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COMPARISON BETWEEN ORGANIC AND CONVENTIONAL FARMING FOR YIELD AND NUTRIENTS CONTENT OF PEPPER PLANT GROWN ON A SANDY SOIL

BY

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ABSTRACT

A field experiment was carried out at Ismailia Agriculture Research Station, Agriculture Research center, during summer season of 2005, to evaluate the increase in yield productivity and nutrients content of pepper plant under organic farming condition as compared to conventional farming (control) condition. Treatments were representing all the combinations of organic N (150 and 225 kg N fed^{-1}) and P fertilizer rates (0, 60, 90 and 120 kg P_2O_5 fed^{-1}) in a randomized complete block design with three replicates.

Results showed that application of organic farming may lead to pepper yield (unmarketable and/or marketable) lower than yield under conventional farming. Most of yield components recorded high values under organic farming as compared to conventional farming. The most promising treatments for production of marketable pepper yield could be: Those of (225 kg organic N + 120 kg P_2O_5 fed^{-1}) which showed a decrement of (-7.85%) and (225 kg organic N + 90 kg P_2O_5 fed^{-1}) with a decrement of (-10.2%). The treatments of (225 kg organic N + 120 kg P_2O_5 fed^{-1}) followed by (225 kg organic N + 90 kg P_2O_5 fed^{-1}) could be recommended for obtaining the highest rate of income from the marketable yield of pepper.

The multiple linear regression shows that there is a highly significant correlation (P=0.01) among marketable pepper yield (y) and stem dry weight, root P content, available N in soil and height plant (R^2 = 90.8 %). The expected equation to predict the marketable pepper yield under organic farming was:

Marketable pepper yield = 2.23 - 0.223 stem dry weight - 34.8 root P content + 0.024 available N in soil – 0.056 plant height.

The path analyses reveals that the most closely variables related to marketable pepper yield is stem dry weight and root P content.

Most nutrients except N content of pepper plant organs increased under organic farming as compared to the recommended rates of mineral fertilization under conventional farming.

Key word: Organic farming, Conventional farming, Pepper yield, Nutrients content.

INTRODUCTION

Organic farming aims to provide sustainable alternative agricultural systems (Stockdale *et al.*, 2001). The management of organic farms excludes the use of synthetic fertilizers and pesticides, while increasing and maintaining soil fertility over the long-term (IFOAM, 2000). To achieve this, organic farming enhances internal nutrient cycling by: incorporating crop residues, introducing crop rotations, using green manures (nitrogen fixing leys) and different types of organic fertilizers. The scarcity of organic fertilizers (manures and slurries) in many agricultural areas often results in highly negative nutrient balances in organically managed agricultural lands (Alfoeldi *et al.*, 2002).

Organic farming currently occupies about 0.3% of agriculture land, mostly in developed countries. This land is farmed according to rules administered by various organic farming associations that, in the case of crops, disallow the use of most inorganic compounds for crop nutrition, synthetic compounds for pest, disease and weed control, and more recently, genetically modified cultivars. Conventional farming, vary enormously in range and amount of 'organic agriculture – prohibited' inputs. They include, for example, many farms in developing countries where agrochemicals are not used because they are either not available or are too expensive (Conner. 2008).

Organic agriculture has been criticized as low-yielding as and less efficient than conventional agriculture in its use of land and resources (Trewavas, 2004). Several trials comparing between organic and conventional farming systems had shown significantly lower yields under organic systems (Stanhill, 1990 and Ryanet *et al.*, 2004). Padel and Lampkin (1994) reported that crop yield comparisons depend on the crop in question, with 60% lower yields in California rice (*Oryza sativa L.*) and 50% higher yields in Midwest oats (*Avena spp.*) for organic agriculture. Other studies of organic and/or alternative (low input/sustainable) systems resort yields comparable to conventional systems in tomatoes (*Lycopersicon lycopersicum*) (Clark *et al.*, 1999), apples (*Malus spp.*) (Reganold *et al.*, 2001), soybeans (*Glycine max (L.) Merr.*) (Pimentel *et al.*, 2005) and Zea mays (Pimentel *et al.*, 2005).

Therefore, the objective of the present work is a trial for inducing the productivity of pepper crop under organic farming system by using the agriculture residues compost (as source of organic N), enriched with rock phosphate (as source of phosphorus) as compared to the recommended rates of mineral fertilization under conventional farming system. Essential parameters of yield and yield components were evaluated.

MATERIALS AND METHODS

A field trial was conducted on a loamy sand soil at Ismailia Agricultural Research Station, by cultivating pepper (*Capsicum annum L.*, cv Marrkony) at summer season of 2005. Main and interaction effects of different rates of compost (as a source of organic N) and rock phosphate (as P source) on yield components and nutrients content of pepper plant were achieved. The experiment was carried out following the randomized complete block design, with three replicates for each experimental unit. The compost was added by thorough mixing with the surface soil layer at a rate of 10 ton/fed (150 kg organic N fed^{-1}) and 15 ton/fed (225 kg organic N fed^{-1}) for compost, which was combined with four P_2O_5 rates of (0, 60, 90 and 120 kg P_2O_5 fed^{-1}) in the form of rock phosphate (12 % P_2O_5). One K fertilization rate (24 kg K_2O fed^{-1}) was added in the form of feldspar (8 % K_2O). The N, P and K fertilization was run entirely through preparing the soil before planting, at the recommended doses of mineral N, P and K fertilization (ammonium sulfate = 400 kg fed^{-1} as source of N, super phosphate = 200 kg fed^{-1} as source of P and potassium sulfate = 300 kg fed^{-1} as source of K) to act as a control treatment which were compared to the other organic treatments.

The experimental plots soil were sampled initially before pepper planting to determine some physical and chemical properties according to the standard procedures outlined by Cottenie (1980) (Table, 1).

Chemical properties of the tested compost and rock phosphate were measured according to the standard methods described by Cottenie (1980) and are shown in (Table, 2). Plant samples were collected from mature pepper plants at harvest stage for analysis. Plant samples were dried at 65C° for 48 hrs, ground and wet digested using H_2SO_4: H_2O_2 method (Cottenie, 1980). The digests were then subjected to measurement of N using Micro-Kjeldahl method; P was assayed using molybdenum blue method (Chapman and Pratt, 1961), while K was determined by Flame Photometer. Ascorbic acid content was assayed using oxalic acid method (Jacobs, 1951).

Table (1): **Some physical and chemical properties of the soil used.**

Soil property	Value	Soil property	Value
Particle size distribution %		**pH (1:2.5 soil suspension)**	7.52
Coarse sand	69.9	**ECe (dS m^{-1})**	1.26
Fine sand	14.2	**Soluble ions (meq L^{-1})**	
Silt	5.70	**Ca^{++}**	6.12
Clay	10.2	**Mg^{++}**	4.60
Texture	Loamy sand	**Na^{+}**	1.94
$CaCO_3$ %	2.50	**K^{+}**	0.12
Saturation percent	23.3	**CO_3^{-}**	**nd**
Organic carbon %	0.01	**HCO_3^{-}**	2.20
Available N (mg kg^{-1})	9.3	**Cl^{-}**	4.98
Available P (mg kg^{-1})	1.8	**SO_4^{-}**	5.60
Available K (mg kg^{-1})	67.5	**CEC (meq 100 g^{-1} soil)**	6.50

Table (2): **Some chemical properties of the used organic compost and rock phosphate.**

Source	**pH (1:2.5)**	**N**	**P**	**K**	**Organic carbon**	**C/N ratio**
				%		
Compost	6.65	2.11	1.36	2.27	33.8	16:1
Rockphosphate	7.60	0.42	12.0	0.11	nd	nd

nd: not detected

RESULTS AND DISCUSSION

1. Effect of organic N and P fertilization on yield and yield components of pepper plants.

Results in (Table, 3) indicate that increasing P fertilization rate under both organic N rates significantly and or insignificantly increased for both yield and yield components. The mostly induced parameters, i.e., marketable, unmarketable yields (unmarketable yield was mean first and second packing), bell length and diameter, ascorbic acid content, and root dry weight all of which under the highest rates of applied organic N (225 kg N fed^{-1}) as well as the highest P fertilization rate (120 kg P_2O_5 fed^{-1}). However, the highest values of stem and leaf dry weights were recorded under the highest organic N rate + 3rd P rate.

In other words the dual synergistic effect probably was mutual for N and P. However, the average values of yield and yield parameters increased significantly under higher organic N compared with the lower N one. Dibb *et al.* (1990) attributed the role of N and P in crop fertilization leading to increased absorption of both elements to that in turn increased top growth, particularly as a result of N absorption. Alabi (2001) reported that pepper production enjoys maximum benefit of organic manure from household refuse for soil fertility maintenance. Organic manure contains large amounts of all the mineral nutrients needed by plant. Increasing the rate of both P and organic fertilizer treatments significantly enhanced fresh fruit yield per plant when compared with the control treatment. This also enhanced significantly the yield per hectare and yield components such as the fruit length and diameter (Alabi, 2006).

Results in Table (4) indicate drastic decrements in both marketable and unmarketable yield of pepper under all treatments of organic farming as compared with mineral fertilization farming. The rate of reduction was partially compensated by increasing the added organic N rate from 150 to 225 kg N fed^{-1} and adding higher P rates consistently.

Table (3): Interaction effect between organic N and P fertilization rates on yield and yield components of pepper plant.

Compost N kg fed^{-1} (N)	Rock P_2O_5 kg fed^{-1} (P)									
	0	60	90	120	Mean	0	60	90	120	Mean
	Marketable yield ton fed^{-1}					Unmarketable yield ton fed^{-1}				
150	5.823	7.507	7.747	9.270	7.587	0.497	0.667	1.080	1.190	**0.859**
225	6.187	8.660	9.380	9.630	8.464	0.557	0.833	1.163	1.193	**0.937**
Mean	**6.005**	**8.083**	**8.563**	**9.450**	**8.025**	**0.527**	**0.750**	**1.121**	**1.191**	
L.S.D.0.5 N=0.243 P=0.242 NP=0.342 Mineral fertilization=10.45						L.S.D.0.5 N=0.058 P=0.039 NP=0.056 Mineral fertilization= 1.710				
	Bell length cm					Bell diameter cm				
150	9.660	11.21	12.35	12.45	**11.42**	8.143	8.710	8.967	9.017	**8.709**
225	11.45	12.47	13.70	14.50	**13.03**	8.680	8.757	9.017	9.230	**8.921**
Mean	**10.55**	**11.84**	**13.02**	**13.47**		**8.411**	**8.733**	**8.992**	**9.123**	
L.S.D.0.5 N=0.284 P=0.504 NP=0.713 Mineral fertilization=10.44						L.S.D.0.5 N=0.112 P=0.232 NP=0.328 Mineral fertilization= 8.620				
	Ascorbic acid content%					Root dry weight g plant^{-1}				
150	52.19	54.93	61.38	63.24	**57.94**	1.643	1.813	2.903	2.927	**2.322**
225	52.85	61.60	63.04	63.97	**60.37**	1.720	2.257	2.957	2.963	**2.474**
Mean	**52.52**	**58.26**	**62.21**	**63.60**		**1.681**	**2.035**	**2.930**	**2.945**	
L.S.D.0.5 N=2.147 P=1.229 NP=1.738 Mineral fertilization= 56.28						**L.S.D.0.5 N=0.039 P=0.068 NP=0.097 Mineral fertilization= 3.340**				
	Stem dry weight g plant^{-1}					Leaf dry weight g plant^{-1}				
150	2.777	4.740	4.850	5.220	4.397	2.023	2.513	3.193	3.823	**2.888**
225	2.979	5.010	5.620	5.547	4.789	2.127	2.400	4.537	4.400	**3.366**
Mean	**2.878**	**4.875**	**5.235**	**5.383**		**2.075**	**2.456**	**3.865**	**4.111**	
L.S.D.0.5 N=0.152 P=0.248 NP=0.351 Mineral fertilization=10.84						L.S.D.0.5 N=0.114 P=0.260 NP=0.368 Mineral fertilization= 9.530				

Note: ton: metric ton

The reduction in marketable and unmarketable yield amounted to (-44.3% and -70.9%), respectively, under 150 kg organic N and without adding P corresponding to (-40.8% and -67.4%) for 225 kg organic N and zero P, respectively. Increasing P rate gradually diminished these reduction percentage to (-11.3 and -30.4) for marketable and unmarketable yield versus (-7.85 and -30.2) for both types of yield under 225 kg organic N + 120 kg P_2O_5 fed^{-1}.

Table (4): Surplus (+) or deficit (-) values for yield relating the different organic fertilization treatments over or under those obtained by the mineral fertilization treatment.

Treatment (kg fed^{-1})		Yield (ton fed^{-1})	
Organic N	P_2O_5	Marketable (%)	Unmarketable (%)
150	0	-44.3	-70.9
	60	-28.2	-61.0
	90	-25.9	-36.8
	120	-11.3	-30.4
225	0	-40.8	-67.4
	60	-17.1	-51.3
	90	-10.2	-32.0
	120	-7.85	-30.2

Finally, the most promising treatments could be: treatments of (225 kg organic N + 120 kg P_2O_5 fed^{-1}) which showed a decrement of (-7.85%) and (225 kg organic N + 90 kg P_2O_5 fed^{-1}) with a decrement of (-10.20%). Translating these values into net income by taking into considerations the price of added fertilizer and expected price of marketable yield, the calculations reveal that the net income for the both organic treatments could be higher than that of conventional farming treatment by 4673 and 5541 Egyptian pound, respectively. The treatments of (225 kg organic N + 120 kg P_2O_5 fed^{-1}) followed by (225 kg organic N + 90 kg P_2O_5 fed^{-1}) could be recommended for obtaining the highest rate of income from the marketable yield of pepper.

With regard to marketable pepper yield under organic farming, correlation coefficient (r) between the marketable pepper yield (y) and each of stem dry weight at harvest stage, root P content, available N in soil and plant height was positively significant.

Meanwhile, the multiple linear regression shows that there is a highly significant correlation (P=0.01) relating marketable pepper yield (Y) to stem dry weight, root P content, leaf Fe content, available N in soil and height plant (R^2 = 90.8 %). The expected equation to predict the marketable pepper yield was:

Marketable pepper yield = 2.23-0.223 stem dry weight - 34.8 root P content + 0.024 available N in soil – 0.056 plant height.

2. Effect of organic N and P fertilization rates on N, P and K of pepper plants.

Results in (Table, 5) show that under both lower and higher organic N rate, values of N content in root, stem, leaf and fruit were increased by increasing P fertilization rate. The N content values in pepper root, stem, leaf and fruit steadily increased as the rate of applied P increased showing average percentages of 1.228, 0.952, 1.806 and 2.339, respectively, under higher organic N rate as compared with lower applied organic N rate (average percentages of 1.183, 0.888, 1.594 and 2.069, respectively). The maximum N content of root, stem, leaf and fruit (1.483, 1.163, 2.373 and 2.603%, respectively) occured under the higher organic N rate (225 kg N/fed) + the highest P fertilization rate (120 kg P_2O_5 fed^{-1}). Alabi (2006) found that increasing the rates of applied P increased significantly the nutrient elements (N, P and K) of pepper plant with increasing the rates of applied poultry droppings.

Under both lower and higher organic N rate, significant increases in P content of root, stem, leaf and fruit occurred under increasing P fertilization rate applied. P content values in pepper root, stem, leaf and fruit increased steadily as the rate of applied P increased showing average percentages of 0.194, 0.227, 0.274 and 0.272, respectively, under higher organic N rate as compared with lower applied organic N rate (average percentages of 0.165, 0.202, 0.217 and 0.268, respectively).

The maximum P content of root, stem, leaf and fruit (0.245, 0.278, 0.364 and 0.305 %, respectively) occurred under the higher organic N rate (225 kg N/fed) and highest P fertilization rate (120 kg P_2O_5/fed). Sah and Mikkelson (1986) reported that rock phosphate enriched manures maintain higher levels of P in soil solution for a longer period than the fertilizer alone. Pazhanivelan *et al.* (2006) added that increasing P uptake when compost was enriched by rock phosphate due to inducing the solubility of P and thereby its availability to crop.

Under both the lower and higher organic N rates, significant increases in K content of root, stem, leaf and fruit took place under increasing P fertilization rate. K content values in pepper root, stem, leaf and fruit steadily increased as the rate of applied P increased showing average percentages of 2.820, 3.114, 3.854 and 2.344 respectively, under higher organic N rate as compared with lower applied organic N rate (average percentages 2.728, 3.042, 3.711 and 2.062, respectively). The maximum K content of root, stem, leaf and fruit (2.995, 3.850, 4.187

and 2.677 %, respectively) occurred under the higher organic N rate (225 kg N fed^{-1}) and highest P fertilization rate (120 kg P_2O_5 fed^{-1}). Alabi (2006) found that increasing the rates of applied P and poultry droppings increased significantly the nutrient elements (N, P and K) of pepper plant.

Regarding the comparison between organic and conventional farming on nutrient content of pepper plant, obtained data (Table, 5) show that N content of stem, root, leaf and fruit increased under conventional farming compared to organic farming condition. On the other hand the P contents in stem, root and leaf pepper was highest under organic farming than conventional farming, but P content in fruit was highest value under conventional farming than organic farming. K content of stem, root, leaf and fruit was highest value under organic farming than conventional farming.

Table (5): Interaction effect between organic N and P fertilization rate on nutrients content of root, stem, leaf and fruit of pepper plant at maturity stage

Compost N kg fed^{-1} (N)	Rock P_2O_5 kg fed^{-1} (P)														
	0	60	90	120	Mean	0	60	90	120	Mean	0	60	90	120	Mean
	Root														
	N%					P %					K %				
150	0.957	1.140	1.183	1.450	1.183	0.141	0.152	0.168	0.200	0.165	2.527	2.660	2.773	2.950	2.728
225	1.010	1.140	1.277	1.483	1.228	0.143	0.178	0.211	0.245	0.194	2.707	2.777	2.800	2.995	2.820
Mean	0.983	1.140	1.230	1.466		0.142	0.165	0.189	0.225		2.617	2.718	2.786	2.972	
L.S.D.$_{0.5}$ N=0.045 P=0.056 NP=0.112						L.S.D.$_{0.5}$ N=0.012 P=0.012 NP=0.017					L.S.D.$_{0.5}$ N=0.116 P=0.088 NP=0.102				
Mineral fertilization= 2.590						Mineral fertiliztion= 0.150					Mineral fertilization=2.590				
	Stem														
	N%					P %					K %				
150	0.683	0.833	1.007	1.027	0.687	0.166	0.180	0.201	0.262	0.202	2.707	2.840	2.923	3.697	3.042
225	0.860	1.097	1.163	0.952	1.257	0.171	0.194	0.264	0.278	0.227	2.763	2.910	2.933	3.850	3.114
Mean	0.771	0.965	1.085	0.989		0.168	0.187	0.232	0.270		2.735	2.875	2.928	3.775	
L.S.D.$_{0.5}$ N=0.048 P=0.068 NP=0.079						L.S.D.$_{0.5}$ N=0.009 P=0.012 NP=0.017					L.S.D.$_{0.5}$ N=0.008 P=0.079 NP=0.125				
Mineral fertilization=1.257						Mineral fertiliztion=0.174					Mineral fertilization= 2.513				
	Leaf														
	N%					P %					K %				
150	0.957	1.277	1.800	2.343	1.594	0.076	0.226	0.264	0.303	0.217	3.400	3.530	3.807	4.107	3.711
225	1.140	1.450	2.260	2.373	1.806	0.205	0.236	0.291	0.364	0.274	3.580	3.770	3.877	4.187	3.654
Mean	1.048	1.363	2.030	2.358		0.140	0.231	0.277	0.333		3.490	3.650	3.842	4.147	
L.S.D.$_{0.5}$ N=0.008 P=0.079 NP=0.112						L.S.D.$_{0.5}$ N=0.003 P=0.012 NP=0.017					L.S.D.$_{0.5}$ N=0.075 P=0.143 NP=0.202				
Mineral fertilization=2.640						Mineral fertiliztion= 0.245					Mineral fertilization=3.097				
	Fruit														
	N%					P %					K %				
150	1.890	2.043	2.110	2.233	2.069	0.207	0.279	0.284	0.303	0.268	1.840	1.903	2.080	2.423	2.062
225	2.070	2.093	2.590	2.603	2.339	0.213	0.270	0.300	0.305	0.272	1.857	2.280	2.560	2.677	2.344
Mean	1.980	2.068	2.350	2.418		0.210	0.274	0.292	0.304		1.848	2.091	2.320	2.550	
L.S.D.$_{0.5}$ N=0.131 P=0.097 NP=0.137						L.S.D.$_{0.5}$ N=0.015 P=0.012 NP=0.017					L.S.D.$_{0.5}$ N=0.088 P=0.131 NP=0.186				
Mineral fertilization=3.230						Mineral fertiliztion=0.309					Mineral fertilization= 2.233				

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مقارنة بين الزراعة العضوية والزراعة التقليدية وأثرها على المحصول والمحتوى من المغذيات لنبات الفلفل النامى فى الارض الرملية

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** قسم الاراضى واستغلال المياه – المركز القومى للبحوث – الدقى – مصر

أجريت تجربة حقلية خلال الموسم الصيفى ٢٠٠٥ بمحطة البحوث الزراعية بالإسماعيلية لدراسة انتاجية المحصول والمحتوى من المغذيات لنباتات الفلفل النامية فى الاراضى الرملية تحت ظروف الزراعة العضوية ومقارنة ذلك تحت ظروف الزراعة التقليدية. وكانت المعاملات عبارة عن تداخل كميات من الكومبوست كمصدر للنيتروجين العضوى (١٥٠و ٢٢٥ كجم ن فدان⁻١) ومعدلات من صخر الفوسفات كمصدر للفوسفور (صفر، ٩٠،٦٠ ، ١٢٠ كجم فو٢أ٥ فدان⁻١).

تشير النتائج الى أن محصول الزراعة العضوية اقل من محصول الزراعة التقليدية، بينما كانت اغلب مكونات المحصول الفلفل تحت ظروف الزراعة العضوية اعلى من المتحصل عليه باستخدام الاسمدة المعدنية او ما يعرف بالزراعة التقليدية. ولقد اعطت المعاملة السمادية ٢٢٥ كجم ن فدان⁻١ + ١٢٠ كجم فو٢أ٥ فدان⁻١ تعطى افضل محصول فلفل قابل للتسويق وكذلك اعلى قيمة للدخل ، حيث سجلت محصول اقل من المتحصل عليه بالزراعة التقليدية بمقدار (– ٥ ٧,٨%) ثم المعاملة ٢٢٥ كجم ن فدان⁻١ + ٩٠ كجم فو٢أ٥ فدان⁻١ والتى اعطت محصول اقل من المتحصل عليه بالزراعة التقليدية بمقدار (– ١٠,٢ %).

توضح معادلة تحليل الانحدار المتعدد ان محصول الفلفل تحت ظروف الزراعة العضوية مرتبط معنويا (P=0.01) بالوزن الجاف للساق، محتوى الجذر من الفوسفور، ومحتوى الاوراق من الحديد، والنيتروجين الميسر فى التربة وكذلك طول النبات ، كما وجد ان الوزن الجاف للساق و محتوى الجذر من الفوسفور الاكثر تأثيرا فى محصول الفلفل، حيث كانت معادلة التنبؤ لمحصول الفلفل كالتالى:

Marketable pepper yield = 2.23 - 0.223 stem dry weight - 34.8 root P content + 0.024 available N in soil – 0.056 plant height.

وتشير النتائج الى انه تحت ظروف الزراعة العضوية يزيد محتوى معظم المغذيات النباتية داخل اجزاء نبات الفلفل المختلفة بالمقارنة تحت ظروف الزراعة التقليدية.