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Growth, Yield and Water Use Efficiency of Grass Pea (*Lathyrus sativus* L.) as Influenced by Phosphorus, Micronutrients and Organics in New Alluvial Zone of West Bengal

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ABSTRACT

A field experiment was conducted to study the crop growth, yield and WUE of grass pea (*Lathyrus sativus* L.) as influenced by phosphorus, micronutrients and organics in rice soils during *rabi* season of 2020-21 at the Teaching Farm, Bidhan Chandra Krishi Viswavidyalaya, Mondouri, Nadia under New Alluvial Zone of West Bengal. The experiment was carried out taking ten different nutrient management practices with three replications in Randomized Block Design to evaluate the performance of *Lathyrus.* The results of the experiment revealed that *Lathyrus* plot fertilized with the recommended dose of fertilizer along with foliar application of Borax @ 0.5% recorded the highest plant height, number of branches plant^{-1}, dry matter accumulation, number of pods per plant, pod length, number of seeds per pod and 100-seed weight. Maximum seed yield (1450 kg ha^{-1}), stover yield (2513 kg ha^{-1}) and highest WUE (10.00 kg ha^{-1} mm^{-1}) were recorded by the plot treated with RDF+ Borax @ 0.5%.With respect to quality parameters, the seed protein content was highest (31.18%) in the plot fertilized with RDF along with ammonium molybdate @ 0.1%. Therefore, it may be concluded from the results of the experiment that the combined use of RDF with Borax @ 0.5% application in grass pea is one of the best option for better production in terms of quality and quantity for cultivation in New Alluvial Zone of West Bengal.

Keywords Boron, *Lathyrus*, Phosphorus, Water use efficiency (WUE), Yield.

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INTRODUCTION

Pulses, commonly referred to as “poor man’s meat” and “rich man’s vegetable,” are the most important sources of proteins, minerals, and vitamins, and contribute considerably to the country’s nutritional security. We are currently on the verge of becoming self-sufficient in pulse production, since we are the world’s leading producer, consumer, and importer. If all goes according to plan, by 2050 we will be able to continueour pulse production, which has gone from net importer to net exporter (Singh *et al.* 2013).

Research finding reveals that rice fallow may be a suitable condition for introduction of pulse as they require short season of three to four months, with low water-requirement as they will thrive best on residual moisture with adequate conservation measures. So, grain legumes such as chickpea (*Cicer arietinum* L.), lentil (*Lens culinaris*), urdbean (*Vigna mungo* L.), mung (*Vigna radiata* L.), grass pea (*Lathyrus sativus* L.) can easily be introduced. Pulses are well recognized for their role in improving soil health, system productivity and sustainability; they're also performing well under conservation tillage in rainfed agro ecosystem of rice-fallows. Therefore, overall productivity and sustainability of the system will improve with inclusion of pulses in rice-fallows (Kumar *et al.* 2018). Among these pulse crops, grass pea (*Lathyrus sativus* L.) is a remarkable drought tolerant crop (Gusmao *et al.* 2012, Kalita and Chakrabarty 2017) that thrives with minimal external inputs (Nazrul and Shaheb 2015) and consequently is a perfect legume for resource-poor farmers.

Grass pea (*Lathyrus sativus* L.) is that the third most vital legume after chickpea and pigeon pea, predominantly grown in India (Dixit *et al.* 2016, Navaz *et al.* 2018). In India, *Lathyrus* is cultivated in 4.70 lakh ha area with the production of 3.65 lakh tonnes and average productivity of 776 kg ha^{-1} (Anonymous 2016-17). It's commonly referred to as chickling pea, chickling vetch, dogtooth pea, grass pea vine, Indian pea, riga pea, wedge pea vine, khesari, teora, lakh, lakhodi. *Lathyrus* is rich in protein (28%) and minerals especially calcium, phosphorus and iron (Bhagat *et al.* 2014, Navaz *et al.* 2018). Besides, it's a really good source of essential amino acids like arginine (7.8 g), lysine (7.4 g), isoleucine (6.7 g), leucine (6.6 g), valine (4.7 g) per 100 g of protein (Parihar and Gupta 2016). Among vetch (*Lathyrus*) species, grass pea is that the most economically important and widely cultivated crops for human consumption, seeds are common staple food in many Asian and African countries. Grass pea is taken into account as an 'insurance crop' as it produces reliable yields when all other crops fail because of harsh environment (Nazrul and Shaheb 2015, Kalita and Chakrabarty 2017). However, the presence of the neurotoxin β-N-oxalyl-L-α, β–di-amino propionic acid (ODAP) within the grain are often problematic for human consumption as ODAP is understood to cause the disease lathyrism or irreversible paralysis (Dixit *et al.* 2016, Kalita and Chakrabarty 2017). Recently, some low toxin lines are developed which will prove safe for both animal and human foods (Gupta *et al.* 2015).

The effects of micronutrients on seed β-ODAP level, on both low and high-toxin cultivars exhibited decreased levels of β-ODAP in response to Co (cobalt) or Mo (molybdenum) when sprayed with 0.5 ppm Co (cobalt nitrate) or 20 ppm Mo (ammonium molybdate) salts at the maximum flowering stage. In grass pea seedlings, Mo also influence on β-ODAP levels in shoots and root (Jiao *et al.* 2006), in which Mo deficiency resulted in obvious increase in β-ODAP levels in shoots at both 7 and 15 days, but within the root only at 7 days after treatments (Jiao *et al.* 2006). Zn deficiency and oversupply of Fe induced increases in the content of β -ODAP in the ripe seeds (Lambein *et al.* 1994). Deficiency of B or Mn in Hoagland solution resulted in a smaller increase in concentration of β-ODAP in shoots, but not in roots (Jiao *et al.* 2006). Boron (B) is also an important constituent of cell walls and is involved in translocation of photosynthates. It also helps in pollen viability and pollen tube development (Jana *et al.* 2020). Information on grass pea response to P fertilization is extremely scarce. Its effect on grain yield and yield components is essentially unknown, particularly in soils with high P retention capacity. However, Sarkar *et al.* (2003) found that applying P increased grass pea grain yield grown in an *Inceptisol* of India with pH 7.5, 0.53% organic carbon, and 26 kg ha^{-1} of P_2O_5. Phosphorus is that the most essential nutrient for increasing pulse productivity (Saraf 1983). P may be a crucial component for converting solar energy into food, fiber and other plant products via photosynthesis (Wyant *et al.* 2013). Hallock (1978) concluded that foliar application of micronutrients was better than soil application for increasing yield. Legume crops require not only adequate macronutrients but also micro-nutrients for increasing the bacterial activity of nodule. Thus, an optimum use of micronutrients under balanced condition is veritably important for achieving advanced productivity.

Keeping the above facts in view, the study entitled 'Growth, yield and water use efficiency of grass pea (*Lathyrus sativus* L.) as influenced by phosphorus, micronutrients and organics in New Alluvial Zone of West Bengal' was taken up.

MATERIALS AND METHODS

The field experiment was conducted at Teaching Farm (22°56'32" N latitude, 88°30'51" E longitude and at 9.75 m above the mean sea level), Mondouri, Nadia under Bidhan Chandra KrishiViswavidyalaya, Mohanpur, Nadia, West Bengal, India during *rabi* season (November – March) of 2020-21 in medium land under sub-tropical humid climate. The texture of the experimental soil was sandy loam belongs to the order *Inceptisol* having soil pH 7. 4, organic carbon 0.56%, available N 225.79 kg ha^{-1}, P_2O_5 32.23 kg ha^{-1} and K_2O 190.6 kg ha^{-1}. Meteorological data pertaining to the cropping seasons revealed that maximum temperature ranged between 24.92°C to 35.54°C, and minimum temperature prevailed between 11.66°C to 20.73°C. The maximum and minimum relative humidity ranged between 87.39 to 91.78% and 35.67 to 51.85%, respectively and the total rainfall was only 0.19 mm (Fig.1).The experiment was laid out in Randomized Block Design (RBD) which was replicated thrice. One single replication comprised total of ten treatments viz., T_1- Control ($N_0P_0K_0$), T_2- $N_{20}P_0K_{20}$, T_3- $N_{20}P_{20}K_{20}$, T_4- $N_{20}P_{40}K_{20}$ (RDF), T_5- $N_{20}P_{60}K_{20}$, T_6- RDF + $ZnSO_4$ @ 0.5%, T_7- RDF + Borax @ 0.5%, T_8- RDF + Ammonium molybdate @ 0.1%, T_9- RDF + $MgSO_4$ @ 0.5% and T_{10}- Vermicompost @ 1 t ha^{-1}.The grass pea seeds var 'Prateek' were sown in small furrows at 30 cm apart line at the rate of 60 kg ha^{-1}. The basal dose of fertilizers and vermicompost @ 1 t ha^{-1} were applied plots as per the treatments. Foliar sprays with 0.5% $ZnSO_4$,0.5% Borax, 0.1% Ammonium molybdate and 0.5% $MgSO_4$were applied in respective plots at 40 DAS and 55 DAS.One irrigation was given after one week of sowing to get better and uniform plant stand. First weeding was done manually with the help of spade at 30 DAS and after one week second hand weeding was done to keep the field free from weeds. The pest infestation was not severe during the cropping period of *Lathyrus*. So, there was no need to take protection measures.The *Lathyrus* crop was sown on 5th of November and was harvested 10th of March. At 80% pod maturity stage, the crop was harvested by uprooting the plants manually and plot-wise bundles of plants were carried to the threshing floor and threshing was done by beating with sticks. Observations were recorded on growth parameters viz. plant height, elongation rate of plant, dry matter accumulation, crop growth rate, numbers of branches plant^{-1} and nodule count.

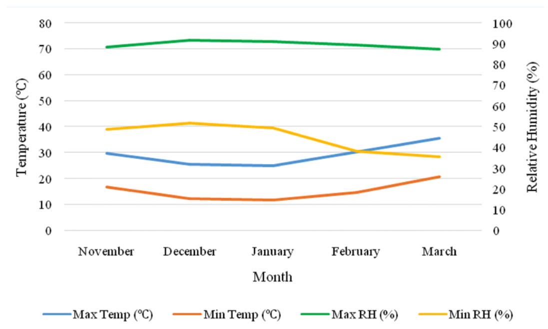

Fig. 1. Monthly temperature, rainfall and relative humidity during cropping period.

$$\text{Elongation rate} = \frac{L_2 - L_1}{T_2 - T_1} \quad (1)$$

Where, L_1 and L_2 are the heights of the plants on two different times of T_1 and T_2 respectively.

CGR was calculated by using the following formula suggested by Watson (1952).

$$\text{CGR} = \frac{W_2 - W_1}{t_2 - t_1} \ (\text{g m}^{-2} \text{ day}^{-1}) \quad (2)$$

where, W_1 and W_2 were the dry weights of aerial plant parts per unit land area at times t_1 and t_2 respectively.

Observations and data were recorded on yield attributes viz. numbers of pod plant^{-1}, numbers of seeds pod^{-1}, pod length, seed yield, stover yield, 100-seed weight, harvest index (HI), and WUE and qualitative traits,viz., protein content (%) and soil nutrient available status (N, P and K) and then all the data were statistically analyzed.

$$\text{Soil moisture content (\%)} = \frac{\text{Fresh weight of soil (g)} - \text{Dry weight of soil (g)}}{\text{Dry weight of soil (g)}} \times 100 \quad (3)$$

Soil moisture content (mm) = Soil moisture content (%) × Ai × D

Where, Ai = Apparent specific gravity of soil (or, bulk density of soil, dimensionless), D = Depth of soil (mm).

The profile water contribution (ΔS) from soil at various depths can be determined from soil moisture content at the time of sowing and harvesting during a crop growth season. This may be presented as,

$$\Delta S = \sum \frac{\text{Mg - Mh}}{100} \times \text{Ai} \times \text{D} \quad (4)$$

Where, ΔS = Profile water contribution (PC), Ms = Moisture content of the soil at sowing (%), Mh = Moisture content of the soil at harvest (%), Ai = Apparent specific gravity of soil (or, bulk density of soil, dimensionless), D = Depth of soil (mm).

Seasonal consumptive use of water (CU)/ Actual evapotranspiration (ETa) is calculated by using the following formula,

$$\text{CU} = \text{ER} + \text{IR} + \Delta S \quad (5)$$

Where, CU = Consumptive use of water by a crop during entire growing season (mm), ER = Effective rainfall during that crop growing season (mm), IR = Irrigation water applied to the crop (mm), ΔS = Profile water contribution (mm).

Water use efficiency of the crop will be calculated on the basis of the economic yield produced per mm of water used by the plant with help of the following formula. It was expressed in kg ha^{-1} mm^{-1}.

$$\text{Water use efficiency (WUE)} = \frac{\text{Economic yield (kg/ha)}}{\text{Concumptive use of water (mm)}} \times 100 \quad (6)$$

RESULTS AND DISCUSSION

Crop growth parameters

The plant growth in terms of plant height of *Lathyrus* was significantly influenced by the nutrient management practices. Irrespective of date of observations and numbers of treatments, the plant height increased progressively with the age of the crop and reached its maximum till the last observation recorded at harvest during investigation.Variations due to different nutrient management practices were much noted at harvest.The highest plant height was attained 81.6 cm under T_7 treatment (RDF+ Borax @ 0.5% spray at 40 DAS and flower initiation stage) followed by treatment T_5 (79 cm) at harvest (Table 1). Minimum plant height 63.0 cm was noted with T_1 treatment (Control - $N_0P_0K_0$). Adhikary *et al.* (2018) got similar result where foliar spray of 0.5% B at 15 DAS, 40 DAS and flower initiation stage recorded highest plant height (38.86 cm) in lentil. Plant development in terms of plant height with reference to their days of crop growth is expressed by plant elongation rate at different stages of *Lathyrus*. Plant height elongation rate (cm day^{-1}) of grass pea varied significantly with the variation of different nutrient management practices. At 60-90 DAS the highest elongation rate (1.10 cm day^{-1}) was recorded in treatment T_7 (RDF+ Borax @ 0.5%) followed by treatments T_5 ($N_{20}P_{60}K_{20}$), T_6 (RDF+ $ZnSO_4$ @ 0.5%), T_8 (RDF+ Ammonium molybdate @ 0.1%) and T_{10} (Vermicompost @ 1t ha^{-1}) with same value of 1.06 cm day^{-1}.Treatment T_1(control) showed the lowest elongation rate (0.94 cm day^{-1}) at 60-90 DAS (Table 1). Irrespective of date of observations and numbers of treatments, the number of branches per plant went on increasing with the age of the crop and reached its maximum till the last observation recorded at harvest during investigation. The number of branches per plant were registered highest (15.93) in T_7 treatment (RDF+ Borax @ 0.5% spray at 40 DAS and flower initiation stage) followed by treatment T_5 (15.73) at harvest and the least number of branches per plant was noted with T_1 treatment (Control - $N_0P_0K_0$) at harvest (11.53) (Table 1). The results are in agreement with the findings of Mahadule *et al.* (2019) where they reported that foliar spray of 0.4% or 0.6% B at 25 DAS and 55 DAS recorded highest number of branches (8.00) in french bean. In *Lathyrus*, dry matter production increased progressively with the advancement of crop growth and their variations were due to crop nutrition.The dry matter accumulation was registered highest (364.32g m^{-2}) in T_7 treatment (RDF+ Borax @ 0.5% spray at 40 DAS

Table 1. Growth parameters of *Lathyrus* as influenced by nutrient management practices during *rabi* season.

Treatments	Plant height at harvest (cm)	Elongation rate (60-90 DAS) (cm day^{-1})	Branches plant^{-1} at harvest	Dry matter production at 90 DAS (g m^{-2})	CGR (60-90 DAS) (g m^{-2} day^{-1})	Number of root nodules plant^{-1} at 60 DAS
T_1- Control ($N_0P_0K_0$)	63.0	0.94	11.53	277.53	4.97	19.4
T_2-$N_{20}P_0K_{20}$	66.6	1.00	12.27	296.34	5.49	21.3
T_3- $N_{20}P_{20}K_{20}$	67.1	1.03	13.40	305.19	5.71	22.7
T_4-$N_{20}P_{40}K_{20}$-RDF	68.3	1.04	15.20	318.36	5.67	23.4
T_5-$N_{20}P_{60}K_{20}$	79.0	1.06	15.73	358.67	5.72	26.2
T_6- RDF+ $ZnSO_4$ @ 0.5%	78.0	1.06	15.60	330.99	5.49	25.3
T_7- RDF+ Borax @ 0.5%	81.6	1.10	15.93	364.32	5.75	25.9
T_8- RDF+ Ammonium molybdate @ 0.1%	78.1	1.06	15.67	339.24	5.51	26.6
T_9- RDF+ $MgSO_4$ @ 0.5%	78.0	1.05	15.67	334.62	5.40	25.5
T_{10}- Vermicompost @ 1 t ha^{-1}	65.9	1.06	12.40	287.43	5.04	21.3
SEm (±)	2.27	0.05	0.57	1.09	0.04	1.21
CD (p=0.05)	6.76	0.15	1.72	3.24	0.14	3.61

and flower initiation stage) followed by treatment T_5 (358.67 g m^{-2}) at 90 DAS. Dry matter production was very poor in control situation at 90 DAS (277.53 g m^{-2}) i.e. where no fertilization has been done (Table 1). These results are in similar finding was reported by Pandey and Gupta (2013) in black gram.This might be due to quick availability of boron to crop during the entire growing season. Boron plays an important role in tissue differentiation and carbohydrate metabolism. The partitioning of crop growth with time and space in terms of crop growth rate (g m^{-2} day^{-1}) of *Lathyrus* was significantly influenced by the application of different nutrient schedule during the trial.The treatment fertilized with Borax @ 0.5% with RDF recorded maximum value of CGR (5.75 g m^{-2} day^{-1}). On the other hand, the lowest CGR value was found under the treatment control plot (4.97g m^{-2}day^{-1}) (Table 1).This finding was supported by Praveena *et al.* (2018). They reported that foliar spray of 0.2% B increased the crop growth rate in green gram.The number of root nodules per plant were registered highest (26.6) in T_8 treatment (RDF+ Mo @ 0.1% spray at 40 DAS and flower initiation stage) followed by (26.2) treatment T_5($N_{20}P_{60}K_{20}$) at 60 DAS. Then the number of root nodules gradually decreased day by day up to 90 DAS. The least number of root nodules per plant was noted with T_1 treatment (Control-$N_0P_0K_0$) at 60 DAS (19.4) (Table 1).This results are in line with the findings of Khan *et al.* (2020). They concluded that application of molybdenum @ 0.3 kg ha^{-1} increased active nodules and nodules weight plant^{-1} in chickpea.

Yield attributes and yield

The yield components of *Lathyrus* in terms of number of pods per plant was significantly influenced by the application of different nutrient schedule during the trial.The number of pods per plant was recorded highest (66.6) in T_7 treatment (RDF+ Borax @ 0.5% spray at 40 DAS and flower initiation stage) followed by (65.8) treatment T_5 ($N_{20}P_{60}K_{20}$) during harvest. Least number of pods per plant was noted (44.9) with T_1 treatment (Control - $N_0P_0K_0$) (Table 2).This results are in line with the findings of Adhikary *et al.* (2018). They revealed that significant improvements in yield attributes of lentil were discovered in terms of higher number of pods per plant, test weight (1000 seed weight) and grain yield, when foliar spray as 0.5% solution of borax at 15, 40 DAS and at flower initiation stage was applied along with NPK fertilizers.The maximum pod length (3.4 cm) was achieved with the combined application of Borax @ 0.5% and $N_{20}P_{40}K_{20}$. The very short pod length (2.6 cm) was observed by the control treatment (Table 2).The number of seeds per pod was noted highest (4.13) in T_7 treatment (RDF+ Borax @ 0.5% spray at 40 DAS and flower initiation stage) followed by (3.83) both the treatments T_5 ($N_{20}P_{60}K_{20}$) and T_8 (RDF+ Ammonium molybdate @ 0.1%) during harvest. The least number of seeds per pod was noted (44.9) with T_1

Table 2. Yield attributes and yield of *Lathyrus* as influenced by nutrient management practices during *rabi* season.

Treatments	No. of pods per plant	Pod length (cm)	No. of seeds per pod	100-seed weight (g)	Seed yield (kg ha^{-1})	Stover yield (kg ha^{-1})	Harvest index (%)
T_1- Control ($N_0P_0K_0$)	44.9	2.6	2.87	5.45	876	2025	30.20
T_2-$N_{20}P_0K_{20}$	53.1	2.9	3.13	5.49	987	2269	30.31
T_3- $N_{20}P_{20}K_{20}$	58.1	2.9	3.43	5.52	1047	2261	31.66
T_4- $N_{20}P_{40}K_{20}$- RDF	63.5	3.1	3.67	5.61	1101	2183	33.50
T_5- $N_{20}P_{60}K_{20}$	65.8	3.2	3.83	5.88	1352	2285	37.18
T_6- RDF+ $ZnSO_4$ @ 0.5%	63.6	3.2	3.80	5.75	1147	2044	35.95
T_7- RDF+ Borax @ 0.5%	66.6	3.4	4.13	6.11	1450	2513	36.59
T_8- RDF + Ammonium molybdate @ 0.1%	63.9	3.2	3.83	5.85	1264	2131	37.23
T_9- RDF+ MgSO4 @ 0.5%	63.8	3.2	3.80	5.84	1197	2035	37.04
T_{10}- Vermicompost @ 1 t ha^{-1}	52.3	3.1	3.47	5.51	896	2067	30.23
SEm (±)	2.64	0.08	0.08	0.04	14.34	14.31	0.31
CD (p=0.05)	7.85	0.25	0.26	0.16	42.6	42.54	0.94

treatment (Control- $N_0P_0K_0$) (Table 2).The highest value of 100-seed weight was noted (6.11 g) in T_7 treatment (RDF+ Borax @ 0.5% spray at 40 DAS and flower initiation stage) followed by (5.88 g) treatment T_5 ($N_{20}P_{60}K_{20}$) during harvest. The least value of 100-seed weight was registered (5.45 g) in T_1 treatment (Control- $N_0P_0K_0$) (Table 2).The land productivity in terms of seed yield of *Lathyrus* was significantly influenced by various nutrient management practices. The lowest seed yield (876 kg ha^{-1}) was recorded with treatment T_1(Control - $N_0P_0K_0$). Treatment T_7 (RDF+ Borax @ 0.5% spray at 40 DAS and flower initiation stage) showed the highest seed yield i.e. 1450 kg ha^{-1} followed by treatment T_5 (1352 kg ha^{-1}) (Table 2). Here, the foliar application of Boron @ 0.5% in treatment T_7, increase the yield of 65.50% over the control. This finding was supported by Adhikary *et al.* (2018). They reported that foliar spray of 0.5% B at 15 DAS, 40 DAS and flower initiation stage recorded 26.98% higher seed yield in lentil. Among the various treatments, T_7 treatment (RDF+ Borax @ 0.5% spray at 40 DAS and flower initiation stage) gave the highest stover yield (2513kg ha^{-1}) over the control ($N_0P_0K_0$), followed by treatment T_5 ($N_{20}P_{60}K_{20}$) gave the yield of 2285 kg ha^{-1}. The lowest stover yield was obtained in control ($N_0P_0K_0$) i.e. 2025 kg ha^{-1} (Table 2). These results are in harmony with those of Ram *et al*. (2017) concluded that 0.2% foliar spray of borax at 35 DAS (pre-flowering) along with 20:60:20 NPK recorded maximum straw yield (2.85 t ha^{-1}) over control in green gram. The source to sink ratio in terms of harvest index of *Lathyrus* was significantly influenced by various nutrient management practices. Among the various treatments, T_8 treatment (RDF+ Mo @ 0.1% spray) gave the highest harvest index of 37.23% followed by T_5 treatment of 37.18% ($N_{20}P_{60}K_{20}$) and the control gave the least harvest index of 30.20% (Table 2).

Water use efficiency (WUE)

The WUE of *Lathyrus* crop was influenced by different nutrient management practices (Table 3). The actual evapotranspiration (Eta) varies from 131.58 mm to 145.06 mm with a variation of 10.24%. Among the different treatments, the highest ETa was noted

Table 3. WUE and seed protein content of *Lathyrus* as influenced by nutrient management practices during *rabi* season.

Treatments	ETa (mm)	WUE (kg ha^{-1} mm^{-1})	Seed protein (%)
T_1- Control ($N_0P_0K_0$)	133.33	6.57	25.73
T_2- $N_{20}P_0K_{20}$	138.94	7.10	27.45
T_3- $N_{20}P_{20}K_{20}$	131.72	7.95	28.18
T_4- $N_{20}P_{40}K_{20}$- RDF	134.99	8.16	28.50
T_5- $N_{20}P_{60}K_{20}$	144.73	9.34	29.63
T_6- RDF + $ZnSO_4$ @ 0.5%	131.58	8.72	29.75
T_7- RDF + Borax @ 0.5%	145.06	10.00	30.39
T_8- RDF + Ammonium molybdate @ 0.1%	139.12	9.08	31.18
T_9- RDF + $MgSO_4$ @ 0.5%	133.95	8.94	29.37
T_{10}- Vermicompost @ 1 t ha^{-1}	133.97	6.68	26.95
SEm (±)	-	0.10	0.28
CD (p=0.05)	-	0.30	0.85

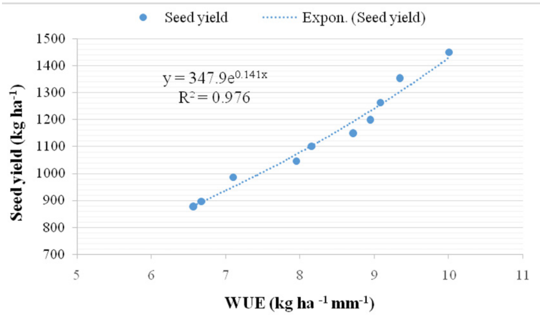

Fig. 2. Relation between seed yield and water use efficiency of *Lathyrus*.

at T_7 (RDF + Borax @ 0.5%) obtaining 145.06 mm followed by T_5 (144.73 mm). The minimum Eta (131.58 mm) was obtained at T_6 (RDF + $ZnSO_4$ @ 0.5%). In case of water use efficiency (WUE) the value varies from 6.57 kg ha^{-1} mm^{-1} to 10.00 kg ha^{-1} mm^{-1} with a variation of 52.20%. The highest WUE (10.00 kg ha^{-1} mm^{-1}) was recorded at T_7 (RDF + Borax @ 0.5%) followed by T_5 (9.34 kg ha^{-1} mm^{-1}). This might be caused by high yield and lower water use. The minimum WUE (6.57 kg ha^{-1} mm^{-1}) was noted at T_1 (Control). The water use efficiency of *Lathyrus* was exponentially increased with increase in seed yield (Fig. 2).

Protein content

The seed protein content of *Lathyrus* varied significantly with different nutrient management practices. The seed protein content was highest (31.18%) in the plot fertilized with RDF along with ammonium molybdate @ 0.1% followed by (30.39%) T_7 treatment (RDF + Borax @ 0.5%). The lowest seed protein content (25.73%) was noted in the control plot (Table 3). This finding was supported by Nasar and Shah (2017). They registered that both Fe @ 1.0 kg ha^{-1} and Mo @ 0.10 kg ha^{-1} applied alone or combined significantly increased protein content of lentil over control.

Nutrient status

After harvest of *rabi lathyrus*, available soil nitrogen, phosphorus, potassium and organic carbon variedsignificantly with different nutrient management practices.

Table 4. Effect of different nutrient management on available N, P, K and C content of soil after harvest during *rabi* season.

Treatments	Nitrogen (kg ha^{-1})	Phosphorus (kg ha^{-1})	Potassium (kg ha^{-1})	Carbon (%)
T_1- Control ($N_0P_0K_0$)	234.2	32.4	191.0	0.37
T_2-$N_{20}P_0K_{20}$	313.6	32.6	216.5	0.44
T_3- $N_{20}P_{20}K_{20}$	342.9	34.4	220.2	0.39
T_4-$N_{20}P_{40}K_{20}$- RDF	351.2	36.2	219.2	0.49
T_5-$N_{20}P_{60}K_{20}$	322.0	38.5	224.0	0.51
T_6- RDF+ $ZnSO_4$ @ 0.5%	355.4	36.3	228.7	0.65
T_7- RDF+ Borax @ 0.5%	347.1	37.7	233.8	0.54
T_8- RDF+ Ammonium molybdate @ 0.1%	359.6	36.7	234.2	0.40
T_9- RDF+$MgSO_4$ @ 0.5%	334.5	36.6	229.3	0.63
T_{10}- Vermicompost @ 1 t ha^{-1}	284.3	33.2	201.0	0.59
SEm (±)	9.4	0.15	0.68	0.01
CD (p=0.05)	27.95	0.45	2.03	0.04

es. The available nitrogen was more (359.6 kg ha^{-1}) in the plot fertilized with RDF along with ammonium molybdate @ 0.1% (Table 4).The highest available phosphorus was recorded in the application of higher dose of phosphorus i.e. $N_{20}P_{60}K_{20}$ in treatment T_5 and lowest available phosphorus was noted in the control plot where no fertilizers were applied (Table 4).The available potassium was more (234.2 kg ha^{-1}) in the plot fertilized with RDF along with ammonium molybdate @ 0.1% (Table 4). The available organic carbon was more (0.65%) in the plot fertilized with RDF along with $ZnSO_4$ @ 0.5%. The lowest available organic carbon (0.37%) was recorded in the control plot where no fertilizers were applied (Table 4).

CONCLUSION

Conclusively, among the various nutrient management practices, foliar application of B @ 0.5% along with RDF (N, P_2O_5 and K_2O at 20, 40 and 20 kg ha^{-1} respectively) were recorded to be more beneficial in terms of growth and seed yield of *Lathyrus* (var Prateek). Here we suggest an integration of RDF (N, P_2O_5 and K_2O @ 20, 40 and 20 kg ha^{-1} respectively) with foliar application of B at 40 DAS and flower initiation stage (55 DAS), not only to improve growth and seed yield of Lathyrus but also to improve soil nutrient status of lower Gangetic new alluvial soil of West Bengal.

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