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INTEGRATED EFFECT OF MINERAL AND ORGANIC NITROGEN FERTILIZATION IN THE PRESENCE OF SOME NITRIFICATION INHIBITORS ON GROWTH, PRODUCTIVITY AND FRUIT QUALITY OF TOMATO

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ABSTRACT

Two field experiments were conducted at Talkha region, Dakahlia Governorate, Egypt, during seasons of 2010 and 2011 to evaluate the integrated effect of mineral and organic nitrogen fertilization in the presence of some nitrification inhibitors, *i.e.,* Dicyandiamide (DCD), 3, 4-dimethylpyrazole-phosphate (DMPP) and neem cake (NC) on growth, chemical composition, productively and fruit quality of tomato F1, GS-12.

The obtained results indicate that:

- The combined addition of 120 kg mineral-N and 80 kg organic-N (5.12 ton compost / fed^{-1}) with DMPP induced significant increment in vegetative growth characters (plant height, foliage fresh weight and leaf area) and chemical composition (N, P and K uptake) of tomato plants. This treatment led to a significant increase in marketable yield of tomato fruits, whereas, the control treatment (mineral-N at 200 kg/ fed^{-1} as the recommended application) showed the highest significant unmarketable tomato yield during both seasons of the study.
- The highest accumulation of nitrate and nitrite contents in tomato fruits were obtained from addition of control treatment, however, the lowest values were obtained under either the addition of 120 kg mineral-N and 80 kg organic-N with DMPP or 80 kg mineral-N and 120 kg organic-N with DMPP.
- Application of 120 kg mineral-N and 80 kg organic-N with DMPP produced the highest significant values of lycopene, total soluble sugars, vitamin C and TSS contents of tomato fruits, also recorded the highest net return and benefit-cost ratio.

It could be concluded that the combined addition of 120 kg mineral-N fertilizer (585.4 kg/ fed^{-1} as ammonium sulphate) and 80 kg organic-N (5.12 ton/ fed^{-1} from rice straw compost) with DMPP (4.8 kg/ fed^{-1}) in tomato fields is the favorable recommendation to increase the vegetative growth characteristics, chemical composition, yield and quality than the recommended mineral-N fertilizer (975.6 kg/ fed^{-1} as ammonium sulphate). Such treatment will save about 40 % of the applied mineral-N fertilizer, giving the remarkable net return and benefit-cost to the farmers as well as minimizing the negative effects of the excessive use of mineral-N fertilizers on environment and human health.

INTRODUCTION

Tomato (*Lycopersicon esculentum*, Mill.) is a major vegetable crop that has achieved tremendous popularity over the last century. It is one of the most important widely grown vegetable crops in Egypt for local utilization either as fresh market or in processing and sometimes exportation. For maximum growth and yield of tomato fruits conventional agricultural production systems are still depending on the excessive use of chemical-based fertilizers (Badr and Fekry, 1998). Nitrogen is the most limiting nutrient in crop production (Ludwick *et al*., 2002), although the over-application can result in negative effects on human health by contamination of ground water and tomato fruits with nitrite and nitrate (Sobulo, 2000). In Egypt, burning rice straw is one of the most important environmental pollution; however, an attractive alternative usage of rice straw is composting (Abd El-Hamid *et al*., 2004). Composted crop residues when applied to soil improves soil fertility through slow-but-lasting release of the inherent nutrients (Akanbi *et al*., 2005), it was found that compost can act as slow-release organic nitrogen fertilizer (Sisouvanh, 2011) and can save up to 20 % of mineral-N fertilizer (Pooran *et al*., 2002). Moreover, application of compost has been shown to positively affect the structure, porosity, water holding capacity, microbial activities, nutrient content and organic matter content of the soil and too improve plant growth, yield and quality (Akanbi *et al*., 2005).

An entirely approach for reducing the losses of nitrogen fertilizer is through the use of nitrification inhibitors which delay the bacterial oxidation of the ammonium ion (NH_4^+) by depressing over a certain period of time the activity of *Nitrosomonas* bacteria in the soil, these bacteria transform ammonium ions into nitrite (NO_2^-), which is further transformed into nitrate (NO_3^-) by *Nitrobacter* and *Nitrosolobus* bacteria, keeping N in the ammonium form which increases N-use efficiency (Trenkel, 2010).

Dicyandiamide (DCD - $H_4C_2N_4$) is considered as the most common nitrification inhibitor used in agriculture, it is produced from calcium cyanamide and has a bacteriostatic depressing or inhibiting effect on Nitrosomonas for a certain period of time (Trenkel, 2010). DCD increased soil N retention by the delayed conversion of NH_4^+ to NO_3^- that led to increase yield of tomato and pepper (Hauck, 1972). Moreover, Amberger (1989) mentioned that DCD reduces nitrate leaching and increases yield and N uptake of potato plants.

3, 4-dimethyl pyrazole-phosphate (DMPP) is a new nitrification inhibitor highly specific in inhibiting nitrification at low concentrations (Macadam *et al*, 2003); it is a non-toxic compound without any residues or side effects on soil biological activity (Zerulla *et al*., 2001). Many studies demonstrated that DMPP has been shown to have several distinct advantages in reducing N loses and improving plant growth and productivity (Banuls *et al*., 2000; Zerulla *et al*., 2001; Trenkel, 2010).

Neem cake (NC) is an organic byproduct of neem (*Azadirachta indica*) seed oil production. Many studies reported that NC showed a highly nitrification inhibition under field conditions (Sharma and Prasad, 1980). Joseph and Prasad (1993) showed that blended NC at 20 % of urea was effective in inhibiting the nitrification than the addition of prilled urea alone. Reddy and Padmodaya (1996) reported that application of NC during tomato production resulted in maximum shoot length, root length and highest fruit yield. Application of NC with inorganic nitrogen fertilizer significantly enhanced plant height, number of leaves and fruit yield of pepper without causing any environmental problems through enhancing availability of nitrogen in the soil for longer duration and reducing the leaching losses (Patil, 2008). Moreover, addition of NC with mineral-N fertilizer has a controlled-release effect, improve nitrogen use efficiency and reduce losses of nitrogen as well as minimizing N fertilizer application by prolonging N available in soil (Laijawala, 2010; Trenkel, 2010).

MATERIALS AND METHODS

Two field experiments were carried out during 2010 and 2011 seasons at Talkha region, Dakahlia Governorate, Egypt to investigate the integrated effect of mineral and organic nitrogen fertilization in the presence of some nitrification inhibitors, *i.e.,* Dicyandiamide (DCD), 3, 4-dimethyl pyrazole-phosphate (DMPP) and neem cake (NC) on growth, chemical composition, yield and quality of tomato. Some physical and chemical properties of the experimental soil were determined according to the methods described by Page *et al*. (1982) and the obtained data are shown in Table (1).

Table 1: Some physical and chemical properties of the experimental soil during the growing seasons of 2010 and 2011.

Soil characters	1st season	2nd Season	Soil characters	1st season	2nd season
Coarse sand (%)	1.51	1.7	E.C. $dS.m^{-1}$	2.54	2.81
Fine sand (%)	13.77	16.17	O.M. (%)	1.12	1.34
Silt (%)	28.4	31.45	pH	8.07	8.11
Clay (%)	56.32	50.68	N (mg/kg)	56.2	47.1
Texture class	Clayey	Clayey	P (mg/kg)	7.1	5.4
Ca CO_3 (%)	2.81	2.69	K (mg/kg)	258	261

On March, 1^{st} in both seasons of the study, tomato transplants, F1 Hybrid GS-12, were transplanted at 50 cm apart on one side of the ridge. The experimental unit consisted of eight ridges each of 1 m wide and 3.5 m long with plot area of 28 m^2. A complete randomized block design with three replicates was adopted to include 9 treatments as follows:

(1) Mineral-N at 200 kg/ fed^{-1} (the recommended N application - Control).
(2) Mineral-N at 120 kg + Organic-N at 80 kg/ fed^{-1}.
(3) Mineral-N at 120 kg + Organic-N at 80 kg/ fed^{-1} + DCD.
(4) Mineral-N at 120 kg + Organic-N at 80 kg/ fed^{-1} + DMPP.
(5) Mineral-N at 120 kg + Organic-N at 80 kg/ fed^{-1} + NC.
(6) Mineral-N at 80 kg + Organic-N at 120 kg/ fed^{-1}.
(7) Mineral-N at 80 kg + Organic-N at 120 kg/ fed^{-1} + DCD.
(8) Mineral-N at 80 kg + Organic-N at 120 kg/ fed^{-1} + DMPP.
(9) Mineral-N at 80 kg + Organic-N at 120 kg/ fed^{-1} + NC.

The mineral-N fertilizer was applied as ammonium sulphate (20.5 % N) and mixed with the used nitrification inhibitors before fertilization. Rice straw compost as a main source of organic-N was prepared according to the method described by Hatem *et al.* (2008) using air-dried local rice straw by chopping and mixing with a fresh local farmyard manure at ratio 3 rice straw: 1 farmyard manure by volume, moisture was adjusted to 50%, the pile was flipped every 10 days to improve aeration and was allowed to decompose for about 60 days to be fully completed and left additional 4 weeks for curing. Chemical properties of the obtained compost during 2010 and 2011 seasons are tabulated in Table 2.

Table 2: Chemical properties of composted rice straw used in the experiment during 2010 and 2011 seasons.

Compost properties	1st season	2nd season	Compost properties	1st Season	2nd season
N (%)	1.45	1.67	Organic carbon (%)	18.42	22.38
P (%)	0.41	0.50	C/N ratio	12.7:1	13.4:1
K (%)	0.57	0.71	pH	7.52	7.81
O.M. (%)	39.1	44.4	EC (dS m^{-1})	1.41	2.24

All experimental units received amounts of P and K fertilizers at rates of 75 and 150 kg/ fed^{-1} as calcium superphosphate (15.5% P_2O_5) and potassium sulphate (48% K_2O), respectively. Supper phosphate and the fully decomposed rice straw compost were applied before planting at rowing preparation. N and K mineral fertilizers were applied at two equal doses, three and seven weeks after transplanting. Mineral-N fertilizer and compost application amounts were applied based on the total nitrogen percentage to provide a total application of 200 kg N/ fed^{-1} for each treatment, the application rate of mineral-N fertilizer and compost used in the experiment are shown in Table 3. The other agricultural treatments for growing tomato plants were followed according to the instruction laid down by Egyptian Ministry of Agriculture.

The treatments included two synthetic inhibitors, DCD, produced by Shanghai Richem International Co., Ltd., China (applied at 4 % of mineral-N fertilizer) and DMPP, produced by Compo GmbH Co, Germany (used at 0.8 % of mineral-N fertilizer) as well as a non-synthetic inhibitor, neem cake (NC) powder as a natural one, produced by Parker Biotech Private Limited, Co, India (used at the rate of 20 % of applied N fertilizer). NC powder was mixed with the mineral-N fertilizer using a simple coating technique as reported by Sharma and Prasad (1980) by dissolving one kg of coal-tar in 2 liters of kerosene as an adhesive substance and gradually mixed with 100 kg of mineral-N fertilizer.

At 90 days from transplanting, five plants from each plot were randomly taken for growth determination expressed as plant height, foliage fresh weight and Leaf area per plant. Leaf area was calculated as a relation between area unit and dry weight of plant leaves (Koller, 1972). Representative samples of tomato plant foliage from each plot at the same time were used to determine N, P and K contents then their uptakes were calculated considering their concentration (%) in dry weight basis. Total nitrogen was determined according to the methods described by Bremner and Mulvaney (1982); phosphorus was estimated colormetrically according to Olsen and Sommers (1982) and potassium was determined flame photometrically as described by Jackson (1973).

Table 3: The quantity of mineral nitrogen fertilizer and compost needed to form the total N-fertilizer as 200 kg N / fed^{-1} during 2010 and 2011 seasons.

Nitrogen additions / Treatments	Mineral-N		organic-N			
			1st season		2nd season	
	Ammonium sulphate (kg/fed^{-1})	N (kg/fed^{-1})	Compost (Ton/fed^{-1})	N (kg/fed^{-1})	Compost (Ton/fed^{-1})	N (kg/fed^{-1})
Mineral-N at 200 kg/ fed^{-1} (recommended N application)	975.6	200	-	-	-	-
Mineral-N at 120 kg + Organic-N at 80 kg/ fed^{-1}	585.4	120	5.52	80	4.79	80
Mineral-N at 80 kg + Organic-N at 120 kg/ fed^{-1}	390.2	80	8.28	120	7.19	120

All harvested fruits from each plot at full maturity stage along the season were used to determine the unmarketable tomato yield (calculated from all disordered tomato fruits) and total marketable yield (calculated from all harvested marketable fruits) as well as total yield (calculated from all harvested fruits from each plot) as tons per feddan. A representative sample of 10 tomato fruits from each experimental plot at the marketable ripe stage was taken from the 3rd picking for determination fruits quality characteristics, *i.e.,* nitrate, nitrite, total soluble sugars, vitamin C and total soluble solids (TSS) contents according to the methods described by (AOAC, 1990). Lycopene in fruits was determinate as described by Fish *et al*. (2002).

Economic performance of tomato plants*, i.e.,* gross return, treatment costs, total variable cost, net return and benefit-cost ratio were calculated based on market prices as average of the two seasons. The benefit-cost ratio was determined according to Boardman *et al*. (2001) by dividing the net return (LE/ fed^{-1}) on total variable cost (LE/ fed^{-1}).

The obtained data were subjected to statistical analysis by the technique of analysis of variance (ANOVA) according to Snedecor and Cochran (1982). The treatments mean were compared using the least significant difference (LSD) at $P \leq 0.05$.

RESULTS AND DISCUSSION

Vegetative growth characteristics:

Data in Table 4 demonstrate the integrated effect of mineral-N fertilization combined with organic-N from composted rice straw and nitrification inhibitors, *i.e.*, DMPP, DCD and NC on growth characters of tomato plants. It is quite obvious that significant effects on plant height, foliage fresh weight and leaf area of tomato plants were observed by the combined application of 120 kg mineral-N and 80 kg organic-N combined with DMPP followed by the addition of 120 kg mineral-N and 80 kg organic-N with

DCD in comparing with the other treatments. The lowest significant values were recorded by the addition of 80 kg mineral-N and 120 kg organic-N without any addition of nitrification inhibitors, during both seasons of the study.

Table 4: Vegetative growth characteristics of tomato plants as affected by the combination of mineral and organic nitrogen fertilization with nitrification inhibitors during 2010 and 2011 seasons.

Characters / Treatments	plant height (cm)		Foliage fresh weight (g)		Leaf area (cm^2)	
	1st season	2nd season	1st season	2nd season	1st season	2nd season
T1	50.10	51.60	754.2	825.0	1804	1856
T2	46.60	48.27	726.2	851.2	1489	1663
T3	53.37	56.07	804.7	900.9	1857	1903
T4	56.85	59.64	860.0	942.0	1967	2058
T5	49.65	51.07	777.3	873.6	1605	1797
T6	43.68	47.88	657.2	782.7	1509	1438
T7	48.38	47.82	709.5	808.8	1647	1754
T8	49.29	54.31	773.6	877.2	1623	1778
T9	47.63	49.37	687.0	821.9	1527	1693
LSD at 5%	3.22	3.19	48.21	37.84	103.7	134.1

(T1) Mineral-N at 200 kg/ fed^{-1} (the recommended N application - Control), (T2) Mineral-N at 120 kg + Organic-N at 80 kg/ fed^{-1}, (T3) Mineral-N at 120 kg + Organic-N at 80 kg/ fed^{-1} + DCD, (T4) Mineral-N at 120 kg + Organic-N at 80 kg/ fed^{-1} + DMPP, (T5) Mineral-N at 120 kg + Organic-N at 80 kg/ fed^{-1} + NC (T6) Mineral-N at 80 kg + Organic-N at 120 kg/ fed^{-1}, (T7) Mineral-N at 80 kg + Organic-N at 120 kg/ fed^{-1} + DCD, (T8) Mineral-N at 80 kg + Organic-N at 120 kg/ fed^{-1} + DMPP, (T9) Mineral-N at 80 kg + Organic-N at 120 kg/ fed^{-1} + NC.

DCD: Dicyandiamide; DMPP: 3, 4-dimethylpyrazole-phosphate; NC: Neem cake.

Such result could be explained on the basis that compost is a good source of humus (Shehata *et al*., 2011), which plays a major role in enhancing growth parameters of plants in both vegetative and generative stages (Arancon *et al*., 2006; Ulukan, 2008). Furthermore, the ability of compost to preserve nutrients added through fertilization from leaching away by irrigation water is an important factor (Smith *et al*., 2001). In this respect Meherunnessa *et al.* (2011) reported that the maximum number of tomato leaves was found by using full recommended dose of compost + ½ recommended dose of chemical fertilizer. Therefore, the combined application of compost and mineral-N are recommended for optimum vegetative growth of tomato plants, this kind of combination was also reported to encourage tomato plant height (Babajide *et al*., 2008 and Sisouvanh, 2011). Moreover, the stimulation of tomato plants vegetative growth may be due to the addition of DMPP as nitrification inhibitor, which, is already known to enhance the vegetative growth of carrot, radish, lettuce and leek; it increased assimilation area of leaves and dry matter (Bundiniene *et al*., 2008). DMPP amended to N fertilizers of tomato plants preserves a larger amount of ammonium in the soil, resulting in less losses of N by leaching, reduced nitrate leaching losses and retaining the applied N in the ammonia form (Banuls *et al*., 2000). Furthermore, the NH_4^+ form has been found to be beneficial to improve tomato plant growth (Tabatabael *et al*., 2008). During early growth stage of tomato, it was found that fertilization with NH_4^+ in comparison to No_3^- showed remarkable ameliorated photosynthetic activity and total chlorophyll as well as carbohydrates (Horchani *et al*., 2010). That may be attributed to the fact that nitrate is used in the synthesis of proteins and other organic compounds in plants, it must be reduced to ammonium, since the assimilation of nitrate is an energy-consuming process (Barker and Pilbeam, 2007) that emphases the role of nitrification inhibitors which works on the temporary delaying of the transformation of NH_4^+ into NO_3^- (Trenkel, 2010).

Chemical composition of tomato plant foliage:

Regarding to the uptake of N, P and K by tomato plants, data in Table 5 indicate that the highest significant values were obtained by the application of 120 kg mineral-N and 80 kg organic-N with DMPP followed by the application of 120 kg mineral-N and 80 kg organic-N with DCD, while, the combined application of 80 kg mineral-N and 120 kg organic-N without any of nitrification inhibitors showed the lowest values, in both seasons of study. Also, it is evidently clear that the addition of 80 kg mineral-N and 120 kg organic-N showed the remarkable decrease in N, P and K uptake by tomato plants compared with the other treatments and control in both seasons.

Similar results were reported by Babajide *et al*. (2008) and Sisouvanh (2011) they found that combined use of straw compost with inorganic fertilizers had a significant effect on N, P and K uptake as well as nutrient efficiency by tomato plants.

Table 5: Nitrogen, phosphorus and potassium uptake of tomato plant foliage as affected by the combination of mineral and organic nitrogen fertilization with nitrification inhibitors during 2010 and 2011 seasons.

Characters / Treatments	N uptake (mg/ dry plant foliage)		P uptake (mg/ dry plant foliage)		K uptake (mg/ dry plant foliage)	
	1st season	2nd season	1st season	2nd season	1st season	2nd season
T1	5188	5498	412.9	445.1	4436	5127
T2	4970	5788	399.1	422.9	4237	5036
T3	5302	6100	432.7	480.4	4700	5342
T4	5576	6206	476.3	521.2	4951	5573
T5	5286	5940	413.6	444.8	4599	5168
T6	4469	5322	349.7	406.5	4088	4630
T7	4825	5500	387.5	430.4	4197	4785
T8	4980	5965	401.6	466.8	4577	5190
T9	4672	5589	375.6	437.3	4064	4862
LSD at 5%	145.4	99.12	33.41	25.44	202.5	151.9

(T1) Mineral-N at 200 kg/ fed^{-1} (the recommended N application - Control), (T2) Mineral-N at 120 kg + Organic-N at 80 kg/ fed^{-1}, (T3) Mineral-N at 120 kg + Organic-N at 80 kg/ fed^{-1} + DCD, (T4) Mineral-N at 120 kg + Organic-N at 80 kg/ fed^{-1} + DMPP, (T5) Mineral-N at 120 kg + Organic-N at 80 kg/ fed^{-1} + NC (T6) Mineral-N at 80 kg + Organic-N at 120 kg/ fed^{-1}, (T7) Mineral-N at 80 kg + Organic-N at 120 kg/ fed^{-1} + DCD, (T8) Mineral-N at 80 kg + Organic-N at 120 kg/ fed^{-1} + DMPP, (T9) Mineral-N at 80 kg + Organic-N at 120 kg/ fed^{-1} + NC.

DCD: Dicyandiamide; DMPP: 3, 4-dimethylpyrazole-phosphate; NC: Neem cake.

The positive effects of compost on nutrient uptake can be attributed to one or more of the following; 1) the addition of compost improves soil chemical, physical and biological properties. 2) Addition of compost led to better plant root development. 3) Compost slowly releases nutrients and prevents the losses of inorganic-N fertilizers through denitrification, volatilization and leaching by binding to nutrients and releasing with the passage of time. 4) The nutrient supply of compost is more balanced. 5) Compost enhances the colonization of mycorrhizae, which improves P supply. 6) Compost enhances the exchange capacity of nutrients and water retention (Abd El-Hamid *et al*., 2004 and Sisouvanh, 2011). Furthermore, compost is a variable source of humus (Shehata *et al*., 2011), which are the most active fractions of compost organic matter by microbial degradation in soil (Velasco *et al*., 2004), humus improve the absorption of nutrients by plants, having a positive effect on the dynamic of N and P in soil, stimulate plant respiration and the photosynthesis process and favor the formation of soil aggregates (Hernandez *et al*., 2001), that reflected on the macronutrient contents in plant (Ulukan, 2008).

The remarkable increases in N uptake as a result of DMPP application may be attributed to decreasing N-losses by delaying the nitrification process and increasing the N-use efficiency as a result of nitrification inhibitor effect and consequently, increase plant absorption of nitrogen (Macadam *et al*, 2003; Trenkel 2010). The superior effect of DMPP in comparison with DCD may be due to that DCD is mineralized more rapidly than DMPP (Weiske *et al*., 2001). Furthermore, DMPP mobility within the soil is rather low, compared to DCD (Chaves *et al*., 2006).

Yield and its components:

Data listed in Table 6 show the integrated effect of mineral-N, organic-N fertilization and nitrification inhibitors on yield of tomato. It is clear that the application of the recommended mineral-N portion (200 kg/ fed^{-1}) showed the highest significant unmarketable tomato yield in comparison to other treatments. On the other hand, application of 80 kg mineral-N fertilizer combined with 120 kg organic-N and DMPP showed the lowest values in this respect, in both seasons of study. Also, the highest significant marketable yield of tomato fruits was obtained from adding 120 kg mineral-N with 80 kg organic-N combined with DMPP, whereas the significant decrease in marketable yield was evident in case of using 80 kg mineral-N with 120 kg organic-N without adding any one of nitrification inhibitors and this was true in both season of study. Moreover, application of the recommended mineral-N fertilizer (control) or 120 kg mineral-N fertilizer and 80 kg organic-N with DMPP had the significant positive effect on the total yield of tomato compared with other treatments.

In general, the presence of 120 kg mineral-N and 80 kg organic-N with DMPP tended to increase marketable yield of tomato fruits. This result could be explained on the basis that such treatment showed the significant decrease in the unmarketable yield. Moreover, it had pronounced positive effects on the vegetative growth of tomato plants (Table 4) and on the N, P and K uptake by tomato plant foliage (Table 5) leading to healthy tomato plants and hence decreasing unmarketable tomato fruits. In this regard, Rautaray *et al.,* (2003) informed that the integrated use of organic amendments and inorganic-N fertilizers is beneficial in improving crop yield through lowering soil pH and increasing available N, P and K in the soil.

Such results are in line with those of Akanbi *et al*. (2005) and Babajide *et al*. (2008) they reported that the combination of compost and inorganic-N fertilizers produced better tomato yield than inorganic N fertilizers alone. Furthermore, Ming *et al*. (2009) demonstrated that application of chemical N fertilizer combined with organic fertilizer as 6:4 increased tomato yield. Also, Meherunnessa et al. (2011) concluded that application of full recommended dose compost + ½ recommended dose of chemical N fertilizer showed the highest tomato yield than inorganic nitrogen fertilization alone. Moreover, DMPP increased marketable yield of tomato (Banuls *et al*., 2000), cabbage (Xu *et al*., 2004) and carrot (Bundiniene *et al*., 2008). The amended of N fertilizers with DMPP offers the advantage of reducing the conventional N fertilization rate and producing a higher yield with the same amount of N (Zerulla *et al*., 2001 and Trenkel, 2010).

Table 6: Yield characteristics of tomato plants as affected by the combination of mineral and organic nitrogen fertilization with nitrification inhibitors during 2010 and 2011 seasons.

Characters / reatments	Unmarketable yield (Ton/fed^{-1})		Marketable yield (Ton /fed^{-1})		Total yield (Ton /fed^{-1})	
	1st season	2nd season	1st season	2nd season	1st season	2nd season
T1	2.89	3.53	27.97	29.48	30.86	33.01
T2	1.80	2.12	26.33	28.68	28.13	30.80
T3	1.25	2.09	28.63	30.46	29.88	32.55
T4	1.13	1.32	30.17	32.52	31.30	33.84
T5	1.92	1.86	26.89	30.34	28.81	32.20
T6	1.38	1.68	22.04	24.88	23.42	26.56
T7	1.24	1.58	23.40	26.74	24.64	28.32
T8	1.02	0.98	24.85	29.01	25.87	29.98
T9	1.29	1.46	22.47	27.81	23.76	29.27
LSD at 5%	0.15	0.10	0.92	1.18	1.48	1.33

(T1) Mineral-N at 200 kg/ fed^{-1} (the recommended N application - Control), (T2) Mineral-N at 120 kg + Organic-N at 80 kg/ fed^{-1}, (T3) Mineral-N at 120 kg + Organic-N at 80 kg/ fed^{-1} + DCD, (T4) Mineral-N at 120 kg + Organic-N at 80 kg/ fed^{-1} + DMPP, (T5) Mineral-N at 120 kg + Organic-N at 80 kg/ fed^{-1} + NC (T6) Mineral-N at 80 kg + Organic-N at 120 kg/ fed^{-1}, (T7) Mineral-N at 80 kg + Organic-N at 120 kg/ fed^{-1} + DCD, (T8) Mineral-N at 80 kg + Organic-N at 120 kg/ fed^{-1} + DMPP, (T9) Mineral-N at 80 kg + Organic-N at 120 kg/ fed^{-1} + NC.

DCD: Dicyandiamide; DMPP: 3, 4-dimethylpyrazole-phosphate; NC: Neem cake.

Fruit quality characteristics:

Data presented in Tables 7 and 8 show some chemical characteristics of tomato fruits expressed on nitrate, nitrite, lycopene, total soluble sugars, vitamin C and TSS. It is clear that all contents were significantly influenced by the integrated additions of mineral and organic-N fertilization as well as nitrification inhibitors in both seasons.

The highest accumulation of nitrate and nitrite contents in tomato fruits were obtained by the control treatment (mineral-N at 200 kg/ fed^{-1}). On the other hand, the lowest values were obtained under either the addition of 120 kg mineral-N fertilizer combined with 80 kg organic-N with DMPP or 80 kg mineral-N combined with 120 kg organic-N with DMPP application.

The same data clearly reveal that application of 120 kg mineral fertilizer combined with 80 kg organic-N with DMPP resulted in the highest significant values of lycopene, total soluble sugars, vitamin C and TSS contents of tomato fruits in both seasons, the unique exception was that of total soluble sugars and vitamin C which did not show any significant response in the second season of this work.

Table 7: Nitrate, Nitrite and Lycopene contents of tomato fruits as affected by the combination of mineral and organic nitrogen fertilization with nitrification inhibitors during 2010 and 2011 seasons.

Characters / reatments	Nitrate content (mg kg^{-1} fresh fruit)		Nitrite content (mg kg^{-1} fresh fruit)		Lycopene (mg kg^{-1} fresh fruit)	
	1st season	2nd season	1st season	2nd season	1st season	2nd season
T1	98.77	112.4	0.868	1.097	62.02	69.01
T2	72.20	77.94	0.696	0.624	68.32	73.38
T3	42.43	35.21	0.285	0.246	75.29	77.31
T4	30.42	25.70	0.241	0.202	78.42	82.03
T5	49.71	53.44	0.349	0.424	70.67	73.08
T6	66.68	52.46	0.586	0.512	66.76	72.60
T7	30.27	41.93	0.266	0.214	70.62	73.78
T8	32.35	28.82	0.214	0.213	73.74	74.29
T9	36.20	48.32	0.406	0.374	69.42	70.53
LSD at 5%	3.35	4.05	0.047	0.059	4.33	4.04

(T1) Mineral-N at 200 kg/ fed^{-1} (the recommended N application - Control), (T2) Mineral-N at 120 kg + Organic-N at 80 kg/ fed^{-1}, (T3) Mineral-N at 120 kg + Organic-N at 80 kg/ fed^{-1} + DCD, (T4) Mineral-N at 120 kg + Organic-N at 80 kg/ fed^{-1} + DMPP, (T5) Mineral-N at 120 kg + Organic-N at 80 kg/ fed^{-1} + NC (T6) Mineral-N at 80 kg + Organic-N at 120 kg/ fed^{-1}, (T7) Mineral-N at 80 kg + Organic-N at 120 kg/ fed^{-1} + DCD, (T8) Mineral-N at 80 kg + Organic-N at 120 kg/ fed^{-1} + DMPP, (T9) Mineral-N at 80 kg + Organic-N at 120 kg/ fed^{-1} + NC.

DCD: Dicyandiamide; DMPP: 3, 4-dimethylpyrazole-phosphate; NC: Neem cake.

The positive effect of the combined addition of 120 kg mineral-N with 80 kg organic-N with DMPP on reducing nitrate and nitrite accumulation in tomato fruits may be attributed to the compatible effect of DMPP as a nitrification inhibitor and compost on delaying the conversion of ammonium to nitrate and avoiding undesirable high nitrate levels in plants, subsequently reducing the accumulation in fruits (Trenkel, 2010). The mentioned significant effect on lycopene, total soluble sugars, vitamin C and TSS contents of tomato fruits in comparison with the other treatments may be attributed to the significant absorption of N, P and K nutrients (Table 5) by tomato plants especially the high K uptake, since potassium plays an important role in water status of plant, promoting the translocation of newly synthesized photosynthesis and mobilization of stored materials as well as promoting the synthesis of sugars and polysaccharides (Mengel and Kirkby, 1982).

Table 8: Total soluble sugars , Vitamin C and TSS contents of tomato fruits as affected by the combination of mineral and organic nitrogen fertilization with nitrification inhibitors during 2010 and 2011 seasons.

Characters / Treatments	Total soluble sugars (%)		Vitamin C (mg/100g FW)		TSS (%)	
	1st season	2nd season	1st season	2nd season	1st season	2nd season
T1	2.61	2.71	24.41	20.97	5.45	6.34
T2	2.90	2.76	26.49	19.92	5.73	6.62
T3	3.09	2.84	28.72	22.63	6.13	7.02
T4	3.39	2.93	32.62	24.56	6.35	7.23
T5	2.98	2.78	29.46	20.96	5.90	6.79
T6	2.83	2.85	27.21	19.15	5.54	6.59
T7	2.93	2.64	25.72	20.28	5.88	6.89
T8	3.11	2.91	26.66	21.99	5.97	6.82
T9	2.91	2.86	27.93	20.60	5.67	6.69
LSD at 5%	0.19	NS	2.22	NS	0.26	0.20

(T1) Mineral-N at 200 kg/ fed^{-1} (the recommended N application - Control), (T2) Mineral-N at 120 kg + Organic-N at 80 kg/ fed^{-1}, (T3) Mineral-N at 120 kg + Organic-N at 80 kg/ fed^{-1} + DCD, (T4) Mineral-N at 120 kg + Organic-N at 80 kg/ fed^{-1} + DMPP, (T5) Mineral-N at 120 kg + Organic-N at 80 kg/ fed^{-1} + NC (T6) Mineral-N at 80 kg + Organic-N at 120 kg/ fed^{-1}, (T7) Mineral-N at 80 kg + Organic-N at 120 kg/ fed^{-1} + DCD, (T8) Mineral-N at 80 kg + Organic-N at 120 kg/ fed^{-1} + DMPP, (T9) Mineral-N at 80 kg + Organic-N at 120 kg/ fed^{-1} + NC.

DCD: Dicyandiamide; DMPP: 3, 4-dimethylpyrazole-phosphate; NC: Neem cake.

Similar results have been recently confirmed by the work of Meherunnessa *et al.* (2011) who found that compost and chemical fertilizers in combination (½ recommended dose compost + full recommended dose of chemical fertilizer) positively influence on the biochemical reactions of tomato fruits, *i.e.,* pH, vitamin C, protein, N, P, K, Ca, Mg and S content. On the other side, Ming *et al.* (2009) mentioned to the significant low concentrations of nitrate and nitrite in tomato fruits when treated with organic fertilizer compared to the chemical fertilizer. Moreover, DMPP reduced the nitrate concentration in leafy vegetables (Xu *et al*., 2004 and Trenkel, 2010). The addition of DMPP to mineral-N fertilizer significantly increasing content of vitamin C, soluble sugars, K, Fe and Zn of cabbage leaves (Xu *et al*., 2004). Furthermore, Su-Xia *et al*., (2010) reported that applying dicyandiamide significantly increased dry matter, glucose and sucrose as well as decreased the content of nitrate in tomato fruit.

Economic returns:

Values of the economic performance of tomato plants as affected by mineral-N, organic-N fertilization and nitrification inhibitors are demonstrated in Table 9. The results reveal that the highest net return (27339 LE/ fed^{-1}) was obtained under the application of 120 kg mineral-N combined with 80 kg organic-N with DMPP treatment; such treatment returns the highest benefit-cost ratio (2.31) in comparing with the other treatments. Thus, this treatment proved to be economical for tomato production under the conditions of this study.

Finally, this investigation imply that, the combined addition of 120 kg mineral-N (585.4 kg/ fed^{-1} as ammonium sulphate) and 80 kg organic-N (5.1 ton/ fed^{-1} of rice straw compost) with DMPP (4.8 kg/ fed-1) in tomato fields could be recommended to improve the vegetative growth characteristics and N, P, K uptakes as well as increase yield and quality of tomato, giving the highest remarkable net return and benefit-cost ratio to the farmers than the recommended mineral-N fertilizer (975.6 kg/ fed^{-1} of ammonium sulphate). Such treatment will save about 40 % of the applied mineral-N with an environmental friendly organic nitrogen application and will also reduce the negative effects of the excessive utilization of mineral-N fertilizer and its hazard effects on human health.

Table 9: Economic performance of tomato plants as affected by the combination of mineral and organic nitrogen fertilization and nitrification inhibitors during 2010 and 2011 seasons.

Characters / Treatments	Marketable yield (Ton fed^{-1})$^{(1)}$	Gross return (LE fed^{-1})$^{(2)}$	Treatment cost (LE fed^{-1})$^{(3)}$	Total variable cost (LE fed^{-1})$^{(4)}$	Net return (LE fed^{-1})$^{(5)}$	Benefit cost ratio$^{(6)}$	Order
T1	28.73	35912	2800	11830	24082	2.04	4
T2	27.51	34388	2195	11225	23163	2.06	3
T3	29.55	36938	2795	11825	25113	2.12	2
T4	31.35	39188	2819	11849	27339	2.31	1
T5	28.62	35775	2795	11825	23950	2.03	5
T6	23.46	29325	1895	10925	18400	1.68	9
T7	25.07	31338	2295	11325	20013	1.77	8
T8	26.93	33663	2311	11341	22322	1.97	6
T9	25.14	31425	2295	11325	20100	1.78	7

(1) Tomato marketable yield as average of two seasons. (2) Gross return as marketable yield (Ton/fed^{-1}) x 1250 LE /Ton. (3) Treatment cost was calculated according to the following prices: compost = 100 LE Ton, ammonium sulphate= 140 LE/ 50kg, DCD = 30 LE/kg (5% of mineral-N fertilizer), NC = 5 LE/kg (20 % of mineral-N fertilizer), DMPP= 130 LE /kg (0.8 % of mineral-N fertilizer). (4) Total variable cost (LE/fed^{-1}) include: Treatment cost plus land leasehold, transplants, P and K fertilizers, microelements, pesticides, labors, and other cultural practices which equal nearly 9030 LE/ fed^{-1}. (5) = (2)-(4). (6)= (5)/ (4).

(T1) Mineral-N at 200 kg/ fed^{-1} (the recommended N application - Control), (T2) Mineral-N at 120 kg + Organic-N at 80 kg/ fed^{-1}, (T3) Mineral-N at 120 kg + Organic-N at 80 kg/ fed^{-1} + DCD, (T4) Mineral-N at 120 kg + Organic-N at 80 kg/ fed^{-1} + DMPP, (T5) Mineral-N at 120 kg + Organic-N at 80 kg/ fed^{-1} + NC (T6) Mineral-N at 80 kg + Organic-N at 120 kg/ fed^{-1}, (T7) Mineral-N at 80 kg + Organic-N at 120 kg/ fed^{-1} + DCD, (T8) Mineral-N at 80 kg + Organic-N at 120 kg/ fed^{-1} + DMPP, (T9) Mineral-N at 80 kg + Organic-N at 120 kg/ fed^{-1} + NC.

DCD: Dicyandiamide; DMPP: 3, 4-dimethylpyrazole-phosphate; NC: Neem cake.

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التأثير المتكامل للتسميد النيتروجيني المعدني و العضوي في وجود بعض مثبطات النترتة علي النمو و المحصول و جودة الطماطم.

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لقد أصبح الاهتمام بالبيئة هدفاً لا يمكن إغفاله في ظل الاهتمام بالإنتاج الكمي لمختلف المحاصيل و ما يتبع ذلك من تعرض صحة الإنسان للخطر و لهذا يهدف هذا البحث إلي التقليل من كميات الأسمدة النيتروجينية المعدنية المستخدمة في إنتاج الطماطم المنزرعة بدلتا النيل بما يعود أثره علي تقليل تلوث البيئة و إنتاج ثمار آمنه علي صحة الإنسان و ذلك من خلال استخدام كمبوست قش الأرز كمصدر متوفر في البيئة المصرية للنيتروجين العضوي في توليفات مختلفة مع السماد النيتروجيني المعدني مع المعاملة بمثبطات النترتة و ذلك علي نمو و محصول و جودة ثمار الطماطم هجين أول "جي إس ١٢".

و قد أجريت تجربتان حقليتان في مزرعة خاصة بناحية طلخا - محافظة الدقهلية خلال موسمي ٢٠١٠ و ٢٠١١ و استخدم لذلك تسع معاملات عبارة عن توليفات مختلفة بين مستويات من التسميد المعدني النيتروجيني المنخفض و كميات مكملة من النيتروجين العضوي (من كمبوست قش الأرز) مع إضافة ثلاثة من مثبطات النترتة و هي داي سيناميد (المثبط الاكثر استخداماً) و داي ميثيل بيرازول فوسفات (مثبط حديث) و كسب النيم (مثبط من مصدر طبيعي) و ذلك بالمقارنة مع معامله التسميد النيتروجيني المعدني الموصي بها من وزارة الزراعة و هي ٢٠٠ وحدة نيتروجين للفدان.

و كانت أهم النتائج المتحصل عليها ما يلي:

- بينت الدراسة بوضوح التأثير المعنوي لإضافة ١٢٠ كجم من السماد النيتروجيني المعدني مع ٨٠ كجم من النيتروجيني العضوي من كمبوست قش الارز (٥,١٢ طن كمبوست / فدان) مع إضافة داي ميثيل بيرازول فوسفات كمثبط للنترتة حيث أدي إلي حدوث زيادة معنوية في صفات النمو الخضري للنباتات (طول النبات و الوزن الغض و المساحة الورقة) و كذلك محتوي أوراق نباتات الطماطم من النيتروجين و الفوسفور و البوتاسيوم.
- كان لإضافة ١٢٠ كجم من السماد النيتروجيني المعدني مع ٨٠ كجم من النيتروجين العضوي مع إضافة مثبط النترتة داي ميثيل بيرازول فوسفات أفضل تأثير علي المحصول التسويقي من ثمار الطماطم، بينما أدي إضافة كلاً من السماد النيتروجيني المعدني بالمعدل الموصي به

(٢٠٠ كجم نيتروجين/ فدان) و كذلك ١٢٠ كجم من النيتروجيني المعدني مع ٨٠ كجم من النيتروجيني العضوي مع إضافة مثبط النترتة داي ميثيل بيرازول فوسفات إلي الحصول علي أعلي محصول كلي من ثمار الطماطم بالمقارنة مع المعاملات الأخرى في كلا الموسمين تحت الدراسة.

- أدي إضافة المعدل الموصي به من السماد النيتروجيني المعدني إلي حدوث زيادة معنوية في تركيز النترات و النيتريت في ثمار الطماطم، بينما كان لإضافة ١٢٠ كجم من السماد النيتروجيني المعدني مع ٨٠ كجم من النيتروجين العضوي مع إضافة داي ميثيل بيرازول فوسفات و كذلك استخدام ٨٠ كجم من السماد النيتروجيني المعدني مع ١٢٠ كجم من النيتروجيني العضوي مع إضافة داي ميثيل بيرازول فوسفات إلي حدوث نقص معنوي في تركيز النترات و النيتريت في الثمار.
- أعطت معاملة ١٢٠ كجم من السماد النيتروجيني المعدني مع ٨٠ كجم من النيتروجيني العضوي مع إضافة مثبط النترتة داي ميثيل بيرازول فوسفات أعلي القيم فيما يخص محتوي ثمار الطماطم من الليكوبين و السكريات الكلية الذائبة و فيتامين ج و المواد الصلبة الذائبة الكلية و كذلك تحقيق أعلى عائد اقتصادي و ذلك مقارنة بباقي المعاملات.

و بناء عليه توصي هذه الدراسة باستخدام السماد النيتروجيني المعدني بمعدل ٦٠ % من الموصي به (١٢٠ كجم نيتروجين/ فدان) و استكمال باقي المعدل بإضافة كمبوست قش الأرز بمعدل ٥,١٢ طن/ فدان بحيث يوفر ٤٠ % من المعدل الموصي به للنيتروجين من مصدر عضوي و هو كمبوست قش الارز (٨٠ كجم نيتروجين/ فدان) مع إضافة داي ميثيل بيرازول فوسفات كمثبط للنترتة خلطاً مع السماد النيتروجيني الكيماوي المستخدم (بمعدل ٠,٨ % من السماد النيتروجيني المعدني المستخدم) لنباتات الطماطم و ذلك للحصول علي أفضل النتائج بالنسبة للنمو و التركيب الكيماوي و المحصول التسويقي و جودة ثمار الطماطم و كذلك تحقيق أفضل عائد اقتصادي مع تقليل الآثار السلبية التي تنتج عن الاستخدام المفرط للأسمدة النيتروجينية المعدنية علي البيئة و صحة الإنسان.

قام بتحكيم البحث

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