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Yield and Nutrient Uptake of Rapeseed (*Brassica campestris* var. *toria*) as Influenced by Phosphorus Sources and Levels in Acidic Soils of Meghalaya

Alok Maurya, Sanjay-Swami

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ABSTRACT

Background: Acidic soils limit the soil phosphorus availability to the crop plants because these soils have tendency to fix P as iron and aluminium phosphate. The present study aims to investigate the influence of phosphorus sources and levels on yield and nutrient uptake of rapeseed (*Brassica campestris* var. *toria*) in acidic soils of Meghalaya.

Methods: A pot culture experiment was conducted during *rabi* season of 2016-17 wherein two sources of P (single super phosphate and Mussoorie rock phosphate) and six levels of P (0, 30, 60, 90, 120 and 150 mg P kg^{-1} of soil) were tested in two types of acidic soils (Alfisols, Inceptisols) in completely randomized design with three replication and rapeseed (cv. M-27) as test crop.

Result: The highest mean dry matter yield of rapeseed (16.1 g pot^{-1}) was recorded with 120 mg P kg^{-1} of soil. Subsequent increase in the level of P significantly decreased the dry matter yield by 4.6% over 120 mg P kg^{-1}. The dry matter yield with Mussorie rock phosphate was lower as compared to single sulphur phosphate (SSP) at each levels of P irrespective of soil type. The concentration of P in plant dry matter of rapeseed increased with each successive levels of P in acidic soils with both P sources; however P uptake increased up to 120 mg P kg^{-1} soil.

Key words: Acidic soils, Levels, Nutrient uptake, Phosphorus sources, Rapeseed, Yield.

INTRODUCTION

Oilseed crops are second most important crop next to cereals. India is the fourth largest consumer of edible oils after United States of America, China and Brazil (Parcell *et al.,* 2018). Globally, rapeseed and mustard contributes almost 6 per cent of global vegetable oil production, 14% of vegetable oil imports and 10% of edible oils (Mir *et al.,* 2010; Sanjay-Swami and Maurya, 2018). Rapeseed-mustard ranks second in area and production among all the oilseed crops after groundnut in India. It contributes to the area (4.1 M ha) and production (6.6 Mt) of total oilseed of India with an average productivity of 11.82 q ha^{-1} (Prasad, 2013). It is cultivated in Meghalaya on an area of 9720 ha with the production of 9270 tonnes and productivity of 9.5 q ha^{-1}. The per capita per day oil availability of 8.0 g that is moderate against the national requirement (Sanjay-Swami *et al.,* 2019).

Out of total cultivated area of North Eastern Hill (NEH) region, about 81% soils are acidic in reaction (Sharma *et al.*, 2006; Singh and Sanjay-Swami, 2020). Acid soil limits the soil phosphorus (P) availability to the crop plants because these soils have tendency to fix P as iron and aluminium phosphate (Sanjay-Swami and Singh, 2020; Sanjay-Swami, 2021). Adequate P supply based on precise assessment of soil P requirement is therefore crucial for improving the crop productivity in the region (Singh *et al.,* 2014; Tamang and Sanjay-Swami, 2021; Satya and Sanjay-Swami, 2021). P is essential for energy transformation especially in oil seed crops and finally, improves the oil content (Fohse *et al.,* 1991; Sanjay-Swami, 2019). However, P recommendation for rapeseed crop in acidic soils (Inceptisols, Alfisols) of Meghalaya is lacking. Therefore, the present investigation was carried out to find out optimum dose and source of P application in acidic soils of Meghalaya for higher productivity of rapeseed.

School of Natural Resource Management, College of Post Graduate Studies in Agricultural Sciences, Central Agricultural University, Umiam, Barapani-793 103, Meghalaya, India.

Corresponding Author: Sanjay-Swami, School of Natural Resource Management, College of Post Graduate Studies in Agricultural Sciences, Central Agricultural University, Umiam, Barapani-793 103, Meghalaya, India.
Email: sanjayswamionline@gmail.com

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MATERIAL AND METHODS

A pot experiment was conducted at School of Natural Resource Management, College of Post-Graduate Studies in Agricultural Sciences, Central Agricultural University, Umiam, Meghalaya during *rabi* season of 2016-17. The experiment consisted of twenty four treatments *viz.,* two types of soil (Alfisols, Inceptisols), two P sources (single super phosphate and Mussoorie rock phosphate) and six levels of P (P_1 = 0, P_2 = 30, P_3 =60, P_4 =90, P_5 =120 and P_6 = 150 mg kg^{-1} of soil) in completely randomized design with three replication. Rapeseed (cv. M-27) was test crop.

Two bulk soil samples were collected from Bhoirymbong (Alfisols) and Umiam (Inceptisols) villages in Ri-Bhoi districts of Meghalaya from 0 to 15 cm soil depth. The soil sample was dried and ground to pass through 2 mm stainless steel sieve to remove gravels and other materials. Physico-chemical properties of the collected soils were estimated using standard methods as mentioned against each parameter and are presented in Table 1.

The amount of P was supplied through the single super phosphate (SSP) and rock phosphate (RP) according to the treatments and posts were kept in poly house. The seed of rapeseed (variety M-27) was obtained from ICAR Research Complex for NEH Region, Barapani, Meghalaya.

The sowing of the seed was done on 5th November, 2016 and it was harvested at physiological maturity on 24th January, 2017 and dry matter yield was recorded. The plant samples collected from each pot were dried in an oven and then grind thoroughly with grinder and preserved separately in sealed and labelled containers. 0.5 g oven dried plant samples were digested with di-acid mixture of HNO_3 + $HClO_4$ in 5:2 ratio and the P concentration in the digested plant samples was determined by yellow colour development method using spectrophotometer at 420 nm wave-length. The uptake of P by rapeseed was worked out by using the following formula:

P uptake by plant (mg pot^{-1}) =
Per cent P concentration in rapeseed x Dry matter yield (per pot) x 10

The data obtained from the experiment were subjected to statistical analysis (ANOVA) and significant difference was calculated at 5% level of significance (Fisher, 1958).

RESULTS AND DISCUSSION

Dry matter yield

The mean plant dry matter yield increased significantly with the increasing levels of P up to 90 mg of P kg^{-1} soil however, the highest mean dry matter yield (16.1 g pot^{-1}) was recorded with the application of 120 mg of P kg^{-1} of soil (Table 2). Further increase in the dose of significantly decreased the dry matter yield by 4.6% over 120 mg of P kg^{-1}. The dry matter yield with RP was lower as compared to SSP at each levels of P irrespective of soil type. Two way and three way interactions were found to be significant. The dry matter yield with the application of P was due to low available P status of the experimental soil. It revealed that optimum mean dry matter yield recorded with 90 mg P kg^{-1} soil was 2.44 times more than the control. The increases in dry matter yields due to varying levels of P are in agreement with the findings of Singh and Bishnoi (1994) and Yousaf *et al.* (2017).

The interaction between different levels of applied P and different rapeseed growing soils was significant for dry matter yield of rapeseed. Tyagi and Rana (1992) reported

Table 1: Physico-chemical properties of experimental soils.

Parameters	Alfisols	Inceptisols	Method used
Soil texture	Sandy loam	Sandy clay loam	International pipette method (Olmstead *et al.*, 1930)
pH	4.86	5.02	pH meter with glass electrode (Piper, 1966)
Organic carbon (%)	1.1	1.3	Rapid titration method (Walkley and Black, 1934)
CEC cmol (p kg^{-1})	2.8	3.7	Ammonium acetate saturation method Jackson (1973)
Available nitrogen (kg ha^{-1})	275.0	350.0	Alkaline potassium permanganate method (Subbiah and Asijah, 1956)
Available phosphorus (kg ha^{-1})	8.0	13.0	Bray and Kurtz No. 1 method (Bray and Kurtz, 1945)
Available potassium (kg ha^{-1})	259.8	280.0	Neutral Normal Ammonium Acetate Method (Knudsen *et al.*, 1982)
Available sulphur (kg ha^{-1})	14.3	18.5	$CaCl_2$-extractable S (Chesnin and Yien, 1951)
	Alfisols	**Inceptisols**	
Available micronutrients	Zn Cu Mn Fe	Zn Cu Mn Fe	DTPA Method (Lindsay and Norvell, 1978)
(mg kg^{-1} soil)	0.53 2.1 3.0 12.32	0.61 2.5 3.45 9.81	

that with the application of P fertilizer, the yield of mustard crop significantly increased up to 80 kg P_2O_5 ha^{-1} which was at par with 100 kg P_2O_5 ha^{-1}. Similar results were also reported by Prabhuraj *et al.* (1993) in sunflower.

Phosphorus concentration

The data presented in Table 3 indicated that there was a significant increase in phosphorus concentration with different P sources and with the increasing levels of applied P. The lowest mean of P content (0.15 per cent) was recorded in control where no P fertilizer was applied, which was significantly increased with the increase in the doses of P up to 150 mg P kg^{-1}. The concentration of P at each respective levels of applied P was higher in Inceptisols than Alfisols. The highest mean P concentration was observed in Inceptisols (0.35 per cent) with SSP whereas in Alfisols it was 0.30 per cent. Two way and three way interactions were found to be significant. The increasing P concentration might be due to the availability of more P in soils with the application of P and initial available P status of the experimental soils. Singh *et al.* (1997) and Yousaf *et al.*, (2017) also observed that the concentration of P was significantly improved in both straw and seed of sunflower and rapeseed, respectively due to increased levels of applied P. Similar results were also obtained by Schultz *et al.,* (2018) for sunflower in North Dakota. The concentration of P was significantly lower in plants grown on Alfisols as compared to Inceptisols owing to less native soil P in these soils.

Phosphorus uptake

Increasing levels of applied P significantly improved the P uptake by rapeseed plants (Table 4). The overall mean P

Table 2: Dry matter yield of rapeseed (g pot^{-1}) as influenced by P sources and levels in acidic soils of Meghalaya.

P levels mg kg^{-1} soil	Alfisols		Inceptisols		Mean
	RP	SSP	RP	SSP	
0	5.57	6.00	7.02	7.20	6.45
30	9.34	10.30	10.77	11.89	10.58
60	12.12	13.20	14.14	15.61	13.77
90	14.21	15.00	16.13	17.68	15.76
120	14.44	15.20	17.02	17.81	16.11
150	14.12	14.90	15.80	16.65	15.37
RP	12.56	Alfisols	12.03		
SSP	13.45	Inceptisols	13.98		
S.E(m)±	0.14				
CD (p=0.05)	0.39				
For Source of P and Soils			**Interaction**		
		S x So	S x L	So x P	S x So x L
S.E(m)±	0.08	0.11	0.19	0.19	0.28
CD (p=0.05)	0.23	0.32	0.55	0.55	0.78

RP: Rock Phosphate, SSP: Single Super Phosphate, S: Sources of P, So: Soils, L: Levels of P

Table 3: P concentration (%) of rapeseed as influenced by P sources and levels in acidic soils of Meghalaya**.**

P levels mg kg^{-1} soil	Alfisols		Inceptisols		Mean
	RP	SSP	RP	SSP	
0	0.12	0.14	0.16	0.18	0.15
30	0.14	0.17	0.21	0.23	0.19
60	0.18	0.20	0.25	0.27	0.23
90	0.24	0.25	0.28	0.31	0.27
120	0.27	0.29	0.30	0.33	0.30
150	0.28	0.30	0.31	0.35	0.31
RP	0.23	Alfisols	0.22		
SSP	0.25	Inceptisols	0.26		
S.E(m)±	0.01				
CD (p=0.05)	0.02				
For Source of P and Soils			**Interaction**		
		S x So	S x L	So x P	S x So x L
S.E(m)±	0.001	0.01	0.01	0.01	0.01
CD (p=0.05)	0.01	0.02	0.03	0.03	0.04

RP: Rock Phosphate, SSP: Single Super Phosphate, S: Sources of P, So: Soils, L: Levels of P.

Table 4: P uptake (mg pot^{-1}) in rapeseed as influenced by P sources and levels in acidic soils of Meghalaya.

P levels	Alfisols		Inceptisols		Mean
	RP	SSP	RP	SSP	
0	6.88	8.63	11.04	12.78	9.83
30	13.35	17.85	22.95	27.84	20.50
60	21.81	26.85	34.92	42.25	31.46
90	33.65	37.91	44.70	54.83	42.77
120	38.96	43.62	50.51	59.37	48.12
150	39.06	45.23	49.52	58.25	48.01
RP	30.61	Alfisols	27.82		
SSP	36.28	Inceptisols	39.08		
S.E(m)±	1.16				
CD (p=0.05)	3.30				
For Source of P and Soils			**Interaction**		
		S x So	S x L	So x P	S x So x L
S.E(m)±	0.67	0.95	1.64	1.64	2.32
CD (p=0.05)	1.91	2.69	4.67	4.67	6.60

RP: Rock Phosphate, SSP: Single Super Phosphate, S: Sources of P, So: Soils, L: Levels of P.

uptake in control was 9.83 mg P pot^{-1}, which increased significantly by 4.9 times with the application of 120 mg P kg^{-1} soil. Irrespective of soils, the P uptake by rapeseed plant showed an increasing trend from no P application to the P level of 120 mg P kg^{-1} of soil and then reduces. The highest P uptake (59.37 mg pot^{-1}) was recorded in Inceptisols through SSP compared to RP (49.52 mg pot^{-1}) whereas in case of Alfisols, highest P uptake (45.23 mg pot^{-1}) was recorded through SSP as compared to RP (39.06 mg pot^{-1}). Inceptisols had 1.5 times more P uptake under both the P sources and their P levels. The mean P uptake (36.61 mg pot^{-1}) was recorded through the SSP compared to RP (36.28 mg pot^{-1}), while in the Inceptisols it was 39.08 mg pot^{-1} than Alfisols (27.82 mg pot^{-1}).

The data in Table 4 indicated that the application of P significantly improved the P uptake under both the sources irrespective of soils. The mean P uptake increased significantly by 4.89 times over control with the application of 120 mg P kg^{-1} soil. The mean uptake of P in different rapeseed-growing acidic soils differed significantly among themselves with highest in Inceptisols followed by Alfisols. The dry matter yield of rapeseed was in close association with available P of soils. Similar to these findings, Singh *et al.* (1997) reported that the application of P significantly enhanced P uptake in sunflower crop grown on different soils.

CONCLUSION

The application of P at lower levels resulted in significant increase in dry matter yield of rapeseed under both the P sources in acidic soils of Meghalaya. The application of P @ 30, 60 and 90 mg P kg^{-1} soil significantly increased the dry matter yield of rapeseed crop in Inceptisols and Alfisols. The dry matter yield with RP was lower than SSP at each levels of P irrespective of soil type. Therefore, application of 90 mg of P kg^{-1} of soil with SSP may be advised to the farmers of Meghalaya for getting higher yield of mustard in Inceptisols and Alfisols.

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