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RESPONSES OF NAPHTHALENE ACETIC ACID AND *PSEUDOMONAS* INOCULUM ON GROWTH, YIELD AND SOME BIOCHEMICAL PARAMETERS OF SESAME (*SESAMUM INDICUM* L. VAR. BARI TIL-4)

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Abstract

An experiment was conducted to evaluate the responses of various concentrations of NAA (25, 50, 75 ppm) and *Pseudomonas* inoculum on growth, yield and some biochemical parameters of sesame (*Sesamum indicum* L. var. BARI Til-4). Results revealed that application of NAA treatments and *Pseudomonas* inoculum reduced plant height non-significantly. Significant result was recorded on number of branches per plants from 50 ppm NAA treated plants. Plants treated with 75 ppm NAA produced maximum number of leaves, fresh and dry weight of leaves and roots, leaf area per plant and specific leaf weight whereas significant variation was found on leaf area. Seeds treated with *Pseudomonas* inoculum exhibited maximum shoot and root ratio which showed non-significant variation with the results of NAA treated plants. Yield contributing parameters *viz.*, number of pods per plant, fresh and dry weight of pods per plant, 1000-seed weight were recorded maximum from 75 ppm NAA which were statistically similar to control. Maximum length of pod and number of seeds per pod were also recorded from 75 ppm NAA treated plants which eventually produced 32.54% higher yield than control. Harvest index was significantly influenced by all the treatments. Foliar NAA treatments and *Pseudomonas* inoculum had stimulatory effects on pigment contents of fresh leaves at vegetative stage where, *Pseudomonas* inoculum treated plants produced significantly higher chlorophyll a and carotenoids content than control. Significantly higher protein content of fresh leaves and seeds were also recorded from 75 ppm NAA treated plants. Out of four treatments, 75 ppm NAA produced better responses in most of the parameters.

Introduction

Sesame (*Sesamum indicum* L.) is one of the ancient oilseed crops cultivated from tropical to temperate regions of the world under the family Pedaliaceae. It occupies fifth position as an oil crop in Bangladesh and plays vital role in human diet having high per cent of oil (42 - 45), protein (20) and carbohydrate (14.20). Seed contains 47% oleic, 39% linoleic acid and rich in omega 6 fatty acid (BARI 1998). Currently the annual demand of oil seeds is approximately 1.4 million metric ton whereas the production at national level is only 0.4 million metric ton (Azad *et al.* 2017). Acute shortage of this edible oil has been prevailing in Bangladesh during the last several decades and about 70% of this shortage has been met through imports, using a huge amount of foreign exchange every year. To meet the demand of oilseeds, Bangladesh needs to improve cultivation of oilseed crops for attaining self-sufficiency in the country. In addition, the yield of sesame is very low in the country due to lack of proper management practices (Rahman *et al.* 1994). The yield of sesame could be increased by using numerous improved technologies and practices where, application of growth regulators and plant growth promoting bacteria is considered as the easiest ways for such an attempt.

Some investigations have showed that naphthalene acetic acid (NAA) had stimulatory effect on different oil seeds crops including sesame (Govindan *et al.* 2000, Haque 2005, Behera 2015,

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Siddik *et al.* 2016). On the other hand, *Pseudomonas*, a plant growth promoting bacterum, stimulates plant growth through different mechanisms and can also reduce the demand of chemical fertilizers (Glick 2004). Findings of Hasanpour *et al.* (2012) revealed that plant growth promoting rhizobacteria had advantageous effect on qualitative characters of sesame. The role of *Pseudomonas flurescens* on the growth of rapeseed has also been evaluated by Yousefi and Heshmatpour (2013). But research work using *Pseudomonas* sp. on any variety of sesame is not reported from elsewhere of the world. Thus, an attempt was made to investigate the effect of foliar application of NAA and *Pseudomonas* inoculum on growth, yield and biochemical parameters of sesame.

Materials and Methods

A field experiment was carried out at the Botanical garden of the Department of Botany, Jagannath University, Dhaka during the period of 2015 - 2016. Experimental soil was sandy loam and according to Fertilizer Recommendation Guide (2012) soil contains very low amount of nitrogen (0.069%), very high amount of phosphorus (80.17 μg/g) and very low amount of potassium (0.065 meq/100g). A modern variety of sesame, BARI Til-4 was used as an experimental material. The experiment was laid out in RBD with three replications. Seeds of BARI Til-4 and the strain of *Pseudomonas* sp. were collected from Bangladesh Agricultural Research Institute (BARI). The total area of the experimental field was 36 m^2 (6 m × 6 m). The experiment consisted of five treatments *viz.*, T_0 = Control (distilled water), T_1 = Seed inoculated with *Pseudomonas* sp. T_2 = 25 ppm NAA, T_3 = 50 ppm NAA and T_4= 75 ppm NAA. Seeds were surface-sterilized with 95% ethanol for 5 min and rinsed 6 times with sterile water, then dried overnight in a sterile blotting paper (Atici *et al.* 2005). Surface sterilized seeds were treated with 1 ml *Pseudomonas* sp. cell suspension (108 cfu/ml). The seeds of sesame were sown on May 2, 2016 maintaining row to row distance of 30 cm and seed to seed distance of 5 cm. Cultural practices and fertilizer application were done following the Hand Book of Agricultural Technology (Chowdhury and Hassan 2013). Urea as a source of nitrogen was not used in case of bacterial treatment. Foliar application of NAA was done in sunny early morning at the age of 25 days.

Growth parameters *viz.*, plant height, number of branches and leaves per plant, fresh and dry weight of leaves and root per plant, shoot-root ratio, leaf area, specific leaf weight and net assimilation rate were recorded at harvest. Pigment and protein contents of fresh leaves were determined at vegetative and flowering stages. Protein contents of fresh seeds was also determined after harvest. The amount of chlorophyll a and b were estimated by using specific absorption co-efficient of Mckinney (1940) and the formulae of Maclachalan and Zalik (1963). The amount of carotenoid was calculated using the equation of von Wettstein (1957). The method of Lowry *et al.* (1951) was employed for the determination of protein content of leaves. Plants were harvested at the age of 90 days. Nine plants from each treatment were harvested separately to record data on different growth and yield parameters. Data were analysed statistically, and treatment means were compared by LSD test at 5% level of significance (Steel *et al.* 1997).

Results and Discussion

Results presented in Table 1 showed that height of BARI Til-4 decreased following all treatments but with non-significant variations. This result is in agreement with the findings of Behera (2005) where height of sesame plant decreased following 10 ppm NAA treatment. However, Haque (2005) and Siddik (2014) reported that height of sesame increased due to NAA application.

Significantly maximum number of primary branches per plant (9.22) was recorded from the plants treated with 50 ppm NAA. Similar results of increase in number of primary branches per plant following 50 ppm NAA treatment was also reported by Siddik (2014) in sesame. Results revealed that number of leaves per plant, fresh and dry weight of leaves and root per plant, leaf area per plant and specific leaf weight (SLW) were maximum from 75 ppm NAA treatment where it was significantly higher in case of leaf area per plant. Siddik (2014) also obtained higher number of leaves in sesame plant due to NAA treatments which conforms to the findings of present investigation. Verma and Sen (2008) recorded maximum fresh and dry weight of leaves with 20 ppm NAA in coriander plant. Siddik *et al.* (2014) obtained increased amount of fresh and dry weight of root following NAA treatment in sesame. Behera (2015) reported that application of NAA had stimulatory effect on SLW of sesame. Haque (2005) recorded significant increases in leaf area of sesame with different NAA treatments. Shoot-root ratio also showed positive response to 75 ppm NAA although the maximum was obtained from *Pseudomonas* treated plants. By applying NAA on soybean, Govindan *et al*. (2000) found 12.48% higher shoot-root ratio over the control whereas, Woyessa and Assefa (2011) found 42% higher shoot-root ratio in *Eragrostis tef* due to inoculation of *Pseudomonas*. The maximum net assimilation rate (NAR) was recorded from both control and 75 ppm NAA treatment but statistically identical to rest of the treatments. Results of Behera (2015) revealed that application of 10 and 20 ppm NAA had higher NAR in sesame.

Results on yield attributes and yield of sesame has been presented in Table 2. Number of pods per plant was found to increase following 75 ppm NAA although statistically not different to control. Increased number of pods per plant following NAA treatments has also been previously reported in sesame (Behera 2015, Siddik *et al*. 2016).

Application of 75 ppm NAA produced significantly longer length of pods than control followed by 50 ppm and *Pseudomonas* inoculum, respectively. Application of NAA treatments significantly increased the pod length in sesame plant (Siddik *et al.* 2016). Abdel-Aziz and Salem (2013) recorded affirmative effect of *Pseudomonas fluorescens* on the pod length of cowpea. Fresh and dry weight of pods per plant and 1000-seed weight were also recorded maximum from 75 ppm NAA although statistically at par with control. Similar results of increase in fresh and dry weight of pods following NAA treatments has also been reported in sesame by other investigators (Haque 2005, Siddik *et al.* 2016). Results revealed that 75 ppm NAA resulted significantly maximum number of seeds per pod followed by 50 ppm NAA and *Pseudomonas* inoculum, respectively. Maqsood *et al.* (1994) found increased number of seeds per pod due to the application of growth promoting *Rhizobium* bacteria. The maximum 1000-seed weight was also found from 75 ppm NAA treatment but statistically identical to the rest of the treatments. Siddik *et al.* (2016) reported that application of NAA treatments had higher 1000-seed weight in sesame plant. The positive influence on yield per plant was observed from the plants treated with 75 ppm NAA which was significantly higher than all the treatments. Yield per plant obtained from 75 ppm NAA was 32.54% higher over control. Increase in yield of sesame due to NAA application has been reported by several other workers (Haque 2005, Behera 2015, Siddik *et al.* 2016). Harvest index (HI) was significantly influenced by different NAA treatments and *Pseudomonas* sp. where, the maximum HI was found in 50 ppm NAA application. By applying 50 ppm NAA, Ullah *et al.* (2007) obtained significantly higher HI in cowpea. Hasanpour *et al.* (2012) recorded 18.10% higher HI when *Pseudomonas fluorescens* was used with *Azospirillum* spp. and *Bacillus subtilis* as mixed treatment.

Results presented in Table 3 showed that NAA and *Pseudomonas* application had both significant and non-significant response on pigment content of leaves at vegetative and flowering stages. Pigment content of leaves was positively influenced by most of the treatments at vegetative

Table 1. Responses of growth parameters of sesame (*Sesamum indicum* L. var BARI Til-4) to foliar application of NAA and *Pseudomonas* inoculum at harvest.

Treatments	Height (cm)	No. of branches/ plant	No. of leaves/ plant	Fresh wt. of leaves/ plant (g)	Dry wt. of leaves/plant (g)	Fresh wt. of root/plant (g)	Dry wt. of root/plant (g)	Shoot root-ratio	Leaf area/ plant (cm^2)	Specific leaf wt. (g/cm^2)	Net assimi-lation rate (gm^2/day)
T_0	143.4	6.67 b	30.56	4.64	1.24	9.05	2.39	6.17	75.21 b	0.018	0.09 a
T_1	127.4	5.67 b	15.67	2.20	0.95	5.52	1.24	6.94	69.09 b	0.014	0.04 a
T_2	123.4	5.56 b	11.89	1.66	0.49	6.09	1.44	5.77	79.29 b	0.007	0.04 a
T_3	127.2	9.22 a	23.22	2.61	0.75	6.90	1.38	6.07	71.16 b	0.012	0.05 a
T_4	136.2	5.67 b	36.22	5.09	1.94	11.01	2.87	6.18	115.27 a	0.022	0.09 a
CV (%)	15.25	11.29	97.51	10.08	10.80	6.83	19.31	14.37	35.20	11.20	11.10
LSD (0.05)	NS	2.03	NS	NS	NS	NS	NS	NS	28.97	NS	0.07

Mean in a vertical column followed by same letter or without letter do not differ significantly at 5 % level.

Table 2. Responses of yield attributes and yield of sesame (*Sesamum indicum* L. var. BARI Til-4) to foliar application of NAA and *Pseudomonas* inoculum at harvest.

Treatments	No. of pods/plant	Length of pod (cm)	Fresh wt. of pods/plant (g)	Dry wt. of pods/plant (g)	No. of seeds/pod	1000-seed wt. (g)	Yield/plant (g)	Harvest index (%)
T_0	38.11 a	2.11c	33.80ab	12.38a	68.27c	2.58a	12.14b	44.87b
T_1	26.11 ab	2.36b	28.11 b	10.72a	81.73b	2.60a	10.63b	52.98a
T_2	22.11 b	2.34b	28.13b	9.10a	80.03b	2.94a	8.97b	53.03a
T_3	28.56 ab	2.39b	30.05b	10.68a	84.43b	3.28a	10.56b	54.45a
T_4	40.00 a	2.59a	44.30a	16.18a	103.60a	3.37a	16.09a	52.98a
CV (%)	41.71	7.69	36.33	35.06	15.43	14.23	35.42	17.75
LSD (0.05)	14.09	0.11	13.09	7.27	6.83	1.00	3.94	7.27

Mean in a vertical column followed by same letter or without letter do not differ significantly at 5% level.

stage whereas, the response was rather negative at flowering stage. Significantly higher chlorophyll a and carotenoids content of leaves were recorded from the inoculation of *Pseudomonas* treatment at vegetative stage. Prakas (1998) reported that application of NAA treatments had both positive and negative response on the photosynthetic pigments of sesame. Mathivanan *et al.* (2017) obtained enhanced pigment content in groundnut leaf due to *Pseudomonas* treatment.

Results presented in Table 4 show that protein content of fresh leaves of BARI Til-4 significantly responded by 50 and 75 ppm NAA treatments at vegetative stage where the maximum amount was noted from 75 ppm. Protein content of leaves was significantly influenced following all treatments at flowering stage where, 75 ppm NAA produced significantly maximum value.

Table 3. Responses of pigment content (mg/g) of fresh leaves of sesame (*Sesamum indicum* L. var. BARI Til-4) to foliar application of NAA and *Pseudomonas* inoculum at two different stages.

Treatments	Vegetative stage			Flowering stage		
	Chl. a	Chl. b	Carotenoids	Chl. a	Chl. b	Carotenoids
T_0	0.42 b	0.29	4.15 b	0.86	0.86 a	6.87 a
T_1	0.73 a	0.40	7.12 a	0.72	0.46 ab	6.79 a
T_2	0.47 b	0.37	5.27 ab	0.43	0.22 b	3.21 b
T_3	0.42 b	0.43	5.84 ab	0.43	0.22 b	4.58 ab
T_4	0.36 b	0.36	5.52 ab	0.62	0.32 b	6.56 ab
CV (%)	13.62	28.35	22.13	17.65	14.93	16.19
LSD (0.05)	0.20	NS	2.10	NS	0.51	3.38

Mean in a vertical column followed by same letter or without letter do not differ significantly at 5% level.

Table 4. Responses of protein content (mg/g) of fresh leaves and seeds of sesame (*Sesamum indicum* L. var. BARI Til-4) to foliar application of NAA and *Pseudomonas* inoculum.

Treatments	Protein content of fresh leaves (mg/g)		Protein content of seeds (mg/g)
	Vegetative stage	Flowering stage	At harvest
T_0	47.01 b	11.19 c	187.63 b
T_1	45.50 b	17.75 b	204.75 b
T_2	51.75 b	16.75 b	223.75 b
T_3	90.63 a	18.00 b	300.13 a
T_4	100.88 a	23.88 a	294.00 a
CV(%)	37.81	25.55	21.48
LSD (0.05)	19.69	4.47	50.93

Mean in a vertical column followed by same letter or without letter do not differ significantly at 5% level.

Results also indicated that 50 ppm NAA had resulted significantly higher amount of seed protein than control but statistically similar to 75 ppm NAA treatment. Outcome of Haque (2005) revealed that protein content of sesame leaves progressively increased with the increasing in concentration of NAA. By applying *Pseudomonas aeruginosa* LES4, Kumar *et al.* (2009) obtained 10.30% higher seed protein than control. Thus, this result is in accord with the findings of previous workers.

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