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Yield maximization of lathyrus through crop establishment methods and foliar nutrition under rice-lathyrus relay cropping system

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Abstract
A field experiment was carried during the *rabi* season of 2021-22 and 2022-23 at IGKV instructional and research farm Raipur (C.G.) with a view to study the "Yield maximization of lathyrus through crop establishment methods and foliar nutrition under rice-lathyrus relay cropping system" to find out the best crop establishment method and foliar nutrition practice in lathyrus. The lathyrus variety prateek was used for the research and the treatments were replicated three times in factorial randomized blocked design. The treatment was made of two crop establishment methods as factor one *i.e.* M_1 (Dry surface seeding) and M_2 (soaked seeds for 3-4 hours) with five foliar nutrition treatments in *viz*., T_1 water spray, T_2 2% urea, T_3 2% DAP, T_4 0.5% KNO_3, T_5 0.5% NPK 19:19:19. Lathyrus was sown with a spacing of 45 cm sowing and in a gross plot size of 5 m × 4m and net plot size we m 4 × 3m. The outcome of the research revealed that among the different treatments methods, M_2 (soaked seeds for 3-4 hours) produced significantly highest seed yield (1018 and 1063 kg ha^{-1}) as compared to M_1 (Dry surface seeding) (944 and 997 kg ha^{-1}). The foliar nutrition treatment i.e., (T_5) 0.5% NPK 19:19:19 produced highest grain yield (1287, 1151, 1219) kg ha^{-1} during both the year and on mean basis. While the interaction was found non-significant.

Keywords: lathyrus, crop establishment, foliar nutrition, water spray, seed yield, Chhattisgarh plains

Introduction
Rice-based cropping system is a major cropping system practiced in India & can be described as mix of farming practices that comprises of rice as the major crop followed by subsequent cultivation of other crops., which include the rotation of crops involving cereals, pulses, oilseeds, cotton, sugarcane, green manures, vegetable, etc. In rice growing areas, several crop combinations (cropping systems) are in practice based on agro-ecological conditions, market and domestic needs and facilities available with farmers. The seed of succeeding crops like lentil, gram, pea, lathyrus, berseem, linseed etc. is sown broadcast in maturing rice crop. This practice saves time; money (to be spent on land preparation etc.) and utilizes residual fertility. This practice is common in both upland and lowland rice culture (Deep *et al*., 2018) [1]. Utera or paira cropping (relay cropping) is age old double cropping system under the rainfed conditions in which succeeding utera crop is directly sown in the standing rice crop after the flowering stage (Sharma *et al*., 2004) [12].

Rice–lathyrus sequential cropping plays a significant role in total productivity of crops especially in Chhattisgarh plain zone (Raipur zone) of Chhattisgarh state. A set of resource conservation approaches in lathyrus cultivation popularly known as utera is being practiced profusely in many states of India including Chhattisgarh (Navaz *et al*., 2017) [5]. Grass pea (*Lathyrus sativus* L.) is the third most important cool-season pulse crop of India, occupying an area of 0.58 million ha with an annual production of 0.43 million tonnes. Grass pea is a food, feed, and fodder crop. It is cultivated primarily in Bihar, Madhya Pradesh, Maharashtra, West Bengal, and Chhattisgarh. The majority of this acreage (~70%) is shared by Chhattisgarh and the Vidarbha region of Maharashtra, which is a rice-growing region where supplemental irrigation is available only for rice. Consequently, water is not available for subsequent winter crops, making grass pea the only alternative for a crop following rice. Grass pea is a climate resilient crop grown mostly in rice fallows. In the Rice-Based Cropping system, utilizing the available moisture, it is grown as a relay crop and it's a better option to earn income from rice fields.

It is also taken as mixed crop and intercrop during *Rabi* and sole crop under "utera" conditions (Dixit *et al*., 2016) [9].

Materials and Methods

The field experiment was conducted during *rabi* season (2021-22) at Agriculture Instructional-cum-research Farm, IGKV, Raipur (Chhattisgarh). The experimental field lies between 21º38 North latitude and 81º82 East longitude with an altitude of 291 m above mean sea level. The field selected was uniform in topography with fairly infestation of location specific weeds representative of this area. Geographically, it is situated at 21°.25' N latitude and 81°.62' E longitude. It stands at 298.15 m above mean sea level. This area is part of the eastern plateau and hill Agro-Climatic Zone. The treatment was made of two crop establishment methods as factor one *i.e.* M_1 (Dry surface seeding) and M_2 (soaked seeds for 3-4 hours) with five foliar nutrition treatments in *viz*., T_1 water spray, T_2 2% urea, T_3 2% DAP, T_4 0.5% KNO_3,T_5 0.5% NPK 19:19:19.

Results and Discussion

Seed yield (kg ha^{-1})

The data on seed yield of lathyrus as in influenced by crop establishment method and foliar nutrition under rice-lathyrus relay cropping system are presented in Table 1.

As regards to crop establishment method, treatment M_2- Soaked seed for 3-4 hrs registered significantly higher seed yield (1018 and 1063 kg ha^{-1}) as compared to M_1- Dry surface seeding (944 and 997 kg ha^{-1}) during the second year and on mean basis, respectively. However, during the first year it was found to be non-significant. Yield is the result of final plant population, number of pods plant $^{-1}$, number of seeds pod$^{-1,}$ pod length and seed index etc. Gupta and Bhowmick (2005) [3] reported that priming of lathyrus seeds help in yield improvement and yield attributing characters. The amount of economic yield depends on the manner in which the net dry matter is produced among different parts of the plant (Das, 2022) [8].

Among the foliar nutrition, T_5 – 0.5% NPK 19:19:19 recorded significantly higher seed yield (1287, 1151 and 1219 kg ha^{-1}) as compared to others during both years and on mean basis, respectively.

Seed yield is the economic yield which is final result of physiological activities of plant. Economic yield is the part of biomass that is converted into economic product (Nichiporovic, 1960) [4]. Source-sink relation contributes to the seed yield. It includes phloem loading at source (leaf) and unloading at sink (seed and fruit) by which the economic part will be getting the assimilates synthesized by photosynthesis. Partitioning of assimilate in the plant during reproductive development is important for flower, fruit, and seeds. Thus, crop yield can be increased either by increasing the total dry matter production or by increasing the proportion of economic yield (harvest index) or both (Gardner *et al.,* 1988) [2]. The results are in line with findings of Das and Jana (2015) [7] who reported 3% NPK (19:19:19) spray recorded highest seed yield. Similar findings were reported by Navaz (2017) [5].

The interaction between crop establishment method and foliar nutrition did not give significant effect on seed yield of lathyrus under rice- lathyrus relay cropping system during both the years and on mean basis.

Stover yield (kg ha^{-1})

Data pertaining to stover yield of lathyrus as influenced by crop establishment method and foliar nutrition under rice-lathyrus relay cropping system are presented in Table 1.

Perusal of results indicated that between crop establishment method, treatment M_2-Soaked seed for 3-4 hrs recorded significantly highest stover yield (2407 and 2406 kg ha^{-1}) as compared to M_1- Dry surface seeding (2230 and 2250 kg ha^{-1}) during the second year and on mean basis, respectively. However, during the first year it was found to be non-significant.

Among the foliar nutrition, treatment T5- 0.5% NPK 19:19:19 recorded significantly higher stover yield (2766, 2689 and 2728 kg ha^{-1}) as compared to others during both the years and on mean basis, respectively. Navaz (2017) [5] reported the higher seed and stover yield in 0.5% NPK (19:19:19) spray at branching and 15 days after 1st spray.

The interaction between crop establishment method and foliar nutrition did not give significant effect on stover yield of lathyrus under rice-lathyrus relay cropping system during both the years and on mean basis.

Harvest Index (%)

The data on harvest index of lathyrus as influenced by crop establishment method and foliar nutrition under rice- lathyrus relay cropping system are presented in Table 1. The findings revealed that harvest index of lathyrus remained unaffected due to crop establishment method and foliar nutrition during both the years and on mean basis.

However, between crop establishment method, M2- Soaked seed for 3-4 hrs recorded higher harvest index (31.5, 29.8 and 30.6%) than M_1- Dry surface seeding (30.6, 29.5 and 30.1%) during both the years and on mean basis, respectively. Harvest index in present investigation was not significantly affected under different treatments of crop establishment method.

As regards to foliar nutrition, T_4- 0.5% KNO_3 recorded maximum harvest index (33.0, 30.7 and 31.8%) and minimum was recorded under T_1- water spray (27.7, 26.8 and 27.3%) during both the years and on mean basis, respectively.

Number of pods plant^{-1}

The number of pods plant^{-1} at harvest of lathyrus was significantly influenced by crop establishment method and foliar nutrition and data are presented in Table 2.

Between crop establishment method, treatment M_2- Soaked seed for 3-4 hrs recorded significantly higher number of pods plant^{-1} (50.9, 49.7 and 50.3) as compared to treatment M_1- Dry surface seeding (45.9, 44.9 and 45.4 pods plant^{-1}) during both the years and on mean basis, respectively. Gupta and Bhowmick (2005) [3] reported that priming of lathyrus seeds significantly increases the number of pods plant^{-1}. Similar findings were also noted by Singh *et al.* (2017) [14] and Das (2022) [8].

Among the foliar nutrition, T_5- 0.5% NPK 19:19:19 recorded significantly higher number of pods plant^{-1} (56.7, 55.3 and 56.0) as compared to others, but it was at par to T_3-2% DAP (51.0, 49.7 and 50.3) during both the years and on mean basis, respectively. Reports of Mudalagiriyappa *et al.* (2016) [6] prevail that foliar spray of 2.0% of NPK (19:19:19) in chickpea at flowering and pod development stages resulted

more yield components in terms of pod plant^{-1} and seed weight over control. Similar observations have been recorded by Singh and Sekhon (2007) [15], Singh *et al.* (2007) [13], Sahu (2008) [10] and Singh *et al.* (2017) [14].

The interaction between crop establishment method and foliar nutrition did not give significant effect on number of pods plant^{-1} of lathyrus under rice-lathyrus relay cropping system during both the years and on mean basis.

Number of seeds pod^{-1}

The data on number of seeds pod^{-1} of lathyrus as influenced by crop establishment method and foliar nutrition under rice-lathyrus relay cropping system are presented in Table 2

Critical analysis of data shows that neither crop establishment method and foliar nutrition nor their interaction had significant effect on number of seeds pod^{-1} during both the years and on mean basis.

Pod length (cm)

The data on pod length of lathyrus as influenced by crop establishment method and foliar nutrition under rice-lathyrus relay cropping system are presented in Table 2.

Critical analysis of data shows that neither crop establishment method and foliar nutrition nor their interaction had significant effect on pod length during both the years and on mean basis.

Between crop establishment method, treatment M_2- Soaked seed for 3-4 hrs recorded significantly higher pod length (4.45, 4.36 and 4.41 cm) as compared to treatment M_1- Dry surface seeding (3.84, 3.55 and 3.70 cm) during both the years and on mean basis, respectively.

Among the foliar nutrition, T_5- 0.5% NPK 19:19:19 recorded significantly higher pod length (4.56, 4.25, and 4.31 cm) as compared to T_1- water spray (3.15, 3.14 and 3.15 cm), but it was at par to T_2- 2% Urea (4.35, 4.12 and 4.24 cm), T_3- 2% DAP (4.39, 4.20 and 4.30 cm) and T_4- 0.5% KNO_3 (4.28, 4.06 and 4.17) during both the years and on mean basis, respectively. Reports of Mudalagiriyappa *et al.* (2016) [6] prevail that foliar spray of 2.0% of NPK (19:19:19) in chickpea at flowering and pod development stages resulted more yield components over control. Similar observations have been recorded by Singh and Sekhon (2007) [15], Singh *et al.* (2007) [13], Sahu (2008) [10] and Singh *et al.* (2017) [14].

The interaction between crop establishment method and foliar nutrition did not give significant effect on seed index of lathyrus under rice-lathyrus relay cropping system during both the years and on mean basis.

Seed index (g)

The data on seed index of lathyrus as influenced by crop establishment method and foliar nutrition under rice-lathyrus relay cropping system are presented in Table 2.

Between crop establishment method, treatment M_2- Soaked seed for 3-4 hrs recorded significantly higher seed index (9.3, 9.2 and 9.3 g) as compared to treatment M_1- Dry surface seeding (8.4, 8.2 and 8.3 g) during both the years and on mean basis, respectively. Gupta and Bhowmick (2005) [3] reported that priming of lathyrus seed reported significantly increase 1000-seed weight in lathyrus.

Among the foliar nutrition, T_5- 0.5% NPK 19:19:19 recorded significantly higher seed index (9.5, 9.2 and 9.2 g) as compared to T_1- water spray (7.4, 7.7 and 7.6), but it was at par to T_2- 2% Urea (9.1, 8.8 and 8.9 g), T_3-2% DAP (9.3, 9.0 and 9.1 g) and T_4- 0.5% KNO_3 (9.1, 8.9 and 9.0 g) during both the years and on mean basis, respectively. Reports of Mudalagiriyappa *et al.* (2016) [6] prevail that foliar spray of 2.0% of NPK (19:19:19) in chickpea at flowering and pod development stages resulted more yield components over control. Similar observations have been recorded by Singh and Sekhon (2007) [15], Singh *et al.* (2007) [13], Sahu (2008) [10] and Singh *et al.* (2017) [14].

The interaction between crop establishment method and foliar nutrition did not give significant effect on seed index of lathyrus under rice-lathyrus relay cropping system during both the years and on mean basis.

Table 1: Seed and stover yield and harvest index of lathyrus at different durations as affected by crop establishment method and foliar nutrition under rice-lathyrus relay cropping system

	Seed yield (kg ha^{-1})			Stover yield (kg ha^{-1})			Harvest index (%)		
Treatment	**2021-22**	**2022-23**	**Mean**	**2021-22**	**2022-23**	**Mean**	**2021-22**	**2022-23**	**Mean**
Crop establishment method									
M1: Dry Surface Seeding	1050	944	997	2270	2230	2250	30.6	29.5	30.1
M2: Soaked seed for 3-4hrs	1109	1018	1063	2406	2406	2406	31.5	29.8	30.6
SEm ±	26.96	23.69	25.33	53.38	50.67	52.03	0.81	0.76	0.7
CD (P=0.05)	NS	70.39	75.25	NS	151.51	155.54	NS	NS	NS
Foliar Nutrition									
T1: Water spray	782	759	770	2085	2062	2074	27.7	26.8	27.3
T2: 2% urea	1072	965	1019	2240	2239	2240	32.4	30.2	31.3
T3: 2% DAP	1137	1023	1080	2328	2327	2327	32.8	30.6	31.7
T4: 0.5% KNO3	1119	1007	1063	2273	2272	2272	33.0	30.7	31.8
T5: 0.5% NPK 19:19:19	1287	1151	1219	2766	2689	2728	31.9	30.1	31.0
SEm ±	42.63	37.47	40.05	84.40	80.11	82.26	1.28	1.19	1.24
CD (P=0.05)	126.65	111.3	118.98	250.72	237.98	244.35	NS	NS	NS
M X T	NS	NS	NS	NS	NS	NS	NS	NS	NS

Table 2: Yield attributes of lathyrus as affected by crop establishment method and foliar nutrition under rice-lathyrus relay cropping system

Treatment	No of Pods plant^{-1}			No of Seeds pod^{-1}				Pod length (cm)			Seed index (g)		
	2021-22	2022-23	Mean	2021-22	2022-23		Mean	2021-22	2022-23	2021-22	2021-22	2022-23	Mean
Crop establishment method													
M1: Dry Surface Seeding	45.9	44.9	45.4	3.6	3.5	3.5	3.84	3.55	3.70	8.4	8.2	8.3	
M2: Soaked seed for 3-4hrs	50.9	49.7	50.3	3.7	3.7	3.7	4.45	4.36	4.41	9.3	9.2	9.3	
SEm ±	1.66	1.32	1.49	0.11	0.12	0.12	0.08	0.06	0.07	0.07	0.15	0.11	
CD (P=0.05)	4.92	3.91	4.41	NS	NS	NS	0.24	0.19	0.22	0.22	0.44	0.33	
Foliar Nutrition													
T1: Water spray	39.3	38.3	38.8	3.2	3.2	3.2	3.15	3.14	3.15	7.4	7.7	7.6	
T2: 2% urea	46.3	45.3	45.8	3.6	3.5	3.5	4.35	4.12	4.24	9.1	8.8	8.9	
T3: 2% DAP	51.0	49.7	50.3	3.7	3.5	3.6	4.39	4.20	4.30	9.3	9.0	9.1	
T4: 0.5% KNO3	48.7	47.8	48.2	3.8	3.8	3.8	4.28	4.06	4.17	9.1	8.9	9.0	
T5: 0.5% NPK 19:19:19	56.7	55.3	56.0	3.9	4.0	3.9	4.56	4.25	4.31	9.5	9.2	9.2	
SEm ±	2.62	2.08	2.35	0.17	0.18	0.18	0.13	0.11	0.12	0.12	0.24	0.18	
CD (P=0.05)	7.78	6.18	6.98	NS	NS	NS	0.37	0.32	0.35	0.35	0.70	0.52	
M X T	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	

Conclusion

On the basis of above carried study, it may be concluded that:

1. As regards to crop establishment method, treatment M2- Soaked seed for 3-4 hrs. registered significantly higher seed yield (1018 and 1063 kg ha-1) and stover yield (2407 and 2406 kg ha^{-1}) as compared to M1- Dry surface seeding (944 and 997 kg ha-1) and stover yield (2230 and 2250 kg ha^{-1}) during the second year and on mean basis, respectively. However, during the first year it was found to be non-significant.
2. Among the foliar nutrition, T_5– 0.5% NPK 19:19:19 recorded significantly higher seed (1287, 1151 and 1219 kg ha^{-1}) and stover yield (2766, 2689 and 2728 kg ha-1) as compared to others during both years and on mean basis, respectively
3. Between crop establishment method, treatment M2- Soaked seed for 3-4 hrs. recorded significantly higher number of pods plant-1 (50.9, 49.7 and 50.3) as compared to treatment M1- Dry surface seeding (45.9, 44.9 and 45.4 pods plant-1) during both the years and on mean basis, respectively.
4. Between crop establishment method, treatment M2- Soaked seed for 3-4 hrs. recorded significantly higher seed index (9.3, 9.2 and 9.3 g) as compared to treatment M1- Dry surface seeding (8.4, 8.2 and 8.3 g) during both the years and on mean basis, respectively.
5. As regards to crop establishment method, treatment M2- Soaked seed for 3-4 hrs registered significantly higher seed yield (1018 and 1063 kg ha-1) as compared to M1- Dry surface seeding (944 and 997 kg ha-1) during the second year and on mean basis, respectively. However, during the first year it was found to be non-significant.

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