GROWTH, NUTRIENT UPTAKE AND YIELD OF SOYBEAN AS INFLUENCED BY PHYTASE ENZYME AND FYM LEVELS IN NON-CALCAREOUS SOIL

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ABSTRACT

A pot culture experiment was conducted to assess the “Nutrient uptake and yield of soybean as influenced by phytase and FYM levels in non calcareous soil” during Kharif 2014 at Division of soil Science and Agricultural Chemistry, College of Agriculture, Pune. The treatment consisted of four levels of each phytase (0, 1200, 2400 and 3600 IU) and FYM (0, 2.5, 5, 7.5 t ha⁻¹) replicated thrice in factorial randomized block design. Yield and nutrient uptake was assessed at 50 % flowering and harvest of soybean. Yield or dry matter production was found significantly influenced with the application of phytase and FYM at both the growth stages. Application of phytase @ 3600 IU or FYM @ 7.5 t ha⁻¹ or their combine application reported significantly higher plant height, root length, root shoot ratio, fresh and dry weight of roots, number and weight of root nodules than rest of the treatment. Significantly higher mean straw yield was recorded with the application of phytase @ 3600 IU (12.86 and 14.31 g pot⁻¹) at 50 % flowering and at harvest. Significantly higher grain and straw yield was recorded with the application of phytase @ 3600 IU (17.34 and 14.31 g pot⁻¹) which was statistically at par with phytase @ 2400 IU (17.28 and 13.74 g pot⁻¹). While in case of FYM application @ 7.5 t ha⁻¹ recorded significantly higher grain and straw yield (17.77 and 14.17 g pot⁻¹). Significantly higher nitrogen (495.53 and 755.37 mg pot⁻¹), phosphorus (66.43 and 111.23 mg pot⁻¹) and potassium (285.12 and 96.41 mg pot⁻¹) uptake was recorded with the application of phytase @ 3600 IU at 50 % flowering and at harvest of soybean respectively. Similar uptake trend was observed for nitrogen (593.44 and 731.29 mg pot⁻¹), phosphorus (72.90 and 110.08 mg pot⁻¹) and potassium (321.94 and 105.47 mg pot⁻¹) with the application of FYM @ 7.5 t ha⁻¹ at 50% flowering and at harvest of soybean respectively.

KEYWORDS: Phytase, FYM, Soybean Growth, Yield, Nutrient Uptake & Non Calcareous Soil

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INTRODUCTION

Phosphorus is critically involved in energy production, transfer and storage of ATP for every biological process in nature. In plant, phosphorus is essential for photosynthesis, transpiration, respiration, energy, metabolism, synthesis of nucleic acids and membranes, nitrogen fixation, gene transfer, reproduction, root growth, flowering and root setting. Phosphorus is a major plant nutrient next to nitrogen in augmenting plant metabolic activity ultimately reflecting on the crop yield.

Soil phosphorus exists both in organic and inorganic form, the organic phosphorus compounds can be classified into i) the inositol phosphatase primarily of plant origin comprising up to 60% of soil organic phosphorus, ii) the nucleic acids and iii) phospholipids. In soils 20-85 per cent of the total phosphorus is in organic form but plants can only utilize this organic phosphorus after its mineralization. The availability of soil phosphorous

(potential or applied) is largely governed by microflora and soil enzymes. Soil enzymes like acid and alkaline phosphatase and phytase are mainly involved in mineralization of fixed phosphorous. The acid phosphatase is predominant in acid soil and alkaline phosphatase is predominant in alkaline soil (Juma and Tabatabai 1987). The acid and alkaline phosphatase and phytase have an important role in mineralization of phosphorous in association with microbial population. Phytate is an organic form of phosphorus present in plant, soil and organic matter which is hydrolyzed by phytase enzyme. Phytase enzyme not only catalyzes the hydrolysis of organic form of phosphorus but also involved in improvement of other soil enzyme activities and microflora. Legumes secrete more phosphatase enzymes than cereals; this may be due to higher requirement of phosphorus by legumes especially soybean.

The soybean growing areas in Maharashtra are either of calcareous or black clayey soils. These soils are alkaline in nature (8-8.5 pH) with moderate to high calcium carbonate content. The content of free calcium carbonate and clay content dominated soils are the main constraints for phosphorous availability. Both these constraints are attributed to the phosphorus fixation either by calcium as calcium phosphate or adsorption of phosphate ions on surface of clay, thereby resulting in lower recovery by crops & buildup of its status in soil. A large proportion of phosphorus applied to soil as fertilizer rapidly becomes unavailable to plants due to fixation of inorganic phosphorus by adsorption and precipitation either with clay or Ca whereas, organic phosphorus fractions gets immobilized in soil organic matter. Hence the study the growth, nutrient uptake and yield of soybean as influenced by phytase enzyme and FYM levels in non-calcareous soil.

MATERIALS AND METHODS

A pot culture experiment was conducted at the Division of Soil science and Agriculture Chemistry, College of Agriculture, Pune, during *Kharif* 2014. The experiment consisted of sixteen treatment combinations based on four levels of phytase (0, 1200, 2400 and 3600 IU) and FYM (0, 2.5, 5 and 7.5 t ha⁻¹) replicated thrice in Factorial Completely Randomised Design. IU is the amount of enzyme that liberates 1 µmol of inorganic orthophosphate from phytin per minute at pH 5.5 and 37°C. (Zyla *et al.*, 1995). The initial soil and FYM analysis was carried by following standard methods (table 1).

The required quantity of black calcareous soil was collected from Agronomy farm, College of Agriculture, Pune. The quantity of FYM required for the experiment was procured from Division of Animal Husbandry and Dairy Science, College of Agriculture, Pune. The phytase isolated from *Aspergillus niger* was obtained from National Collection of Industrial Microorganisms (NCIM), National Chemical Laboratory (NCL), Pune, India. The initial physico chemical and biochemical properties of soil were analyzed by using standard methods and presented in table 1. Forty eight earthen pots with 10 Kg black calcareous soil were used during the experiment. Further another set of sixteen pots were maintained up to 50 % flowering of soybean. Thereafter, pots were broken down to collect rhizospheral soil samples. Treatment wise required quantity of phytase and FYM were thoroughly mixed with soil and sowing of soybean carried out. No phosphatic fertilizer was applied. However, recommended dose of nitrogen was supplied through urea.

Periodical yield and nutrient uptake was assessed at 50 % flowering and harvest of soybean. The dry matter yield of soybean was taken for grain and straw by estimating their dry weight. Uptake of nutrients was determined by estimating the dry weight and nutrient concentration of soybean grain and straw separately.

Table: 1: Initial Soil Fertility Status and FYM Composition

Soil Fertility Status		FYM Composition	
Soil Parameter	Value	FYM Parameter	Value
pH (1:2.5)	8.0	Organic carbon (%)	11.76
EC (1:2.5) (dSm ⁻¹)	0.29	Total N (%)	0.56
Organic carbon (%)	0.70	Total P (%)	0.37
CaCO ₃ (%)	4.5	Total K (%)	0.52
Available N (kg ha ⁻¹)	245	C:N ratio	21
Available P (kg ha ⁻¹)	16.04	C:P ratio	31.78
Available K (kg ha ⁻¹)	310		

RESULTS AND DISCUSSIONS

Growth Attributes

Plant morphological observations like plant height, root length, root-shoot ratio, fresh and dry weight of roots, number and weight of active root nodules at 50% flowering of soybean were significantly influenced by the application of phytase enzyme and FYM levels.(2a to 2g)

Significantly higher mean plant height (41 cm) of soybean was reported with the application of 3600 IU phytase followed by 2400 and 1200 IU (38 cm). However, application of FYM @7.5 t ha⁻¹ reported significantly higher plant height (43 cm). Interaction effect between 3600 IU phytase along with 7.5 t ha⁻¹ reported significantly higher plant height (46 cm) than rest of the treatment. Data revealed that significantly higher root length at 50% flowering was recorded with the application of 3600 IU phytase (67 cm) while FYM application @7.5 t ha⁻¹ recorded 68 cm. The combine application of phytase and FYM were found non-significant for root length but numerically higher root length (74 cm) recorded with the application of 3600 IU phytase along with 7.5 t ha⁻¹.

Significant and consistent increase in root-shoot ratio, fresh and dry weight of roots of soybean at 50% flowering was recorded with the application of phytase as well as FYM in non-calcareous soil. Significantly higher root-shoot ratio (1.66 and 1.68), fresh (7.92 and 8.43 g) and dry weight of roots (5.57 and 6.15 g) at 50% flowering of soybean were recorded with the application of 3600 IU phytase and 7.5 t ha⁻¹FYM.

In case of number and fresh weight of active root nodules at 50% flowering of soybean were significantly influenced by phytase and FYM application. Significantly higher numbers of active root nodules were noticed with phytase @ 3600 IU (62) and FYM 7.5 t ha⁻¹ (65). However combine application of 3600 IU phytase + 7.5 t ha⁻¹FYM recorded higher number of active root nodules (77) than rest of the treatment. Application of phytase @ 3600 IU and FYM @ 7.5 t ha⁻¹ noted significantly higher fresh weight of active root nodules (0.69 and 0.66 g). Numerically higher weight of active root nodules (0.84 g) was recorded with 3600 IU phytase + 7.5 t ha⁻¹FYM.

The increase in plant height, root length, root-shoot ratio, root weight and nodule number might be ascribed to solubilisation of inorganic phosphorus by action of organic and inorganic acid secreted by microorganism and ultimately reduction in pH of soil which cause higher solubility (Yadav and Verma, 2012). Gujar *et.al.*,(2013) studied effect of phytase from *Aspergillus niger* on plant growth and mineral assimilation in wheat (*Triticum aestivum* Linn.) on calcareous soil and its potential for use as a soil amendment at NCL, Pune during 2012 and concluded that phytase isolated from *Aspergillus niger* promoted plant growth (upto 200 %). The length of root was higher in pots supplemented with phytase than uninoculated control. Vibha *et al.*, 2014 studied impact of phosphorus solubilisation of fungi on yield of mung bean

on sandy loam soil and concluded significantly higher root length with inoculation of *Aspergillus niger* strains No. 2. Tarafdar, (2008) conducted an experiment on mobilization of native phosphorus for plant nutrition at Central Arid Zone Research Institute, Jodhpur. He concluded that seed inoculation with *Aspergillus fumigates* and soil inoculation with *Glomus mosseae* increased root length. Muhammad Iqbal *et al.*, (2013) concluded that phosphate solubilizing bacteria enhance the growth (plant height, root length, dry weight of shoot and root) through simultaneous exudation of organic acids (by decreasing pH) and/or through releasing phosphatases and ACC-deaminase. Tarafdar and Rao, (2001) reported that root nodulation of cluster bean was increased with inoculation of AMF + Rhizobium and FYM. This could be attributed to a more extensive root system, tapping a large volume of soil for water and nutrients.

Grain Yield and Dry Matter Production

The production of soybean dry matter at 50% flowering was ranged between 8.52 to 15.08 g pot⁻¹ (Table 3 and 4). Consistent increase in mean soybean dry matter was noticed either with application of FYM or phytase. Significantly higher mean dry matter was recorded with application of phytase @ 3600 IU (12.86 g pot⁻¹) followed by 2400 IU (12.83 g pot⁻¹). Dry matter production of soybean was low in the pots where no phytase was applied. Application of FYM @ 7.5 t ha⁻¹ (14.08 g pot⁻¹) recorded significantly higher mean soybean dry matter accumulation followed by FYM @ 5 t ha⁻¹ (12.86 g pot⁻¹). At harvest, grain yield of soybean was influenced significantly by graded levels of phytase and FYM. Application of phytase @ 3600 IU (17.34 g pot⁻¹) recorded significantly higher grain yield which was statistically at par with phytase @ 2400 IU (17.28 g pot⁻¹). Similar trend of soybean was also reported for straw yield. Phytase application @ 3600 IU recorded higher mean straw yield (14.31 g pot⁻¹) followed by 2400 IU (13.74 g pot⁻¹) and 1200 IU (12.71 g pot⁻¹). Application of graded levels of FYM significantly influenced grain yield of soybean. Significantly higher mean grain yield was noticed with application of FYM @ 7.5 t ha⁻¹ (14.17 g pot⁻¹).

Application of FYM had additive effect on dry matter production and seed yield. This could be attributed to a more extensive root system, tapping a large volume of soil for water and nutrients. Vibha *et al.*, 2014 studied impact of phosphorus solubilisation of fungi on yield of mung bean on sandy loam soil and concluded significantly higher root length, dry weight and seed yield with inoculation of *Aspergillus niger* strains No. 2 which has more ability to secrete phytase. Tarafdar and Rao, (2001) reported that dry matter production of clusterbean was increased with inoculation of AMF + Rhizobium and FYM. Application of FYM had additive effect on dry matter production and seed yield. This could be attributed to a more extensive root system, tapping a large volume of soil for water and nutrients.

Nutrient Uptake

The major nutrient uptakes of soybean at 50 % flowering were significantly influenced by various levels of phytase and FYM (Table 5 and 6). It was ranged between 238.03-643.93 mg pot⁻¹, 10.26-29.64 mg pot⁻¹ and 29.15-84.60 mg pot⁻¹ for nitrogen, phosphorus and potassium respectively. The uptake of these nutrients was reported to be in increasing trend with either levels of phytase and FYM. Application of different levels of phytase recorded increasing trend for mean nitrogen, phosphorus and potassium uptake by soybean at 50% flowering. Similar increasing trend with various levels of FYM was recorded for mean nitrogen, phosphorus and potassium. The major nutrient uptake viz. nitrogen, phosphorus and potassium by soybean at 50% flowering were significantly higher 495.53, 66.43 and 285.12 mg pot⁻¹ with application of phytase @ 3600 IU and 643.93, 82.89 and 321.94 with application of FYM respectively.

The uptake of major nutrient namely, nitrogen, phosphorus and potassium were significantly influenced by phytase and FYM. Consistent increase in the uptake of nitrogen, phosphorus and potassium was observed with the graded levels of phytase from 0, 1200, 2400 and 3600 IU. Significantly higher ($755.37 \text{ mg pot}^{-1}$) uptake of nitrogen was noticed with application of 3600 IU phytase than rest of the treatment. However, application of phytase @ 3600 IU recorded statistically at par results for phosphorus ($111.23 \text{ mg pot}^{-1}$) and potassium ($96.41 \text{ mg pot}^{-1}$) uptake by soybean respectively. Similar trend was observed with the levels of FYM from 0, 2.5, 5, 7.5 t ha^{-1} . Application of FYM @ 7.5 t ha^{-1} recorded significantly higher mean nitrogen, phosphorus and potassium uptake by soybean in non calcareous soil (731.29 , 110.08 and $105.47 \text{ mg pot}^{-1}$).

Khan *et al.*, 2013 found positive correlation ($r=0.79$) between dry matter yield and phosphorus uptake by rye grass in high clay textured soil with 61.8 g kg^{-1} organic carbon. Effect of inoculation with phosphatase producing fungi on dry matter production and grain yield of cluster bean, chickpea and wheat was studied by Tarafdar *et al.*, 1995, Tarafdar and Rao 1996. They concluded higher nitrogen, phosphorus, potassium and calcium uptake by cluster bean, chickpea and wheat due to inoculation with phosphatase producing fungi. Gujar *et al.*, 2013 concluded that phytase promoted phosphorus mineral assimilation much more efficiently as compared to chemical fertilizer.

CONCLUSIONS

Application of phytase @ 3600 IU, FYM @ 7.5 t ha^{-1} and their related application was found superior for growth attributes of soybean at 50% flowering. However individual application or combine application of higher level of either phytase or FYM was found to be better for grain and straw yield and nutrient uptake of soybean at 50% flowering or at harvest.

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Plant Height

Table 2: Growth Attributes of Soybean at 50% Flowering as Influenced by the Application of Phytase Enzyme and FYM in Non-Calcareous Soil

FYM(F) Phytase (P)	Plant Height (cm)				
	0 tha ⁻¹	2.5 tha ⁻¹	5 tha ⁻¹	7.5 tha ⁻¹	Mean
0 IU	28	33	37	41	35
1200 IU	31	36	41	43	38
2400 IU	35	37	40	42	38
3600 IU	36	41	42	46	41
Mean	32	37	40	43	
	P		F		P × F
S.E. ±	0.425		0.425		0.85
CD at 5%	1.23		1.23		2.459

Root Length

FYM (F) Phytase (P)	Root Length (cm)				
	0 tha ⁻¹	2.5 tha ⁻¹	5 tha ⁻¹	7.5 tha ⁻¹	Mean
0 IU	48	55	58	62	56
1200 IU	52	57	60	68	59
2400 IU	56	61	65	69	63
3600 IU	58	66	69	74	67
Mean	53	60	63	68	
	P		F		P × F
S.E. ±	0.462		0.462		0.924
CD at 5%	1.337		1.337		NS

Root-Shoot Ratio

FYM (F) Phytase (P)	Root-Shoot Ratio				
	0 tha ⁻¹	2.5 tha ⁻¹	5 tha ⁻¹	7.5 tha ⁻¹	Mean
0 IU	1.49	1.48	2.37	1.70	1.76
1200 IU	1.46	1.50	1.15	2.03	1.53
2400 IU	1.65	1.43	1.69	1.28	1.51
3600 IU	1.57	1.74	1.60	1.73	1.66
Mean	1.54	1.54	1.70	1.68	
	P		F		P × F
S.E. ±	0.044		0.044		0.088
CD at 5%	0.127		0.127		0.254

Fresh Weight of Roots

FYM (F) Phytase (P)	Fresh Weight of Roots (g)				
	0 tha ⁻¹	2.5 tha ⁻¹	5 tha ⁻¹	7.5 tha ⁻¹	Mean
0 IU	5.53	6.38	7.44	8.01	6.84
1200 IU	5.94	7.06	7.91	8.24	7.29
2400 IU	6.79	7.31	7.94	8.60	7.66
3600 IU	7.25	7.62	7.96	8.86	7.92
Mean	6.38	7.09	7.81	8.43	
	P		F		P × F
S.E. ±	0.199		0.199		0.397
CD at 5%	0.575		0.575		NS

Dry Weight of Roots

FYM (F) Phytase (P)	Dry Weight of Roots (g)				
	0 tha ⁻¹	2.5 tha ⁻¹	5 tha ⁻¹	7.5 tha ⁻¹	Mean
0 IU	3.24	4.10	5.16	5.73	4.56
1200 IU	3.66	4.77	5.62	5.95	5.0
2400 IU	4.50	5.34	5.66	6.32	5.46
3600 IU	4.97	5.03	5.68	6.58	5.57
Mean	4.09	4.81	5.53	6.15	
	P		F		P × F
S.E. ±	0.17		0.17		0.34
CD at 5%	0.492		0.492		NS

Number of Active Root Nodules

FYM (F) Phytase (P)	Number of Active Root Nodules				
	0 tha ⁻¹	2.5 tha ⁻¹	5 tha ⁻¹	7.5 tha ⁻¹	Mean
0 IU	33	43	48	56	45
1200 IU	35	45	48	59	47
2400 IU	40	51	54	70	54
3600 IU	46	59	65	77	62
Mean	38	49	54	65	
	P		F		P × F
S.E. ±	0.529		0.529		1.057
CD at 5%	1.53		1.53		3.06

Fresh Weight of Active Root Nodules

FYM (F) Phytase (P)	Fresh Weight of Active Root Nodules (g)				
	0 tha ⁻¹	2.5 tha ⁻¹	5 tha ⁻¹	7.5 tha ⁻¹	Mean
0 IU	0.28	0.31	0.33	0.35	0.32
1200 IU	0.40	0.43	0.60	0.70	0.53
2400 IU	0.44	0.52	0.65	0.75	0.59
3600 IU	0.59	0.63	0.70	0.84	0.69
Mean	0.43	0.47	0.57	0.66	
	P		F		P × F

S.E. $\pm$	0.022	0.022	0.043
CD at 5%	0.063	0.063	NS

Table 3: Dry Matter Production of SOYBEAN at 50% Flowering as Influenced by the Application of Phytase Enzyme and FYM in Non-Calcareous Soil

FYM (F) Phytase (P)	Dry Matter (g Pot ⁻¹)				
	0 tha ⁻¹	2.5 tha ⁻¹	5 tha ⁻¹	7.5 tha ⁻¹	Mean
0 IU	8.52	10.18	12.17	13.61	11.12
1200 IU	9.49	11.58	12.84	13.19	11.77
2400 IU	11.63	12.20	13.08	14.43	12.83
3600 IU	11.11	11.93	13.34	15.08	12.86
Mean	10.19	11.47	12.86	14.08	
	P		F		P $\times$ F
S.E. $\pm$	0.327		0.327		0.654
CD at 5%	0.946		0.946		NS

a. Grain yield:

Table 4: Grain and Straw Yield of Soybean as Influenced by the Application of Phytase Enzyme and FYM in Non-Calcareous Soil

FYM (F) Phytase (P)	Grain (g Pot ⁻¹)				
	0 tha ⁻¹	2.5 tha ⁻¹	5 tha ⁻¹	7.5 tha ⁻¹	Mean
0 IU	14.33	15.32	16.44	15.55	15.41
1200 IU	15.37	16.41	16.81	18.21	16.70
2400 IU	15.91	17.02	17.55	18.65	17.28
3600 IU	15.89	16.91	17.89	18.68	17.34
Mean	15.37	16.41	17.17	17.77	
	P		F		P $\times$ F
S.E. $\pm$	0.17		0.17		0.341
CD at 5%	0.493		0.493		NS

b. Straw Yield

FYM (F) Phytase (P)	Straw (g Pot ⁻¹)				
	0 tha ⁻¹	2.5 tha ⁻¹	5 tha ⁻¹	7.5 tha ⁻¹	Mean
0 IU	12.37	12.42	13.44	13.68	12.98
1200 IU	12.58	12.45	12.32	13.51	12.71
2400 IU	13.25	13.39	13.65	14.67	13.74
3600 IU	13.81	14.30	14.30	14.84	14.31
Mean	13.00	13.14	13.43	14.17	
	P		F		P $\times$ F
S.E. $\pm$	0.059		0.059		0.118
CD at 5%	0.17		0.17		0.341

I. Nitrogen Uptake

Table 5: Effect of Phytase and FYM Levels on Nitrogen, Phosphorus and Potassium Uptake of Soybean at 50 Percent Flowering

FYM (F) Phytase (P)	mg pot ⁻¹				Mean
	0 t ha ⁻¹	2.5 t ha ⁻¹	5 t ha ⁻¹	7.5 t ha ⁻¹	
0 IU	238.03	340.13	416.27	566.47	390.23
1200 IU	264.80	405.50	477.07	578.40	431.44
2400 IU	365.23	445.37	560.87	584.97	489.11
3600 IU	354.73	507.37	476.10	643.93	495.53
Mean	305.70	424.59	482.58	593.44	
	P		F		P × F
SE ±	11.086		11.086		22.171
CD at 5%	32.079		32.079		64.158

II). Phosphorus Uptake

FYM (F) Phytase (P)	mg pot ⁻¹				Mean
	0 t ha ⁻¹	2.5 t ha ⁻¹	5 t ha ⁻¹	7.5 t ha ⁻¹	
0 IU	29.10	42.67	60.13	66.61	49.63
1200 IU	36.35	47.81	59.18	69.81	53.29
2400 IU	52.07	60.05	62.07	72.27	61.62
3600 IU	53.64	55.22	73.98	82.89	66.43
Mean	42.79	51.44	63.84	72.90	
	P		F		P × F
SE ±	1.811		1.811		3.623
CD at 5%	5.242		5.242		10.483

III). Potassium Uptake

FYM (F) Phytase (P)	mg pot ⁻¹				Mean
	0 t ha ⁻¹	2.5 t ha ⁻¹	5 t ha ⁻¹	7.5 t ha ⁻¹	
0 IU	135.85	228.40	282.84	303.85	237.74
1200 IU	173.11	221.71	258.55	298.64	238.00
2400 IU	194.29	222.67	280.50	330.51	256.99
3600 IU	242.21	250.97	292.56	354.75	285.12
Mean	186.37	230.94	278.61	321.94	
	P		F		P × F
SE ±	7.183		7.183		14.366
CD at 5%	20.786		20.786		NS

I) Nitrogen uptake:

Table 6: Effect of Phytase and FYM Levels on Nitrogen, Phosphorus and Potassium Uptake of Soybean (Grain) at Harvest

FYM (F) Phytase (P)	mg pot ⁻¹				Mean
	0 t ha ⁻¹	2.5 t ha ⁻¹	5 t ha ⁻¹	7.5 t ha ⁻¹	
0 IU	534.08	587.77	602.18	689.09	603.28
1200 IU	570.20	655.96	659.04	697.74	645.74
2400 IU	676.87	712.55	716.34	780.81	721.64
3600 IU	711.26	750.77	801.95	757.50	755.37
Mean	623.10	676.76	694.88	731.29	
	P		F		P × F
SE ±	4.029		4.029		8.058
CD at 5%	11.659		11.659		23.318

II). Phosphorus Uptake

FYM (F) Phytase (P)	mg pot ⁻¹				
	0 t ha ⁻¹	2.5 t ha ⁻¹	5 t ha ⁻¹	7.5 t ha ⁻¹	Mean
0 IU	50.42	78.31	84.94	97.20	77.72
1200 IU	68.36	88.03	94.83	99.84	87.77
2400 IU	83.67	88.80	95.78	115.18	95.86
3600 IU	97.17	97.72	121.96	128.08	111.23
Mean	74.91	88.21	99.38	110.08	
	P		F		P × F
SE ±	3.958		3.958		7.915
CD at 5%	11.452		11.452		22.905

III). Potassium Uptake

FYM (F) Phytase (P)	mg Pot ⁻¹				
	0 t ha ⁻¹	2.5 t ha ⁻¹	5 t ha ⁻¹	7.5 t ha ⁻¹	Mean
0 IU	50.69	52.58	70.32	101.63	68.81
1200 IU	62.87	65.16	79.21	94.54	75.45
2400 IU	69.08	82.98	95.95	111.00	89.75
3600 IU	74.66	92.87	103.39	114.72	96.41
Mean	64.33	73.40	87.22	105.47	
	P		F		P × F
SE ±	0.674		0.674		1.347
CD at 5%	1.949		1.949		3.898