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National Academy of Agricultural Science (NAAS) Rating : 3. 03

"Effect of Nitrogen, Phosphorus and Biofertilizers on Growth, Yield and Quality of Summer Sesamum [*Sesamum indicum* L.]"

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ABSTRACT: *A field experiment was conducted in factorial randomized block design with three replications during the summer season of 2010 at the college of Agricultural Junagadh (Gujarat). The experiment consisting eighteen (18) treatments combinations comprising of three levels of nitrogen (0, 25 and 50 kg N ha^{-1}), three levels of phosphorus (0, 25 and 50 kg P_2O_5 ha^{-1}) and two levels of biofertilizers (no inoculation and seed inoculation with* Azotobacter + *PSB). The result revealed that better crop yield with higher net return can be obtained from summer sesamum by fertilizing the crop with 50 kg N ha^{-1} and 50 kg P_2O_5 ha^{-1} in the medium black calcareous soil of South Saurashtra Agro climatic region.*

Key words: *Nitrogen, Phosphorus, Biofertilizers and Summer Sesamum.*

India is the world leader with maximum production (25.8%) from the largest area (29.3%) and highest export (40%) of sesamum in the world (Duhoon *et al.*, 2004). The cultivated area of sesamum in Gujarat is about 3.00 lakh ha and production 1.41 lakh tonnes with average productivity of 470 kg ha^{-1} (Anon., 2008). This crop is generally cultivated as sole or mixed crop during *kharif* and semi-*rabi* season and now a day in summer season in all the districts of the state except Dangs and Valsad. The productivity of sesamum under summer season is two times more than *kharif* season. In recent years, crop cultivation requires the use of chemical fertilizer, but it is expensive for people who have not capacity to buy fertilizer. Now a day, more attention has been given to biofertilizers with low energy requirement for easy establishment on plant roots.

Nitrogen is primary essential element required to increase agricultural production. It plays an important role in synthesis of chlorophyll and amino acids that contribute to the building unit of protein and thus growth of plants (Singh *et al.*, 2001). The deficiency of nitrogen results in yellowing of plant and stunted growth, which adversely affects the yield of crop, hence judicious use of this element is advocated. Beside nitrogen, phosphorus is the second most important plant nutrient and is the key element in the process of conservation of solar energy into chemical energy, stimulates root development and growth. The interaction between nitrogen and phosphorus are also found to be of greater significance in crop production. This interaction is often synergistic, occasionally additive and in some cases can be antagonistic as revealed by available results of research (Biswas and Prasad, 1991).

Biofertilizers like *Azotobactor* and phosphate solubilising bacteria are widely suited as microbial inoculants for crops like sorghum, wheat, sesame etc. The beneficial effect of *Azotobacter* is attributed to its N-fixing capacity and also ability to produce growth promoting substances and antifungal antibiotics, which inhibits the growth of root pathogens. Phosphorus solubilizing bacteria (PSB) solubilize the unavailable bound phosphates of the soil and make them available to plants which increase overall plant growth resulting in 10 to 15 per cent increase in yield.

Information on the effect of inorganic fertilizers like nitrogen and phosphorus and biofertilizers is not well documented especially for summer season in South Saurashtra region.

A field experiment was conducted during the summer season of 2010 at the college of Agricultural Junagadh. The soil of experimental plot was Clayey in texture, low in nitrogen, medium in phosphorus and potassium and alkaline in reaction with pH of 7.9 with good drainage. The experiment was laid out

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in factorial randomized block with three replication. There were 18 treatment combinations comprising of three levels of nitrogen (0, 25 and 50 kg N ha^{-1}), three levels of phosphorus (0, 25 and 50 kg P_2O_5 ha^{-1}) and two levels of biofertilizers (no inoculation and seed inoculation with *Azotobacter* + PSB). The seeds of sesamum GT-2 were sown manually in previously fertilized opened furrow at the depth of 3 to 5 cm with spacing of 30 cm x 10 cm on 22nd February 2010. The seeds were treated with mixture of *Azotobacter chroccocum* and *Pseudomonas striate* at the rate of 600 g per 3 kg seeds. The biometric observations for growth and yield attributing characters were taken at 30 DAS, 45 DAS, 60 DAS and at harvest stage of crop by randomly selected five plants per plot. Oil content in sesamum seed was estimated by Nuclear Magnetic Resonance (NMR) determined oil content in seed as per the method suggested by Tiwari *et al*., (1974). The protein content was estimated nitrogen percentage by micro-kjeldhal method (AOAC, 1972) and protein content was worked out using factor 6.25. Data obtained on various variables were analyzed by analysis of variance method (Panse and Sukhatme, 1985).

RESULT AND DISCUSSION

Effect of Nitrogen on growth parameters

The data presented in (Rable 1) indicated that the application of nitrogen significantly observed highest plant height at harvest. The highest plant height was recorded with the application of nitrogen @ 50 kg ha^{-1} as compared to control (N_0). The increase in plant height was recorded through-out the crop growth span. The increase in plant height with increased nitrogen levels would be attributed to favourable effect of nitrogen in increasing cell wall material resulted in increased size of cell which in turn expressed morphologically as increased plant height. Enhance vegetative growth under the influence of nitrogen application was also observed by Mondal *et al*., (1997), Pathak *et al*., (2002), Singh *et al*., (2006) and Duary and Mandal (2006).

The results pertaining to number of branches per plant (Table 1) indicated that the varying levels of nitrogen exhibited their significant effect on number of branches per plant at harvest up to 50 kg N ha^{-1}. This might be due to favourable influence of nitrogen in produces cell division and cell elongation which promoted vegetative growth and ultimately increased number of branches per plant. These results are already in agreement with those reported by Subramaniyan and Arulmozhi (1999), Pathak *et al*., (2002) and Singh *et al*., (2006).

Effect on yield attributes and yield

Nitrogen is essential for vegetative and reproductive growth, being a major structural constituent of cell. Yield attributes of crop which decide the crop yield are function of vegetative build up of a crop and partitioning of photosynthesis between basic selection of plant and yield attributes. The results pertaining to yield attributing character (Table 1) showed that fertilizing the crop with nitrogen significantly improved the yield attributes like number of capsules per plant, length of capsule, number of seeds per capsule, seed weight per plant and test weight (1000-seed weight) of sesamum crop. The application of nitrogen @ 50 kg ha^{-1} remarkably increased number of capsules per plant (46.19), length of capsule (2.07 cm), number of seeds per capsule (62.66), seed weight per plant (4.00) and 1000-seed weight (2.87 g) as compared to without nitrogen application. Nitrogen had increased photosynthetic activity during the reproductive phase and activity channelized the

Table 1
Growth/yield attributing characters as influenced by Nitrogen, Phosphorus and Biofertilizers

Treatments	*Plant height (cm)*	*Number of branches*	*Number of capsules per plant*	*Length of capsule (cm)*	*Number of seeds per capsule*	*Seed weight per plant (g)*	*1000-seed weight (g)*
Nitrogen (kg N ha^{-1})							
N_0	69.61	2.05	34.16	1.88	49.44	2.83	2.67
N_{25}	71.50	3.12	45.16	1.90	58.02	3.37	2.74
N_{50}	76.00	3.60	46.19	2.07	62.66	4.00	2.87
S.Em.±	1.10	0.06	0.76	0.02	0.90	0.06	0.02
C.D. at 5 %	3.18	0.19	2.20	0.08	2.64	0.18	0.08
Phosphorus (kg P_2O_5 ha^{-1})							
P_0	70.16	2.52	37.66	1.88	53.05	3.15	2.66
P_{25}	72.55	3.04	41.66	1.93	57.97	3.37	2.78
P_{50}	74.38	3.22	46.19	2.04	59.11	3.68	2.84
S.Em.±	1.10	0.06	0.76	0.02	0.90	0.06	0.02
C.D. at 5 %	3.18	0.19	2.20	0.08	2.64	0.18	0.08
Biofertilizer inoculation							
B_0 (No inoculation)	73.88	2.85	41.27	1.94	56.51	3.33	2.75
B_1 (*Azotobacter* + PSB)	74.90	3.00	42.40	1.95	56.90	3.47	2.77
S.Em. ±	0.90	0.05	0.62	0.02	0.74	0.04	0.02
C.D. at 5 %	NS	NS	NS	NS	NS	NS	NS
Interaction							
N × P	NS	Sig.	Sig.	Sig.	Sig.	Sig.	NS
N × B	NS	NS	NS	NS	NS	NS	NS
P × B	NS	NS	NS	NS	NS	NS	NS
N × P × B	NS	NS	NS	NS	NS	NS	NS
C.V. %	6.49	9.63	7.78	8.38	6.79	7.49	3.21

photosynthates accumulated during the vegetative phase to the sink. The results were also accordance with the findings of Mondal *et al*., (1997), Mitra and Pal (1999), Subramaniyan and Arulmozhi (1999), Prakasha *et al*., (2001), Pathak *et al*., (2002), and Duary and Mondal (2006) on sesamum crop.

Application of nitrogen brought about significant variation in seed yield of sesamum (Table 2). Fertilizing crop with 50 kg N ha^{-1} produced appreciably higher seed yield of sesamum to the extent of 8 and 18 per cent over 25 kg N and no nitrogen application respectively. This might be due to improvement in growth characters that favorably modified the yield attributes *viz*., number of capsules per plant, length of capsule and number of seeds per capsule (Table 1). Among them nitrogen plays an important role in plant metabolism by virtue of being an essential constituent of diverse types of metabolically active compounds like amino acids, proteins, nucleic acid, enzymes, co-enzymes and alkaloids which are important for higher growth and yield. This increase in growth and yield attributes ultimately helped in realization of higher seed yield. These results are in corroboration with those reported by Mitra and Pal (1999), Prakash *et al*., (2001), Pathak *et al*., (2002), Duary and Mandal (2006) and Sarkar and Saha (2006).

Table 2
Yield and quality of Sesamum as influenced by Nitrogen, Phosphorus and Biofertilizers

Treatments	*Seed yield (g/plant)*	*Seed yield (kg ha^{-1})*	*Stover yield (kg ha^{-1})*	*Harvest index (%)*	*Oil content (%)*	*Protein content (%)*
Nitrogen (kg N ha^{-1})						
N_0	2.83	765	979	43.91	50.50	26.73
N_{25}	3.37	823	1062	43.62	51.25	26.87
N_{50}	4.00	902	1108	44.83	52.30	27.39
S.Em.±	0.06	22.48	17.98	0.62	0.64	0.18
C.D. at 5 %	0.18	64.67	51.73	NS	1.84	0.54
Phosphorus (kg P_2O_5 ha^{-1})						
P_0	3.15	780	1010	43.59	50.06	26.45
P_{25}	3.37	845	1050	44.53	51.40	27.01
P_{50}	3.68	865	1088	44.23	52.70	27.53
S.Em.±	0.06	22.48	17.98	0.62	0.64	0.18
C.D. at 5 %	0.18	64.67	51.73	NS	1.84	0.54
Biofertilizer inoculation						
B_0 (No inoculation)	3.33	819	1039	44.03	51.25	26.87
B_1(*Azotobacter* + PSB)	3.47	841	1060	44.21	51.57	27.13
S.Em.±	0.04	18.35	14.68	0.51	0.52	0.15
C.D. at 5 %	NS	NS	NS	NS	NS	NS
Interaction						
N × P	Sig.	Sig.	Sig.	NS	NS	NS
N × B	NS	NS	NS	NS	NS	NS
P × B	NS	NS	NS	NS	NS	NS
N × P × B	NS	NS	NS	NS	NS	NS
C.V. %	7.49	11.49	7.21	6.02	5.28	2.95

Similarly stover yield was significantly influenced due to application of nitrogen. The results in respect of stover yield (Table 2) indicated that 50 kg N ha^{-1} increased stover yield conspicuously over no nitrogen application. This might be profound increase in plant height, number of branches per plant with increasing nitrogen levels (Table 1) resulted in higher stover yield. Appreciable higher N and P uptake by stover with higher levels of nitrogen (Table 2) might have favourably modified the plant growth and ultimately resulted in to higher stover yield. The finding lend support to the results of Shrivastava and Tripathi (1992), Tiwari *et al*., (2000), Prakash *et al*., (2001), Patel (2007) and Vaghani (2010).

Effect on quality parameters

The data presented in (Table 2) showed that the application of nitrogen produce significant effect on oil content and oil yield. The higher oil content (52.30 %) was recorded under the application of nitrogen @ 50 kg ha^{-1}. The results were agreement with Rao *et al*., (1993), Mankar *et al*., (1995), Dutta *et al*., (1996), Patra (2001) and Singh *et al*., (2006).

The higher value of protein content (27.39 %) was recorded with 50 kg N ha^{-1}. Higher content of protein in seed due to higher N level might be the reason for higher protein content as nitrogen is important element for improving protein content in seed of sesame as also reported by Mankar *et al*., (1995), Thakur *et al*., (1998) and Singh *et al*., (2006).

EFFECT OF PHOSPHORUS

Effect on growth parameters

An appraisal of data on growth parameters (Table 2) revealed that phosphorus fertilization significantly observed highest plant height at harvest (74.38 cm) observed under application of 50 kg P_2O_5 ha^{-1} as compared to no phosphorus application.

Similarly number of branches per plant at harvest was significantly influenced due to different levels of phosphorus (Table 4.3). The highest number of branches per plant at harvest (3.22) was observed under application of 50 kg P_2O_5 ha^{-1}. This might be due to favourable influence of phosphorus.

Application of higher dose of phosphorus (50 kg ha^{-1}) created a situation favourable for higher plant growth i.e. plant height and number of branches per plant. These results are conformity with result observed by Chaplot (1998), Muthusamy *et al*., (1999) and Patra (2001) in sesamum.

Effect on yield attributes and yield

Fertilizing the crop with phosphorus significantly increased yield attributes of sesamum crop (Table 2) over no phosphorus application. Application of phosphorus at 50 kg ha^{-1} remarkably increased number of capsules per plant (46.19), length of capsule (2.04 cm), number of seeds per capsule (59.11), seed weight per plant (3.68 g) and test weight (2.84 g) as compared to control. This might be attributed to the role played by phosphorus nutrition in metabolism of plant. Phosphorus is a structural element of certain co-enzymes like ATP, ADP and AMP which are involved in energy transfer and thus, improve photosynthesis process and Better growth might have produced and converted more photosynthates into numerious metabolites needed for such yield attributes. The results are in close proximity with these reported by, Puste and Maiti (1990), Prakasha and Thimmegowda (1992) and Thanki *et al*., (2004) in case of sesamum.

Application of phosphorus brought significant variation in seed and stover yields of sesamum (Table 2). The significant response in seed (865 kg ha^{-1}) and stover (1088 kg ha^{-1}) yield of sesamum were obtained under application of 50 kg P_2O_5 ha^{-1}. This increase in seed and stover yield of sesamum with higher level of phosphorus evidently resulted higher number of capsules per plant, length of capsule and number of seeds per capsule (Table 1). Among them phosphorus is a fascinating plant nutrient and involved in a wide range of plant processes from cell division to the development of good root system and ensuring timely and uniform ripening of the crop. It is needed mostly by young, fast growing tissues and performs a number of functions related to growth, development, photosynthesis and utilization of carbohydrates. It is constituent of ADP and ATP, two of the most important substances in life processes (Tandon, 1987). These all process favourably improved with higher rate of phosphorus and resulted into higher seed and stover yield of sesamum. The results obtain in present study are in close conformity with the findings of Khade *et al*. (1996), Chaplot (1998), Thakur *et al*., (1998) and Thanki *et al*., (2004) in case of sesamum crop.

Effect on quality parameters

Data presented in Table 2 showed that application of phosphorus to sesamum enhanced the oil content, and protein content. The significantly highest oil content (52.70 %) and protein content (27.53 %) recorded under application of 50 kg P_2O_5 ha^{-1}. Similar results were also obtained by Thakur *et al*., (1998), Patra (2001) and Thanki *et al*., (2004).

EFFECT OF BIOFERTILIZERS

Effect on growth parameters

Data presented in Table 1 revealed that none of the growth parameters of sesamum crop, like plant height and number of branches per plant differed significantly due to biofertilizers inoculation. The results are in conformity with the findings of Subbian and Chamy (1984).

Effect on yield attributes and yield

Among all the yield attributing characters *viz*, number of capsules per plant, length of capsule, number of seeds per capsule, seed weight per plant, test weight (Table 1) and seed yield, Stover yield as well as harvest index (Table 2) were affected and recorded maximum values as compared to no inoculation. However, inoculation with biofertilizers not attain up to significant levels in respect of yield attributes and yield of sesamum. The results are in conformity with the findings of Subbian and Chamy (1984), Arunachalam and Venkatesan (1984) and Ghosh and Mohiuddin (2000).

Effect on quality parameters

Data presented in Table 2 revealed that biofertilizers inoculation to sesamum seed recorded higher value but did not manifest its significant effect on oil content and protein content in sesamum seeds.

INTERACTION EFFECT OF NITROGEN, PHOSPHORUS AND BIOFERTILIZERS

The interaction effects between nitrogen and phosphorus were observed significant in respect of number of branches per plant (Table 1). Significant increase in number of branches per plant of sesamum was observed up under combination of nitrogen 50 kg ha^{-1} + phosphorus @ 50 kg ha^{-1}. This indicated that synergistic effects of nitrogen and phosphorus nutrients might be improving plant growth parameters. Increase in growth parameter also reported by Paul and Savithri (2003) and Imayavaramban *et al*., (2004).

A significant increase in respect of yield attributes and yield *viz*., number of capsules per plant, length of capsule (cm), number of seeds per capsule, seed weight per plant (g) (Table 1), seed and stover yields (kg ha^{-1}) (Table 2) with combine application of 50 kg N ha^{-1} and 50 kg P_2O_5 ha^{-1}. This indicated the synergistic effects of nitrogen and phosphorus application in improving productivity of sesamum. Increase in yield due to combine application of nitrogen and phosphorus was also reported by Duhoon *et al*., (2001), Sarala *et al*., (2002), Imayavaramban *et al*., (2004) and Sahoo *et al*., (2010) in sesame crop.

From the result it could be concluded that better crop yield with higher net return can be obtained from summer sesamum by fertilizing the crop with 50 kg N ha^{-1} and 50 kg P_2O_5 ha^{-1} in the medium black calcareous soil of South Saurashtra Agro climatic region.

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