GRASAS Y ACEITES, 60 (1),
ENERO-MARZO, 55-67, 2009,
ISSN: 0017-3495
DOI: 10.3989/gya.032508

Agronomic performance and chemical response of sunflower (*Helianthus annuus* L.) to some organic nitrogen sources and conventional nitrogen fertilizers under sandy soil conditions

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RESUMEN

Respuesta química y eficacia agronómica de cultivos de girasol (*Helianthus agnnuus* L.) a fuentes de nitrógeno orgánico y fertilizantes convencionales nitrogenados en suelos áridos.

El girasol (*Helianthus annuus*) es una opción para la producción de semillas oleaginosas, en particular en terrenos arenosos debido al buen desarrollo de sus raíces. En este trabajo, dos estudios de campo fueron realizados en la región de El-Ishattara (Sharkia Governorate, Egypt) durante la estación 2005. El efecto de diversas fuentes de nitrógeno orgánico (ON) y el de su combinación, así como el efecto de ON y sulfato amónico (AS) como fertilizante convencional añadido individualmente o en combinación ha sido estudiado en base a su crecimiento, rendimiento de los componentes, porcentaje de aceite y consumo de micronutrientes en girasoles crecidos en suelos arenosos. El tratamiento con estiércol de pollo (CM) y una mezcla de estiércol de corral (FYM) con CM fue superior a otros tratamientos y dio el más alto rendimiento, la mayor cantidad de materia seca, y el mayor consumo de NPK por la planta en todos los estadios de crecimiento, así como en el rendimiento de la semilla en el estado de madurez El efecto promotor de los diferentes ON en el rendimiento del cultivo y sus componentes puede seguir el orden siguiente: CM> residuos de palma (PR)> FYM. Este efecto fue mayor cuando los materiales fueron mezclados con AS en una proporción 3:1 y 1:1. El consumo de nitrógeno (N), fósforo (P) y potasio (K) por la plantas dependió de la adición de diferentes fuentes de nitrógeno y tratamientos. El consumo y contenido de nutrientes más alto del tallo fue obtenido cuando se trató con CM seguido por PR en todos los estadios de crecimiento, mientras que PR fue seguido por CM para semillas. Se ha encontrado que la recuperación del aceite responde a la adición de nitrógeno, pero los cambios en los ácidos grasos no fueron significativamente diferentes. Sin embargo la aplicación de fertilizantes orgánicos resultó en un incremento de los ácidos grasos insaturados.

PALABRAS CLAVE: Aceite de semilla – Ácidos grasos – Estiércol orgánico – Girasol – Helianthus annuus *L. – Materias nitrogenadas – Suelos arenosos.*

SUMMARY

Agronomic performance and chemical response of sunflower (*Helianthus annuus* L.) to some organic nitrogen sources and conventional nitrogen fertilizers under sandy soil conditions.

Sunflower (*Helianthus annuus* L.) is an option for oilseed production, particularly in dry land areas due to good root system development. In this study, two field experiments were performed in the El-Khattara region (Sharkia Governorate, Egypt) during the 2005 season. The objective of this research was to determine the effect of organic-nitrogen (ON) sources and their combinations as well as to compare the effect of ON and ammonium sulfate (AS) as a conventional fertilizer added individually or in combination on growth, yield components, oil percentage and the uptake of some macronutrients by sunflowers grown on sandy soil. The treatments of chicken manure (CM) and a mixture of farmyard manure (FYM) with CM were superior to the other treatments and gave the highest yield, dry matter yield, NPK uptake by plants at all growth stages along with seed yield at the mature stage. The effect of the different ON on crop yield and its components may follow the order; CM> palma residues (PR)> FYM. This was more emphasized when the materials were mixed with AS at a ratio of 3:1 and 1:1. The uptake of nitrogen (N), phosphorus (P) and potassium (K) by plants was affected by the addition of different N sources and treatments. The highest nutrient content and uptake by straw were obtained when treated with CM followed by PR at all growth stages, while it was PR followed by CM for seeds. Oil recovery was shown to respond to the N supply and the changes in individual fatty acids were not statistically different. However, it seems that the application of organic fertilizers resulted in an increase in total unsaturated fatty acids compared to the control.

KEY-WORDS: Fatty acids – Helianthus annuus *L – Nitrogen sources – Organic manures – Seed oil – Sunflower – Sandy soil.*

1. INTRODUCTION

Egypt's oil consumption has increased over recent years. In 2005 the production average of sunflower (*Helianthus annuus* L.) was 39.000 tons, whereas the consumption amounted to 376.000 tons in the same year (FAO, 2006). The production of vegetable oils is still, therefore, below current needs, since it covers about 10% of the consumption (El-Fayoumy *et al.*, 1999). Sunflower is considered one of the most important oil crops in the world. Therefore, an improvement of the productivity of this crop is needed to meet the shortage of vegetable oils. In Egypt, the sunflower is adapted to different types of soils and climate conditions. This wide adaptability led to the fact that sunflower can be grown in less productive soils, particularly, in the newly reclaimed areas of Egypt.

The poor quality of desert soil particularly the sandy soil requires extensive efforts to improve its hydro-physical properties as well as its productivity. Thus, applications of organic matter to such soil are needed. Organic materials contain significant amounts of macro-nutrients (i.e., N, P and K). Many organic materials contain other components that can contribute significantly to an increase in crop yields, including secondary nutrients and micro-nutrients. On the other hand, land application of animal waste is a common practice which when conducted judiciously can provide a cost-effective strategy for recycling organic matter and essential plant nutrients as well as assisting in solid waste disposal. The production benefits garnered from animal sludge has been extensively documented (Adegbidi and Briggs, 2003; Yang *et al*., 2004; Hiltbrunner *et al*., 2005 and Zhou *et al*., 2005). Several experiments showed that N fertilizer increased the seed yield of sunflowers. Basha (2000) showed a significant yield response by sunflowers to N levels and a highly significant increase in seed and oil yield. (El-Zahar and El-Kafoury, 1999) and El-Zahar *et al*. (1999) reported that the highest seed and oil yields of Vidoc cultivar were obtained from the highest N fertilizer (60 kg N acre^{-1}) and that the application of 20 kg N acre^{-1} gave the highest seed oil recovery. Lawlor (2002) stated that metabolic processes, based on protein, lead to increases in vegetative and reproductive growth and yield is totally dependent upon the adequate supply of N. Scheiner *et al*. (2002) pointed out that N fertilization affected the seed yield and number of seeds per head. Moreover, yield increased by 17% when N was added, regardless of fertilizer rate. Thomas *et al.* (2006) reported that using of sludge-scrubber by-product mixture as an N fertilizer produced significant increases in leaf area, dry shoot, root mass and seed yield for mature plants grown in sludge-treated soil relative to the control. A Higher N concentration resulted in a higher shoot dry matter production per plant and the effect was apparent from 29 days after sowing (Cechin and Fatima-Fumis, 2004). The differences in dry matter production were mainly attributed to the effect of N in leaf production and on individual leaf dry matter.

The purpose of the present investigation is to study the effects of some organic nitrogen (ON) sources and their combinations as well as to compare the effect of ON sources and ammonium sulfate (AS) as a conventional fertilizer added individually or in combination on growth, yield components, yield quality, oil recovery as well as the uptake of some macronutrients by plants grown in a sandy soil. Two experiments were carried out; in the first one, ON sources and their combinations were studied, while in the second experiment, conventional N source (AS) was applied individually or in combination with different organic manures.

2. MATERIALS AND METHODS

2.1. Field Experiments

Two field experiments were carried out during the 2005 season in the El-Khattara region (El-Sharkia governorate, Egypt) to study the response of sunflowers to some ON sources and their combination as well as the influence of some N sources and N addition treatments under sandy soil conditions. A representative soil sample (0-30 cm) was taken before planting to determine some physical, chemical and nutritional properties (Table 1). Levels of particle size distribution were 574.4 g/kg C. Sand, 346.7 g/kg F. sand, 59.2 g/kg silt and 19.7 g/kg clay. Levels of organic matter and $CaCO_3$ were 5.9 g/kg and 6.9 g/kg, respectively. Soil pH was 8 and EC was 0.052 S m^{-1}. Nitrogen sources used were; AS and three ON sources included farmyard manure (FYM), chicken manure (CM) and palm residues (PR) as agro-industrial wastes. Organic-N sources were applied at 119.0 kg N ha^{-1} according to the total N in each source. The chemical compositions of the ON sources are shown in Table 2.

Organic sources (FYM, CM and PR) were added and mixed thoroughly with soil two weeks before seeding. A randomized complete blocks design with three replicates, having a plot area 4 $\times$ 2.5 m^2, was used. Each plot consisted of 8 rows 50 cm apart, two plants/hill and 20 cm between hills. Sunflower seeds (*Helianthas annus* L. cv. Vidoc hybrid) were sown after soil preparation and seeding was carried out on June 15th, 2005. The plants were thinned to

Table 1
Chemical properties of the experimental soil

[a] Cations (cmol kg^{-1})	Anions (cmol kg^{-1})	Macronutrients (mg kg^{-1})	Micronutrients (mg kg^{-1})
Ca^{+2} 1.2	CO_3^{-2} 0.0	N 17.5	Mn 2.30
Mg^{+2} 0.7	HCO_3^{-1} 1.8	P 5.16	Zn 0.68
Na^{+1} 1.4	Cl^{-1} 1.5	K 23.2	Cu 0.43
K^{+1} 1.6	SO_4^{-2} 1.6		

[a] Soluble cations and anions in (1: 2.5) soil: water extract.

Table 2
Chemical characteristics of the organic nitrogen sources used in the current study

Characteristics	FYM	PR	CM
Total carbon (g 100g^{-1})	27.6	32.3	20.4
C/N ratio	19.7:1	12.9:1	8.7:1
Total macro nutrients (g 100g^{-1})			
N	1.40	2.50	2.35
P	0.21	0.37	0.58
K	0.33	1.91	1.05
Total micro nutrients (mg kg^{-1})			
Fe	152	473	358
Mn	88	119	219
Zn	62	72	198

a single plant per hill after 21 days from sowing. Phosphorus fertilizer was added to all plots before sowing at a rate of 71.4 kg P_2O_5 ha^{-1} as superphosphate (15.5% P_2O_5). Potassium sulfate (48%, K_2O) was applied as soil application at a rate of 119.0 kg K_2O ha^{-1} in two equal splits, 30 and 45 days after sowing. Nitrogen was added at 50 kg N fed^{-1} according to the following treatments:

First Experiment

1- Control (without N); 2- FYM; 3- CM; 4- PR; 5- FYM + CM; 6- FYM + PR; 7- CM + PR.

Second Experiment

1) Ammonium sulfate (AS)
2) FYM, 1:0 (119.0 kg N ha^{-1}); 3:1 (89.25 kg N ha^{-1} as FYM + 29.75 kg N ha^{-1} as AS); 1:1 (59.50 kg N ha^{-1} as FYM + 59.50 kg N ha^{-1} as AS) and 3/1 (29.75 kg N ha^{-1} as FYM + 89.25 kg N ha^{-1} as AS).
3) CM, 1:0 (119.0 kg N ha^{-1}); 3:1 (89.25 kg N ha^{-1} as CM + 29.75 kg N ha^{-1} as AS); 1:1 (59.50 kg N ha^{-1} as CM + 59.50 kg N ha^{-1} as AS) and 3:1 (29.75 kg N ha^{-1} as CM + 89.25 kg N ha^{-1} as AS).
4) PR, 1:0 (119.0 kg N ha^{-1}); 3:1 (89.25 kg N ha^{-1} as PR + 29.75 kg N ha^{-1} as AS); 1:1 (59.50 kg N ha^{-1} as PR + 59.50 kg N ha^{-1} as AS) and 3:1 (29.75 kg N ha^{-1} as PR + 89.25 kg N ha^{-1} as AS).

Plant samples were taken at 45, 65 and 90 days after sowing (DAS) corresponding to vegetative, flowering and maturity stages, respectively. Dry matter yield (DW) as well as the total contents of N, P and K in plants were measured. At maturity, two rows of each plot were harvested, air dried, then straw yield (kg $acre^{-1}$), seed yield (kg $acre^{-1}$), seed oil percentage, oil yield (kg $acre^{-1}$) and protein yield (kg $acre^{-1}$) were estimated. In addition, a representative ten plants were taken randomly from each plot to record the following characteristics: head weight (g $plant^{-1}$), seed weight $head^{-1}$ (g), 100 seed weight (g), seed yield (kg $acre^{-1}$), straw yield (kg $acre^{-1}$), biological yield (kg $acre^{-1}$), crop index (seed yield/straw yield) $\times$ 100, protein (%), protein yield (kg $acre^{-1}$) = protein percentage x seed yield, seed oil content (%), oil yield (kg $acre^{-1}$) = seed yield $\times$ oil percentage.

2.2. Methods of analysis

Seed and straw samples were digested with a mixture of concentrated sulfuric and perchloric acids for N, P and K determination. The analysis of plants and soil were made using the methods described by Black (1965) and Chapman and Pratt (1961). Available Fe, Mn and Zn were extracted by DTPA (Lindsay and Norvell, 1978) and determined using Inductively Coupled Plasma (ICP) Spectrometer model 400 (Soltampour, 1985). Oil amount was determined using the Soxhlet method (AOAC, 1990). Protein percentage was calculated by multiplying the N percentage by the converting factor 6.25 (Hymowitz *et al.*, 1972).

2.3. Gas liquid chromatography analysis of fatty acid methyl esters

Fatty acids were transesterified into methyl esters by heating in borontrifluoride (10% solution in methanol, Merck, Darmstadt, Germany) according to the procedure reported by Metcalfe *et al.* (1966). Fatty acid methyl esters were identified on a Shimadzu GC-14A equipped with a flame ionization detector and C-R4AX chromatopac integrator (Kyoto, Japan). The flow rate of the carrier gas (helium) was 0.6 ml/min and the split value with a ratio of 1:40 was used. A sample of 1μl was injected on a 30 m $\times$ 0.25 mm $\times$ 0.2g film thickness Supelco SP M-2380 (Bellefonte, PA, USA) capillary column. The injector and detector temperatures were set at 250°C. The initial column temperature was 100°C programmed by 5°C/min up to 175°C and maintained at 175°C for 10 min: then 8°C/min up to 220°C and maintained at 220°C for 10 min. A comparison between the retention times of the samples and those of an authentic standard mixture (Sigma, St. Louis, MO, USA; 99% purity specific for GLC), run on the same column under the same conditions, was made to facilitate identification. The quantification of each fatty acid was carried out by comparing the peak area of its methyl ester with that of methyl nonadecanoate without the application of any correction factor.

The obtained data were subjected to the analysis of variance as described by (Snedecor and Cochran, 1967). Then Duncan's multiple range test (Duncan, 1955) was used to compare among means.

3. RESULTS AND DISCUSSION

The data representing the effect of some organic manure on sunflower yield, yield components and its chemical constituents are recorded in Tables 3 and 4 and Figures 1 and 2.

3.1. Dry matter at vegetative and flowering stages

Data illustrated in Figure 1 showed that dry matter yields at vegetative and flowering stages were increased with the application of different ON sources and their combinations compared to the control treatment. Abdel-Sabour *et al.* (1999) stated that the dry matter yield of leaves, stems and flowers at different growth stages were significantly increased by the application of different types or rates of compost. This may be due to the complete

Table 3
Effect of organic nitrogen sources and their combinations on sunflower yield and its components

Nitrogen sources	Head weight (g plant^{-1})	100 seed weight (g)	Seed weight / head (g)	Seed yield (Kg acre^{-1})	Straw yield (Kg acre^{-1})	Biological yield (Kg acre^{-1})	Crop index (CI)	Oil recovery (g kg^{-1} seed)
Control	68.8 b	5.76	19.1 d	762 d	1991 d	2753 c	38.3	351
FYM	73.6 b	7.17	27.1 c	1082 c	3892 bc	4947 b	27.8	365
CM	108 a	7.80	42.7 a	1707 a	6524 a	8231 a	26.2	379
PR	124 a	7.99	41.4 a	1657 a	5208 ab	6865 a	31.8	369
FYM + CM	107 a	8.04	35.9 b	1437 ab	5376 ab	6813 a	26.7	383
FYM + PR	72.2 b	6.78	29.4 c	1177 bc	3696 bcd	4873 b	31.8	381
CM + PR	72.1 b	7.26	33.3 b	1334 bc	3041 cd	4375 b	43.9	388

Table 4
Effect of nitrogen sources and nitrogen addition treatments on sunflower yield and its components

Nitrogen sources (S)		(R) Rates of N (sources N/AS)				
		1/0	3/1	1/1	1/3	Mean
Head weight (g plant $^{-1}$)	FYM	83.8	110	154	149	124
	CM	108	142	167	136	138
	PR	118	163	146	124	138
	Mean	103	138	156	136	
	LSD at 0.05	(R): **		N (S): *		RX S: **
Seed weight / head (g)	FYM	27.1	30.5	42.1	35.4	33.8
	CM	42.7	45.2	48.4	29.8	41.5
	PR	41.4	47.9	47.8	35.7	43.2
	Mean	37.1	41.2	46.1	33.6	
	LSD at 0.05	(R): **		(S): **		RX S: **
100 seed weight (g)	FYM	7.17	7.45	7.53	7.32	7.37
	CM	7.80	7.60	8.48	7.52	7.85
	PR	7.99	7.99	7.78	8.21	7.99
	Mean	7.65	7.68	7.93	7.68	
	LSD at 0.05	(R): ns		(S): ns		RX S: ns
Straw yield (kg acre^{-1})	FYM	3892	4799	7840	7336	5967
	CM	6524	8176	9072	7644	7854
	PR	5208	9324	8148	6076	7189
	Mean	5208	7433	8353	7019	
	LSD at 0.05	(R): **		(S): **		RX S: *
Seeds yield (kg acre^{-1})	FYM	1082	1221	1685	1414	1351
	CM	1707	1807	1937	1193	1661
	PR	1657	1912	1918	1429	1729
	Mean	1482	1647	1847	1345	
	LSD at 0.05	(R): **		(S): **		RX S: **
Crop index (CI)	FYM	27.8	25.4	21.5	19.3	23.5
	CM	26.2	22.1	21.4	15.6	21.3
	PR	31.2	20.5	23.5	23.5	24.7
	Mean	28.4	22.7	22.1	19.5	
Oil recovery (g kg^{-1} seed)	FYM	365	369	375	363	368
	CM	379	385	399	372	383.7
	PR	369	371	378	368	371.5
	Mean	371	375	384	367.6	

Yield for all nitrogen as ammonium sulfate were 92.9, 37.2 and 7.96 for head weight, seed weight head^{-1} and 100 seed weight, respectively as well as 4144 and 1487 for straw yield and seed yield, respectively. Crop index for all nitrogen as ammonium sulfate was 35.9%.

decomposition of organic matter and release of nutrients in the available form. Also, improvement in the soil's physical, chemical and biological properties as well as nutritional status due to the addition of organic manures must have contributed to the higher yield. Tahoun *et al*. (2000) reported that adding an organic matter and manure supply in appreciable amounts of P and K and smaller

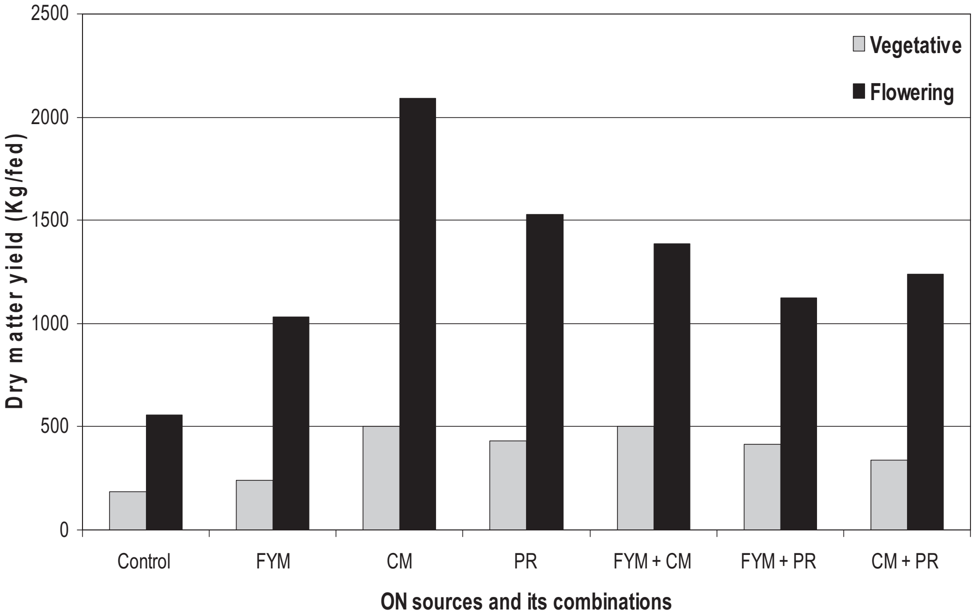

Figure 1
Dry matter yield of sunflower at vegetative and flowering stages as affected by organic nitrogen sources and their combinations.

amounts of other elements in addition to N increased the base-exchange capacity, the relative potential fertility and organic matter content of soil. Similar results were also reported by Awad *et al*. (2003).

The data in Figure 1 show that the addition of N as a mixture of the ON source and mineral source (AS) significantly increased the dry matter yields at the vegetative and flowering stages. This shows the positive effect of the mineral source (AS) which would increase the decomposition of organic matter and thereby release the nutrients in their available form. El-Awag *et al*. (1996) found that the application of urea may increase the decomposition of the soil's organic matter and thereby release the nutrients in their available form. An increase in dry matter production at the different growth stages was reported by Legha *et al*. (1999); Awad *et al*. (2000); Mostafa (2001) and Ibrahim *et al*. (2003). Organic matter (FYM, CM and PR) may have acted as chelating agents for nutrients. Such organic residues contain nutrients other than N (Table 2) which must have contributed to their superiority over the treatment which received the entire N rate as soluble AS.

The positive effect of the FYM, CM and PR was most pronounced with the 3:1 and 1:1 rates. The highest dry matter was observed from the addition of CM (3:1 ratio) at vegetative and flowering stages. According to the above results, it could be concluded that the promoting effect of the different organic sources of N on the dry matter and straw yield may follow the order; CM> PR> FYM. This was more emphasized when the materials were mixed with AS at the ratio of 3:1.

3.2. Yield and its components

The data in Table 3 reveal that sunflower yield and its components i.e., head weight, seeds weight head^{-1}, seed yield, straw yield and crop index were significantly increased due to the addition of ON sources individually or combined. The relative values of seed and straw yield due to the treatments over the control were as follows: 142.0, 224.0, 217.5, 188.6, 154.4 and 175.1% for seed and 195.5, 327.7, 261.6, 270.0, 185.6 and 152.7% for straw. The 100 seed weight showed an increase but not significant. The data in Table 3 also show that when organic manures were added individually, the CM was superior followed by PR and then FYM for both seed and straw yield. Comparing the combination of the used organic manures, the data present the following descending order: FYM + CM> CM + PR> FYM + PR for seeds and FYM + CM> FYM + PR> CM + PR for straw.

These results are in full agreement with these obtained by Abdel-Sabour *et al*. (1999); Basha (2000); Ahmed (2001); Darwish *et al.* (2002) and Abou Youssef and El-Eweddy (2003). Moreover, Faiyad (1999) suggested that the increasing effect of organic manures may be due to the ability of organic matter in rendering soil nutrients more available and chelation of these elements by humic substances.

By adding a mixture of ON and AS, data in Table 4 revealed that, head weight, 100 seed weight and seed weight head^{-1} of sunflowers were the highest under the treatment of CM at the rate of 1:1 (10.5 kg N ha^{-1} as CM + 10.5 kg N ha^{-1} as AS). Similar results were obtained by (Basha, 2000); (Abou Youssef and El-Eweddy, 2003); (Solaiman and

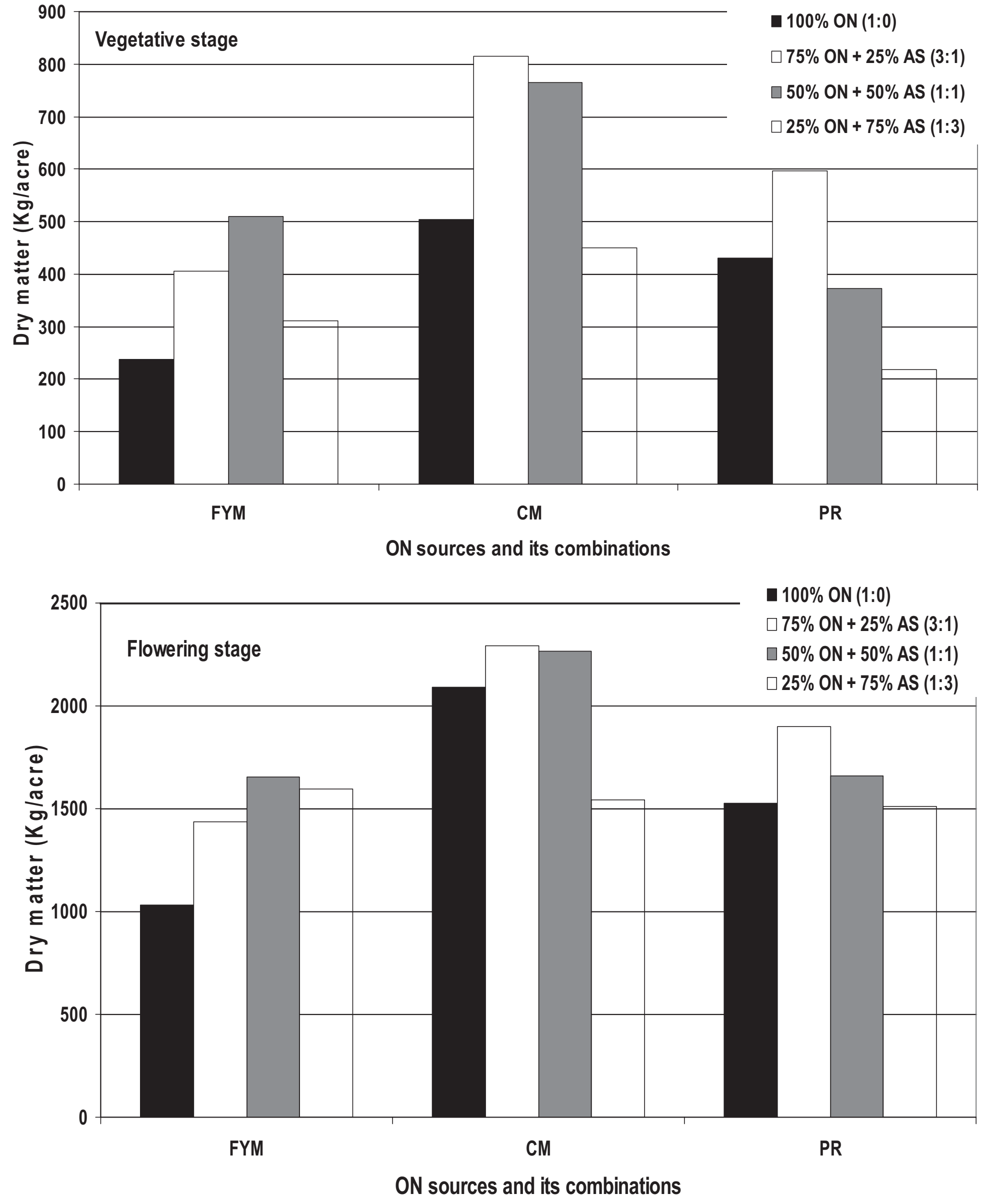

Figure 2
Dry matter yield (kg acre^{-1}) of sunflower vegetative and flowering stages as affected by addition of nitrogen as a mixture of organic source and ammonium sulfate.

Hassan, 2004) (Shaban and Helmy, 2006). This may be partially due to the low total organic matter and soluble N in the soil of the experimental site as shown in Table 1. In this respect, the addition of N sources and increasing N levels increased sunflower yield per plant as reported by Nel *et al*. (2000); Murad *et al*. (2000); Salehi and Bahrani (2000); Nawar and El-Kafoury (2001); Gajendra and Giri (2001) and Scheiner *et al*. (2002). Similar results were obtained by Ibrahim *et al*. (2003) who found that head diameter, head dry weight, number of seeds/head and 100 seeds weight as well as seed, straw and biological yield were increased significantly as the N level was increased from 0 to 30 and 60 kg fed^{-1} in the two seasons.

The highest straw yield and biomass (9324 and 11236 kg acre^{-1}, respectively) were obtained due to the addition of PR at the rate of 3:1 (89.25 kg N ha^{-1} as PR + 29.75 kg N ha^{-1} as AS). The highest seed yield (1937 kg acre^{-1}) was obtained under the application of CM at the rate of 1:1 (59.50 kg N ha^{-1} as PR + 59.50 kg N ha^{-1} as AS). These results are shown in Table 4. This increment in seed yield may be due to the increase in 100-seed weight, head weight and number of seeds/head. It seems probable, that N encouraged the accumulation of dry matter during the seed filling period of the sunflower. These findings confirm those obtained by Zubillaga *et al*. (2002). It is clear from the recorded data that, the interactive effect of N source (S) x N rate (R) was significant for seed weight head^{-1}, straw yield, seed yield and biological yield while, it was not significant for plant height and 100-seed weight. According to the above results, it could be concluded that the effect of the different ON sources on the yield and its components may follow the order; CM> PR> FYM and this was more emphasized when the materials were mixed with AS at the ratio of 3:1 and 1:1.

3.3. Crop index (seed/straw ratio)

The data in Table 3 reveal that the application of organic manures decreased crop index compared with the control treatment. This resulted from the high relative increase in straw yield compared to that of seed yield. Regarding the combined effect of the organic manures used, the data show that the combination of ON sources also decreased crop index except when CM was combined with PR which showed the highest ratio as a result of a low relative increase in straw. Similar results were obtained by Geweifel *et al*. (1997). As for the addition of N as a mixture, the data in Table 4 show that it may follow the order; 1:0> 3:1> 1:1> 1:3. Hence, the increase in AS levels led to a decrease in crop index.

3.4. Seed protein parameters

The Data illustrated in Figure 3 demonstrate that the application of different organic sources and their combinations significantly increased the protein yield compared with the control treatment. The individual effect of organic sources showed a descending increases in the order of, PR> CM> FYM. Regarding the effect of the combinations among the ON sources, the treatments followed the order of, FYM + CM> CM + PR> FYM + PR. Data in Figure 4 illustrate that the addition of N as a mixture of organic sources plus AS significantly increased protein yield. Scheiner *et al*. (2002) reported that N fertilization increased seed protein content. The individual effect of organic sources showed a descending increase in the order of CM> PR> FYM and this was more emphasized when the materials were mixed with AS at the ratio of 1:1.

3.5. Oil recovery and fatty acid composition

The effect of sowing dates and irrigation has been extensively studied on seed yield of standard genotypes (D'Amato and Giordano, 1992; Lanza *et al*, 1992; Salera, 1992; Sarno *et al*, 1992; Quaglietta Chiaranda` and d'Andria, 1994; Dimic *et al*., 1996), whereas the changes in oil recovery and fatty acid profile of sunflowers due to fertilizing using different

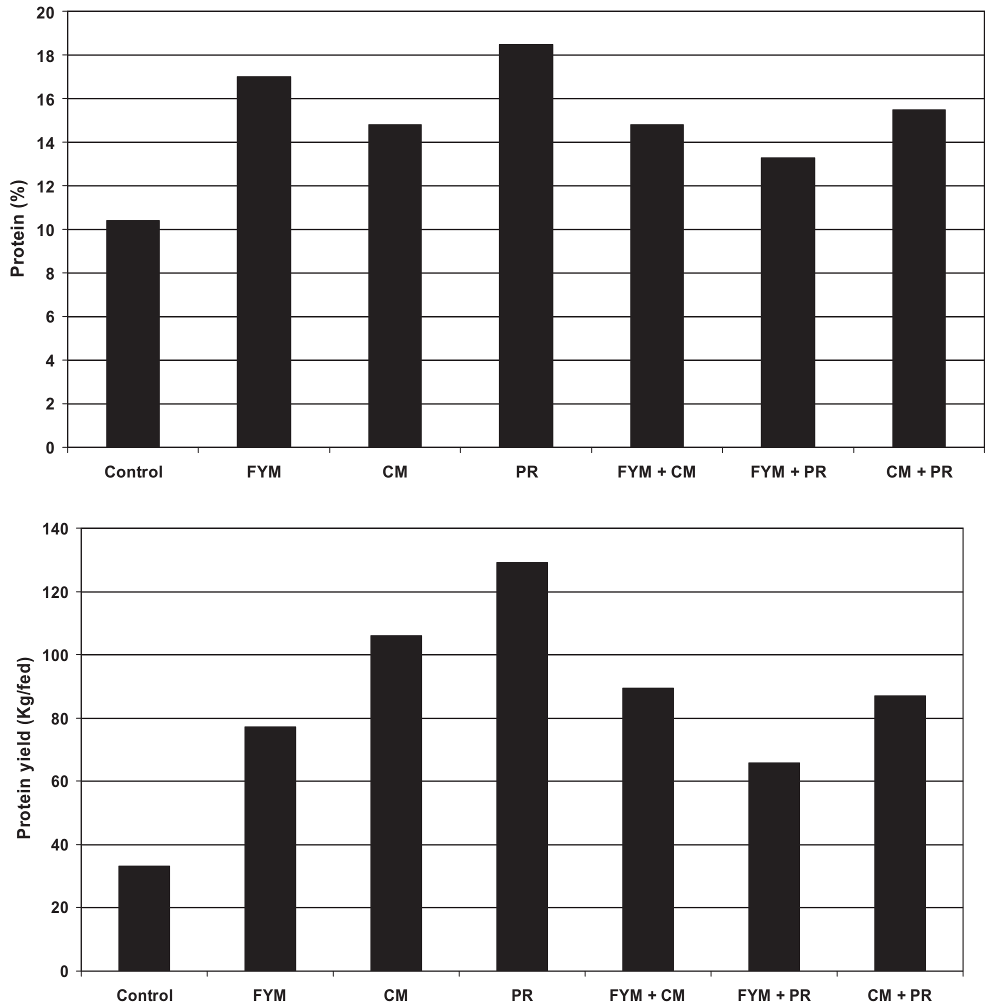

Figure 3
Protein percentage and protein yield as affected by organic nitrogen sources and their combinations.

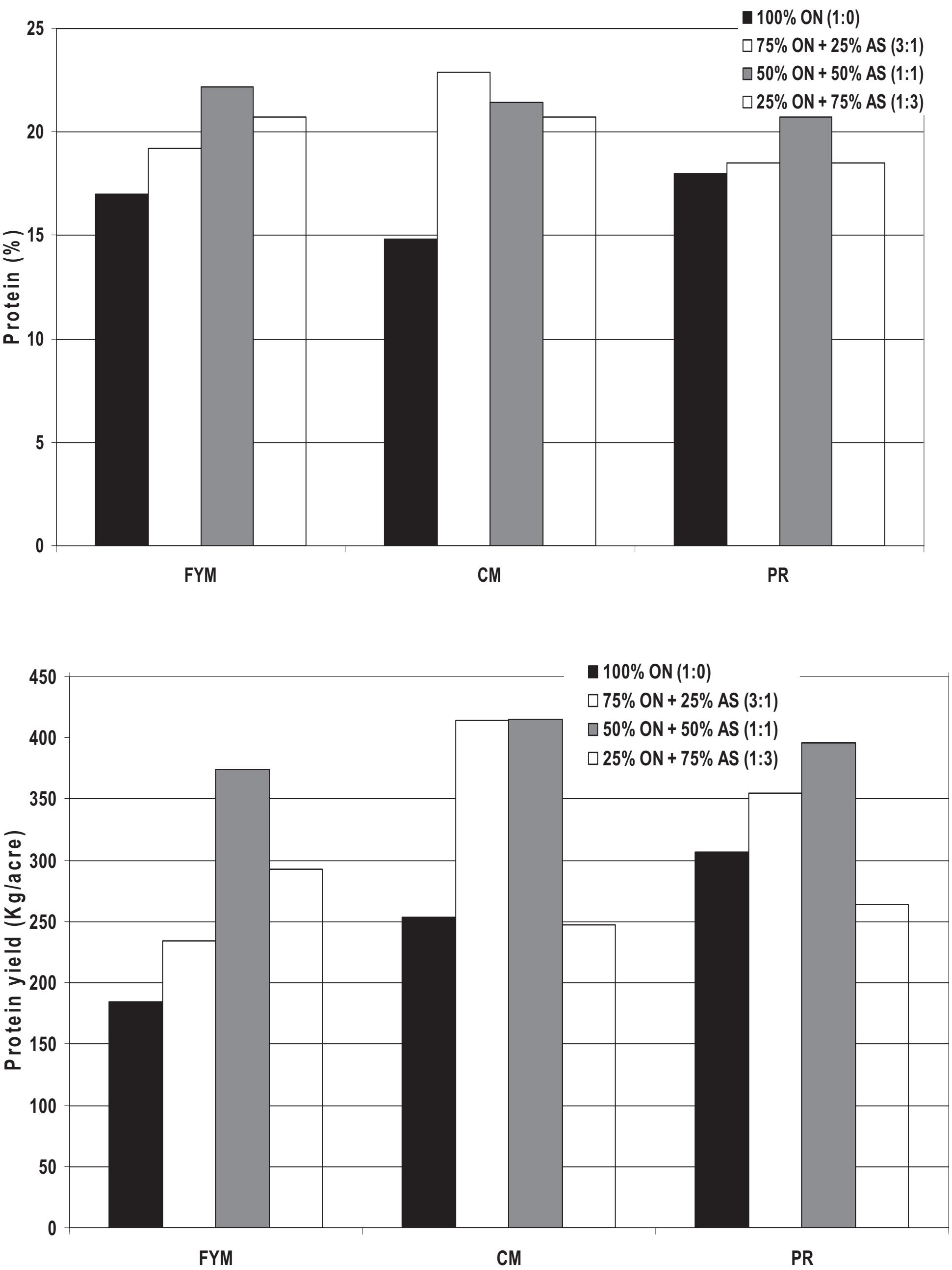

Figure 4
Protein percentage and protein yield as affected by organic nitrogen sources and its mixtures with ammonium sulfate.

N sources have been poorly investigated. The results on oil recovery presented in Table 3 and 4 demonstrate that the application of different organic sources and their combinations increased oil recovery compared to the control (35.1%) and AS (35.5%). The individual effect of organic sources showed an increases in the following order CM> PR> FYM. Concerning the impact of ON sources, the treatments followed the order of CM + PR> FYM + CM> FYM + PR. On the other hand, the addition of N as a mixture of organic sources and AS remarkably increased oil content. The individual effect of organic sources showed an increases in the order of CM> PR> FYM and this was noted when the organic sources were mixed with AS at the ratio of 1:1.

The relative proportion of single fatty acid residues is an important attribute particularly for marketing and processing. In particular, the fatty acid composition is known to differ between cultivars and with environmental conditions (Connor and Sadras, 1992). Genotype and temperature during oil formation exert the major effect on the proportions of oleic and linoleic acids, whereas the effect of N supply is small and depends on the timing of N applications (Steer and Seiler, 1990). With regards to fatty acid composition (Table 5), small differences were evident between the two

Table 5
Impact of nitrogen source on the relative percentage (%)[a] of main fatty acids

Treatment	16:0 Palmitic	18:0 Stearic	18:1 Oleic	18:2 Linoleic	TU/TS[b]
Control	7.5	6.4	20.0	63.3	5.99
Ammonium sulfate (AS)	7.7	6.2	19.9	63.2	5.97
FYM manure	5.8	6.0	29.2	57.0	7.30
Chicken manure (CM)	5.7	6.1	29.1	57.1	7.30
Palma residues (PR)	5.9	6.0	29.0	57.2	7.24
FYM + CM (1:1)	5.8	5.9	29.5	57.1	7.40
FYM + PR (1:1)	6.1	6.0	28.9	57.3	7.12
Pa + CM (1: 1)	5.9	5.9	28.7	58.0	7.34
FYM + AS (1:1)	5.5	5.9	29.5	57.5	7.63
CM+ AS (1:1)	5.6	6.0	30.0	56.1	7.42
PR + AS (1:1)	5.4	6.1	29.3	57.0	7.50
FYM + AS (1:3)	5.4	5.9	29.5	57.1	7.66
CM + AS (1:3)	5.2	5.8	29.0	57.4	7.85
PR + AS (1:3)	5.8	6.0	29.7	57.3	7.37
FYM + AS (3:1)	5.9	5.8	29.4	57.1	7.39
CM+ AS (3:1)	5.7	6.1	29.3	57.3	7.33
PR + AS (3:1)	5.5	6.1	29.5	57.2	7.47

[a] Mean data from three replicates.
[b] TU/TS ratio = (total unsaturated fatty acids)/(total saturated fatty acids).

experiments, with a slight decrease in palmitic, stearic and linoleic acids and an increase in oleic acid when organic nitrogen sources were applied. Therefore, it seems that the application of organic fertilizers resulted in an increase in total unsaturated fatty acids over the control. The results are difficult to interpret in terms of our current knowledge of lipid biosynthesis. Nitrogen sources may affect the rate of hydrolysis of fatty acid complexes or their transport from the proplastid to the cytosolic compartment. From the nutritional point of view, a diet rich in monounsaturated fatty acids has been suggested to reduce cholesterol in blood plasma, in that it lowers low density lipoprotein but not high density lipoprotein (Delpanque, 2000) and, thus, the risk of coronary heart disease (Grundy, 1986).

3.6. Macronutrient Uptake

3.6.1. Nitrogen uptake

The data in Table 6 show that CM treatment was superior for increasing the uptake of N in straw at all growth stages compared to the other treatments. The superiority of CM over all the organic manures for N uptake can be attributed to its higher content of total N and narrow C/N ratio which led to rapid mineralization and decomposition in the soil. Cordovil *et al*. (2001) reported that the incorporation of organic wastes always led to an increase in potentially available N in the soil. These results are in agreements with those obtained by Tahoun *et al*. (2001); Solaiman and Hassan (2004). The data also revealed an ascending increases in N uptake in the order of CM> PR> FYM for straw at all growth stages and in the order of PR> CM> FYM for seeds. As for the combined effect of ON sources, the data show that it followed the same trend as that observed with dry matter yield. Hence the treatment of FYM + CM was superior to the other treatments at all growth stages and gave the highest straw yield at all growth stages as well as seed yield at maturity stage. Regarding the addition of N as a mixture of organic sources and AS, data in Table 7 revealed an ascending increase in N uptake in the order of CM> PR> FYM for straw and seeds. This was more emphasized when the materials were mixed with AS at the ratio of 3:1 and 1:1. The highest straw yield was observed from the addition of CM (3:1 ratio) at vegetative and maturity stages, while at the flowering stage it was due to CM (1:1 ratio). Highest seed yield was obtained due to CM (1:1 ratio).

3.6.2. Phosphorus uptake

The data in Table 6 show that the P uptake was increased significantly due to the different treatments compared with the control. This may be due to the benefits of organic matter supply to the soil on the basis of anion replacement or competition between humate and phosphate ions on the active sites of adsorbing surfaces. Products of organic decay such as organic acids and humus are thought to be effective in forming complexes with iron and aluminum compounds which are mainly responsible for P fixation in soils El-Sherbieny *et al*. (2003). Data also revealed an ascending increases in P uptake in the order of CM> PR> FYM for straw as well as seed yield at all growth stages. Regarding the combined effect of ON sources, data show that it followed the same trend as that observed with dry matter yield. Hence the treatment of FYM + CM was superior to the other treatments at all growth stages and gives the

Table 6
Nitrogen, Phosphorus and Potassium uptake (Kg acre^{-1}) of sunflower as affected by organic nitrogen sources and their combination

Nitrogen treatments	K uptake				P uptake				K uptake			
			Maturity				Maturity				Maturity	
	Vegetative	Flowering	Straw	Seeds	Vegetative	Flowering	Straw	Seeds	Vegetative	Flowering	Straw	Seeds
Control	2.06 c	8.58	28.3 c	12.6 c	1.83 e	4.32 d	5.33 b	11.1 d	1.97 e	5.12 d	19.3 b	13.1 c
FYM	5.06 bc	23.2	69.1 c	29.4 b	2.80 de	10.8 c	30.3 a	20.1 c	4.03 d	10.5 c	42.3 ab	20.9 b
CM	14.3 a	49.5	148 ab	40.4 ab	6.15 a	22.9 a	30.6 a	28.9 a	8.35 a	23.7 a	70.8 a	30.4 a
PR	13.7 a	41.6	85.9 bc	47.7 a	4.44 bc	15.8 b	25.4 a	26.2 ab	6.22 bc	15.5 b	57.7 a	30.1 a
FYM + CM	11.8 ab	34.5	192 a	34.0 ab	5.62 ab	14.2 bc	33.8 a	25.2 ab	7.62 ab	16.3 b	67.7 a	29.2 a
FYM + PR	9.30 abc	26.7	83.1 bc	25.1 bc	4.37 bc	9.95 c	18.2 ab	19.9 c	5.06 cd	12.7 bc	40.9 ab	23.3 ab
CM + PR	9.61 abc	32.3	52.6 c	33.1 ab	3.50 cd	11.0 c	15.7 ab	23.3 bc	4.26 d	13.7 bc	37.3 ab	27.1 ab

Table 7
Nitrogen uptake (kg acre^{-1}) of sunflower as affected by nitrogen sources and nitrogen mixtures with ammonium sulfate

Nitrogen sources (S)	(R) Rates of N (sources N/AS)									
	1:0	3:1	1:1	1:3	Mean	1:0	3:1	1:1	1:3	Mean
	Vegetative stage					Flowering stage				
FYM	5.06	17.8	18.7	11.8	13.3	23.2	54.3	33.3	54.7	41.4
CM	14.3	24.1	20.8	14.4	18.4	49.5	67.8	72.3	64.8	63.6
PR	13.7	16.2	12.8	7.48	12.5	41.6	49.5	57.0	28.6	44.2
Mean	11.0	19.4	17.4	11.2		38.1	57.2	54.2	49.4	
LSD at 0.05	R: *	S: *		RXS: ns		R: ns	S: *		RXS: ns	
	Maturity stage									
	Straw					Seeds				
FYM	69.1	102	139	156	117	29.4	37.6	59.8	46.8	43.4
CM	147	213	172	136	167	40.4	66.3	66.5	39.5	53.2
PR	86.2	177	174	144	145	47.7	56.7	63.3	42.3	52.5
Mean	101	164	162	145		39.2	53.5	63.2	42.9	
LSD at 0.05	R: ns	S: ns		RXS: ns		R: **	S: ns		RXS: ns	

Nitrogen uptake for all nitrogen as ammonium sulfate were 7.17, 31.1, 63.7 and 58.1 (kg acre^{-1}) at vegetative and flowering stages, straw and seed yield, respectively.

highest straw yield at all growth stages as well as seed yield at maturity stage. It was observed from the data shown in Table 8 that the increases in P uptake followed the order of CM> PR> FYM for straw at vegetative and flowering stages, while it was in the order of PR> CM> FYM for straw and seeds at maturity stage. This was more emphasized when the materials were mixed with AS at the ratio of 3:1 and 1:1.

3.6.3. Potassium uptake

Data presented in Table 6 indicate that K uptake was significantly increased due to the addition of N as organic sources. This happened at all growth stages. Such a positive response might reflect the different characteristics of the added organic manures (their chemical composition and nutritional status), hence the rate of decomposition and the differences in the subsequent release of included nutrients. The addition of organic manure to the soil resulted in creating favorable soil physical conditions (such as structure), which must have affected the solubility and availability of nutrients and thus the uptake of nutrients Rabie *et al*. (1997). Similar results were obtained by El-Sherbieny *et al*. (1999) and Mohamed (2002). As for the combined effect of ON sources, the data show that it followed the same trend of that observed with P uptake. Hence, the treatments of CM and FYM + CM were superior to the other treatments and give the highest K uptake at all growth stages as well as seed yield at the maturity stage.

Based on the foregoing results, it can be concluded that the highest values of sunflower yield, yield quality and its components as well as N, P and K uptake were obtained with the plants supplied with CM or FYM + CM which were superior to the other treatments. Regarding the addition of organic sources as a mixture with AS, the data in Table 9 indicate that K uptake was significantly increased due to the addition of N as organic

Table 8
Phosphorus uptake (kg acre^{-1}) of sunflower as affected by nitrogen sources and nitrogen mixtures with ammonium sulfate

Nitrogen sources (S)	(R) Rates of N (sources N/AS)									
	1:0	3:1	1:1	1:3	Mean	1:0	3:1	1:1	1:3	Mean
	Vegetative stage					Flowering stage				
FYM	2.80	4.89	5.74	3.27	4.18	10.8	11.8	18.5	15.2	14.1
CM	6.15	10.0	8.95	4.81	7.48	22.9	22.5	27.2	13.7	21.6
PR	4.44	6.32	3.83	2.20	4.20	15.8	18.4	15.6	17.8	16.9
Mean	4.46	7.07	6.17	3.43		16.5	17.6	20.4	15.6	
LSD at 0.05	R: **	S: **		RXS: ns		R: ns	S: **		RXS: *	
	Maturity stage									
	Straw					Seeds				
FYM	29.4	17.3	33.2	33.9	28.5	20.1	18.7	29.6	21.5	22.5
CM	29.7	38.7	32.0	41.4	35.5	28.9	26.8	28.4	18.8	25.7
PR	25.4	41.7	56.6	23.0	36.7	26.2	33.3	31.8	21.6	28.2
Mean	28.2	32.6	40.6	32.8		25.1	26.3	29.9	20.6	
LSD at 0.05	R: *	S: ns		RXS: **		R: **	S: **		RXS: **	

Phosphorus uptake for all nitrogen as ammonium sulfate were 3.77, 10.1, 26.9 and 22.1 (kg acre^{-1}) at vegetative and flowering stages, straw and seed yield, respectively.

Table 9
Potassium uptake (kg acre^{-1}) of sunflower as affected by nitrogen sources and nitrogen mixtures with ammonium sulfate

Nitrogen sources (S)	(R) Rates of N (sources N/AS)									
	1:0	3:1	1:1	1:3	Mean	1:0	3:1	1:1	1:3	Mean
	Vegetative stage					Flowering stage				
FYM	4.03	7.73	8.61	5.67	6.51	10.5	15.5	17.2	19.0	15.6
CM	8.35	11.8	16.4	6.17	10.7	23.7	26.5	27.7	18.8	24.2
PR	6.22	14.3	5.95	3.95	7.61	15.5	21.4	18.5	17.4	18.2
Mean	6.20	11.3	10.3	5.26		16.6	21.1	21.1	18.4	
LSD at 0.05	R: **	S: **RXS: **				R: *	S: **		RXS: *	
	Maturity stage									
	Straw					Seeds				
FYM	44.1	56.7	110	91.7	75.6	20.9	21.4	38.6	28.7	27.4
CM	69.4	101	114	87.8	93.1	30.2	33.9	37.3	24.9	31.6
PR	56.3	107	95.0	85.4	85.9	30.1	40.0	45.8	32.0	37.0
Mean	56.6	88.2	106	88.3		27.1	31.8	40.6	28.5	
LSD at 0.05	R: **	S: ns		RXS: ns		R: **	S: **		RXS: *	

Potassium uptake for all nitrogen as ammonium sulfate were 3.62, 10.9, 47.6 and 27.1 (kg acre^{-1}) at vegetative and, flowering stages straw and seed yield, respectively.

sources and different N addition treatments. This was true at all growth stages except for straw at maturity stage which did not show any significant increase due to organic sources (S) effect and for rates of organic sources/added -N (R) × N-sources (S). The data also reveal an ascending increases in K uptake in the order of CM> PR> FYM for straw at all growth stages while it was in the order of PR> CM> FYM for seeds and this was more emphasized when the materials were mixed with AS at the ratio of 1:1.

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Recibido: 17/3/08
Aceptado: 14/5/08