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Varnekar KD
Ph.D. Scholar, Department of Agronomy, Post Graduate Institute, MPKV, Rahuri. Maharashtra, India

Ilhe SS
Professor, Department of Agronomy, Post Graduate Institute, MPKV, Rahuri. Maharashtra, India

Godase MM
Ph.D. Scholar, Department of Agronomy, Post Graduate Institute, MPKV, Rahuri. Maharashtra, India

Salgar SB
Ph.D. Scholar, Department of Agronomy, Post Graduate Institute, MPKV, Rahuri. Maharashtra, India

Solanke AV
Head, Department of Agronomy, Post Graduate Institute, MPKV, Rahuri. Maharashtra, India

Corresponding Author:
Varnekar KD
Ph.D. Scholar, Department of Agronomy, Post Graduate Institute, MPKV, Rahuri. Maharashtra, India

Effect of cutting management and phosphorus levels on seed quality of berseem (*Trifolium alexandrinum* L.)

Varnekar KD, Ilhe SS, Godase MM, Salgar SB and Solanke AV

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Abstract
The field experiment conducted at Instructional Farm, Department of Agronomy, Post Graduate Institute, Mahatma Phule Krishi Vidyapeeth, Rahuri, Dist. Ahmednagar, Maharashtra (India) during *rabi* season 2020-21 and 2021-22 on "Influence of cutting management and phosphorus levels on growth, quality and seed yield of berseem (*Trifolium alexandrinum* L.)" The experiment was laid out in split plot design with three replications. There were 24 treatment combinations formed with six main plot treatments of cutting management *viz.*, C_1- All cut for forage production, C_2- Left for seed production, C_3- 1 cut after left for seed production, C_4- 2 cut after left for seed production, C_5- 3 cut after left for seed production, C_6- 4 cut after left for seed production and four Sub plot treatment of phosphorus levels *viz.*, P_1- 0% P_2O_5, P_2- 75% P_2O_5, P_3- 100% P_2O_5 and P_4- 125% P_2O_5. The results showed that the cutting management practice left for seed production (C_2) treatment with phosphorus level 125% P_2O_5 (P_4) recorded significantly higher seed quality parameters *viz.*, seed germination (%), seed recovery (%), abnormal seed (%), dormant seed (5.88%) and hard seed (%), respectively during both the years and on pooled mean basis.

Keywords: Berseem, cutting, phosphorus, seed, quality

Introduction
Worldwide Sustainable crop production focused due to reduction in production resources and increased population in current and imminent farming systems. Fodder crops play a vital role in agriculture because, the supply of nutritious fodders in sufficient amount is a basic requirement for livestock to fulfill the increasing demand of milk, butter and other dairy byproducts for utilization by human beings (Roy *et al.*, 2015) [7]. Due to ever increasing human population pressure, arable land mainly used for food and fodder production is limited only to 4.60% of the total cultivable land. At present, the country faces a net deficit of 35% green fodder, 10% dry crop residues and 33% feeds. Berseem (*Trifolium alexandrinum* L.) is one of the most important *rabi* fodder crop. It is considered as the most potential crop from productivity as well as maintenance of soil fertility.

Phosphorus is an essential plant nutrient as it stands next to nitrogen which is required for the root growth and also helps in absorption of different plant nutrients. Berseem, being a leguminous crop, requires sufficient quantity of 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 (ADP, ATP). Thus, phosphorus is essential for a numerous metabolic processes. Through the sufficient research work has been conducted on phosphate fertilization of berseem in different part of country, which has proved that application of phosphate has produced tremendous effect on the yield of berseem and its quality. Also, several workers (Rana *et al.*, 1992, Mani and Singh, 1997 and Godara *et al.*, 2016) [6, 4, 2] reported that increasing phosphorus fertilization. The successful crop production depends mainly on the availability of the quality seed, which is one of the critical inputs for the agriculture. Quality seeds will enhance the yield and biomass. However; the seed yield of Berseem is comparatively low due to their excessive vegetative growth as well as reduced seed set. Indian farmers faces acute shortage of green fodder and non - availability of quality seeds is one of the key reason for such fodder shortage. At current situation the availability of quality seeds is approximately 30 percent in cultivated fodder crops.

Due to lack of seed production and technological skills, the berseem seed producers could not get the optimum yield levels. Keeping the above view in consideration, the present study was undertaken to find out the effect of Phosphorus levels and cutting management, the time of last cutting after which crop is retained for seed production on seed yield and quality of berseem.

Materials and Methods

A field experiment was carried out during *rabi* season 2020-21 and 2021-22 at the Mahatma Phule Krishi Vidyapeeth, Rahuri, Dist. Ahmednagar Maharashtra (India), is situated between 19° 48' and 19° 57' North latitude and 74° 52' and 74° 19' East longitude, 511 m above sea level. The soil of experimental field was clayey in texture with low in available nitrogen (162.00 kg ha^{-1}), medium in available phosphorus (17.20 kg ha^{-1}) and high in available potassium (320.00 kg ha^{-1}). The soil pH, EC and OC content was (8.20, 0.40 dSm^{-1} and 0.52%), respectively. The soil moisture constants *viz*., field capacity (32.33%), permanent wilting point (17.66%), bulk density (1.33 g cm^{-3}) and porosity (48.26%) indicate that soil was good in water retention capacity.

Climatologically, it falls in semi - arid tropics with an annual rainfall varying from 307 to 619 mm. The average annual rainfall is 520 mm. Out of the total annual rainfall, about 80 percent rains are received from South – West monsoon (June to September), while rest receives from North – East monsoon (October to December). The number of rainy days varies from 15-45 in a year. The mean annual maximum and minimum temperature ranges from 33 ^{0}C to 43 ^{0}C and 3 ^{0}C to 18 ^{0}C, respectively. The mean relative humidity during morning and evening hours is 59 and 35 percent, respectively. The mean pan evaporation ranges from 5.3 to 12.1 mm and sunshine hours ranges from 7 to 9 day^{-1}.

The experiment was laid out in Split Plot Design with three replications during both the years of experimentation. The treatments consist of six main plot treatments of cutting management *viz*., C_1- All cut for forage production, C_2- Left for seed production, C_3- 1 cut after left for seed production, C_4- 2 cut after left for seed production, C_5- 3 cut after left for seed production, C_6- 4 cut after left for seed production and four Sub plot treatment of phosphorus levels *viz*., P_1- 0% P_2O_5, P_2- 75% P_2O_5, P_3- 100% P_2O_5 and P_4- 125% P_2O_5. The recommended dose of N and K is applied at the time of sowing. Seed treatment of *Rhizobium*, PSB and Trichoderma is common to all.

Results and Discussion

Cutting management

Data presented in Table 1 revealed that seed germination (%) of berseem was significantly influenced during both the years and on pooled mean basis. The treatment left for seed production (C_2) recorded significantly maximum seed germination (%) was (88.24, 90.38 and 89.31%, respectively), seed recovery was (84.00, 86.25 and 85.13%, respectively), significantly minimum abnormal seed was (2.35, 1.92 and 2.14%, respectively), significantly minimum dormant seed was (6.47, 5.29 and 5.88%, respectively) and significantly minimum hard seed was (2.95, 2.40 and 2.68%, respectively) than rest of the other cutting management treatments during both the years and on pooled mean basis. Whereas, the treatment 4 cut after left for seed production (C_6) recorded significantly minimum seed germination (%) was (65.66, 67.91 and 66.78%, respectively), significantly minimum seed recovery was (61.00, 63.67 and 62.33%, respectively), significantly maximum abnormal seed was (6.87, 6.42 and 6.64%, respectively), significantly maximum dormant seed was (18.89, 17.65 and 18.27%, respectively) and significantly maximum hard seed was (8.59, 8.02 and 8.30%, respectively) during both the years and on pooled mean basis.

Phosphorus levels

Data presented in Table 1 revealed that seed germination (%) of berseem was influenced significantly due to different of phosphorus level treatments during both of the years and on pooled mean basis. The treatment 125% P_2O_5 (P_4) recorded significantly maximum seed germination (%) was (85.12, 87.32 and 86.22%, respectively), significantly maximum seed recovery was (80.60, 83.00 and 81.80%, respectively), significantly minimum abnormal seed was (2.98, 2.54 and 2.76%, respectively), significantly minimum dormant seed was (8.18, 6.97 and 7.58%, respectively) and significantly minimum hard seed was (3.72, 3.17 and 3.44%, respectively) than rest of the other phosphorus level treatments during both the years and on pooled mean basis. Whereas, the treatment 0% P_2O_5 (P_1) recorded significantly minimum seed germination (%) was (72.75, 75.18 and 73.97%, respectively), significantly minimum seed recovery was (68.40, 70.87 and 69.63%, respectively), significantly maximum abnormal seed was (5.45, 4.96 and 5.21%, respectively), significantly maximum dormant seed was (14.99,13.65 and 14.32%, respectively) and significantly maximum hard seed was (6.82, 6.21 and 6.51%, respectively) during both the years and on pooled mean basis.

Interaction

Data presented in Table 1 revealed that the interaction effect between cutting management and phosphorus levels was found to be significant in respect of seed germination (%) of berseem during both the years and on pooled mean basis. (Table 1a, b, c, d and e) The treatment left for seed production with treatment 125% P_2O_5 (C_2 x P_4) recorded significantly maximum seed germination was (93.93%), significantly maximum seed recovery was (89.50%), significantly minimum abnormal seed was (1.22%), significantly minimum dormant seed was (3.34%) and significantly minimum hard seed was (1.52%), respectively than rest of the treatment combinations on pooled mean basis. Whereas, the significantly minimum seed germination was recorded by 4 cut after left for seed production (C_6) with 0% P_2O_5 (C_6 x P_1) was (58.46%), significantly minimum seed recovery was (54.33%), significantly maximum abnormal seed was (8.31%), significantly maximum dormant seed was (22.85%) and significantly maximum hard seed was (10.39%), respectively on pooled mean basis. This might be due to favorable climatic condition throughout the period of crop growth and left for seed production treatment get more time for growth and development. In respect of phosphorus levels, seed P content is an important factor for seed germination and improved seedling vigour. Similar results were reported by Viera (1986) [11], Shukla and Kohli (1991) [10], Khyad (1995) [3], Prahlad *et al.* (2015) [5], Digamber *et al.* (2023) [1], Sanja *et al.* (2023) [8] and Senapati *et al*. (2022) [9].

Table 1: Seed germination (%), seed recovery (%), Abnormal seed (%), dormant seed (%) and hard seed (%) of berseem as influenced by different treatment

Treatment	Seed germination (%)			Seed recovery (%)			Abnormal seed (%)			Dormant seed (%)			Hard seed (%)		
	2020-21	2021-22	Pooled	2020-21	2021-22	Pooled	2020-21	2021-22	Pooled	2020-21	2021-22	Pooled	2020-21	2021-22	Pooled
A. Cutting management (C)															
C_1: All cut for forage production	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
C_2: Left for seed production	88.24	90.38	89.31	84.00	86.25	85.13	2.35	1.92	2.14	6.47	5.29	5.88	2.95	2.40	2.68
C_3: 1 cut left for seed production	85.60	88.24	86.92	81.25	83.92	82.58	2.88	2.35	2.62	7.92	6.47	7.20	3.57	2.94	3.26
C_4: 2 cut left for seed production	82.81	84.69	83.75	78.42	80.17	79.29	3.44	3.06	3.25	9.45	8.42	8.94	4.30	3.83	4.06
C_5: 3 cut left for seed production	77.52	80.41	78.96	73.25	76.17	74.71	4.50	3.92	4.21	12.37	10.78	11.57	5.63	4.90	5.26
C_6: 4 cut left for seed production	65.66	67.91	66.78	61.00	63.67	62.33	6.87	6.42	6.64	18.89	17.65	18.27	8.59	8.02	8.30
S.Em.±	0.28	0.25	0.40	0.20	0.68	0.62	0.06	0.05	0.10	0.15	0.14	0.27	0.07	0.06	0.12
C.D. at 5%	0.91	0.83	1.47	0.66	2.23	1.82	0.18	0.17	0.29	0.50	0.45	0.81	0.24	0.21	0.36
B. Phosphorus levels (P)															
P_1: 0%	72.75	75.18	73.97	68.40	70.87	69.63	5.45	4.96	5.21	14.99	13.65	14.32	6.82	6.21	6.51
P_2: 75%	79.15	81.55	80.35	74.80	77.20	76.00	4.17	3.69	3.93	11.47	10.14	10.81	5.19	4.61	4.90
P_3: 100%	82.83	85.25	84.04	78.53	81.07	79.80	3.43	2.95	3.19	9.44	8.11	8.78	4.30	3.69	3.99
P_4: 125%	85.12	87.32	86.22	80.60	83.00	81.80	2.98	2.54	2.76	8.18	6.97	7.58	3.72	3.17	3.44
S.Em.±	0.25	0.14	0.12	0.17	0.64	0.27	0.05	0.03	0.02	0.14	0.08	0.07	0.06	0.04	0.03
C.D. at 5%	0.72	0.41	0.34	0.48	1.84	0.77	0.14	0.08	0.07	0.40	0.23	0.19	0.18	0.10	0.08
Interaction (C x P)															
Between two sub plot means at same level of main plot means															
S.Em.±	0.56	0.32	0.29	0.37	1.43	0.67	0.11	0.06	0.06	0.31	0.18	0.16	0.14	0.08	0.07
C.D. at 5%	1.61	0.93	0.83	1.08	4.12	1.90	0.32	0.19	0.17	0.89	0.51	0.45	40	0.23	0.21
Between two main plot means at same level of sub plot means															
S.Em.±	0.56	0.38	0.56	0.38	1.41	0.85	0.11	0.08	0.11	0.31	0.21	0.31	0.14	0.09	0.14
C.D. at 5%	1.66	1.15	1.63	1.14	4.20	2.45	0.33	0.23	0.33	0.92	0.63	0.90	42	0.29	0.41
General mean	79.97	82.33	81.15	75.58	78.03	76.81	4.01	3.53	3.77	11.02	9.72	10.37	5.01	4.42	4.71

Table 1a: Pooled interaction effect of cutting management and phosphorus levels on seed germination (%) of berseem

Pooled seed germination (%)						
Phosphorus levels	**Cutting management**					
	C_1	**C_2**	**C_3**	**C_4**	**C_5**	**C_6**
P_1: 0%	-	82.45	79.47	76.65	72.80	58.46
P_2: 75%	-	88.59	86.73	83.27	77.78	65.40
P_3: 100%	-	92.29	89.65	86.95	81.63	69.70
P_4: 125%	-	93.93	91.83	88.14	83.64	73.58
Source					S.Em.±	C.D. at 5%
Between two sub plot means at same level of main plot means					0.29	0.83
Between two main plot means at same level of sub plot means					0.56	1.63

Table 1b: Pooled interaction effect between cutting management and phosphorus levels on seed recovery (%) of berseem

Pooled seed recovery (%)						
Phosphorus levels	**Cutting management**					
	C_1	**C_2**	**C_3**	**C_4**	**C_5**	**C_6**
P_1: 0%	-	78.17	75.17	72.00	68.50	54.33
P_2: 75%	-	84.33	82.33	78.67	73.50	61.17
P_3: 100%	-	88.50	85.33	82.50	77.50	65.17
P_4: 125%	-	89.50	87.50	84.00	79.33	68.67
Source					S.Em.±	C.D. at 5%
Between two sub plot means at same level of main plot means					0.67	1.90
Between two main plot means at same level of sub plot means					0.85	2.45

Table 1c: Pooled interaction effect of cutting management and phosphorus levels on dormant seed (%) of berseem

Pooled dormant seed (%)						
Phosphorus levels	**Cutting management**					
	C_1	**C_2**	**C_3**	**C_4**	**C_5**	**C_6**
P_1: 0%	-	9.65	11.29	12.84	14.96	22.85
P_2: 75%	-	6.27	7.30	9.20	12.22	19.03
P_3: 100%	-	4.24	5.70	7.18	10.10	16.67
P_4: 125%	-	3.34	4.49	6.52	9.00	14.53
Source					S.Em.±	C.D. at 5%
Between two sub plot means at same level of main plot means					0.16	0.45
Between two main plot means at same level of sub plot means					0.31	0.90

Table 2: Pooled interaction effect between cutting management and phosphorus levels on abnormal seed (%) of berseem

Pooled abnormal seed (%)						
Phosphorus levels	**Cutting management**					
	C 1	**C 2**	**C 3**	**C 4**	**C 5**	**C 6**
P_1: 0%	-	3.51	4.11	4.67	5.44	8.31
P_2: 75%	-	2.28	2.66	3.35	4.44	6.92
P_3: 100%	-	1.54	2.07	2.61	3.67	6.06
P_4: 125%	-	1.22	1.63	2.37	3.27	5.28
Source					S.Em.±	C.D. at 5%
Between two sub plot means at same level of main plot means					0.06	0.17
Between two main plot means at same level of sub plot means					0.11	0.33

Table 3: Pooled interaction effect between cutting management and phosphorus levels on hard seed (%) of berseem

Pooled hard seed (%)						
Phosphorus levels	**Cutting management**					
	C 1	**C 2**	**C 3**	**C 4**	**C 5**	**C 6**
P_1: 0%	-	4.40	5.13	5.84	6.80	10.39
P_2: 75%	-	2.85	3.26	4.18	5.56	8.65
P_3: 100%	-	1.93	2.59	3.27	4.60	7.58
P_4: 125%	-	1.52	2.04	2.96	4.09	6.60
Source					S.Em.±	C.D. at 5%
Between two sub plot means at same level of main plot means					0.07	0.21
Between two main plot means at same level of sub plot means					0.14	0.41

Conclusion

The significantly maximum berseem seed quality was recorded by treatment left for seed production with 125% P_2O_5.

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