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Optimization of Seed Rate and Priming Methods on Growth and Yield of Field Pea grown under Rice Fallow System of Lower Gangetic Plains

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ABSTRACT: A field experiment was conducted on field pea in alluvial soil growth under rice fallow system of Kalyani AB Block Farm in West Bengal during Rabi 2021-22. Nine treatments were tested in randomised block design with three replications, Treatment combinations included were different priming methods and at different seed rates. The results showed that treatments with 1% KNO_3 priming + 120 kg/ha seed rate (T_9) and hydro priming + 120 kg/ha (T_6) were on par with each other and recorded significantly higher growth and yield attributes over other treatments. However, treatment with hydro priming + 100 kg/ha (T_5) excelled over the other treatments by recording a highest B:C ratio of 2.93.

Keywords: Seed rate, Priming, Rice fallow, KNO_3 (potassium nitrate) and Hydropriming.

INTRODUCTION

Total food grain production in the country is estimated as 305.44 million tonnes in 2020-21. Among food grains pulses account for around 20 percent of the area and contribute around 7-10 percent of the total food grains production in the country. Among all the pulse crops field Pea (*Pisum sativum* L.) is the third most important crop at global level after dry beans and Chickpea, it is also called as pois proteagineux in French, guisante in Spanish, pisello in Italian, futterebse in German and matter in Hindi. It is an important winter-season grain legume crop largely confined to cooler temperate zones. The average productivity of field pea in India is 900 kg ha^{-1}. The most probable centre of origin of pea is Mediterranean region of Europe and Central Asia. Field Pea is generally grown for dry seeds which are used for a variety of snack preparation and dal. The mature pea is highly nutritive, containing high proportion of digestive protein (22.5%), carbohydrates (62.1 %), fat (1.8%), minerals (calcium, iron) and vitamins (Riboflavin, thiamine etc.) (Dwivedi *et al.*, 2011).

With the advent of the green revolution, which promoted rice and wheat using external inputs and modern varieties of seeds, pulses were pushed to marginal lands. Pulses improve soil health by enriching nitrogen status, long-term fertility and sustainability of the cropping systems. Therefore, their inclusion in cereal-based cropping systems contributes to soil fertility by enriching organic nitrogen, reducing the demand for chemical fertilizers, enhancing soil micro flora as well as supplementing a protein diet for large population of the country suffering from protein malnutrition. To meet the projected requirement, the productivity needs to uplift at about 1200 kg per ha and about 3 to 5 million ha additional area has to be brought under pulses besides drastically reducing the postharvest losses. Inclusion of pulse crops in the eastern plain and prevalent rice ecosystems holds the key along with the peninsula. Rice-fallow cropland areas are those areas where rice is grown during the *kharif* season (June–October), which is commonly followed by a fallow during the rabi season (November– February) in northern India and IGP (Indo - Gangetic Plains). Low water-requiring (thriving best on residual moisture with adequate conservation measures) grain legumes such as chickpea (*Cicer arietinum* L.), and lentils field pea. Traditionally, lathyrus and lentils are sown after rice as a relay crop in low land rice fields of Bihar, Jharkhand, West Bengal, eastern Uttar Pradesh and Chhattisgarh. Therefore, cropping system intensification involving two crops in this way further could improve a smallholding farmer's income, human health via protein supplementation and soil health through nitrogen-fixing legume crop as well as addressing food security challenges of burgeoning populations without having to expand croplands (Gumma *et al.*, 2016).

Seed priming alone was also known to increase grain yield by 10 percent. As a result of reduced soil compaction and aeration, higher microbial activities were observed under it (Singh *et al*., 2017). When combined with seed priming (4-6 hours of seed soaking in water), the inoculation improved nodulation (by increasing nodules/plant by 25.2% and nodules dry weight/plant by 42.2%), growth and yield attributes (36.4 and 8% higher in pods/plant and 100-seed weight, respectively), and urdbean seed yield (25% more) by decreasing soil resistances to root penetration. With these considerations in mind, the current study titled "Effect of Seed rate and Seed priming on Field Pea (*Pisum sativum* var. *arvense*) grown under surface seeding in the Rice fallow of Lower Gangetic Plain" was carried out in 2021-2022 at AB Black Farm (district seed farm), BCKV, Kalyani.

MATERIALS AND METHODS

The study entitled "Effect of seed rate and priming on field pea grown under surface seeding in the rice fallow of Lower Gangetic Plain" was conducted in 2021–2022 at AB Block Kalyani, Bidhan Chandra Krishi Viswavidyalaya, Nadia, West Bengal. The site is located at latitude 22°56' N and longitude 88°32' E and 9.75 meters above mean sea level. The experimental site falls in the sub-tropical humid climate with short and mild winters. With the break of the south-west monsoon during the first week of June, the rainy season starts. It ends in October when the south-west monsoon withdraws from the area during the first week of October. This season is characterized by the normal temperature, relatively lower than summer season. The humidity is at its maximum reach and most of the annual precipitation occurs during this period. Winter extends from November to February when the minimum monthly temperature falls below 20°C with lower humidity and occasional rainfall generally, the month of January. The soil was sandy loam in texture with almost neutral pH. The soil had a good drainage capacity.

The variety grown for the experiment was Rachana and the experiment was laid out in Randomized Block Design having 3 replications and 9 treatments such as T_1: No priming + seed rate 80 kgha^{-1}, T_2: No priming + seed rate 100 kgha^{-1}, T_3: No priming + seed rate 120 kgha^{-1}, T_4: on-farm priming+ seed rate 80 kg ha^{-1}, T_5: on farm priming+ seed rate100 kgha^{-1}, T_6: on farm priming+ seed rate120 kgha^{-1}, T_7: 1 % KNO_3 priming + seed rate 80 kgha^{-1}, T_8: 1 % KNO_3 priming + seed rate100 kgha^{-1} and T_9: 1 % KNO_3 priming + seed rate 120 kgha^{-1}. The crop was cultivated without irrigation. According to AICRP MuLLARP standards, the recommended fertilizer dose of NPK was at a ratio of 20:40:40 kg ha^{-1}. Crop growth and yield attributes were recorded and analyzed in the study.

RESULTS AND DISCUSSION

A. Growth attributes

A higher plant population was observed in the treatment with a higher seed rate than recommended. The maximum plant population was recorded under T_6 (73 plants m^{-2}) but it was statistically at par with T_9 (71 plants m^{-2}). The higher population was due to higher seed rates than recommended with hydro priming and KNO_3 priming led to more vigour and less mortality. The beneficial effect of hydro priming and 1% KNO_3 priming on seed germination, breaking seed dormancy and stimulating hypocotyl growth, increased plant population. Hydro priming also resulted in more vigour of seeds and established a greater plant stand as also supported by literature (Golezani *et al*., 2008). The plant height of field pea was significantly influenced by seed rate and seed priming at all stages. The increased seed rate caused plants to grow taller to compete for more solar light harnessing. When compared to unprimed seeds, primed seeds even with a higher seed rate produced plants that were noticeably taller at 30, 60 and 90 DAS, significantly highest plant height was recorded under the T_9 (36.80, 101.11 and 120.38 cm) at 30, 60 and 90 DAS respectively. The priming of KNO_3 might also have contributed to the rise in plant height along with branching, as potassium encourages cell division and cell elongation, which results in internodal elongation. Bandyopadhyay *et al.* (2018) also interpreted the same results.

Light interception increases as the leaf area index increases. A significant increase of LAI has been observed in both 60 and 90 DAS in the "on-field priming" where hydro priming has been followed and potassium nitrate primed seeds resulted over the non-primed seeds. Maximum leaf area index was recorded under T_9 (0.98, 4.01 and 3.61) at 30, 60 and 90 DAS respectively. Lone *et al.* (2009); Prusinski and Borowska (2022) also reported similar findings concerning LAI. Increased LAI, in turn, provided increased opportunity for light harvesting, which ultimately led to more dry matter. Both the priming treatments recorded more dry matter plant^{-1} than non-primed at all growth stages. Among the treatments, T_9 had significantly recorded the highest dry matter accumulation per plant (549.96, 660.06 and 943.48 gm^{-2} at 30, 60 and 90 DAS respectively) over other treatments. Seed rate and seed priming both had a significant impact on the dry weight of nodules till 50 DAS. These findings align with the research of Muhammad *et al.* (2017) and Aysen and Acikgoz (2017), who also observed increased plant dry weight with primed seeds. Seed priming likely facilitated enhanced root development, creating favorable conditions for nitrogen-fixing bacteria and consequently resulting in an increased root nodule count. The results revealed that T_9 recorded the highest number of nodules plant^{-1} 9.00 and 24.33 at 30 and 50 DAS among all treatments and it was at par with T_6. Consistent with this, Mishra *et al.* (2017); Sarmadi *et al.* (2014) reported that seed priming with KNO_3 significantly increased nodule dry weight compared to the control. Better soil organic carbon, soil microbial biomass and Dehydrogenase activity in such conditions were reported by Das *et al.* (2019) which might have contributed to better nodulation. Treatment T_9 stood out with the highest nodule dry weight per plant which may be attributed to increased root proliferation and a greater number of root nodules per plant, as highlighted in the work of Mishra *et al.* (2017).

Table 1: Effect of seed rate and priming on plant height(cm), LAI and Dry matter (g m-²) of field pea at 30, 60 and 90 DAS.

Treatments	No. of plants m^{-2}	plant height(cm)			LAI			Dry matter (g m^{-2})		
		30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS
T_1: no priming + seed rate 80 kg ha^{-1}	41	22.64	94.78	99.93	0.22	0.94	0.77	42.97	309.62	460.14
T_2: no priming + seed rate 100 kg ha^{-1}	54	26.63	100.24	110.17	0.30	1.49	1.24	55.77	397.63	606.94
T_3: no priming + seed rate120 kg ha^{-1}	61	30.33	101.82	116.67	0.34	1.84	1.54	63.94	546.30	626.54
T_4: on farm priming + seed rate 80 kg ha^{-1}	49	25.51	98.51	100.19	0.28	1.00	0.95	55.64	340.52	548.08
T_5: on farm priming + seed rate 100 kg ha^{-1}	63	32.89	102.33	118.26	0.41	1.89	1.68	69.15	599.22	780.21
T_6: on farm priming+ seed rate 120 kg ha^{-1}	73	33.33	102.68	119.37	0.46	1.91	1.75	74.14	622.60	982.99
T_7: 1 % KNO_3 priming + seed rate 80 kg ha^{-1}	50	28.64	100.29	110.80	0.29	1.56	1.41	58.21	440.30	621.91
T_8: 1 % KNO_3 priming + seed rate 100 kg ha^{-1}	59	31.85	102.24	117.74	0.35	1.86	1.66	65.28	587.38	664.02
T_9: 1 % KNO_3 priming + seed rate 120 kg ha^{-1}	71	36.80	105.11	120.38	0.49	1.95	1.80	90.27	660.06	1110.55
SEm ±	2.25	0.89	1.12	4.73	0.02	0.04	0.03	7.89	43.07	49.73
LSD 5%	6.76	2.65	3.36	14.19	0.05	0.12	0.10	23.65	129.12	149.09

Table 2: Effect of seed rate and seed priming on No. of nodules $plant^{-1}$ and Dry weight of nodules (mg $plant^{-1}$) 30 and 50 DAS.

Treatments	No. of nodulesplant^{-1}		Dry weight of nodules (mg $plant^{-1}$)	
	30DAS	50DAS	30DAS	50DAS
T_1: no priming + seed rate 80 kgha^{-1}	5.33	12.00	8.70	61.40
T_2: no priming + seed rate 100 kgha^{-1}	6.00	15.33	10.66	62.60
T_3: no priming + seed rate 120 kgha^{-1}	7.00	20.33	12.73	66.32
T_4: on farm priming+ seed rate 80 kgha^{-1}	5.67	13.67	8.96	61.70
T_5: on farm priming+ seed rate 100 kgha^{-1}	8.00	23.00	13.77	76.84
T_6: on farm priming+ seed rate 120 kgha^{-1}	8.33	23.33	14.17	77.20
T_7: 1 % KNO_3 priming + seed rate 80 kgha^{-1}	6.33	19.00	11.50	64.00
T_8: 1 % KNO_3 priming + seed rate 100 kgha^{-1}	7.33	21.67	12.50	68.63
T_9: 1 % KNO_3 priming + seed rate 120 kgha^{-1}	9.00	24.33	14.80	78.30
SEm ±	0.42	1.07	0.63	0.23
LSD 5%	3.20	3.20	1.89	0.68

B. Yield and yield attributes

Among all the treatments T_9 had significantly recorded the highest number of pods per plant (22.15) followed by T_8 (21.14). The increased pod count could be attributed to better resource utilization, reduced intra and inter-plant competition, and the role of potassium in facilitating sugar synthesis and efficient translocation for seed formation and development. Similar findings were reported by Pakbaz *et al.* (2014); Arshad *et al.* (2008); Ahmad *et al.* (2007). The results showed that the highest seed yield production was obtained under T_9 (1979 kgha^{-1}) and was at par with T_6 (1906 kgha^{-1}). Yield is influenced by factors such as final plant population, number of pods per plant, seed index, and others. In rice fallow conditions, plant population has a significant impact on yield. Pakbaz *et al.* (2014) reported similar results of increased yield in KNO_3 Priming. The results revealed that T_9 had the highest Stover production (3837.39 kgha^{-1}) being at par with T_6 (3748.40 kgha^{-1}). This increase in biological yield could be related to the higher dry matter accumulation, enhanced availability of food reserves during the seed development stages, and the production of hydrolytic enzymes in KNO_3 priming.

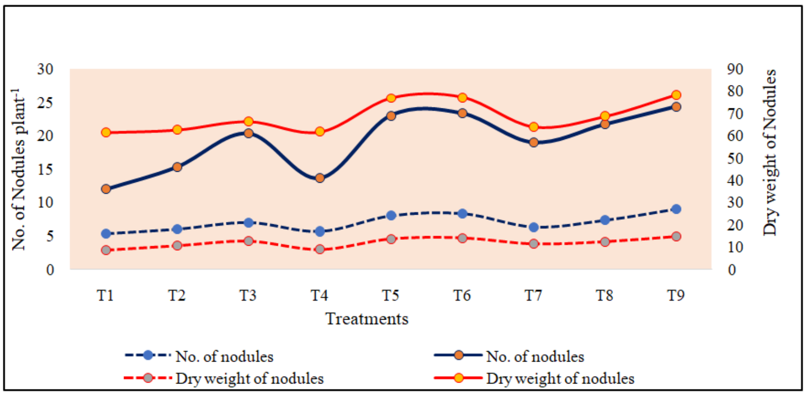

Fig. 1. Number of Nodules plant^{-1} and Dry weight of Nodules (gm plant^{-1}) influenced by seed rate and seed priming.

However, T_8 had significantly the highest test weight (18.39 g), on par with T_5 (18.22 g). The increase in test weight could be related to the increased dry matter accumulation, higher availability of food reserves during the seed development stages, and also the production of more hydrolytic enzymes as a result of

KNO$_3$ priming. A similar observation of increasing test weight despite a higher seed rate in lentil was reported by Ahmed *et al*, (2007). T$_9$ showed the highest harvest index (34.17 %) among all the treatments and was at par with T$_6$ (33.86 %). The poor harvest index in T1 (26.33%) might be due to increased competition for light, space, and nutrients, which brought up plant height, increased shoot dry matter, and decreased harvest index. Laishram *et al.* (2020) found that when seed rates increased the harvest index decreased gradually.

C. Economics

The cost of cultivation, gross return, and net return, along with the benefit-to-cost ratio, were calculated and presented in Table 4. The maximum cost of cultivation (Rs. 48172/- ha^{-1}) was observed in treatment T$_9$, which involved a seed rate of 120 kg ha^{-1} with priming (1% KNO$_3$). Conversely, treatments T$_1$ and T$_4$ recorded the minimum cost of cultivation (Rs. 41269/- per ha). Among all the treatments, T$_5$ yielded the highest gross return (Rs. 127558/- ha^{-1}) and net return (Rs. 84048/- ha^{-1}) resulting in the highest benefit-cost ratio (2.93) which made it most profitable. The second highest B:C ratio (2.87) was obtained from T$_9$, aligning with the observations reported by Baird *et al.* (2009), where a relatively lower seed rate led to better economic outcomes due to considerations of seed cost.

Table 3: Effect of seed rate and seed priming on Test weight(gm), Stover yield (kgha^{-1}), yield(kgha^{-1}) and Harvest index of field pea.

Treatments	Pods plant^{-1}	Stover yield (kg ha^{-1})	yield (kg ha^{-1})	Test weight (gm)	Harvest index
T$_1$: no priming + seed rate 80 kg ha^{-1}	14	3527.75	1031	16.76	29.35
T$_2$: no priming + seed rate 100 kg ha^{-1}	16	3777.32	1325	17.54	35
T$_3$: no priming + seed rate 120 kg ha^{-1}	17	3772.03	1498	17.98	39.61
T$_4$: on farm priming+ seed rate 80 kg ha^{-1}	14	3936.6	1300	17.70	33.24
T$_5$: on farm priming+ seed rate 100 kg ha^{-1}	19	4326.63	1849	18.22	43.03
T$_6$: on farm priming+ seed rate 120 kg ha^{-1}	16	4395.62	1906	16.61	43.71
T$_7$: 1 % KNO$_3$ priming + seed rate 80 kg ha^{-1}	15	3539.65	1363	17.14	38.25
T$_8$: 1 % KNO$_3$ priming + seed rate 100 kg ha^{-1}	21	4160.97	1754	18.39	42.37
T$_9$: 1 % KNO$_3$ priming + seed rate 120 kg ha^{-1}	22	4500.06	1979	17.83	44.36
SEm ±	0.73	216.56	92.25	0.52	1.70
LSD 5%	2.19	649.26	276.51	NS	5.09

NS(non-significant)

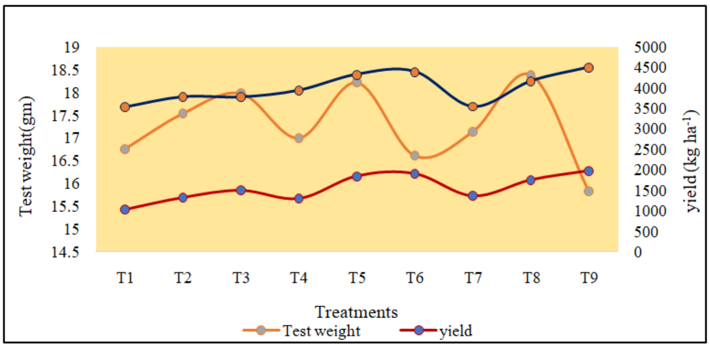

Fig. 2. Test weight(gm) and yield (kg ha^{-1}), Stover yield (kg ha^{-1}) influenced by seed rate and seed priming.

Table 4: Effect of seed and rate seed priming on Economics of field pea cultivation under rice fallow.

Treatments	Fixed cost	Variable cost	Total Cost	GR (Rs ha^{-1})	NR (Rs ha^{-1})	BC ratio
T$_1$: no priming + seed rate 80 kg ha^{-1}	32301	8968	41269	71139	29871	1.72
T$_2$: no priming + seed rate 100 kg ha^{-1}	32301	11210	43511	91425	47915	2.1
T$_3$: no priming + seed rate 120 kg ha^{-1}	32301	13452	45753	103362	57610	2.26
T$_4$: on farm priming+ seed rate 80 kg ha^{-1}	32301	8968	41269	89700	48432	2.17
T$_5$: on farm priming+ seed rate 100 kg ha^{-1}	32301	11210	43511	127558	84048	2.93
T$_6$: on farm priming+ seed rate 120 kg ha^{-1}	32301	13452	45753	131514	85762	2.87
T$_7$: 1 % KNO$_3$ priming + seed rate 80 kg ha^{-1}	32301	10581	42881	94047	51166	2.19
T$_8$: 1 % KNO$_3$ priming + seed rate 100 kg ha^{-1}	32301	13226	45527	121049	75523	2.66
T$_9$: 1 % KNO$_3$ priming + seed rate 120 kg ha^{-1}	32301	15871	48172	136522	88350	2.83
Farm Gateway prices- Price: field pea seed- Rs 110kg^{-1}; field pea Grain- Rs 76kg^{-1}						

CONCLUSIONS

More number of plants were recorded as a result of seed priming and higher seed rates, than no seed priming and lesser seed rates. Hydro priming also resulted in more vigour of seeds and established a greater plant stand. The increased seed rate caused plants to grow taller to compete for more solar light harnessing. The priming of

KNO_3 might also have contributed to the rise in plant height along with branching, as potassium encourages cell division and cell elongation, which results in internodal elongation which in turn leads to the highest dry matter accumulation, yield, test weight, and stover yield. High LAI has been observed in both 60 and 90 DAS has been observed in the "on farm priming" where hydro priming has been followed and potassium nitrate primed seeds over non-primed seeds. The increase in root nodule count with seed priming might have been owing to an increase in root development and thus provided better conditions for nitrogen-fixing bacteria. However, the poor harvest index value could be due to relatively closer plants resulting in increased competition for light, space, and nutrients which enhanced plant height and increased shoot dry matter hence decreasing the harvest index.

FUTURE SCOPE

The results validate no tilled surface seeding in field pea for rice fallow situations in the Gangetic plains of West Bengal. However, the experiment needs to be repeated over multiple years for conclusive recommendations. The research could be expanded to other cool-season pulse legumes like lentil, chick pea, and lathyrus in the New Alluvial Zone, enabling farmers to make better crop choices. The study can also be extended to understand crop rhizosphere and soil behaviour in stressed dry years.

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