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Original Research Article

Alternative Strategies for Improving Nitrogen Nutrition of Some Economical Crops Using ^{15}N Stable Isotope

S.M.Soliman[1], S.Ghabour[2], Y.G.M.Galal[1], D.M.El-Sofi[2],
A.A.Moursy[1*] and M.M.El-Sofi[1]

[1]Atomic Energy Authority, Nuclear Research Center, Soil and Water Research Department, Abou-Zaabl, 13759, Egypt
[2]Faculty of Agriculture, Soil Department, Fayoum University, Fayoum, Egypt
**Corresponding author*

ABSTRACT

Three different economical crops namely sesame, maize and wheat were grown on virgin sand soil. A field experiment was constructed under drip irrigation system. Fertilization treatments were arranged in a complete randomized block design with three replicates. ^{15}N labeled ammonium sulfate with 2% atom excess was applied as a source of mineral nitrogen fertilizer at rates of 100, 120 and 45 kg N fed^{-1} (hectare equal 2.4 feddan) for wheat, maize and sesame, respectively. Isotope dilution technique was followed to distinguish between the different sources of nitrogen derived by tested crops and quantify their accurate portions. Results indicated that local prepared compost either applied individually or in combination with mineral fertilizer contributed remarkable grain or seed yields as well as total biomass of sesame, wheat and maize. Also, it gave values of dry matter yield and nitrogen gains nearly closed to those of fully mineral fertilized (100% MF) crops. Proportions of nitrogen derived from mineral fertilizer and organic compost revealed that %Ndff in all crops and organs was nearly closed to each other. Similar trend but to somewhat high extent was noticed with portions of N derived from organic composts. In general, nitrogen use efficiency by different crops showed the superiority of local compost (CE) which induces the highest %NUE over all other treatments.It could be concluded that integrated organic and inorganic fertilizers benefits productivity and nitrogen nutrition of sesame, wheat and maize much more than individual fertilization treatments.

Keywords

Compost/ Nitrogen / 15N technique / Wheat, Sesame, Maize

Introduction

In agronomic techniques, by using high quality inputs, agronomic management practices etc. can raise yield per unit area (Khavazi et al. 2005) Sustainable agriculture based on the Bio-fertilizers with purpose of significant reduction or elimination in the use of chemical inputs, is an optimal solution for overcoming these problems. To achieve sustainable agriculture in areas with limited resources, we need to use ways to reduce production costs and improves stability of yield (Ghaderi-Daneshmand et al.2012). The benefits from the application of organic materials to the soil surface or incorporation in the topsoil have widely been appreciated in tropical agriculture and agroforestry (Ogunwole et al. 2010; Abbasi et al. 2009; Ogbodo 2009; Sarwar et al. 2008; Nunes et al. 2008; Moyin-Jesu 2007; Ferreras et al. 2006; Mubarak et al. 1999, 2001a, 2001b, 2003). However, its efficiency varies with the sources of these organic materials. Environmental problems associated with application of raw organic manures might be mitigated by chemical or biological immobilization during composting (Cooperband et al. 2002).

The quantity of organic matter in the soil is a major indicator of latter's quality. To achieve higher grain yield, we should apply chemical, bio and organic fertilizers. For sustainability, it is important to incorporate bio-organisms and organic matter into the soil. Koopmans and Goldstein (2001) stated that to improve soil quality we should treat our organic matter like a bank account. A bank account lets us deposit, save, and withdraw something we value. For sustainability, it is important todeposit in the account active bio-fertilizers along with organic matter in the soil on aregular basis, thereby, building cultura lfertility. Poulton (1995) summarized that long term experiments are essential in determining the factors affecting soil fertility and sustainable production.

In the tropics, there is an increasing interest in using crop residues for improving soil productivity that can reduce the use of inorganic fertilizer (Fening et al. 2005; Tetteh 2004). The residues left in the field represent a significant resource in terms of organic matter and plant nutrients. The use of crop residues as a soil fertility amendment will enhance the farmers' crop yields and reduce the need for large imports of mineral fertilizers.

Sesame or benniseed (*Sesamumindicum* L.)is cultivated in almost all tropical and sub tropical Asia and African countries for its highly nutritious and edible seeds. (Iwo et al., 2002). It is potentially capable of producing large quantities of seeds per unit area but low yield ha^{-1} (Ahmad et al., 2001) and improper fertilization (Rao et al, 1994).Sesame (*Sesamum indicum* L.) is considered as one of the important oil seed crops. Sesame has high oilcontent (46 – 64 %) and a dietary energy of 6355 Kcal/kg. The seeds serve as a rich source of protein (20 – 28%), Sugar (14 – 16 %) and minerals (5 – 7%) (Thanvanathan et al. 2001).

Following wheat and rice, maize (*Zea mays*) ranks third most important cercal crop which has added great value to the lives of both man animals (FAO, 2002).Continuous cropping of such plants leads to decline soil fertility and have continuously depressed yield obtained in farmers' field on yearly basis. This necessitates research into avenues for improving crop productivity through the use of such soil amendments as liquid organic fertilizers, organic manure or inorganic fertilizer (Enujeke 3013). In this respect, Saber(1998) reported that inorganic fertilizers are not only costly and inaccessible to resource poor farmers, but lead to adverse environment, agricultural and health consequences. Liquid organic fertilizers or solid raw materials are environmentally friendly fertilizers that promotes healthy plant growth and development because they are fortified with nutrients (Danbara and Green Planet, 2003).

Concerning the contribution of organic residues, earlier studies showed inharmonious estimations. They elucidate that the direct effect of N released from organic residue on the cropping system varies from yield decrease due to immobilization of N during decomposition

(Hubbard and Jordan 1996) or no effect due to insufficient quantities ofcrop residues (Kouyate et al. 2000) to an increase in yielddue to rapid release of N (Konboon et al. 2000). Application of crop residues can substantially reduce the amount of inorganic fertilizers used as such is a valuable management practice in both environmental and economic terms (Rezig et al. 2012). It has been appreciated that mineral fertilizers can only supply plant nutrients to the soils but they cannot take care of other physical, chemical and biological attributes of soil health. On the other hand, organic materials play a much more positive role in this respect. The problems associated with the use of chemical fertilizers, led Ano and Agwu(2005) to recommend the combined use of organic and inorganic manures as soil amendment for increasing crop productivity. Integration of mineral fertilizers and organic manures has special significance for many of the Asian countries because the arable soils of most tropical and subtropical countries are poor in organic matter due to high temperature and more intense microbial activity (Gaur 2006). Hence, a regular and sizeable addition of organic material to soil is essential for maintaining optimum organic matter status and, thereby, sustaining the health of the soil(Manna et al. 2005).

The present work aimed to evaluate the effect of different origin compost and mineral nitrogen fertilizer either individually or in combination On yield productivityof wheat, sesame and maize crops under virgin sand soil conditions and drip irrigation system. Labeled nitrogen isotope was used to distinguish perfectly between the different N sources and accurately quantify the amount of N derived from the different proportions.

Most strains of MS mutans especially *S.mutans* but not *S. sobrinos* (Balakrishnan, *et al*., 2000) produce intracellar iodine-staning polysaccharides (IPS) from sucrose which typically resemble glycogen, IPS can be metabolized leading to continued acid production which, according to result from experiments with rats, may contribute to their virulence (Kuramitsu, 1993).

Because of this intracellular polysaccharide storage, these cariogenic bacteria have the ability to continue fermentation in the absence of exogenous food supplies (Loeshe, 1986). It was shown that therapeutic agents that diminish EPS and IPS concentrations in biofilms also reduce the development of dental caries in rats (Koo *et al*., 2005), confirming the importance ofthese polysaccharides in *S. mutans* cariogenicity.

S. mutans synthesis exocellular polysaccharide (EPS) i.e. glucan, from the glucosylresiduse of sucrose by secretion glucosyltransferase (GTFs). It is well known that *S.mutans* has at least three GTFs (GTF-B, C, and D). (Nishimura, *etal*., 2012). GT-B and D mainly synthesize water-insoluble α-(1-3) - and water soluble α-(1-6)-glucan. GTF-C associates with insoluble and soluble glucan synthesis, which is controlled by the genes *gtfB*, *gtfC*, and *gtfD* (Koo *et al*., 2010; Monchois*etal*., 1999). The *gtfB* and *gtfC* genes are tandomly arranged on *S. mutans* chromosomal DNA. (Ueda and Kuramitsu, 1988). The nucleotide sequences of *gtf* genes from different oral streptococci comply with the same basic pattern. The GTFs are very large proteins of approximately 1300- 1700 amino acids long (Devulapalle*et al*., 1997). Streptococcal GTFs have two common functional domains. The amino-terminal portion, the catalytic domain, is responsible for the cleavage of sucrose, and the carboxyl-terminal portion, the glucan binding domain, is responsible for glucan binding (Colby and Russell, 1997). In addition the two genes share extensive nucleotide sequence homology.

The primary amino acid sequences of the streptococcal GTF enzymes are highly homologous. The synthesis of extracellular water-insoluble glucans from sucrose is necessary for the formation of dental plaque by *S. mutans* (Hamada and Slade, 1980). It is generally understood that this polymerization is catalyzed by two types of extracellular glucosyltransferase one synthesizing a water-soluble product from sucrose (GTF-S) and another synthesizing water-insoluble product from sucrose (GTF-I). These two types of GTF, when combined, synthesize a complex, highly branched, adherent, water-insoluble glucan (Walker, 1978).The GTF produced by *S. mutans* can be found either in the culture supernatant or on the cell surface in an associated form. Certain GTFs can bind to the cell surface of MS and promote cellular adherence via insoluble glucan synthesized *de novo* from sucrose (Horikoshi*et al*., 1995). The origin of cell-associated enzyme of sucrose-grown cells has not been determined, nor has the role of soluble enzyme in the formation of cell-associated enzyme been investigated (Horikoshi*et al*., 1995). Two form of cell-associated GTFs from the serotype c *S. mutans* strain GS-5 one enzyme was extracted by treatment 1 M-NaCl from cells grown in TH broth. The other GTFs was an intracellular enzyme released after distruption of cells (Kuramitsu, 2006).

Materials and Methods

Field experiment was conducted at the experimental station of Soil and Water Research Department, Nuclear Research Center, Ayomic Energy Authority, Abou-Zaabl. Experimental soil was sand and its chemical and physical characteristics are presented in Table (1). Characteristics of experimental soil were carried out according to Carter and Gregorich (2008). Different crops, i.e. sesame, wheat and maize were cultivated under drip irrigation system.

Tested crops

Seeds of Sesame (*Sesamumindicum* L Shandaweel3,c.v.), Maize (*Zea mays*c.v. Hybrid one10), supplied by the Agriculture Research Centre (ARC), Giza, Egypt and seeds of Wheat cultivar (*Triticumsativum* c.v. Gmiza9,) cultivars were used.

Organic materials

Cow manure and two locally composted plant residues were used as organic fertilizers. Organic materials were air-dried, ground and subjected to chemical analyses (Table 2).

Mineral fertilizer

^{15}N-Labeled ammonium sulfate with 2% ^{15}N atom excess was applied as a source of mineral nitrogen (ammonium sulfate) at different rates depending on tested crop once after four weeks from planting.

Field experiment layout

A field experiment was carried out according to complete randomized block design with three replicates under drip irrigation system. Seeds were planted as recommendationof Agriculture Research Centre, Giza, Egypt.

The experiment is consisted of 21 treatments for each crop**.**These treatments includes one treatment of 100 % Mineral fertilizer (control), three treatments of 100 % organic manure (OM) and three treatments of 50% organic manure (OM) + 50% Mineral fertilizer (MF). The treatments could be explained in details as follows:

T1 100 % Mineral fertilizer(ammonium sulfate) .

T2 (Compost 1) = compost of 100 %.

T 3(Compost 1) = compost of 50 %+ 50% Mineral fertilizer (ammonium sulfate).

T 4(Compost2) = compost of 100 %.

T 5(Compost 2) = compost of 50 %+ 50% Mineral fertilizer (ammonium sulfate).

T 6(cattle manure) = cattle manure of 100 %.

T7 (cattle manure) = of 50 %+ 50% Mineral fertilizer (ammonium sulfate).

A basic supplemental doses of N fertilizer was applied to each plots (2.25 x 10 m^2) at the rate of 100 kg fed^{-1} (equal 240 kg N ha^{-1}) as organic manure or mineral fertilizer (ammonium sulfate) of wheat, whilesesame received 45kg N $ha^{-1}$and Maize supplied with 120 kg N ha^{-1}.The phosphorus and potassium were applied at rate of 30 kg $P_2O_5$and 24 kg K_2O as phosphoric acid and potassium sulfate, respectively.

Sesame, maize and wheat crops were uprooted at harvest (120 days for maize and sesame, and 240 days for wheat) and separated into shoot, root and grain. Plant samples were subjected to chemical analysis according to Hamdy (2005). The following parameters were analyzed and estimated:

- plant dry matter yield
- Plant nitrogen uptake
- Nitrogen derived from air (Ndff)
- Nitrogen derived from organic compost (Ndfoc)
- Nitrogen use efficiency (%NUE)

Abovementioned nitrogen derived from the different sources were estimated using the standard equations described by IAEA (2001).

Statistical analysis

The obtained data were subjected to ANOVA analysis followed by Duncan's Multiple Range Test (DMRT) for comparison between means according to SAS software (2002).

Results and Discussion

Dry matter and grain yield

Wheat grain yield significantly positively affected by combined treatments of mineral and organic composts comparable to those of individual mineral or organic fertilizers (Table 3). Among individual organic and inorganic N sources, wheat plants well responded to applied compost of Atomic Energy Authority (local production, CE) where it induces the best yield of grain (7.15 kg plot-1), shoot (3.51kg plot-1) and root (0.77kg plot-1) followed by those of manure compost and commercial one for the same sequence. On the other hand, all combined treatments had achieved higher yield of wheat grain, shoot and root than those recorded with all individual treatments including the fully mineral fertilized plants. In this regard, application of local compost (CE) in combination with mineral N in half to half ratio induced the highest values of grain, shoot and root yields. It seems that local produced compost (CE) either applied individually or in combination with mineral fertilizer achieved the best values of grain yield andshoot and root dry matter biomass. This finding is in agreement withMeade et al. (2011) who found that animal manure combined with inorganic N increased grain yield and quality in wheat production through improved crop nutrition. In this respect, Cassman et al. (2002), explained that achieving synchrony between inorganic and organic N supply and crop demand is the key to optimizing tradeoffs between yield, profit and environmental protection.Many previous studies have focused primarily on the positive benefits of applied organic manure to cereal crops in the absence of inorganic fertilizers (Sørensen and Thomsen, 2005), but limited research has been conducted on organic manure use, in combination with inorganic N fertilizer in nutritional programs for winter wheat.

Another scenario carried out byGhaderi-Daneshmand et al. (2012) indicated that the use of biological fertilizers lead to significant differences in grain number per spike, grainweight, biological yield and harvest index. Combined treatments of microorganismsbacteria and *Pesudomonas fluorescent* and chemical fertilizers had the greatest impact on thestudied traits. Analyze of variance suggest that highest yield of grain was achieved bycomplete use of all three fertilizers in recommended fertilizer rate compared to controltreatment. Overall, the results showed that, biological fertilizers have a significant role inimproving yield and yield components of wheat, and Bio-fertilizers with chemical fertilizersmay be useful to increase the yield and reduce environmental pollution.Similar results have been reported byBasu et al. (2008) and Shata et al. (2007).

According to Kendra and Prasad (2011), the highest grain yields were recorded when the crop received combined bio-fertilizers. From the above results it may be stated that the use of bio-fertilizers is beneficial in improving the growth and productivity of wheat. Their corroborative findings have been reported by Sharma andSingh (2008) for wheat grown under irrigation and fertility variables.

Similar trends were noticed with sesame crop but with low accumulation of dry matter yield and seeds yield as compared to wheat plant. Shehu et al. (2010) stated that proper fertilization of sesame with nitrogen fertilizer in addition to phosphorus and potassium ones leads to increases in grain yield and dry matter yield. On harmony, Paul and Savithri (2003) showed the better vegetative growth of plants in plots supplied with 30 kg inorganic N ha^{-1} alone resulted in a larger photosynthetic area and thereby more photosynthates. Further, the efficient translocation of these photosynthates to the reproductive parts resulted in the production of higher number of capsules per plant, more number of seeds per capsule and higher weight of capsule per plant which contributed to highest seed yield. They added that the natural occurrence of both *Azospirillum* and *Azotobacter*, initial medium fertility status of the

soil, incorporation of rice stubbles and FYM along with application of the recommended dose of 30 kg inorganic N ha^{-1} contributed to a substantial increase in seed yield of sesame in summer rice fallow and thereby resulted in highest total returns.On harmony, Shaban et al. (2012) found that the combined application of either the organic fertilizers or bio-fertilizer with the different mineral N fertilizer rates markedly increased most of growth characters of sesame, i.e. No of capsules plant^{-1} , seed weight plant^{-1}, seed yield kg fed^{-1} and weight of 1000 seeds (g). Similarly,Pathak et al. (2002) indicated that nitrogen rate at 45 kg ha^{-1} recorded the highest mean values ofsesame plant height, branches No. Plant^{-1} , capsules No. plant^{-1}, 1000-seeds weight and seed yield. While, Maliket al. (2003) found that nitrogen fertilization at 80 kg N ha^{-1} produced the highest sesame yield (7.79 ton ha^{-1}), the highest 1000- seed weight (3.42 g) and the highest seed oil content (45.88%). In the same way, Enujeke (2013) recorded higher grain yield of maize which obtained at 15 l ha^{-1} than 5, 10, 18, 20 and 25 l ha^{-1} at different methods of application. This rate of liquid organic fertilizer resulted inoptimum benefit cost ratio. In the same way, Kabirinejad and Hoodaji(2012) found that biosolid application increased the dry matter of *Z. mays*. They explained that these growth parameters were obtained withincrease as biosolid rates. The highest dry biomass wasobtained for the high sewage sludge application rate of50 t ha^{-1}. Application of sewage sludge (50 t ha^{-1}) significantly($P<0.01$) increased the shoot dry matter from7.7 to 28.7 g per pot.

Nitrogen uptake

Nitrogen uptake by wheat grain was enhanced by combined treatments of organic supplements and mineral fertilizer omparable to individual treatments (Table 4). The best value is detected with combined treatment of local compost (CE) plus half dose of mineral fertilizer (217.7 g plot^{-1}) followed by commercial compost combined with mineral nitrogen (142 g plot^{-1}). Nitrogen released from individual CE and accumulated in grains is nearly closed to those derived from mineral fertilizer. In case of shoot, combined treatment of CE+MF is still superior over all other treatments. In this respect, among the individual treatments 100% mineral nitrogen resulted in higher uptake than other individuals. Similar trends but to somewhat low extent were noticed with N uptake by roots. In general, wheat grains accumulated more nitrogen than shoots and roots. It means that nitrogen was positively translocated from below-ground system to the aboveground green parts including grains.

Nitrogen accumulated in seeds of sesame crop followed the same trend of wheat grain where it positively significantly affected by CE either alone or in combination with mineral fertilizer. It is clear that mineral fertilizer and CE treatments were the best among the individuals whereas CE and CC were superior over CM when all combined with mineral fertilizer. In comparison, sesame shoot accumulated more nitrogen than seeds or roots as affected by fertilization sources. Nitrogen accumulated in whole plant reflected the superiority of CE compost either solely added or combined with mineral fertilizer over all other treatments.

Shaban et al. (2012) indicated that the highest values of N content in seeds of sesame accounted for 3.46%, was achieved by soil application of humic acid combined with the high rate of mineral N fertilizer. They also concluded that bio-fertilizer and organicmaterials like, compost, humic acid and compost tea could be used as an integrated plant nutrition with 20, 30 or40 kg fed^{-1}of mineral N fertilizer producing higher sesame yield quantity and quality than those produced by theconventional recommended mineral N dose alone

Another view was observed with maize crop whereas 100% MF resulted in higher content of nitrogen in grains (284.4 g plot^{-1}) than those of the three composts. In this regard, CM came to the next followed by CE compost. Among the combined treatments, CE is still superior over CC and CM composts. Similar trendbut to low extent was noticed with shoots and roots. On line with us, Kabirinejad and Hoodaji(2012) explained that the application of biosolids caused a significant ($P<0.01$)increase of nitrogen contentsin maize shoot in sewage sludge and compost treatments.

Applicationof agricultural wastes alone and in combinationwith reduced rates of NPK fertilizer improved soil propertiesand significantly increased the growth and yieldcomponents of maize. The effects of agricultural wastealone and in combination with NPK fertilizer were significanton the growth and yield characteristics of maize and nitrogen content of leaves (Ogundare et al. 2012). In addition, they found poultry manure was better than Chromolaena, Parkia, neem seed cake, and melon shell in increasing the growth, yield characteristics and N uptake of maize.

Comparison between the three crops indicated that maize accumulated more nitrogen from both organic and inorganic sources followed by wheat then sesame crops.

Nitrogen proportions derived to tested crops

Data released from $^{14}N/^{15}N$ ratio analysis gave us the opportunity to distinguish between the different N sources that compensate nitrogen to plants (Table 5). Nitrogen derived from fertilizer (%Ndff) by different parts of wheat doesn't affected significantly by fertilization treatments. Shoots showed a little bit high portions of Ndff as compared to grain and roots especially with 100% MF and 50%MF+50%CM.

On the other hand, 100% MF was superior over other treatments when sesame crop's organs were concerned. In this respect, %Ndff by roots was significantly higher than those of grain and shoots. Combined treatments didn't reflect significant differences between each other as %Ndff was considered. Similar trend was noticed with maize crop.

On the other hand, absolute values of Ndff by wheat grain reflected that combined treatment of 50%CE+50%MF (45.5 g) surpass either individual mineral fertilizer or other combined treatments. This holds true with shoot and root but to somewhat lower extent. Similar trend was noticed with sesame and maize crops. Comparison between the Ndff by tested crops didn't reflects significant difference.

Nitrogen derived from organic compost Ndfoc

Percentage of nitrogen derived from organic composts and gained by wheat grain, shoot and root didn't significantly vary as affected by compost origin (Table 6). Similar trends were observed with other crops. Absolute values of Ndfoc showed the superiority of local produced compost CE over commercial and manure ones since it resulted in the highest Ndfoc (mineralized form) values. It means that local produced compost was much more easily to decomposed and positively benefits the tested crops through the mineralized nitrogen released during mineralization process.

Nitrogen use efficiency %NUE

Efficient use of mineral nitrogen either applied solely or in combination with organic composts was significantly affected by fertilization treatments and varied according to tested crop (Table 7).It is obvious that mineral nitrogen was most efficiently used by wheat grains when combined with locally produced compost CE comparable to other combined treatments or individual mineral fertilizer. Similar trendwas noticed with seeds of sesame and grain of maize with the same treatment but varied in percentage. The highest percent NUE was detected with maize grain (%58.9) followed by wheat grain (%46) then seeds of sesame (%42.3) when 50% CE plus 50% MF was applied. In case of wheat and maize mineral fertilizer either applied solely or in combination with organic compost was efficiently used by grain higher than both shoot and root. Opposite direction was noticed with sesame whereas mineral nitrogen was efficiently used by shoots rather than seeds and roots.

Table.1 Some physical and chemical properties of experimental soil**.**

Coarse sand%	Fine sand %	Silt%	Clay%	Texture
64.1	26.4	2.7	6.8	Sandy

Cations				Anions			
Soluble cations and anions (meq 100 gm^{-1} soil)							
Ca	Mg	Na	K	CO3	HCO3	Cl	SO4
1.25	1	0.32	0.09	----	0.88	1.25	0.53

pH (1: 2.5)	EC (dSm^{-1})	O.C %	O.M%	T.N %	C/N Ratio	Ca CO$_3$ %
7.97	0.27	0.017	0.03	0.007	2.43	1.0

Table.2 Some chemical characteristics of the tested organic materials.

value	Compost Atomic	Compost Commercial	Cattle manure
pH (1:5)	6.70	6.14	6.68
EC dSm^{-1}	12.70	12.3	13.3
C/N ratio	12.62	15.3	26.0
O.M%	56.89	43.10	39.89
N %	2.83	1.63	0.89
P%	0.84	1.21	0.53
K %	0.692	0.966	0.507
Total Fe (µg g^{-1})	2897.5	1585.83	2730
Total Cu (µg g^{-1})	212.25	154.92	148.08
TotaMn (µg g^{-1})	137.83	156.17	130.75
Tota Zn (µg g^{-1})	155.08	131.28	222.58

Table.3 Effect of inorganic-N fertilizer and organic compost on dry weight (kg plot^{-1}) of wheat, sesame and maize crops.

LSD	**0.3375**	**0.8642**	**0.3232**		**0.6867**	**3.094**	**0.1378**		**0.3182**	**0.3460**	**0.0756**	
Dry weight kg plot												
Treatment	**Wheat**				**Sesame**				**Maize**			
	Grain	**Shoot**	**Root**	**Total**	**Seeds**	**Shoot**	**Root**	**Total**	**Grain**	**Shoot**	**Root**	**Total**
100% MF	4.95	2.69	0.52	8.16	2.03	3.00	0.63	5.65	15.8	4.5	1.24	21.5
100% CM	5.25	2.88	0.58	8.72	1.00	4.00	0.80	5.80	14.2	4.0	1.19	19.4
100% CE	7.15	3.51	0.77	11.4	3.30	4.20	1.30	8.80	13.4	3.1	1.19	18.6
100% CC	5.12	2.84	0.56	8.53	2.03	2.95	0.60	5.57	13.0	3.9	1.13	18.0
50%CM+50%MF	6.86	3.45	0.73	11.0	3.04	4.50	0.85	8.39	14.8	4.3	1.20	19.1
50%CE+50%MF	8.04	3.90	0.90	12.8	4.05	4.60	1.45	10.1	17.2	4.6	1.25	23.0
50%CC+50%MF	6.09	3.18	0.67	9.95	3.04	4.33	0.79	8.16	14.8	4.4	1.20	20.4

Table.4 Effect of inorganic-N fertilizer and organic compost on nitrogen uptake (g plot^{-1}) by different organs of wheat, sesame and maize crops.

Nitrogen uptake g plot^{-1}												
Treatment	**Wheat**				**Sesame**				**Maize**			
	Grain	**Shoot**	**Root**	**Total**	**Seeds**	**Shoot**	**Root**	**Total**	**Grain**	**Shoot**	**Root**	**Total**
100% MF	130	56.5	7.32	.194	66.8	60.0	10.1	136.9	284.4	63.0	14.9	362.3
100% CM	102	34.0	6.0	142.5	25.0	72.0	10.4	107.4	184.6	44.0	10.7	239.3
100% CE	127.3	38.6	7.3	173.2	79.2	71.4	14.3	164.9	160.8	35.9	8.3	205.0
100% CC	84.5	32.7	4.7	121.1	42.5	56.0	8.4	106.9	117.0	31.2	7.9	156.1
50%CM+50%MF	139.3	48.3	8.18	195.7	78.1	99.0	14.4	192.4	207.2	51.6	12.0	270.8
50%CE+50%MF	217.7	89.7	16.2	323.7	93.1	101.0	30.4	224.6	344.0	73.6	17.5	435.1
50%CC+50%MF	142.0	60.4	8.8	211.3	85.0	99.6	15.0	199.7	222.0	57.2	13.2	292.4
LSD	1.4836.50 1.073				13.04 19.10 2.982				2.337 1.264 0.5512			

Table.5 Nitrogen derived from fertilizer (%Ndff) by wheat, sesame and maizecrops as affected by organic manure and mineral fertilizer.

%Ndff												
Treatment	**Wheat**				**Sesame**				**Maize**			
	Grain	**Shoot**	**Root**		**Seeds**	**Shoot**	**Root**		**Grain**	**Shoot**	**Root**	
100% MF	22.3	24.0	21.1		23.0	22.6	27.0		23.2	24.6	24.5	
50%CM+50%MF	22.3	24.0	21.1		21.1	20.4	21.5		22.0	21.4	20.9	
50%CE+50%MF	20.9	22.1	20.8		20.5	22.1	17.7		20.6	21.7	18.9	
50%CC+50%MF	21.1	21.2	21.0		21.7	20.3	20.1		21.6	22.8	18.8	
LSD	2.337 1.264 0.5512				2.337 1.264 0.5512				2.337 1.264 0.5512			
100% MF	29.0	13.6	1.5		15.4	13.6	2.7		66.0	15.5	3.7	
50%CM+50%MF	31.1	11.6	1.7		16.5	20.2	3.1		45.6	11.0	2.5	
50%CE+50%MF	45.5	19.8	3.4		19.1	22.3	5.4		70.9	16.0	3.3	
50%CC+50%MF	30.0	12.8	1.8		18.4	20.2	3.0		48.0	13.0	2.5	

Table.6 Nitrogen derived from organic compost (%Ndfoc) by wheat, sesame and maize crops as affected by organic manure and mineral fertilizer.

%Ndfoc												
Treatment	**Wheat**				**Sesame**				**Maize**			
	Grain	**Shoot**	**Root**		**Seeds**	**Shoot**	**Root**		**Grain**	**Shoot**	**Root**	
50%CM+50%MF	79.1	77.9	79.2		77.0	77.3	78.5		78.8	78.5	79.0	
50%CE+50%MF	78.8	78.7	78.9		79.5	77.9	73.0		79.4	79.2	81.0	
50%CC+50%MF	79.8	79.0	78.8		78.3	79.7	79.9		78.4	62.2	66.2	
LSD	2.337 1.264 0.5512				2.337 1.264 0.5512				2.337 1.264 0.5512			
Ndfoc g plot^{-1}												
100% MF	-	-	-		-	-	-		-	-	-	
50%CM+50%MF	110.2	37.6	6.5		60.1	76.5	11.3		163.3	40.5	9.5	
50%CE+50%MF	171.5	71.0	12.8		74.0	78.7	22.2		273.1	58.3	14.2	
50%CC+50%MF	113.3	47.7	6.9		66.6	79.4	12.0		174.0	35.6	8.7	

Table.7 Nitrogen use efficiency (%NUE) by wheat, sesame and maize crops as affected by organic manure and mineral fertilizer.

%NUE												
Treatment	**Wheat**				**Sesame**				**Maize**			
	Grain	**Shoot**	**Root**		**Seeds**	**Shoot**	**Root**		**Grain**	**Shoot**	**Root**	
100% MF	29.2	11.6	1.73		31.3	27.2	4.0		37.9	10.6	2.5	
50%CM+50%MF	29.1	19.8	1.55		40.4	49.8	6.9		50.2	11.3	2.6	
50%CE+50%MF	46.0	12.0	3.40		42.3	49.6	18.2		58.9	12.7	2.8	
50%CC+50%MF	28.6	12.7	1.9		41.0	44.8	6.7		40.0	18.0	3.7	
LSD	2.337	1.264	0.5512		2.337	1.264	0.5512		2.337	1.264	0.5512	

Generally, mineral N used by roots of all three crops was much less than those of grain or seeds and shoots.

The significant difference in %NUE between the three crops may be attributed to C_3 and C_4 photosynthetic cycle. In this regard, there is precedence for investigating the differences in nutrient use efficiencies of C_3 and C_4 species. Brown(1978) speculated that C_3 and C_4 species differ in theirnitrogen (N) use efficiencies. Sage and Pearcy (1987a, b) investigated this idea and found that photosynthetic parameters and growth must be considered together since, whilea C4 species seemed to be more efficient at carbon fixation during N stress, its growth patterns were less efficient than those of a C_3 analogue.

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