INTERNATIONAL JOURNAL OF AGRICULTURE & BIOLOGY
ISSN Print: 1560–8530; ISSN Online: 1814–9596
08–253/HUT/2008/10–6–627–632
http://www.fspublishers.org

Full Length Article

Effect of Fertilizers on Growth, Yield, Yield Components, Quality and Certain Nutrient Contents in Broccoli (*Brassica oleracea*)

BASEL A. OUDA AND ATIF Y. MAHADEEN[1]
Plant Production Department, Faculty of Agriculture, Mu'tah University, P.O. Box 7, Al-Karak, Jordan
[1]Corresponding author's e-mail: atif_mahadeen@yahoo.com

ABSTRACT

The plastic-house experiment was carried out during winter 2006-2007 to determine of the effect of organic and inorganic fertilizers on yield and quality of broccoli (*Brassica oleracea* L. var. *Italica*). Four organic fertilizer doses (0, 40, 60 & 80 t ha^{-1}) and three inorganic fertilizer doses (0, 30 & 60 kg ha^{-1}) were used. Application of 60 kg inorganic fertilizers with 60 ton organic manure per hectare produced the highest broccoli yield (40.05 t ha^{-1}). Head number per plant, chlorophyll content and head diameter were higher when a combination of organic and inorganic fertilizers was added compared with their individual addition. Chlorophyll content was higher when inorganic fertilizer adding with organic manure compared with using organic manure alone. Yield and number of broccoli heads had same trend in response to treatments combinations. Fresh and dry weights of broccoli shoots were not significantly affected by application of different doses of fertilizers. Leaf macro-(N, P & K) and micro-nutrient (Fe, Mn & Zn) contents were increased by application of either organic manure or inorganic fertilizer compared to control. Soil pH, EC and organic matter contents were not significantly affected by application of different doses of inorganic fertilizer. Soil electrical conductivity and organic matter were increased by increasing organic fertilizer dose, but soil pH was not affected by different fertilizer doses. Optimum yield (40.05 t ha^{-1}) of broccoli can be obtained by application of 60 ton organic manure with 60 kg inorganic fertilizer ha^{-1}. Broccoli plants can be grown better in soil amended with organic fertilizer. Application of a combination of organic and inorganic fertilizers gave the best values for all tested parameters.

Key Words: Fertilizer; Manure; Growth; Chlorophyll; Soil properties

INTRODUCTION

Broccoli (*Brassica oleracea* L. var. *Italica*) is a member of the *Brassicaceae* family as a wild form of this family, which found along the Mediterranean region (Decoteau, 2000). Broccoli is an Italian vegetable, native to the Mediterranean region, cultivated in Italy in ancient roman times and about 1720 in England. On the other hand, the USA it first appeared in 1806, but it was commercially cultivated of broccoli was started around 1923 (Decoteau, 2000). In Jordan, broccoli is cultivated on a limited area (Ministry of Agriculture, 2006). However, due to increase in its popularity, there is a trend to increase cultivation by farmers as well as consumption by consumers. Broccoli is an important vegetable crop and has high nutritional and good commercial value (Yoldas *et al*., 2008). It is low in sodium food, fat free and calories, high in vitamin C and good source of vitamin A, vitamin B_2 and calcium (Decoteau, 2000). Nowadays, broccoli attracted more attention due to its multifarious use and great nutritional value (Salunkhe & Kadam, 1998; Talalay & Fahey, 2001; Rangkadilok *et al*., 2002 & 2004).

Generally, excessive amounts of inorganic fertilizers are applied to vegetables in order to achieve a higher yield (Stewart *et al*., 2005) and maximum value of growth (Badr & Fekry, 1998; Arisha & Bardisi, 1999; Dauda *et al*., 2008). However, the use of inorganic fertilizers alone may cause problems for human health and the environment (Arisha & Bardisi, 1999). So, inorganic fertilizer is considered a major source of plant nutrients (Adediran *et al*., 2004; Naeem *et al*., 2006). Organic manure can serve as alternative practice to mineral fertilizers (Gupta *et al*., 1988; Wong *et al*., 1999; Naeem *et al*., 2006) for improving soil structure (Bin, 1983; Dauda *et al*., 2008) and microbial biomass (Suresh *et al*., 2004). Therefore, utilization of locally produced manures by vegetable production operations may increase crop yields with less use of chemical fertilizer. In recent times, consumers are demanding higher quality and safer food and highly interested in organic products. Broccoli in Jordan is considered as a promising vegetable that could be developed for local and export purposes (Ministry of Agriculture, 2006). However, in Jordan, organic farming is still applied to very small sector of agriculture. The aim of this study was to determine of the effects of different doses of organic and inorganic fertilizers on yield and quality of broccoli.

To cite this paper: Ouda, B.A. and A.Y. Mahadeen, 2008. Effect of fertilizers on growth, yield, yield components, quality and certain nutrient contents in broccoli (*Brassica oleracea*). *Int. J. Agri. Biol.*, 10: 627–32

MATERIALS AND METHODS

A plastic-house experiment was conducted at the Mu'tah University, Agricultural Research Station, Rabba in the southern part of Jordan, during the growing season of 2006/2007. Some physical and chemical characteristics of the soil are shown in Table I. Fertilizer treatments consisted of organic fertilizers (chicken, sheep & cow manure at ratio1:1:1) at four doses of 0, 40, 60 and 80 ton ha^{-1} and inorganic fertilizer (green leaves 20-20-20+trace elements) at three doses of 0, 30 and 60 kg ha^{-1}. Organic fertilizers were obtained from a Jordanian Company in Amman for organic fertilizer production. Experimental treatments were arranged as factorial in a randomized complete block design with three replications. The soil was prepared for planting by plowing, disking and leveling. Organic fertilizer doses were incorporated into the soil of the respective plots according to field randomization to a depth of 15 cm one week before transplantation. Then manual raised-beds with 0.6 m width, 20 cm height were prepared. Drip irrigation system was used along raised beds and covered with black polyethylene plastic mulch. Broccoli transplants (Ben cultivar) were transplanted in first week of December 2006. Each plot (3.6 m^2) contained 10 plants. The distance between raised-bed centers was 1 m. Plants within a row were separated by 0.4 m. Inorganic fertilizer (green leaves 20-20-20+ trace elements) doses were added monthly by using drip irrigation system. The first dose was added one month after plantation then continued up to later in March. Irrigation commenced at a time of planting and continued throughout growing season (two times a week). Average number of leaves per plant was counted by taken four plants from each treatment after two months of transplantation. At the same time, fully expanded leaf samples were used to determine total chlorophyll content according to Harborne (1973) by using spectrophotometer (Unicam Helios Alpha). Immature and well developed broccoli heads from each treatment were harvested at 7–10 days interval throughout the harvesting season (February to April 2007). Heads with stems were cut to 15 cm long (Decoteau, 2000) and the yield and its components were calculated and expressed on per hectare basis. Fully expanded leaves were selected for tissue nutrients analysis (Tandon, 1995). Leaves samples were oven dried at 75°C for 72 h to the constant weight and grounded to reduce the material to a fineness suitable size by using a mechanical grinder. The samples were stored in airtight plastic containers for chemical analysis. Total nitrogen was determined by digesting 0.5 g dry leaf samples with 68% H_2SO_4 in Kjeldahl digestion unit until sample colorless and titrated with 0.1 N of H_2SO_4 (Tandon, 1995). Phosphorus and potassium was determined using flame photometer (Jenway, UK) according to standard methods of analysis plants. Micronutrient (Fe, Mn, Zn) were estimated with atomic absorption spectrophotoneter (Perken Elmer AAS-300). At the end of growing season, three plants were cut down to soil surface to determine shoot fresh weight. Their dry weights were subsequently determined following drying in a drying chamber to a constant weight at 75°C for 72 h according to Tandon (1995). Soil samples were taken from treated plots for chemical analysis at the end of the experiment. Samples were then prepared for pH, electrical conductivity (EC) (1:2.5 w/w) and organic matter according to standard methods. Data were subjected to analysis of variance (ANOVA) by MSTATC program and means were separated using Duncan's Multiple Ranges Test (DMRT) with $P< 0.05$ (Steel & Torrie, 1980).

RESULTS AND DISCUSSION

Vegetative growth. Shoot fresh and dry weights of broccoli plants tended to increase by increasing dose of organic manure; however, this increment was not significant (Table II). Also, number of leaves per plant showed a little increase with increased organic manure dose (80 t ha^{-1}). Each increase in inorganic fertilizer dose tended to increase number of leaves per plant compared with control. Generally, plots receiving a combination of organic and inorganic fertilizers produced slightly higher (P>0.05) fresh and dry weights of shoot. These results are in accordance with Shiralipour and Faber (1996) on broccoli (*B. oleracea*var Italica); Wong *et al.* (1999) and Magnusson (2002) on chinensis cabbage (*B. chinesis*) and Abdelrazzag (2002) on onion (*Allium cepa*). The highest numbers of leaves, fresh and dry weights of broccoli were obtained by application of 60 and 80 kg organic manure with 60 kg inorganic fertilizer. This variation might be due to the availability of nutrients especially nitrogen and could be due to the improvement of soil water holding capacity as mentioned earlier by Roe and Cornforth (2000). Furthermore, organic manure activates many species of living organisms, which release phytohormones and may stimulate the plant growth and absorption of nutrients (Arisha *et al.*, 2003). Such organisms need nitrogen for multiplication. This is plausible reason that use of organic manure with inorganic fertilizer showed a beneficial effect on dry matter accumulation.

Yield and its components. Yield of main heads was significantly affected by adding organic manure and inorganic fertilizers. Generally, application of the highest dose of inorganic fertilizer (60 kg ha^{-1}) with the highest dose of organic manure (80 t ha^{-1}) produced the highest yield of main heads (3.16 t ha^{-1}). However, application of the highest dose of organic manure (80 kg ha^{-1}) caused a reduction in lateral and total heads yield compared with application of 60 kg ha^{-1} organic manure (Table III). Regardless of organic manure dosages, using the higher doses of inorganic fertilizer (60 kg ha^{-1}) produced higher yields of main, lateral and total heads compared with control. Main, lateral and total heads yields of broccoli followed the same trend in response to organic manure and inorganic fertilizers treatments. Organic manure seemed to be less effective in increasing the yield than did inorganic fertilizer. The present

Table I. Some physical and chemical soil characteristics of the experimental site

Texture	pH	EC (dS m^{-1})	$CaCo_3$ (%)	Organic matter (%)	Total N (%)	$NaHCO_3$-P (ppm)
Sand Clay Loam	7.78	1.28	32	1.63	0.06	18

Table II. Organic and inorganic fertilizer doses on shoot "fresh and dry weights" (kg/plant), and leaves number of broccoli

Fertilizer type		Weight (g $plant^{-1}$)		Number of leaves per plant
Organic (ton ha^{-1})	Inorganic (kg ha^{-1})	Fresh	dry	
0	0	4.30	0.698	28.5f
	30	4.47	0.705	33.2cd
	60	4.14	0.714	37.6bc
40	0	4.14	0.698	29.6f
	30	4.51	0.775	33.7cd
	60	4.52	0.822	35.3bcd
60	0	4.47	0.768	31.3de
	30	4.66	0.856	33.3cd
	60	4.78	0.868	39.4ab
80	0	4.34	0.739	36.0bcd
	30	4.72	0.839	34.2ef
	60	4.80	0.897	40.8a

Means with different letters are significantly different at P<0.05. Means without letter differ non-significantly

Table III. Organic and inorganic fertilizer doses on main, lateral, total head (ton/ha) and number of heads

Fertilizer type		Yield			Number of heads per plant
Organic (ton ha^{-1})	Inorganic (kg ha^{-1})	Total	Main	Lateral	
0	0	2.06cd	21.85d	24.06d	65.5d
	30	2.04cd	30.46ab	32.50bc	80.2cd
	60	3.04ab	31.82ab	33.86ab	89.8bc
40	0	1.95d	24.30cd	26.64cd	70.9cd
	30	3.18a	30.78abc	33.71abc	81.0bcd
	60	2.92b	31.70ab	36.58a	90.8bc
60	0	2.21cd	26.87bcd	28.82bcd	75.3cd
	30	3.05ab	34.25ab	37.43ab	87.9bc
	60	3.09ab	36.00a	40.05a	120.1a
80	0	2.26c	24.34cd	26.36cd	75.6cd
	30	2.93b	31.67abc	34.72abc	94.5bc
	60	3.16a	34.97a	38.14a	104.4ab

Means with different letters are significantly different at P<0.05

Table IV. Organic and inorganic fertilizer doses on leaf chlorophyll content (mg g^{-1} fresh wt.) and head diameter (cm) of broccoli

Fertilizer type		Leaf chlorophyll content (mg g^{-1} fresh weight)	Head diameter (cm)	
Organic (ton ha^{-1})	Inorganic (kg ha^{-1})		Main	Lateral
0	0	19.48c	7.5e	5.0e
	30	26.83abc	8.5cde	6.1d
	60	26.31abc	8.5cde	6.2cd
40	0	21.86bc	7.7de	5.4e
	30	25.26abc	9.6ab	6.2cd
	60	26.96abc	9.5abc	6.8a
60	0	20.33bc	7.8cde	5.4e
	30	27.96ab	9.6ab	6.2cd
	60	27.79ab	9.9a	6.8a
80	0	23.52abc	8.0bcde	6.4bcd
	30	27.96ab	9.5ab	6.3bcd
	60	31.16a	10.3a	6.7ab

Means with different letters are significantly different at P<0.05

results are partially similar with results obtained by Blatt (1991) and Dufault *et al.* (2001) on broccoli (*B. oleracea* var. Italica); Bjelic and Stankovic (2000) and Al-Nasir (2002) on cauliflower (*B. oleracea* var. *Botrytis*); Radwan *et al.* (1993) and Togun and Akanbi (2003) on tomato (*Lycopersicon esculentum*) and Abdelrazzag (2002) on onion (*A. cepa*). It is seemed that organic manure need more time for nutrients to be available for plant absorption. However, the beneficial effect of organic manure on yield may be due to an increase in organic matter rate caused by the generation of carbon dioxide during compost decomposition (Wilkinson, 1979) and improvement of the

Table V. Organic and inorganic fertilizer doses on broccoli leaves macro- and micro-nutrient contents

Fertilizer type		Macronutrient			Micronutrient (mg kg^{-1})		
Organic (ton ha^{-1})	Inorganic (kg ha^{-1})	N (%)	P (mg kg^{-1})	K (mg kg^{-1})	Zn	Fe	Mn
0	0	3.18d	511	258b	119b	156e	3.25e
	30	3.33cd	532	271ab	138ab	188bcde	3.68de
	60	3.37bcd	553	302ab	148ab	211abc	4.00cde
40	0	3.21cd	555	272ab	137ab	166de	3.59de
	30	3.48abcd	559	294ab	145ab	189bcde	3.71de
	60	3.60abc	548	324ab	150ab	217ab	4.63bc
60	0	3.24cd	548	289ab	143ab	177cde	3.68de
	30	3.52abcd	550	337ab	148ab	191bcde	4.06bcd
	60	3.84ab	579	359ab	149ab	220ab	4.81b
80	0	3.33cd	567	313ab	149ab	205abc	4.03bcde
	30	3.55abcd	555	342ab	149ab	222ab	4.20bcd
	60	3.87a	565	399a	151a	223a	5.02a

Means with different letters are significantly different at P<0.05. Means without letter differ non-significantly

Table VI. Organic and inorganic fertilizers effect on soil pH, EC and organic matter contents

Fertilizer type		pH	EC (dS m^{-1})	Organic matter (%)
Inorganic(kg ha^{-1})	Organic (ton ha^{-1})			
0	0	7.8	1.27f	2.73b
	30	7.9	1.22f	2.65b
	60	7.8	1.28f	2.69b
40	0	7.8	1.36e	3.12ab
	30	7.9	1.46de	3.37ab
	60	7.8	1.69cd	3.36ab
60	0	7.9	1.79cd	3.46a
	30	8.0	1.80cd	3.45a
	60	7.9	1.92bc	3.63a
80	0	8.1	1.98abc	3.54a
	30	8.1	2.18ab	3.60a
	60	8.1	2.26a	3.75a

Means with different letters are significantly different at P<0.05. Means without letter differ non-significantly

soil structure conditions, which encouraged the plant to have a good root development by improving the aeration of the soil (Arisha *et al.*, 2003).

Number of heads per plant was significantly (P>0.05) affected by different combinations of organic and inorganic fertilizers (Table III). The highest number of heads (120.1 plant^{-1}) was produced by adding of 60 ton ha^{-1} organic manure with 60 kg ha^{-1} inorganic fertilizer. While the lowest number of heads per plant (65.5 plant^{-1}) was obtained from control plots (without fertilizer). These results are in agreement with those obtained by Stamatiadis *et al.* (1999). Roe and Cornforth (2000) found that highest broccoli heads number (75 heads plant^{-1}) produced by application of compost at rate 90 t ha^{-1}. Generally, yield and number of broccoli heads had the same trend in response to organic manure doses, inorganic fertilizers doses and their interactions.

Diameter (cm) of main and lateral heads was increased due to application of the highest dose of organic manure (80 t ha^{-1}) and inorganic fertilizers dose (60 kg ha^{-1}). Regardless of organic manure dosages, each increase in inorganic fertilizers dose caused a gradually increased in diameter of main and lateral heads. Application of 60 kg ha^{-1} inorganic fertilizer with different organic manure doses produced significantly larger main and lateral heads diameter compared with 0 and 30 kg ha^{-1} inorganic fertilizer (Table IV). Positive effects of inorganic fertilizers on head diameter may be due to the better availability of soil nutrients that produced healthy plants with large vegetative growth, which reflected in the yield and head diameter (Arisha *et al.*, 2003) and improvement soil chemical and physical properties by using organic manure (Roe & Cornforth, 2000).

Leaf chlorophyll content. Leaf chlorophyll content was significantly higher when inorganic fertilizer adding with organic manure compared with using organic manure alone (Table IV). Application the highest dosages of organic manure (80 ton ha^{-1}) with highest dose of inorganic fertilizer (60 kg ha^{-1}) induced the highest leaf chlorophyll content, while the lowest chlorophyll content obtained by control treatment. These results agreed with the previous findings obtained on other vegetable crops (Arisha & Bradisi, 1999; Al-Tarawneh, 2005). A promotion effect of organic and inorganic fertilizers on chlorophyll contents might be attributed to the fact that N is a constituent of chlorophyll molecule. Moreover, nitrogen is the main constituent of all amino acids in proteins and lipids that acting as a structural compounds of the chloroplast (Badr & Fekry, 1998; Arisha & Bradisi, 1999).

Leaf mineral composition. Leaf nitrogen content was significantly increased by the application of organic manure and inorganic fertilizer. The highest leaf N content (3.87%) was produced when the greatest dose of both organic manure and inorganic fertilizer was applied; while the

lowest (3.18%) produced by control treatment. Adding 30 and 60 kg inorganic fertilizer/ha with organic manure caused higher leaf N contents compared without inorganic fertilizer (Table V). Similar results were obtained by Radwan *et al.* (1993); Wong (1990); Abdelrazzag (2002) and Magnusson (2002) on several vegetable crops. A higher value of leaf N content could be attributed to the ability of organic manure to supply nutrients throughout mineralization and improvement the physical and chemical properties of the soil and the ability of organic fertilizer to release nutrients gradually throughout the growing season. Leaf P and K contents were not significantly affected by different fertilizer combinations, except leaf K content was significantly lower without adding fertilizers. However, the differences among fertilizer dosages were found non-significant. This may be due to that broccoli heads needed these elements to induce heads formation. Therefore, P and K concentrations in the leaves were decline due to remobilization of them to the heads.

Leaf mineral contents (Fe, Mn & Zn) were significantly affected by the application of organic and inorganic fertilizers (Table V). In general, each increase in organic manure and inorganic fertilizers dosages resulted in an increase in Fe, Mn and Zn leaf contents, but the differences in some cases were found non-significant. The highest broccoli leaf Fe (151 mg kg^{-1}), Mn (223 mg kg^{-1}) and Zn (5.02 mg kg^{-1}) contents were observed by application the highest dosages of both organic manure (80 t ha^{-1}) and inorganic fertilizer (60 kg ha^{-1}), whereas the lowest leaf contents were observed by control treatment (Adediran *et al.*, 2004; Bokhtiar & Sakurai, 2005). The effect of organic manure on Fe-uptake, could be due to the reason that organic carbon acts as a source of energy for soil microorganism, which upon mineralization releases organic acids that decreased soil pH and improves availability of makes Fe (Adediran *et al.*, 2004; Bokhtiar & Sakurai, 2005).

Certain soil characteristics. Organic and inorganic fertilizers and their interactions had no significant effects on the soil pH (Table VI), which is similar to the findings of Zane and Basil (1980) and Mahendra *et al.* (1988). This could be due to the soil of experimental site had a relatively high buffering capacity based on its high carbonate contents and can fix any change in its pH during organic matter decomposition (Wong *et al.*, 1999). Soil EC was significantly increased by adding of inorganic fertilizer with organic manure compared with only inorganic fertilizer treated plots (Zane & Basil, 1980). The possible explanation for increasing EC may be due to the large quantities of soluble salts and HCO^{-}_{3} contained in the manure compost (Wong *et al.*, 1999). Application of different doses of organic manure with or without inorganic fertilizer was significantly increased organic matter percentage in the soil, but application of inorganic fertilizer alone had no effects (Zane & Basil, 1980; Theodora *et al.*, 2003; Al-Tarawneh, 2005).

CONCLUSION

Broccoli can be grown better in soil amended with organic fertilizer but application rate and availability of all minerals should be considered. Broccoli plants grown in soil amended with organic fertilizer were shown a vigorous vegetative growth (leaf number, fresh & dry weights), high yield and large head diameter comparing with application chemical fertilizer alone. Furthermore, organic broccoli products are expected to be healthy for human and may be more profitable than those from conventional production system. Further studies are needed to determine optimal rates of organic for proper growth and production of broccoli.

REFERENCES

Abdelrazzag, A., 2002. Effect of chicken manure, sheep manure and inorganic fertilizers on yield and nutrient uptake by onion. *Pakistan J. Biol. Sci*., 5: 266–8

Adediran, A.J., B.L. Taiwo, O.M. Akande, A.R. Sobule and J.O. Idowu, 2004. Application of organic and inorganic fertilizer for sustainable maize and cowpea yields in Nigeria. *J. Plant Nutr*., 27: 1163–81

Al-Nasir, F., 2002. Effect of organic fertilizers on yield and nutrients concentration of cauliflower plant. *Arch. Acker-Pfl. Boden*, 48: 37–47

Al-Tarawneh, A.A., 2005. The effects of two types of organic manure and NPK on growth, yield and quality of lettuce and strawberry. *M. Sc. Thesis*, Mu'tah University, Jordan

Arisha H.M. and A. Bradisi, 1999. Effect of mineral fertilizers and organic fertilizerss on growth, yield and quality of potato under sandy soil conditions. *Zagazig J. Agric. Res*., 26: 391–405

Arisha, H.M.E., A.A. Gad and S.E. Younes, 2003. Response of some pepper cultivars to organic and mineral nitrogen fertilizer under sandy soil conditions. *Zagazig J. Agric. Res*., 30: 1875–99

Badr, L.A.A. and W.A. Fekry, 1998. Effect of intercropping and doses of fertilization on growth and productivity of taro and cucumber plants. 1-vegetative growth and chemical constituents of foliage. *Zagazig J. Agric. Res*., 25: 1087–101

Bjelic, V.N. and L.N. Stankovic, 2000. Effect of manuring on cauliflower development and yield. *Acta Hort*., 533: 397–8

Bin, J., 1983. Utilization of green manure for raising soil fertility in China. *Soil Sci*., 135: 65–9

Blatt, C.R., 1991. Comparison of several organic amendments with a chemical fertilizer for vegetable production. *Sci. Hortic.*, 47: 177–89

Bokhtiar, S.M. and K. Sakurai, 2005. Integrated use of organic manure and chemical fertilizer on growth, yield and quality of sugarcanes in High Ganges River floodplain soils of Bangladesh. *Soil Sci. Plant Analysis*, 36: 1823–37

Dauda, S.N., F.A. Ajayi and E. Ndor, 2008. Growth and yield of water melon (*Citrullus lanatus*) as affected by poultry manure application. *J. Agric. Soc. Sci.*, 4: 121–4

Decoteau, D.R., 2000. *Vegetable Crops*. Upper Rever Company. New Jersey, U.S.A

Dufault, J.R., A. Korkmaz and B. Ward, 2001. Potential of biosolids from shrimp aquaculture as a fertilizer for broccoli production. *Compost Sci and Utilization*, 9: 107–14

Gupta, A.P., S.R. Antil and P.R. Narwal, 1988. Effect of farmyard manure on organic carbon, available N and P contents of soil during different periods of wheat growth. *J. Indian Soil Sci*., 36: 269–73

Harborne, J.B., 1973. Chlorophylls. *In*: *Phytochemical Methods: A Guide to Modern Techniques of Plant Analysis*, 2nd edition, pp: 215–22

Magnusson, M., 2002. Mineral fertilizers and green mulch in Chinese cabbage (*Brassica Pekinensis* Rupr): effect on nutrient uptake, yield and internal tipburn. *Soil Plant Sci*., 52: 25–35

Mahendra, S.B., S.D. Kenneth, R.S. Venkastewara and E.P. Vincent, 1988. Application of poultry manure influences Thompson seedless Grape production and soil properties. *Hort. Sci*., 23: 1010–12

Naeem, M., J. Iqbal and M.A.A. Bakhsh, 2006. Comparative Study of Inorganic Fertilizers and Organic Manures on Yield and Yield Components of Mungbean (*Vigna radiat* L.). *J. Agric. Soc. Sci*., 2: 227–9

Ministry of Agriculture, 2006. *Annual Report of Plant Production*. Plant production division, Amman, Jordan

Radwan, S.A., M. Aboel-fadl and E.A. Abo-Hussien, 1993. Effect of salinity and organic material (farmyard manure) addition on growth and mineral contents of tomato in sandy calcareous soil of Egypt. *Menofiya J. Agric. Res*., 18: 1929–46

Rangkadilok, N., M.E. Nicolas, R.N. Bennett, D.R. Eagling, R.R. Premier and W.J. Taylor, 2004. The effect of sulfur fertilizer on glucoraphanin levels in broccoli (*B. oleracea* L. var. italica) at different growth stages. *J. Agric. Food Chem*., 52: 2632–9

Rangkadilok, N., M.E. Nicolas, R.N. Bennett, R.R. Premier, D.R. Eagling and P.W.J. Taylor, 2002. Determination of sinigrin and glucoraphanin in *Brassica* species using a simple extraction method combined with ion-pair HPLC analysis. *Scientia Horticulturae*, 96: 27–41

Roe, E.N. and C.G. Cornforth, 2000. Effect of dairy lot scraping and composted dairy manure on growth, yield and profit potential of double-cropped vegetables. *Compost Sci. and Utilization*, 8: 320–7

Salunkhe, D.K. and S.S. Kadam, 1998. *Handbook of Vegetable Science and Technology: Production, Storage and Processing*, 1st edition. Marcel Dekker, Inc. Madison Avenue, New York, USA

Shiralipour, A. and B. Faber, 1996. Greenhouse Broccoli and Lettuce growth using composted bioslids. *Compost Sci. and Utilization*, 4: 38–44

Stamatiadis, S., M. Werner and M. Buchanan, 1999. Field assessment of soil quality as affected by compost and fertilizer application in a broccoli field (San Benito County, California). *Appl. Soil Ecol*., 12: 217–25

Steel, R.G.D. and J.H. Torrie, 1980. *Principles and Procedures of Statistics: A Biometrical Approach*, 2nd edition. McGraw-Hill, New York

Stewart, M.W., W.D. Dibb, E.A. Johnston and J.T. Smyth, 2005. The Contribution of Commercial Fertilizer Nutrients to Food Production. *Agron. J.*, 97: 1–6

Suresh, K.D., G. Sneh, K.K. Krishn and C.M. Mool, 2004. Microbial biomass carbon and microbial activities of soils receiving chemical fertilizers and organic amendments. *Archives Agron. Soil Sci.*, 50: 641–7

Talalay, P. and J.W. Fahey, 2001. Phytochemicals from Cruciferous plants protect against cancer by modulating carcinogen metabolism. *American Soc. Nutr. Sci.*, 23: 3027–33

Tandon, H., 1995. *Methods of Analysis of Soil, Plants, Waters and Ferilizer*, p: 144. Fertilizers Development and Consultation Organization, New Delhi, India

Theodora, M., S.L. Anastasios and A.G. Athanasios, 2003. Effects of injected liquid cattle manure on growth and yield of winter wheat and soil characteristics. *Agron. J.*, 95: 592–60

Togun, A.O. and W.B. Akanbi, 2003. Comparative effectiveness of organic-based fertilizers to mineral fertilizers on tomato growth and fruit yield. *Compost Sci. and Utilization*, 11: 337–42

Wilkinson, S.R., 1979. Plant nutrient and economic value of animal manures. *J. Animal Sci*., 48: 121–33

Wong, H.M., 1990. Comparison of several solid wastes on the growth of vegetable crops. *Agric. Ecosys. Envirn.*, 1: 49–60

Wong, J.W.C., K.K. Ma, K.M. Fang and C. Cheung, 1999. Utilization of manure compost for organic farming in Hong Kong. *Bio-resource Technol*., 67: 43–6

Yoldas, F., S. Ceylan, B. Yagmur and N. Mordogan, 2008. Effect of nitrogen fertilizer on yield quality and nutrient content in broccoli. *J. Plant Nutr*., 31: 1333–43

Zane, F.L. and D.D. Basil, 1980. Residual effects of dairy cattle manure on plant growth and soil properties. *Agron. J.*, 72: 123–30

(Received 21 August 2008; Accepted 19 September 2008)