Zagazig J.Agric. Res., Vol . 30 No.(1) 2003 **231-244**

EFFECT OF TILLAGE AND NITROGEN APPLICATION REGIME ON : I. YIELD AND NITROGEN CONTENT OF SUNFLOWER CULTIVATED UNDER CALCAREOUS SOIL CONDITIONS

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Received 4 / 11 / 2002 *Accepted 2 / 1 / 2003*

ABSTRACT: The use of conservation tillage methods, including no-tillage, has increased dramatically in recent years. At the present time, there is great concern that farmers are applying more nitrogen (N) fertilizer than is environmentally or economically sound. In order to determine if N requirement for optimum yield differs with tillage system, tests were initiated to study tillage and N dose effects on N content and yield of sunflower. The study was established in 2002 on calcareous soil, Maryout soil. Two rates of N (0, and 45 kg /fed.) were applied to plots managed with 3 tillage systems: chisel plow, moldboard plow, and no-tillage. The nitrogen was supplied as 2, 3 and 4 splits dose divided to equal portions.

Obtained data show that sunflower seed yield increased with increasing number of applied N dose up to four doses. The seed yield was affected by interaction between tillage and N-dose. Maximum yield within the moldboard plow system was achieved with the four doses of N . When averaged for N doses, yields were 2.05, 3.93 and 4.47 kg plot^{-1} in the no-tillage, chisel and moldboard tillage, respectively. Total N uptake by plants was greater in the moldboard tillage than the no-tillage or chisel system; N uptake was affected by N dose and tillage system. This study indicates that, on calcareous soil, no-tillage can not improve N utilization and yield of sunflower. The seed N uptake was affected by tillage and N dose, and also by interaction between the two factors. Seed N uptake with no-tillage tended to be lower than that with moldboard and chisel tillage . Seed N uptake with moldboard tended to be greater and more significant than N uptake with chisel tillage at all N doses.

The net return from fertilization increased with increased number of N applications. Among the tillage system within N applications,

the economic benefits of tillage system show significant increased net return from fertilization with chisel and moldbord tillage than no-tillage (3.76, 4.30 and 1.88 E.£ /plot, respectively). The highest increase for net return of nitrogen dose was noticed in the case of moldboard tillage with N used at four equal doses.

INTRODUCTION

Sunflower is one of the most important oil crops all over the world and in Egypt, particularly, to face the increasing demand on vegetable oils. The annual production of vegetable oils in Egypt, is insufficient to cover the local consumption. Therefore sunflower is considered one of the most promising crop to face the shortage of vegetable oil production and it has been successfully grown at widely scattered geographical areas. This wide adaptability led to the fact that sunflower can be grown under the low productive soils, particularly, in the newly reclaimed areas in Egypt.

Several experiments in Egypt showed that nitrogen fertilizer increased seed yield of sunflower (Hasan, 1993 and Geweifel et. al., 1997). Ahmed (1977) and Hasan (1993) found that nitrogen fertilizer increased oil content in seeds. Also, Basha (2000) showed a significant response yield of sunflower to nitrogen levels and a highly significant increase in seed and oil yield/fed..

The time of nitrogen dressing must satisfy the nitrogen demand of the crop during growth and development, through the applied splits. Khalifa (1973) and Ibrahim and Gendy (1996), found that application of N fertilizers to wheat either at seedling stage or split into three equal doses applied at seeding, tillering and booting stages gave the greatest yield response. Also, Basha and El-Bana (1994) reported that, splitting N rate into three equal doses (1/3 at sowing + 1/3 at tillering + 1/3 at jointing) significantly increased number of tillers, grain yield/fed. and spikes/m^2, as well as straw and biological yield/fed. in barley. Moreover, Basha (1998) showed that adding nitrogen at three equal doses gave the highest values of root weight/plant, and shortest plant height of fodder beet cultivated on sandy soil.

Moreover, El-Beheidi et.al. (1996) found that pea plants supplied by 60 kg N/fed., divided to three subsequent equal portions, attained the highest values for photosynthesis pigments content in leaves, number and weight of pods/plant and total yield of pods/fed.. This treatment has also proved to be the most efficient one for promoting the induction of nitrogen, proteins and all studied amino acids in pea seeds.

Farmers increasingly rely on conservation tillage to sustain high yield of crops and comply with soil erosion guidelines to protect their soil resources. No-tillage is one of the most popular conservation tillage systems. No-tillage changes numerous soil properties, compared with a plowed soil (CT), many of which may profoundly affect crop production (Ismail, et. al., 1994)

Part of the effects of both tillage system and soil compaction on crop production may be derived from their influence on N dynamics in the plant-soil system (Torbert and Reeves, 1994). Certain conservation tillage techniques have been reported to affect N leaching (Tyler and Thomas, 1977), N denitrification and N immobilization (Gilliam and Hoyt, 1987)

Because of increasing farmer adaptation of conservation tillage techniques, a study was initiated to investigate tillage effects on dosage of N fertilizer, N recovery and yield of sunflower grown on Maryout calcareous soils.

MATERIALS AND METHODS

The study was conducted in Maryut. The soil was a sandy clay loam. Soil analysis values at initiation of the experiment are summarized in Table (1).

Table (1): Some physical and chemical properties of the studied soil.

Depth cm	pH in saturated	EC dS/cm in saturated	$CaCO_3$ %	O.M %	Particle size distribution %			Total N ppm
					Sand	Silt	Clay	
0–30	7.98	2.80	27.9	0.42	48.2	20.0	31.8	120

The experimental design was a randomized complete block, treatments being replicated 3 times. Each block (2 by 8 m) was split for randomization to tillage systems (chisel, moldboard, and no tillage). Also, block was randomized for N fertilizer treatments (0 and 45 kg N/fed.) boradcasted by hand beside the plot 3 weeks after planting. The nitrogen fertilizer was applied as ammonium nitrate (33.5% N) in 2, 3 and 4 dose splits divided to equal portions.

Sunflower hybrid "Vidoc" was planted during the first week in June. Seeding rate was 5 kg seed fed⁻¹.

Sunflower was harvested in late August. Whole plants were taken at harvest from each plot to determine seed yield. Six plants were selected at random from each plot to determine N concentration. Seed samples were dried and ground to pass a 0.5 mm stainless steel screen. Nitrogen was determined on 0.5g subsamples by the macro-Kjeldahl method (Phillips, et. al., 1980). Concentrations were evaluated on an oven dry basis. Apparent N recovery was calculated according to the assumed following formula (after Huggins and Pan, 1993) :

[(Total above ground N uptake in the fertilized plants – Total N uptake in the 0 N plants) x 100]/N rate

Soil in each plot after harvest was sampled to a 10 cm depth to determine soil NO_3-N and NH_4-N level. Samples were extracted with 2*M* KCl and analyzed with flow injection autoanalysis (Nelson and Bremner, 1975).

The obtained data were subject to statistical analysis and differences between means were tested by LSD values according to Snedecor and Cochran (1980).

RESULTS AND DISCUSSION

Sunflower seed yields

The data in Table (2) represent the response of sunflower seed yield to the tillage system and N treatments.

Data show that the application of N at the three doses (2, 3 and 4) increased the seed yield under the different tillage methods. The added N increased the sunflower seed production over that treatment without N (rate 0 N). Maximum yield was achieved with adding N at four equal doses.

The statistical analysis of the data in Table (2) showed that the 0 N rate yielded sunflower seed significantly lower than that yielded with other N treatments. On the other hand, high significant differences were detected among the indicated N treatments of different splitting.

The soil tillage main effects on yield were significant in sunflower seed yields (Table 2). Sunflower seed yield was greater in the moldboard system than in either the chisel or no-tillage. Within the no-tillage, chisel and moldboard systems, seed yield continued to increase with increasing the number of added N doses; however, the response was the same for all tillage systems. The yield response to N was nearly the same for the chisel and moldboard tillage. These results are in agreement with those obtained by Kitur, et.al (1984), Ismail, et.al. (1994), Potter, et.al. (1996) and Abou Yuossef and El Kot (1999) who found that grain yields with no-tillage tended to be lower than yields with chisel or moldboard systems at the used N rates. They agree also with those of Iragavarapu and Randall (1995) who showed that corn grain yield and N removal in the grain were consistently greater for moldboard plowing than for no-tillage.

The statistical analysis of the data of Table (2) showed a highly significant effect for the interaction between N treatment divided to equal doses and tillage on the sunflower seed yield. Such interaction was more pronounced with the moldboard tillage than the other tillage systems at all N doses.

Table (2): Sunflower seed yield (kg/plot) as affected by number of fertilizer N doses and tillage system.

Number of N dose	Seed Yield (kg/plot)			Mean
	No-tillage	Chisel	Moldboard	
0	1.37	2.50	2.90	2.25
2	2.05	3.77	4.30	3.37
3	2.08	4.55	5.00	3.87
4	2.73	4.91	5.70	4.44
Mean	2.05	3.93	4.47	
LSD Tillage	0.42			
LSD N rate	0.48			
LSD (TxN)	0.39			

N – concentration in seed:

Nitrogen treatment and tillage effects on sunflower seed N concentration are shown in Table (3). Values ranged from 8.62 to 28.99 g/kg. N content in seed was affected by both tillage and N dose. In all three tillage systems, seed-N concentration increased with increasing the number of N applications, but when values were averaged for N dose, the seed-N concentration was higher in the moldboard tillage (16.3, 19.8, and 22.9g/kg for the no-tillage, chisel and, moldboard tillage, respectively). A significant interaction between tillage and N dose occurred within the chisel and moldboard tillage. The response to N gave a significant linear relationship between N content and number of N dose under the three tillage systems; regression analysis showed that maximum seed-N concentration occurred when N was used at four doses.

Table (3): N concentration (ppm) in sunflower seed as affected by number of fertilizer N doses and tillage system.

Number of N dose	N concentration in seed (ppm)			Mean
	No-tillage	Chisel	Moldboard	
0	8.6	9.9	13.1	10.5
2	18.0	21.5	23.4	21.0
3	18.2	23.2	26.1	22.5
4	20.4	24.5	29.0	24.6
Mean	16.3	19.8	22.9	
LSD Tillage	1.59			
LSD N rate	1.84			
LSD (TxN)	3.19			

Total N Uptake:

Total N uptake by the sunflower plants was affected by both tillage and N dose (Table 4). Total N uptake was higher in the moldboard tillage than in the other two tillage systems at all used treatments of N splitting. When averaged over such N treatments, total-N uptake was 35.57, 82.96 and 108.62 g/plot for the no-tillage, chisel and moldboard systems, respectively These results are in agreement with those obtained by Abou Yuossef and El Kot (1999) who found greater N uptake for moldboard plowed system compared with no-tillage and chisel tilled corn when fertilizer N rate was less than 50.25 kg fed^{-1}.

Table (4): N-total content in sunflower seed (g/plot) as affected by number of fertilizer N doses and tillage system.

Number of N dose	N-uptake (g/plot)			Mean
	No-tillage	Chisel	Moldboard	
0	11.80	24.87	38.04	24.91
2	36.87	81.13	100.57	72.86
3	37.79	105.33	130.65	91.25
4	55.82	120.54	165.24	113.87
Mean	35.57	82.96	108.62	
LSD Tillage	10.95			
LSD N rate	12.65			
LSD (TxN)	21.91			

Apparent N Recovery:

More N applied at equal splitted doses was recovered in the sunflower seed for the moldboard tillage than in the other two tillage systems (Table 5). When averaged for N doses and tillage systems, apparent N recovery was 9.39, 22.95 and 28.88% for the no-tillage, chisel and moldboard systems, respectively.

At the used N four doses, N recovery by sunflower seeds under no-tillage and moldboard tillage were 13.04% and 37.68%, respectively. Fertilizer N recovery with moldboard tillage was favoured relative to conventional tillage at all N treatments. These observations can be interpreted as indicating greater N fertilizer efficiency in moldboard tillage system because an added increment of fertilizer usually increases yield more with moldboard tillage than with no-tillage and chisel tillage systems.

Table (5): Fertilizer N recovery in sunflower seed as affected by number of fertilizer N doses and tillage system.

Number of N dose	Recovery of N%			Mean
	No-tillage	Chisel	Moldboard	
2	7.43	16.66	18.52	14.21
3	7.70	23.84	27.44	19.66
4	13.04	28.34	37.68	26.36
Mean	9.39	22.95	27.88	

The rather low recovery of fertilizer N in seeds and reduced seed yield of no-tillage sunflower at all N treatments is probably attributed to increased immobilization of surface applied fertilizer N and higher denitrification losses with the no-tillage system and/or increased mineralization with chisel and moldboard tillage.

Nitrogen uptake efficiency and utilization efficiency:

Nitrogen uptake efficiency was calculated from the seed N regression relationship (Seed N / [N soil + N fertilizer]) (Table 6). Nitrogen uptake efficiency ranged from 0.109 to 0.489. Ranked within tillage, the N uptake efficiencies were generally highest on the moldbord tillage and lowest on the no-tillage. These results are in agreement with those obtained Huggins and Pan (1993) who found that N uptake efficiency significantly greater in conventional tillage than in no-tillage. Also, Abou Yuossef and El Kot (1999) who found that uptake efficiency increased with chisel and moldbord tillage.

Uptake efficiency generally increased with increased the number of N applications, the N uptake efficiencies were generally highest with N applied at equal four doses and lowest with N applied at equal two doses (0.337 and 0.218, respectively).

The differences in uptake efficiency were in part due to differences in N availability resulting from varying degrees of leaching and denitrification. Poor N fertilizer uptake efficiency could have resulted in greater N loss because less N was removed by crop, leaving a greater amount of N that could be lost from soil profile (Fiez, et. al.; 1995).

Table (6): N uptake efficiency in sunflower seed as affected by number of fertilizer N doses and tillage system.

Number of N dose	N-uptake efficiency			Mean
	No-tillage	Chisel	Moldboard	
2	0.109	0.240	0.298	0.218
3	0.111	0.312	0.387	0.270
4	0.165	0.357	0.489	0.337
Mean	0.128	0.303	0.391	

Differences in N uptake efficiency often occur among tillage systems. However, these differences may or may not result in yield or seed N differences among those systems.

Nitrogen utilization efficiency was calculated from the seed yielded regression relationship (Seed yield / aboveground seed N uptake), Table 7. Nitrogen utilization efficiency ranged from 34.49 to 55.58. With regard to tillage, the N utilization efficiencies were generally highest on the no-tillage and lowest on the moldbord.

Nitrogen utilization efficiency generally decreased with increased number of N applications, the N utilization efficiencies were generally highest when N was applied at equal two doses and lowest with N being applied at equal four doses (48.26 and 41.37, respectively).

Table (7): N utilization efficiency in sunflower seed as affected by number of fertilizer N doses and tillage system.

Number of N dose	N-utilization efficiency			Mean
	No-tillage	Chisel	Moldboard	
2	55.58	46.46	42.75	48.26
3	55.03	43.19	38.27	45.50
4	48.35	40.73	34.49	41.37
Mean	53.17	43.46	38.49	

Nitrogen utilization efficiency at optimum seed yield was negatively correlated wit N-seed (r = -0.73**). These results are in agreement with those obtained by Fiez, et. al. (1995) who found negative correlation between nitrogen utilization efficiency and N-grain.

Units N requirements (UNR) were expressed as inverse of the product of N uptake efficiency and N utilization efficiency. This parameter is defined as follows (after Fiez, et.al., 1995):

UNR= 1/[(N uptake efficiency)x(N utilization efficiency)]

The UNR varied among the tillage systems and N treatments (Table 8). UNR decreased with increased number of N application; such UNR were generally highest with N being applied N equal two doses and lowest when N was applied at equal four doses (11.08 and 8.38, respectively). With respect to tillage, the UNR were generally highest on the no-tillage and lowest on the moldbord.

Table (8): Units nitrogen requirement of sunflower seed as affected by number of fertilizer N doses and tillage system.

Number of N dose	Unit N requirements			Mean
	No-tillage	Chisel	Moldboard	
2	0.164	0.089	0.078	0.110
3	0.162	0.074	0.067	0.101
4	0.123	0.068	0.059	0.083
Mean	0.150	0.077	0.068	

The variability in the UNR is a resultant of difference in the included efficiencies, N uptake efficiency and N utilization efficiency. Increasing either efficiency, even with the other remains constant, will lower the UNR (Fiez, et. al.,1995). Among the tillage systems and N treatments, UNR were correlated with both N uptake efficiency (r = -0.76**) and N utilization efficiency (r= -0.60**). Partial R^2 values obtained from the multiple stepwise regression procedure for UNR were 0.70 for N uptake efficiency and 0.37 for N utilization efficiency. While both N uptake efficiency and N utilization efficiency are related to the variation in the UNR, differences in N uptake efficiency among N doses and tillage systems, at optimum yield level, appear to be the most effective.

Nitrogen loss percentage:

The difference between the N supply and the amount of N that could be accounted for at harvest was quantified by calcaulating N loss percentage (after Fiez, et.al., 1995):

N loss percentage = {[N supply-(N-uptake + soil N at harvest)]/fertilizer N}100

The data in Table (9) represent the N loss percentage as affected by the tillage system and N treatment. Data show that the application of N at the three regime doses (2, 3 and 4) decreased the N loss percentage under the different tillage methods (78.37, 72.92 and 66.21%, respectively). Minimum N loss percentage was achieved with adding N at four equal doses. With regard to tillage, the N loss percentage was generally highest with the no-tillage and lowest with the moldbord (87.09 and 60.78%, respectively).

Table (9): Nitrogen loss percentage as affected by number of fertilizer N doses and tillage system.

Number of N dose	Nitrogen loss percentage			Mean
	No-tillage	Chisel	Moldboard	
2	89.05	75.92	70.15	78.37
3	88.78	68.74	61.23	72.92
4	83.43	64.23	50.96	66.21
Mean	87.43	69.63	60.78	

Overall, high N loss percentage indicate that alternative management strategies, such as split N application, should be implemented to increase plant N uptake and to decrease the potential for N losses.

Economical seed yield of sunflower

To lay out fertilizing policy of any crop, the economical aspect should be considered. Due to the increase of nitrogen fertilizer prices and tillage costs, the yield per unit nitrogen and tillage system should not be overlooked, as the economical yield is not necessary the highest.

A net return from fertilization was calculated for each management case as follows (after Fiez, et.al., 1994):

net return from fertilization = (yield)x(seed price)–(fertilizer rate) x (fertilizer N price)

The results of no added N show little benefit (2.25 £.E /plot) from treatments of variable N dose (Table 10), while, the improvement in net return from the spatially variable N application at four equal doses was maximum of 4.21 £.E/plot. With regard to N dose, net return from fertilization increased with increased the number of N applications.

Table (10): Net return from fertilization of sunflower as affected by number of fertilizer N doses and tillage svstem.

Number of N doses	Net return from fertilizatior [illegible] t)			Mean
	No-tillage	Chisel	[illegible]oard	
0	1.37	2.50	[illegible].90	2.25
2	1.82	3.54	4.07	3.14
3	1.85	4.32	[illegible].77	3.64
4	2.50	4.68	5.47	4.21
Mean	1.88	3.76	4.30	

Among the tillage systems within N application treatments, the economic benefits of tillage system show significant increased net return from fertilization with chisel and moldbord tillage than no-tillage (3.76, 4.30 and 1.88 £.E/plot, respectively). The highest increase for net return of N dose was noticed in the case of moldboard tillage followed by chisel for the two N doses when use N at three and four equal doses.

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تأثير الحرث و تنظيم إضافة النيتروجين على: ١- محصول عباد الشمس و المحتوى النيتروجيني تحت ظروف الأرض الجيرية

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في تجربة حقلية تم تقييم تأثير عمليات الحرث وتنظيم إضافة التسميد النيتروجيني مجزآ على إنتاجية محصول عباد الشمس تحت ظروف الأرض الجيرية بمنطقة مريوط. لذلك تم دراسة تأثير ثلاث أنواع من الحرث (بدون حرث ، محراث حفار ، محراث قلاب) وكذلك مستويين من التسميد النيتروجيني (صفر و ٤٥كجم نيتروجين / الفدان) وتم إضافة النيتروجين على ٢ ، ٣ ، ٤ دفعات متساوية وعند الحصاد تم تقدير محصول البذور (كجم/شريحة) ، كما تم تقدير عنصر النيتروجين في البذور.

أظهرت النتائج أنه بزيادة عدد مرات إضافة دفعات التسميد النيتروجيني زاد محصول البذور، ولقد تأثر محصول البذور بعمليات الحرث أيضا. تم الحصول على أعلى محصول عند استخدام المحراث القلاب و أضافة التسميد النيتروجيني على أربع دفعات.

تأثر محتوى البذور من النيتروجين و الـ uptake بعمليات الحرث و عدد مرات إضافة دفعات التسميد النيتروجيني. وكان التأثير واضحا مع استخدام المحراث القلاب ومع زيادة عدد مرات إضافة دفعات التسميد النيتروجين.

أظهرت النتائج زيادة في العائد الاقتصادي من التسميد بزيادة عدد مرات دفعات التسميد النيتروجين وكذلك تأثر العائد الاقتصادي معنويا بعمليات الحرث باستخدام المحراث الحفار و القلاب مقارنة بمعاملة بدون حرث (كان العائد ٣,٧٦ و ٤,٣٠ و ١,٨٨ جنيه مصري/شريحة، على الترتيب)، وكان أعلى عائد عند استخدام المحراث القلاب مع إضافة السماد النيتروجيني على ٤ دفعات.