6.25, estimated by conventional micro-Kjeldhal method (AOAC, 2001.11). Economics was worked out on the basis of prevailing market prices of inputs and outputs in the local market. The experimental data were analyzed by using OPSTAT software available on CCS Haryana Agricultural University website (Sheoran *et. al.*, 1998). The results are presented at five per cent level of significance (p=0.05) for making comparison between treatments

RESULTS AND DISCUSSION

Berseem genotypes

Data presented in Table 1 reveal that among different varieties, maximum average number of tillers/m^2 (634.7) was recorded in JHB-20-2, which was at par with JHB-20-1 and (BB-2) Bundel Berseem-2. However, the lowest number of tillers/m^2 (43.61) was

TABLE 1
Effect of phosphorus levels on performance of berseem genotypes during *Rabi* 2022-23

Treatment	Average no. of tillers/m^2	Average plant height (cm)	Total green fodder yield (q/ha)	Total dry matter yield (q/ha)	Per day productivity of GFY (q/ha)	Per day productivity of DMY (q/ha)
A. Entries						
JB-08-17	584.8	54.9	694.7	96.3	3.66	0.51
JHB-20-1	630.2	58.7	786.1	112.5	4.14	0.59
JHB-20-2	634.7	59.1	799.3	114.3	4.21	0.60
PC-114	569.7	52.4	657.6	88.6	3.46	0.47
BB-2	616.3	57.5	763.6	109.3	4.02	0.58
Wardan	565.9	52.5	614.3	83.1	3.23	0.44
SEm±	8.9	1.7	25.4	4.3	-	-
CD (*p*=0.05)	28.4	NS	81.1	13.7	-	-
B. P Levels						
60 kg P_2O_5/ha	526.4	51.3	633.5	87.2	3.33	0.46
80 kg P_2O_5/ha	624.1	57.1	747.7	105.6	3.94	0.56
100 kg P_2O_5/ha	650.1	59.1	776.6	109.3	4.09	0.58
SEm±	7.6	0.5	6.1	1.1	-	-
CD (*p*=0.05)	22.2	1.4	18.0	3.2	-	-

recorded with the genotype Bundel Berseem-2. Plant height was not affected significantly among different varieties. The cut-wise performance of average number of tillers/m^2 and plant height of the berseem genotypes is given in Fig. 2 & 3, respectively. The differences in growth characters of varieties may be attributed to their inherent characteristics. Highest total green fodder and dry matter yield (799.3 and 114.3 q/ha, respectively) were recorded with the genotype JHB-20-2, which were at par with JHB-20-1 and BB-2 (Bundel Berseem- 2). This may be described that the differences in growth and yield attributing parameters of varieties are due to genetic characters of each variety and the variety JHB-20-2, JHB-20-1 and BB-2 recorded significantly higher growth attributes character as compared to other varieties. The cut-wise performance of green fodder and dry matter yield of the berseem genotypes is given in Fig. 2 and 3, respectively. Maximum per day productivity of GFY and DMY (4.21 and 0.60 q/ha/day) was recorded in JHB-20-2 followed by JHB-20-1 and BB-2 (Table 1). Data presented in Table 2 reveal that among different varieties, maximum mean crude protein content (21.34%) was estimated in BB-2 which was at par with JHB-20-1 and JHB-20-2. Cut-wise crude protein content of different berseem genotypes is also presented Table 2. The maximum crude protein yield (23.95 q/ha) was recorded with JHB-20-2 which was on a par with JHB-20-1 and BB-2. Godara *et. al.* (2016) and Satpal *et al*. (2020) also reported genotypic variations among berseem genotypes for fodder yield and quality.

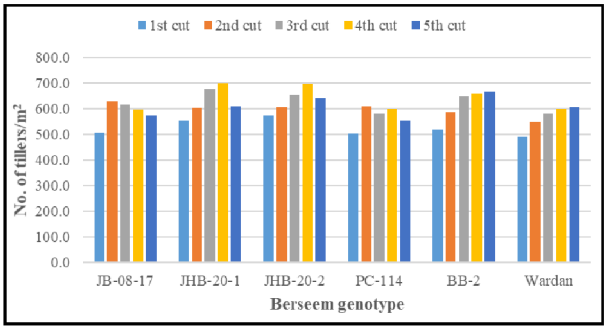

Fig. 2. Cut-wise tiller/m^2 in berseem genotypes.

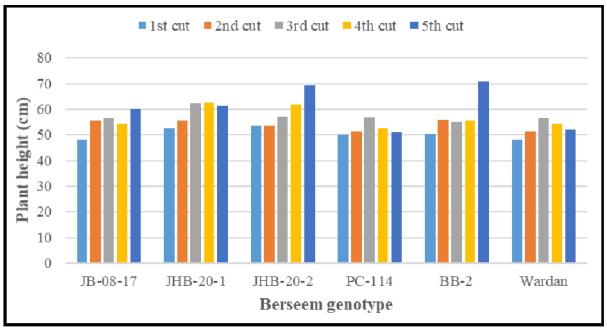

Fig. 3. Cut-wise plant height of berseem genotypes.

Phosphorus levels

All the growth parameters, green fodder as well as dry matter yield and average crude protein content and yield increased with increasing levels of phosphorus. Highest average number of tillers per square meter (58.5) and plant height (59.1 cm) were recorded with application of 100 kg P_2O_5/ha which were significantly superior than the application of 80 and 60 kg P_2O_5/ha. The cut-wise performance of

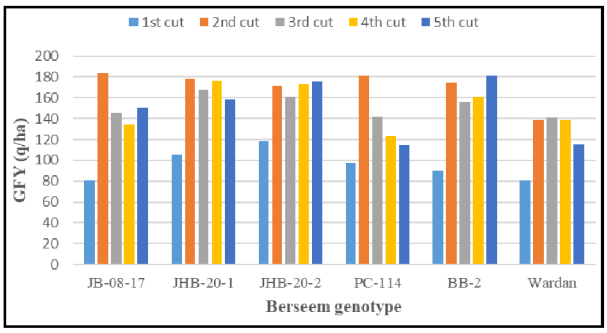

Fig. 4. Cut-wise green fodder yield of berseem genotypes.

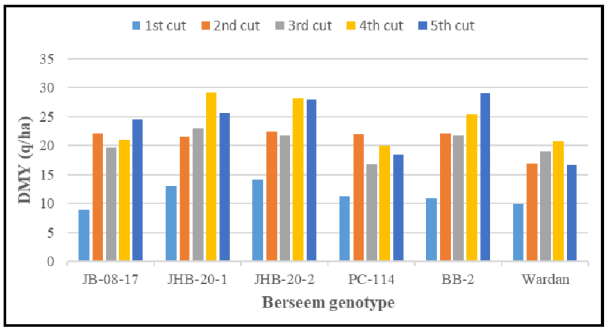

Fig. 5. Cut-wise dry matter yield of berseem genotypes.

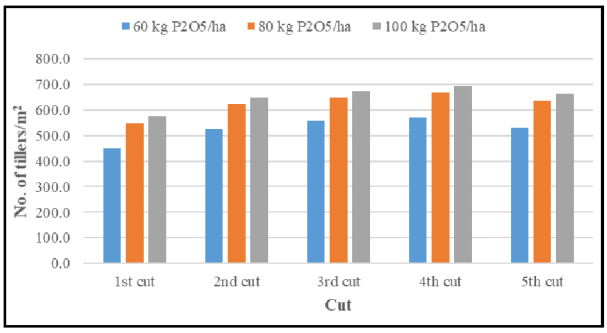

Fig. 6. Cut-wise tiller/m^2 at different P levels.

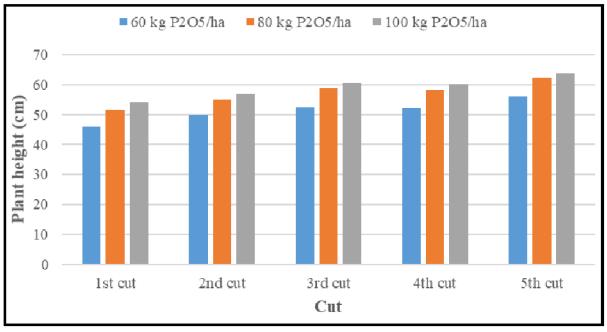

Fig. 7. Cut-wise plant height at different P levels.

average number of tillers/m^2 and plant height of the berseem genotypes at different phosphorus levels is given in Fig. 6 & 7, respectively. Highest green fodder and dry matter yield (776.6 and 109.3 q/ha, respectively) were recorded with the application of 100 kg P_2O_5/ha which were significantly superior to 80 and 60 kg P_2O_5/ha. It may be due to the good

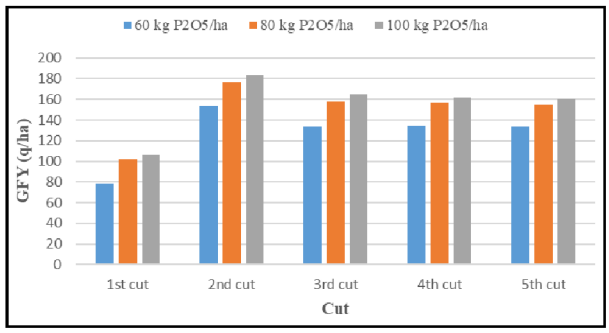

Fig. 8. Cut-wise green fodder yield at different P levels.

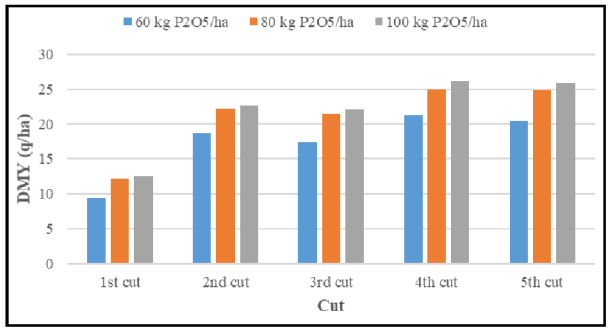

Fig. 9. Cut-wise dry matter yield at different P levels.

emergence and more number of branches which resulted to higher fresh forage yield (Saeed *et. al.*, 2011). The cut-wise performance of green fodder and dry matter yield of the berseem genotypes at different phosphorus levels is given in Fig. 8 & 9, respectively. The result confirms the findings of Godara *et. al* (2016). Maximum per day productivity of GFY and DMY (4.09 and 0.58 q/ha/day) was recorded with the application of 100 kg P_2O_5/ha followed by 80 and 60 kg P_2O_5/ha (Table 1). The increase in growth characters, forage and crude protein yields in this investigation might be attributed to increased cell expansion and various metabolic processes because of greater nutrient uptake in the presence of abundant available phosphorus. Highest mean crude protein content (21.96%) was estimated with the application of 100 kg P_2O_5/ha which was significantly superior over the lower levels of phosphorus. Similar trend was also observed in crude protein yield.

Interaction

The interaction between factor A (Entries) and B (P Levels) was found to be non-significant for Average no. of tillers/m^2, average plant height, total green fodder yield and total dry matter yield. The interaction between factor A (Entries) and B (P Levels) was found to be significant for 'B at same level of A' and 'A at same level of B' for CPC 1st cut and 4th cut

TABLE 2
Crude protein content (CPC) of berseem genotypes as influenced by different phosphorus levels

Treatment	1st cut	2nd cut	3rd cut	4th cut	5th cut	Mean CPC (%)
A. Entries						
JB-08-17	22.63	22.21	20.45	20.12	18.99	20.88
JHB-20-1	22.22	21.15	20.18	20.91	21.08	21.11
JHB-20-2	21.32	21.71	21.91	20.70	19.05	20.94
PC-114	19.81	20.01	19.69	19.26	18.24	19.40
BB-2	22.56	22.03	20.91	20.79	20.42	21.34
Wardan	19.78	21.02	20.11	20.96	20.44	20.46
SEm±	0.42	0.35	0.24	0.22	0.51	0.13
CD (*p*=0.05)	1.33	1.10	0.76	0.71	1.82	0.43
B. P Levels						
60 kg P_2O_5/ha	19.38	19.52	19.01	18.76	18.16	18.96
80 kg P_2O_5/ha	21.82	21.90	21.01	20.90	19.99	21.14
100 kg P_2O_5/ha	22.95	22.64	21.61	21.71	20.94	21.96
SEm±	0.14	0.14	0.15	0.18	0.26	0.08
CD (*p*=0.05)	0.42	0.40	0.43	0.52	0.80	0.22
Factor B at same level of A						
SEm±	0.72	0.6	0.41	0.38	0.89	0.23
CD (*p*=0.05)	1.08	NS	NS	1.3	NS	0.57
Factor A at same level of B						
SEm±	0.51	0.44	0.38	0.42	0.67	0.2
CD (*p*=0.05)	1.57	NS	NS	1.26	NS	0.62

TABLE 3
Crude protein yield (CPY) of berseem genotypes as influenced by different phosphorus levels

Treatment	1st cut	2nd cut	3rd cut	4th cut	5th cut	Total CPY (q/ha)
A. Entries						
JB-08-17	2.04	4.95	4.04	4.22	4.68	19.93
JHB-20-1	2.89	4.60	4.68	6.11	5.42	23.70
JHB-20-2	3.04	4.89	4.77	5.88	5.36	23.95
PC-114	2.27	4.43	3.33	3.87	3.40	17.29
BB-2	2.47	4.89	4.58	5.33	5.98	23.25
Wardan	1.99	3.56	3.84	4.36	3.40	17.16
SEm±	0.12	0.19	0.25	0.35	0.22	0.86
CD (P=0.05)	0.39	0.61	0.81	1.12	0.69	2.74
B. P Levels						
60 kg P_2O_5/ha	1.82	3.66	3.32	3.98	3.72	16.49
80 kg P_2O_5/ha	2.66	4.88	4.52	5.22	4.99	22.26
100 kg P_2O_5/ha	2.88	5.13	4.78	5.68	5.42	23.89
SEm±	0.06	0.11	0.08	0.14	0.09	0.24
CD (P=0.05)	0.17	0.33	0.24	0.42	0.25	0.72
Factor B at same level of A						
SEm±	0.21	0.33	0.44	0.61	0.37	1.49
CD (P=0.05)	NS	NS	NS	NS	NS	1.87
Factor A at same level of B						
SEm±	0.17	0.30	0.3	0.45	0.28	0.99
CD (P=0.05)	NS	NS	NS	NS	NS	3.09

(%), and Mean CPC (%) (Table 2) and for total CPY (q/ha) (Table 3).

ECONOMICS

Economic data presented in Table 4 reveal that amongst genotypes, the maximum gross returns (Rs. 1,59,865/ha), net return (Rs. 86072/ha) and B:C (2.16) were fetched with JHB-20-2. Among different phosphorus levels, application of 100 kg P_2O_5/ha gave maximum gross returns (Rs. 1,55,323/ha), net returns (Rs. 80,508/ha) and B:C ratio (2.08). However, the BC ratio (2.08) fetched with the application of 100 kg P_2O_5/ha was on a par with 80 kg P_2O_5/ha (2.03). Satpal *et al*. (2020) reported that berseem crop fertilized with 100

TABLE 4
Effect of phosphorus levels on economics of berseem genotypes

Treatment	Cost of cultivation (Rs./ha)	Gross returns (Rs./ha)	Net returns (Rs./ha)	BC ratio
A. Entries				
JB-08-17	73793	138935	65143	1.88
JHB-20-1	73793	157226	83433	2.13
JHB-20-2	73793	159865	86072	2.16
PC-114	73793	131526	57733	1.78
BB-2	73793	152717	78924	2.07
Wardan	73793	122854	49061	1.66
SEm±	-	5080	5080	0.07
CD (p=0.05)	-	16216	16216	0.22
B. P Levels				
60 kg P_2O_5/ha	72770	126693	53923	1.74
80 kg P_2O_5/ha	73793	149545	75753	2.03
100 kg P_2O_5/ha	74815	155323	80508	2.08
SEm±	-	1228	1228	0.02
CD (p=0.05)	-	3607	3607	0.05

kg P_2O_5/ha resulted into maximum remunerations in terms of B:C (1.60) which were significantly higher over the lower levels of P dose (80 and 60 kg P_2O_5/ha).

CONCLUSION

Based on the results, it was concluded that among genotypes, the berseem test entry JHB-20-2 performed superior over others but it was on a par with other test entry JHB-20-1 and one check (BB-2) in terms of fodder yield and quality. For getting higher quantity of fodder with better quality, berseem crop should be fertilized with 100 kg P_2O_5/ha at sowing. However, the BC ratio (2.08) fetched with the application of 100 kg P_2O_5/ha was on a par with 80 kg P_2O_5/ha (2.03).

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