

Original Research Article

(Revised & corrected)

Effect of Phosphorous levels and Phosphorous Solubilizing Bacteria (PSB) on Growth, Quality Parameters and Profitability of Berseem (*Trifolium alexandrinum* L.)

ABSTRACT

The present study was conducted at Research farm of R.A.K., college of Agriculture, Sehore, Madhya Pradesh during 2020-21. The experiment was laid out using **Randomized Block Design** with different levels of Phosphorus with or without PSB application (T_1 - 45 kg P_2O_5 /ha, T_2 - 60 kg P_2O_5 /ha, T_3 - 75 kg P_2O_5 /ha, **T_4 -90 kg P_2O_5 /ha**, T_5 - 45 kg P_2O_5 /ha + PSB @ 5g/kg seed, T_6 - 60 kg P_2O_5 /ha + PSB @ 5g/kg seed, T_7 - 75 kg P_2O_5 /ha + PSB @ 5g/kg seed, T_8 - 90 kg P_2O_5 /ha + PSB @ 5g/kg seed). Treatment T_7 found to be best for yield and yield attributes of berseem. Maximum plant height (54.8, 71.5 and 65.5 cm), number of branches/plant (5.44, 6.72 and 8.53), dry matter accumulation (4.90, 6.64 and 5.00 g/plant) at 1st cutting, 2nd cutting and at harvest respectively, dry matter (13.01 %), crude protein (19.99 %), crude protein yield (420.21 kg/ha), Gross return (87,660 ₹/ha), net return (59,412 ₹/ha) and B:C ratio (3.03). While minimum recorded with treatment T_1 (45kg P_2O_5 /ha without PSB application).

Keywords: Phosphorous levels, PSB, Growth, Quality

INTRODUCTION

Berseem (*Trifolium alexandrinum* L.) is an important winter legume forage crop of irrigated area. It has become popular owing to rapid growth, multi-cut nature, good recovery after cuttings, higher yield, long period of fodder supply, high nutritive value and excellent palatability besides enrichment of the soil through biological nitrogen fixation (Chatterjee and Das, 1989).

Berseem or Egyptian clover is regarded as “King of fodder”. It is a nitrogen-fixing annual leguminous crop which is highly adaptable to the semi-arid climate of Northern India. It's also a nutritious and high-yielding leguminous fodder crop. It has a cosmopolitan adaptability and diverse quality. It increases the amount of milk produced by cows and buffaloes.

On an average berseem fodder has 20-21% crude protein, 25.9% crude fibre, 40.7 percent nitrogen free extract, 14.16 percent ash, 1.92 percent calcium, 0.28 percent phosphorus, 70-72 percent dry matter digestibility and is calcium-rich. Berseem productivity is quite poor in India. There are a number of factors that contribute to low berseem yields, but inappropriate fertilizer application is one of the most significant. Correct and judicious fertilizer application can increase production by up to 50% (Zia *et al.*, 1991) while also improving fodder quality (Keshwa and Singh, 1992).

The availability of adequate quality and quantity fodder is linked to the low productivity of Indian livestock. It's been a while seen as a big stumbling block in maximizing the livestock's potential (Palsaniya *et al.*, 2011 and Sarvade *et al.*, 2019).

Berseem is grown in India, Pakistan, Turkey, Egypt and countries of Mediterranean region. In India, it is grown mainly in irrigated area of Northern India and Western part of country. The main state growing this crop are Punjab, Haryana,

Delhi, Rajasthan, Uttar Pradesh, Gujarat, and some parts of Bihar, Maharashtra, and Andhra Pradesh, (Vijay *et al.*, 2017).

Phosphorus plays an important role as a structural component of cell constituents and metabolically active compounds. The protein synthesis is controlled by the supply of phosphorus in plants. Phosphorus has an important role in the process of photosynthesis in plants (Amon, 1953.). It is an essential constituent of nucleic acid, phytin, phospholipids and enzymes and is responsible for root development and seed formation (Naphade and Naphade, 1991). Moreover, P is an essential nutrient for growth and development which gives rapid and vigour start to plant and stimulate flowering and also help in nutrient uptake of N (Yawalkar *et al.*, 1977). Phosphorus plays important role in legume crops. The effect of P is known to activate microbial population responsible for nodulation. Phosphorus in soil increases concentration of P ions of soil solution and ultimately affects formation of more nodules, Vigorous root development, better nitrogen fixation and overall better development of plants. Efficient nodulation due to P fertilization enhances N-fixation to be utilized by plants and ultimately increases protein content. Being a leguminous crop, it enriches the soil by fixing atmospheric N with the association of *Rhizobium trifoli* (De *et al.*, 1983).

The microorganisms that are involved in phosphorus solubilization are looking for soluble phosphorus and promoting the effectiveness of biological nitrogen fixation, which results in greater availability to other trace minerals by developing plant growth promoting substances, and ultimately plant growth is improved (Gyaneshwar *et al.*, 2002). PSB creates organic acids such as lactate, oxalate, succinate, tartarate, acetate, gluconate, glycolate, citrate, ketogluconate, and others (Gyaneshwar *et al.*, 1998). Phosphate-solubilizing microorganisms can create and release organic acids and protons in their environment, lowering the pH and thereby solubilizing calcium-phosphorus complexes. PO_4^{2-} is swapped by acid anion or chelated as a result of these organic acids, and therefore forms dissolved mineral phosphate (Bajpal and Rao 1971).

MATERIALS AND METHODS

The study was conducted during rabi season of 2020-21 at experimental block of Research farm, R.A.K. College of Agriculture, Sehore, Madhya Pradesh, India. The Farm is situated in the Eastern part of Vindhyan Plateau in sub-tropical zone at the latitude of 23° 12' North and longitude of 77° 05' East at an altitude of 498.77 m from mean sea level in Madhya Pradesh, India. The crop sown with inoculated and un-inoculated seeds of berseem (var. Bar-Bar) was given phosphorus fertilizer at the levels 45, 60, 75 and 90 kg P_2O_5 ha⁻¹ in the form of single super phosphate (SSP). The experiment was laid out in **randomized block design** with three replications measuring a net plot size of 4 m X 5 m the seeds of berseem var. Bar-Bar were inoculated with PSB peat mixer and broadcasted in a well-prepared seed bed in middle of November. A basal dose of 20 kg N ha⁻¹ and 40 kg K ha⁻¹ were given during land preparation. All the other cultural practices were kept normal and uniform for all the treatments. The crop was harvested 150 DAS sowing at pod formation. The growth parameters like plant height, number of branches per plant were recorded by randomly selecting five plants from each plot. The plant height was measured with the help of measuring tape from ground level to highest leaf tip. For dry matter percentage, the sample was dried in shade and dried to electric oven at 70°C up to a period till constant weight was achieved. A fraction of dry mass was taken and grinded and then it was preserved in polythene bags for quality analysis.

Quality parameters like dry matter (DM), crude protein (CP) of the samples were determined according to Association of the Official Analytical Chemist (AOAC) (Anonymous 1990). The dry matter was determined by drying the samples at 80°C till constant weight. Crude protein was estimated by micro 'Kjeldhal' method. The percent of nitrogen indicated the estimation of CP. The observations on growth, quality parameters and economics were calculated using SPSS software, IBM Inc. 2009 and least significant was computed at $p \leq 0.05$ as described in Gomez and Gomez (1984).

RESULTS

A. Growth Parameters

1. Plant height (cm)

The data on account plant height, presented in Table-1 revealed that different treatments had significantly influenced the plant height. Maximum plant height (54.8, 71.5 and 65.5 cm) during first cutting, second cutting and at harvest, respectively was observed with the treatment T₇ (75 kg P₂O₅/ha + PSB 5 g/kg seed). Although, the treatment T₈ (90 kg P₂O₅/ha + PSB 5 g/kg seed) *i.e.*, 53.7, 69.5 and 64.1 cm and T₃ (75 kg P₂O₅/ha) *i.e.*, 52.6, 68.9 and 63.4 cm during first cutting, second cutting and at harvest, respectively was *at par* with the treatment T₇. Although, the treatment T₁ (45 kg P₂O₅/ha) recorded minimum plant height *i.e.*, 47.0, 60.2 and 58.1 cm during first cutting, second cutting and at harvest, respectively.

Table 1 : Effect of Phosphorous levels and Phosphorous Solubilizing Bacteria (PSB) on Growth, Quality Parameters of Berseem (*Trifolium alexandrinum* L.)

Seed Yield Treatments		Plant height (cm)			Number of branches/plant			Dry matter accumulation (g/plant)			Dry matter (%)	Crude protein (%)	Crude protein yield (kg/ha)
		70 DAS	110 DAS	At Harvest	70 DAS	110 DAS	At Harvest	70 DAS	110 DAS	At Harvest			
T ₁	45 kg P ₂ O ₅ /ha	47.0	60.2	58.1	4.21	5.05	6.08	3.63	3.90	3.89	11.83	15.25	273.93
T ₂	60 kg P ₂ O ₅ /ha	48.0	62.2	58.3	4.43	5.16	6.17	3.75	5.13	4.15	12.17	16.75	305.49
T ₃	75 kg P ₂ O ₅ /ha	52.6	68.9	63.4	5.11	6.45	8.34	4.67	6.45	4.91	12.60	18.37	377.37
T ₄	90 kg P ₂ O ₅ /ha	50.6	67.9	62.3	4.96	6.17	7.64	4.57	6.19	4.86	12.51	18.10	349.08
T ₅	45 kg P ₂ O ₅ /ha + PSB @ 5 g/kg seed	48.2	62.6	58.4	4.47	5.84	6.64	4.19	5.71	4.24	12.38	16.85	323.27
T ₆	60 kg P ₂ O ₅ /ha + PSB @ 5 g/kg seed	49.3	66.5	61.4	4.88	5.94	7.19	4.19	5.90	4.56	12.47	17.66	342.90
T ₇	75 kg P ₂ O ₅ /ha + PSB @ 5 g/kg seed	54.8	71.5	65.5	5.44	6.72	8.53	4.90	6.64	5.00	13.01	19.99	420.21
T ₈	90kg P ₂ O ₅ /ha + PSB	53.7	69.5	64.1	5.21	6.65	8.52	4.72	6.53	4.91	12.90	19.27	409.49

	@ 5 g/kg seed												
	S.Em±	0.79	0.90	0.70	0.15	0.10	0.21	0.11	0.14	0.07	0.15	0.08	7.53
	CD (5%)	2.37	2.70	2.10	0.45	0.29	0.63	0.32	0.41	0.21	0.45	0.24	22.54

2. Number of branches/plant

The data on account number of branches/plant, presented in Table-1 revealed that different treatments had significantly influenced the number of branches/plant. Maximum number of branches/plant (5.44, 6.72 and 8.53) during first cutting, second cutting and at harvest, respectively was observed with the treatment T₇ (75 kg P₂O₅/ha + PSB 5 g/kg seed). Although, the treatment T₈ (90 kg P₂O₅/ha + PSB 5 g/kg seed) *i.e.*, 5.21, 6.65 and 8.52 and T₃ (60 kg P₂O₅/ha) *i.e.*, 5.11, 6.45 and 8.34 during first cutting, second cutting and at harvest, respectively was *at par* with the treatment T₇. While, the treatment T₁ (45 kg P₂O₅/ha) recorded minimum number of branches/plant *i.e.*, 4.21, 5.05 and 6.08 during first cutting, second cutting and at harvest, respectively.

3. Dry matter accumulation (g/plant)

The data on account dry matter accumulation/plant, presented in Table-1 revealed that different treatments had significantly influenced the dry matter accumulation (g/plant). Maximum dry matter accumulation (4.90, 6.64 and 5.00 g/plant) during first cutting, second cutting and at harvest, respectively was observed with the treatment T₇ (75 kg P₂O₅/ha + PSB 5 g/kg seed). Although, the treatment T₈ (90 kg P₂O₅/ha + PSB 5 g/kg seed) *i.e.*, 4.72, 6.53 and 4.91 g/plant during first cutting, second cutting and at harvest, respectively and T₃ (60 kg P₂O₅/ha) *i.e.*, 4.67, 6.45 and 4.91 g/plant during first cutting, second cutting and at harvest, respectively, was *at par* with the treatment T₇. While, the treatment T₁ (45 kg P₂O₅/ha) recorded minimum dry matter accumulation *i.e.*, 3.63, 3.90 and 3.89 g/plant during first cutting, second cutting and at harvest, respectively.

B. Quality Parameters

1. Dry matter (%)

The data on account dry matter (%), presented in Table-1 revealed that different treatments had significantly influenced the dry matter (%). Maximum dry matter (13.01 %) was observed with the treatment T₇ (75 kg P₂O₅/ha + PSB 5 g/kg seed). Although, the treatment T₈ (90 kg P₂O₅/ha + PSB 5 g/kg seed) *i.e.*, 12.90 % and T₃ (60 kg P₂O₅/ha + PSB 5 g/kg seed) *i.e.*, 12.60 % at harvest, respectively, was *at par* with the treatment T₇. While, the treatment T₁ (45 kg P₂O₅/ha) recorded minimum dry matter *i.e.*, 11.83 %.

2. Crude Protein (%)

The data on account crude protein (%), presented in Table-1 revealed that different treatments had significantly influenced the crude protein (%). Maximum crude protein (19.99 %) was observed with the treatment T₇ (75 kg P₂O₅/ha + PSB 5 g/kg seed). While, the treatment T₁ (45 kg P₂O₅/ha) recorded minimum crude protein *i.e.*, 15.25 %.

3. Crude Protein Yield (kg/ha)

The data on account of crude protein yield (kg/ha), presented in Table-1, revealed that different treatments had significantly influenced the crude protein yield (kg/ha). Maximum crude protein yield (420.21 kg/ha) was observed with the treatment T₇ (75 kg P₂O₅/ha + PSB 5 g/kg seed). Although, the treatment T₈ (90 kg P₂O₅/ha + PSB 5

g/kg seed) *i.e.*, 409.49 kg/ha was *at par* with the treatment T₇. While, the treatment T₁ (45 kg P₂O₅/ha) recorded minimum crude protein yield *i.e.*, 273.93 kg/ha.

C. Economics

The maximum gross monetary return was recorded with the treatment T₇ (75 kg P₂O₅/ha + PSB 5 g/kg seed) *i.e.*, 87,660 ₹/ha. Although, the treatment T₁ (45 kg P₂O₅/ha) recorded minimum gross monetary return *i.e.*, 67,093 ₹/ha.

The maximum net monetary return was recorded with the treatment T₇ (75 kg P₂O₅/ha + PSB 5 g/kg seed) *i.e.*, 59,412 ₹/ha. Although, the treatment T₁ (45 kg P₂O₅/ha) recorded minimum net monetary return *i.e.*, 39,526 ₹/ha.

The maximum B:C ratio of berseem was recorded with the treatment T₇ (75 kg P₂O₅/ha + PSB 5 g/kg seed) *i.e.*, 3.03 per ₹ invested. Although, the treatment T₁ (45 kg P₂O₅/ha) recorded minimum B:C ratio *i.e.*, 2.43 per ₹.

Table 2 : Effect of Phosphorous levels and Phosphorous Solubilizing Bacteria (PSB) on Economics of Berseem (*Trifolium alexandrinum* L.)

Treatments		Cost of Cultivation (₹/ha)	Gross Monetary Return (₹/ha)	Net Monetary Return (₹/ha)	B:C Ratio
T ₁	45 kg P ₂ O ₅ /ha	27,567	67,093	39,526	2.43
T ₂	60 kg P ₂ O ₅ /ha	28,223	70,380	42,157	2.49
T ₃	75 kg P ₂ O ₅ /ha	28,879	81,207	51,646	2.81
T ₄	90 kg P ₂ O ₅ /ha	29,536	79,253	50,374	2.68
T ₅	45 kg P ₂ O ₅ /ha + PSB @ 5 g/kg seed	27,592	74,424	44,888	2.69
T ₆	60 kg P ₂ O ₅ /ha + PSB @ 5 g/kg seed	28,248	76,617	49,025	2.71
T ₇	75 kg P ₂ O ₅ /ha + PSB @ 5 g/kg seed	28,904	87,660	59,412	3.03
T ₈	90kg P ₂ O ₅ /ha + PSB @ 5 g/kg seed	29,560	84,759	55,855	2.86

DISCUSSION

A. Growth Parameters

Maximum plant height and number of branches/plant was observed with the treatment T₇ (75 kg P₂O₅/ha + PSB 5 g/kg seed) and minimum plant height and number of branches/plant was observed with the treatment T₁ (45 kg P₂O₅/ha). The possible reasons may be attributed to PSB inoculation. Application of PSB might have solubilize the phosphate by the micro-organisms through the production of organic acids, citric acids and ketogluconic acids act as powerful chelator of Ca while humic acid and fulvic acid form stable complexes with iron and aluminum phosphate and thus make increased quantity of phosphorus available to plants. Similar effect of PSB on cluster bean was reported by Ayub *et al.* (2013). Chintapalli *et al.* (2012) recorded the significant effect of Rhizobium + PSB on plant height of berseem. El-Gizawy and Mehasan (2004) also reported significant

increase in plant height and number of branches per plant of chickpea by PSB inoculation.

Increase in plant height with higher rate of P is attributed to its favourable effect on cell division and multiplication (Dunnan and Ohlrogge, 1958; Boatwright and Viets, 1966). Since P plays an important role in extensive root development and translocation of photosynthates and phospholipids, its application increase different growth parameters (Abbas *et al.*, 1995), and hence plant height of oat has increased with P application under the present investigation. The potent role of P increasing plant height of berseem has been reported by many workers like Hussain *et al.*, (1976), Sardana and Narwal (1999). Inferior growth in height of plant under lower rate of P might be due to the fact that under phosphate deficiency, the synthesis of protein is adversely affected because of the accumulation of arginine in the tissues of leguminous plants which results in restricted plant growth (Ranjan *et al.*, 1962). Increase of P level beyond 80 kg ha⁻¹ adversely affects the plant growth and the same were statistically at par with those achieved with the application of 80 kg P₂O₅ ha⁻¹ (Roy *et al.*, (2015).

Maximum dry matter accumulation was observed with the treatment T₆ (@ 60 kg P₂O₅/ha + PSB @ 5 g/kg seed). It might be due to taller plants height, more tillers/plant and number of leaves (Shrivastava *et al.*, 2020). The capacity of plant to accumulate dry matter is determined by its rate of CO₂ fixation, photosynthetic area, and duration of crop, tillers/plant and environmental factor besides management practices (Jasjeet *et al.*, 2011).

B. Quality Parameters

Application of phosphorus was significant for all quality parameters except the ash content. Higher dry matter percentage, crude protein percentage and crude protein yield were obtained with P application of treatment T₇ (75 kg P₂O₅/ha + PSB 5 g/kg seed). However, significantly lowest dry matter percentage, crude protein percentage and crude protein yield with 45 kg P₂O₅ ha⁻¹. It might be due to smaller plants height, less tillers/plant and number of branches with low level of Phosphorus (Shrivastava *et al.*, 2020). Ayub *et al.* (2013) reported the significant effect of P application on dry matter percentage and crude fibre content of cluster bean. Grewal *et al.* (2004) and Yadav *et al.* (2011) also recorded significant effect of P on crude protein percentage of cluster bean. Better quality green forage produced with 75 kg P ha⁻¹ might be the results of better root development which provides a better habitat for the activity of biological nitrogen fixing bacteria. The higher root mass exploits the soil from surrounding more effectively and improves the nutrients availability for plants (Roy *et al.*, 2015).

C. Economics

Among different treatments, application of treatment T₇ (75 kg P₂O₅/ha + PSB 5 g/kg seed) gave maximum gross returns (Rs. 87,660/ha), net returns (Rs. 59,412/ha) and B:C ratio (3.03) closely followed by treatment T₈ (90 kg P₂O₅/ha + PSB 5 g/kg). The result confirms the findings of Godara *et. al.*, (2016).

CONCLUSION

On the basis of results obtained in present investigation it is concluded that treatment T₇ (75 kg P₂O₅/ha + PSB 5 g/kg seed) was found to be the best and closely followed by treatment T₈ (90 kg P₂O₅/ha + PSB 5 g/kg seed) and treatment T₃ (75 kg P₂O₅/ha) for morphological (plant height, no. of branches/plant, dry matter accumulation/plant) and quality (dry matter, crude protein, crude protein yield) parameters.

Although, for profitability in berseem cultivation the treatment T₇ (75 kg P₂O₅/ha + PSB 5 g/kg seed) was also found to be the best, which was closely followed by treatment T₈ (90 kg P₂O₅/ha + PSB 5 g/kg seed), while the minimum profitability recorded with treatment T₁ (45 kg P₂O₅/ha).

REFERENCES

- Abbas, M.; Tomar, S. S. and Nigam, K. B. (1995). Effect of phosphorus and sulphur fertilization in sunflower (*Carthamus tinctorius*). *Indian Journal of Agronomy*, **40**(2): 243-245.
- Anonymous (1990). Official Methods of Analysis. Association of the Official Analytical Chemist (AOAC). Arlington, Virginia, USA.
- Arnon, D.J. (1953). Biochemistry of phosphorus in plants. In soil and Fertilizer phosphorus in crop nutrition. Agronomy Monograph No. 4. Academic press. Inc. New York.
- Ayub, M.; Ali, S.A.; Tahir, M.; Tahir, Sh.; Tanveer, A. and Siddiqui, M.H. (2013). Evaluating the role of phosphorus solubilizing bacterial inoculation and phosphorus application on forage yield and quality of cluster bean (*Cyamopsis tetragonoloba* L.). *International Journal of Modern Agriculture*, **2**(1): 26-33
- Bajpal, P.D. and Rao, W.V.B.S. (1971). Phosphate solubilizing bacteria. Part 2. Extracellular production of organic acids by selected bacteria solubilizing insoluble phosphate. *Soil Science and Plant Nutrition*, **17**: 44-45.
- Boatwright, G O. and Viets, F. G. (Jr) (1966). Phosphorus absorption during various growth stages of spring wheat and intermediate grass. *Agronomy Journal*, **58**: 185-188.
- Chatterjee, B.N. and Das, P.K. (1989). In. Forage Crop Production Principles and Practices. Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi.
- Chintapalli; Basanti; Biyan; Subhash, C.; Dhuppara, P. and Rao, D. S. (2012). Studies on the potential of integrated nutrient management for improving the vegetative and reproductive performance of berseem crop. *Forage Research*, **37**(4): 248-250.
- De; Rao, R. Y. Y. and Ali, W. (1983). Grain and fodder legumes as preceding crops affecting the yield and N - economy of rice. *Journal of Agricultural Science*, Cambridge **101**: 463-466.
- Dunan, W. G. and Ohlrogge, A. J. (1958). Principles of nutrient uptake from fertilizer bands 11. Root development in band. *Agronomy Journal*, **50**: 605-608.
- El-Gizawy, N. K. B and Mehasen, S.A.S. (2004). Yield and seed quality responses of chickpea to inoculation with phosphorein, phosphorus fertilizer and spraying with iron. In. Proceedings of the 4th Scientific Conference of Agricultural Sciences, Assiut. pp: 791-802.
- Godara, A. S.; Satpal, Joshi, U.N. and Jindal, Y. (2016) Response of berseem (*Trifolium alexandrinum* L.) genotypes to different phosphorus levels. *Forage Res.*, **42**: 40-43.
- Gomez, K.A. and Gomez, A.A. (1984). In. Statistical Procedures for Agricultural Research. John Wiley and Sons, New York.

- Grewal, K.S.; Metha, S.C. and Singh, N.(2004). Quantity-intensity relationship of potassium as affected by continuous cropping and fertilizer application under different cropping sequences. *Annals of Biology*, **20**: 149-152.
- Gyaneshwar, P.; Kumar, G.N. and Parekh, L.J. (1998). Effect of buffering on the phosphate solubilizing ability of microorganisms. *World Journal of Microbiology Biotechnology*, **14**: 669-673.
- Gyaneshwar, P.; Kumar, G.N.; Parekh, L.J. and Poole, P.S. (2002). Role of soil microorganisms in improving P nutrition of plants. *Plant Soil*, **245**: 83-93.
- Hussain, M. M.; Bains, S. S. and Rajat D.E. (1976). Studies on die effect of phosphate fertilization, cutting interval and varieties on forage yield and chemical composition in berseem. *Indian Journal of Agronomy*, **21**(4): 375–378.
- Jasjeet, D.; Pankaj, K.; Tiwari, B.N. and Rakesh, P. (2011). Chemo- pharmacological aspects of alfalfa: A Review. *Journal of Advanced Scientific Research*, **2**: 50-53.
- Keshwa, G.L. and Singh, H. (1992). Response of bajra varieties to nitrogen grown mixed with cluster bean for forage production in summers. Haryana. *Journal of Agronomy*, **8**: 157-159.
- Naphade, P.C. and Naphade, K.T. (1991). Root CEC and P fertilization in sunflower. *Annals of plant physiology*, **5**(2): 247-252.
- Palsaniya, D.R.; Dhyani, S.K. and Rai, P. (2011). Silvipasture in India: Present Perspectives and Challenges Ahead. Scientific Publishers, Jodhpur, India, pp. 207.
- Ranjan, S. R. M.; Pandey, R. K.; Srivastava, S. L. and Loloraya, M. M. (1962). Effect of phosphorus deficiency on metabolic changes in free amino acid in certain leguminous crop plants. *Nature*, **193**: 997-998.
- Roy, D. C.; Ray, M.; Tudu, N. K. and Kundu, C. K. (2015). Impact of Phosphate Solubilizing Bacteria and Phosphorus Application on Forage Yield and Quality of Berseem in West Bengal. *I.J.A.E.B.*, **8**(2): 315-321.
- Sardana, V. and Narwal, S. S. (1999). Effect of seed inoculation, nitrogen and phosphorus on the fodder and seed yields of Egyptian clover (*Trifolium alexandrinum* L.). *Indian J.Agron.* **44** (3): 639 – 46.
- Sarvade, S.; Upadhyay, V.B. and Agrawal, S.B. (2019). Quality fodder production through silvo-pastoral system: a review. In: Agroforestry for Climate Resilience and Rural Livelihood, Eds: Inder Dev, Asha Ram, Naresh Kumar, Ramesh Singh, Dhiraj Kumar, A.R. Uthappa, A.K. Handa and O.P. Chaturvedi. Scientific Publishers. Jodhpur (Raj.). PP- 345-359.
- Shrivastava, A.K.; Sarvade, S., Bisen, N.K.; Prajapati, B.; Agrawal, S.B. and Goswami, Pooja (2020). Growth and yield of rabi season forage crops under Chattisgarh plain of Madhya Pradesh, India. *Int.J.Curr.Microbiol.App.Sci.*, **9**(2): 878-885.
- Vijay, D.; Manjunatha, N.; Maity, A.; Kumar, S.; Wasnik, V. K.; Gupta, C. K.; Yadav, V. K. and Ghosh, P. K. (2017). BERSEEM- Intricacies of Seed Production in India. *Technical Bulletin*. ICAR-Indian Grassland and Fodder Research Institute, Jhansi. Pp. 47.
- Yadav, B. K. (2011). Interaction effect of phosphorus and sulphur on yield and quality of cluster bean in typicHaplustept. *World Journal of Agricultural Science*, **7**: 556-560.
- Yawalkar, K.S.; Agarwal, J.P. and Bokde, S. (1977). Manures and fertilizers, Agri-Horti Publishing House, Nagpur, pp. 300.
- Zia, M.S.; Gill, M.A.; Aslam, M. and Hussain, M.F. (1991). Fertilizer use efficiency in Pakistan. *Progressive Farming*, **11**: 35-38