Research Journal of Agriculture and Biological Sciences, 8(1): 45-54, 2012
ISSN 1816-1561
This is a refereed journal and all articles are professionally screened and reviewed

ORIGINAL ARTICLES

Response of Sesame Crop to the Biofertilizer Cerealine with or without Mineral Nitrogen Fertilization

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ABSTRACT

Two field experiments were conducted during the two successive seasons 2007 and 2008 at the Agricultural Experimental and Research Station, Faculty of Agriculture, Cairo University, Giza, Egypt. The biofertilizer Cerealine (*Azospirillum brasilense*) was adopted as soil inoculant, either alone or as a supplement to mineral fertilization. Their effect on growth and yield of sesame plant (*Sesamum indicum* L.) was studied. Three treatments were applied, i.e. the recommended rate of mineral nitrogen (40kgMN/fed.), half rate of MN combined with half rate of Cerealine or the recommend dose of Cerealine (400g/fed.). Two cultivars of sesame viz. Toushki 1 and Schandweel 2000 were studied. Regardless of cvs. effect, dry weight of shoots tended to be doubled in plants, those received Cerealine alone in the first season. While maximum dry weight of shoots was achieved in plants which received the recommended dose of MN in the second season. Moreover, most of growth characters varied in their response to the applied treatments comparing the two growing seasons. Highest values were obtained where the plants received the biofertilizer alone in the first season, and vice versa in the second one. As to the cultivar effect, results revealed insignificant differences between cultivars in most of growth traits. In the second season, the cultivar Schandweel 2000 was apparently vigorous than Toushki 1. Concerning the cultivars vs. the treatments, the investigation exhibited the existence of genotypic variability under the influence of various treatments. Most growth traits gave insignificant differences; due to various treatments. Toushki 1 significantly behaved better in root length and dry weight separated leaves by combined treatment in the first season. Means of main stem height and root length varied significantly in the second one, as the cultivars received the recommended dose of MN, higher values were for Schandweel 2000 cv. Significant differences were detected also between the cultivars in the number of primary branches as affected by both mineral nitrogen or Cerealine treatments, Toushki 1 cv. was the superior. Yield attributes were insignificantly higher as detected by Cerealine application in the first season. Number of capsuled nodes and capsules/plants and seed yield/plant were positively affected by applying the MN alone in the second season. Highest seed index was insignificantly obtained in plants with combined treatment. Variable seasonal influences were detected due to the applied treatments on growth and yield attributes. The results revealed that the biofertilizer Cerealine could be replaced partially instead of inorganic nitrogen approaching to reducing the harmful effect of chemical fertilization. This may be lead to clean and sustainable agriculture. Variable anatomical responses were detected between the studied cultivars under the effect of the applied treatments. Most of stem tissues of Toushki 1 cv. were negatively affected by applying the combination treatment comparing to MN or Cerealine treatments, thickness of fiber groups was drastically reduced. In other words stem diameter was surpassed in Toushki 1 plants those received the bio fertilizer treatment compared to the other treatments. Most of stem tissues of Schandweel 2000cv. Consequently whole stem diameter were reduced as the plants received either the combination treatment or Cerealine one compared to MN treatment.

Key words: Inoculation, *Azospirillumbrasilense*, Mineralnitrogen, Sesame growth and yield.

Introduction

Sesame (*Sesamum indicum* L.) is an important oil seed crop belonging to family Pedaliaceae. Sesame oil has excellent nutritional, medicinal, cosmetic and cooking qualities. Seeds are termed as the seed of immortality due to the presence of potent antioxidants (Duhoon *et al*., 2004). Sesame is considered a drought-tolerant crop (Weiss, 2000). Its cultivation is extended beyond tropical and subtropical zones to temperate and subtemperate zones of the world (Ali *et al*., 2000). Martinez (2000) reported the ability of *Azospirillum* to supply 20-40 kg nitrogen/ha each season. It is applied by hand during flowering, when available nitrogen is scarce. It produces growth promoting substances Indole Acetic Acid (IAA) to boost root biomass production. The author added that the inoculant enhanced root branching and root hair density, leading to increase minerals and water uptake. Inoculated plants can extract more soil moisture from deep soil layers and withstand salt stress.

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Many investigators pointed out several combinations including *Azospirillum brasilense* (as seed inoculant) as an integrated nutrient management, i.e. growth hormones, arbuscular mycorrhizal fungi or mineral nitrogen fertilization. These associations were reported to enhance seed germination, growth, dry matter production, yield attributes and productivity of sesame plants (Palaniappan *et al*., 1999; Tholkappian *et al*., 2000, Thiruppathi *et al*., 2001; Sabannavar and Lakshman, 2008; Deshumkh *et al*., 2010 and Sahoo *et al*., 2010). *Azospirillum brasilense* applied alone or combined with phytohormones and micronutrients were reported to enhance the uptake of nitrogen, phosphorus and potassium as well as sesame seed oil and protein contents (Singaravel *et al*., 1998 and Thiruppathi *et al*., 2001).

The present work was laid out to investigate the influence of Cerealine (*Azospirillum brasilense*) as soil inoculant, alone or combined with mineral nitrogen fertilization on growth and yield characters of sesame plant. Reducing the amounts of mineral fertilization is of great importance in reducing soil pollution approaching to sustainable agricultural development. Partial replacement of biofertilizer instead ofthemineral one, could be considered to avoid the expected soil pollution due to the residual effect of mineral fertilization.

Materials And Methods

The current investigation was carried out at the Agricultural Experimental and Research Station, Faculty of Agriculture, Cairo University, Giza, Egypt, during two successive summer seasons 2007 and 2008. Two cultivars of sesame (*Sesamum indicum* L.) viz., Toushki 1 and Schandweel 2000 were utilized. Seeds were obtained from Oil Crops Section, Agricultural Research Center (ARC), Ministry of Agriculture, Giza, Egypt. *Azospirillum brasilense* carried on vermiculite (Cerealine) was obtained from Production Unit for Biofertilizers, (ARC), Giza, Egypt. Field experiment was laid out in a Randomized Complete Block Design (RCBD) with three treatments replicated twice. Seeds were sown on July 3rd and June 25th in the first and second seasons, respectively. Seeds were hand planted in hills, spaced 20 cm in one side of ridges, 4 meters long and 65 cm apart. Plants were thinned to two plants hill^{-1} after sowing. N-fertilization was given in the form of urea (46% N) at the dose of 40 kg MN feddan^{-1}. The amount of mineral nitrogen was divided into two halves .One was applied before the first irrigation, 2weeks after sowing, and the other before the second irrigation,4weeks after sowing. The inoculant Cerealine was added 40 days after sowing (at flowering onset). The recommended dose of Cerealine was 400g/fed.

Three treatments included mineral nitrogen and Cerealine were carried out as follows:

1- The recommended dose of mineral nitrogen, 40 kg MN/fed. (control).
2- Half dose of mineral nitrogen + half dose of Cerealine.
3- The recommended dose of Cerealine 400g/fed.

The other cultural practices in vicinity were applied according to recommendations.

Vegetative growth characters were estimated 70 days after sowing (40 days after sowing+ 30 days after Cerealine application). They included main stem height (MH), root length (RL), number of internodes/ main stem (No. IN), numbers of capsuled nodes /main stem and/plant in the first and second seasons respectively (No.CapN70), dry weight of separated leaves (Dwt L), dry weight of shoots, leafless main stem and branches (DwtSh), number of primary branches (No. Br.) and dry weight of reproductive organs, flowers and green capsules (Dwt Rep).

At harvest, 100 days from sowing,number of capsuled nodes/plant (No.CapNH), number of capsules/plant (No.Cap/pl), seed yield /plant (SYP) were estimated.Seed index (SI) was estimated in the second season.Soil of the experimental site was loam clay soil [the physical and chemical characteristics are shown in Table (1)].

Anatomical study:

Specimens were taken from the median internode of the main stem at the age of 70 days in the second season. For studying the response of main stem tissues to the applied treatments, specimens were killed and fixed at least 48 hrs. in FAA (10 ml formalin, 5 ml glacial acetic acid and 85ml ethyl alcohol 70%). The selected materials were washed in 50% ethyl alcohol, dehydrated in a normal butyl alcohol series, embedded in paraffin wax of melting point 56^{o}C. Sections of 20 microns thick were cut using a rotary microtome. Safranin- fast green combination method (Sass, 1961) was used for staining. Stained sections were cleared in xylene and mounted in Canada balsam (Willey, 1971). Sections were microscopically examined. Measurements were taken (µ) for each of main stem diameter between corners (MDC) and grooves (MDG), cortex thickness at corners (CTC) and grooves (CTG), phloem thickness (PTC) and fiber thickness (FTC) at corners, xylem thickness at corners (XTC) and grooves (XTG) and pith thickness including cavity (PI+HO). Averages of 3 readings from 2 slides were calculated. Photomicrographs were taken.

Table 1: Chemical and physical parameters of the experimental soil.

Chemical characteristics			Physical characteristics	
Character		Value	Character	Value
pH		8.10	Coarse sand	6.0
E.C (mmohs /cm)		0.63		
$CaCO_3$ (%)		4.80		
Soluble anions (meq/L)	HCO_3^-	2.80		
	Cl^-	1.00	Fine sand	37.0
	SO_4^{-2}	2.50		
Soluble cations (meq/L)	Ca^{+2}	1.00		
	Mg^{+2}	1.80		
	Na^+	2.60	Silt	22.0
	K^+	0.57		
Microelements (ppm)	Mn	11.60		
	Zn	2.46	Clay	35.0
	Cu	2.06		
	Fe	5.60		
Macro elements (ppm)	N	121.00	Textural class	Clay loam
	P	114.00		
	K	592.00		

Results And Discussion

Growth characteristics:

Data in Table (2) illustrate the effect of the biofertilizer Cerealine (*Azospirillum brasilense*), mineral nitrogen fertilization and the combination on different growth traits of sesame (*Sesamum indicum* L.) at the age of 70 days, 30 days after Cerealine application. Regardless of cultivars effect, insignificant differences were detected between the applied treatments, concerning all growth characters under study. Exceptions were recorded by means of main stem length and dry weight of shoots (leafless main stem and branches), in the first season and number of primary branches in the second one.

Table 2: Effect of Cerealine, mineral nitrogen or their combinationon growth, yield and yield attributes of sesame plant in 2007 and 2008 seasons.

Trait	Season	Treatments effect			CVs. effect	
		MN	0.5+0.5	Cerealine	Toushki 1	Schandweel 2000
MH	2007	80.13 b	87.00 a	102.13 a	92.33 a	87.17 a
	2008	150.98 a	149.57 a	149.05 a	143.25 b	156.48 a
R L	2007	15.38 a	16.13 a	17.38 a	18.33 a	14.25 a
	2008	27.40 a	26.65a	26.17a	23.37 b	30.12 a
No. IN	2007	24.63 a	24.88 a	31.50 a	27.00 a	27.00 a
	2008	53.25 a	54.17 a	51.38 a	55.20 a	50.67 a
No.CapN70	2007	9.00 a	13.50 a	19.00 a	12.42 a	15.25 a
	2008	28.08 a	32.65 a	26.75a	28.55a	29.77 a
Dwt L	2007	6.75a	8.23 a	15.32 a	12.90 a	7.30ab
	2008	19.10 a	15.40 a	15.00 a	15.38 a	17.62 a
DwtSh	2007	9.13 b	11.05ab	21.67 a	17.00 a	10.90 a
	2008	29.98 a	23.33 a	24.93 a	23.23 a	28.92 a
No.Br.	2007	2.13 a	2.00 a	2.63 a	1.92 a	2.58 a
	2008	3.48 a	1.70 b	3.38 a	3.63a	2.07 b
Dwt Rep	2007	3.35a	2.95 a	4.40 a	4.99 a	2.15 a
	2008	13.55a	11.85 a	10.10 a	8.30 a	15.37 a
No.CapNH	2007	37.90 a	37.35a	50.90 a	48.20 a	35.90 a
	2008	119.80 a	105.60 a	71.40 a	125.57 a	72.30 b
SI	2008	4.11 a	4.31 a	4.23 a	3.68 b	4.75 a
SYP	2007	9.07a	9.10 a	11.27a	8.88 a	10.75 a
	2008	30.45 a	23.25a	16.35 a	22.82 a	23.88 a
No.Cap/pl	2007	49.08 a	49.10 a	73.07 a	60.72 a	53.45 a
	2008	162.50 a	137.60 a	101.75a	157.43 a	110.47 a

Means followed by the same letters are not statistically different.

In the first growing season, means of number of capsuled nodes per mainstem (19.00 nodes) and dry weight of leafless shoots (21.67g) and separated leaves (15.32g), all, were more or less doubled in plants, those whogiven the biofertilizer alone compared to those received the recommended dose of mineral nitrogen. Doubling of shoots dry weight was accompanied by insignificant differences between both applied treatments concerning number of primary branches (2.63 and 2.13 branches for Cerealine and MN, respectively). This may be attributed to weaker primary branches which developed by plantsthose received the recommended dose of mineral nitrogen only.

The highest dry weight of shoots (29.98g) was produced by plants which received the recommended dose of mineral nitrogen (40 kg MN/fed) applied alone in the second growing season, compared to the other treatments. This could be attributed to the tallest main stem (150.98cm) and number of primary branches (3.48 branches), which developed by these plants. Producing of higher dry weight of shoots could be due to higher assimilation rate. Accumulation of dry matter proved by higher leaves dry weight (19.10g) was produced by such plants.

Data in Table (2) clearly show that the highest values of most of growth characters were recorded in plants which received the biofertilizer Cerealine alone in the first season. Although differences were very high between many figures yet, most of them were insignificant. Meanwhile, plants treated by mineral nitrogen behaved better in the second one. Means of plants those received the combination treatment were located in a medium position between those treated with the biofertilizer or mineral nitrogen alone. In other words, variable responses were detected by sesame plants those received the applied treatments comparing the two growing seasons. Meteorological data in Figs. (1&2) exhibited variable relative humidity and temperature values prevalent in 2007 and 2008 seasons. The first season was apparently dryer with lower temperature than the second one especially in July. Values of temperature and relative humidity tended to increase up to onset August, average temperature values were around 31ºC and 27ºC in the first and second seasons, respectively. The last growing period, mid-August to onset September, was characterized by wider variations between the two growing seasons, especially in temperature values. The widest range was determined by end August (around 28ºC and 31ºC for the first and second seasons, respectively.

Regardless of the applied treatments, insignificant differences were detected between the studied cultivars in most of growth traits under study (Table 2). Exceptions were detected by means of leaves dry weight in the first season, main stem height, root length and number of primary branches in the second one.The cultivar Schandweel 2000 was apparently more vigorous than Toushki 1 cultivar in the second season. The former was suppressed in main stem height, root length &dry weight of leaves and shoots. Meanwhile, averages number of primary branches developed by Toushki 1 cv. plant was significantly surpassed those of Schandweel 2000.

Concerning the response of the studied cultivars to the applied treatments, insignificant differences were detected within the applied treatments in most growth characters under study (Table 3). In the first season, the two cultivars varied significantly with respect to root length and leaves dry weight under the influence of the combination between mineral nitrogen and Cerealine, the cultivar Toushki 1 was the superior (20.25cm and 11.80g).

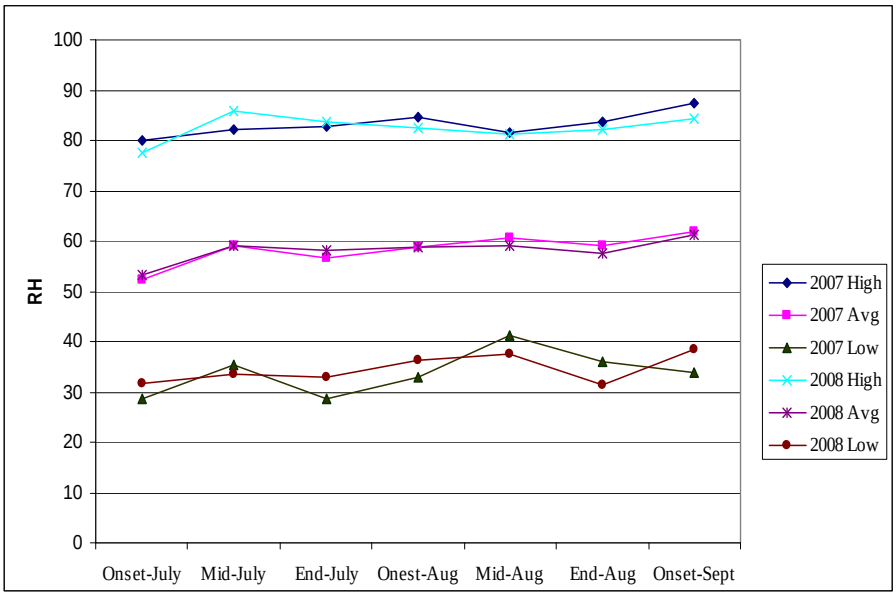

Fig. 1: Relative humidity during the growth period of sesame plants in 2007 and 2008 seasons.

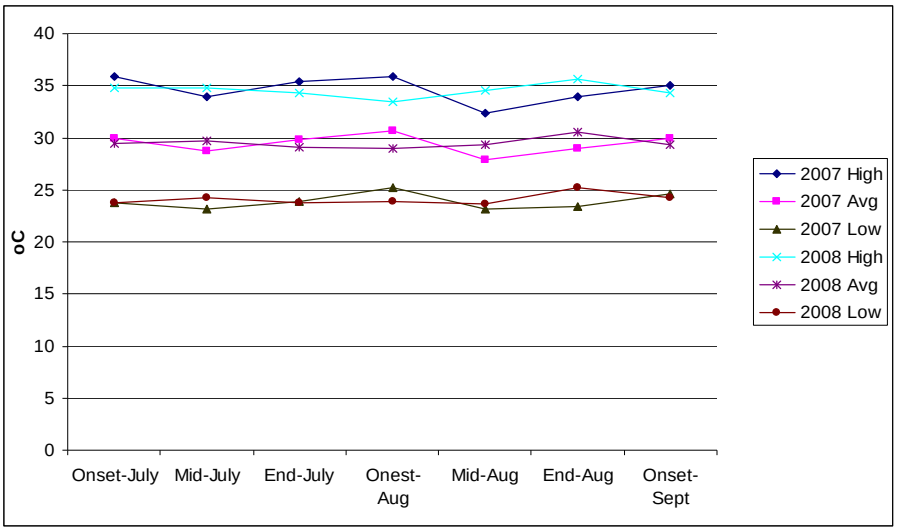

Fig. 2: Air temperatures during the growth period of sesame in 2007 and 2008 seasons.

Table 3: Effect of mineral nitrogen, Cerealine or their combination on growth, yield and yield attributesof two sesame cultivars in2007 and 2008 seasons.

Trait	Season	MN		0.5+0.5		Cerealine	
		Toushki 1	Schandweel 2000	Toushki 1	Schandweel 2000	Toushki 1	Schandweel 2000
MH	2007	87.25 ab	73.00 b	87.00 ab	87.00 ab	102.75 a	101.50 a
	2008	140.00 b	161.95 a	141.80 a	157.35 a	147.95 a	150.15 a
R L	2007	17.75 a	13.00 a	20.25 a	12.00 b	17.00 a	17.75 a
	2008	23.00 b	31.80 a	22.45 b	30.85 a	24.65 a	27.70 a
No. IN	2007	24.75a	24.50 a	25.25 a	24.50 a	31.00 a	32.00 a
	2008	51.65 a	54.85 a	56.65 a	51.70 a	57.30 a	45.45 a
No.CapN70	2007	8.25 a	9.75 a	8.50 a	18.50 a	20.50 a	17.50 a
	2008	22.30 a	33.85 a	34.00 a	31.30 a	29.35 a	24.15 a
Dwt L	2007	8.60 a	4.90 b	11.80 a	4.65 b	18.30 a	12.35 b
	2008	17.00 a	21.20 a	14.25 a	16.55 a	14.90 a	15.10 a
DwtSh	2007	10.90 a	7.35 a	14.70a	7.40 a	25.40 a	17.95 a
	2008	26.15 a	33.80 a	20.65 a	26.00 a	22.90 a	26.95 a
No.Br.	2007	1.75 a	2. 50 a	1.75 a	2.25 a	2.25 a	3.00 a
	2008	4.30 a	2.65 b	1.95 b	1.45 b	4.65 a	2.10 b
Dwt Rep	2007	5.36 a	1.35 a	3.95 a	1.95 a	5.65 a	3.15 a
	2008	6.50 a	20.60 a	9.65 a	14.05 a	8.75 a	11.45 a
No.CapNH	2007	45.20 a	30.60 a	34.90 a	39.80 a	64.50 a	37.30 a
	2008	131.60 a	108.00 a	146.00 a	65.20 b	99.10 a	43.70 a
SI	2008	3.53 b	4.68 a	3.69 b	4.94 a	3.82 b	4.64 a
SYP	2007	7.10 a	11.05 a	6.00 a	12.20 a	13.55 a	9.00 a
	2008	21.90 a	39.00 a	25.65 a	20.85 a	20.90 a	11.80 a
No.Cap/pl	2007	50.00 a	48.15 a	41.60 a	56.60 a	90.55 a	55.60 a
	2008	153.50 a	171.50 a	178.80 a	96.40 a	140.00 a	63.50 a

Means followed by the same letters are not statistically different.

In the second growing season, means of main stem height and root length (161.95 and 31.80cm) were varied significantly as the two cultivars received the recommended dose of mineral nitrogen; higher values were recorded for the cultivar Schandweel 2000. A significant difference was detected also between the two cultivars concerning the number of primary branches under the influence of mineral nitrogen or Cerealine applied alone, the cultivar Toushki 1 was the superior (4.30 and4.65 branches for MN and cerealine, respectively). It could be concluded therefore that, means of most of growth characters varied in their response to the applied treatments comparing the two growing seasons. As higher values were obtained in plants which received the biofertilizer treatment alone in the first season and vice versa in the second one. This observation could be interpreted by variable seasonal influences on sesame plants received the applied treatments under study.

Most of studied growth characters exhibited insignificant differences as affected by the applied treatments. Dry weight of shoots and leaves tended to be doubled in plants which received the biofertilizer alone in the first season. Meanwhile, maximum dry weight of both was recorded as the plants received the recommended dose of MN in the second season. The study concluded variable genotypic responses as the two cultivars received the applied treatments. The cultivar Toushki 1 behaved better concerning root length and leaves dry weight under

the influence of the combination treatment in the first season with significant differences. Means of main stem height and root length varied significantly in the second one as the cultivars received the recommended dose of MN, the highest values was for Schandweel 2000 cv. Significant differences were detected also between the cultivars concerning the number of primary branches under the effect of mineral nitrogen or Cerealine applied alone, Toushki 1 cultivar was the superior.

Improvement in growth parameters of sesame plants by applying the biofertilizers as seed inoculation was previously reported (Singaravel *et al*., 1998; Ghosh and Mohuiddin, 2000). The former attributed an increase in plant height and dry matter production to increasing nutrient uptake in sesame plants treated with *Azospirillum*.

On contrary, many investigations proved no or insignificant differences in sesame plants inoculated with biofertilizer (s) (Thanki *et al*., 2004 and Debnath *et al*., 2007). The latter pointed out that the average performance of un-inoculated control was apparently the best for almost all growth parameters in two growing seasons. El-Habbasha *et al*. (2007) stated insignificant differences between two sesame cultivars concerning all characters; except for plant height in plants those received different combinations between organic and inorganic fertilizations. While Debnath *et al*. (2007) reported the existence of genotype specific responses in growth parameters interpreted by variation occurred in performance of individual genotypes after different biofertilizer application.

Yield and yield components:

Table (2) illustrates the influence of Cerealine or mineral nitrogen added alone or the combination on yield and yield components of sesame plants in both growing seasons. Insignificant differences were detected in the first season concerning all yield attributes by any way of comparison. Concerning the treatment effect, higher numbers of capsuled nodes (50.90) and capsules/plant 73.07), as well as seed yield per plant 11.27g), were achieved as the plants received Cerealine treatment alone in the first season. These traits behaved better and recorded the maximum values (119.80, 162.50 and 30.45g) in plants those treated with mineral nitrogen alone in the second season without significant differences.

Vegetative growth enhancement occurred in the second season as a result of applying mineral nitrogen alone was reflected on the performance of means number of capsules and capsuled nodes per plant as well as seed yield per plant. Notable but insignificant increment was observed in reproductive organs dry weight of plants received such treatment. Paul and Savithri (2003) reported better vegetative growth in sesame plants received the recommended rate of mineral nitrogen alone. They pointed out that the efficient translocation of photosynthates to reproductive organs resulted in higher yield attributes.

Table (2) shows insignificant differences between the treatments under study with respect to number of capsuled nodes, number of capsules/plant and seed yield per plant in the second season. Meanwhile, the number of primary branches, counted 70 days after sowing was significantly reduced under the influence of the combination treatment compared to mineral nitrogen or Cerealine treatment applied individually. This indicates vigorous and capsuled–carrier plants which received the combination treatment.Data revealed insignificant differences between the combination treatment compared to the control with respect to seed yield / plant and the seed index in the second season. Moreover the highest weight of 1000 seeds (4.31g) was obtained by the combination treatment compared to the other two treatments.

Regarding the cultivars' effect, insignificant differences were detected between the two cultivars concerning yield attributes in the first season. Plants of cultivar Toushki 1 possessed the highest number of capsuled nodes (125.60 nodes) compared to cultivar Schandweel 2000 (72.30 nodes) in the second season with significant difference. This may be attributed to higher numbers of primary branches produced by such cultivar. On the other hand Schandweel 2000 cultivar produced higher seed index (4.75g) compared to Toushki 1 cultivar (3.68g) due to heavier-weight seeds.

Higher weight of reproductive organs (4.99g) was recorded by Toushki 1 cultivar in the first season. The cultivar Schandweel 2000 was the superior in the second one(15.37g). Meanwhile, plants of Toushki 1 cultivar produced higher number of capsuled nodes at harvest sample (125.75 nodes) compared to the cultivarSchandweel 2000 (72.30 nodes) with significant differences. Under the influence of various treatments in the second season, weight of reproductive organs of Schandweel 2000 cultivar was apparently higher than those of Toushki 1 one.

Under the effect of the applied treatments, Toushki 1 cultivar performed better than Schandweel 2000 with respect to the number of capsuled nodes (146.00 nodes) as well as number of capsules per plant (178.80 capsules) when the combination treatment was received. This may be attributed to higher number of primary branches and internodes per main stem produced by Toushki 1 cultivar. On the other hand, insignificant difference was detected between the two cultivars concerning seed yield/ plant under such treatment.

In conclusion, yield attributes were apparently higher under the influence of Cerealine application in the first season without significant differences with the other two treatments. The promotive effects achieved in growth characters due to applying the recommended rate of MN in the second season, apparently reflected on

sesame plant yield and yield attributes. It is worthy to note that the highest seed index was obtained in plants received the combination treatment without significant difference. Variable seasonal influences were detected concerning the effect of the applied treatments on growth and yield attributes. This may be interpreted by variable climatic conditions prevalent in the two growing seasons.

Azospirillum brasilense applied alone as seed inoculation was reported to enhance sesame yield and yield attributes (El-Mandooh and Abdoul-Majid, 1996 and Singravel *et al*., 1998). The latter author pointed out the occurrence of significant varietal differences between 4 cultivars concerning seed yield / plot under the influence of this inoculant. Integrated nutrient management was reported to enhance sesame yield and yield attributes. As different combinations included *Azospirillum brasilense* led to sesame yield improvement (Sinthilkumar, 2000 and El-Habbasha *et al*., 2007). Thanki *et al*. (2004) estimated insignificant differences in yield parameters due to the application or non-application of biofertilizers.

Anatomical Study:

General Description:

Main stem cross section exhibited quadrangular –shaped outline. It contains four corners and grooves with uniseriate epidermal cells. Epidermal layer characterized by the presence of glandular, unicellular, bicellular and multicellular hairs. The glandular hair possesses a stalk of 1- few uniseriate cells. In corners, the epidermis underlay by layers of lamellar collenchyma intercepted by chlorenchyma and both followed by lacunar collenchyma tissue. Grooves are with thick-walled parenchyma. Few layers of parenchyma preceded the phloem both in grooves and corners. Collenchym,chlorenchyma and parenchyma are collectively termed the cortex. Cortex is followed by collateral vascular bundles forming nearly complete vascular cylinder. The secondary thickening was apparently induced at this age of growth. Vascular cylinder composed of groups of phloem, intercepted by parenchyma cells, and amounts of secondary xylem were recognized. Broad area of secondary and primary xylem extends across the stem section. Strands, occasionally few, of fibrous cells were attached to each phloem group. Highly lignified cells were observed around the vessels all over xylem region. The central area of the main stem is occupied by wider parenchyma cells with intercellular spaces. Hollow cavity could be distinguished.

Treatments' effect:

Transections were made in the median internode of sesame main stem at the age of 70 days after sowing (30 days after Cerealine application). Table (4) represents the effect of the applied treatments on the internal structure of main stem of both studied cultivars. Most of stem tissues of Toushki 1 cv. were negatively affected by applying the combination treatment compared to either MN or Cerealine treatments (Fig. 3a, b&c). Consequently, stem diameter at two directions (6375.00 and 5500.00µ) was apparently reduced. Mean thickness of fiber groups was drastically reduced 76.50 and 38.25µ for MN and combination treatments respectively.

Table 4: Effect of mineral nitrogen, Cerealine or their combination on different main stem tissues (µ) in twosesame cultivars in season (2008).

Treatments / Character	MN		0.5+0.5		Cerealine	
	Toushki 1	Schandweel 2000	Toushki 1	Schandweel 2000	Toushki 1	Schandweel 2000
MDC	8250.00	11500.00	6375.00	9000.00	8625.00	9500.00
MDG	6500.00	10000.00	5500.00	7500.00	6750.00	8125.00
CTC	199.75	225.00	182.75	251.60	263.50	250.75
CTG	340.00	595.00	340.00	459.00	340.00	510.00
PTC	76.50	156.40	59.50	102.00	85.00	102.00
FTC	76.50	68.00	38.25	68.00	72.25	68.00
XTC	990.25	1466.25	850.00	1049.75	956.25	1028.50
XTG	314.50	1232.50	352.75	603.50	280.5	450.50
PI+HO	5142.50	6885.00	3570.00	5397.50	5312.50	6035.00

Stem diameter was obviously surpassed in Toushki 1plants; those received the bio fertilizer treatment in comparison to the other treatments. It is worthy to notice from Table (3) that, mean dry weight of leafless shoots of Toushki 1 plants being received the biofertilizer alone was reduced compared to those of plants being treated by MN. Hence, increment in main stem diameter of the former was mainly due to increasing of pith diameter

and hollow cavity creation (5312.50µ and 5142.50µ for Cerealine and MN treatments, respectively) Fig. (3 b&c). Increments were estimated also in cortex and phloem thickness measured at corners. No differences were detected for cortex thickness measured at grooves under the effect of various treatments.

Concerning Schandweel 2000 cv., most of stem tissues consequently whole main stem diameter were apparently reduced as the plants received either the combination treatment or Cerealine one, compared to those treated by MN (Fig. 4 a,b&c). A great reduction was induced in xylem thickness at both corners and grooves.

Wider main stems were recognized in Schandweel 2000 plants which received the biofertilizer Cerealine (9500.00µ and 8125.00µ) compared to those treated by the combination treatment (9000.00µ and 7500.00µ), formain stem diameter at corners and grooves respectively (Fig. 4 c&b). Increment was mainly due to increasing cortex thickness as well as pith diameter including cavity. It is worthy to notice from Table (2) that Schandweel 2000 cv. plants were apparently vigorous than Toushki 1 ones in the second season. As the former produced higher means dry weight of leafless shoots and separated leaves compared to the latter. Wider cross sections were recorded for stems of Schandweel 2000 cv. compared to those of Toushki 1. The differences could be recognized in most of measurements taken for main stem transections under the effect of various treatments (Table 4) and Figs. (3a and 4a).

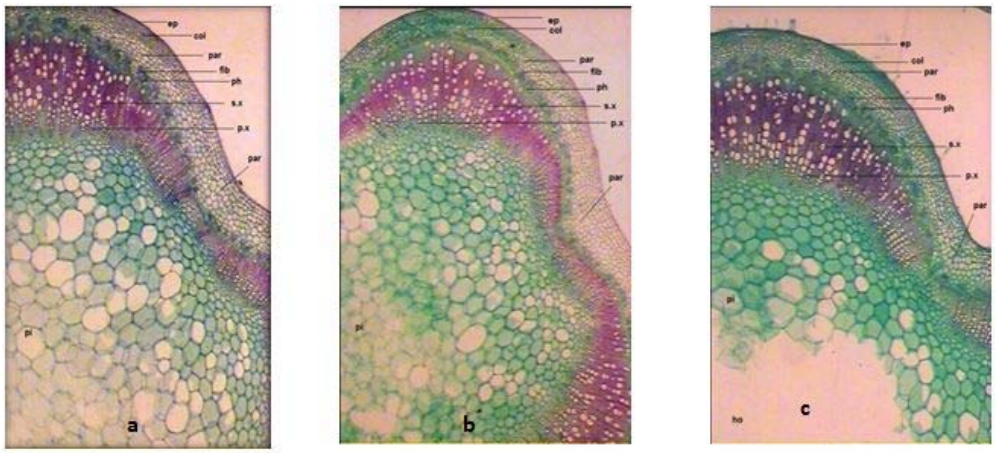

Fig. 3: Transections of sesame main stem at the age of 70 days, the cultivar Toushki 1.
a-Mineral nitrogen treatment; b-Combination treatment; c-Cerealinetreatment.

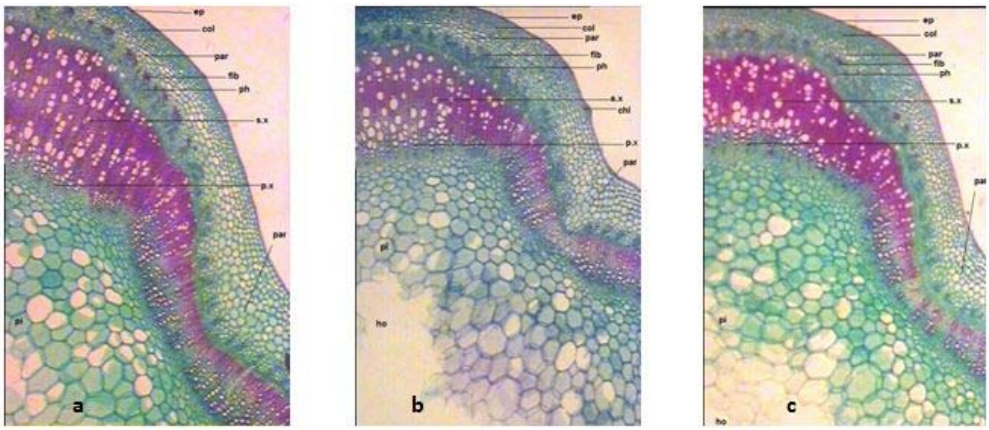

Fig. 4: Transections of sesame main stem at the age of 70 days, the cultivar Schandweel 2000.
a-Mineral nitrogen treatment; b-Combination treatment; c-Cereal rteatment.
Ep: epidermis; col: collenchyma; chl: chlorenchyma; par: parenchyma; fib: fiber group; ph: phloem; s.x: secondary xylem; p.x: primary xylem; pi: pith; ho: hollow cavity

In conclusion, variable anatomical responses were detected between the studied cultivars under the effect of the applied treatments. Most of stem tissues of Toushki 1 cv.were negatively affected by applying the combination treatment comparing to MN or Cerealine treatments, thickness of fiber groups was drastically reduced. In other words stem diameter was surpassed in Toushki 1 plants those received the bio fertilizer treatment compared to the other treatments.It could be concluded also that, most of stem tissues of Schandweel

2000cv. Consequently whole stem diameter were reduced as the plants received either the combination treatment or Cerealine one compared to MN treatment.

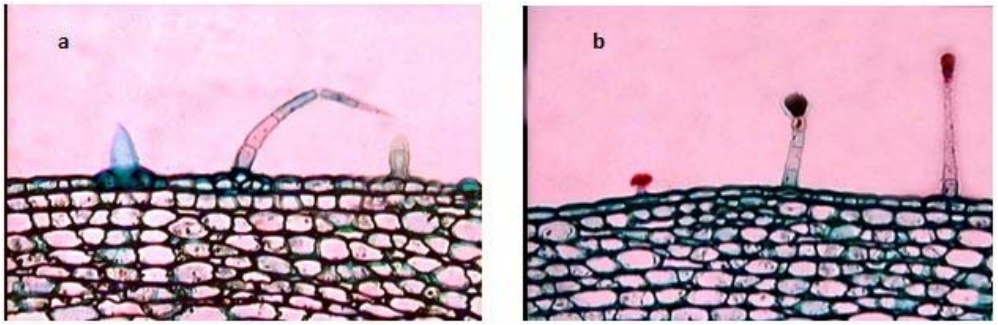

Fig. 5: Epidermal layer with different types of hairs.
a- one-celled, two-celled and multicellular hairs; b- glandular hairs.

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