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# Partial Replacement of the Mineral Nitrogen Fertilizers by Organic Alternatives in Sandy Soils

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***Authors' contributions***

*This work was carried out in collaboration between all authors. Author RTR performed the statistical analysis managed the literature searches and wrote the manuscript. Author KAS managed the agricultural practices and laboratory analyses of the samples, and RAH designed the study and participated in the agricultural practices. All authors read and approved the final manuscript.*

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## ABSTRACT

**Aims:** A field experiment had been carried out to study the effect of partial substitution of the mineral nitrogen (N) fertilization by using the compost on the peanut productivity in sandy soil.
**Study Design:** Each experiment was carried out in a complete randomized block. Twelve treatments resulting from the factorial treatment structure of two factors: compost with 3 rates (0, 11.90 and 23.81 Mg $ha^{-1}$) plowed 25 days before peanut lines planting and mineral N with 4 rates (0, 119.05, 178.57 and 238.1 kg N $ha^{-1}$) after 21, 40 and 55 days of peanut planting applied in the form of ammonium nitrate (33% N).
**Place and Duration of Study:** During the two successive summer seasons 2012 and 2013.
**Methodology:** Seeds of peanut were sown and fertilization practices were performed as recommended. Soil and plant analysis had been carried out according to references. Data were calculated, analyzed and fertilizers use efficiency indices were calculated.
**Results:** It was found that the combination between both sources of N fertilizers has increased the soil available nutrients; NPK, Zn, Mn, and Fe, the peanut seeds yield and weight of pods yield as the fertilization rates increase compared with the non-fertilized control samples. The seeds yield had increased by 178.04%, 257.26% and 373.14% while the oil content of seeds increased by

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1.55%, 1.63%, 8.69% for the compost/0 – mineral treatment, mineral/0 – compost treatment and the compost/mineral treatment, respectively. The seeds content of NPK, protein and total carbohydrates for the mentioned treatments had also increased.
**Conclusion:** The numerical values of the N use efficiency indices of the organic compost were greater than those for the mineral fertilizer indicating the greater fertilizing effect of the former than the later. But high rates of a mineral fertilizer in presence of an organic one may diminish many of the N use efficiency indices due to loss by leaching or consuming in the microbial activity of OM.

*Keywords: Mineral N fertilizers; compost; N use efficiency indices; peanut in sandy soil; organic fertilizers.*

## ABBREVIATIONS

*Nitrogen use efficiency (NUE); Apparent N recovery (ANR); Agronomic Efficiency (AE); Physiological Efficiency (PE)*

## 1. INTRODUCTION

Sandy soils are generally in need of improvement of their nutrient status because they are deficient in the major soil nutrients, resulting in low productivity or yield. Nutrition as an important aspect of the cropping system includes an adequate supply of the essential nutrients like nitrogen (N), phosphorus (P), potassium (K) etc. to the plant. Nutrient deficient soils like sandy soils do not have the right balance of nutrients due to leaching. Additionally, plants remove nutrients from the soil as they grow, so these nutrients need to be replaced for the soil to stay productive. Therefore, adequate fertilization which encourages rejuvenation of the depleted soil is required. Synthetic fertilizers are commonly used for growing all crops, with application rates depending on the soil fertility. Application of agricultural wastes and organic manure maintains soil fertility for a longer time than the easily leached synthetic fertilizers [1].

“Conventional” agriculture may be considered to cause environmental damage due to the over applying of the readily soluble inorganic/mineral fertilizers, and pest-control formulations (herbicides, insecticides, fungicides, etc.). “Sustainable” agriculture attempts to find alternatives to such practices that are economically feasible and less potential to cause environmental damage. It emphasizes on the use of organic materials as soil amendments and sources of plant nutrients (“organic” farming systems). Organic matter (OM) management is believed to solve many chemical and physical problems of the low fertility soils including their low nutrient reserves. Although sandy soils OM build up does not take place easily, some recent research has shown that it is possible to improve the OM content by a continuous supply of organic inputs with minimum disturbance. Long-term field experiments suggested that the chemical composition of the soil OM (SOM) is affected by the type of fertilization. SOM can build complexes with the clay minerals and the ability of soil to form stable organo mineral complexes increases with the clay content [2-4].

Nitrogen (N) requires careful management when used for crop production in sandy soils because of the leaching losses and to minimize the groundwater contamination. Some of N availability tests are not recommended due to the rapid change in the soil content [3-6]. In plant, N is a part of all living cells and is a necessary part of all enzymes and metabolic processes involved in the synthesis and transfer of energy. It is a part of the chlorophyll molecule’s structure, helps plants for rapid growth, increasing seed and fruit production and improving the quality of the leaf and forage crops [7]. It is an important constituent of the protein makeup of all plant parts, organic fraction of the soil and is present in the soil solution, mostly in the form of nitrate ($NO_3^-$) compounds. Nitrates are subjected to movement and leaching with rainfall and irrigation water. The organic N reserves are limited by the low proportion of OM. Nitrogen deficiency is hard to diagnose by foliar symptoms; they are not easily recognized until the deficiency becomes severe, a rare occurrence. Symptoms of the excess N are easier to identify than deficiency symptoms, and excess N can adversely affect yield and quality. If plants do not have enough N, they are stunted, with small leaves that may be pale yellow-green (chlorotic), sometimes completely yellow or red-tinted, less N results in less chlorophyll, and thus less green color, less photosynthesis, and less crop growth [8].

Cereal crops access N from 3 major pools: Stable Organic N (SON) that is released slowly throughout the season, and is by far the largest N source in the soil. Residue Organic N (RON) that is mineralised rapidly into $NH_4^+$ and $NO^{3-}$ is highest following legume crops. Fertiliser N is applied to a crop by growers where the above sources cannot meet the needs of the crop. Once nitrate is formed, it is prone to leaching, particularly in sandy textured soils in high rainfall zones [9].

Organic sources of N include amino acids, proteins, amino sugars, and other complex unidentified compounds. Soil N is very dynamic and is constantly shifting back and forth between inorganic and organic forms. Both immobilization and mineralization are in balance with one another. As much N is being liberated into the soil by mineralization (OM decomposition) as is being immobilized (absorbed by plants). This balance can easily be disrupted by the incorporation into the soil system of organic residues which have high C/N ratios [7].

Although the microbial biomass constitutes only a small part of the soil OM, it has a relatively rapid turnover and a considerable effect on the N availability. The transition from N immobilization to mineral N release is regulated through the soil microbial biomass by the ratio of available C to N substrates. Resistant carbonaceous compounds, i.e. lignin and poly-phenols have been found to retard the decomposition and N mineralization and interfere with its release [2-4].

Nitrogen behavior in the soil is difficult to predict. Nitrogen in most soils is unavailable for plant uptake because it is fixed in soil [8]. The N that is in the organic forms becomes available to the crop as the OM is mineralized (decomposed) by microbial transformations by the soil organisms. Farm manure, soybean meal, compost, compost tea and commercial compost can be good sources of N because of the gradual and extended availability of their N [3,4]. This characteristic makes such N sources of greatest value in the more readily leached sandy soils [10,11]. Compost is one of the most stable forms of the crop nutrient sources, and applying it is an effective means to help build long-term stable soil OM. Compost will not “damage” plants if added to the soil before seed germination or transplanting [12]. Nitrogen in compost is in a more stable form than N in manure. Thus, there is a decrease of losing N from a compost application. The farmer needs to decide if supplemental N fertilizer is needed, and if so, how much [8,13,14].

The present study aims to evaluate the effect of incorporating the compost as an organic alternative to the mineral N fertilizer in sandy soil on the peanut productivity.

## 2. MATERIALS AND METHODS

A field experiment was carried out at the Ismailia Agric. Res. Station during the two summer successive seasons 2012 and 2013, to study the effect of partial substitution of mineral N fertilization using compost on peanut productivity in sandy soil.

In both seasons, each experiment was carried out in a complete randomized block with four replicates. Twelve treatments resulting from the factorial treatment structure of two factors: compost with 3 rates (0, 11.90 and 23.81 Mg ha$^{-1}$) plowed 25 days before peanut lines planting and mineral N with 4 rates (0, 119.05, 178.57 and 238.1 kg N ha$^{-1}$) after 21, 40 and 55 days of peanut planting applied in the form of ammonium nitrate (33% N).

| **Compost rates (Mg ha$^{-1}$)** | | | | |
|---|---|---|---|---|
| **0.00** | **11.90** | **23.81** | | |
| | | | 0.00 | Mineral N fertilizer rates (kg N ha$^{-1}$) |
| | | | 119.05 | |
| | | | 178.57 | |
| | | | 238.1 | |

**Field area map**

The experimental plot unit was 5 × 10 m (50 m2), 25 rows (40 cm apart). Seeds of peanut were sown in hills on one side of ridge (planting line) at a rate of three seeds per hill with 25 cm between hills. One plant per hill was maintained by thinning at 21 days after sowing.

Calcium super phosphate (15.5% P2O5) was applied at rate of 357.14 kg ha$^{-1}$ during soil preparation. Mineral N was from was applied at three rates. Potassium sulphate (48% K2O) was applied at rate of 178.57 kg ha$^{-1}$ in two doses 21 and 45 days after sowing.

### 2.1 Soil Analysis

Two representative soil samples were taken before planting and after harvesting in each season for analysis. Before planting, the two soil samples for both seasons were taken from the surface layer (0 – 30 cm), air dried, mixed thoroughly and sieved by a 2 mm sieve. Calcium carbonate was determined using a Calcimeter and calculated as CaCO3%. Organic matter was measured as described previously [15] .Total soluble salts were determined in the saturated soil paste extract [16]. The pH was measured using a pH meter in soil suspension (1: 2.5) soil water [17]. Soluble cations and anions were determined in the soil paste extract [18]. Some of the main physical and chemical properties of the soil before planting were recorded in Table 1.

After harvesting, soil samples for both seasons were analyzed for the available nutrients (Table 3a, b). Available N was measured according to the modified Kjeldahl method [18] while available P was extracted by 0.5 N (NaHCO3) and determined colorimetrically according to Olsen s' method [19]. The available K was determined using the flame photometer [20]. Available micronutrients were extracted using ammonium bicarbonate + (DTPA) and measured by the Inductively Coupled Plasma Spectrophotometer (ICP) [20]. The compost used was prepared by using two tons of straw crop residuals (rice straw, maize Stover and faba bean straw), air–dried made into 5 – 10 layers, and each is about 50 cm thick. Three hundred (300) kilograms of farmyard manure were added per pile to enhance microorganism activity, and then soaked in a sufficient quantity of water until it became well decomposed. The compost analysis was done according to the standard methods (Table 2) [21,22].

Sowing peanut seeds (variety Gregory; Arachis hypogaea) was carried out in the 20th May 2012 and 15th May 2013. The harvesting stage was in the 15th October 2012 and 2013 respectively. Each fresh plant sample was separated into pods and the following characteristics were recorded:

(1) Seeds yield (Mg $ha^{-1}$)
(2) Weight of yield pods (Mg $ha^{-1}$)
(3) 100 - seed weight (g) (the 100 - seed weight is a measure of seed size. It is the weight in grams of 100-seeds. Seed size and the 100 - seed weight can vary from one crop to another, between varieties of the same crop and even from year to year or from field to field of the same variety. Because of this variation in seed size, the number of seeds and, consequently, the number of plants in a pound or a bushel of seed are also highly variable. By using the 100 - seed weight, a producer can account for seed size variations when calculating seeding rates, calibrating seed drills, and estimating shattering and combine losses).

**Table 1. Some of the physical and chemical properties of the soil before planting**

| Coarse sand (%) | Fine sand (%) | Silt (%) | Clay (%) | | Texture | OM (%) | | CaCO$_3$ (%) |
|---|---|---|---|---|---|---|---|---|
| 20.19 | 63.22 | 6.94 | 9.65 | | Loamy sand | 0.45 | | 1.27 |
| **pH (1: 2.5)** | **EC (dS $m^{-1}$)** | **Cations (meq $l^{-1}$)** | | | | **Anions (meq $l^{-1}$)** | | |
| | | **$Ca^{++}$** | **$Mg^{++}$** | **$Na^{+}$** | **$K^{+}$** | **$HCO_3^-$** | **$Cl^-$** | **$SO_4^{--}$** |
| 7.92 | 1.25 | 1.29 | 4.93 | 5.46 | 0.82 | 1.69 | 4.93 | 6.22 |
| **Macronutrients (mg $kg^{-1}$)** | | | **Micronutrients (mg $kg^{-1}$)** | | | | | |
| **N** | **P** | **K** | **Fe** | | **Mn** | | **Zn** | |
| 34 | 5.22 | 160 | 1.82 | | 0.98 | | 0.47 | |

**Table 2. Chemical analysis of compost**

| Moisture Content (%) | EC (dS $m^{-1}$) | pH | C (%) | C/N | OM (%) | Available (%) | | | Available (mg $kg^{-1}$) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | N | P | K | Fe | Mn | Zn |
| 22-25 | 3.49 | 7.36 | 30 | 13.7 | 39 | 2.19 | 0.80 | 1.57 | 225 | 95 | 125 |

## 2.2 Plant Analysis

Seeds of ten random plants collected from each plot one day before harvesting were separated, air dried, oven dried at 70°C, and then dry matter weight was recorded. The samples were ground and a 0.5 g of each sample was wet digested using $H_2SO_4$ and $HClO_4$ mixture [18]. The seeds content of N, P, K, Fe, Mn and Zn was measured by the ICP – spectrophotometer [23]. Protein percentage in the peanut seeds was calculated by multiplying the N (%) by the converting factor 6.25 [24]. Total soluble sugars and total carbohydrates were determined in dry leaves using the method described by Dubois et al. (1956) [25].

## 2.3 Nitrogen Use Efficiency Indices

They were calculated according to Craswell and Godwin (1984) and Roozbeh et al. (2011), Nitrogen use efficiency **(NUE)** also expressed as Apparent N recovery **(ANR)** [26, 27]:

**1. N Use Efficiency (NUE/ANR) =**

$$\frac{(Pn_f - Pn_0)}{Fertilizer\ rate\ (Mg\ of\ N\ applied)} \times 100$$

**$P_n$ =** seed nitrogen (N) content
**$P_{nf}$ =** seed N in fertilized plots **f =** fertilized plots
**$P_{n0}$ =** seed N in non fertilized plots
**0** = non-fertilized plots

**2. Agronomic Efficiency (AE) =**

$$\frac{Y_f - Y_0}{Fertilizer\ rate\ (Mg\ of\ N\ applied)} \times 100$$

**Y =** seed yield

**3. Physiological Efficiency (PE) =**

$$\frac{Y_f - Y_0}{Pn_f - Pn_0} \times 100$$

The obtained data were statistically analyzed using the COSTAT program and L.S.D. test at the probability levels of 5% according to Gomez and Gomez [28].

# 3. RESULTS AND DISCUSSION

## 3.1 Soil Available Nutrients at Different Rates of Fertilization

The combination between the organic and the mineral sources of the N fertilizers has increased both available macro- and micronutrients according to Table 3(a,b). Soil available nutrients; NPK, Zn, Mn, and Fe have increased as the fertilization rates by the compost and the mineral N increase compared with the non-fertilized control samples of 0 – fertilization rate [14,17]. The increase was more pronounced for available N as being the predominant nutrient followed by other nutrients. The increase percentage (%) was calculated by subtracting the value (average value of both seasons) of the specified treatment from that of the control (0 – fertilized). Compared with the control (0 – fertilized); the maximum increase at maximum rates was by 26.48% for compost/0 – mineral treatment, 7.11% for mineral/0 – compost treatment and 35.97% for compost/mineral treatment. As previously stated, this is often due to the high OM content of compost which is bio-compatible with the plant nutrition system and enhances the soil biological activity. Functional groups of the OM can react chemically and/or physically with the soluble nutrients so that they are better available and usable by plant. Better utilization of the mineral fertilizers by using compost reduces the required chemical dose and maintains soil fertility for a longer time than synthetic fertilizers [1].

## 3.2 Peanut Yield at Different Rates of Fertilization

As the fertilization rates increased for both compost and mineral N; the seed yield, weight of pods yield and the 100 seed weight increased compared with the non fertilized control (0 – fertilization rate) Table 4. For example, the seeds yield had increased by 178.04%, 257.26% and 373.14% for the compost/0 – mineral treatment, mineral/0 – compost treatment and the compost/mineral treatment, respectively compared with the control treatment (0 – fertilized).

The 100 – seed weight had increased by 14.73%, 13.65% and 19.92% for the same treatments respectively. Mineral nutrients quickly release and usually lost before being taken up by the crops. Utilization of the mineral fertilizer might be improved in presence of the compost. The compost added with these additives was better than the compost alone in enhancing growth [14]. The yield values increased in the presence of the mineral fertilizer at 119.05, 178.57 and 238.1 kg N $ha^{-1}$ along with the compost more than their increase due to the different rates of the compost or the mineral alone i.e. 0 – mineral or compost fertilization rate.

**Table 3a. Soil available macro-nutrients at different rates of fertilization**

| Compost rates ($Mg\ ha^{-1}$) | Mineral N rates ($kg\ N\ ha^{-1}$) | N ($mg\ kg^{-1}$) 1st | N ($mg\ kg^{-1}$) 2nd | SD | SE | P ($mg\ kg^{-1}$) 1st | P ($mg\ kg^{-1}$) 2nd | SD | SE | K ($mg\ kg^{-1}$) 1st | K ($mg\ kg^{-1}$) 2nd | SD | SE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.00 | 0 | 37.3 | 38.6 | 0.92 | 0.27 | 5.38 | 5.43 | 0.04 | 0.01 | 164 | 169 | 3.54 | 1.02 |
| 11.90 | | 44.5 | 45.7 | 0.85 | 0.24 | 5.83 | 5.89 | 0.04 | 0.01 | 173 | 176 | 2.12 | 0.61 |
| 23.81 | | 46.9 | 49.1 | 1.56 | 0.45 | 6.04 | 6.08 | 0.03 | 0.01 | 182 | 184 | 1.41 | 0.41 |
| 0.00 | 119.05 | 38.4 | 39.7 | 0.92 | 0.27 | 5.49 | 5.62 | 0.09 | 0.03 | 168 | 173 | 3.54 | 1.02 |
| 11.90 | | 45.9 | 46.2 | 0.21 | 0.06 | 5.96 | 5.98 | 0.01 | 0.00 | 179 | 185 | 4.24 | 1.22 |
| 23.81 | | 47.2 | 48.1 | 0.64 | 0.18 | 6.12 | 6.17 | 0.04 | 0.01 | 193 | 196 | 2.12 | 0.61 |
| 0.00 | 178.57 | 38.8 | 40.1 | 0.92 | 0.27 | 5.52 | 5.86 | 0.24 | 0.07 | 169 | 174 | 3.54 | 1.02 |
| 11.90 | | 46.0 | 46.7 | 0.49 | 0.14 | 6.16 | 6.22 | 0.04 | 0.01 | 182 | 185 | 2.12 | 0.61 |
| 23.81 | | 48.2 | 48.6 | 0.28 | 0.08 | 6.33 | 6.45 | 0.08 | 0.02 | 198 | 203 | 3.54 | 1.02 |
| 0.00 | 238.1 | 40.2 | 41.1 | 0.64 | 0.18 | 5.59 | 6.04 | 0.32 | 0.09 | 172 | 175 | 2.12 | 0.61 |
| 11.90 | | 48.6 | 49.5 | 0.64 | 0.18 | 6.22 | 6.35 | 0.09 | 0.03 | 189 | 192 | 2.12 | 0.61 |
| 23.81 | | 51.3 | 51.9 | 0.42 | 0.12 | 6.45 | 6.52 | 0.05 | 0.01 | 195 | 205 | 7.07 | 2.04 |

**Table 3b. Soil available micro-nutrients at different rates of fertilization**

| Compost rates ($Mg\ ha^{-1}$) | Mineral N rates ($kg\ N\ ha^{-1}$) | Fe ($mg\ kg^{-1}$) 1st | Fe ($mg\ kg^{-1}$) 2nd | SD | SE | Mn ($mg\ kg^{-1}$) 1st | Mn ($mg\ kg^{-1}$) 2nd | SD | SE | Zn ($mg\ kg^{-1}$) 1st | Zn ($mg\ kg^{-1}$) 2nd | SD | SE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.00 | 0 | 1.98 | 2.04 | 0.04 | 0.01 | 1.06 | 1.12 | 0.04 | 0.01 | 0.52 | 0.55 | 0.02 | 0.02 |
| 11.90 | | 2.33 | 2.42 | 0.06 | 0.02 | 1.18 | 1.19 | 0.01 | 0.00 | 0.56 | 0.63 | 0.05 | 0.05 |
| 23.81 | | 3.28 | 3.56 | 0.20 | 0.06 | 1.29 | 1.31 | 0.01 | 0.00 | 0.61 | 0.66 | 0.04 | 0.04 |
| 0.00 | 119.05 | 2.03 | 2.08 | 0.04 | 0.01 | 1.09 | 1.15 | 0.04 | 0.01 | 0.55 | 0.59 | 0.03 | 0.03 |
| 11.90 | | 2.46 | 2.55 | 0.06 | 0.02 | 1.35 | 1.39 | 0.03 | 0.01 | 0.60 | 0.66 | 0.04 | 0.04 |
| 23.81 | | 3.52 | 3.63 | 0.08 | 0.02 | 1.40 | 1.45 | 0.04 | 0.01 | 0.63 | 0.71 | 0.06 | 0.06 |
| 0.00 | 178.57 | 2.04 | 2.10 | 0.04 | 0.01 | 1.12 | 1.19 | 0.05 | 0.01 | 0.57 | 0.60 | 0.02 | 0.02 |
| 11.90 | | 2.63 | 2.77 | 0.10 | 0.03 | 1.44 | 1.48 | 0.03 | 0.01 | 0.66 | 0.69 | 0.02 | 0.02 |
| 23.81 | | 3.75 | 3.86 | 0.08 | 0.02 | 1.51 | 1.53 | 0.01 | 0.00 | 0.69 | 0.74 | 0.04 | 0.04 |
| 0.00 | 238.1 | 2.07 | 2.16 | 0.06 | 0.02 | 1.15 | 1.20 | 0.04 | 0.01 | 0.62 | 0.63 | 0.01 | 0.01 |
| 11.90 | | 2.77 | 2.88 | 0.08 | 0.02 | 1.49 | 1.55 | 0.04 | 0.01 | 0.69 | 0.72 | 0.02 | 0.02 |
| 23.81 | | 3.86 | 3.94 | 0.06 | 0.02 | 1.55 | 1.60 | 0.04 | 0.01 | 0.74 | 0.77 | 0.02 | 0.02 |

**Table 4. Peanut yield at different rates of fertilization**

| Compost rates (Mg ha$^{-1}$) | Mineral N rates (kg N ha$^{-1}$) | Seed yield Mg ha$^{-1}$ | | SD | SE | Weight of yield pods (Mg ha$^{-1}$) | | SD | SE | 100 seed (g) | | SD | SE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1st | 2nd | | | 1st | 2nd | | | 1st | 2nd | | |
| 0.00 | 0 | 0.69 | 0.71 | 0.01 | 0.01 | 1.16 | 1.21 | 0.04 | 0.01 | 69.33 | 74.25 | 3.48 | 1.00 |
| 11.90 | | 1.56 | 1.61 | 0.04 | 0.02 | 2.51 | 2.55 | 0.03 | 0.01 | 82.19 | 82.47 | 0.20 | 0.06 |
| 23.81 | | 1.94 | 1.98 | 0.03 | 0.02 | 2.68 | 2.74 | 0.04 | 0.01 | 82.59 | 82.14 | 0.32 | 0.09 |
| 0.00 | 119.05 | 1.41 | 1.42 | 0.01 | 0.00 | 1.99 | 2.01 | 0.01 | 0.00 | 75.19 | 75.20 | 0.01 | 0.00 |
| 11.90 | | 2.26 | 2.30 | 0.03 | 0.02 | 2.79 | 2.81 | 0.01 | 0.00 | 83.55 | 83.69 | 0.10 | 0.03 |
| 23.81 | | 2.75 | 2.80 | 0.04 | 0.02 | 3.31 | 3.32 | 0.01 | 0.00 | 84.88 | 84.93 | 0.04 | 0.01 |
| 0.00 | 178.57 | 1.78 | 1.79 | 0.01 | 0.00 | 2.27 | 2.43 | 0.11 | 0.03 | 81.10 | 80.22 | 0.62 | 0.18 |
| 11.90 | | 2.69 | 2.69 | 0.00 | 0.00 | 2.99 | 3.01 | 0.01 | 0.00 | 83.88 | 83.97 | 0.06 | 0.02 |
| 23.81 | | 2.88 | 2.89 | 0.01 | 0.00 | 3.55 | 3.59 | 0.03 | 0.01 | 85.17 | 85.25 | 0.06 | 0.02 |
| 0.00 | 238.1 | 2.51 | 2.52 | 0.01 | 0.00 | 2.81 | 2.83 | 0.01 | 0.00 | 81.55 | 81.63 | 0.06 | 0.02 |
| 11.90 | | 2.88 | 2.89 | 0.00 | 0.00 | 3.23 | 3.24 | 0.01 | 0.00 | 84.05 | 84.12 | 0.05 | 0.01 |
| 23.81 | | 3.32 | 3.35 | 0.01 | 0.01 | 3.65 | 3.70 | 0.04 | 0.01 | 86.04 | 86.14 | 0.07 | 0.02 |

### 3.3 Peanut Seeds' Quality at Different Rates of Fertilization

The enhancement effect of the mineral fertilizer combined with the compost had been reflected in the peanut seeds' content of NPK nutrients, protein, total carbohydrates and oil as indicated by Tables 5 and 6, respectively. Increased rates of the compost had improved the seeds' quality in the absence of the mineral fertilizer and to a higher extent in the presence of the mineral fertilizer. At maximum rates, the N (%) was increased by 34.8%, 17.87%, 45.24% for the compost/0 – mineral treatment, mineral/0 – compost treatment and the compost/mineral treatment, respectively compared with the control treatment (0 – fertilized). For the protein (%) at the same treatments the increase limits were 34.78%, 17.85%, 45.25%, respectively while the total carbohydrate content increased by 11.34%, 11.56%, 33.08% and the oil (%) increased 1.55%, 1.63%, 8.69%, respectively.

### 3.4 Nitrogen use Efficiency Indices

The N use efficiency indices were calculated from two points of view: **1.** With respect to the different compost rates at a single mineral treatment, and **2.** With respect to the different mineral fertilizer rates at the same category of compost treatments.

#### 3.4.1 Indices with respect to the compost treatments

According to Table 7, through one single mineral treatment the NUE/ANR and AE values were almost decreased as the compost rates increase. The values of these indices were also decreased at high concentrations of the mineral fertilizer. On the other hand, the PE values were increased for single mineral treatment as the compost rates increase. At the maximum compost rates the PE values increased as the mineral rates increase except for its maximum rate (238.1 kg N $ha^{-1}$) [25,26].

#### 3.4.2 Indices with respect to the mineral fertilizers rates

For the same compost treatments, the NUE/ANR values were increased then slightly decreased among the mineral treatments while the AE and PE values were decreased then slightly increased among the same mineral treatments.

Generally, the numerical values of the NUE/ANR and the AE indices with respect to the compost were greater than those for the mineral fertilizer. The opposite was true for the PE values. This indicates the greater effect of the organic compost than the mineral fertilizer. Nutrition status due to the mineral fertilizer had been enhanced in presence of compost more than individual types of additives. Possible chemical reactions between the compost organic matter and the highly soluble mineral fertilizer produce nutrients like amino-acids [1,5,7]. But high rates of a mineral fertilizer in presence of an organic one may diminish many of the N use efficiency indices due to loss by leaching or consuming in the microbial activity of OM. Much of the mineral fertilizer may be often wasted as indicated by the use efficiency indices leading to serious economic and environmental impacts. Although the maximum values of almost all the estimated parameters for soil and plant were obtained for the maximum rates of compost and mineral N; 23.81 Mg $ha^{-1}$ and 238.1 kg $ha^{-1}$, respectively, the N use efficiency indices shows a different result. According to the present study, the recommended fertilization rates are 11.9 Mg $ha^{-1}$ compost combined with 119.05 or 178.57 kg N $ha^{-1}$.

## 4. CONCLUSION

A field experiment had been carried out to study the effect of the partial substitution of the mineral nitrogen (N) fertilization by using the compost on the peanut productivity in sandy soil. The combination between both sources of N was found to increase the soil available nutrients; NPK, Zn, Mn, and Fe, the peanut seeds yield and quality as the fertilization rates increase compared with the non-fertilized control samples. The seeds yield had increased by 373.14% for the compost/mineral treatment, compared to 178.04% and 257.26% for the compost/0 – mineral treatment and the mineral/0 – compost treatment, respectively. This effect had been reflected in the peanut seeds' content of NPK nutrients, protein, total carbohydrates and oil which was increased by 8.69%, 1.55%, and 1.63% for the mentioned treatments respectively. The numerical values of the N use efficiency indices NUE/ANR and the agronomic efficiency (AE) indices with respect to the compost were greater than those for the mineral fertilizer.

**Table 5. Seeds' nutrients content at different rates of fertilization**

| Compost rates ($Mg\ ha^{-1}$) | Mineral N rates ($kg\ N\ ha^{-1}$) | N (%) | | SD | SE | P (%) | | SD | SE | K (%) | | SD | SE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1st | 2nd | | | 1st | 2nd | | | 1st | 2nd | | |
| 0.00 | 0 | 2.14 | 2.17 | 0.02 | 0.01 | 0.23 | 0.25 | 0.01 | 0.00 | 1.24 | 1.28 | 0.03 | 0.01 |
| 11.90 | | 2.76 | 2.81 | 0.04 | 0.01 | 0.35 | 0.38 | 0.02 | 0.01 | 1.68 | 1.72 | 0.03 | 0.01 |
| 23.81 | | 2.88 | 2.93 | 0.04 | 0.01 | 0.42 | 0.45 | 0.02 | 0.01 | 1.75 | 1.80 | 0.04 | 0.01 |
| 0.00 | 119.05 | 2.22 | 2.28 | 0.04 | 0.01 | 0.25 | 0.30 | 0.04 | 0.01 | 1.30 | 1.32 | 0.01 | 0.00 |
| 11.90 | | 2.88 | 2.93 | 0.04 | 0.01 | 0.36 | 0.42 | 0.04 | 0.01 | 1.74 | 1.78 | 0.03 | 0.01 |
| 23.81 | | 2.97 | 3.04 | 0.05 | 0.01 | 0.45 | 0.48 | 0.02 | 0.01 | 1.79 | 1.83 | 0.03 | 0.01 |
| 0.00 | 178.57 | 2.48 | 2.52 | 0.03 | 0.01 | 0.28 | 0.32 | 0.03 | 0.01 | 1.36 | 1.38 | 0.01 | 0.00 |
| 11.90 | | 3.01 | 3.04 | 0.02 | 0.01 | 0.42 | 0.47 | 0.04 | 0.01 | 1.85 | 1.88 | 0.02 | 0.01 |
| 23.81 | | 3.08 | 3.010 | 0.05 | 0.01 | 0.47 | 0.53 | 0.04 | 0.01 | 1.93 | 1.96 | 0.02 | 0.01 |
| 0.00 | 238.1 | 2.53 | 2.55 | 0.01 | 0.00 | 0.31 | 0.35 | 0.03 | 0.01 | 1.39 | 1.42 | 0.02 | 0.01 |
| 11.90 | | 3.06 | 3.08 | 0.01 | 0.00 | 0.46 | 0.49 | 0.02 | 0.01 | 1.94 | 1.95 | 0.01 | 0.00 |
| 23.81 | | 3.12 | 3.14 | 0.01 | 0.00 | 0.50 | 0.55 | 0.04 | 0.01 | 1.98 | 1.99 | 0.01 | 0.00 |

**Table 6. Protein, total carbohydrate and oil analysis of peanut seeds at different rates of fertilization**

| Compost rates ($Mg\ ha^{-1}$) | Mineral N rates ($kg\ N\ ha^{-1}$) | Protein (%) | | SD | SE | Total carbohydrate ($mg\ g^{-1}\ dwt^{-1}$) | | SD | SE | Oil (%) | | SD | SE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1st | 2nd | | | 1st | 2nd | | | 1st | 2nd | | |
| 0.00 | 0 | 13.38 | 13.56 | 0.13 | 0.04 | 196.5 | 201.3 | 3.39 | 0.98 | 41.52 | 41.55 | 0.02 | 0.01 |
| 11.90 | | 17.25 | 17.56 | 0.22 | 0.06 | 201.9 | 208.1 | 4.38 | 1.27 | 41.85 | 41.93 | 0.06 | 0.02 |
| 23.81 | | 18.00 | 18.31 | 0.22 | 0.06 | 219.1 | 223.8 | 3.32 | 0.96 | 42.16 | 42.20 | 0.03 | 0.01 |
| 0.00 | 119.05 | 13.88 | 14.25 | 0.26 | 0.08 | 201.8 | 213.0 | 7.92 | 2.29 | 41.69 | 41.78 | 0.06 | 0.02 |
| 11.90 | | 18.00 | 18.31 | 0.22 | 0.06 | 222.0 | 225.1 | 2.19 | 0.63 | 42.33 | 42.46 | 0.09 | 0.03 |
| 23.81 | | 18.55 | 19.00 | 0.32 | 0.09 | 234.5 | 236.4 | 1.34 | 0.39 | 43.15 | 43.20 | 0.04 | 0.01 |
| 0.00 | 178.57 | 15.50 | 15.75 | 0.18 | 0.05 | 214.3 | 216.8 | 1.77 | 0.51 | 41.85 | 41.88 | 0.02 | 0.01 |
| 11.90 | | 18.81 | 19.00 | 0.13 | 0.04 | 241.0 | 242.6 | 1.13 | 0.33 | 43.25 | 43.30 | 0.04 | 0.01 |
| 23.81 | | 19.25 | 18.81 | 0.31 | 0.09 | 255.6 | 258.1 | 1.77 | 0.51 | 43.78 | 43.95 | 0.12 | 0.03 |
| 0.00 | 238.1 | 15.81 | 15.94 | 0.09 | 0.03 | 220.0 | 223.8 | 2.69 | 0.78 | 42.19 | 42.23 | 0.03 | 0.01 |
| 11.90 | | 19.13 | 19.25 | 0.08 | 0.02 | 263.1 | 263.5 | 0.28 | 0.08 | 44.25 | 44.32 | 0.05 | 0.01 |
| 23.81 | | 19.50 | 19.63 | 0.09 | 0.03 | 264.6 | 264.8 | 0.14 | 0.04 | 45.10 | 45.19 | 0.06 | 0.02 |

**Table 7. Nitrogen use efficiency indices**

| Compost rates (Mg ha$^{-1}$) | Mineral N rates (kg N ha$^{-1}$) | Seed N content (%) | | Average | (NUE/ ANR) [1] (%) | (NUE/ ANR) [2] (%) | Seed yield Mg ha$^{-1}$ | | Average (Mg ha$^{-1}$) | AE (%)[1] | AE (%)[2] | PE (%)[1] | PE (%)[2] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1st | 2nd | | | | 1st | 2nd | | | | | |
| 0.00 | 0 | 2.14 | 2.17 | 2.16 | - | - | 0.293 | 0.299 | 0.70 | - | - | - | - |
| 11.90 | | 2.76 | 2.81 | 2.79 | 5.29 | | 0.656 | 0.677 | 1.59 | 7.48 | | 141.27 | |
| 23.81 | | 2.88 | 2.93 | 2.91 | 3.15 | | 0.813 | 0.833 | 1.96 | 5.29 | | 168.00 | |
| 0.00 | 119.05 | 2.22 | 2.28 | 2.25 | - | 0.09 | 0.591 | 0.598 | 1.42 | - | 0.62 | - | 740.00 |
| 11.90 | | 2.88 | 2.93 | 2.91 | 5.50 | | 0.950 | 0.967 | 2.28 | 7.23 | | 130.30 | |
| 23.81 | | 2.97 | 3.04 | 3.01 | 3.17 | | 1.156 | 1.177 | 2.78 | 5.71 | | 178.95 | |
| 0.00 | 178.57 | 2.48 | 2.52 | 2.50 | - | 0.13 | 0.749 | 0.753 | 1.79 | - | 0.58 | - | |
| 11.90 | | 3.01 | 3.04 | 3.03 | 4.41 | | 1.129 | 1.133 | 2.69 | 7.56 | | 169.81 | 429.17 |
| 23.81 | | 3.08 | 3.01 | 3.05 | 2.29 | | 1.208 | 1.215 | 2.88 | 4.58 | | 198.18 | |
| 0.00 | 238.1 | 2.53 | 2.55 | 2.54 | - | 0.12 | 1.055 | 1.060 | 2.52 | - | 0.63 | - | 513.79 |
| 11.90 | | 3.06 | 3.08 | 3.07 | 4.45 | | 1.208 | 1.215 | 2.88 | 3.03 | | 67.92 | |
| 23.81 | | 3.12 | 3.14 | 3.13 | 2.48 | | 1.395 | 1.406 | 3.33 | 3.40 | | 137.29 | |

*1 (With respect to the compost rates);2 (With respect to the mineral fertilizer rates)*

This indicates the greater effect of compost than the mineral one Nutrition status due to the mineral fertilizer had been enhanced in presence of compost more than individual types of additives. Possible chemical reactions between the compost organic matter and the highly soluble mineral fertilizer produce nutrients like amino-acids. But high rates of a mineral fertilizer in presence of an organic one may diminish many of the N use efficiency indices due to loss by leaching or consuming in the microbial activity of OM. Much of the mineral fertilizer is often wasted as indicated by the use efficiency indices leading to serious economic and environmental impacts.

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