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EFFECT OF ORGANIC AND INORGANIC N FERTILIZER ON GROWTH AND YIELD OF CHICKPEA (*CICER ARIETINUM* L.) GROWN ON SANDY SOIL USING 15N TRACER

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Abstract

A field experiment was carried out to study combined effect of organic and/or inorganic N fertilizer on growth and yield of chickpea plants grown on sandy soil using ^{15}N tracer. Results revealed an increase in weight of shoot and seed yields in the plot amended with cow manure (50% MF + 50%OM) and, relatively the increase was 21.84 and 38.78% over control, respectively. The highest N accumulated in plant tissues of shoot (49.0 g/plot) and seeds (155.0 g/plot) as compared to the control (100% MF) which recorded 23.1 and 59.0 g/plot, respectively.

Introduction

Chickpea (*Cicer arietinum* L.) is the third most widely grown grain legume in the world after bean and soybean. The agronomical importance of chickpea is based on its high protein concentration (approx. 19.3 - 25.4%) for the human and animal diet, being used more and more as an alternative protein source. Moreover, it is also widely used as fodder and green manure (Ali *et al.* 2004, Togay *et al.* 2008, Erman *et al.* 2011, Namvar *et al.* 2011). Chickpea is the principal grain legume crop grown in the Mediterranean region, and Spain is the main chickpea-producer in Europe, 31,600 ha and 30,100 t in 2008 (FAO 2010).

Mckenzie and Hill (1995) studied the effects of two levels of N applications (0 and 50 kg N / ha) on chickpea and reported that the increase of N rate from 0 to 50 kg N/ha significantly enhanced seed and dry matter yield, harvest index, number of pods per plant and 1000 seed weight. Walley *et al.* (2005) investigated chickpea response to starter N (0, 15, 30 and 45 kg N/ha) and stated that the application of 45 kg N/ha enhanced seed yield by as much as 221 kg /ha over control. The recommended dose of nitrogen for chickpea was supplemented with different combinations of organic manures with equal proportions based on their N content. The required quantity of organic manures as per treatment was incubated for 30 days before sowing of crop under shade with regular watering and were applied at the time of sowing as per the treatments (Patil *et al.* 2012). Thus, the present study was aimed at investigating the influence of mineral N and organic manures alone and in various combinations on growth and yield of chickpea using ^{15}N.

Materials and Methods

A field experiment was carried out at the Plant Nutrition and Fertilization Unit, Soils and Water Research Department, Nuclear Research Center, Atomic Energy Authority, Inshas, Egypt on chickpea. A sandy soil was collected from Inshas, Sharkia Governorate. The soil sample was air dried, ground and sieved to pass through a 2 mm sieve then subjected to some physical and chemical analysis (88.5% sand silt 2.7% and 8.8% clay, pH(1: 2.5) 7.97, EC(dSm-) 0.27, O.C170 mg/kg, O.M 0.3 g/kg, total N70 mg/kg, C/N 2.4, Ca CO_3 10.0 mg/kg**.**

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The chickpea seed of chickpea (cv. Giza 2) was provided by the Agriculture Research Centre (ARC), Giza, Egypt.

Chickpea straw, cow manure and compost were used as organic manure (Table 1).

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Table 1. Chemical characteristics of the chickpea straw, cow manure and compost.

Parameter	Chickpea straw	Cow manure	Compost
C:N ratio	29.66	26.0	12.62
OM%	74.1	39.9	56.89
Total N %	1.45	0.89	2.83
Total P "	0.32	0.53	0.84
Total K "	0.980	0.507	0.692
Total Fe (µg/ g)	836	2730	2898
Cu "	114	148	212
Mn "	103	131	138
Zn "	225	223	155

Nitrogen-fertilizer was applied and thoroughly mixed with soil in the field experiment in the form of ^{15}N-Labeled ammonium sulfate with 5% ^{15}N atom excess at the rate of 48 kg N /ha as one full single dose after two weeks from sowing. The experiment was arranged in a complete randomized block design with three replicates. The drip irrigation system occupied the main plots. Plant residues and cow manure were added before 30 days of sowing while compost was added and incorporated at planting. The treatment plan is represented as follows:

T1 100% mineral fertilizer (ammonium sulfate) as a control

T2 100% compost

T3 50% compost + 50% mineral fertilizer

T4 25% compost + 75% mineral fertilizer

T5 100% cow manure

T 6 50% cow manure + 50% mineral fertilizer

T7 25% cow manure + 75% mineral fertilizer

T8 100% chickpea straw

T9 50% chickpeas straw + 50% mineral fertilizer

T10 25% chickpeas straw + 75% mineral fertilizer

Basic supplements of N, P and K fertilizers were applied to each plot ($2 \times 5m^2$) at the rate of 48 kg N/ha as organic materials **or** mineral fertilizer for chickpea crop. The P and K elements were applied as basal doses recommended by Ministry of Agriculture, Egypt.

Chemical and physical analyses of tested soil samples were determined according to Page *et al*. (1982) and Black (1965). % Ndff, % Ndfs and % Ndfo were calculated according to Hardarson and Danso (1990) as follows:

$$\% \text{ Ndff} = \frac{\% \ ^{15}\text{N atom excess in plant}}{\% \ ^{15}\text{N atom excess in fertilizer}} \times 100 \qquad (1)$$

$$\% \text{ Ndfs} = 100 - \%\text{Ndff} \qquad (2)$$

$$\text{A soil} = \frac{100 - \%\text{Ndff (unin)}}{\%\text{Ndff (unin)}} \times \text{Rate of applied N} \quad (3)$$

$$\text{A soil + air} = \frac{100 - \%\text{Ndff (unin)}}{100 - \%\text{Ndff (in)}} \times \text{Rate of applied N} \quad (4)$$

$$\text{A air} = \text{A (soil + air)} - \text{A soil} \quad (5)$$

$$\%\text{Ndfa} = \frac{\%\text{Ndff (in)}}{\text{Rate applied N}} \times 100 \quad (6)$$

where,

Ndff = Nitrogen derived from fertilizer, Nddfa = Nitrogen derived from air, Nddfa = Nitrogen derived from soil, Nddfa = Nitrogen derived from organic material, nitrogen derived from composted and plant residues (Ndfo), % Ndfo = 100 [1– $\%\text{Ndff}_{\text{treated}}/n \times \text{Ndff}_{\text{untreated}}$] + $\%\text{Ndff}_{\text{treated}}(1/n^{-1})$.

Where *n* is the amount of fertilizer N applied to the treated crop divided by the amount applied to the non-treated crop. $\%\text{Ndff}_{T}$, $\%\text{Ndff}_{NT}$ are the percentages of N derived from fertilizer by treated and non-treated crop, respectively.

The analysis of variance for the final data was statistically assayed using the system ANOVA and the values L.S.D from the controls were calculated at 0.05 level according to SAS (1987).

Results and Discussion

Data illustrated graphically in Table 2, showed that, in general, shoot and seeds yield of chickpea plants were significantly increased over control treatment (100% mineral N) alone as enhanced by the addition of organic manure and mineral fertilizer alone and in combinations. Furthermore, the highest shoot (4.113 kg/plot) and seeds (5.720 kg/plot) were observed in plot that received cow manure at rate of (50% MF + 50% OM) ratio. Relatively increased by 21.84 and 38.78% over control treatment (100% MF) which recorded 3.537 kg/plot and 4.373 kg/plot for shoot and seeds, respectively. The lowest shoot (2.310 kg/plot) and seeds (3.348 kg/plot) were marked with compost treatment (100% OM) as compared to the control.

The results indicated using N fertilization had positive effects on growth indices and, consequently, on yield and its attributes of chickpea. Adding N increases the production of dry matter in plants (Salvagiotti *et al.* 2008, Erman *et al.* 2011) which can increase the potential of plant to produce more plant height, branches, pods and seeds that ultimately results in high grain and biological yield.

N-uptake by shoot and seeds of chickpea plants**.** Data in Table 3, showed that, in general, values of N-uptake and accumulated in shoot and seeds of chickpea were significantly increased as affected by the addition of organic manure and mineral fertilizer. Furthermore, the highest values of N-uptake and accumulated in plant tissues of shoot (58.1 g/plot) and seeds (154.1 g/plot) observed in plot incorporated with cow manure at rates of (50% MF + 50% OM) and (100% OM) ratios which were 132.73 and 172.71% higher than the control which recorded 23.1.0 and 58.1 g/plot, respectively. The lowest values of N-uptake by shoot (24.9 g/lot) and seeds (61.1 g/plot)

observed in the plot which received compost treatment at rate of (100% OM) ratio as compared to the control (100% MF) with the same sequence.

Table 2. Values of shoot and seed yield (kg/plot) of chickpea plant as affected by organic source and/or inorganic fertilizer.

Rate of nitrogen applied %		Shoots				Seeds			
		Organic sources			Mean	Organic sources			Mean
Organic (%)	Mineral (%)	Cow manure	Chickpea straw	Compost		Cow manure	Chickpea straw	Compost	
100	0	3.150	2.731	2.31	2.730	4.280	3.646	4.248	4.058
75	25	3.169	4.092	2.66	3.306	4.452	5.688	5.100	5.080
50	50	4.113	3.700	2.71	3.537	5.720	6.000	5.280	5.667
	Mean	3.480	3.508	2.56		4.817	5.111	4.876	
100% mineral		3.537				4.373			
LSD: 0.05		Organic source 0.735 , Mineral fertilizer 0.815Interaction (orgnic × mineral) 1.420				Organic source 0.310, Mineral fertilizer 0.360, Interaction (orgnic × mineral) 1.319			

Table 3. N-Uptake by shoot and seed yield (g/plot) of chickpea plant as affected by organic source and/or inorganic fertilizer.

Rate of nitrogen applied %		Shoots				Seeds			
		Organic sources			Mean	Organic sources			Mean
Mineral	Organic	Cow manure	Chickpea straw	Compost		Cow manure	Chickpea straw	Compost	
0	100	41.0	33.1	24.9	33.0	154.1	60.5	61.1	91.9
25	75	27.2	52.0	29.8	36.3	89.1	137.1	71.1	99.1
50	50	58.1	46.0	25.7	43.3	142.1	134.1	146.1	140.8
	Mean	42.1	43.7	26.8		128.4	110.6	92.8	
100% mineral		23.1				58.1			
LSD: 0.05		Organic source 0.312, rate of nitrogen applied 0.370, Interaction (orgnic × mineral) 1.325				Organic source 3.139, rate of nitrogen applied 3.198, Interaction (orgnic × mineral) 6.420			

In this regard, Rupa *et al.* (2014) reported that the highest N content in seed yield 0f mungbean was observed in 10 t/ha vermicompost 75% of recommended dose of inorganic fertilizer (3.39%) that was followed by 10 t/ha + 75% of recommended dose of inorganic fertilizer (3.33%), 10 t/ha t/ha vermicompost + 50% of recommended dose of inorganic fertilizer (3.36 %) and 10 t/ha cowdung + 50 % of recommended dose of inorganic fertilizer (3.31%) while lowest in control (3.19%). Datt *et al.* 2013, reported that the minimum increase was available N was observed in chemical fertilizer applied treatment followed by organic treatment and integrated treatments, respectively. Workneh *et al.* (1993) who reported that microbial activity and nitrogen mineralization rates were higher under organic production than under conventional production practices. Available nitrogen was more in integrated treatments as compared organic treatments. It might be due to fact that integration of organic and chemical fertilizer has increased the mineralization owing to narrow C/N ratio as compared to organic treatments. In chemical

fertilizers applied treatment low available nitrogen is owing high mineralization and low organic matter caused nutrients mining.

The application of ^{15}N isotope dilution technique. Data presented in Table. 4, showed that, in general, values of nitrogen derived from nitrogen (% Ndff), soil (% Ndfs), organic (% Ndfo) and air (% Ndfa) by shoot and seeds of chickpea plants were markedly increased as influenced by the addition of organic manure and mineral fertilizer alone and in combinations in case of, % Ndff, the highest values were 27.0 and 24.0% observed in the plot amended with cow manure (75% MF + 25% OM) and (50% MF + 50% OM) against 46.0 and 48.0% obtained control for shoot and seeds of chickpea plants, respectively. For partitioning of % Ndfs, the highest values were 1.2% and 1.1% noted in the plot which received cow manure and compost (75% MF + 25% OM) against 3.3 and 2.5% observed in control for shoot and seeds of chickpea plants, respectively.

Table 4. Percentages of nitrogen recovered from fertilizer (Ndff), from soil (Ndfs) and from organic (Ndfo) in shoot and seed yields of chickpea.

Organic N- sources	Rate of N applied (%)		Nitrogen derived from N- sources (%)							
			Shoot				Seeds			
	Mineral	Organic	Nff	Nfs	Nfo	Nfa	Nff	Nfs	Nfo	Nfa
Control	0	100	46.0	3.3	-	35.6	48.7	2.5	-	38.8
Cow manure	25	75	27.0	1.2	37.5	34.4	24.0	0.9	26.1	49.0
	50	50	24.0	1.1	30.9	44.0	29.9	1.0	20.0	49.1
Chickpea	25	75	27.9	0.9	33.9	38.3	26.9	1.3	34.9	36.9
	50	50	27.7	0.7	32.3	39.3	26.7	1.3	38.5	33.7
Compost	25	75	27.0	1.1	31.7	40.0	28.1	0.9	31.4	39.6
	50	50	26.9	0.4	31.7	42.0	27.9	0.8	32.7	38.6
LSD: 0.05	Organic source 2.93, rate of nitrogen applied 2.47, interaction (orgnic × mineral) 4.95.									

Nitrogen derived from fertilizer (Nff), nitrogen derived from soil (Nfs), nitrogen derived from organic (Nfo), nitrogen derived from air (Nfa).

For portioning of Ndfo%, the highest values of shoot (33.9%) and seeds (38.5%) were observed in the plot incorporated with chickpea straw treatment (75% MF + 25% OM) and (50% MF + 50% OM) ratios against 30.9 and 20.0% (50% MF + 50% OM) as cow manure. In the case of Ndfa%, the highest values of shoot (44.0%) and seeds (49.0%) were observed in the plot incorporated with cow manure and chickpea straw treatments at rates of (50% MF + 50% OM) and (75% MF + 25% OM) ratios against 35.6 and 38.8% in 100% control. Ghoneim (2008) reported that percentage of N derived from rice residues as a fraction of total N uptake ranged from 0.92 to 2.13% with N recovery (%Ndfr) being higher in rice straw than in rice straw compost.

Results suggest that integrated uses of organic and inorganic sources are good for chickpea crop. The best result was obtained from plots which received 50% N from organic manure with 50% mineral N.

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