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Significance of Applied Organic Manure Combined with N-Mineral Fertilizer to Alleviate the Possible Risks of Chemical Pollution for Broccoli

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A FIELD experiment was conducted on a clayey soil at Sinnuris district, El-Fayoum Governorate, Egypt during the two successive seasons of 2006-2007 and 2007-2008 to evaluate the response of vegetative growth, nutritional status and yield of broccoli (*Brassica oleracea* L. var. Italica) as well as head quality to a partial substitution of 25 % N-mineral by N-organic source (chicken manure at the rates of 8, 12 and 16 ton/fed) as compared with applying 100 % recommended dose of N-mineral fertilizer in the form of ammonium nitrate (33.5% N), hopping an alleviation of the possible fears of chemical pollution for such a vegetable crop and environmental risks.

According to the field studies and analytical data of soil initial state. the obtained results show that the studied soil is mainly encompassing the Nile alluvium deposits as a parent material and it belongs to a taxonomic unit at a family level of "Typic haplotorrrts. fine clay, smectitic, hyperthermic" as well as it could be evaluated as moderately suitable for irrigated agriculture land, with a slight intensity degree for each of soil limitations of texture (s_1), $CaCO_3$ (s_3) and gypsum (s_4) as well as it was suffering from zinc deficient. From the economical point of view, data of the studied plant characters indicate that the greatest vegetative growth parameters of broccoli (*i.e.*, leaf area plant^{-1}, number of leaves plant^{-1}. dry weight of leaves plant^{-1}, dry weight of stem plant^{-1}, leaf sugar and leaf nutritional status) were achieved by plants supplied with the combined treatment of 12 ton chicken manure/fed + 75 % recommended dose of N-mineral fertilizer as ammonium nitrate. Such favourable conditions were positively reflected on the followed growth stages and gave the greatest total yield/fed (*i.e.*, central head weight and lateral head weight), with relative increase percentages reached 13.8 and 13.9 % for both seasons, respectively, as well as better quality parameters of broccoli (*i.e.*, central head weight, lateral head weight, number of lateral heads plant^{-1} and sugar head) during both two studied seasons. Such beneficial conditions were more attributed with the optimum soil case of the current experiment, which was achieved by ameliorated values of soil physico-chemical properties and the nutrients status.

Superiority of the applied N-mineral in combination with chicken manure was mainly attributed to the later due to it plays a direct role for improving 1) Soil hyrophysical properties (*i.e.*, soil aggregation, bulk density, total porosity, aeration, hydraulic conductivity and available water range), 2) Soil chemical characteristics (*i.e.*, soil pH, released organic constituents of active groups such as fulvic and humic acids which have the ability to retain the essential plant nutrients in complex and available chelate forms), 3) Soil biological conditions (*i.e.*, a source of energy for the microorganism activities which enhance in releasing necessary nutrients in available forms throughout their mineralization) and 4) Soil fertility status (*i.e.*, slow release for nutrients which support root development among the different growth stages), that finally leading to improve vegetative growth, chemical constituents and higher yield of broccoli with better quality heads. Moreover, the periodical application of such natural organic manure is considered the best option not only for reducing the harmful effects of using chemical fertilizers, but also for sustaining soil fertility status and help to alleviate the possible risks of environmental pollution on human health.

Keywords: Chicken manure, N-mineral fertilizer, Clayey soil, Vegetative growth, Yield and quality of broccoli.

Humankind, particularly in the developed countries of World, faces a great problem either in the human health or in the environmental pollution due to the excessive uses of mineral or chemical fertilizers, especially those of nitrogenous ones. Interest in the N-excessive use, it could be partially attributed to the advent of high yielding crop cultivars under assured perennial irrigation. So that, there is a renewed interest in organic recycling to nutrients supply as well as to improve soil fertility status and its productivity. Moreover, the periodical application of the natural organic wastes to soils has gained momentum in the recent past and takes place different aspects, *i.e.*, organic agriculture, clean agriculture and bio-agriculture. The integrated use of the natural organic manures and mineral fertilizers is considered the best option not only for reducing the previous enormous consumption of chemical fertilizers, but also for sustaining soil fertility status and help to maximize fertilizer use efficiency in soil (Singh *et al.*, 1999; Bhatia *et al.*, 2001 and Palm *et al.*, 2001). Thus, the way of clean agriculture with a minimum pollution should be include a conjunctive use of local organic manure and N-mineral fertilizers. The application of manure to soil provides several potential benefits, *i.e.*, ameliorating soil fertility status, structure and available moisture range as well as increasing the natural soil organic component vs reducing the amount of synthetic fertilizer needed for crop production (Grandy *et al.*, 2002).

The favourable soil conditions, which are associated with the applied organic manures, are ascribed by many investigators such as Khater *et al.* (2004) who found that the added organic manure as a soil amendment leads to improve its physical, chemical and fertility status, *i.e.*, bulk density, hydraulic conductivity, available water content, pH value and organic matter content as well as the released nutrient contents of N, P, K, Fe, Mn, Zn and Cu. They added that the beneficial effects of soil treated with organic manure were closely extended to the cultivated plants. Moreover, such positive effects depend mainly on the C/N ratio of the applied manure, which plays an important role for the degree or rate of decaying. In this connection, Salib (2002) reported that, in general, crop yield and its components responded markedly to the applied organic amendments, however, their beneficial effects are cleared through released organic acids as chelating agents enhancing the nutrients availability, mobility and easily uptake by plants.

Also, Negm *et al.* (2003) found that the added organic manure reduced soil pH value vs an increase in soil organic matter content and available content of each N, P and K in soil. The authors showed that the curve of increase reached its peak after harvest stage of the grown plants and gradually tended to reduce again. In addition, Mohammed (2004) reported that the conjunctive use of N-mineral fertilizers and local organic manure in the newly cultivated desert soils had favourable higher influence on crop yield than the recommended doses of N, P and K fertilizers. This may be due to the applied organic manure caused an improvement in soil fertility status as a result of already its extend to long run. Singer *et al.* (2004) pointed out that the applying organic manure as a soil amendment to cropland reduces the synthetic fertilizer requirements, and may eliminate yield differences between conventional and minimum tillage. Also, they found that crop producers can enhance yield with multiple organic compost application and eliminate yield differences between conventional and no-till systems. Nevertheless, organic manure application for soil organic material enhancement must be balanced with P input to minimize the potential for excessive soil P accumulation.

Yung-Yu Shu (2006) studied the effects of applied different kinds of organic composts on some plant characteristics as compared to those treated with the mineral fertilizers alone, and reported that at the most active vegetative growth stages of the plants, the amount of nutrients absorbed from the chemical fertilizers were found to be higher than those treated wit organic manure. Whereas, the values of the studied plant parameters and nutrient uptake by the plants with the organic manure treatment were the highest at the maturity stage. The later case confirmed by the plants of the next crop, however, the values of the same plant parameters at the organic manure treatment were also recorded the highest among all the treatments at the maturity stages. It could be interpreted such phenomena on the fact that the chemical fertilizer was a fast-release fertilizer used to supply nutrients at the early stages of growth in the first crop, while the beneficial effect of the composts on plant growth and nutrient uptake was conspicuous in the next crop as compared with that of routine treatment of chemical fertilizer. Singer *et al.* (2007) reported that organic manure amendment increased whole-plant P and K uptake 19 and 21% averaged across 2 years. Because organic manure amendment increases soil organic matter, and then soil plant water status was hypothesized to affect the tillage by organic materials response. In spite plants growing in organic manure-amended soil accumulated more P and K than plants growing in non-amended soils, but the greater uptake was not associated with increased crop yield. This was true, since sequential organic manure application can reduce inorganic N inputs for crop production, but must be balanced with P removal to avoid excessive soil P accumulation.

Wanas (2006) executed a study to maximize the efficiency of plowing through incorporating some types of organic manures (cotton stalks compost, sugar cane refuse compost and water hyacinth plant compost) to a clayey soil during plowing operation and creating the physical soil and water conditions suitable for grown plants. He found that the obtained results revealed that soil bulk density significantly decreased and total porosity increased at the treatments of (plowing + organic manure) as compared with plowing alone (control). The recorded values either in decrease and/or increase were higher in shallow plowing than the deep one. The percentage of water stable aggregates (WSA%, > 0. 25 mm) significantly increased more than those of <0.25mm, which acted positively upon the structure coefficient. On the other hand, drainable pores significantly increased and water holding ones as well, but the increase in drainable pores was much higher than those of water-holding pores. The changes in WSA% and pore system significantly influenced on available moisture content and saturated hydraulic conductivity. Such best conditions were significantly increased crop yield, particularly with the deep plowing than with shallow one. Accordingly, it can say generally that applied organic manure had the ability to change positively clayey soil hydrophysical properties and raising its productivity.

Recently, more attentions extending towards the devoted cultivated areas and increasing the production of some untraditional vegetable crops including broccoli, through the pathway of nutrition, for local consumption and early exportation to European countries, have been directed. So, the current work aimed at evaluating the partially N-mineral substitution by an alternative N-source supplied from some local organic manures (chicken manure) to achieve the new approaches of clean, organic and bio-agriculture on maximizing the productivity and head quality of a newly vegetable crop such as Broccoli. Broccoli (*Brassica oleracea L.*var. italica) belongs to family Brassicacea and considers a number of cole vegetable crops; which includes cabbage, cauliflower, chinese cabbage, broccoli, brussels sprouts and kohlrabi. It well known that, broccoli has enormous nutritional and medicinal values due to its high contents of vitamins (A, B1, B2, B5, B6 and E), besides minerals (Ca, Mg, Zn and Fe) and number of health supporting antioxidant substances, which prevent the formation of cancer causing agents (Beecher, 1994). So that, it is widely, cultivated in many European and American countries. In Egypt, broccoli still a grown in a very limited scattered areas and the total cultivated area is not exactly known (Abou El-Magd *et al.*, 2006).

Material and Mmetods

A field experiment was carried out during the two successive seasons of 2006-2007 and 2007-2008 at a private farm occupied an area Sinnuris, district, El-Fayoum Governorate, Egypt characterized by clayey soil to evaluate the response of vegetate growth and yield of broccoli (*Brassica oleracea* L. var. *italica*) as well as head quality to a partial substitution of 25 % N-menial as ammonium nitrate (33.5%N) by an alternative N-source supplied from some local organic manures (chicken manure) as compared with the 100 % recommended dose of N-mineral fertilizer.

The main chemical characteristics and nutrients status of the applied chicken manure are presented in Table 1.

TABLE 1. The main chemical characteristics of applied chicken manure (dry weight basis).

Character	Value	Character	Value
Weight of 1 m^3 (kg)	573.00	C/N ratio	13.47
pH (1:10 water suspension)	7.04	Total P %	1.15
EC (dS/m, 1:10 water extract)	4.63	Total K %	2.38
Moisture content %	8.91	Available Fe (mg kg^{-1})	2129
Organic matter %	54.45	Available Mn (mg kg^{-1})	205
Organic carbon %	31.66	Available Zn (mg kg^{-1})	176
Total N %	2.35	Available Cu (mg kg^{-1})	34

Disturbed and undisturbed soil samples were collected from the initial state of the experimental soil at the depths of 0-35, 35-70, 70-105 and 105-150 cm for determining the main soil characteristics. The obtained data of the studied soil properties and nutrients status are presented in Table 2. Soil physical (*i.e.*, particle size distribution, bulk density, total porosity, available water range and soil structure factor) and chemical properties (*i.e.*, pH, ECe, soluble ions, ESP, gypsum, $CaCO_3$ and organic matter contents) according to the standard methods outlined by Black *et al.* (1965); Jackson (1973) and Page *et at.* (1982). Available N, P and K were extracted and determined according to the methods under taken by Soltanpour & Schwab (1977) and Jackson (1973), respectively. Also, available Fe, Mn, Zn, and Cu were extracted using ammonium bicarbonate DTPA extract according to Lindsay & Norvell (1978), and measured by using Inductively Coupled Plasma Spectrometry instrument (Plasma JY Ultima).

TABLE 2. The main soil characteristics of the experimental field.
a. Morphological features of the studied soil profile*.

Physiographic unit	Soil parent material	Slope gradient	Horizon symbol	Soil depth (cm)	Soil colour			Modified texture class	Soil structure	Soil consistency
					Hue	Dry	Moist			
El-Fayoum alluvial fan	The Nile alluvium	Almost flat	Ap	0-35	10YR	5/2	4/2	Clayey	Mmsbk	Hard
			C1	35-70					Mmsbk	Firm
			C2	70-105					Mmsbk	Firm
			C3	105-150					Cstsbk	Firm

Soil structure: Mmsbk =Medium moderate subangular blocky and Cstsbk=Coarse strong subangular blocky.

* Outlined by USDA (2003). ** Mmunsell Colour Chart (1975).

b. The main physico-chemical properties of the studied soil profile.

Depth (cm)	Particle size distribution %				Modified textural class	Soil bulk density (g cm^{-3})	Total porosity %	Available water range %	Soil structure factor %	Hydraulic conductivity (cm/h)	Organic matter %	$CaCO_3$ %	$CaSO_4.2H_2O$ %	Soil sodicity (ESP)
	Coarse sand	Fine sand	Silt	Clay										
0-35	5.85	23.34	21.56	49.25	Clayey	1.27	52.08	17.86	79.50	1.75	1.74	4.47	0.72	7.15
35-70	4.30	21.83	23.70	50.17		1.29	51.32	17.15	78.44	1.46	0.93	3.50	0.65	8.02
70-105	3.51	25.35	22.19	48.95		1.30	50.94	16.72	75.36	1.30	0.75	2.75	0.54	9.76
105-150	2.25	20.30	24.55	52.90		1.32	50.19	15.94	73.05	1.12	0.56	1.93	0.48	10.93

c. Chemical analysis of soil paste extract of the studied soil profile.

Depth (cm)	Soil pH*	ECe (dS/m)	Soluble cations (m mmolc L^{-1})				Soluble anions (m mmolc L^{-1})			
			Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	CO_3^{2-}	HCO_3^{-}	Cl^{-}	SO_4^{2-}
0-35	7.86	2.95	14.84	3.43	10.92	0.75	0.00	2.25	15.60	11.79
35-70	7.87	3.24	12.95	4.58	14.97	0.60	0.00	2.20	17.34	13.56
70-105	7.91	2.86	11.70	3.75	12.95	0.55	0.00	2.40	15.10	11.45
105-150	7.95	2.73	9.63	4.60	13.20	0.47	0.00	2.85	14.75	10.30

* Soil pH was determined in 1:2.5 soil water suspensions.

d. Available nutrient contents in the studied soil.

Soil depth (m)	Macronutrients (mg/kg)			Micronutrients (mg/kg)			
	N	P	K	Fe	Mn	Zn	Cu
0-35	81.30	10.52	476.93	8.75	3.63	0.82	0.64
35-70	74.75	9.47	435.84	7.62	2.91	0.70	0.55
Critical levels of the studied available plant nutrients (mg/kg), after Lindsay & Norvell (1978)							
Nutrient	N	P	K	Fe	Mn	Zn	Cu
Low	< 40.0	< 5.0	< 85	< 4.0	< 2.0	< 1.0	< 0.5
Medium	40.0-80.0	5.0-10.0	85-170	4.0-6.0	2.0-5.0	1.0-2.0	0.5-1.0
High	> 80.0	> 10.0	> 170	> 6.0	> 5.0	> 2.0	> 1.0

The experimental treatments were included:

1. 100 % of N-mineral fertilizer as a control treatment (120 kg/fed, recommended N-mineral fertilizer for broccoli under El-Fayoum Governorate Conditions, (Tolba, 2005).
2. 75 % recommended dose of N-mineral fertilizer + 8 ton chicken manure/fed.
3. 75% recommended dose of N-mineral fertilizer + 12 ton chicken manure/fed.
4. 75% recommended dose of N-mineral fertilizer + 16 ton chicken manure/fed.

Half the applied chicken manure rates was broadcasted and incorporated during the soil preparation (25 cm depth into the topsoil) a lightly irrigation was executed to boost up the biological activity for enhancing the organic materials decomposition before planting, while the other amount was added after 4 weeks from transplanting; the remainder quantities of chicken manure rates, consecutively was side banded beside plants and covered with soils. As for the applied N-mineral fertilizer, 30 or 22.5 kg/fed of ammonium nitrate (33.5 % N) was broadcasted and incorporated during the soil preparation in cases of 100 % or 75% N-mineral fertilizer, respectively, while after 3 and 6 weeks from transplanting; one third and two third of the remainder quantities of N-mineral fertilizer consecutively were side banded. Also, calcium superphosphate (15.5 % P_2O_5), as a source of phosphorus, was broadcasted and incorporated at a uniform dose during soil preparation. Potassium sulphate (48 % K_2O), as a respective K source, was broadcasted and incorporated during the soil preparation at a rate of 12 kg K_2O/fed, then one third and two third of the remainder quantities of K_2O fertilizers consecutively were side banded after 3 and 6 weeks from transplanting.

The different treatments were arranged in complete randomized blocks design with four replications. Seeds of broccoli (*Brassica oleracea* L. var. *italica*) by Battistini Sementi company, Italia were drilled in foam trays of 209 holes in a media consisting on peat moss and vermiculite 1:1 on September 17, 2006 and September 5, 2007. After 35 days seeds drilling, trays were brought as well as transplants were planted on rows of 6 m in length and 0.60 m in width as well as interplant spacing was 40 cm along each row (about 16000 plants/fed). Each plot was planned to consist of 5 rows (the experimental plot area was $18m^2$) and every two plots were separated from each other with one row. The irrigation water was applied through a furrow irrigation system and all other recommended agro-managements required for broccoli production as irrigation, cultivation and protection against pests and diseases were practiced whenever it was necessary.

Recorded data

The observations on vegetative growth features were taken using five randomly selected plants from the first row, in each experimental unit at 70 days after transplanting. The aerial parts of the chosen plants were cut off at the ground level and sub-divided into leaves and stem. The following vegetative parameters were recorded: number of leaves plant^{-1}, leaf area plant^{-1} using leaf area-leaf weight relationship from leaf disks obtained by a cork borer (Wallacce & Munger, 1965), dry weight of leaves and stem plant^{-1} by drying in a forced–air oven at 70 °C till the weight became constant.

In each experimental plot, plants of the two middle rows were allocated to record observations on total head yield and its components. At harvest, total yield in kg/fed (*i.e.*, central and lateral heads having closed flowers buds, dark green colour and good compactness), and stalks, then were trimmed. The following parameters were considered: central head weight plant^{-1}, number and weight of lateral heads plant^{-1}, *i.e.*, average weight of lateral head plant^{-1}, total central and lateral heads weight plant^{-1}, central, lateral and total heads yield fed^{-1}.

A plant sample consists of five plants was randomly chosen from the fourth row, in each experimental unit, for chemical determinations. At sampling time, seventy days after transplanting, plant samples were cut off at the ground level, sub-divided into leaves and heads. Total N in leaves and heads was estimated using the Microkjeldahal apparatus as described in A.O.A.C. (1995), phosphorus was determined using spectrophotometer apparatus according to Jackson (1967), potassium was determined using Flame photometer (Perkin-Elmer, model 52) with acetylene burner as outlined by Brown & Lilliand (1966), Fe, Mn, Zn and Cu (Inductively Coupled Plasma Spectrometry instrument, Plasma JY Ultima) and leaf or head sugar (A.O.A.C., 1995).

Also, disturbed and undisturbed soil samples were collected from the treated experimental plots at 70 days after transplanting to monitory the changes in soil physico-chemical properties and the nutrients status, *i.e.*, soil bulk density, total porosity (Black & Hartge, 1986), structure factor, hydraulic conductivity, available water range (Klute, 1986), soil organic matter (Walkely and Black method after Hesse, 1971), pH, ECe and ESP (Jackson, 1973). Available macronutrients of N, P and K were extracted by 1 % potassium sulphate, 0.5 M sodium bicarbonate and 1 N ammonium acetate, respectively (Soltanpour & Schwab, 1977) and their contents in soil were determined according to Jackson (1973). Available micronutrients of Fe, Mn, Zn, and Cu in soil were extracted using ammonium bicarbonate-DTPA extract according to Soltanpour & Schwab (1977) and their contents in soil were measured by using Inductively Coupled Plasma Spectrometry instrument (Plasma JY Ultima).

Statistical analysis

All data of the two seasons were subjected to the statistical analysis according to Snedecor & Cochran (1980) to define the least significant difference test (L.S.D. at p = 0.05 level), which was used to verify the differences between the tested treatments.

Results and Discussion

A general view on the experimental soil

Soil morphology

Data illustrated in Table 2.a indicate that the experimental soil is mainly encompassing the Nile alluvial fan of El-Fayoum depression, and it is developed under climatic conditions of long hot rainless summer and short mild winter. The studied soil is characterized by a clayey texture grade throughout the different profile layers. Due to the prevailing ECe and ESP less than dS m^{-1} and 15 %, it was surveyed as a non-saline and non-sodic soil, respectively. Soil morphological features showed also that the initial state of the studied soil site was characterized by a deep effective soil (more than 150 cm), sub-angular blocky structure and without mottling phenomena in the subsoil layers, which reflected the signs of better soil aeration.

Analytical data

The results obtained of particle size distribution, Table 2.bc, reveal that the studied soil is characterized by fine texture (clayey), and it attains low content of $CaCO_3$ and very low contents of gypsum and organic matter. The later may be ascribed to the low accumulated plant residues and the prevailing hot and arid climatic conditions. Also, the studied soil has relatively low values of sodicity (*i.e.*, ESP, non-alkali soil), soil pH tended to slight alkaline, ECe less than 4 dSm^{-1} and ESP, which led to classified the studied soil as non-saline and non-alkaline. Such results are emphasized by the positive effects of the progressive increments of soluble Ca^{2+} + Mg^{2+} which surpassed the soluble content of Na^{+} that reflected the signs of better soil aggregation (structure factor), bulk density, total porosity and available water range. On the other hand, the studied soil was suffering from micronutrients deficient, however, the available contents of Mn, Zn and Cu are found in inadequate amounts to the sufficient levels for plant, as shown in Table 2.d.

Soil taxonomy and evaluation in the current condition

According to the obtained results of soil morphological and physio-chemical characteristics as well as based on the outlines of classification system after Soil Survey Staff (USDA, 2006), the experimental soil could be classified at the family level as "Typic Haplotorrerts, fine clayey, smectitic, hyperthermic". By using a parametric system undertaken by Sys & Verheye (1978), the intensity degrees of soil limitations were calculated to define the suitability class of the studied soil, as shown in Table 3. The obtained data show that soil texture (s_1), $CaCO_3$ (s_3), and gypsum (s_4), with an intensity degree ranged moderate-slight (85-90 %), are represented the main soil limitations for productivity. Also, the suitability condition in either current or potential classes of the studied soil could be categorized as moderately suitable (S_2) for irrigated agriculture land, with a suitability index of rating Ci = 72.68 %.

TABLE 3. Rating of soil limitations and its suitability for irrigated agriculture land.

Suitability condition	Topography (t)	Wetness (w)	Physical characteristics				Salinity & alkalinity (n)	Suitability rating	Suitability class	Suitability class and limitations
			Texture (s_1)	Depth (s_2)	$CaCO_3$ (s_3)	Gypsum (s_4)				
Current	100	100	85	100	95	90	100	72.68	S2	$S2s_1$
Potential	100	100	85	100	95	90	100	72.68	S2	$S2s_1$

Effect of applied mineral fertilizer and organic manures on soil properties

Soil physico-chemical properties

The effects of N-mineral fertilizer added as either solely or combined with organic manure to the experimental soil plots under cultivation with broccoli, furrow irrigation and efficient drainage systems, caused a pronounced ameliorated effect in each of the studied soil characters, *i.e.*, soil bulk density, total porosity, structure factor, hydraulic conductivity, available water range, soil organic matter and pH, as shown in Table 4.

TABLE 4. Some soil physico-chemical as affected by applied N-mineral fertilizer and organic manure at 70 days after transplanting.

Treatments	Bulk density (g/cm^3)	Total porosity %	Structure factor %	Hydraulic conduct (cm/h)	Available Water %	Organic matter %	Soil pH*
Season 2006-2007							
100 % N-mineral	1.25	52.83	81.16	1.83	19.05	1.76	7.85
75% N-mineral+8 ton/fed OM	1.20	54.72	85.70	2.15	21.87	1.89	7.73
75% N-mineral+12 ton /fed OM	1.16	56.23	89.85	2.76	23.92	1.95	7.69
75% N-mineral+16 ton /fed OM	1.15	56.60	90.46	2.80	24.16	1.98	7.67
L.S.D. at 0.05	0.05	1.72	4.41	0.20	1.53	0.09	0.065
Season 2007-2008							
100 % N-mineral	1.24	53.21	81.75	1.90	19.61	1.78	7.84
75% N-mineral+8 ton/fed OM	1.19	55.09	86.44	2.21	22.04	1.92	7.71
75% N-mineral+12 ton /fed OM	1.14	56.98	90.02	2.89	24.17	1.97	7.66
75% N-mineral+16 ton /fed OM	1.13	57.36	91.75	2.92	24.38	2.00	7.65
L.S.D. at 0.05	0.05	1.76	4.50	0.22	1.94	0.10	0.067

OM=Chicken manure. *in 1:2.5 soil water suspension.

It is noteworthy to mention that there was a more beneficial effect for each of these studied soil characters in the second season attributed with the residual effect of the applied chicken manure, but without significant differences between the two successive seasons. The sequence of the superiority for the applied treatments under the current experimental conditions could be arranged into an ascending order of 16 ton of chicken manure/fed + 75 % of N-mineral fertilizer ≥ 12 ton of chicken manure/fed + 75 % of N-mineral fertilizer > 8 ton of chicken manure/fed + 75 % of N-mineral fertilizer > 100 % of N-mineral fertilizer.

The obtained data showed also that there was no significant difference between the positive changes in soil physico-chemical properties which were accompanied to soil plots received the combined treatments of either 12 or 16 ton of chicken manure/fed + 75 % of N-mineral fertilizer, which surpassed the other applied ones. Hence from the economical point of view, the combined treatment of 12 ton of chicken manure/fed + 75 % of N-mineral fertilizer is considered the superiority over than the other treatments was great enough to reach the level of significance under the prevailing conditions of the current experiment. That was true, since the positive effect of the progressive increment of active organic acids, derived from the applied organic chicken manure, improves soil pH, soil structure parameters particularly bulk density, water stable soil aggregates and their inter-aggregates (useful ≈ storage pores) or outeraggregates pores (conductive pores). Both pore types lead to ameliorate soil moisture regime through increasing the soil available water range and hydraulic conductivity, respectively. The later character enhances in more salts could be leached out the root zone, and then reduces osmotic potential which result in an increase for soil available water range.

Soil content of some available nutrients

It is noteworthy to indicate that the studied Nile alluvial soil is distinctly micronutrients deficient, *i.e.,* Mn Zn and Cu, which are considered of the most essential micronutrients for plants, as shown in Table 1.d. Thereby, after executing the organic fertilization, data illustrated in Table 5 showed a progressive significant increases in all the studied available nutrients upon treating the soil with the chicken manure in combination with 75 % N-mineral fertilizer, particularly at the applied rate of 16 ton/fed as compared to the treatment of 100% N-mineral fertilizer as well as the initial state of the studied soil.

TABLE 5. The nutrients status in the studied soils as affected by applied N-mineral fertilizer and organic manure at 70 days after transplanting.

Treatments	Macronutrients %			Micronutrients (mg/kg)			
	N	P	K	Fe	Mn	Zn	Cu
Season 2006-2007							
100 % N-mineral	105.45	11.05	498.12	9.10	4.21	0.98	0.83
75% N-mineral+8 ton/fed OM	96.30	11.84	552.75	10.24	4.87	1.35	0.97
75% N-mineral+12 ton /fed OM	114.67	12.75	579.34	11.28	5.66	1.87	1.15
75% N-mineral+16 ton /fed OM	121.83	13.92	586.96	12.55	5.80	2.34	1.27
L.S.D. at 0.05	8.11	1.01	44.50	0.93	0.41	0.17	0.11
Season 2005-2008							
100 % N-mineral	106.79	11.37	501.96	9.28	4.29	1.01	0.85
75% N-mineral+8 ton/fed OM	97.18	11.96	557.04	10.65	4.94	1.41	1.01
75% N-mineral+12 ton /fed OM	116.54	12.92	584.12	11.41	5.70	1.94	1.19
75% N-mineral+16 ton /fed OM	122.32	14.03	592.38	12..63	5.91	2.38	1.32
L.S.D. at 0.05	8.81	1.08	45.30	1.01	0.43	0.17	0.12

OM=Chicken manure .

The superiority of applied chicken manure is mainly attributed to it attains high contents of essential macro and micronutrients, beside its beneficial effects on soil properties through lowering soil pH and maintaining a suitable air-moisture regime, as discussed previously. The latter conditions led to enhance the microbial activity in soil, which accelerate the decomposition of organic matter and maximize soil content of nutrients, especially for those of micronutrient deficient in the soil. These findings are confirmed by the results undertaken after Sarker *et al.* (1992) who found that, the organic manure provided a substantial modification of physical properties such as bulk density and aeration, which affected solubility, adsorption and availability of nutrients.

Response of broccoli yield and quality to the applied treatments

Vegetative growth characters

Vegetative growth characters of broccoli (*i.e.,* leaf area plant^{-1}, number of leaves plant^{-1}, dry weight of leaves plant^{-1} and dry weight of stem plant^{-1}) were widely differed between the tested treatments as shown in Table 6. The obtained data show clearly that, the greatest values of the studied vegetative growth characters of broccoli plants were achieved by plants supplied with chicken manure at both rates of 12 and 16 ton/fed, without significant differences, in combination with 75 % N-mineral. Meanwhile, the lowest values of vegetative growth characters were recorded at the treatment of 8 ton chicken manure/fed in combination with 75 % N-mineral. These findings were similar and true in both the studied two seasons of study.

TABLE 6. The vegetative growth parameters of broccoli as affected by applied N-mineral fertilizer and organic manure at 70 days after transplanting.

Treatments	Leaf area plant^{-1} (cm^2)	Number of leaves plant^{-}	Dry weight of leaves plant^{-} (g)	Dry weight of stem plant^{-1} (g)
Season 2006-2007				
100 % N-mineral	6542	35.83	57.99	56.25
75% N-mineral+8 ton/fed OM	5837	32.46	51.85	50.43
75% N-mineral+12 ton / fed OM	7548	40.15	65.76	64.87
75% N-mineral+16 ton / fed OM	7579	40.71	66.10	65.12
L.S.D. at 0.05	506	3.22	5.36	5.13
Season 2007-2008				
100 % N-mineral	6578	36.44	58.24	56.74
75% N-mineral+8 ton/fed OM	5864	32.85	52.67	51.08
75% N-mineral+12 ton / fed OM	7596	40.97	66.98	65.97
75% N-mineral+16 ton / fed OM	7615	41.12	67.45	66.22
L.S.D. at 0.05	511	3.29	5.39	5.11

OM=Chicken manure.

The vigor of broccoli plants growth supplied with chicken manure over than that supplied with N-mineral fertilizer might be due to the more accompanied easily available essential macro and micronutrients. Moreover, the chicken manure slowly nutrients released at a longer time, which directly absorbed by roots system, hence reflected on the plant growth. The noticeable increases of morphological parameters of broccoli plants by increasing the applied rates of chicken manure may be confirmed by the progressively increases of the nutritional elements in rooting zone, and consequently the absorption of more nutrients. The positively response of applied organic manure was studied by many authors such as Abdel-Mouty (2000); Salman *et al.* (2002) and Mohamed (2006).

From the economical point of view, the superiority over than the other treatments was great enough to reach the level of significance, so that the treatment of 12 ton chicken manure/fed in combination with 75 % N-mineral is considered the better one. These results held good in the two successive experimental seasons as well as were coincided with those reported by Abou El-Magd *et al.* (2006). The sequence of the superiority for the applied treatments under the current experimental conditions could be arranged into an ascending order of 16 ton of chicken manure/fed + 75 % of N-mineral fertilizer ≥ 12 ton of chicken manure/fed + 75 % of N-mineral fertilizer > 100 % of N-mineral fertilizer ≥ 8 ton of chicken manure/fed + 75 % of N-mineral fertilizer.

Nutrient and sugar contents in broccoli leaves

Results in Table 7 show that there were significant differences in the nutrient (*i.e.,* N, P, K, Fe, Mn, Zn and Cu) and sugar contents of broccoli leaves at a period of 70 days after transplanting by using different organic manure treatments in the two seasons of study. However, there was an increase in each of the studied nutrients with increasing the applied rates of chicken manure.

TABLE 7. Effect of the applied treatments on nutrient and sugar contents of broccoli leaves at 70 days after transplanting.

Treatment	Macronutrients %			Micronutrients (mg/kg)				Sugar %
	N	P	K	Fe	Mn	Zn	Cu	
Season 2006-2007								
100 % N-mineral	3.48	0.345	2.25	110.3	71.74	37.91	11.70	6.32
75% N-mineral+8 ton/fed OM	3.02	0.307	1.99	94.8	60.91	33.42	9.85	5.41
75% N-mineral+12 ton /fed OM	3.89	0.394	2.68	116.7	75.28	40.78	12.47	7.01
75% N-mineral+16 ton /fed OM	3.97	0.397	2.70	117.6	76.81	41.54	12.93	7.16
L.S.D. at 0.05	0.37	0.032	0.22	5.40	3.16	2.61	0.70	0.59
Season 2007-2008								
100 % N-mineral	3.52	0.347	2.31	111.7	73.13	38.70	12.02	6.55
75% N-mineral+8 ton/fed OM	3.10	0.312	2.04	96.2	63.05	34.36	10.13	5.72
75% N-mineral+12 ton /fed OM	3.98	0.396	2.72	117.8	76.78	41.83	12.76	7.26
75% N-mineral+16 ton /fed OM	4.05	0.403	2.76	119.0	78.42	42.62	13.29	7.34
L.S.D. at 0.05	0.33	0.037	0.25	5.80	3.22	2.72	0.68	0.62

OM=Chicken manure.

Accordingly, the greatest values of the studied nutrient and sugar contents in tissues of broccoli leaves were produced by applying chicken manure at a rate of 16 ton/fed in the two successive seasons of study, with insignificant differences with those received 12 ton chicken manure/fed. These findings emphasized that the later treatment was great enough to reach the level of significance, so it is considered a better one from the economical point of view. On the contrary, the lowest leaf nutrient contents were found by N-mineral fertilizer treatment, without any application of organic manure, in the two seasons. Concerning the superiority in elemental values in tissues of broccoli by increasing the chicken manure, may be attributed to the relatively high contents of essential plant macro and micronutrients in the chicken manure, which are mostly found in a form of high availability, mobility as well as are found in an enough quantity which required for a good plant growth.

Broccoli yield and its quality

Results illustrated in Table 8 show that there were significant differences in the total yield of broccoli in kg/fed (*i.e.*, central head weight and lateral head weight/fed) as well as quality parameters of broccoli (*i.e.*, central head weight, lateral head weight, number of lateral heads $plant^{-1}$, head nutritional status and sugar of head %) as affected by increasing the applied rates of organic manure, which are actually combined with N-mineral fertilizer, in the two seasons of study.

TABLE 8. Total yield and its quality of broccoli as affected by applied N-mineral fertilizer and organic manure.

Treatments	Total yield (kg/fed)		Yield quality parameters		
	Central heads	Lateral heads	Central heads (g/plant)	Lateral heads (g/plant)	Number of lateral heads/ plant
Season 2006-2007					
100 % N-mineral	4268	4696	263.40	300.07	5.76
75% N-mineral+8 ton/fed OM	3793	4192	235.95	264.15	5.22
75% N-mineral+12 ton / fed OM	4813	5387	300.87	343.94	6.43
75% N-mineral+16 ton / fed OM	4875	5476	304.64	347.76	6.57
L.S.D. at 0.05	356	408	25.40	29.30	0.50
Season 2007-2008					
100 % N-mineral	4325	4737	264.71	303.63	5.85
75% N-mineral+8 ton/fed OM	3847	4253	237.15	267.92	5.27
75% N-mineral+12 ton / fed OM	4874	5448	301.50	346.02	6.49
75% N-mineral+16 ton / fed OM	4916	5512	306.28	350.85	6.64
L.S.D. at 0.05	377	429	24.90	31.20	0.53

OM=Chicken manure.

The greatest total yield of broccoli heads was produced by plants supplied by chicken manure at the rates of 16 and 12 ton/fed in combination with 75 % N-mineral fertilizer in the two successive seasons of study, without significant differences between the two treatments. This was true, since the favourable conditions of soil properties as a result of the applied organic manure should be ensuring their responsibility according to broccoli needs at different growth stages and managed in optimum crop yield and its components at harvest time. On the contrary, the relatively low total yield of broccoli heads was produced by pants received either the recommended N-mineral fertilizer or 8 ton chicken manure/fed in combination with 75 % N-mineral fertilizer, these findings held good in both experimental seasons. These results are in accordance with those obtained by Real-Rosas *et al.* (2002).

The positive effect of both mineral fertilizer in combination with chicken manure on yield and its components may be due to increasing the availability of macro and micronutrients in rooting zone and consequently, the absorption of more nutrients which resulted a significant increase in leaf and stem dry weight plant^{-1}, number of leaves and Leaf area plant^{-1}. Thus these increments may be led to the favoured increase in yield and its components. As well as yield increases in response to chicken manure applications are frequently attributed to N and other accompanied nutrient effects (Hochmuth *et al.*, 1993 and Hue & Sobiezczyk, 1999), however, chicken manure contains a wide range of plant nutrients, and it is also considered a good source of Mg and Ca (Mengbo *et al.*, 1997). In fact, P levels in both soils and plant tissues have been shown to significantly increase with chicken manure application, and may actually lead to excessive P levels in soils not deficient in that nutrient (Cheung & Wong, 1983; Browaldh, 1992 and Hue & Sobiezczyk, 1999). These trends are in a good accordance with those outlined by many investigators such as Ali & Abdel-Mouty (2000); Salman *et al.* (2002) and Mohamed (2006).

In here, the magnitudes of broccoli yield parameters at harvest were also behaved the same trend as mentioned before through the discussion of vegetative growth ones, as follows: 16 ton of chicken manure/fed + 75 % of N-mineral fertilizer $\geq$ 12 ton of chicken manure/fed + 75 % of N-mineral fertilizer > 100 % of N-mineral fertilizer $\geq$ 8 ton of chicken manure/fed + 75 % of N-mineral fertilizer. Such magnitude confirmed the fact that plant life represents a continuous or complete life cycle. However, the relatively high values were observed with the combined treatments of 16 or 12 ton of chicken manure/fed + 75 % of N-mineral fertilizer, while the relatively low ones were associated with either solely treatment of N-mineral fertilizer or combined one of 8 ton of chicken manure/fed + 75 % of N-mineral fertilizer. These results are in agreement with those obtained by Gomaa (1997) and Mcmullan *et al.* (1998) who pointed out that total yield was highly correlated with the development of vegetative growth as well as dry matter accumulation.

The increase in the total yield of broccoli resulting the organic manuring may be attributed to that organic materials derived from applied chicken manure (active organic acids) enhanced soil aggregation, soil aeration and increasing water holding capacity and offers good environmental conditions for the root system of broccoli plants Abou El-Magd *et al.* (2005). In addition, the applied chicken organic manure is rich in essential nutrient contents that slow release nutrients allover the growth stages along the growing season. These favourable conditions create better nutrients absorption and favours the vegetative growth and development of root system which in true and dry matter accumulation. Consequently, better total yield would be obtained by applying chicken manure in a suitable rate and in combination with the usefulness doses of mineral fertilizers to alleviate the possible fears of chemical pollution for broccoli as a vegetable crop and environmental risks.

The tabulated data in Table 8 show clearly also that the better quality parameters of broccoli plants (*i.e.*, central head weight, lateral head weight, number of lateral heads plant^{-1} and sugar head) were recorded by using chicken manure at either 16 or 12 ton of chicken manure/fed + 75 % of N-mineral fertilizer, without significant differences between the two rates of organic manure. Meanwhile, the relatively low quality parameters were associated with the solely treatment of N-mineral fertilizer. These results held good in the two experimental seasons.

Nutrient and sugar contents in broccoli heads

Results given in Table 9 reflected significant differences in the contents of nutrients and sugar in the tissues of broccoli heads as a result from increasing the applied rates of chicken manure, which actually combined with N-mineral fertilizer. However, the greatest values of the studied nutrients and sugar in the tissues of broccoli heads were produced by plants supplied by chicken manure at the rates of 16 and 12 ton/fed in combination with 75 % N-mineral fertilizer in the two successive seasons of study, without significant differences between the two treatments. On the other hand, the relatively low values were associated with the solely treatment of N-mineral fertilizer. These results held good in the two experimental seasons. Also, the obtained results are in good agreement with that obtained by Sanchez *et al.* (1996).

Concerning the superiority in both nutrients and sugar values in tissues of broccoli heads by increasing chicken manure rates, may be attributed to the high macro & micronutrient contents as well as their high availability, mobility and are mostly found in an enough quantity which required for a good plant growth, consequently higher yield and more better quality were achieved. These findings are in accordance with those obtained by Real-Rosas *et al.* (2002). Also, increasing such chemical constituent concentrations in leaves or heads of broccoli plants with mineral or chicken manure fertilizers might be due to the increased plant capacity to absorb nutrient, which increased the root surface per soil volume unit. These obtained results are cope with those obtained by Mohamed & Matter (2001); Mohamed *et al.* (2001); Mohamed & El-Ganaini (2003); Mohamed & Medani (2005) and Mohamed (2006).

TABLE 9. Effect of the applied treatments on head nutrient and sugar contents for the tested broccoli crop.

Treatment	Macronutrients %			Micronutrients (mg/kg)				Sugar %
	N	P	K	Fe	Mn	Zn	Cu	
Season 2006-2007								
100 % N-mineral	3.89	0.613	3.18	122.4	79.52	42.23	12.03	10.43
75% N-mineral+8 ton/fed OM	3.45	0.547	2.79	105.6	68.04	37.31	10.46	9.35
75% N-mineral+12 ton /fed OM	4.37	0.698	3.68	128.9	84.77	45.99	13.87	11.94
75% N-mineral+16 ton /fed OM	4.48	0.719	3.76	130.3	86.29	46.45	14.39	12.21
L.S.D. at 0.05	0.38	0.054	0.29	6.20	5.12	2.92	1.24	0.94
Season 2007-2008								
100 % N-mineral	3.93	0.622	3.24	123.8	80.74	43.72	12.52	10.75
75% N-mineral+8 ton/fed OM	3.50	0.554	2.85	107.5	69.42	38.43	10.84	9.82
75% N-mineral+12 ton /fed OM	4.46	0.710	3.79	131.7	85.96	47.18	14.27	12.16
75% N-mineral+16 ton /fed OM	4.53	0.731	3.82	133.0	87.08	48.79	14.96	12.48
L.S.D. at 0.05	0.41	0.062	0.32	7.10	5.08	3.12	1.33	0.96

OM=Chicken manure.

In addition, the applied chicken manure plays an important role on both the availability of nutrients and other biological activity in the vicinity of roots through lowering soil pH value, besides the ameliorating soil drainage and aeration, which encouraged the bio-mechanism of nutrients uptake. Such results are in harmony with those reported by Tisdale *et al.* (1993) who pointed out that plant uptake of nutrients precedes best at a neutral pH value and their contents depressed by increasing its value. Differences in rhizosphere pH of up 0.81 units have been observed for the control treatment versus combined one of 16 ton/fed in combination with 75 % N-mineral fertilizer under cultivation of broccoli plants.

Thus, the use efficiency of chicken manure showed an-useful phase, since large released amounts of nutrients, which are available for uptake under the modified favorable soil media (Isfan *et al.*, 1995). Jones *et al.* (1991) reported that the increment of nutrient uptake is mostly dependent upon biological activity that is markedly affected by soil temperature, moisture, aeration and original soil pH. Thereby, the increments in available nutrients encouraged their uptake by plants (Tables 5 and 7) and the growth parameters (Table 6), which were also resulted from increasing the net photosynthesis, stomatal conductance and transpiration rate when broccoli plants were subjected to the prevailing best conditions (Naire & Khuble, 1990).

Finally using Italica crop cv. of broccoli with chicken manure at the economical rate of 12 ton/fed could be followed for producing high yield of broccoli with high quality of heads. That was true, since that interaction treatment, in general, significantly affected all vegetative growth characters of broccoli plants, probably due to the applied chicken manure besides it is considered as a source for all essential macro & micronutrients, plays a direct role for ameliorating soil hyrophysical properties (*i.e.,* soil aggregation, bulk density, total porosity, aeration, hydraulic conductivity and available water range), soil chemical characteristics (*i.e.*, soil pH, released organic constituents of active groups such as fulvic and humic acids which have the ability to retain the essential plant nutrients in complex and available chelate forms), soil biological conditions (*i.e.,* a source of energy for the microorganism activities which enhance in releasing necessary nutrients in available forms throughout their mineralization), and in turn soil fertility status (*i.e.,* slow release for nutrients which support root development among the different growth stages), that finally leading to higher yield and better quality of broccoli plants.

Moreover, it could by concluded that, the applied treatment of 75% recommended dose of N-mineral fertilizer as ammonium nitrate + 12 ton chicken manure/fed is the best to improve soil properties which positively reflected on vegetative growth, chemical constituents and total yield of broccoli, *i.e.*, central and lateral heads with relative increase percentages reached 13.8 and 13.9 % for both seasons, respectively, as compared to the recommend dose of 100 % N-mineral as ammonium nitrate/fed. Moreover, the periodical application of such natural organic manure is considered the best option not only for reducing the harmful effects of using chemical fertilizers, but also for sustaining soil fertility status and help to alleviate the possible risks of environmental pollution on human health.

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أهمية المخصب العضوى المضاف مع النتروجين المعدنى لتقليل المخاطر المحتملة من التلوث الكيماوى للبروكلى لمحصول خضر

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أجريت تجربة حقلية على تربة طينية بمركز سنورس - محافظة الفيوم – مصر خلال موسمى ٢٠٠٦- ٢٠٠٧، ٢٠٠٧- ٢٠٠٨ لتقييم مدى إستجابة النمو الخضرى، والحالة الغذائية و إنتاجية محصول البروكلى (*Brassica oleracea* L. var. Italica)، وكذا جودة الرؤوس لإحلال جزئى يقدر بـ ٢٥٪ من النتروجين المعدنى بمصدر بديل عضوى (سماد الدواجن المضاف بمعدلات ٨، ١٢، ١٦ طن/فدان) مقارنة بـ ١٠٠٪ من السماد النتروجينى المعدنى الموصى به فى صورة نترات الأمونيوم (٣٣,٥٪نتروجين)، آملا فى تقليل المخاوف المحتملة من التلوث الكيميائى الناجم عن إستخدام تلك الأسمدة المعدنية لحاصلات الخضر وكذا المخاطر البيئية.

وطبقا للدراسات الحقلية والتحليلات المعملية للتربة فى حالتها الأولية، فان النتائج المتحصل عليها توضح أن تربة التجربة تحت الدراسة تكونت من الرسوبيات النهرية كمادة أصل ، وتنتمى إلى الوحدة التقسيمية حتى مستوى العائلة "Typic Haplotorrrts, fine clay, smectitic, hyperthermic"، وكذا الوحدة التقييمية "متوسطة الصلاحية للأراضى الزراعية المروية" مع تواجد معوقات إنتاجية ذات تأثير بسيط تتمثل فى قوام التربة، المحتوى من كربونات الكالسيوم والجبس، كما تعانى تربة التجربة من نقص ملحوظ فى محتواها من عنصر الزنك.

ومن الناحية الإقتصادية ، فان نتائج الخصائص النباتية تحت الدراسة تشير إلى أن قياسات النمو الخضرى الأعلى لنباتات البروكلى (مساحة الأوراق/نبات ، عدد الأوراق/نبات ، الوزن الجاف للأوراق/نبات ، الوزن الجاف للسيقان/نبات ، المحتوى من السكريات والحالة الغذائية للأوراق) قد تحققت فى حالة النباتات التى أضيف إليها ١٢ طن من مخصب الدواجن العضوى/فدان + ٧٥٪ من النتروجين المعدنى الموصى به. ومثل هذه الظروف الجيدة قد إنعكست بصورة إيجابية على مراحل النمو التالية والتى أعطت أعلى محصول كلى/فدان من البروكلى سواء كانت كأوزان للرؤوس المركزية أو الجانبية ، بزيادة نسبية وصلت ألى ١٣,٨، ١٣,٩٪ مقارنة بـ ١٠٠٪ من السماد النتروجينى المعدنى الموصى به خلال موسمى الزراعة على الترتيب، بالإضافة إلى تحسين فى قياسات جودة رؤوس البروكلى (أوزان الرؤوس المركزية الجانبية ، عدد الرؤوس الجانبية/نبات ومحتواها من السكر). ومثل هذه الظروف الجيدة والأكثر إرتباطا بالحالة المتميزة لتربة التجربة تحت الدراسة قد تحققت من خلال تحسين خصائص التربة الطبيعية والكيميائية وكذا حالتها الغذائية.

وترتبط أفضلية المعاملة المشتركة ما بين السماد النتروجينى المعدنى (٧٥٪ من النتروجين المعدنى الموصى به) والمخصب العضوى للدواجن بتواجد الأخير لما يلعبه من دور مباشر فى تحسين:

١- الصفات الهيدروفيزيائية للتربة (حالة تجمع التربة ، الكثافة الظاهرية ، المسامية الكلية ، التهوية ، النفاذية ، مدى الماء الميسر).
٢- الصفات الكيميائية للتربة (الرقم الهيدروجينى، إنطلاق الأحماض العضوية النشطة مثل أحماض الفلفيك والهيوميك والتى لها القدرة على خلب المغذيات الضرورية للنبات والإحتفاظ بها فى صورة مخلبية ميسرة) .
٣- الخصائص البيولوجية للتربة (مصدر للطاقة لنشاط الكائنات الدقيقة والتى تساعد فى إنفراد المغذيات الضرورية للنبات فى صورة ميسرة من خلال معدنيتها).
٤- الحالة الخصوبية للتربة (الإنطلاق البطىء للمغذيات مما يدعم تطور المجموع الجذرى للنبات على إمتداد أطوار نموه).

وأخيرفان تلك التأثيرات الإيجابية تؤدى إلى تحسين قياسات النمو الخضرى ، المكونات الكيميائية و الحصول على إنتاجية عالية من محصول البروكلى مع جودة أفضل لرؤوسه. علاوة على أن الإضافة الدورية من مثل هذا المخصب العضوى الطبيعى لا تعتبر فقط أفضل إختيار لتقليل التأثيرات الضارة لإستخدام الأسمدة المعدنية بل أيضا لإستمرارية حالة خصوبة التربة ، كما تساعد على تقليل المخاطر المحتملة من تلوث البيئة على صحة الإنسان.