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Evaluation of the influence of nitrogen fixing, phosphate solubilizing and potash mobilizing biofertilizers on growth, yield, and fatty acid constituents of oil in peanut and sunflower

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Three biofertilizers nitrobein, phosphorein, and potash, containing nitrogen fixing, phosphate solubilizing, and potash mobilizing microorganisms, respectively were studied in peanut (*Arachis hypogea* L.) and sunflower (*Helianthus annuus* L.). Amendment with each of these biofertilizers enhanced different growth parameters of 30-day-old peanut and sunflower plants. Dry matter in both plants was generally correlated with enhancement of chlorophyll a and b pigments with the three used biofertilizers. The carotenoid contents of these plants were approximately comparable to those of the corresponding controls. In the field experiment, total biomass and seed yield showed superiority in peanut and sunflower cultivated in soil incorporated with potash. The enhancement effect was followed by supplementation of nitrobein in peanut and phosphorein in sunflower plants. The percentage increase in seed yield, compared to the corresponding controls were 122.03, 120.11, 176.62 in peanut and 149.22, 168.75, and 173.44 in sunflower for nitrobein, phosphorein and potash amendments, respectively. The oil content produced per plant was also increased as a result of application of nitrobein, phosphorein and potash in a similar trend to that obtained with biomass gain and seed yield. Generally, saturated fatty acid levels (palmitic, stearic and arachidic acids) were decreased and unsaturated ones, particularly the polyunsaturated essential fatty acids linoleic and linolenic were evoked with these biofertilizer amendments. Maximum increase in linoleic and linolenic acid were exerted by phosphorein and nitrobein, respectively in peanut oil and by potash and phosphorein, respectively in sunflower oil.

Key words: Peanut, sunflower, biofertilizers, growth, yield, oil, fatty acids, sodic soil.

INTRODUCTION

In Egypt, soil fertility is diminishing gradually due to soil erosions, loss of nutrients, accumulation of salts and toxic elements, water logging and unbalanced nutrient compensation (Kotba et al., 2000).

One of the main bases of green revolution depends upon the availability of fertilizes for high yielding of seeds and essential agronomical products. Intensive agriculture faces the risk of excessive fertilization. Thus, the use of microorganisms is of immense value in order to promote the circulation of plant nutrients and reduce the need for chemical fertilizers, where organic agriculture is one of the ways that can produce high quality crops (Zarabi et al., 2011). Biofertilizers are organic products containing specific micro-organisms in concentrated forms, derived from the soil root zone (Rhizosphere) (Mishra and Dadhich, 2010). Consequently, microbiological fertilizers are considered as an important part of environment friendly sustainable agricultural practices, with low cost inputs; mainly including nitrogen fixing, phosphate solubilizing, potash mobilizing and plant promoting microorganisms (Sharma and Namdeo, 1999).

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Nitrogen supply is a key limiting factor in crop production so; bioN-fertilizers have greater amounts of symbiotic and non symbiotic bacteria which are responsible of atmospheric nitrogen fixation (Mekonnen et al., 2003). Bedaiwi et al. (1997) suggested that the use of microbein and nitrobein as commercial nitrogen biofertilizers gave the same effects as full nitrogen application and also 1/3 of the recommended nitrogen was saved. A similar conclusion was attained on using commercial microbein (Ismail and Hasabo, 2000) and nitrobein (Abdalla, 2005). The stimulatory effects of microbein and nitrobein biofertilizers could be attributed to the activation of the growth of microflora, which might also furnish the soil with many plant growth stimulators (Fisinin et al., 1999). Moreover, the influence of nitrogen on plant growth and development is often connected with enhancement of photosynthesis because relatively high nitrogen levels determine the formation and the functional state of assimilation apparatus of plants (Ivanova and Vassilev, 2003). Nitrogen does also enhance the production of bioactive substances such as hormones and enzymes, which control soil diseases and accelerate decomposition of lignin materials in the soil (Hussain et al., 2002). The concomitant enhancement of growth parameters would then improve crop productivity (Ghosh and Mohiuddin, 2000). Microorganisms in the biological system also evolve the mineral phosphate solubilizing trait(s) to enhance sufficient phosphorous, where these microorganisms (mainly *Pseudomonas, Bacillus* and *mycorrhyzae* species) are found in all soils (Zarabi et al., 2011). Increased soil fertility and plant growth parameters were recorded on the use of commercial phosphorein in normal conditions (Hassan et al., 2005; Mostafa and Abo-Baker, 2010) and under water stress (Zarabi et al., 2011). Phosphorus is involved in cell division and development, photosynthesis, breakdown of sugar, energy transfer, nutrient transfer within the plant and cell signal transduction (Sharma and Namadeo, 1999), so the supply of this element to plant is essential for achieving optimum growth and crop yield.

At present, there is also considerable interest in the potassium mobilizing symbiotic bacterium *Frateuria aurantia.* The biofertilizer formulations containing this microorganism enable potash mobilization in the soil to the plant. It is recommended to be used with many crops including peanuts and sunflower (Rodriguez and Fraga, 1999; Asean Agritechnologies Pvt. Ltd., 2011).

Peanut and sunflower plants (Osman and Awed, 2010) were selected due to their high economic value as seed sources of protein for human, cattle and poultry and as important sources of oil. According to the USDA (United States Department of Agriculture) in addition to their high nutritive values, peanut and sun flower oils are appreciated for their high smoke points (232°C), relative to many other cooking oils. Both peanut and sunflower plants are promising for cultivation in wastelands and reclaimed soils as well as under stress conditions.

Thus, this present work intended to evaluate the effects of three microbiological fertilizers on the growth, yield and oil contents and properties of sunflower and peanut plants. The three biofertilizers used included nitrobein (containing species of the nitrogen fixing non-symbiotic bacteria *Azospirillum* and *Azotobacter*), phosphorein (containing phosphate- dissolving *Pseudomonas, Bacillus* and *mycorrhyzae* species) and potash (containing the potash mobilizing symbiotic bacteria *Frateuria aurantia*).

MATERIALS AND METHODS

Two pure strains of peanut (*Arachis hypogea L.* cv Giza 6) and sunflower (*Helianthus annuus* cv Ferok) were obtained from the Field Crops Research Institute, Agricultural Research Center (ARC), Ministry of Agriculture, Giza, Egypt.

The three used biofertilizers, namely nitrobein, phosphorein, and potash were kindly provided by the Soil Fertility Self- Sponsored Unit, Faculty of Agriculture, Ain Shams University, Cairo, Egypt.

Pot experiment

The pot experiment trial was carried out in the green house, The Botanic Garden, Faculty of Science, Ain Shams University. Seeds of the two species were surface sterilized by rinsing for 3 min in Clorox solution (0.05% NaOCl), followed by rinsing thoroughly in sterilized distilled water. Then, the seeds of each species were air dried on paper towels.

Four groups of plastic pots (30 cm diameter) containing equal amounts of homogeneous soil (2:1; washed sand: clay) were prepared. Each group consisted of 5 plastic pots. One group was left as a control, whereas the second, third and fourth were subjected to equal volumes (recommended rates) of one type of the biofertilizers used (nitrobein, phosphorein and potash). Equal number of seeds was sown in each pot at constant depth from the surface and equal distances apart, and then covered with equal amounts of soil, 48 h after addition of the biofertilizers. Each biofertilizer was incorporated at a constant volume into the top soil layer in each pot. The pots were placed under natural condition of day light (14 h) and darkness (10 h), where the temperature varied from 30 ± 2°C during the day to 18 ± 2°C at night.

Irrigation of all pots was carried out routinely, using a constant amount of tap water. The stage corresponding to 30 day-old plants were collected for different analysis. Ten randomly chosen plant samples were taken for the measurements of different growth criteria.

Determination of photosynthetic pigments

Photosynthetic pigments (chlorophylls a, b, and carotenoids) were determined in fresh leaf tissues (the first fully expanded leaf from the top) following the method of Metzner et al. (1965). A Josco V530 UV/ vis spectrophotometer was used for extinction measurements of the acetone (85%) extracts of different pigments.

Field experiment

This experiment was carried out at Belbis area (50 km North East Cairo) in a sandy, saline sodic newly reclaimed soil. Seeds of the two species under investigation were sown in randomized plots with three replications for each treatment. The area devoted to the experiment was approximately one feddan (4200 m^2); 1/ 2 feddan

Table 1. Chlorophylls a and b, total chlorophylls (a+b), carotenoids and total pigment contents in leaves of peanut and sunflower plants (30-day-old) under the effect of three biofertilizers namely nitrobein (nitrogen fixing), phosphorein (phosphate solubilizing) and potash (potash mobilizing).

Plant	Treatment	Chlorophyll a	Chlorophyll b	Total Chlorophyll (a +b)	Carot	Total pigment
Peanut	Control	14.16	5.63	19.79	2.91	22.70
	N	15.57	5.69	21.26	2.31	23.57
	P	14.4	6.91	21.31	2.51	23.82
	K	19.22	7.78	27.00	1.82	28.82
Sunflower	Control	9.93	1.06	10.99	4.93	15.92
	N	10.32	1.73	12.05	4.89	16.94
	P	10.52	1.76	12.25	4.85	17.13
	K	9.78	0.95	10.73	4.57	15.37

Each biofertilizer was incorporated at a constant volume into the surface layer of each pot (30 cm. diameter), 48 h before sowing. Seeds were sown at equal numbers, depth, and distance apart. Photosynthetic pigments were extracted from the first expanded leaves from the top. The values listed are the means of duplicate samples for two independent experiments, which showed similar values. The results are expressed as mg/g dry weight equivalent of the leaf tissue.

for each species. Each plot was surrounded from each side by a bare area of two meters to separate the different treatments. The groups within each species were equally divided into four groups, the first for the control and the second, third and fourth were subjected to one of the biofertilizers used (nitrobein, phosphorein and potash). The recommended rates of the biofertilizers were mixed in equal amounts of compost and kept overnight. This mixture was incorporated in the soil at the time of sowing. Irrigation was regular every 10 days after germination. At harvest, 20 randomized plants were taken for each measurement with the two species. Total biomass/plant, fresh weights of pods/plant (in case of peanut) or flowers (in case of sunflower), dry seed yield/ plant were calculated to evaluate the yield. Mineral and oil contents of the yielded seeds were determined in the dry harvested seeds of each plant. Fractionation of fatty acid esters was also carried out in oil of each plant, for comparing the oil components.

Soil samples were taken from the experimental site (before cultivation) at various depths (0, 15, 30 cm) and mixed together. Analysis for the physical properties of soil and the chemical composition of soil and irrigation water were carried out in the Soil and Water Research Institute, Agriculture Research Center, Ministry of Agriculture, Egypt. The methods used are described in details by El-Senoosy (2006).

Extraction and determination of total lipids and estimation of fatty acids by gas liquid chromatography (GLC)

Oil was extracted from the harvested dry seeds of peanuts and sunflower, according to Floch et al. (1957). Fractionation of fatty acid methyl esters was carried out by GLC according to Kates (1972).

Statistical analysis

Statistical analysis was done using "T test" (Snedecor and Cochran, 1980). In case of photosynthetic pigments, total lipids and fatty acids the values of duplicate samples were remarkably close, so only the mean values were presented.

RESULTS

Three biofertilizers namely nitrobein, phosphorein, and potash have been used in this present work. Table 1 shows the effects of soil incorporation with the recommended rates of each of these biofertilizers on the photosynthetic pigment contents of 30-day-old peanut and sunflower plants grown in pots. Generally, the results indicated increased contents of total chlorophylls (a+b) and total pigments, in response to different biofertilizer amendments. This increase was more evident on application of potash in peanut plants and phosphorein and nitrobein, respectively in sunflower plants. Table 1 also shows that slight changes, if any, were recorded in the carotenoid contents of peanut and sunflower plants, in response to different fertilizer treatments, as compared with corresponding controls (Sharma and Namadeo, 1999).

Figure 1 shows the effects of the biofertilizer treatments under investigation on the growth parameters of peanut and sunflower plants (30-day-old). From this figure, it is obvious that the shoot and root lengths of plants have significantly been increased, in response to the applied treatments, with maximum effect by potash in case of peanut and each of phosphorein and potash in sunflower. The fresh and dry weights of both plants also showed significant increments as a result of soil amendment with the three biofertilizers under investigation, with a maximum effect by potash. In this respect, phosphorein generally exerted higher increase in the growth parameters of both plants over that induced by nitrobein.

Field experiment

This experiment was carried out in field in a newly reclaimed soil at Belbis desert (55 km Northern East Cairo) in a private farm. The results of soil and water analyses of the experimental site shown in Table 2 revealed that soil was saline- sodic (EC of soil solution = 8.82 dsm^{-1}), where the source of salinity is mainly Na^+

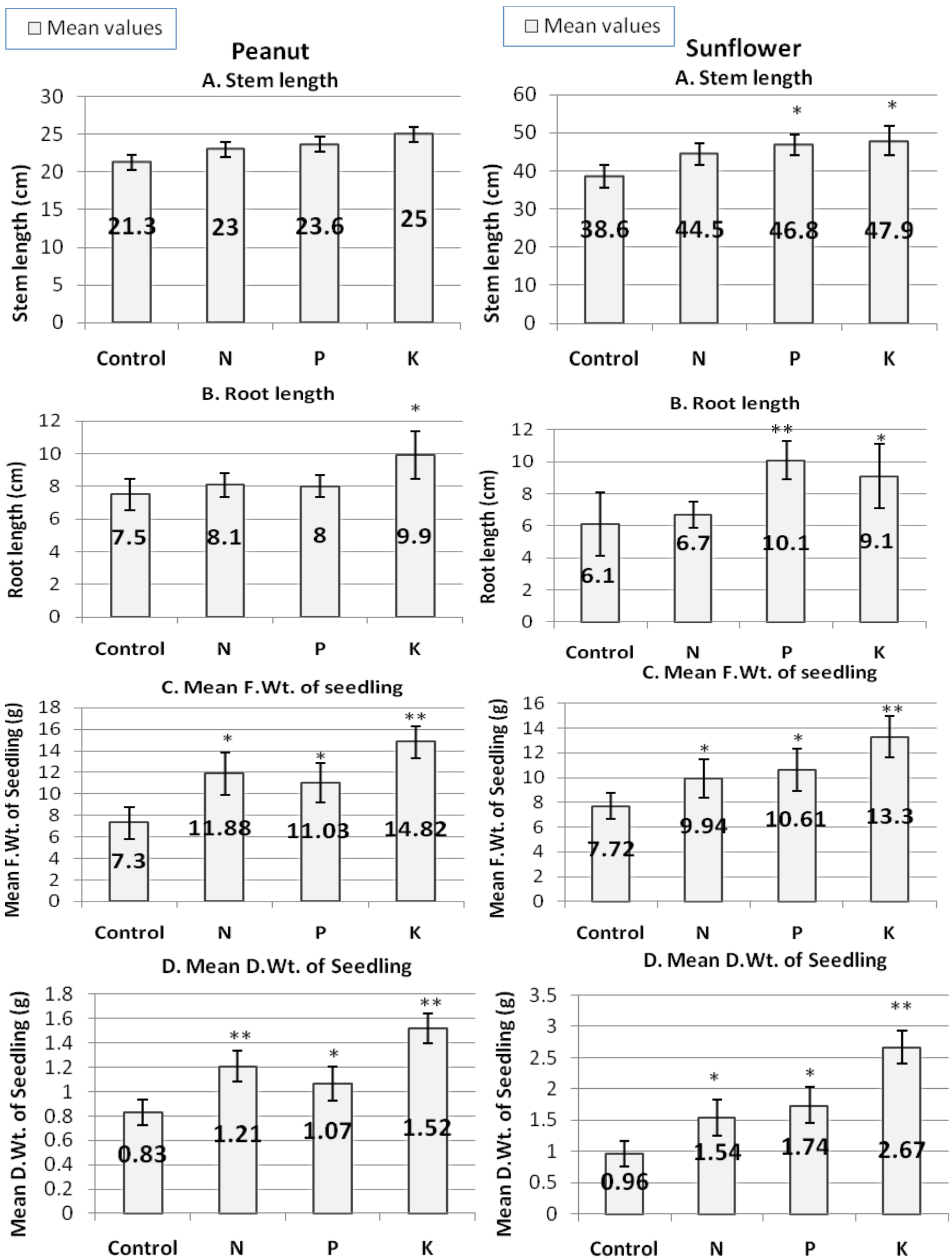

Figure 1. Different growth criteria of peanut and sunflower plants (30-day-old) under the effect of three biofertilizers namely nitrobein (nitrogen fixing), phosphorein (phosphate solubilizing), and potash (potash mobilizing). Each biofertiler was incorporated at a constant volume into the surface layer of each pot (30 cm diameter), 48 h before sowing. Seeds were sown at equal numbers, depth and distances apart. The values presented are the means of 10 replicates ± standard deviations. (*$p \leq 0.05$, **$p \leq 0.01$ calculated by the student's t test).

Table 2. Physical and chemical properties of soil (soil suspension 1: 2.5 soil: irrigation water) and analysis of ground irrigation water (well) in the experimental site of a newly reclaimed soil at Belbis desert, 55 km Northern East Cairo.

Soil type	**Physical property, EC, pH and $CaCO_3$**						
	Particle size (%)			**Texture**	**EC dsm^{-1}**	**pH**	**$CaCO_3$**
	Sand	**Silt**	**Clay**	Sandy	8.82	8.45	Negative
Sandy	96	2	2				

Chemical property

Soluble cations (meq 1^{-1})			**Soluble anions (meq 1^{-1})**		
Na^+	**Ca^{2+}**	**Mg^{2+}**	**Cl^-**	**HCO_3^-**	**SO_4^{2-}**
61.67	14.25	7.33	38.97	3.41	38.98

Available nutrient elements (ppm)

N	**P**	**K**	**Fe**	**Zn**	**Mn**
22.45	2.23	75.01	0.82	0.42	0.23

Irrigation water

EC, pH and soluble cations and anions

EC (dsm^{-1})	**pH**	**Soluble cations (meq 1^{-1})**				**Soluble anions (meq 1^{-1})**			
		Na^+	**K^+**	**Ca^{2+}**	**Mg^{2+}**	**Cl^-**	**CO_3^{2-}**	**HCO_3^-**	**SO_4^{2-}**
		13.09	0.19	15.90	11.98	18.0	-ve	6.6	16.34

Nutrient elements

N	**P**	**K**	**Fe**	**Zn**	**Mn**	**Cu**	**B**
5.97	Trace	1.78	0.05	-ve	-ve	-ve	1.99

ions (concentration = 61.67 meq 1^{-1}). Irrigation water was moderately saline (2800 ppm).

The results presented in Figure 2 show that all the yield criteria of peanut and sunflower plants at harvest time [plant total biomass, fresh weight of pods (peanut) or fresh weight of flowers (sunflower)/ plant, number of seeds/plant and weight of seeds/ plant] significantly increased as a result of different biofertilizer treatments, as compared with the corresponding control values. Figure 3 shows that the percentage increases over the control values in dry mass gain were in peanut 178.59, 146.70, and 192.71 and in sunflower, 116.91, 131.68, and 146.03, in response to supplementation of nitrobein, phosphorein, and potash, respectively. The percentage increase in yield showed similar trends to those obtained with their corresponding dry mass values, reaching 122.03, 120.11, 176.62 in peanut and 149.22, 168.75, and 173.44 in sunflower, for nitrogen, phosphorein, and potash amendments, respectively. The biofertilizer-enhancement effects on yield were also higher in sunflower than peanut (Figure 3).

Table 3 shows the changes in the oil contents and fatty acid components of the yielded seeds of peanut and sunflower plants as a result of soil incorporation treatments with the biofertilizers nitrobein, phosphorein and potash. In peanut seeds, the oil percentage was increased, as compared with the corresponding control value, in soil amendments with nitrobein and potash (in the given manner), but was slightly decreased in application of phosphorein. In sunflower seeds, the oil content was increased in treatment with potash and decreased on application of nitrobein and phosphorein, with further decrease in the former.

The soil incorporation treatments with nitrobein, phosphorein and potash biofertilizers had generally remarkable effects on fatty acid constituents of peanut and sunflower oils (Table 3). Saturated fatty acids namely palmitic (C16:0), stearic (C18:0), arachidonic acid (C20:0) were in most cases decreased, whereas unsaturated fatty acids particularly the polyunsaturated fatty acids (PUFAs) linoleic (C18:2) and linolenic (C18:3) were obviously increased as compared with those of corresponding controls.

DISCUSSION

Soil incorporation with the recommended rates of each of three biofertilizers, namely nitrobein, phosphorein, and potash, generally led to enhancement of the photosynthetic pigment contents of leaves in 30-day-old peanut and sunflower plants (Table 1). This increase was expressed as elevated total chlorophylls (a+b) and total pigments (total chlorophylls+carotenoids), particularly on

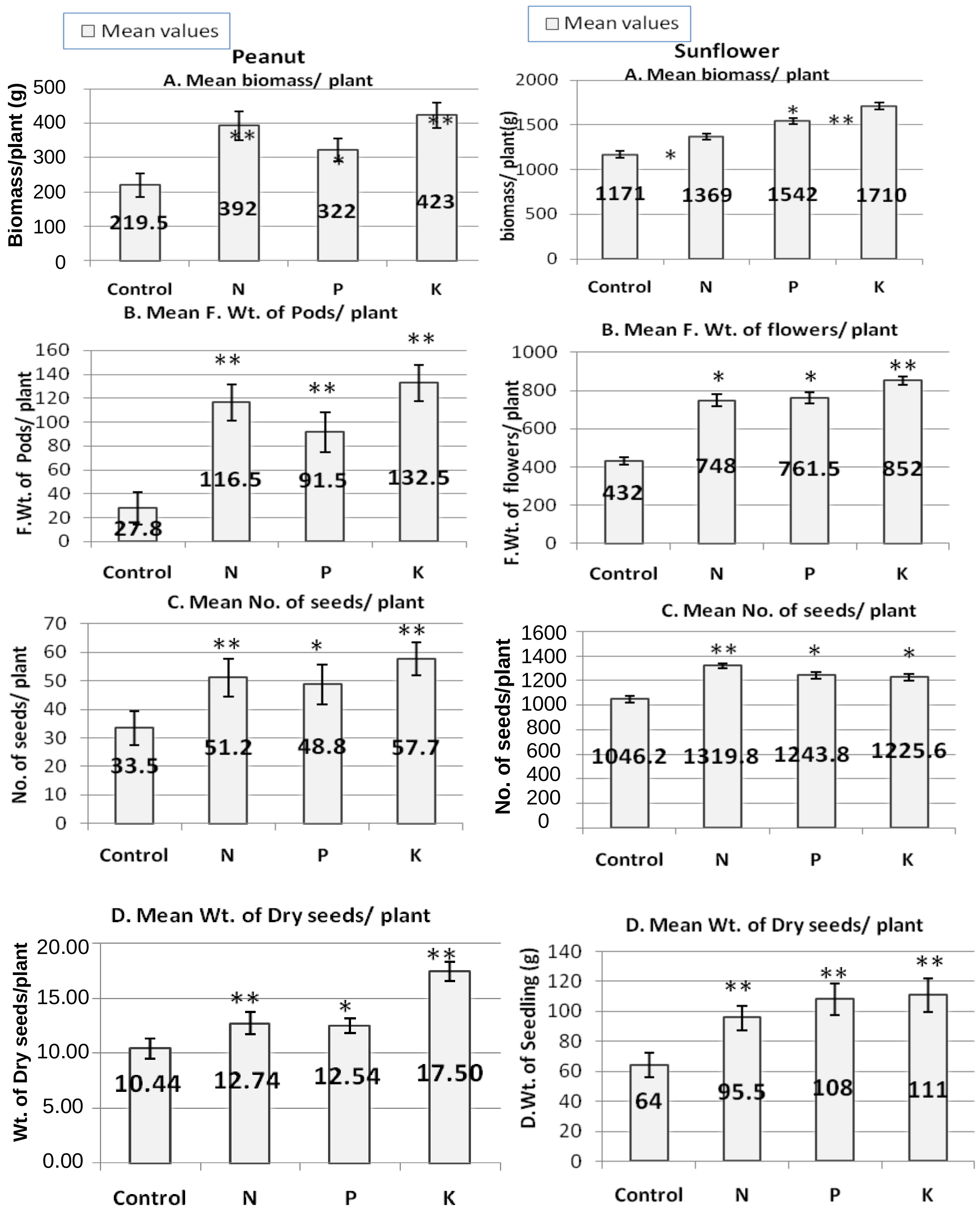

Figure 2. Different yield criteria of peanut and sunflower plants at harvesting stage, in response to the effects of three biofertilizers namely nitrobein (nitrogen fixing), phosphorein (phosphate solubilizing), and potash (potash mobilizing). The experiment was carried out in the field in a newly reclaimed soil at Belbis desert region. The recommended rates of the biofertilizers were mixed in equal amounts of compost and kept overnight, then incorporated in the soil at the time of sowing. The values presented are the means of 20 randomized replicates ± standard deviations. (*p≤ 0.05, **p ≤ 0.01 calculated by the student's t test).

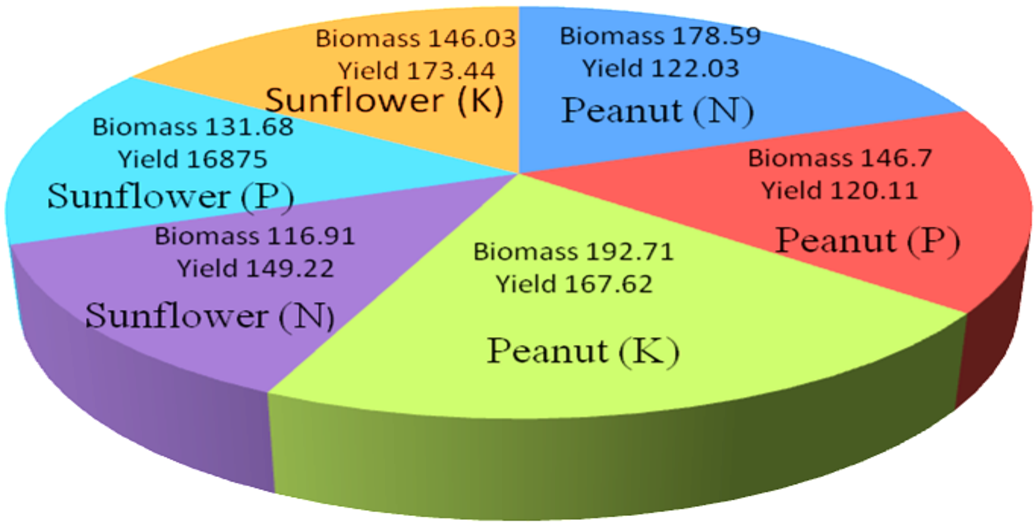

Figure 3. The percentage increase in the main yield criteria at harvest time (mean total biomass/ plant and mean weight of yielded seeds/ plant in grams), of peanut and sunflower plants as a result of soil incorporation treatments with the recommended rates of the commercial biofertilizers nirtobein (N), phosphorein (P) and potash (K). The results were taken for the plants cultivated in a newly reclaimed sandy saline sodic soil at Belbis desert (EC of soil solution = 8.82 dsm^{-1}, Na^+ ion concentration = 61.67 meq 1^{-1}) irrigated by moderately saline ground water (2800 ppm).

Table 3. The percentage of oil content of seeds (g/ 100 g), oil content produced / plant, and the fatty acid composition (g/ 100 g oil) of the harvested dry seeds of peanut and sunflower plants as a result of soil incorporation treatments with the recommended rates of the commercial biofertilizers nitrobein (N), phosphorein (P) and potash (K).

Plant	Treatment	% Oil in seeds	Oil content of seeds/ plant	Fatty acid					
				Saturated			Unsaturated		
				C16:0	C18:0	C20:0	C18:1	C18:2	C18:3
Paenut	Control	42.2	4.41	17.69	2.61	0.62	47.08	28.59	0.08
	N	49.1	6.26	16.38	2.89	0.46	49.69	29.46	0.16
	P	41.1	5.15	12.24	2.46	1.31	50.16	32.18	0.12
	K	46.4	8.12	12.66	2.08	1.38	50.15	28.98	0.13
Sunflower	Control	44.35	28.38	8.09	3.06	0.32	41.85	37.43	0.01
	N	36.1	34.48	5.87	2.99	0.24	47.93	42.69	0.07
	P	41.7	45.04	6.23	3.16	0.20	50.57	42.77	0.15
	K	46.1	51.17	5.94	2.20	0.21	47.44	46.96	0.06

The results are taken for the plants cultivated in a newly reclaimed sandy saline sodic soil (EC of soil solution = 8.82 dsm^{-1}, Na ion concentration = 61.67 meq l^{-1}) irrigated by moderately saline ground water (2800 ppm). Seeds were taken from at least 20 randomly choice plants. The values listed are the means of duplicate samples C16:1 = palmitoleic acid, C18:1 = oleic acid, C18:2 = linoleic acid, C18:3 = linolenic acid.

application of potash in peanut and phosphorein or nitrobein, respectively in sunflower plants. Other workers also reported enhancement of photosynthetic pigments and efficiency, as a result of treatments with biofertilizers including nitrobein and phosphorein (Nijjar, 1990; Hassan et al., 2005; Mostafa and Abo- Baker, 2010). The growth parameters of peanut and sunflower plants (30-day-old) showed also significantly increased shoot and root lengths with a maximum effect by potash in case of peanut and each of phosphorein and potash in sunflower. The fresh and dry weights of both plants showed maximum increase over the control in response to application of potash. Phosphorein also generally exerted higher increase in the growth parameters of both peanut and sunflower plants than nitrobein (Figure 1). In this present work (Table 1 and Figure 1), it could also be concluded on the bases of the results obtained that the increment in total chlorophylls and total photosynthetic pigments coincided to a wide extent with the concomitant increase of the dry mass gain of the plants subjected to the different biofertilizer treatment. Increment of growth parameters by biofertilizer treatments has been recorded in many plants; for example, soybean (Javaid and Mahmood, 2010), wheat (Javaid and Shah, 2010), and lettuce (Hasaneen et al., 2009). This might indicate that dry matter accumulation in peanut plants was directly correlated with increased capacity for enhancement of chlorophyll a and b pigments (Jungklang, 2005). However, this conclusion was not consistent in sunflower plants, in which potash treatment resulted in evoked dry mass accumulation in spite of their decreased photosynthetic pigment contents. This might be assumed to a potash enhancement effect in sunflower plants on processes other than photosynthetic pigment content. In this respect, plant growth and development may be connected with evoked functional state of the assimilation apparatus of plants and phytohormone balance rather than elevated photosynthetic pigments (Ivanova and Vassilev, 2003). Biofertilizer treatments stimulated net assimilation rates and plant growth indirectly via the production of growth promoting substances (Abu-Hussein et al., 2002) and bioactive substances such as hormones and enzymes (Hussain et al., 2002).

The enhancement effect of potash is usually attributed to potash mobilization in the soil to the plant. Therefore, it is recommended for stimulating growth productivity and yield components in many crops including peanuts and sunflower (Rodriguez and Fraga, 1999; Asean Agritechnologies Pvt. Ltd., 2011). The stimulatory effect of biophosphorus fertilizers on plant growth and marketable yields have been concluded to result from the ability of their included microorganisms to: (a) convert insoluble phosphate to soluble forms and/ or to secret organic acids such as formic, acetic and lactic acids, which lower the soil pH value, thus enable the dissolution of bound forms of phosphate to be available to plants (Abdalla, 2002; Hassan et al., 2005). The positive effect of N-biofertilizers on plant growth is mainly attributed to enhancement of atmospheric nitrogen fixation (Mekonnen et al., 2003). Fisinin et al. (1999) also suggested that nitrogen biofertilizers led to activation of the growth of microflora, which might furnish the soil with many plant growth stimulators.

A field experiment was also designed in this present work to investigate the effects of nitrobein, phosphorein, and potash on the productivity and oil properties of peanut and soybean plants in a newly reclaimed soil at Belbis desert (55 km Northern East Cairo). Analyses of soil and water in the experimental site indicated a saline-sodic soil (EC of soil solution = 8.82 dsm^{-1}), where the source of salinity is mainly Na^+ ions (concentration = 61.67 $meq1^{-1}$). Irrigation water was moderately saline (2800 ppm).

The different biofertilizers under investigation led to significant increases in all the yield criteria of peanut and sunflower plants [plant total biomass, fresh weight of pods (peanut) or fresh weight of flowers (sunflower)/ plant, number of seeds/plant and weight of seeds/ plant] at harvest time (Figure 2). In this respect, the percentage increase in yield of both peanut and sunflower plants showed similar trends to those obtained with their corresponding dry mass values. Best results for biomass and seed yield were obtained by potash in both plants (Figure 3). As a result of potash treatment, the increases in dry mass gain (as compared to the controls) were 192.71 and 146.03% in peanut and sunflower, respectively whereas the percentages increase in yield were 167.62 and 173.44 in the given manner. This conclusion could be supported by other research work, dealing with involvement of K^+ in plant metabolic processes which lead to improvement of growth and crop yield (Innocenti et al., 2009; Dixit et al., 2011) and alleviation of stress conditions (Tomar and Dwivedi, 2008). Potash performance in this present work was followed by nitrobein in peanuts and phosphorein in sunflower plants. However, application of nitrogen and phosphorus biofertilizers is also known to enhance yield in many crops both leguminous and non-leguminous (Daiss et al., 2008; Javaid, 2009; Zarabi et al., 2011). It should also be added that the enhancement of total biomass yield, as a result of biofertilizer amendment, is not only of significance for the plant productivity of seeds but also required for use as animal forages and silage in both peanut (Eckert et al., 2010) and sunflower (Mafakher et al., 2010).

Peanut and sunflower are considered to be partially salinity tolerant and recommended for cultivation in wastelands and reclaimed sandy soils (Mostafa and Abo-Baker, 2010; Osman and Awed, 2010; EU BAN on Egyptian Peanuts import, 2011). Thus, the pronounced enhancement of the yield of peanut and sunflower (over the control) in this present work in spite of the pronounced salinity of the experimental field would be attributed to an ameliorating effect of the three biofertilizers under investigation (Table 3). In this context, the adverse effects of salinity on plant growth and productivity are well known factors among other stressful conditions (Orcutt and Nilsen, 2000). On the other hand, the ameliorative effects of biofertilizers to salinity and other stresses are also reported by many authors (Hasaneen et al., 2009; Zarabi et al., 2011). The results obtained in this present work showed different magnitudes of responsiveness of peanut and soybean plants to the applied biofertilizers. Thus, it might be concluded that elucidation of the nutrient ratios is a critical process which must be determined for each plant alone to realize the proper fertilizer rate required to optimize its yield potential. In this connection, Ranade-Malvi (2011) pointed that extensive work is required to understand the nutrient requirements of each plant species so as to bridge the gap between potential yields and actual yields.

The oil contents and fatty acid components of the yielded seeds of peanut and sunflower plants were also increased as compared with the corresponding control value in response to soil amendment with nitrobein or potash (in the given manner), but were slightly decreased on application of phosphorein. This conclusion could be supported by the results of other workers, showing inconsistent trends by different biofertilizers (or chemical fertilizers) regarding the oil contents of seeds of many plants. Thus, the oil content of seeds was either evoked (Shehata and El-Khawas, 2003; Akbari et al., 2011; Rahmani et al., 2011), slightly changed from the control (Yasari and Patwardhan, 2007), or decreased (Ghasemnezhad and Honermeier, 2008; Grant et al., 2011) with different fertilizer treatments. Moreover, Scheiner et al. (2002) and Karmakar et al. (2007) concluded that in sunflower, certain excessive rates of biofertilization lowered the oil content as related to higher protein content of seed.

However, in this present work, the oil content of seeds per plant was considered to be markedly increased, in the response to the different applied biofertilizers, due to the significant increase in yield per plant (Table 3). On these bases, it could be concluded that maximum enhancement of the oil content was induced by potash in both peanut and sunflower followed by nitrobein in peanut and phosphorein in sunflower, which are the same trends shown by total biomass and yield/plant. Thus, the total biomass/plant, the seed yield/plant and the oil content/plant might be considered as yield-attributing characters in both peanut and sunflower plants.

The different soil incorporations with nitrobein, phosphorein and potash biofertilizers had generally remarkable effects on the constituting fatty acids of peanut and sunflower oils (Table 3). Saturated fatty acids namely palmitic (C16:0), stearic (C18:0), arachidonic acid (C20:0) were in most cases decreased, whereas unsaturated fatty acids particularly the polyunsaturated fatty acids (PUFAs) linoleic (C18:2) and linolenic (C18:3) were obviously increased, as compared with the corresponding controls. Saturated fatty acids are known to have tendency for increasing blood cholesterol levels, whereas unsaturated fatty acids show a reverse trend (Anneken et al., 2006; Wikipedia, 2011). Therefore, the changes induced by the biofertilizers under investigation are desirable characteristics for edible uses. Linoleic acid (LA, ω-6, 18:2, 9, and 12) and linolenic acid (ALA, ω-3, 18: 3, 9, 12, 15) are essential fatty acids which are only obtained from the diet. In humans, arachidonic acid (20: 4, 5, 8, 11, and 14) can also be synthesized from LA by desaturation and chain elongation, and some long chain ω-3 PUFAs can also be synthesized from ALA. Oleic acid has also been reported to inhibit the breast cancer-promoting gene (Menendez et al., 2004) and linoleic acid could act as antiproliferative for breast cancer (Reyes et al., 2004) and colorectal and prostatic cancer cells (Palomboa et al., 2002). Maximum increase in linoleic acid and linolenic acid was achieved by phosphorein and nitrobein, respectively in peanut oil and by potash and phosphorein, respectively in sunflower oil.

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