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Crop Performance and Estimation of the Effective Level of Phosphorus in Sesame (*Sesamum indicum* L.)

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Abstract: The experiment was conducted at the Regional Agricultural Research Station, Ishurdi during early *kharif* (summer) season of 2008 and 2009 to observe the crop performance under variable phosphorus levels and to estimate the optimum and economic levels of phosphorus for yield of sesame. Five phosphorus levels viz. 0, 30, 60, 90 and 120 kg ha^{-1} (P_0, P_{30}, P_{60}, P_{90} and P_{120}) were selected as treatments. The highest seed yield of sesame was 1290-1366 kg ha^{-1} at P_{90} contributed by higher yield contributing characters like number of branches plant^{-1} (3.98-4.26), number of capsules plant^{-1}(65.15-81.40), length of capsule (2.51-2.54 cm) and 1000-seed weight (3.22-3.25 g). Moreover, 90 kg ha^{-1} of phosphorus application gave the highest monetary advantage in respect of gross return (Tk. 59760.00 ha^{-1}) and gross margin (Tk. 2814.00 ha^{-1}). By using the developed functional relationship ($Y=872.50+7.87x-0.0428x^2$, $R^2=0.91$)) between yield of sesame and applied phosphorus level the estimation of optimum and economic levels of phosphorus were 92 and 63 kg ha^{-1}, respectively.

Key words: Sesame · Phosphorus · Crop yield · Fertilizer management · Oilseed

INTRODUCTION

Sesame (*Sesamum indicum* L.) is an important source of edible oil has diverse nutritive values. It is one of the popular oilseeds in Bangladesh which occupies the second position after mustard among the edible oils [1]. Total area coverage of sesame is 87,000 hectares with an annual production of 88,000 metric tones [2]. It has multiple uses for mixing with various food items. Sesame oil is used as hair tonic from very old age in the country. Therefore, it is traditionally cultivated in the different parts of Bangladesh. The yield of sesame is much lower in the farmers' field as compared to the research field. The yield of sesame can be increased in adopting modern production technologies. Nutrient management is very important for yield improvement of crop [3, 4]. Phosphorus is an important plant nutrient which helps in growth and development of plant and ultimately improved crop yield. It involves in many biochemical functions in the physiological system of plant. It is essential parts of skeleton of plasma membrane, nucleic acid, many coenzymes, organic molecules and phosphorylated compounds in plant system [5]. Phosphorus has very important capacity of forming energy bonds within the plant through such materials as adenosine diphosphate and adenosine triphosphate [6]. It plays an important role in energy transfer reactions and oxidation reduction process. Lack of phosphorus therefore hampers metabolic process such as the conversion of sugar into starch and cellulose. Phosphorus is mostly concentrated in the reproductive organ of plant contributing to seed development. A seed needs enough phosphorus and its deficiency therefore causes shriveled seed [6]. Thus phosphorus is an important nutrient for seed development and seed filling contributing to better yield formation [7]. Consequently, it increases seed yield of sesame especially under irrigation condition [8]. Therefore, the study was undertaken to observe the crop performance under variable phosphorus levels and to estimate the optimum and economic levels of phosphorus for yield of sesame.

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MATERIALS AND METHODS

The experiment was conducted at the Regional Agricultural Research Station, Ishurdi, Pabna (24° 8' 24" N and 89°4'11" E) during early *kharif* season of 2008 and 2009. The experiment was laid out in a randomized complete block design with four replications. The treatments were five phosphorus levels viz. 0, 30, 60, 90 and 120 kg ha^{-1} of phosphorus (P_0, P_{30}, P_{60}, P_{90} and P_{120}). The unit plot size was 5.0 m x 4.8 m. BARI Till 3 was on 15 March and harvested on 14-16 June for each year. Phosphorus was applied as per specification of the treatments. Other nutrients were applied @ 60-30-20-2-2 kg ha^{-1} of N-K-S-Zn-B. All P-K-S-Zn-B and half of N was applied as basal. The rest amount of N was top dressed at 30 DAE (Days after emergence). Weeding cum thinning was done at 15 DAE. The soil was sandy loam representing low to very low status of initial nutrient elements (total N=0.06%, available P=12 ppm, exchange K=0.17 meq/100 g soil, available S=0.88 ppm and available Zn=0.20 ppm). The crop received 357 and 286 mm rainfall during the growing season of 2008 and 2009 respectively. The maximum and minimum temperature varied from 20.1 to 41.3 °C and 18.0 to 41.5 °C during the growing season of 2008 and 2009, respectively. Data on yield and yield contributing characters of sesame were collected and analyzed statistically. Means were separated by DMRT. Agronomic efficiency of phosphorus application was calculated using the following formula [9]:

Agronomic efficiency (AE_P)= $\frac{Y_p - Y_o}{A_p}$;

Where,

AE_p=Agronomic efficiency for phosphorus application

Y_P= Yield of sesame at applied P level

Y_0=Yield of sesame without P application

A_P=Amount of P application for Y_P.

Optimum and economic levels of phosphorus was estimated using the flowing polynomial function generally stated as bellow:

$Y=a+bx-cx^2$, where Y= Yield of sesame (dependent variable), a=Intercept (constant) and b and c are the regression coefficients, x= applied phosphorus level (independent variable). From the function, optimum and economic level of phosphorus for sesame can be determined as follows [10]:

Optimum level of phosphorus for maximum yield of sesame (P_O) = $\frac{-b}{2c}$ (1)

Economic level of phosphorus for maximum profit (P_E) = $\frac{1}{2c}\left(\frac{R_P}{R_Y} - b\right)$ (2)

R_P and R_Y are the prices of the phosphorus and yield of sesame, respectively.

Prediction of yield was also estimated against optimum and economic phosphorus levels through developed functional relationship.

RESULTS AND DISCUSSION

Yield Contributing Characters and Yield of Sesame: All the studied characters of sesame varied significantly among the applied phosphorus levels except plant population and seeds $capsule^{-1}$ in both the years (Table 1 and Table 2). Plant height (91-99 cm) and branches $plant^{-1}$ (3.92-4.28) were the highest in P_{60}, P_{90} and P_{120} while the lowest in P_0 in 2008 and 2009 (Table 1). Capsules $plant^{-1}$ (65.15-81.40) were the highest in P_{90} which was identical with P_{120} (65.02-76.83) followed by P_{60} but the lowest in P_0 in both the years. Similarly, increased number of branches and capsules $plant^{-1}$ were observed at higher level of phosphorus by Ojikpong *et al.* [11]. Length of capsule was the highest (2.51-2.54 cm) in P_{90} and P_{120} followed by P_{60} and P_{30} producing the lowest in P_0 for both the years of 2008 and 2009 (Table 2). Weight of 1000-seed was the highest in P_{90} (3.22-3.25 g) which was identical with P_{120} (3.15-3.17 g) followed by P_{60} and P_{30} but the lowest in P_0 for each year. Sharar *et al.* [4] also observed increased 1000-seed weight in higher level of P application. Seed yield was the highest in P_{90} (1290-1366 kg ha^{-1}) which was statistically at par with P_{120} (1286-1355 kg ha^{-1}) followed by P_{60} and P_{30} while the lowest in P_0 in both the years. The higher level of phosphorus improved yield contributing characters contributing to higher seed yield of sesame. Similar results also have been reported by Sahrawat and Islam [7] and BARI [12].

Yield Increase and Agronomic Efficiency for Phosphorus Application: Sesame yield increased in applied P levels showing higher trend in higher levels of P application (Table 3). The results are in conformity with the findings of Sahrawat and Islam [7]. However, P_{90} gave the highest average yield increase (52.44%) followed by P_{120} (51.60 %) while the lowest in P_{30}. Yield increase over control showed

Table 1: Plant population, plant height, branches plant^{-1}, capsules plant^{-1} of sesame as influenced by phosphorus level

Phosphorus level	Population m^{-2} (no.)		Plant height (cm)		Branches plant^{-1} (no.)		Capsules plant^{-1} (no.)	
	2008	2009	2008	2009	2008	2009	2008	2009
P_0	61	59	61c	60c	3.41c	3.29c	40.08d	45.85d
P_{30}	61	60	88b	85b	3.83b	3.63b	52.89c	53.85c
P_{60}	63	59	97a	91a	4.02a	3.92a	58.28b	65.77b
P_{90}	62	58	98a	92a	4.26a	3.98a	65.15a	81.40a
P_{120}	61	61	99a	93a	4.28a	3.99a	65.02a	76.83a
CV (%)	7.2	5.98	5.48	3.85	5.32	4.23	3.84	4.71

Similar letter (s) within the column do not differ significantly at 0.05 level of probability

Table 2: Length of capsule, seeds capsule^{-1}, 1000-seed weight and seed yield of sesame as influenced by phosphorus level

Phosphorus level	Length of capsule (cm)		Seeds capsule^{-1} (no.)		1000 seed wt. (g)		Seed yield (kg ha^{-1}.)	
	2008	2009	2008	2009	2008	2009	2008	2009
P_0	2.00c	2.02c	73	73	2.56c	2.23c	824c	921c
P_{30}	2.31b	2.24b	73	73	2.94b	2.65b	1098b	1128b
P_{60}	2.35b	2.32b	74	73	3.03b	2.73b	1193b	1264b
P_{90}	2.54a	2.51a	75	74	3.25a	3.22a	1290a	1366a
P_{120}	2.54a	2.53a	74	74	3.17a	3.15ab	1286a	1355a
CV (%)	3.78	4.15	2.53	3.01	2.46	3.01	14.85	4.34

Similar letter (s) within the column do not differ significantly at 0.05 level of probability

Table 3: Yield increase and agronomic efficiency of P application in sesame

Phosphorus level	Yield increase (%) over control			Agronomic efficiency (kg ha^{-1})		
	2008	2009	Mean	2008	2009	Mean
P_0	-	-	-	-	-	-
P_{30}	33.25	22.48	27.87	9.13	6.90	8.02
P_{60}	44.78	37.24	41.01	6.15	5.72	5.94
P_{90}	56.55	48.32	52.44	5.18	4.94	5.06
P_{120}	56.07	47.12	51.60	3.85	3.62	3.74

higher values in 2008 than in 2009. This was happened due to lower seed yield of control treatment in 2008 over 2009. Agronomic efficiency was higher in P_{30} (6.90-8.02 kg seed yield per kg application of P) followed P_{60} and P_{90} while the lowest in P_{120}. Agronomic efficiency for P application reduced in higher levels. The average agronomic efficiency ranged from 3.74 to 8.02 kg seed yield per kg application of P.

Functional Relationship Between Seed Yield and Applied Phosphorus Level: The functional equation of $Y=872.50+7.87x-0.0428x^2$ ($R^2=0.91$) was well fitted showing a second degree polynomial function (Fig. 1). The coefficient of determination representing $R^2=0.91$ expressed the yield response of sesame about 91% due to P application. Sesame yield increased 7.87 kg ha^{-1} due to application of 1 kg ha^{-1} of phosphorus. The results are in agreement with the findings of Ullah *et al.* [13] and Mian [14].

Optimum and Economic Level of Phosphorus: By using the developed function, the optimum and economic levels of P were 92 and 63 kg ha^{-1}, respectively (Table 4). The predicted yields of sesame were 1234 and 1198 kg ha^{-1} against the optimum and economic levels of P. Similar prediction was also estimated by using the functional relationship in wheat by Hasan [15].

Table 4: Optimum and economic levels of P and predicted yield of sesame under estimated level

Estimation of P	Estimated level of phosphorus (kg ha^{-1})	Predicted yield (kg ha^{-1})
Optimum level	92	1234
Economic level	63	1198

Table 5: Economic performance of sesame as influenced by phosphorus level

Phosphorus level	Cost of cultivation (Tk.ha^{-1})	Gross return (Tk.ha^{-1})	Gross margin (Tk.ha^{-1})	Benefit cost ratio (BCR)
P_0	21720.00	39263.00	17543.00	1.80
P_{30}	25020.00	50085.00	25065.00	2.00
P_{60}	28320.00	55283.00	26963.00	1.95
P_{90}	31620.00	59760.00	28140.00	1.89
P_{120}	34920.00	59423.00	24503.00	1.70

1 USD = Aprox. 72 Tk.

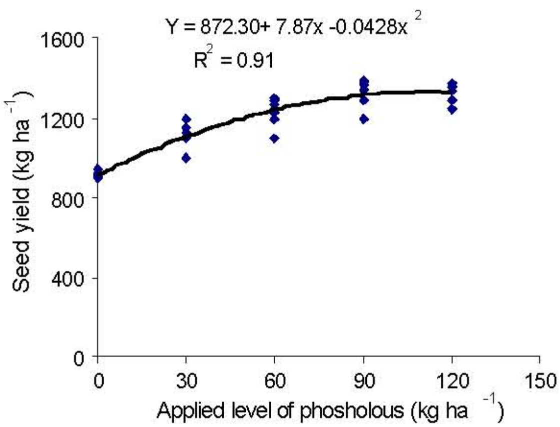

Fig. 1: Functional relationship between seed yield of sesame and applied level of phosphorus

Economic Performance: The cost of cultivation was higher in higher level of P due to more cost involvement for higher amount of P application (Table 5). Gross return was the highest (Tk. 59760.00 ha^{-1}) in P_{90} followed by P_{120} (Tk. 59423.00 ha^{-1}) while the lowest in P_0. Similar trend was also observed in the case of gross margin showing the highest in P_{90} (Tk. 28140.00). The highest seed yield of sesame in P_{90} produced the highest gross return and gross margin. The results have been supported by the findings of Mian (2008). The highest BCR was in P_{30} (2.00) followed by P_{60} (1.95) while the lowest in P_{120}. BCR reduced as the increasing level of phosphorus application. This was occurred due to higher cost involvement at higher level of P application. The results are in conformity with the findings of Mian [14].

Two years experimental results (2008 and 2009) indicates that P_{90} is the best for producing the highest seed yield giving the highest gross return and gross margin. According to prediction, phosphorus 92 kg ha^{-1} is optimum for the highest yield of sesame and 63 kg ha^{-1} is the best maximum profit at Iswardi region of Bangladesh.

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