RESEARCH ARTICLE Legume Research- An International Journal, Volume 43 Issue 3: 421-426 (June 2020)

Effect of Potassium and Boron Fertilization on Growth, Forage Yield and Quality of Berseem (*Trifolium alexandrinum* L.)

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10.18805/LR-4290

ABSTRACT

The field experiment was conducted during *rabi* season of 2017-18 at the Forage Research Farm of Chaudhary Charan Singh Haryana Agricultural University, Hisar with the objective to study the effect of potassium and boron fertilization on growth, forage yield and quality of berseem. Treatment combinations comprised of four potassium levels *i.e.* 0, 20, 40 and 60 kg K_2O ha^{-1} and four levels of boron *i.e.* 0, 2, 4 kg B ha^{-1}, and 0.2% B spray at flowering initiation and at 50% flowering. The experiment was laid out in split plot design and replicated thrice. Growth characters improved with the application of potassium and boron. Maximum green fodder (444.24 q ha^{-1}) and dry matter yields (55.32 q ha^{-1}) were obtained when berseem was fertilized with 40 kg K_2O ha^{-1}. Crude protein yield was highest with 60 kg K_2O ha^{-1} (10.29 q ha^{-1}) and digestible dry matter at 40 kg K_2O ha^{-1} (37.19 q ha^{-1}). Incremental dose of applied boron resulted in a significant improvement in green fodder and dry matter yields upto 2 kg B ha^{-1}. Significant interaction effects of potassium and boron on total green fodder and total dry matter yields indicated better effects with the combination of 40 kg K_2O ha^{-1} and 2 kg B ha^{-1}.

Key words: Berseem, Crude protein, Dry matter yield, Fodder yield.

INTRODUCTION

Among green fodders, berseem (*Trifolium alexandrinum* L.) is popular among livestock farmers as “King of Fodder Crops”. Berseem is one of the most important forage legumes in India. It was first introduced in Sindh (now in Pakistan) in 1904. It belongs to the clover group and internationally famous as Egyptian clover. Among the berseem growing countries, India is having highest area of about 2 million hectares followed by Egypt and Pakistan (Muhammad *et al*., 2014). Berseem is one of the major *rabi* forage crops in northern India and occupies maximum area among winter forage crops (Hazra, 1995). The hemicellulose present in it helps in increasing the milking capacity of livestock. Berseem provides green fodder for prolonged period of time i.e. from November to May in 4-5 cuts with green fodder yield of about 70-75 tons per hectare.

Number of field studies have reported that application of certain nutrients particularly boron, molybdenum and potassium have significant influence on the forage and seed yields of berseem. Potassium is absorbed by plants in the form of K^+ ions and plays an important role in photosynthesis and regulates the opening and closing of stomata, activation of enzymes for production of Adenosine Triphosphate (ATP), regulation of water in plants through osmoregulation, protein and starch synthesis in plants. Abiotic stresses such as drought, cold, and salt stress are also strongly influenced by K^+ availability e.g. K^+ deficiency has a negative impact on drought tolerance (Cakmak, 2005). Additionally, fundamental physiological processes in plants including photosynthesis, photorespiration and growth are dramatically affected by K^+ availability (Gattward *et al*., 2012). It has been observed that application of potassium in alfisols increased the seed yield and fodder yield of berseem (Misra *et al*., 2012).

Boron absorbed as boric acid (H_3BO_3) and borate ($H_2BO_3^-$) by plants roots is transported within the plant by the transpiration stream through xylem and accumulates near the leaf tips and the margins of older leaves (Bennet, 1993). It plays a key role in a diverse range of plant functions including cell wall formation and stability, maintenance of structural and functional integrity of biological membranes, movement of sugar or energy into growing parts of plants, seed setting and effective nitrogen fixation and nodulation in legume crops. Its requirement during reproductive period is much higher than vegetative perid of plants (Loomis and Durst, 1992). Boron also has a positive impact on the uptake of potassium and phosphorus in many plants. Although most of the Indian soils have been reported to be rich in potassium but intensive cultivation of high yielding crop varieties with indiscriminate use of high rates of nitrogen and phosphorus

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How to cite this article: Akshit, Sheoran, R.S., Harender, Kumar, S. and Kavinder (2020). Effect of Potassium and Boron Fertilization on Growth, Forage Yield and Quality of Berseem (*Trifolium alexandrinum* L.). Legume Research. 43(3): 421-426.

Submitted: 27-11-2019 **Accepted:** 14-01-2020 **Published:** 18-03-2020

fertilizers tend to deplete the potassium reserve of soil at a fast rate. The information pertaining to the effect of two nutrients *i.e.* potassium and boron on forage production and quality of berseem is very scanty. Hence, keeping in view the above facts, the present study was planned with the objective to study effect of potassium and boron on growth, forage yield and quality of berseem.

MATERIALS AND METHODS

The study was carried out at Forage Research Farm, Chaudhary Charan Singh Haryana Agricultural University, Hisar during *rabi* season of 2017-18. The soil of experimental site was sandy loam in texture with pH 7.8, organic carbon (0.48 %), EC (0.5 dS/m), $KMnO_4$ oxidizable N (141.7 kg/ha), 0.5 M $NaHCO_3$ extractable P (16.2 kg/ha) and 1 N NH_4OAC extractable K (238.5 kg/ha) and hot water soluble boron (0.85 mg/kg). The experiment was laid out in split plot design consisting of 16 treatment combinations with three replications. Potassium @ 0, 20, 40, 60 kg ha^{-1} was applied through murate of potash in main plot. Boron as solubor (20%) as 0, 2, 4 kg ha^{-1} and 0.2% foliar spray at flowering initiation and 50% flowering were kept in sub plots. The berseem variety HB1 was sown on December 1, 2017 using seed rate of 25 kg ha^{-1} by broadcasting method. 1st cut was taken after 60 days of sowing and subsequent cuttings were taken after 30 days interval. Growth and forage yield parameters were recorded by standard methods. At each cutting, a random sample of 500 g green fodder was taken from each plot in a paper bag and dried in sun and then in an oven for final drying at a temperature of 65°C to a constant dry weight. Dry matter yield was calculated by multiplying dry matter content with green fodder yield. These samples were also used for chemical analysis of quality traits. Crude protein was estimated by A.O.A.C. (1970) method. The crude protein yield (q ha^{-1}) was calculated by multiplying the crude protein content (%) with dry matter yield. *In vitro* dry matter digestibility of oven dried samples of dry fodder was estimated by using the method given by Tilley and Terry (1963) as modified by Barnes *et al.* (1971). IVDMD per cent was worked out as per the formula given below:

$$\text{IVDMD (\%)} = \frac{\text{0.25 - Weight of oven dried residue (mg)}}{\text{Weight of oven dried material taken (}i.e.\text{ 0.25 mg)}} \times 100$$

Digestible dry matter yield (q ha^{-1}) was computed by multiplying the *in vitro* dry matter digestibility (%) with the dry matter yield. The raw data observed during the whole experiment, was statistically analysed to draw the valid differences among the treatments using and OPSTAT software. The significant difference among treatments was tested by calculating critical difference (C.D.) at 5% level of significance.

RESULTS AND DISCUSSION

Crop growth studies

No significant results were observed in plant height at 1st and 2nd cut whereas at 3rd cut significant increase in plant height was observed upto 40 kg K_2O ha^{-1} over low levels of potassium and same trend was noticed at harvesting stage. No significant effect was observed on plant height at 1st and 2nd cut with boron levels but at 3rd cut a significant increase in height was observed with 2 kg B ha^{-1} over control (Table 1).

No significant increase was observed in number of tillers m^{-2} at 1st cut whereas, at 2nd, 3rd cut and at harvest significant improvement in tillers was observed with potassium application upto 40 kg K_2O ha^{-1}. Potassium an essential nutrient for the activation of enzymes like nitrogenase and nitrate reductase, responsible for the fixation of atmospheric nitrogen in the nodules as well as better nitrogen uptake might have contributed for better growth of the plants in terms

Table 1: Effect of potassium and boron on growth attributes at different cuts.

Treatments	Plant height (cm)				Number of tillers m^{-2}				Leaf : Stem		
	1st cut	2nd cut	3rd cut	At harvest	1st cut	2nd cut	3rd cut	At harvest	1st cut	2nd cut	3rdcut
Potassium levels (kg ha^{-1})											
0	30.53	60.61	60.55	62.36	183.02	411.11	422.29	408.31	1.22	0.83	0.77
20	31.41	60.28	60.74	63.85	182.87	425.01	435.21	424.89	1.23	0.88	0.78
40	31.82	60.86	62.95	65.34	184.01	447.37	459.22	450.22	1.24	0.86	0.78
60	31.71	59.95	62.52	64.03	187.52	440.18	454.06	443.91	1.20	0.89	0.80
SEm ±	0.21	0.62	0.34	0.45	1.62	3.71	3.82	3.42	0.01	0.02	0.01
CD (p=0.05)	NS	NS	1.25	1.37	NS	12.24	12.67	10.93	NS	0.04	0.04
Boron levels (kg ha^{-1})											
0	31.12	59.63	60.47	61.51	184.81	411.73	423.21	412.94	1.22	0.85	0.79
2	31.93	61.02	63.01	64.57	186.03	452.01	464.43	454.15	1.23	0.86	0.79
4	31.29	60.11	62.77	65.88	182.81	442.32	453.75	443.42	1.23	0.88	0.81
0.2% spray at initiation of flowering and at 50% flowering	31.02	60.79	60.43	62.71	183.82	417.75	429.43	416.93	1.20	0.85	0.78
SEm ±	0.49	0.51	0.29	0.39	1.44	2.41	2.45	2.32	0.02	0.01	0.01
CD (p=0.05)	NS	NS	0.9	0.9	NS	7.03	7.12	6.92	NS	NS	NS

of tiller number (Evans, 1954). Application of boron at 1st cut marked non-significant effect, whereas at 2nd and 3rd cut, number of tillers m^{-2} was significantly increased upto 2 kg B ha^{-1} over control. Boron's structural role in cell wall development and stimulation or inhibition of specific metabolism pathways and development of more meristematic tissues had lead to high number of tillers m^{-2}. At 2nd cut and 3rd cut, maximum number of tillers were observed with combination of 40 kg K_2O ha^{-1} and 2 kg B ha^{-1}.

Leaf–stem ratio remained unaffected at 1st cut but at 2nd and 3rd cuts significant increase was found with application to 60 kg K_2O ha^{-1} over control. Application of boron had no significant effect on leaf stem ratio at any of the cuts (Table 1).

Forage yield studies

The data presented in Table 2 revealed that potassium had a significant effect on green fodder yield of berseem at all the cuts. Green fodder yield increased significantly upto 40 kg K_2O ha^{-1} at all the cuts and thus overall total green fodder. At 1st cut, a significant effect of potassium was found on dry matter yield upto 40 kg K_2O ha^{-1}. Potassium plays an imperative role in the photosynthesis process and the subsequent carbohydrate translocation and metabolism, which eventually increase the crop yield (Zorb *et al.*, 2014). The results on green fodder and dry matter yields are in close conformity with the findings of Aboelgoud *et al.* (2015) in berseem and Patel and Kotecha (2006) in lucerne. The crop had positively responded upto 2 kg B ha^{-1} of boron application. Boron application at 1st cut revealed non-significant effect but had significant influence on dry matter yield at 2nd, 3rd cuts and total dry matter yield. The favorable effect of boron in on yield may be owing to the important role of B maintenance of meristematic tissues and their activity and synthesis of N-bases such as uracil (Albert, 1968). These results are concurrent with the findings of Pradhan and Samant (1995) and Joshi and Bhilare (2006) in berseem. The crop was taken for seed purpose so at harvest stage after threshing crop for seed, straw was left instead of green fodder.

Interaction effects of potassium and boron levels on green fodder yield and dry matter yield at different cuts were noticed to be non-significant at Ist cut whereas, at IInd, IIIrd cut and total green fodder yield found to be significantly higher with the combination of 40 kg K_2O ha^{-1} and 2 kg B ha^{-1} over other low levels (Table 3 and 4).

Table 2: Effect of potassium and boron on fodder yield of berseem.

Treatments	Green fodder yield (q ha^{-1}) at different cuttings				Dry matter yield (q ha^{-1})			
	1st cut	2nd cut	3rd cut	Total	1st cut	2nd cut	3rd cut	Total
Potassium levels (kg ha^{-1})								
0	60.27	166.73	179.82	406.82	7.16	21.28	22.96	51.40
20	60.61	172.23	186.58	419.42	7.19	21.99	23.83	53.01
40	66.23	181.12	196.89	444.24	7.85	23.12	25.14	56.11
60	65.81	177.79	194.44	438.05	7.80	22.70	24.82	55.32
SEm ±	1.02	1.55	1.76	3.51	0.12	0.31	0.37	0.54
CD (p=0.05)	3.61	5.34	6.13	12.23	0.35	1.12	1.32	1.89
Boron levels (kg ha^{-1})								
0	62.33	165.07	181.14	408.54	7.39	21.07	23.12	51.59
2	64.24	185.32	200.39	449.95	7.68	23.66	25.58	56.93
4	63.01	179.49	194.82	437.32	7.52	22.92	24.87	55.31
0.2% spray at initiation of flowering and at 50% flowering	63.31	167.87	181.43	412.61	7.45	21.43	23.16	52.04
SEm ±	1.05	1.13	1.25	2.42	0.15	0.19	0.24	0.43
CD (p=0.05)	NS	3.44	3.53	7.15	NS	0.56	0.72	1.18

Table 3: Interaction effect of boron and potassium on total green fodder yield.

Treatments	Boron levels (kg ha^{-1})				Mean	Source	SEm±	CD (p=0.05)
Potassium levels (kg ha^{-1})	0	2	4	0.2% spray at initiation of flowering and at 50% flowering				
0	386.72	425.95	414.71	400.13	406.82	Potassium	3.51	12.22
20	402.15	441.89	425.65	408.17	419.42	Boron	2.43	7.14
40	416.72	477.93	460.49	421.65	444.24	K x B	6.89	15.07
60	428.46	449.57	453.27	420.71	438.05	B x K	5.33	17.24
Mean	408.54	449.95	437.32	412.61				

Effect on quality

An significant increasing trend in crude protein content and crude protein yield at 1st cut was noticed with the increasing levels of potassium. Increase upto 60 kg K_2O ha^{-1}. No significant effect of B application was observed on crude protein content and yield at 1st cut and 2nd cut, however, significant increase in crude protein content and yield at 3rd cut was observed with 4 kg B ha^{-1} (Table 5). The physiological basis for such effects may be Involvement of boron in uracil synthesis, which is an essential component of RNA and in

Table 4: Interaction effect of boron and potassium on total dry matter yield.

Treatments	Boron levels (kg ha^{-1})				Mean	Source	SEm±	CD (p=0.05)
Potassium levels (kg ha^{-1})	0	2	4	0.2% spray at initiation of flowering and at 50% flowering				
0	48.87	53.80	52.38	50.54	51.40	Potassium	0.54	1.89
20	50.71	55.88	53.89	51.56	53.01	Boron	0.40	1.18
40	52.62	60.45	58.14	53.23	56.11	K x B	1.07	2.53
60	54.14	56.78	57.23	53.12	55.32	B x K	0.88	2.77
Mean	51.59	56.93	55.31	52.04				

Table 5: Effect of potassium and boron on crude protein content and yield.

Treatments	Crude protein content (%)			Crude protein yield (q ha^{-1})			
	1st cut	2nd cut	3rd cut	1st cut	2nd cut	3rd cut	Total
Potassium levels (kg ha^{-1})							
0	18.57	16.70	15.96	1.37	3.53	3.58	8.48
20	19.03	17.55	16.31	1.41	3.80	3.87	9.08
40	19.18	17.95	16.91	1.57	4.13	4.28	9.99
60	19.53	19.11	17.52	1.59	4.36	4.33	10.29
SEm ±	0.11	0.10	0.17	0.02	0.07	0.08	0.21
CD (p=0.05)	0.41	0.37	0.63	0.09	0.26	0.30	0.75
Boron levels (kg ha^{-1})							
0	18.83	17.55	16.56	1.44	3.70	3.91	9.05
2	19.26	17.86	16.70	1.49	4.16	4.18	9.84
4	19.54	18.19	17.01	1.55	4.18	4.19	9.88
0.2% spray at initiation of flowering and at 50% flowering	18.68	17.72	16.43	1.45	3.78	3.83	9.06
SEm ±	0.30	0.28	0.17	0.05	0.07	0.05	0.14
CD (p=0.05)	NS	NS	0.33	NS	0.23	0.15	0.42

Table 6: Effect of potassium and boron on *in vitro* dry matter digestibility and digestible dry matter yield.

Treatments	IVDMD (%)			Digestible dry matter yield (q ha^{-1})			
	1st cut	2nd cut	3rd cut	1st cut	2nd cut	3rd cut	Total
Potassium levels (kg ha^{-1})							
0	65.63	63.92	62.14	4.83	13.52	13.93	32.28
20	67.27	65.36	64.65	4.99	14.12	15.34	34.45
40	66.31	66.65	65.13	5.43	15.29	16.48	37.19
60	66.15	66.53	64.81	5.38	14.91	15.76	36.04
SEm ±	0.41	0.53	0.45	0.08	0.24	0.25	0.38
CD (p=0.05)	NS	1.57	1.43	0.31	0.87	0.89	1.18
Boron levels (kg ha^{-1})							
0	65.36	65.46	64.23	5.01	13.67	15.13	33.81
2	67.52	65.74	63.15	5.23	15.28	15.76	36.27
4	66.61	64.67	63.83	5.25	14.79	15.54	35.54
0.2% spray at initiation of flowering and at 50% flowering	66.37	65.73	64.76	5.17	14.11	15.07	34.34
SEm ±	0.83	0.96	0.81	0.17	0.28	0.32	0.75
CD (p=0.05)	NS	NS	NS	NS	NS	NS	NS

Table 7: Effect of potassium and boron on economics of various treatments.

Treatments	Total cost (Rs/ha)	Gross returns (Rs/ha)	Net income (Rs/ha)	B: C
Potassium levels (kg ha^{-1})				
0	99070	155305	56234	1.57
20	99630	160818	61187	1.61
40	100190	167345	67154	1.67
60	100752	167718	66965	1.66
Boron levels (kg ha^{-1})				
0	99070	155636	56565	1.57
2	101570	163684	62114	1.61
4	104070	163228	59157	1.57
0.2% spray at initiation of flowering and at 50% flowering	101870	171359	69489	1.68

presence of boron, the ribosome are produced numerically, thereby the protein synthesis process was enhanced. The role of boron in protein synthesis has been also reviewed by Amberger (1975). Price *et al.* (1972) also reported the possible role of boron in auxin metabolism, protein synthesis and phosphate utilization

At 1st cut, non-significant effect of potassium on IVDMD was observed. At 2nd and 3rd cuts significant effect was observed on IVDMD with the increasing potassium levels and highest IVDMD percentage was observed with the 40 kg K_2O ha^{-1}. Boron levels did not marked any significant effect on IVDMD at any of the cut (Table 6).

With different potassium levels significant effect on digestible dry matter yield was observed with 40 kg K_2O ha^{-1}, which was statistically at par with 60 kg K_2O ha^{-1}. Applied boron hadn't marked any significant influence on the digestible dry matter yield (Table 6).

Economics

Highest gross returns were fetched at 60 kg K_2O ha^{-1}, whereas, maximum net returns and B:C ratio was worked out with 40 kg K_2O ha^{-1}. Overall, treatment with 0.2% spray at initiation and 50% flowering realized maximum B:C among both potassium and boron levels as quantity of boron used is less in this treatment which help in increasing seed yield which is expensive than fodder which lead to high gross and net returns (Table 7).

CONCLUSION

As per the research findings, it may be concluded that green fodder yield and dry matter yield of berseem can be maximized with the application of 40 kg K_2O ha^{-1} and 2 kg B ha^{-1}.

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