Performance of forage multi-cut berseem (*Trifolium alexandrinum* L.) genotypes for growth, forage yield, and quality parameters under different phosphorus levels

Abstract:

Background: The shortage of green and dry fodder remains a significant challenge for the livestock and dairy sectors. Currently, the country is facing a deficit in both green fodder and dry fodder. This is primarily due to the limited area under fodder cultivation, which directly impacts overall fodder availability. To address this issue, there is a pressing need either to expand the area under fodder crops or to adopt advanced production technologies that maximize yield per unit area. Among various fodder crops, berseem (*Trifolium alexandrinum* L.) stands out as a crucial legume cultivated during the winter season globally. Fertilizers, particularly phosphorus, play a key role in optimizing crop productivity. Phosphorus is essential for energy transfer in root nodules and also contributes significantly to root development, nutrient uptake, and overall plant growth. The present study aimed to evaluate the performance of different promising berseem genotypes under varied phosphorus application levels for growth and yield parameters.

Methods: The study was conducted in forage berseem crop during Rabi season of 2023-24 under the AICRP on Forage Crops at BAIF's Central Research Station, Urulikanchan, Pune. The objective was to evaluate the performance of AVT-2 berseem genotypes (six genotypes) under different phosphorus levels (three levels). A field study was undertaken in a split-plot design with three replications.

Result: Among the genotypes evaluated, JB-08-17 recorded the tallest plants at 66.10 cm, while PC-114 exhibited the highest leaf stem ratio of 0.772. Application of 100 kg P_2O_5 per hectare resulted in the maximum average plant height of 63.08 cm, whereas the highest leaf stem ratio (0.69) was observed with 80 kg P_2O_5 per hectare. In terms of green fodder yield, JHB-20-2 recorded the highest yield of 967.36 q/ha, followed by PC-114 with 966.72 q/ha. PC-114 also produced the significantly highest dry fodder yield (134.19 q/ha) and crude protein yield (28.79 q/ha). Phosphorus application at 100 kg/ha led to the maximum yield of green fodder (959.29 q/ha), dry matter (114.38 q/ha), and crude protein (23.68 q/ha). These results highlight the potential of specific berseem genotypes and optimal phosphorus application levels to enhance fodder productivity and contribute to addressing the ongoing deficit in green and dry fodder availability.

Keywords: Berseem, Genotypes, Fertilizer, Phosphorus, Green fodder yield

Introduction:

In rural India, livestock rearing has traditionally played a crucial role in supporting household livelihoods alongside agriculture the decades, its role has grown increasingly significant, particularly due to the steady and sustainable cash income it provides even in years when crop failures occur. The growing demand for milk and milk-based products, has made dairy farming an emerging and profitable enterprise in the country.

Despite these positive developments, India continues with a longstanding shortage of green fodder. One of the key contributors to this deficit is the limited land allocated for fodder cultivation (Kale and Takawale, 2023). According to Singh et al. (2022), At present, India faces a net shortfall of 35.6% in green fodder, 10.5% in dry fodder, and 44% in concentrate feed components, posing a significant challenge to livestock productivity. Given the constraints on expanding the area under fodder crops, enhancing fodder availability remains a critical challenge (Takawale et al., 2022).

To overcome this, forage scientists must focus on maximizing fodder yield from the existing land through efficient utilization and advanced agronomic practices. This includes the adoption of integrated cropping systems, use of improved fodder varieties, crop rotation, cultivation on marginal or degraded lands, and strategic fertilizer management.

Among the various fodder crops, berseem (*Trifolium alexandrinum* L.) plays a crucial role, particularly during the rabi season. Its widespread adoption by farmers is due to its multi-cut nature, prolonged fodder availability, high green biomass yield, superior digestibility, palatability, and nutritional value. Berseem contains approximately 20% crude protein and 62% total digestible nutrients, making it highly nutritious for livestock (Singh et al., 2018).

In addition to being a valuable fodder source, berseem significantly contributes to soil fertility. As a leguminous crop, it fixes atmospheric nitrogen in the soil, enhancing its fertility when used in rotation with other crops (Singh et al., 2019).

Given the importance of berseem in both livestock nutrition and soil health, effective nutrient management becomes vital for achieving optimum yields. Among the various agronomic inputs, fertilizer management plays a pivotal role in enhancing plant growth by improving nutrient availability. Most chemical fertilizers are water-soluble, allowing for quick absorption by plant roots.

Phosphorus, in particular, is an essential macronutrient for root development and facilitates the uptake of other nutrients. In leguminous crops like berseem, phosphorus is especially important as it supports root nodulation and enhances biological nitrogen fixation. It is also a key component of ATP (Adenosine triphosphate), the energy molecule that drives nearly all plant cellular processes. In addition, phosphorus is essential for the synthesis of DNA and RNA, thereby facilitating cell division and the development of tissues (Rawat et al., 2020).

Although various studies have examined berseem production and fertilizer strategies, the current research focuses specifically on the performance of AVT-2 (Second Advanced Varietal Trial) berseem genotypes under different phosphorus levels. This study aims to identify the optimal phosphorus requirement for maximizing both fodder yield and nutrient content while supporting sustainable agricultural practices.

Material and Methods:

A field experiment was conducted during the *Rabi* season of 2023-24 under the All India Coordinated Research Project on Forage Crops at BAIF's Central Research Station, Urulikanchan, Pune. The objective was to evaluate the performance of berseem genotypes under different phosphorus levels.

The experiment was conducted using a Split Plot Design, with six AVT-2 berseem genotypes assigned to the main plots and three phosphorus application levels (60, 80, and 100 kg ha^{-1}) allocated to the sub-plots. Each treatment was replicated three times. Seeds were manually sown with an inter-row spacing of 30 cm. Crop management practices were followed as per the recommended package of practices for berseem cultivation, except for the phosphorus treatments, which were applied as per the experimental design.

Observations were recorded on various growth parameters including plant height and leaf stem ratio, as well as yield parameters such as green fodder yield, dry matter yield, and crude protein content. The first harvest was carried out at 60 days after sowing (DAS), with subsequent cuts taken at 30-day intervals. Plant samples collected at the 50% flowering stage were used for laboratory analysis of dry matter and crude protein content. A 500 g fresh sample was collected from each net plot for dry matter estimation. These samples were dried in a hot air oven at 70°C ± 2°C until a constant weight was achieved. The dried samples were then ground using a Wiley mill to pass through a 1 mm sieve. Total nitrogen content was determined using the Kjeldahl digestion and distillation method. Crude protein was calculated by multiplying the nitrogen percentage by 6.25 (AOAC, 1965).

Result and discussion:

Performance of AVT-2 Berseem Genotypes Under Varying Phosphorus Levels for Growth and Quality Parameters:

Growth parameters such as plant height and leaf stem (L:S) ratio were recorded at each cutting, and the average data are presented in Table 1. The results revealed that while berseem genotypes exhibited significant differences in plant height. Phosphorus levels did not significantly affect this parameter. Among the genotypes, JB-08-17 recorded the maximum plant height of 66.10 cm, which was significantly higher than other genotypes. However, Wardan (NC) (63.52 cm) and JHB-20-2 (63.25 cm) were statistically at par. These findings align with previous studies by Nanda et al. (2022) and Godara et al. (2016), which reported significant genotypic variation in plant height, L:S ratio, and crude protein (CP) content in berseem. Such variability can be attributed to the inherent genetic potential of each genotype, as also noted by Naveen et al. (2021).

Although phosphorus application did not significantly influence plant height, a numerically higher average was observed with 100 kg P_2O_5 ha^{-1} (63.08 cm), followed by 80 kg ha^{-1} (62.12 cm). The leaf stem ratio measured at each cut showed no significant variation among the genotypes or phosphorus treatments.

Laboratory analysis of quality parameters revealed that both genotype and phosphorus levels had a positive impact on dry matter content and crude protein content. Among the genotypes, the highest dry matter content of 13.88% was recorded in both PC-114 and BB-2 (CZ), followed by JHB-20-1 with 12.27%. In terms of crude protein, PC-114 (21.45%) and Wardan (NC) (21.52%) exhibited significantly higher contents.

With regard to phosphorus treatments, the application of 60 kg ha^{-1} and 80 kg ha^{-1} resulted in significantly higher dry matter contents (12.72% and 12.20%, respectively) and crude protein contents (20.92% and 20.60%, respectively). These findings are consistent with Roy et al. (2015), who reported a significant influence of phosphorus application on the L:S ratio and nutritional composition of berseem. Phosphorus plays a crucial role in plant physiology, particularly in enzyme activation, DNA and RNA synthesis, and energy transfer processes (e.g., ATP, ADP), all of which are essential for protein synthesis and plant growth (Satpal et al., 2020).

Table 1: Effect of phosphorus levels and performance of AVT-2 genotypes for growth and quality parameters

Treatments	Average plant height (cm)	Average Leaf Stem ratio	Average Dry matter content (%)	Average Crude Protein Content (%)
AVT -2 genotypes of berseem				
JB-08-17	66.10	0.607	11.29	20.52
JHB-20-1	58.93	0.688	12.27	19.63
PC-114	60.91	0.772	13.88	21.45
BB-2 (CZ)	61.27	0.630	13.88	19.86
Wardan (NC)	63.52	0.649	11.10	21.26
JHB-20-2	63.25	0.679	11.24	21.52
SEm±	1.55	0.042	0.001	0.003
CD@5%	NS	NS	0.003	0.008
Phosphorus levels				
60 kg/ha	61.56	0.641	12.72	20.92
80 kg/ha	62.12	0.693	12.20	20.60
100 kg/ha	63.08	0.679	11.96	20.61
SEm±	0.398	0.030	0.001	0.002
CD@5%	1.17	NS	0.002	0.006
Interaction	NS	NS	0.005	0.014

Performance of AVT-2 genotypes to varied phosphorus levels for green fodder, dry matter, and crude protein yield of berseem:

The data on green fodder, dry matter, and crude protein yields of AVT-2 berseem genotypes under different phosphorus levels were recorded at each harvest and are presented in Table 2. The results indicate that both genotype and phosphorus application had significant effects on the yield attributes.

Among the evaluated genotypes, JHB-20-2 recorded the highest green fodder yield during the first (290.32 q/ha) and second (281.81 q/ha) cuts. In contrast, PC-114 produced a superior green fodder yield in the third (265.69 q/ha) and fourth (182.75 q/ha) cuts. The total cumulative green fodder yield was marginally higher in JHB-20-2 (967.36 q/ha) compared to PC-114 (966.72 q/ha).

For dry matter yield, PC-114 recorded significantly higher dry matter yield in the second (38.16 q/ha), third (36.88 q/ha), and fourth (25.37 q/ha) cuts, culminating in a total dry matter yield of 134.19 q/ha. In the first cut, BB-2 (CZ) produced the highest dry matter yield (39.65 q/ha), with PC-114 statistically at par. Other high performers included BB-2 (CZ) (36.51 q/ha) and JHB-20-1 (34.36 q/ha) in the second cut, and JHB-20-2 (29.79 q/ha) in the third cut. Cumulative dry matter yield for BB-2 (CZ) was 119.33 q/ha, statistically comparable to PC-114.

Regarding crude protein yield, PC-114 recorded significantly higher yields in the second (8.18 q/ha), third (7.91 q/ha), and fourth (5.44 q/ha) cuts, with a total of 28.79 q/ha. BB-2 (CZ) had the highest crude protein yield in the first cut (7.83 q/ha) and also performed well in subsequent cuts. The cumulative protein yield of BB-2 (CZ) was 23.58 q/ha, ranking second after PC-114. On the lower end, Wardan (NC) recorded the lowest cumulative yields for green fodder (821.06 q/ha), dry matter (91.20 q/ha), and crude protein (19.42 q/ha). These variations in productivity are largely attributed to the genetic potential of each genotype. Previous studies by Naveen et al. (2021), Devi & Satpal (2019), and Singh et al. (2020) have similarly reported significant differences in fodder yield performance across berseem varieties, reinforcing the present findings.

In case of Phosphorus levels, application significantly influenced all yield components. The 100 kg P_2O_5 ha^{-1} treatment consistently produced the highest green fodder yield across all four cuts: 294.71, 277.43, 252.48, and 134.68 q/ha in the first to fourth cuts, respectively. The total green fodder yield was 959.29 q/ha, representing 12.81% and 8.07% higher yields than the 60 and 80 kg P_2O_5 ha^{-1} treatments, respectively. Yield remained consistent up to the third cut before declining, likely due to increasing temperatures affecting plant growth.

For Dry matter yield highest values were observed at 100 kg P_2O_5 ha^{-1} in the first (34.95 q/ha), third (30.16 q/ha), and fourth (16.24 q/ha) cuts. Interestingly, the second cut recorded a higher yield (33.50 q/ha) under 60 kg P_2O_5 ha^{-1}. The total dry matter yield with 100 kg P_2O_5 ha^{-1} was 114.38 q/ha, showing an increase of 5.51% and 5.47% over 60 and 80 kg ha^{-1}, respectively.

For crude protein yield, the 100 kg P_2O_5 ha^{-1} treatment resulted in the highest yields in the first (7.23 q/ha), third (6.25 q/ha), and fourth (3.38 q/ha) cuts. The second cut saw a slightly higher yield (7.02 q/ha) at 60 kg P_2O_5 ha^{-1}. Cumulatively, phosphorus application at 100 kg/ha increased crude protein yield by 6.52% over 80 kg/ha and 4.27% over 60 kg/ha. These findings highlight the essential role of phosphorus in plant metabolic processes, including energy transfer (ATP), photosynthesis, and protein synthesis. Particularly in leguminous crops like berseem, adequate phosphorus is critical for maximizing biomass and protein output.

The results align with those of Arif et al. (2022), who reported improved forage yields with 120 kg P_2O_5 ha^{-1}, and Kumar et al. (2016), who confirmed that 80–100 kg P_2O_5 ha^{-1} significantly enhances green and dry fodder yields. Similarly, Smantha et al. (2023) emphasized the role of phosphorus and potassium in promoting overall forage productivity and quality.

Table 2: Effect of phosphorus levels and AVT2 genotypes on yield parameters of berseem

#	Green Fodder Yield (q ha^{-1})					Dry Matter Yield (q ha^{-1})					Crude Protein Yield (q ha^{-1})				
	I^st cut	II^nd cut	III^rd cut	IV^th cut	Total	I^st cut	II^nd cut	III^rd cut	IV^th cut	Total	I^st cut	II^nd cut	III^rd cut	IV^th cut	Total
AVT-2 Berseem genotypes															
JB-08-17	278.77	241.04	238.25	124.84	882.90	31.42	27.18	26.87	14.01	99.48	6.44	5.58	5.51	2.87	20.41
JHB-20-1	259.34	280.04	234.95	121.29	895.60	31.56	34.36	28.75	14.90	109.57	6.21	6.1	5.68	2.95	21.65
PC-114	243.33	274.96	265.69	182.75	966.72	33.79	38.16	36.88	25.37	134.19	7.25	8.18	7.91	5.44	28.79
BB-2 (CZ)	285.88	263.27	232.67	79.12	860.93	39.65	36.51	32.27	10.91	119.33	7.83	7.21	6.37	2.17	23.58
Wardan (NC)	263.65	270.38	206.12	80.90	821.06	29.29	30.04	22.86	8.99	91.20	6.24	6.39	4.86	1.92	19.42
JHB-20-2	290.32	281.81	265.18	130.05	967.36	32.62	31.68	29.79	14.61	108.70	7.02	6.82	6.41	3.14	23.39
SEm±	10.45	12.66	18.33	11.35	35.49	1.33	1.62	2.41	1.28	4.64	0.27	0.32	0.48	0.27	0.93
CD @5%	NS	NS	NS	36.24	NS	4.26	5.17	7.70	4.09	14.82	0.86	1.03	1.54	0.85	2.96
Phosphorus levels															
60 kg/ha	251.02	262.83	228.28	107.51	850.33	31.86	33.50	29.19	13.86	108.41	6.67	7.02	6.11	2.91	22.71
80 kg/ha	264.92	265.49	239.97	117.29	887.67	32.35	32.44	29.36	14.29	108.45	6.60	6.65	6.02	2.96	22.23
100 kg/ha	294.71	277.43	252.48	134.68	959.29	34.95	33.03	30.16	16.24	114.38	7.23	6.83	6.25	3.38	23.68
SEm±	3.19	4.68	5.41	3.91	12.31	0.41	0.56	0.6	0.50	1.54	0.09	0.12	0.14	0.11	0.32
CD @5%	9.35	NS	15.90	11.50	36.16	1.22	NS	NS	1.47	4.51	0.26	NS	NS	0.31	0.94
Interaction	NS	NS	NS	NS	NS	3.17	4.25	5.17	3.79	11.72	0.66	0.89	1.07	0.80	2.44

Performance of AVT-2 genotypes to varied phosphorus levels for per day production of green fodder, dry matter, and crude protein yield of berseem:

Per day productivity for green fodder, dry matter, and crude protein was calculated for each cut by considering the respective yields and the number of days between harvests. The results are summarized in Table 3. The data revealed a positive influence of phosphorus levels on per day productivity across cuts, except for the second cut. In contrast, the effect of different berseem genotypes on green fodder yield per day was non-significant in most cuts, except the fourth.

Among genotypes, PC-114 recorded the highest cumulative green fodder productivity, averaging 6.45 q/ha/day, followed by JHB-20-1 with 5.97 q/ha/day. Individual cuts showed peak values as BB-2 (CZ) in the first cut: 4.77 q/ha/day, JHB-20-1 in the second cut: 9.33 q/ha/day, PC-114 in the third and fourth cuts: 8.86 and 6.09 q/ha/day, respectively.

Regarding phosphorus levels, a significant effect was observed on per day green fodder productivity across all cuts except the second. The application of 100 kg P_2O_5 ha^{-1} consistently resulted in higher productivity, recording yield increases of 17.46%, 5.59%, 10.35%, and 25.42% over the 60 kg P_2O_5 ha^{-1} treatment in the first, second, third, and fourth cuts, respectively.

The maximum cumulative green fodder productivity of 6.40 q/ha/day was also observed under the 100 kg P_2O_5 ha^{-1} treatment, outperforming both 60 and 80 kg P_2O_5 ha^{-1} applications. For dry matter and crude protein productivity per day, significant differences were noted among genotypes and phosphorus levels: The highest cumulative daily dry matter yield (0.763 q/ha/day) and crude protein yield (0.158 q/ha/day) were obtained with the application of 100 kg P_2O_5 ha^{-1}. This represented an increase of 5.68% and 5.53% over 60 and 80 kg P_2O_5 ha^{-1} for dry matter productivity, respectively. For crude protein, the improvement was 3.95% and 6.76% over the same phosphorus levels.

These findings are consistent with the results of Arif et al. (2022), who reported maximum per day productivity at 120 kg P_2O_5 ha^{-1}, with green fodder and dry matter yields of 578 kg/ha/day

Table 3: Effect of phosphorus levels and AVT2 genotypes on yield parameters of berseem

Treatments	Green Fodder Yield (q/ha/day)					Dry Matter Yield (q/ha/day)					Crude Protein Yield (q/ha/day)				
	Ist cut	IInd cut	IIIrd cut	IVth cut	Total	Ist cut	IInd cut	IIIrd cut	IVth cut	Total	Ist cut	IInd cut	IIIrd cut	IVth cut	Total
AVT-2 Berseem genotypes															
JB-08-17	4.64	8.03	7.94	4.16	5.89	0.523	0.906	0.896	0.468	0.663	0.107	0.187	0.183	0.097	0.134
JHB-20-1	4.32	9.33	7.83	4.04	5.97	0.527	1.15	0.960	0.498	0.731	0.103	0.227	0.189	0.099	0.144
PC-114	4.06	9.16	8.86	6.09	6.45	0.563	1.27	1.23	0.847	0.893	0.122	0.274	0.261	0.181	0.192
BB-2 (CZ)	4.77	8.78	7.76	2.64	5.74	0.660	1.22	1.07	0.36	0.794	0.129	0.242	0.213	0.071	0.159
Wardan (NC)	4.39	9.01	6.87	2.70	5.47	0.489	1.00	0.762	0.300	0.609	0.104	0.213	0.163	0.063	0.130
JHB-20-2	4.84	9.39	8.84	4.33	6.45	0.543	1.06	0.993	0.487	0.726	0.117	0.228	0.212	0.104	0.156
SEm±	0.174	0.422	0.611	0.378	0.236	0.022	0.054	0.080	0.042	0.031	0.005	0.011	0.017	0.009	0.006
CD@5%	NS	NS	NS	1.21	NS	0.072	0.172	0.255	0.135	0.100	0.015	0.034	0.055	0.028	0.020
Phosphorus levels															
60 kg/ha	4.18	8.76	7.63	3.58	5.67	0.532	1.12	0.972	0.462	0.722	0.111	0.234	0.203	0.097	0.152
80 kg/ha	4.42	8.85	8.00	3.91	5.92	0.538	1.08	0.979	0.477	0.723	0.111	0.223	0.199	0.099	0.148
100 kg/ha	4.91	9.25	8.42	4.49	6.40	0.583	1.10	1.00	0.543	0.763	0.119	0.228	0.208	0.111	0.158
SEm±	0.053	0.156	0.180	0.130	0.082	0.007	0.019	0.022	0.017	0.010	0.002	0.004	0.005	0.003	0.002
CD@5%	0.156	NS	0.530	0.383	0.241	0.020	NS	NS	0.049	0.030	0.005	NS	NS	0.010	0.006
Interaction	NS	NS	NS	NS	NS	0.053	0.142	0.170	0.127	0.079	0.013	0.030	0.035	0.026	0.016

and 64 kg/ha/day, respectively. Their study also indicated that 100 kg P_2O_5 ha^{-1} was statistically at par with the higher dose. Overall, the observed variations in per-day productivity for green fodder, dry matter, and crude protein were largely attributed to differences in total yield and the duration between cuts, which were significantly influenced by genotype performance and phosphorus application levels.

COMPETING INTERESTS DISCLAIMER:

Authors have declared that they have no known competing financial interests OR non-financial interests OR personal relationships that could have appeared to influence the work reported in this paper.

References:

1. AOAC. 1965: Official methods of analysis. 10th ed. Association of Official Agricultural Chemicals. Washington, DC, USA
2. Arif, M., Kumar, A., Pourouchottamane, R., Gupta, D.L., and Rai B. Assessment of forage berseem (*Trifolium alexandrinum* L.) for productivity and profitability under varying seed rates and phosphorus fertilization. *Journal of Crop and Weed*. 2022; 18 (3): 19-25
3. Devi, U., and Satpal. Performance of berseem (*Trifolium alexandrinum* L.) genotypes at different phosphorus levels. *Forage Research*. 2019; 44 (4): 260-263.
4. Godara, A.S., Satpal, Joshi U.N., and Jindal Y. Response of berseem (*Trifolium alexandrinum* L.) genotypes to different phosphorus levels. *Forage Research*. 2016; 42(1): 40-43.

5. Kale R.V., and Takawale P.S. Performance of different fodder pearl millet varieties to varied levels of nitrogen under western Maharashtra. *Forage Research.* 2023; 49(2): 36-38
6. Kumar Naveen., Satpal, Kharor Neeraj , Kumar Suresh , Phogat D. S., and Jindal Y. Genotypic Response of Berseem (*Trifolium Alexandrinum* L.) to Different Phosphorus Levels. *Forage Research*. 2021; 47 (3): 329-333
7. Kumar R., Rathore D.K., Singh M., Kumar P., Khippal A. Effect of phosphorus and zinc nutrition on growth and yield of fodder cowpea. *Legume Research International Journal*. 2016; 39 (OF): 262-267
8. Nanda, G., Nilanjaya and Yadav A.K.S. Response of berseem genotypes to graded phosphorus levels. *Forage Research.* 2022; 48(3): 215-220
9. Rawat, P., Das, S., Shankhdhar, D. Phosphate-Solubilizing Microorganisms: Mechanism and Their Role in Phosphate Solubilization and Uptake. *Journal of Soil Science and Plant Nutrition*. 2021; 21: 49–68 https://doi.org/10.1007/s42729-020-00342-7
10. Roy, D.C., Ray, M. Tudu, N.K. and Kundu, C.K. Impact of phosphate-solubilizing bacteria and phosphorus application on forage yield and quality of berseem in West Bengal. *International Journal of Agriculture Environment and Biotechnology*. 2015; 8(2): 315-321
11. Samanta Sourav, Kumar Sourabh, Rajeev, Kumar Rakesh , Maity Narayan, Sharma Shailja, Fayaz Suhail and Bhaumik Sudip. Effect of Phosphorus and Zinc on Fodder Yield and Quality of Leguminous Fodder: Berseem (*Trifolium alexandrinum* L.). *International Journal of Environment and Climate Change*. 2023; 13(10):1209-1221, Article no. IJECC.103817

12. Satpal, R.S., Sheoran, J., Tokas, and Jindal Y. Phosphorus influenced nutritive value, yield and economics of berseem (*Trifolium Alexandrinum* L.) genotypes. *Chemical Science Review and Letters*. 2020; 9(34): 365- 373.

13. Singh Deo Narayan, Bohra J.S., Tyagi V., Singh T., Banjara T.R., Gupta G. A review of India's fodder production status and opportunities. *Grasses and Forage Science*. 2022; 77 (1): 1-10

14. Singh Digvijay, Choudhary Alka, and Uikey Vinod. Comparative Analysis of Exotic and Notified Berseem (*Trifolium Alexandrinum* L.) Varieties for Fodder, Quality and Nutrients Uptake. *Forage Research.* 2020; 46 (2): 168-175

15. Singh Harender Dahiya and Tomar Jaibir. Quality characteristics and economics of different berseem (*Trifolium alexandrinum* L.) Cultivars as influenced by biofertilizers and cutting management. *Forage Research.* 2018; 44 (3): 192-196

16. Singh, T., Radhakrishna, A., Seva Nayak D., and Malaviya D.R. Genetic improvement of berseem (*Trifolium alexandrinum*) in India: Current status and prospects. *International Journal of Current Microbiology and Applied Science*. 2019; 8: 3028-3036.

17. Takawale, P.S., Kauthale, V.K., and Kale, R.V. Production Performance and Economics of Forage Cropping Systems under Irrigated Conditions of Western Maharashtra. Agricultural Science Digest. 2022; DOI: 10.18805/ag.D-5505