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Performance of summer sesame (*Sesamum indicum* L.) and estimation of economic and optimum doses of nitrogen and phosphorus in red and laterite soils of West Bengal

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ABSTRACT

A field experiment was conducted at the Regional Research Substation, Sekhampur, Birbhum, Bidhan Chandra Krishi Viswavidyalaya, West Bengal during early summer of 2009 and 2010 to study the performance of sesamum grown with variable rates of N and P levels and to compute the optimum and economic levels of the applied nutrients. The treatments comprised of four levels each of N (0, 20, 40 and 80 kg ha^{-1}) and P (0,10,20 and 40 kg ha^{-1}) laid out in a factorial randomized complete block design with three replications. Increasing the application rates of N and P enhanced the number of seeds/capsule, number of capsules/plant and thousand grains weight. The highest average mean seed yields were obtained with 80 kg ha^{-1}N (953 kg ha^{-1}) and 40 kg ha^{-1}P (857 kg ha^{-1}).The agronomic efficiencies were highest with lower application rates of N (16.3 kg kg^{-1} of N) and P (22.6 kg kg^{-1} of P). The relationship between the applied amounts of N and P with sesamum yield was defined by quadratic functions. The estimated optimum levels of N and P were 72 and 36 kg ha^{-1}while the economic levels were 61 and 35 kg ha^{-1}respectively.

Keywords*:* Economic and optimum yield, nitrogen, phosphorus, sesame

Sesame (*Sesamum indicum* L.), an indigenous oil producing crop, has the longest history of cultivation in India. Increasing global demand has opened up prospective market options for sesame. Although India is still the world leader contributing 25% of the production from the largest acerage of 29.8% of the world, there is much scope for enhancing sesame production. Proper fertilizer application is commonly not practiced in the traditional sesame growing areas. Consequently, the economic viability of sesame cultivation suffers a great degree of uncertainty in the major growing states including West Bengal. Proper nutrient management is considered to be a major contributing factor in the yield performance of crops (Campbell *et al*., 2005).Applications of N and P fertilizers were reported to enhance sesame yield (Subhramanian *et al*., 1979). Soils of the dry and lateritic tracts of West Bengal are inherently low in organic carbon, N and P as well as other secondary and plant micro nutrient elements (Motsara, 2002). Moreover, low capital investing capacity of the farming community in the region is also one of the constraints. Considering the spiraling increase in fertilizers cost and, on the other hand, not so commensurate increase in market prices of the produces, indiscriminate application of plant nutrient supplements, more specifically N and P will result in loss rather than profit for the producer (Engel and Bergman, 1997). In agriculture, there is a strong need for advice on fertilizer rates that is specific for individual sites and crop types (Reid, 2002). Refinement of on-site nutrient management has led to the initiation of the present study. The purpose of this study was to ascertain the optimum and economic levels of N and P for sesamum cultivation under dry land conditions.

MATERIALS AND METHODS

The two years field trial were conducted at the RRSS, Sekhampur, BCKV, Birbhum during the early summer seasons of 2009 and 2010 to determine the effect of N and P nutrients on the performance of sesame (cv. B-57) during the early summer seasons of 2009 and 2010 were conducted at the RRSS, Sekhampur, BCKV, Birbhum. Each year the different experimental fields, kept under fallow for 2 years, distanced at 80 m, were chosen for the trial. Composite soil samples were drawn from the fields and analysed for the physico-chemical properties by standard analytical procedures (Jackson, 1967). The treatments consisting of four N levels (0, 20, 40 and 80 kg ha^{-1}) and four P levels (0, 10, 20 and 40 kg ha^{-1}) were laid out in a completely randomized factorial block design with each treatment combination replicated thrice in plots of size 5 × 5m^2. Sesame was sown on February 16 and 21 in 2009 and 2010 respectively after proper land preparation with spacing of 30 cm within rows and 10 cm between plants. Half of the N and full dose of P were applied in the form of urea and single super phosphate as basal, respectively. The rest half of N was top dressed at 30 days after emergence (DAE). All the plots received a blanket basal application of 30 kg K ha^{-1} in the form of muriate of potash. Weeding and thinning were done at 15 DAE. Biometric observations on plant height, number of branches plant^{-1}, number of seeds capsule^{-1} and 1000-seeds weight were recorded

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from 10 representative samples from each plot. The yield plot^{-1} was recorded from plant samples in an area, excluding two border rows and converted into yield ha^{-1} on June 20, 2009 and June 27, 2010. The data were analysed statistically in a factorial randomized block design using SPSS (ver 11.0) statistical software package. The treatment means were separated using Fisher's critical difference (Gomez and Gomez, 1984). The Agronomic efficiency (AE) **(c**rop yield increase per unit kg grain kg^{-1} nutrient) was calculated using the formula as given below:

AE = $(GY_{(xr)} - GY_{(c)})/R_{(xr)}$ where, $GY_{(xr)}$= grain yield (kg ha^{-1}) of treatment receiving fertilizer nutrient at rate r; GY(c) : grain yield (kg ha^{-1}) of the control treatment ; R (xr) : rate of fertilizer (x) application (kg ha^{-1}) (Prasad and van Keulen, 2003).

The optimum and economic levels of N and P for both the years were estimated by the best fit model, i.e. quadratic model which defined the yield-fertilizer relation best among the linear, quadratic, square root and Mitscherlich equations. The polynomial function used was: $Y= a+bx+cx^2$ where Y is the yield of sesame (dependent variable) and a, b and c are regression coefficients while x is dose (kg ha^{-1}) of the applied nutrient The economic decision rule for optimizing input is a function of three variables: the marginal contribution of the input to output as measured through production function and the prices of input and output. Differentiating Y with respect to N and P doses of the regression model give the doses for maximum yield which is estimated by the equation $P_{max} = - b/2c$. The equation for economic dose for maximum profit is $E = 1/2c\ (P_s/P_{NU} - b)$ where P_s and P_{NU} are prices of sesame seed and nutrients respectively (Colwell, 1994). The unit price of sesamum was taken as Rs 26.50 per kg as the two years average value. The two year average prices of N and P were Rs 11.65 and Rs 34.85 respectively.

RESULTS AND DISCUSSION

Data obtained on the effects of N and P on yield attributing characters of sesame are presented in table- 1. There were significant increases in plant height with incremental doses of N and P. Sesame plants attained maximum height of 87.0 cm (2009) and 78.2 cm (2010) when N was applied at 80 kg ha^{-1} in contrast to that of 63.2 cm (2009) and 58.2 cm (2010) in the control treatment. Application of P at 40 kg ha^{-1} registered the tallest plants (86.0 cm in 2009 and 77.8 cm in 2010) among the treatments. Better vegetative growth promoted by increasing N application rates was reported by Malik *et al*. (1998).

There was remarkable increase in number of branches plant^{-1} with the application of 40 kg (5.9 in 2009 and 5.3 in 2010) and 80 kg N ha^{-1} (6.6 in 2009 and 5.5 in 2010) than 20 kg (3.7 in 2009 and 3.3 in 2010) and 0 kg N ha^{-1} (2.8 in 2009 and 2.7 in 2010). Application of 40 kg P ha^{-1} produced the most number of branches plant^{-1} (4.8 in both the years) which was statistically similar to the other treatments including the control treatment in 2009 and that of 10 and 20 kg P ha^{-1} in 2010. There was distinct increase in number of capsules plant^{-1} with higher application rates of N and P. The highest and statistically significant number of capsules plant^{-1} was obtained with 80 kg N ha^{-1} (51 in 2009 and 44 in 2010) and 40 kg P ha^{-1} (50 in 2009 and 41 in 2010) among the other application rates.

The increase in number of capsules/plant resulted from increased availability of N and P with higher doses of application of the nutrients enhancing the vegetative growth leading to improved fruiting (Sharma and Kewat, 1995). Application of incremental doses of N and P increased the number of seeds/capsule but there were no statistical differences between 40 and 80 kg N ha^{-1} during both the years and 20 and 40 kg P ha^{-1} in 2010. The most number of seeds capsule^{-1} could be obtained with 80 kg N ha^{-1} (59 in 2009 and 54 in 2010) and 40 kg ha^{-1} (61 in 2009 and 52 in 2010). Better plant growth with higher N application rates might have resulted in increasing the number of seeds capsule^{-1}. This is in line with the findings of Malik *et al.* (2003). The 1000-grains weight increased significantly with the increase in doses of N and P in 2009 but was statistically similar in 2010. This is in conformity with the observations of Mankar *et al*. (1995) and Sharar *et al*. (2002) who reported increase in 1000-grains weight with elevated levels of N and P applications.

There was distinct enhancement of seed yield as the doses of N and P were increased during both the years of study (Table 2). The highest and statistically significant increases were manifested with 80 kg N ha^{-1} (989 kg ha^{-1} in 2009 and 912 kg ha^{-1} in 2010) and 40 kg P ha^{-1} (901 kg ha^{-1} in 2009 and 814 kg ha^{-1} in 2010). The average increases in seed yield with 80 kg N ha^{-1} were 36.0, 27.1 and 14.55 % over 0, 20 and 40 kg N ha^{-1}, while that of 40 kg ha^{-1} were 9.45, 23.28 and 30.1% respectively over the controls. The maximum seed yield with 80 kg N ha^{-1} was due to the combined effect of improvement in the yield components. Parihar *et al*. (1999) and Tiwari *et al*. (2000) also observed higher seed yield with increased N application rates. Application of 40 kg P ha^{-1} exhibited augmentation of yield components and seed yield because good supply of P promotes root proliferation and density which in turn aids in exploration and more supply of nutrients and water to the growing parts. The observed increase in yield due to higher P application rates was consistent with Shehu *et al*. (2010) but at variance with Muhammam *et al*. (2009) who reported increase in yield with 45 kg P ha^{-1} but was not statistically significant.

Table 1: Effect of N and P application on growth and yield parameters of sesame

Treatment	Plant height (cm)		Branches plant^{-1}		Capsules plant^{-1}		Seeds capsule^{-1}		1000-seeds weight (g)	
	2009	**2010**	**2009**	**2010**	**2009**	**2010**	**2009**	**2010**	**2009**	**2010**
N levels (kg ha^{-1})										
N0	63.2	58.2	2.8	2.7	31	24	49	37	2.25	1.97
N20	73.5	65.7	3.7	3.3	34	31	52	41	2.42	2.04
N40	80.3	74.0	5.9	5.3	43	36	55	49	2.53	2.12
N80	87.0	78.2	6.6	5.5	51	44	59	54	2.69	2.43
LSD (0.05)	**3.93**	**7.17**	**0.71**	**0.72**	**2.91**	**3.08**	**3.18**	**5.16**	**0.103**	**N.S**
P levels (kg ha^{-1})										
P0	65.5	60.4	4.3	3.6	30	26	47	39	2.23	1.99
P10	72.6	65.2	4.5	3.9	37	31	52	42	2.31	2.05
P20	80.0	72.7	4.8	4.5	42	36	55	47	2.52	2.12
P40	86.0	77.8	4.8	4.8	50	41	61	52	2.84	2.41
LSD (0.05)	**3.93**	**7.17**	**0.71**	**0.72**	**2.91**	**3.08**	**3.18**	**5.16**	**0.10**	**NS**
Interaction (N × P)	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

Table 2: Yield of sesame and agronomic efficiency of different N and P application rates

Treatment	Seed yield (kg ha^{-1})		Increase over control (%)	Agronomic efficiency (kg seed kg^{-1} nutrient applied)
	2009	**2010**		
N levels (kg ha^{-1})				
N0	336	388	-	-
N20	667	710	14.66	16.30
N40	778	833	27.10	11.07
N80	917	989	36.00	7.38
LSD (0.05)	**39.3**	**71.7**		
P levels (kg ha^{-1})				
P0	472	498	-	-
P10	692	732	9.45	22.60
P20	719	789	21.28	13.45
P40	815	901	30.10	9.30
LSD (0.05)	**39.3**	**71.7**		
Interaction (N × P)	**NS**	**NS**		

Note: NS = Not significant

The average agronomic efficiency (AE) ranged from 7.38 to 16.3 and 9.3 to 22.6 kg seed per kg of N and P respectively (Table 2). Lower rates of N and P applications showed higher agronomic efficiencies. Reduction in agronomic efficiency with higher P application rates was also reported by Mian *et al*. (2011). The regression equations $Y= 376.99 + 15.77x – 0.11x^2$ ($R^2 = 0.98$) for N and $Y = 500.84 + 19.66x – 0.27x^2$ ($R^2 = 0.95$) for P were well fitted showing a second degree polynomial function (Fig. 1 and 2). About 98 and 95 % variation in sesame yield could be explained by the applications of N and P respectively. Deriving from the equations the optimum levels of N and P were 72 and 36 kg ha^{-1} with predicted yield levels of 942 and 857 kg ha^{-1} respectively. On the other hand, the estimated economic levels were 61 kg ha^{-1} and 35 kg ha^{-1} with predicted yield levels of 929 kg ha^{-1} and 858 kg ha^{-1} for N and P, respectively.

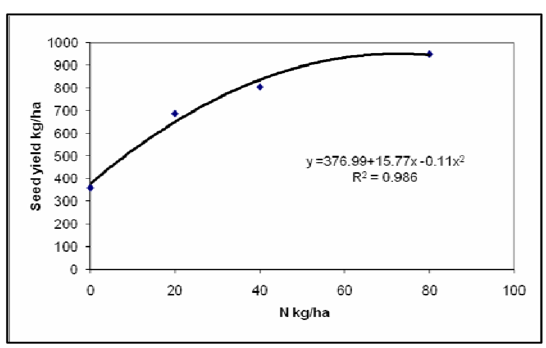

Fig. 1: Relationship between seed yield of sesame and N levels

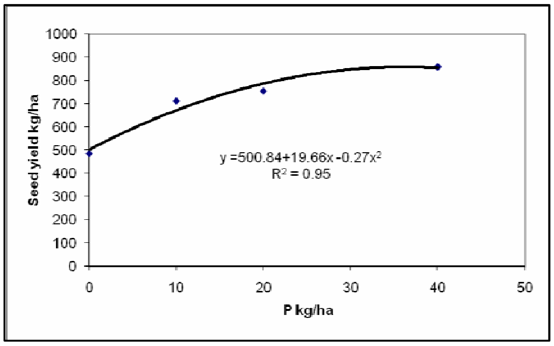

Fig. 2: Relationship between seed yield of sesame and P levels

Results from the present study indicate that the best performance of sesame could be obtained with application of 80 kg N and 40 kg P ha^{-1}. However, it would be rational to apply 61 and 35 kg ha^{-1} N and P, respectively in terms of economical return in the dry and laterite tracts of West Bengal.

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