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GROWTH AND YIELD OF SPINACH (SPINACIA OLERACEA L.) UNDER FLUCTUATING LEVELS OF ORGANIC AND INORGANIC FERTILIZERS

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ABSTRACT

A field trial was conducted in a three replicated Randomized Complete Block Design during 2016 at Sindh Agriculture University to examine the production of spinach under varying levels of organic and inorganic fertilizers. The treatments included: T_1=Control, T_2=50 kg N ha^{-1}, T_3=50 kg N + 4 tons FYM ha^{-1}, T_4=50 kg N + 6 tons FYM ha^{-1}, T_5=75 kg N ha^{-1}, T_6=75 kg N + 4 tons FYM ha^{-1} and T_7=75 kg N + 6 tons FYM ha^{-1} (FYM = Farm yard menure). The results revealed that spinach plantation nourished with 75 kg N + 6 t ha^{-1} FYM produced the plants of 37.42 cm height on average, produced 18.05 leaves $plant^{-1}$, 43.31 g fresh weight, took 23.33 days to first cutting, 23.47 cm leaf length, 4.29 kg spinach yield $plot^{-1}$ and 7.152 t ha^{-1} spinach yield. The crop fertilized with 75 kg N + 4 t ha^{-1} FYM produced plants of 33.05 cm height, 16.26 leaves $plant^{-1}$, 39.02 g fresh weight, took 24.00 days to first cutting, 21.97 cm leaf length, 3.53 kg spinach yield $plot^{-1}$ and 5.879 t ha^{-1} spinach yield. The crop given 75 kg N ha^{-1} only (no FYM) produced plants of 30.76 cm height, 14.73 leaves $plant^{-1}$, 35.34 g fresh weight, took 24.67 days to first cutting, 18.55 cm leaf length, 2.97 kg spinach yield $plot^{-1}$ and 4.955 t ha^{-1} spinach yield. The values for almost all the characters declined with decreasing N and FYM levels and spinach crop given 50 kg N ha^{-1} + 6 t ha^{-1} FYM, produced plants of 29.97 cm height, 14.70 leaves $plant^{-1}$, 35.28 g fresh weight, took 26.00 days to first cutting, 18.50 cm leaf length, 2.73 kg spinach yield $plot^{-1}$ and 4.545 t ha^{-1} spinach yield. The treatment 50 kg N ha^{-1} + 4 t ha-1 FYM, 50 kg ha^{-1} N (without FYM) as well as control resulted in decline in value for all the traits investigated, minimum being in control. It was concluded that the spinach growth and yield as substantially higher under combined application of organic manures (FYM) in addition to inorganic nitrogen (as urea); and 75 kg N + 6 t ha^{-1} FYM resulted in optimum crop performance; while decrease in N, FYM or N application without FYM showed adverse impact on spinach yields.

INTRODUCTION

Spinach is leafy vegetable, botanically named as *Spinacia oleracea*. It is an edible flowering plant belongs to the *Amaranthaceae* family and probably originated in the central and southwestern Asia. The plant may survive over winter in temperate regions. The leaves are alternate, simple, and ovate to triangular-based, very variable in size from about 2–30 cm long and 1–15 cm broad, with larger leaves at the base of the plant and small leaves higher on the flowering stem. The flowers are inconspicuous, yellow-green, 3–4 mm diameter, maturing into a small, hard, dry, lumpy fruit cluster 5–10 mm across containing several seeds.

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Common spinach, *Spinacia oleracea*, was long considered to be in the *Chenopodiaceae* family, but in 2003, the *Chenopodiaceae* family was combined with the *Amaranthaceae* family under the family name '*Amaranthaceae*' in the order *Caryophyllales*. Within the *Amaranthaceae* family, *Amaranthoideae* and *Chenopodioideae* are now subfamilies, for the amaranths and the chenopods, respectively (Rolland and Sherman, 2006).In the nutritional context, the 100 g edible spinach contains Energy 97 kJ (23 kcal), Carbohydrates 3.6 g, Sugars 0.4 g, Dietary fiber 2.2 g, Fat 0.4 g, Protein 2.9 g, Water 91.4 g, Vitamin A equiv. 469 µg (59%), Vitamin A 9377 IU, Beta-Carotene 5626 µg (52%), Lutein and zeaxanthin 12198 µg, Thiamine (vit. B1), 0.078 mg (7%), Riboflavin (vit. B2), 0.189 mg (16%), Niacin (vit. B3), 0.724 mg (5%), Vitamin B6 0.195 mg (15%), Folate (vit. B9) 194 µg (49%), Vitamin C 28 mg

(34%), Vitamin E 2 mg (13%), Vitamin K 483 µg (460%), Calcium 99 mg (10%), Iron 2.71 mg (21%), Magnesium 79 mg (22%), Manganese 0.897 mg (43%), Phosphorus 49 mg (7%), Potassium 558 mg (12%), Sodium 79 mg (5%) and Zinc 0.53 mg (6%) (USDA, 2005). Irrespective of chemical fertilizers, the application of nutrients in organic form is gaining popularity due to fast growing organic farming worldwide and manures which included essentially required macro- and micronutrients are now being marketed. Reports indicate remarkable effect of manures and other organic forms of nutrients including farmyard manure. The farmyard manure is another organic nutrient that has proved to be one of the most effective organic sources of nutrients for crop production (Ayoola and Adeniyan, 2006).

The organic forms of nutrients must first be mineralized into plant-available forms such as nitrate. The FYM contains all the nutrients needed for crop growth including trace elements, albeit in small quantities. The rate of mineralization is variable and depends on soil type, moisture, temperature, and manure composition. When cow dung and urine are mixed, a balanced nutrition is made available to the plants. Swift, *et al*. (1994) observed that in households where crop and livestock production are integrated, FYM can become a major nutrient source for food crops and reduce the need for fertilizers. The integrated use of organic and inorganic fertilizers not only increase mutual efficiency but also helps in the substitution of costly chemical fertilizers (Hussain and Ahmed, 2000). Manures play a significant role in crop production by reducing the expenses on chemical fertilizers coupled with a practice of soil conservation. It has been experienced that partially decomposed manure is an excellent source of both nitrogen and phosphorus. Twenty tons of manure per acre can contribute more than 50 kg of nitrogen and significantly improve phosphorus nutrition. Manure may be used as a supplement to the regular fertilizer program. The nutrient elements in manure become available to plants over an extended time. In addition to the nutrients added with manure, the organic material supplied by manure improves soil structure and helps to make other fertilizer elements more readily available to the plant (Corgan, 2005).

Masarirambi *et al*. (2012) reported remarkable effect of farmyard manure when applied in addition to mineral fertilizers and partially replacing the NPK fertilizers on the growth and yield of leafy vegetables. El-Dewiny *et al*. (2006) reported improved yield and plant nutrient contents when FYM was applied in parallel to mineral fertilizers in spinach and radish crops. Patel *et al*. (2008) indicated that the FYM addition modified the distribution of various plant nutrient fractions leading to reduction in the plant nutrient availability. Therefore, FYM application could show beneficial effect to mitigate the adverse effect of Pb in the high Pb containing sewage irrigated soil. Ansari (2008) reported that farmyard manure and chemical fertilization improved the productivity of spinach significantly. Popat *et al*. (2009) reported significantly maximum fresh yield plant^{-1} (54.70 g at 1st, 33.53 g at 2nd cutting and 88.23 g total green leaf yield) and per hectare (14237 kg at 1st, 9296 kg at 2nd cutting). Dua *et al*. (2010) reported that agronomic and physiological efficiencies in spinach increased significantly in the presence of FYM in addition to balanced NPK status of soil. Alamgir *et al*. (2011) found that addition of FYM with straight NPK fertilizer program improved the crop yield substantially and soil fertility status also improved.

Rani *et al*. (2013) found that application of farm yard manure in addition to chemical fertilizers increased the growth substantially in spinach in spinach as well as in other leafy vegetables. Sevgi *et al*. (2014) found that highest lettuce yield (71.8 and 76.5 t ha^{-1}) was obtained with green manuring + FYM treatment and indicated that combined use of green manure and farmyard manure can be successfully used in organic lettuce production. The present study was carried out to examine the production of spinach under varying levels of organic and inorganic fertilizers.

MATERIALS AND METHODS

The experiment was conducted during 2016, to examine the production of spinach under varying levels of organic and inorganic fertilizers at the experimental area of Orchard, Department of Soil Science, Sindh Agriculture University Tandojam, Pakistan. The common spinach variety (Sindhi Palak) was used for this study. The experiment was laid out in Randomized Complete Block Design with three replications and seven treatments. The treatments were distributed at random in accordance with the statistical field design. The experimental soil was loamy in texture as per the visual observation. The sowing of the experimental crop was done on ridges in the 30 cm row spacing. The following treatments were tested in this experiment:

Treatments = 07

T1^=^Control
T2^=^50 kg N ha^{-1}
T3^=^50 kg N + 4 tons FYM ha^{-1}
T4^=^50 kg N + 6 tons FYM ha^{-1}
T5^=^75 kg N ha^{-1}
T6^=^75 kg N + 4 tons FYM ha^{-1}
T7^=^75 kg N + 6 tons FYM ha^{-1}

The well rotten FYM was applied at the time of sowing by mixing in the soil alongwith 1/3rd of urea, while the remaining urea was applied in two equal splits with a fortnight interval. Nitrogen was applied in the form of urea and a uniform dose of phosphorus (50 kg ha^{-1}) as single super phosphate (SSP) was also applied at the time of sowing.

Observations recorded:

- Plant height (cm)
- Number of leaves plant^{-1}
- Fresh leaves weight (g plant^{-1})
- Number of days taken to first cutting
- Leaf length (cm)
- Yield (kg plot^{-1})
- Yield (kg ha^{-1})

Procedures for recording observations

Plant height (cm): The plant height was recorded by using measuring tape in all the labeled five plants in each plot and then replication-wise averages were worked out.

Total number of leaves plant^{-1}: The total number of leaves sprouted in the spinach plant in each plot was counted on the basis of randomly selected five plants and then averages were calculated.

Fresh leaves weight plant^{-1} (g): At each cutting, the fresh weight of leaves plant^{-1} from the marketed produce was taken in grams to examine the overall treatment effect on the apparent quality of leaves and average plant^{-1} for each plot was worked out.

Number of days taken to first cutting: The days from sowing to first cutting were noted in each plot and accordingly the averages worked out.

Leaf length: Naturally, the leaves in spinach plants are not uniform in length and width, but for achieving an average size of the leaves, length of leaves in tagged plants was measured and average was worked out.

Yield plot^{-1} (kg): The fresh weight in each plot was summed up for all the cuttings in kilograms.

Yield ha^{-1} (kg): The total yield achieved from each plot was gathered and on the basis of yield plot^{-1}, the yield ha^{-1} was calculated.

Statistical analysis: by using Least Significant Difference (LSD) test.

RESULTS

In order to examine the production of spinach under varying levels of organic and inorganic fertilizers, the experiment was conducted during 2016, at the experimental area of orchard, Department of Soil Science, Sindh Agriculture University Tandojam, Pakistan. The experiment was laid out in Randomized Complete Block Design with three replications and seven treatments. The treatments included: T_1=Control, T_2=50 kg N ha^{-1}, T_3=50 kg N + 4 tons FYM ha^{-1}, T_4=50 kg N + 6 tons FYM ha^{-1}, T_5=75 kg N ha^{-1}, T_6=75 kg N + 4 tons FYM ha^{-1} and T_7=75 kg N + 6 tons FYM ha^{-1}. The parameters studied in this experiment included: plant height (cm), number of leaves plant^{-1}, leaf fresh weight (g), number of days taken to first cutting, leaf length (cm), yield plot^{-1}(kg) and yield ha^{-1} (tons ha^{-1}). The results on the characters mentioned above are given in Tables 1 to 7 and the analysis of variance for each parameter is shown as Appendix I to VII. The results on the basis of statistical outcome are interpreted and presented under respective sub-headings in this chapter.

Plant height (cm)

The effect of organic manure and inorganic nitrogen on the plant height of spinach was investigated and the results are presented in Table^{-1}; while the analysis of variance is given as Appendix-I. The analysis of variance (Appendix-I) demonstrated that the plant height of spinach was significantly (P<0.05) affected by different levels of organic manures nitrogen fertilizer. The spinach crop fertilized with 75 kg N + 6 tons FYM ha^{-1} produced significantly maximum plant height of 37.42 cm, followed by average plant height of 33.05 cm observed in plots receiving 75 kg N + 4 tons FYM ha^{-1}. Similarity in plant height of spinach was observed in plots receiving 75 kg N ha^{-1} without FYM (30.76 cm) and 50 kg N + 6 tons FYM ha^{-1} (29.97 cm); while considerable decrease in plant height was observed in plots fertilized with 50 kg N + 4 tons FYM ha^{-1} (27.65 cm) and 50 kg N ha^{-1} without FYM (23.65 cm). However, the minimum plant height of 16.29 cm was recorded in control plots, neither where N was applied and nor the FYM was given to the experimental spinach. The results indicated that application of inorganic manure (goat/sheep manure) in addition to inorganic nitrogen (as urea) was significantly beneficial for increasing the plant growth in spinach as compared to the plots given inorganic nitrogen without organic manures. Hence for achieving desired plant height in spinach, the crop needs to be fertilized with 75 kg N + 6 tons FYM ha^{-1}. However, 50 kg N + 6 tons FYM ha^{-1} or 75 kg N ha^{-1} alone resulted almost equal plant height, which indicates that 25 kg N could be compensated by 6 tons ha^{-1} FYM.

Table 1. Plant height (cm) of spinach as influenced by different levels of organic and inorganic fertilizers

Treatments (Organic manure and nitrogen levels)	RI	RII	RIII	Mean
Control	14.25	16.65	17.98	16.29 f
50 kg N ha^{-1}	23.65	24.65	22.65	23.65 e
50 kg N + 4 tons FYM ha^{-1}	27.65	28.65	26.65	27.65 d
50 kg N + 6 tons FYM ha^{-1}	29.65	30.60	29.65	29.97 c
75 kg N ha^{-1}	30.58	31.25	30.45	30.76 c
75 kg N + 4 tons FYM ha^{-1}	32.65	33.12	33.40	33.05 b
75 kg N + 6 tons FYM ha^{-1}	35.98	38.45	37.84	37.42 a
S.E. ±		0.7444		
LSD 0.05		1.6219		
LSD 0.01		2.2738		

In a column, means followed by same letters are not significantly different at P=0.05 as suggested by LSD test.

Leaves plant^{-1}

Leaves plant^{-1} in leafy vegetables like spinach is a character that contributes vitally to the overall crop produce. The results in relation to number of leaves plant-1 of spinach as influenced by different levels of organic manure and inorganic nitrogen are given in Table-2 and the analysis of variance as Appendix-II. The analysis of variance suggested that the leaves plant^{-1} of spinach were significantly (P<0.05) influenced by varied levels of organic manures and inorganic nitrogen. The crop given 75 kg N + 6 tons FYM ha^{-1} produced highest number of leaves plant^{-1} (18.05) , followed by 16.26, 14.73 and 14.70 average number of leaves plant-1 observed in plots receiving 75 kg N + 4 tons FYM ha^{-1}, 75 kg N ha^{-1} without FYM and 50 kg N + 6 tons FYM ha^{-1}, respectively. A considerable reduction in the number of leaves plant^{-1} was noted when the spinach crop was given 50 kg N + 4 tons FYM ha^{-1} (13.98) and 50 kg N ha^{-1} without FYM (12.83). However, the lowest number of leaves plant^{-1} (10.41) was observed in control plots, that were kept unfertilized of organic manure and inorganic N.

Table 2. Leaves plant^{-1} of spinach as influenced by different levels of organic and inorganic fertilizers

Treatments (Organic manure and nitrogen levels)	RI	RII	RIII	Mean
Control	9.650	10.320	11.250	10.41 f
50 kg N ha^{-1}	12.650	13.250	12.580	12.83 e
50 kg N + 4 tons FYM ha^{-1}	13.650	14.250	14.050	13.98 d
50 kg N + 6 tons FYM ha^{-1}	14.650	14.900	14.550	14.70 c
75 kg N ha^{-1}	15.020	14.650	14.510	14.73 c
75 kg N + 4 tons FYM ha^{-1}	16.650	16.250	15.880	16.26 b
75 kg N + 6 tons FYM ha^{-1}	17.650	17.840	18.650	18.05 a
S.E. ±		0.3791		
LSD 0.05	0.8259			
LSD 0.01	1.1579			

It was observed that combined application of inorganic N alongwith FYM at higher rate resulted remarkably better

performance for this trait when inorganic N was applied without FYM even at higher rate. However, 50 kg N + 6 tons FYM ha^{-1} or 75 kg N ha^{-1} alone resulted almost equal number of leaves $plant^{-1}$, indicates 6 tons ha^{-1} FYM compensated the cost of 25 kg N and also advantageous towards improving soil organic matter. In a column, means followed by same letters are not significantly different at P=0.05 as suggested by LSD test.

Fresh weight $plant^{-1}$

Fresh weight $plant^{-1}$ of spinach has direct effect on the final crop yields in spinach. The data in regards to fresh weight $plant^{-1}$ of spinach as affected by different levels of organic manure and inorganic nitrogen are given in Table-3 and the analysis of variance as Appendix-III. The analysis of variance indicated that varied levels of organic manures and inorganic nitrogen had significant (P<0.05) effect on the fresh weight $plant^{-1}$ of spinach. The spinach fertilized with 75 kg N + 6 tons FYM ha^{-1} produced highest fresh weight $plant^{-1}$ (43.31 g) , followed by 39.02 g, 35.34 g and 35.28 g average fresh weight $plant^{-1}$ observed in plots receiving 75 kg N + 4 tons FYM ha^{-1}, 75 kg^{-1} without FYM and 50 kg N + 6 tons FYM ha-1, respectively. A significant (P<0.05) reduction in the fresh weight $plant^{-1}$ was observed spinach crop given 50 kg N + 4 tons FYM ha^{-1} (33.56 g) and 50 kg N ha^{-1} without FYM (26.41 g). However, the minimum fresh weight $plant^{-1}$ (16.29 g) was noted in control (without manure and N application). The results showed that inorganic N and FYM when applied in combination at higher rates produced excellent performance for fresh weight; while in absence of FYM the crop performance for this trait was adversely affected. The LSD test suggested that the differences in fresh weight between 50 kg N + 6 tons FYM ha^{-1} or 75 kg N ha^{-1} alone were statistically non-significant.

Table 3. Fresh weight $plant^{-1}$ (g) of spinach as influenced by different levels of organic and inorganic fertilizers

Treatments (Organic manure and nitrogen levels)	RI	RII	RIII	Mean
Control	15.650	14.650	18.570	16.29 f
50 kg N ha^{-1}	25.650	26.340	27.250	26.41 e
50 kg N + 4 tons FYM ha^{-1}	32.760	34.200	33.720	33.56 d
50 kg N + 6 tons FYM ha^{-1}	35.160	35.760	34.920	35.28 c
75 kg N ha^{-1}	36.048	35.160	34.824	35.34 c
75 kg N + 4 tons FYM ha^{-1}	39.960	39.000	38.112	39.02 b
75 kg N + 6 tons FYM ha^{-1}	42.360	42.816	44.760	43.31 a
S.E. ±	0.9111			
LSD 0.05	1.9851			
LSD 0.01	2.7830			

In a column, means followed by same letters are not significantly different at P=0.05 as suggested by LSD test.

Days taken to first cutting

Generally the days to first cutting in spinach have no direct influence on crop yields, but the variation may be associated with the type and nutritional status of the soil. The results related to days taken to first cutting of spinach as influenced by varying levels of organic manure and inorganic nitrogen are presented in Table-4 and the analysis of variance as Appendix-IV. The analysis of variance showed that varied levels of organic manures and inorganic nitrogen had significant (P<0.05) impact on the days taken to first cutting. The crop given 75 kg N + 6 tons FYM ha^{-1} resulted the crop ready for first cutting in only 23.33 days, followed by 24.00, 24.67 and 26.00 days taken to first cutting observed in plots receiving 75 kg N + 4 tons FYM ha^{-1}, 75 kg N ha^{-1} without FYM and 50 kg N + 6 tons FYM ha^{-1}, respectively. Lesser days to first cutting were noted in crop given 50 kg N + 4 tons FYM ha^{-1} and 50 kg N ha^{-1} without FYM equally took 27.00 days to first cutting. However, the maximum days to first cutting (31.33) were noted in control, where no manure or N was applied. It was observed that with increasing the N level and addition of FYM resulted the crop ready to first cutting earlier than the crop receiving lower N levels and FYM or control. Statistically, the differences in days to first cutting in plots receiving 75 kg N ha^{-1}, 75 kg N + 4 tons FYM ha^{-1} and 75 kg N + 6 tons FYM ha^{-1} or among 50 kg N ha^{-1}, 50 kg N + 4 tons FYM ha^{-1} and 50 kg N + 6 tons FYM ha^{-1} were non-significant (P>0.05) and significant (P<0.05) when these both treatment groups were compared with each other or control.

Table 4. Days to first cutting of spinach as influenced by different levels of organic and inorganic fertilizers

Treatments (Organic manure and nitrogen levels)	RI	RII	RIII	Mean
Control	33.00	30.00	31.00	31.33 c
50 kg N ha^{-1}	28.00	27.00	26.00	27.00 b
50 kg N + 4 tons FYM ha^{-1}	28.00	26.00	27.00	27.00 b
50 kg N + 6 tons FYM ha^{-1}	25.00	26.00	27.00	26.00 b
75 kg N ha^{-1}	24.00	25.00	25.00	24.67 a
75 kg N + 4 tons FYM ha^{-1}	24.00	24.00	24.00	24.00 a
75 kg N + 6 tons FYM ha^{-1}	23.00	24.00	23.00	23.33 a
S.E. ±	0.7935			
LSD 0.05	1.7289			
LSD 0.01	2.4238			

In a column, means followed by same letters are not significantly different at P=0.05 as suggested by LSD test.

Leaf length (cm)

The impact of FYM and inorganic N on the leaf length of spinach was examined and the results are shown in Table-5; while the analysis of variance as Appendix-V. The analysis of variance (Appendix-V) illustrated that the leaf length of spinach was significantly (P<0.05) affected by different levels of organic manures and nitrogen. The spinach crop fertilized with 75 kg N + 6 tons FYM ha^{-1} produced significantly maximum leaf length of 23.47 cm, closely followed by average leaf length of 31.97 cm observed in plots receiving 75 kg N + 4 tons FYM ha^{-1}. Similarity in leaf length of spinach was observed in plots receiving 75 kg N ha^{-1} without FYM (18.55 cm) and 50 kg N + 6 tons FYM ha^{-1} (18.50 cm); while marked decrease in leaf length was observed in plots fertilized with 50 kg N + 4 tons FYM ha^{-1} (16.78 cm) and 50 kg N ha^{-1} without FYM (13.72 cm). However, the minimum leaf length of 8.17 cm was noted in control plots, neither where N and nor the FYM was applied. The results indicated that application of inorganic manure in addition to inorganic nitrogen (as urea) was highly beneficial for increasing the plant growth which resulted in increased length of leaves as compared to the plots given N (as urea) without FYM. Hence for achieving desired spinach growth, the crop needs to be fertilized with 75 kg N + 6 tons FYM ha^{-1}. However, the LSD test suggested non-significant differences in length of leaves in plots receiving 75 kg N + 6 tons FYM ha^{-1} and 75 kg N + 4 tons FYM ha^{-1} or 50 kg N + 6 tons FYM ha^{-1} and 75 kg N ha^{-1} alone. This suggested that crop spinach crop needs 75 kg N + 4 tons FYM ha^{-1} for producing optimally economic results for this trait.

Table 5. Leaf length (cm) of spinach as influenced by different levels of organic and inorganic fertilizers

Treatments (Organic manure and nitrogen levels)	RI	RII	RIII	Mean
Control	7.140	8.250	9.130	8.17 e
50 kg N ha^{-1}	13.250	14.650	13.250	13.72 d
50 kg N + 4 tons FYM ha^{-1}	15.650	16.240	17.250	16.38 c
50 kg N + 6 tons FYM ha^{-1}	19.250	18.260	17.980	18.50 b
75 kg N ha^{-1}	19.200	18.440	18.020	18.55 b
75 kg N + 4 tons FYM ha^{-1}	20.150	22.650	23.120	21.97 a
75 kg N + 6 tons FYM ha^{-1}	22.250	23.650	24.510	23.47 a
S.E. ±	0.7676			
LSD 0.05	1.6725			
LSD 0.01	2.3447			

In a column, means followed by same letters are not significantly different at P=0.05 as suggested by LSD test.

Yield plot^{-1} (kg)

The results in relation to yield plot-1 of spinach as affected by different levels of organic manure and inorganic nitrogen are given in Table-6 and the analysis of variance as Appendix-VI. The analysis of variance suggested that varied levels of organic manure and inorganic nitrogen had significant (P<0.05) effect on the yield plot^{-1} of spinach. The spinach crop fertilized with 75 kg N + 6 tons FYM ha^{-1} produced highest yield plot^{-1} (4.29 kg), followed by 3.53 kg, 2.97 kg and 2.73 kg average yield plot^{-1} observed in plots receiving 75 kg N + 4 tons FYM ha^{-1}, 75 kg N ha^{-1} without FYM and 50 kg N + 6 tons FYM ha^{-1}, respectively. A significant (P<0.05) decrease in yield plot^{-1} was observed spinach crop given 50 kg N + 4 tons FYM ha^{-1} (2.01 kg) and 50 kg N ha^{-1} without FYM (1.54 kg). However, the minimum yield plot^{-1} (0.80 kg) was observed in control (without manure and N application). The yield plot^{-1} increased simultaneously with increasing N levels or FYM quantities as well as with application pattern of N and FYM. The results showed that inorganic N and FYM when applied in combination at higher rates produced markedly higher yield plot^{-1}; while in absence of FYM the crop performance for yield plot^{-1} was adversely affected. The LSD test suggested linear and significant (P<0.05) effect of increasing N levels and FYM on the yield plot^{-1}.

Table 6. Yield plot^{-1} (kg) of spinach as influenced by different levels of organic and inorganic fertilizers

Treatments (Organic manure and nitrogen levels)	RI	RII	RIII	Mean
Control	0.75	0.67	0.99	0.80 f
50 kg N ha^{-1}	1.71	1.42	1.48	1.54 e
50 kg N + 4 tons FYM ha^{-1}	1.93	2.22	1.89	2.01 d
50 kg N + 6 tons FYM ha^{-1}	2.79	2.47	2.92	2.73 c
75 kg N ha^{-1}	2.99	2.99	2.94	2.97 c
75 kg N + 4 tons FYM ha^{-1}	3.53	3.58	3.47	3.53 b
75 kg N + 6 tons FYM ha^{-1}	4.19	4.49	4.19	4.29 a
S.E. ±	0.0975			
LSD 0.05	0.3003			
LSD 0.01	0.4210			

In a column, means followed by same letters are not significantly different at P=0.05 as suggested by LSD test.

Yield (t ha^{-1})

The yield ha^{-1} of spinach was calculated on the basis of yield plot^{-1} and the results in regards to this parameter as affected by different levels of organic manure and inorganic nitrogen are presented in Table-7; while the analysis of variance as Appendix-VII. The analysis of variance indicated that varied levels of organic manure and inorganic nitrogen had significant (P<0.05) impact on the yield ha^{-1} of spinach. It is evident from the results (Table-7) that the spinach crop fertilized with 75 kg N + 6 tons FYM ha^{-1} produced highest yield ha^{-1} (7.152 t ha^{-1}), followed by 5.879 t ha^{-1}, 4.955 t ha^{-1} and 4.545 t ha^{-1} average yield recorded in plots receiving 75 kg N + 4 tons FYM ha^{-1}, 75 kg N ha^{-1} without FYM and 50 kg N + 6 tons FYM ha^{-1}, respectively. A considerable (P<0.05) reduction in yield ha^{-1} was observed in spinach crop given 50 kg N + 4 tons FYM ha^{-1} (3.356 t ha^{-1}) and 50 kg N ha^{-1} without FYM (2.563 t ha^{-1}). However, the minimum yield ha^{-1} (1.339 t ha^{-1}) was noted in control (without manure and N application). It was observed that the spinach yield ha^{-1} increased concurrently with increased N or FYM levels or with application pattern of N and FYM. The inorganic N and FYM when applied in combination at higher rates produced higher spinach yield ha^{-1}; while in absence of FYM the spinach yield ha^{-1} declined considerably. The LSD test suggested that differences in spinach yield ha-1 between 50 kg N + 6 tons FYM ha^{-1} and 75 kg N ha^{-1} was non-significant (P>0.05) indicating that that FYM compensated effectively to additional N for producing higher spinach yields.

Table 7. Yield (t ha^{-1}) of spinach as influenced by different levels of organic and inorganic fertilizers

Treatments (Organic manure and nitrogen levels)	RI	RII	RIII	Mean
Control	1.251	1.111	1.654	1.339 f
50 kg N ha^{-1}	2.854	2.365	2.471	2.563 e
50 kg N + 4 tons FYM ha^{-1}	3.224	3.698	3.145	3.356 d
50 kg N + 6 tons FYM ha^{-1}	4.651	4.111	4.874	4.545 c
75 kg N ha^{-1}	4.984	4.987	4.895	4.955 c
75 kg N + 4 tons FYM ha^{-1}	5.887	5.965	5.784	5.879 b
75 kg N + 6 tons FYM ha^{-1}	6.985	7.485	6.985	7.152 a
S.E. ±	0.2316			
LSD 0.05	0.5047			
LSD 0.01	0.7075			

In a column, means followed by same letters are not significantly different at P=0.05 as suggested by LSD test.

DISCUSSION

The soil organic matter content in Sindh province has been decrease severely due to continuous cropping and farmers' lack of knowledge for soil management after each crop harvest. The farmers generally rely on inorganic fertilizers, and little attention is paid to the application of organic manures, that are the source of improving crop yield and maintaining soil organic matter. The present study was carried out to examine the production of spinach under varying levels of organic and inorganic fertilizers. The findings of the study showed that 75 kg N + 6 t ha^{-1} FYM produced the plants of 37.42 cm height on average, produced 18.05 leaves plant^{-1}, 43.31 g fresh weight, took 23.33 days to first cutting, 23.47 cm leaf length, 4.29 kg spinach yield plot^{-1} and 7.152 t ha^{-1} spinach yield. The crop fertilized with 75 kg N + 4 t ha^{-1} FYM produced plants of 33.05 cm height, 16.26 leaves plant^{-1}, 39.02 g fresh weight, took 24.00 days to first cutting, 21.97 cm leaf length, 3.53 kg spinach yield plot^{-1} and 5.879 t ha^{-1} spinach yield. The crop given 75 kg N ha^{-1} only (no FYM) produced plants of 30.76 cm height, 14.73 leaves plant^{-1}, 35.34 g fresh weight, took 24.67 days to first cutting, 18.55 cm leaf length, 2.97 kg spinach yield plot^{-1} and 4.955 t ha^{-1} spinach yield. The values for almost all the characters declined with decreasing N

and FYM levels and spinach crop given 50 kg N ha^{-1} + 6 t ha^{-1} FYM, produced plants of 29.97 cm height, 14.70 leaves $plant^{-1}$, 35.28 g fresh weight, took 26.00 days to first cutting, 18.50 cm leaf length, 2.73 kg spinach yield $plot^{-1}$ and 4.545 t ha^{-1} spinach yield. The treatment 50 kg N ha^{-1} + 4 t ha^{-1} FYM, 50 kg ha^{-1} N (without FYM) as well as control resulted in decline in value for all the traits investigated, minimum being in control. It was concluded that the spinach growth and yield was substantially higher under combined application of organic manures (FYM) in addition to inorganic nitrogen (as urea); and 75 kg N + 6 t ha^{-1} FYM resulted in optimum crop performance; while decrease in N, FYM or N application without FYM showed adverse impact on spinach yields. These results are in accordance with those of Chat *et al*. (2005) who found that application of NPK fertilizers in addition to some amounts of cattle or goat/sheep manure resulted in higher leaf growth and quality when used as vegetable. Nguyen and Preston (2006) found linear responses in biomass yield to higher levels of biodigester effluent in addition to recommended rate of N in spinach. Patel *et al*. (2008) indicated that the FYM in addition to recommended NPK fertilizers resulted in significant increase in spinach leaf yield and chemical composition. Canali *et al*. (2008) reported that N application at the rate of 150 kg ha^{-1} and 10 tons ha^{-1} farmyard manure resulted in higher leaf yield and quality of spinach. Patel *et al*. (2008) suggested that FYM application could show beneficial effect to mitigate the adverse effect of Pb in the high Pb containing sewage irrigated soil when such soils are used for spinach cultivation.

Popat *et al*. (2009) reported significantly maximum fresh yield $plant^{-1}$ (54.70 g at 1st, 33.53 g at 2nd cutting and 88.23 g total green leaf yield) and per hectare (14237 kg at 1st, 9296 kg at 2nd cutting). Dua *et al*. (2010) reported that agronomic and physiological efficiencies in spinach increased significantly in the presence of FYM in addition to balanced NPK status of soil. Najafi and Parsazadeh (2010) The greatest spinach shoots nitrate concentration was found in nitrate to ammonium ratio of 100:0 and pH of 8.0, while the greatest concentrations of organic N + inorganic ammonium and total N in spinach were observed in nitrate to ammonium ratio of 25:75 and pH of 6.5. Alamgir *et al*. (2011) found that addition of FYM with straight NPK fertilizer program improved the crop yield substantially and soil fertility status also improved. Islam *et al*. (2011) reported that increasing the application of poultry manure alongwith nitrogen at higher rates enhanced the spinach growth and increased fresh weight significantly. Sajirani *et al*. (2012) evaluated the effect of urea and manure on spinach yield and indicated that higher urea and manure application rates increased yield. Rani *et al*. (2013) found that application of farm yard manure in addition to chemical fertilizers increased the growth substantially in spinach in spinach as well as in other leafy vegetables. Sevgi *et al*. (2014) found that highest lettuce yield (71.8 and 76.5 t ha^{-1}) was obtained with green manuring + FYM treatment and indicated that combined use of green manure and farmyard manure can be successfully used in organic lettuce production.

Conclusion

It was concluded that the spinach growth and yield was substantially higher under combined application of organic manures (FYM) in addition to inorganic nitrogen (as urea); and 75 kg N + 6 t ha^{-1} FYM resulted in optimum crop performance; while decrease in N, FYM or N application without FYM showed adverse impact on spinach yields.

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