Proceedings of Pakistan Society for Horticultural Science
2nd International Conference on Horticultural Sciences, February 18-20, 2016
Theme: Production Challenges and Food Security
Institute of Horticultural Sciences, University of Agriculture, Faisalabad, Punjab 38040, Pakistan

The Comparative Response of Radish (*Raphanus sativus* L. cv. Mino Early) Regarding Growth, Yield and Quality During First Year of Transition to Organic Farming System

Muneeb Ahmed Khan*[1], Muhammad Amjad[1], Naveed Ahmad[2]
[1]Institute of Horticultural Sciences, University of Agriculture Faisalabad, 38000, Pakistan
[2]Directorate of Floriculture, Research and Training Lahore, 54000, Pakistan
Emails: ahmedmuneeb47@gmail.com (M.A.K), amjaduaf@gmail.com (M.A)

Abstract

Organic farming is gaining popularity worldwide due to its harmony with nature and the positive effects on human health. Usually the organic produce gets better market response in health-conscious societies owing to the reported health benefits. There is tremendous potential for development of organic vegetable sector in Pakistan due to availability of cheap labour. A study was conducted in the winter growing season 2010-2011, to draw comparison between the recommended chemical fertilizer treatment and different organic manure treatments to estimate the response of radish during first year of transition to organic production. Chemical fertilizer sources applied to meet the recommended NPK requirements were urea, sulphate of potash (SOP) and diammonium phosphate (DAP). Organic manures included in the study were green manure (GM), farmyard manure (FYM) and poultry manure (PM). Organic manures were applied singly or in combinations. Growth, yield and quality parameters were the focus of the study. Growth and yield of chemical fertilizer treatment was better than organic manure treatments. The various bio-chemical attributes such as TSS, TA, pH and vitamin C were similar in both farming systems. Among the mineral contents nitrogen percentage was significantly higher in chemical fertilizer treatment than some of the organic treatments while there was no significant difference regarding phosphorous, calcium, potassium, magnesium, iron and zinc contents of radishes from both types of farming systems. However significant differences were noted among various organic treatments regarding these minerals. The overall performance of T_8 (FYM+PM) was better than other organic treatments regarding growth, yield and nutritional quality. The poorest performance regarding growth and yield was exhibited by control which did not receive any of the fertilizer treatments. But interestingly control showed better results regarding dry matter percentage than other treatments.

INTRODUCTION

The demand for organically produced commodities is increasing globally. It is due to increase in awareness in people regarding the threats imposed by modern, high input agricultural practices to the health of consumers and ecosystems. This awareness and consciousness has paved the way for organic agriculture to be recognized worldwide as sustainable and eco-friendly agricultural production system that not only lays stress on yield but also on quality. In addition, it has positive effects on soil; ecosystems and human health. Proponents of organic farming consider organic farming as a solution of problems created by modern high input agricultural systems on ecosystems, soil fertility animal and human health. On the contrary, proponents of conventional farming consider organic production systems to be low in yields, poor in quality and against ecosystem. However more research is needed to evaluate which system is better in yield and quality.

Pondel *et al.* (2002) found that tomato yield was lower in organic systems during 1^{st}, 2^{nd} and 4^{th} year of study while greater in 3^{rd} and 5^{th} year than conventional 2 tomatoes (two-year rotation). They also found that there was 37% decrease in tomato yields in conventional 4 (four-year rotation) in last year of research and 17% decrease in conventional 2 tomatoes from the previous year. Maggio *et al.* (2008) found that organic farming resulted in a 25% marketable yield reduction in potatoes but these potatoes had higher dry matter percentage than potatoes from conventional system. Citak and Sonmez (2010) found that, in spinach number of leaves per plant, leaf length, petiole length, petiole diameter and stem diameter were more in conventional treatments. It is also reported that chemical fertilizers resulted in 6 to 10-fold increase in yield than control and 2 to 3-fold increase in yield than organic spinach. They also concluded that amongst all organic manures used, chicken manure (3.5 tonnes ha^{-1}) resulted in more vegetative growth and ultimate yield.

Moreira *et al.* (2003) reported that organically produced Swiss chard retained turgidity, colour and brightness for longer period than their conventionally produced counterparts. Mitchell *et al.* (2007) found that flavonoid glycones such as quercetin and kaempferol were 79% and 97% higher respectively in organic tomatoes than conventional over a 10 year mean level. Meyer and Adam (2008) reported that organic broccoli and red cabbage contained considerably higher amounts of glucobrassicin (aglucosinolate, which are thought to have protective effects in human body against various ailments including cancer).

Kelly and Bateman (2010) found that nitrate concentration is almost double in conventional lettuce than organic samples while organic lettuce has slightly higher phosphate concentrations but there is no significant difference in sulphate concentrations in both types of samples. Regarding trace elements organic lettuce contained higher $\delta^{15}N$, Cu and Rb. For tomatoes, they noted that organic tomatoes had higher $\delta^{15}N$, Ca, Zn, Rb and Cu while conventional samples had considerably higher Mn concentrations.

MATERIALS AND METHODS

Experimental Site

The experiment was conducted at the Experimental Vegetable Research Area, Institute of Horticultural Sciences, University of Agriculture Faisalabad, Pakistan (Latitude = 31°- 26' N, Longitude = 73°- 06' E, Altitude = 184.4 m). The experimental site was not under cultivation for the past few years. For soil analysis samples were taken at four depths (15, 30, 45 and 60 cm). Manures were also analysed for their chemical properties. The chemical properties of soil and manures are given in tables 1 and 2 respectively, while the climatic conditions during growth and development of crop are given in the table 3.

Manure and Fertilizer Application

In organic plots green manure (GM), farmyard manure (FM) and poultry manure (PM) were used as source of organic fertilizers. Egyptian Riverhemp, *Sesbaniasesban* (L.) Merr, locally called as jantar was used as green manure crop. Farmyard and poultry manures were collected from dairy and poultry farms of the University of Agriculture, Faisalabad. There were nine treatments with three replications in the study. The detail of treatments is as follows: T_1 Control (no synthetic or organic input); T_2 NPK 120+65+100 kg ha^{-1}; T_3 GM; T_4 FM 20 t ha^{-1}; T_5 PM 20 t ha^{-1}; T_6 GM+FM 20 t ha^{-1}; T_7 GM+PM 20 t ha^{-1}; T_8 FM 20 t ha^{-1}+PM 20 t ha^{-1}; T_9 GM+FM 20 t ha^{-1}+PM 20 t ha^{-1}. Each treatment unit measured 60 sq ft (10 X 6 ft) with two ridges, each having 8 ft length and running parallel to the length of treatment unit. Two adjacent treatment units were separated by 1.5ft wide bund to act as buffer zone between them. Green manure crop was sown on June 16, 2010 and it was chopped and mixed in soil on August 5, 2010 after 50 days of sowing. Farmyard manure and poultry manure was also applied to their respective treatment units manually at the time of incorporation of green manure. Then the field was left as such for proper decomposition of incorporated manures during hot and humid summer till crop sowing in October. To meet the requirement of nutrients in conventional treatment units, inorganic fertilizers (Urea; 46% N, DAP; 46% P+18%N and SOP; 50% K) were applied @120+65+100 kg NPK ha^{-1}. Nitrogen was applied in three splits i.e. 1^{st} during seed bed preparation, 2^{nd} after 21 days of seedling emergence and 3^{rd} after 42 days of seedling emergence. Whole dose of P and K was applied at seed bed preparation.

Cultivation of Experimental Crop

Radish variety 'Mino Early' was sown on October 16, 2010 at a distance of 5 cm plant × plant and 30 cm row × row. Sowing was done on both sides of the ridges in lines. Canal water was used for irrigation purpose at proper intervals according to irrigation needs of the crop. Weeding was done twice manually in both types of growing regimes. There was no major insect attack on the crop and thus no organic or conventional insect control measure was carried out.

Growth and Yield Analysis

Harvesting was done after 60 days of emergence (62 days after sowing), when the crop reached at optimum horticultural maturity and various vegetative growth and yield parameters such as root length, root diameter, number of leaves, shoot dry matter percentage, root dry matter percentage and yield were measured. To measure dry matter percentage shoots and roots were shade-dried for 2 weeks and then oven dried for48-72 hours, respectively, at 65°C.

Biochemical Analysis

Harvesting of crop was done after 60 days of emergence on December 17, 2010. For bio-chemical analyses three tap roots from each experimental unit were harvested and brought to laboratory where they were washed and their juice extracted with electronic juicer. Total soluble solids (TSS) were measured with digital refractometer (ATAGO RS-5000, Japan) and the reading was expressed as °Brix. Titratable acidity percentage (TA) of juice was measured by titration method using phenolphthalein indicator. The pH of juice was determined using digital pH meter (HI 98107, Hanna Instruments, Mauritius). Vitamin C contents of juice were calculated by taking 10 ml juice and making its volume 100 ml with 0.4% oxalic acid solution and then titrating 5 ml of the filtered aliquot with 2, 6-dichlorophenolindophenol dye.

Mineral Analysis

To determine mineral elements three tap roots were harvested from each experimental unit and brought to laboratory. These samples were properly washed, chopped into small pieces along with their peels, shade dried for 2 weeks and then oven dried at 65^o C for 72 hours. The oven dried pieces were grinded to a fine powdered form in an electronic grinder and stored in air tight bottles for further analyses. One gram dried and powdered sample was used for digestion. Nitrogen was determined by digesting with digestion mixture (K_2SO_4, CuSO4 and $FeSO_4$) and concentrated H_2SO_4 and subsequent distillationaccording to Kjeldhal method. The digestion for estimation of P, K, Ca, Mg, Fe and Zn was done with HNO_3 and $HClO_4$. The digested samples were properly bottled and stored for further analyses. Phosphorus was determined by spectrophotometer (Irmeco U2020, UV-vis spectrophotometer, Germany) while potassium was determined by flame photometer. Calcium, Magnesium, Iron and Zinc were determined through Atomic Absorption Spectrophotometer (Z-8200 Series Polarized Zeeman, Hitachi, Japan). Potassium was determined by flame photometer (Sherwood 410, Sherwood Scientific Ltd. UK). Calcium, magnesium, iron and zinc were determined by Atomic Absorption Spectrophotometer (Z-8200 Series Polarized Zeeman, Hitachi, Japan) by using specific lamp for each element.

Statistical Analysis

The experiment was carried out under Randomized Complete Block Design (RCBD). Analysis of Variance (ANOVA) test was used to evaluate the significance of the data. The Least Significant Difference (LSD) test ($P \leq 0.05$) was used to compare the differences among treatment means. The collected data were statistically analysed using the Statistix 8.1 software.

Table 1: Chemical properties of soil.

Soil Depth (cm)	**Soil Texture**	**pH**	**EC (dSm^{-1})**	**O.M. (%)**	**Mineral Contents (mg Kg^{-1})**						
					N*	**P****	**K**	**Ca**	**Mg**	**Fe**	**Zn**
0-15	Sandy loam	7.29	1.25	0.78	0.7	4.98	23.85	13.5	13.27	0.04	0.02
15-30	Loam	7.31	1.36	0.52	0.7	4.94	17.41	12.57	12.43	0.04	0.02
30-45	Loam	7.57	1.03	0.26	0.7	4.93	7.34	12.91	9.68	0.03	0.02
45-60	Loam	7.73	0.75	0.10	0.7	4.97	5.42	14.6	12.84	0.05	0.02
Average	**-**	**7.47**	**1.09**	**0.41**	**0.7**	**4.95**	**13.50**	**13.39**	**12.05**	**0.04**	**0.02**

O.M. – Organic Matter, EC –Electrical Conductivity

*N is Kjeldhal nitrogen given in percent value

**P is the value of total phosphorus in soil while the rest of elements are extractable minerals extracted from saturated soil paste and expressed as mg Kg^{-1}.

Table 2: Mineral composition of manures.

	N (%)	P (mg Kg-1)	K (mg Kg-1)	Ca (mg Kg-1)	Mg (mg Kg1)	Fe (mg Kg-1)	Zn (mg Kg1)
Green Manure	4.2	5.2	6077	1433	2389	163	56
Poultry Manure	2.68	6.77	6666	6214	4811	556	44
Farmyard Manure	1.05	5.38	6046	6215	3978	536	40

Table 3: Climatic conditions during growth and development of radish crop.

Months	**Average Daily Temperature (°C)**	**Relative Humidity (%)**	**Rainfall (mm)**	**Sunshine Radiation (Hours)**
October	26.3	59.6	0	7.56
November	18.8	62.3	0	8.5
December	14.80	70.4	0	7.3

RESULTS AND DISCUSSION

Growth and Yield Parameters

Root length did not differ significantly in treatments, the overall non-significant difference between chemical fertilizer treatment and all organic treatments shows that radish root length is responsive to these treatments in almost similar way (Table 4). The exact reason why did almost all treatments have achieved similar root lengths cannot be given. However, El-Desuki (2005) reported that average root length in radish increased with increase in N fertilizer treatment.

Root diameter significantly differed in treatments and the highest value for root diameter was achieved by NPK treatment (Table 4). There was no significant difference between treatments T_3, T_4 and T_5 meaning that green manure (T_3), farmyard manure (T_4) and poultry manure (T_5) had similar effect on radish root diameter. The poorest performance was shown by T_1, which was outcompeted by all other treatments. Results also show that the combination of manures (as in T_6, T_7, T_8 and T_9) gave better results than application of manures alone (as in T_3, T_4 and T_5). El-Desuki (2005) reported that average root diameter in radish increased with increase in N fertilizer treatment.

Number of leaves per plant significantly differed in treatments and the highest number of leaves per plant is achieved by chemical fertilizer treatment (Table 4). This means that synthetic fertilizers have more prominent effect on number of leaves per plant than organic fertilizers in radish. The higher number of leaves produced by T_2 plants might be the result of readily available nutrients released by NPK fertilizers and their quick uptake as compared to organic manures. Reported by Acquaah (2002) inorganic fertilizers release nutrients quickly which are readily available to plants in comparison to manures where nutrients are released slowly. The higher number of leaves produced by green manure than farmyard manureand poultry manure is obviously the result of more nitrogen percentage of leguminous green manure than poultry manure and farmyard manure (*Sesbaniasesban* Linn. contained 4.2% N as compared to 2.68% N in poultry manure and 1.05% N in farmyard manure). Our results regarding number of leaves per plant are supported by the results reported by Citak and Sonmez (2010) for spinach, where number of leaves per plant in conventional spinach was more than organic spinach and chicken manure gave more number of leaves per plant than farmyard manure.

Shoot dry matter percentage significantly differed in treatments and the highest value for shoot dry matter percentage was achieved by FYM and control, respectively (Table 4). It is interesting to note that the treated radish plants had poor performance based on their vegetative growth and shoot dry matter percentage e.g. the performance of T_1 and T_4 was not better than other treatments on the basis of general vegetative growth but these treatments gave better results on the basis of their shoot dry matter percentage. However, contrary to our findings Asaduzzaman *et al.* (2010) found that lettuce dry matter percentage increased with the increase in manure level and was higher in manure treatments than in control treatments.

Root dry matter percentage significantly differed in treatments and the highest value for root dry matter percentage was achieved by control (Table 4). The mean root dry matter percentage achieved by T_1 at harvesting was 11.62% and that of T_9 was 6.16%, while the rest of treatments were between these two values. The highest root dry matter percentage obtained by T_1 shows that fertilizers (chemical or organic) increase water contents and decrease dry matter percentage of radish tap roots. However contrary to our findings Asaduzzaman *et al.* (2010) found that lettuce dry matter percentage increased with increase in manure level and was higher in manure treatments than in control treatment.

Yield significantly differed in treated radish plants and the highest value for yield was achieved by T_2 (NPK) and the lowest value achieved by T_1 (control), respectively. The surprising thing to be noted is that green manure alone gave yields (92 tons ha^{-1}) comparable to the yields given by a combination of GM+FYM+PM (97 tons ha^{-1}). The possible reason for this might be the poor response of radish to a highly enriched soil fertilization regime, as it is a natural law that the positive response of an organism to an increase in input is up to a certain level beyond which the increasing input may reduce the outcome and even may cause negative impacts. This phenomenon is also obvious from the findings of Citak and Sonmez (2010) for the number of leaves per plant in spinach where number of leaves per plant were more in the alone application of chicken manure than a combined application of chicken manure, farmyard manure and blood meal. The reason why FYM and PM had lower yields than GM might be due to higher N provided by green manure (as it contained 4.2% N) than poultry manure (2.68% N) and farmyard manure (1.05% N). Yields of radish reported in literature are very low as compared to the yields obtained in present study. Cortez *et al.* (2010) also reported higher yields in radish with increase in manure and nitrogen fertilizers, but they found that N fertilizer gave significantly higher yields in radish than cattle manure. They also reported that increasing manure or fertilizer beyond a specific level caused reduction in yield of radish which is also in confirmation of our study that yield in GM+FYM+PM treatment was lower than GM+PM and FYM+PM treatments. However, findings of Haase *et al.* (2007) are contradictory to our findings in which cattle manure secured significantly higher yields in potato tubers than non-fertilized control.

Biochemical Attributes

Total soluble solids (TSS) did not differ significantly between organic and conventional system (Table 5), however one treatment (T_6; GM+FM) differed significantly from control. The non-significant difference among majority of the treatments indicates that this characteristic may not be influenced by organic or synthetic fertilizers in radish during first year of production under the given soil and climatic conditions. Total soluble solids percentage estimated in radishes by delAguila *et al.* (2008) were 3.5% lower than the estimated values. Juroszek *et al.* (2009) also reported non-significant differences in TSS of organically and conventionally grown tomatoes in conformation of our findings for radish. Lombardo *et al.* (2012) reported significantly lower TSS in organically grown potatoes which is contradictory to our findings of non-significant differences in radish.

Titratable acidity (TA) percentage did not differ significantly (Table 5). The non-significant results showed that fertilizers, whether conventional or organic, do not have any characterizing effect on titratable acidity of the radish tap roots during the first year of production, however further studies are needed to draw a conclusion. Titratable acidity percentage estimated by delAguila *et al.* (2008) in fresh cut radishes was 0.05% which is in confirmation to the estimated value. Juroszek *et al.* (2009) also reported non-significant differences in TA of organically and conventionally grown tomatoes in conformation of our findings.

The ***pH*** value of radish tap root also did not differ significantly among majority of the treatments (Table 5), however, two treatments, the inorganic treatment and the treatment in which a combination of GM+FM+PM was used, differed significantly from the control, which scored lowest pH value. The value of pH obtained in our study lies in the range 6.78-704 which is close to the values, 5.85-6.20, reported by Okine *et al.* (2007). Juroszek *et al.* (2009) also reported non-significant differences in pH of organically and conventionally grown tomatoes.

Vitamin C contents did not differ significantly between the growing systems, all organic treatments and the conventional fertilizer treatments shared the same statistical position (Table 5). Vitamin C estimated is in range of 19.89-23.87 mg 100 ml^{-1} which is close to the value22 mg 100 g^{-1}, given in the USDA Agricultural Research Service Nutrient Database for Standard Reference [USDA ARS NDB] (2011a). The vitamin C estimated by delAguila *et al.* (2008) in radish is 19 mg 100 g^{-1} which is also close to our estimated value. Worthington (2001) found overall 6% less vitamin C in organic carrots but 22% more in organic potatoes than conventional ones after reviewing various studies. Masamba *et al.* (2008) reported non-significant difference in vitamin C contents of conventionally and organically grown carrots which is in confirmation of our findings for radish. However, Citak and Sonmez (2010) observed higher vitamin C in organic spinach which is in contradiction of our findings of non-significant difference in vitamin C between organic and conventional radish. Vitamin C contents also depend on season of production as found by Citak and Sonmez (2010) in spinach and cultivar and year of production, besides the agricultural regime, as observed in some fruits by Camin *et al.* (2011). Thus, more cultivars of radish under different seasons of year and in different years of production must be analysed to draw a conclusion regarding differences in vitamin C contents of radish in both growing agricultural regimes.

Mineral Elements

Nitrogen percentage significantly differed among various organic treatments and also to some extent between the growing systems (Table 6). The conventional treatment and one organic treatment (T_8; FM+PM) significantly differed from control and those organic treatments which received only one type of organic fertilizer (T_3; GM, T_4; FM and T_5; PM). Although non-significant, yet surprisingly, T_9 (GM+FM+PM) received all three organic manures scored lower N value than T_6 (GM+FM) and T_7 (GM+PM). In the similar way, although non-significant, FM treatment scored higher N value than GM and PM treatments but it received less N on the basis of manure analysis report, shows that it had received less nitrogen (1.05%) than PM (2.68%) and GM (4.2%). Some researchers have reported non-significant difference in concentration of nitrogen in organic and conventional vegetables such as in carrots, potatoes and onions (Warman and Havard, 1997; Warman and Havard, 1998). However contrary to this, Herencia *et al.* (2011) and Kristensen *et al.* (2012) have have reported significantly higher N in conventional crops such as carrots and potatoes. Also, Igbokwe *et al.* (2005) reported non-significant difference in nitrogen concentration between conventional and organic sweet potatoes during first year of production but found significant difference in nitrogen concentration in the second year of cultivation.

Phosphorus contents did not differ significantly in various treatments (Table 6). The reason behind why all treatments scored similar phosphorus value cannot be given however an error during tissue digestion and further analysis may be a logical reason. Soil and manure analysis also showed very little phosphorus concentration. It is generally assumed that 1 ppm available soil phosphorus is enough for plant growth. However, phosphorus in the soil solution of the majority of agricultural soils is in the range of <0.01 to 1 ppm (Mullins, 2009). The value of phosphorus in oriental dried radish given in USDA National Nutrient Database for Standard Reference (2011b) is 204 mg 100 g^{-1} which is very high than the value obtained from this study and we assume that either due to very less P contents in manure and soil such lower value of P (total soil P was near 5 ppm while P in manures was 5-6 ppm) resulted in radish root tissues possibly an experimental error during any stage of analysis might have resulted in this very low value of phosphorus.

Potassium contents also did not differ significantly among various organic and the chemical fertilizer treatment (Table 6). It is unexplainable that all organic treatments and the conventional treatment scored the same statistical position with control which did not receive any synthetic or organic input. The value of Kgiven for oriental dried radish in USDA ARS NDB (2011b) is 3494 mg 100 g^{-1}which is almost four times higher than the value we obtained from our work, while the value of potassium reported for different cultivars of radish by Kaymak *et al.* (2010) lies in the range of 185-288 mg 100 g^{-1} on dry weight basis which is almost four times less than the values obtained. Warman and Havard (1997) reported non-significant differences in potassium contents in conventional and organic carrots during the first year of production is in line with our findings. However, some researchers have reported higher K value in organic potatoes and onions (Jarvan and Edesi, 2009; Warman and Havard., 1998; Wszelaki *et al.*, 2005) or even inconsistent trend have been reported (Herencia *et al.*, 2011).

Calcium contents did not differ significantly among various treatments (Table 6). The exact reason for this unexpected response needs to be further worked out. The value of calcium given for oriental dried radish in USDA ARS NDB (2011b) is 629 mg 100 g^{-1} close to the value we obtained from our work while the value of calcium mentioned for different cultivars of radish given by Kaymak *et al.* (2010) lies in range of 18-46 mg 100 g^{-1} which is far less than the value obtained. Similar results of non-significant difference between conventional and organic vegetables, regarding their calcium contents, are already reported by some researchers for other vegetables such as in carrots and onions (Warman and Havard, 1997). However, some scientists have reported higher Ca value in organic vegetables such as potatoes and sweet potatoes (Igbowke *et al.*, 2005; Jarvan and Edesi, 2009; Warman and Havard, 1998).

Magnesium contents differed significantly only between treatments T_6 (GM+FM) and T_3 (GM) while there was no significant difference among other treatments (Table 6). Although non- significant, control and all organic treatments, except T_3, scored higher magnesium value than NPK treatment. The value of magnesium reported for different cultivars of radish by Kaymak *et al.* (2010) lies in range of 8-21 mg 100 g^{-1} which is in confirmation of the value we obtained. However, the value of magnesium in oriental dried radish reported in USDA ARS NDB (2011b) is 170 mg 100 g^{-1} which is almost seven times higher than the value obtained from this research. However contrary to our finding, some researchers have reported significantly higher magnesium contents in organic vegetables such as in carrots, potatoes and sweet potatoes (Igbowke *et al.*, 2005; Jarvan and Edesi, 2009; Warman and Havard, 1997; Warman and Havard, 1998; Worthington, 2001; Wszelaki *et al.*, 2005).

Iron contents differed significantly only in treatment T_6 (GM+FM) which had higher iron contents than treatments T_1 (control), T_3 (GM) and T_9 (GM+FM+PM) while there was no significant difference among these and the rest of treatments (Table 6). However, the organic radishes did not differ statistically from conventional radishes. The value of iron given for oriental dried radish in USDA ARS NDB (2011b) is 6.73 mg 100 g^{-1} closed to the estimated values. Similar findings of non-significant differences in Fe concentration were reported for other vegetables such as carrots and onions (Warman and Havard, 1997). Contrary to our finding, some researchers have reported significantly higher iron concentration in organic vegetables such as in carrots and potatoes (Warman and Havard., 1998; Worthington, 2001).

Zinc contents showed a mixed trend (Table 6) and treatments T_1 (control), T_2 (NPK) and T_8 (FM+PM) significantly differed from T_5 (PM) while there was no significant difference among these and the rest of treatments regarding zinc contents. On overall basis, there is no significant difference between the two agricultural regimes. The value of zinc given for oriental dried radish in USDA ARS NDB (2011b) is 2.13 mg 100 g^{-1} which is almost three times less than the values estimated for this study. Similar findings of non-significant differences in Zn contents between organic and conventional vegetables are already reported in carrots and onions (Warman and Havard, 1997). However contrary to our finding for radishes, Warman and Havard (1998) reported higher zinc contents in conventional potato tubers.

Table 4: Vegetative growth and yield.

Treatment	Root length (cm)	Root diameter (cm)	Number of leaves	Shoot dry matter (%)	Root dry Matter (%)	Yield (tons ha^{-1})
Control	28.47 b	1.51 d	13.22 d	12.25 ab	11.62 a	21.11 d
Mineral Fertilizer	36.95 a	3.24 a	26.10 a	11.01 bc	6.28 c	147.80 a
GM	34.84 ab	2.58 bc	21.44 b	10.58 cd	6.96 bc	92.59 abc
FM	32.87 ab	2.19 c	17.66 c	12.72 a	8.08 abc	51.17 bcd
PM	32.99 ab	2.24 c	19.663 bc	11.18 abc	6.223 c	73.35 bcd
GM+FM	34.55 ab	2.78 abc	19.993 bc	11.37 abc	10.55 ab	38.23 cd
GM+PM	35.82 ab	2.77 abc	22.107 b	9.11 d	6.330 c	105.01 ab
FM+PM	38.11 a	2.66 abc	22.217 b	10.60 cd	6.623 c	108.63 ab
GM+FM+PM	36.75 a	3.08 ab	21.107 bc	10.62 cd	6.163 c	97.45 abc
LSD Value	**7.38**	**0.64**	**3.46**	**1.57**	**3.70**	**61.05**

Table 5: Biochemical attributes of radish as affected by different organic manures and chemical fertilizers.

Treatments	TSS	TA	pH	Vitamin C
Control	4.33±0.57 b	0.05±0.02 a	6.78±0.08 b	21.88±6.21 a
Mineral Fertilizer	4.78±0.33 ab	0.06±0 a	7.03±0.06 a	20.87±2.99 a
GM	4.45±0.30 ab	0.06±0 a	6.85±0.08 ab	23.87±5.17 a
FM	4.39±0.17 ab	0.04±0.01 a	6.81±0.02 ab	21.88±1.73 a
PM	4.44±0.39 ab	0.05±0.01 a	6.85±0.12 ab	23.87±2.99 a
GM+FM	4.92±0.37 a	0.05±0.01 a	6.87±0.12 ab	19.89±4.56 a
GM+PM	4.56±0.19 ab	0.05±0.02 a	6.85±0.22 ab	19.89±4.56 a
FM+PM	4.73±0.34 ab	0.05±0.01 a	6.81±0.21 ab	19.89±4.56 a
GM+FM+PM	4.87±0.16 ab	0.05±0.01 a	7.04±0.12 a	19.89±6.21 a
LSD Value	**0.58**	**0.02**	**0.23**	**4.16**

Table 6: Mineral contents of radish as affected by different organic manures and chemical fertilizers.

Treatments	**N**	**P**	**K**	**Ca**	**Mg**	**Fe**	**Zn**
Control	1.02±0.33 b	0.3667 a	795.07±61 a	220.60±67.08 a	21.0±2.60 ab	10.63±1.53 b	7.90±0.46 a
Mineral Fertilizer	2.33±0.40 a	0.3667 a	847.60±58.37 a	212.30±39.31 a	18.50±0.87 ab	12.66±4.07 ab	7.86±0.25 a
GM	1.16±0.20 b	0.3633 a	820.30±66.33 a	211.17±12.12 a	17.0±3.12 b	10.80±1.85 b	7.70±0.10 ab
FM	1.21±0.39 b	0.3633 a	822.50±45.11 a	226.23±68.20 a	22.0±2.29 ab	11.53±2.19 ab	7.70±0.30 ab
PM	1.16±0.53 b	0.3700 a	825.83±50.73 a	190.63±38.45 a	19.0±3.77 ab	12.23±4.09 ab	7.36±0.06 b
GM+FM	1.51±0.40 ab	0.3700 a	856.50±48.98 a	223.80±43.34 a	22.50±3.97 a	15.86±0.78 a	7.66±0.25 ab
GM+PM	1.58±0.77 ab	0.3633 a	776.50±146.48 a	208.87±87.25 a	21.0±2.60 ab	11.83±2.63 ab	7.76±0.15 ab
FM+PM	2.35±1.17 a	0.3733 a	833.70±58.08 a	220.80±131.08 a	20.0±4.33 ab	11.73±0.42 ab	7.83±0.06 a
GM+FM+PM	1.44±0.32 ab	0.3633 a	819.87±41.56 a	192.70±25.25 a	19.50±2.60 ab	10.60±1.57 b	7.50±0.30 ab
LSD Value	**0.91**	**0.0122**	**113**	**88.12**	**5.34**	**4.35**	**0.44**

CONCLUSION

The overall vegetative growth and yield of radish in chemical fertilizer treatment was better than radish from various organic manures applied singly and in various combinations. Among various organic treatments GM+PM (T_7) and FYM+PM (T_8) can be recommended considering the growth and yield response of radish following their incorporation. When selection is to be made for a single manure application for good vegetative growth and yield then green manure of Jantar (*Sesbania sesban* L.) should be preferred over farmyard manure and poultry manure as it is easy to raise, is comparatively cheaper and seed is widely available. Based on these findings it has been concluded that organically grown radish is not superior in quality than their conventional counterparts during first year of production. We have observed an inconsistent trend in nutritional quality of radishe among various organic manure treatments and concluded that various organic manures also do not confer a different nutritional trend, with respect to each other, during the first year of application. However, we strongly recommend that further studies in this regard should be carried out covering a broad range of vegetables and their varieties, geographical regions, soil and climatic conditions, varying management practices and sufficient time periods with replicated trials to reach on a conclusion about the nutritional superiority of vegetables produced in either type of the growing system.

REFERENCES

Acquaah, G. 2002. Horticulture: Principles and Practices. 108. Prentice Hall of India, Private Limited, New Delhi.

Asaduzzaman, M., S. Sultana and M.A. Ali. 2010. Combined effect of mulch materials and organic manure on the growth and yield of lettuce. American-Eurasian Journal of Agricultural & Environmental Sciences. 9: 504-508.

Camin, F., M. Perini, L. Bontempo, S. Fabroni, W. Faedi, S. Magnani.2011. Potential isotopic and chemical markers for characterising organic fruits. Food Chemistry. 125: 1072-1082.

Citak, S. and S. Sonmez. 2010. Effects of conventional and organic fertilization on spinach (*Spinacea oleracea* L.) growth, yield, vitamin C and nitrate concentration during two successive seasons. Scientia Horticulturae. 126:415-420.

Cortez, J.W.M., A.B.C. Filho, E.L. Coutinho and A. Alves. 2010. Cattle manure and N-urea in radish crop (*Raphanus sativus*). (*Ciencia e Investigación Agraria)*. 37:45-53

Del Aguila, J.S., F.F. Sasaki, L.S. Heiffig, E.M.M. Ortega, M.J. Trevisan and R.A. Kluge. 2008. Effect of antioxidants in fresh cut radishes during the cold storage. Brazilian Archives of Biology and Technology. 51:1217-1223.

El-Desuki, M., S.R. Salman, M.A. El-Nemr and A.M.R. Abdel-Mawgoud. 2005. Effect of plant density and nitrogen application on the growth, yield and quality of radish (*Raphanus sativus* L.). Journal of Agronomy. 4:225-229.

Haase, T., C. Schüler and J. Heß. 2007. The effect of different N and K sources on tuber nutrient uptake, total and graded yield of potatoes (*Solanum tuberosum* L.) for processing. European Journal of Agronomy. 26:187–197.

Herencia, J.F., P.A. Garcia-Galavis, J.A.R. Dorado andC. Maqueda. 2011. Comparison of nutritional quality of the crops grown in an organic and conventional fertilized soil. Scientia Horticulturae. 129:882-888.

Igbokwe, P.E., L.C. Huam, F.O. Chukwuma and J. Huam. 2005. Sweet potato yield and quality as influenced by cropping systems. Journal of Vegetable Science. 11(4):35-46.

Järvan, M. and L. Edesi. 2009.The effect of cultivation methods on the yield and biological quality of potato. Agronomy Research, 7:(Special issue I): 289-299.

Juroszek, P., H.M. Lumpkin, R.Y. Yang, D.R Ledesma and C.H. Ma. 2009. Fruit quality and bioactive compounds with antioxidant activity of tomatoes grown on-farm: comparison of organic and conventional management systems. Journal of Agricultural and Food Chemistry. 57:1188-1194.

Kaymak, H.C., I. Guvenc and A. Gurol. 2010.Elemental analysis of different radish (*Raphanus sativus* L.) cultivars by using wavelength-dispersivex-ray fluorescence spectrometry (WDXRF). Bulgarian Journal of Agricultural Science.16:769-774.

Kelly, S.D. and A.S. Bateman. 2010. Comparison of mineral concentrations in commercially grown organic and conventional crops – Tomatoes (*Lycopersicon esculentum*) and lettuces (*Lactuca sativa*). Food Chemistry. 119: 738–745.

Lombardo, S., G. Pandino, G. Mauromicale. 2012.Nutritional and sensory characteristics of ''early'' potato cultivars under organic and conventional cultivation systems. Food Chemistry. 133: 1249-1254.

Maggio, A., P. Carillo, G.S. Bulmetti, A. Fuggi, G. Barbieri and S.D Pascale. 2008. Potato yield and metabolic profiling under conventional and organic farming. European Journal of Agronomy. 28:343–350.

Masamba K.G. and M. Nguyen. 2008. Determination and comparison of vitamin C, calcium and potassium in four selected conventionally and organically grown fruits and vegetables. African Journal of Biotechnology. 7(16):2915-2919.

Meyer, M. and S.T Adam. 2008. Comparison of glucosinolate levels in commercial broccoli and red cabbage from conventional and ecological farming. European Food Research and Technology. 236:1429-1437.

Mitchell, A.E., Y.J. Hong, E. Koh, D.M. Barrett, D.E Bryant, R. Denyson And S. Kaffka. 2007. Ten-year comparison of the influence of organic and conventional crop management practices on the content of flavonoids in tomatoes. Journal of Agricultural and Food Chemistry. 55:6154-6159.

Moreira, M.D.R., S.I. Roura and C.E.D. Velle. 2003. Quality of Swiss chard produced by conventional and organic methods. Lebensmittel-Wissenschaft Und-Technologie-Food Science and Technology. 36:135-141.

Mullins, G. 2009. Phosphorus, agriculture and the environment. Virginia Cooperative Extension. VirginiaStateUniversity.Publication424-029.Availableonlineat http://pubs.ext.vt.edu/424/424-029/424-029_pdf.pdf (accessed on August 2, 2011)

Okine, A., A. Yimamu, M. Hanada, M. Izumita, M. Zunong and M. Okamoto. 2007. Ensiling characteristics of daikon (*Raphanus sativus*) by-product and its potential as an animal feed resource. Animal Feed Science and Technology.136:248-264.

Pondel, D.D., W.R. Howarth, W.T. Lanini, S.R. Temple and A.H.C. Van-Bruggen. 2002. Comparison of Soil N availability and leaching potential, crop yields and weeds in organic, low input and conventional farming systems in Northern California. Agriculture, Ecosystems and Environment. 90: 125-137.

Thorup-Kristensen, K., D.B. Dresbøll and H.L. Kristensen. 2012. Crop yield, root growth, and nutrient dynamics in conventional and three organic cropping systems with different levels of external inputs and N re-cycling through fertility building crops. European Journal of Agronomy. 37:66-82.

USDA Agricultural Research Service Nutrient Database for Standard Reference.2011a. Nutrient data for 11430, Radishes, oriental, raw. Release 24. Retrieved fromhttp://ndb.nal.usda.gov/ndb/foods/show/3216

USDA Agricultural Research Service Nutrient Database for Standard Reference. 2011b. Nutrient data for 11432, Radishes, oriental, dried. Release 24. Retrieved fromhttp://ndb.nal.usda.gov/ndb/foods/show/3216.

Warman, P.R. and K.A. Havard. 1997. Yield, vitamin and mineral contents of organically and conventionally grown carrots and cabbage. Agriculture, Ecosystems and Environment. 61:155-162.

Warman, P.R. and K.A. Havard. 1998.Yield, vitamin and mineral contents of organically and conventionally grown potatoes and sweet corn. Agriculture, Ecosystems and Environment. 68:207-216.

Worthington, V. 2001. Nutritional Quality of Organic Versus Conventional Fruits, Vegetables, and Grains. The Journal of Alternative and Complementary Medicine.7:161-173.

Wszelaki, A.L., J.F. Delwiche, S.D. Walker, R.E. Liggett, J.C. Scheerens and M.D. Kleinhenz. 2005. Sensory quality and mineral and glycoalkaloid concentrations in organically and conventionally grown redskin potatoes (*Solanum tuberosum*). Journal of the Science of Food and Agriculture. 85: 720-726.

Warman, P.R. and K.A. Havard. 1998. Yield, vitamin and mineral contents of organically and conventionally grown potatoes and sweet corn. Agriculture, Ecosystems and Environment. 68:207-216.