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Effect of organic and inorganic nutrient sources on soil health and quality of carrot

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ABSTRACT

Field experiments were conducted at CAZRI, Jodhpur during *rabi* seasons of 2008-09 and 2009-2010 to study the effects of organic and inorganic nutrient sources on carrot grown under irrigated conditions. Experiments were laid out in a RBD with eight treatments in three replications. Treatments comprising of 75% NPK through fertilizers + 25% N through VC (T_4) or compost (T_5), though were at par with 100% NPK through fertilizers (T_1) exhibited slightly higher values for root yield and its attributes and was *vice versa* for green top yield. Carrot quality attributes such as reducing sugar, total sugars and ascorbic acid content significantly increased with the higher level of N substitution (*i.e.*, for 100 and 75%) through compost or VC. Soil quality indicators such as soil *p*H, organic C, penetration resistance and FC moisture responded significantly better to organic manures at 100 or 75% N substitution as compared to solely inorganic fertilizers.

Key words: Organic, inorganic, INM, carrot, yield, quality, soil properties.

INTRODUCTION

Among the root vegetables, carrot (*Daucus carota* L.) is one of the most popular and remunerative vegetable crops in irrigated arid regions of western Rajasthan probably due to prevalence of loose textured sandy soils, which might favour better roots development. Being rich in nutrients, carrot foliage are fed to animals as green fodder in this region. Carrot is a heavy feeder of nutrients, which removes 100 kg N, 50 kg P_2O_5 and 180 kg K_2O ha^{-1} and is very sensitive to nutrient and soil moisture (Sunanada Rani and Malla Reddy, 13). Although inorganic fertilization is very important for the healthy plant growth and development, the organic source of nutrients have the advantage of consistent and slow release of nutrients, maintaining ideal C:N ratio, improvement in water holding capacity and microbial biomass of soil profile, without any adverse residual effects (Yadav *et al.*, 15). Furthermore, there have been positive responses of organic manures for quality attributes in different vegetables. Therefore, a balanced and integrated supply of various nutrient supplements is of great relevance for the quality and sustainable carrot production, more particularly in arid regions, where soils are loose, less in organic matter content and poor in water retention. Moreover, integrated use of inorganic and organic fertilizers reduces erosion, improves water infiltration, soil aeration and plant root growth, and also minimizes the risk of downstream flooding (Smaling, 11). Keeping the importance of organic manures in view, the experiment was undertaken to study the effect of different organic manures alone or in combination with inorganic fertilizers on yield and quality attributes of carrot. Besides, their effects on some of the soil physical and chemical properties were also studied.

MATERIALS AND METHODS

The experiments were conducted at Horticulture Block of the Central Research Farm, Central Arid Zone Research Institute, Jodhpur during *rabi* seasons of 2008-09 and 2009-10 to study the effect of organic and inorganic nutrient sources alone and in combinations on growth, yield and quality parameters of carrot. The soil of experimental field belonging to Pal Series was loamy sand in texture, having moderately high *p*H (8.30) and EC (0.29 dSm^{-1}), low organic carbon (0.195%), low available N and high available P and K. The average *p*H and EC of irrigation water were 7.8 and 2.05 dSm^{-1}, respectively. The experiment was laid out in a randomized block design with eight treatments comprising of organic and inorganic nutrient sources alone or in combinations (Table 1), replicated thrice. The N, P and K were applied at the rate of 120, 60 and 80 kg ha^{-1}. Nitrogen, phosphorus and potash were applied in the form of urea, single super phosphate and muriate of potash, respectively. Organic manures were added on the basis of nitrogen percentage (oven dry weight). The nitrogen content in compost and vermicompost was 0.45 and 1.05%, respectively. Full dose of manures and fertilizers for P and K were applied to each plot at field preparation

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whereas, fertilizer N in two splits, half as basal before sowing and remaining half as top dressing after 30 days of sowing. The gross plot size for each treatment was 3.5 m × 3.0 m and 1.0 m and 0.50 m space was left between plots and blocks, respectively. The carrot (cv. Supar Red) was sown in flat beds at a spacing of 30 cm × 5 cm in second fortnight of October and was harvested at horticultural maturity. The uniform irrigation was given by hose pipe at every interval (5-6 days) to each plot. The data on growth, yield and forking was recorded at the crop harvest. The quality parameters of freshly harvested carrots were determined at horticultural maturity. Soil samples were collected for estimation of *p*H, EC and organic C. The penetration resistance (cone index, CI) and field capacity (FC) soil moisture in 10 cm soil surface at crop harvest were recorded at field capacity, attaining by overnight drainage of saturated soil. The carrot quality attributes such as total soluble solids (TSS) content was determined with ERMA hand refractometer (0-32°Brix) and ascorbic acid content and the total and reducing sugar contents were estimated following standard procedures. The two year mean data were subjected to statistical analysis as per the method suggested by Gomez and Gomez (6).

RESULTS AND DISCUSSION

Application of different levels of manures, fertilizers (inorganic) and their combinations significantly influenced the plant height, root length, root diameter, root yield and green top (foliage) yield (Tables 1 & 2). Above ground biomass, *i.e.*, plant height (62.45 cm) and green top yield (23.44 t ha^{-1}) was maximum with the application of 100% NPK through fertilizers (T_1) compared to other treatments. The substitution of 25% N through VC along with 75% NPK through fertilizer (T_4) significantly increased carrot root yield (32.43 t ha^{-1}) and yield attributes such as root length (17.16 cm), root diameter (3.34 cm), fresh root weight (57.54 g) and root dry matter content (10.17 g 100 g^{-1}), which was on a par with the treatments, 100% NPK through fertilizer (T_1) and 25% N substitution through compost with 75% NPK as fertilizers (T_5). Root dry matter slightly improved with combined nutrient sources but the difference was non-significant for different treatments (Tables 1 & 2).

The beneficial effects of combined application of organic manure (VC or compost) and fertilizers might be attributed to the increased efficacy of inorganic fertilizers (Fritz and Wonneberger, 5) and supply of all the essential nutrients in a balanced amount owing to their control release coinciding with the stage of root development marked with increased root thickness, fresh root weight and dry matter accumulation after cessation of root growth. This result agrees with the finding of Sunanda Rani and Malla Reddy (12). As the crop was grown under irrigated condition, the beneficial effect of organic manures with inorganic fertilizers was envisaged by greater and longer availability of nutrients as per the demand of crop (Hegde and Dwivedi, 8). Though, same quantity of N was supplied through either organic or inorganic sources or in combination, application of full dose of N through organic sources (compost or VC) recorded lower value of plant growth and yield parameters compared to inorganic fertilizers alone or in combination, as was also reported by (Smitha *et al.*, 12). This might be due to the slow availability and release of nutrients in solely organic manure fertilized plots compared to inorganic or combined application of the two, *i.e.*, organic and inorganic sources.

The sources of nutrient application and their combinations significantly affected the root forking in carrot, which is an undesirable character from marketing point of view (Table 2). The significant

Table 1. Effect of different nutrient treatments on plant growth characters of carrot.

Treatment	Plant height (cm)	Root length (cm)	Root dia. (cm)	Root FW (g $plant^{-1}$)	Root DW (g 100 g^{-1})
T1, 100% NPK through fertilizers (NPK)	62.45	17.11	3.21	53.83	9.96
T-2, 100% N through VC	56.32	16.22	3.11	51.74	9.73
T-3, 100% N through compost	55.67	15.95	3.06	51.23	9.68
T-4, 75% NPK + 25% N through VC	60.23	17.16	3.34	57.54	10.17
T-5, 75% NPK + 25% N through compost	59.73	16.92	3.23	55.33	10.08
T-6, 25% NPK + 75% N through VC	57.12	16.87	3.19	53.56	9.87
T-7, 25% NPK + 75% N through compost	56.83	16.66	3.15	52.24	9.74
T-8, Control	49.65	15.14	2.73	42.32	9.19
$CD_{0.05}$	4.42	0.28	0.23	4.12	NS

Table 2. Effect of different nutrient treatments on forking and yield of carrot root and green top.

Treatment	Root yield ($t\ h^{-1}$)	Forked root (%)	Green top yield ($t\ ha^{-1}$)
T1, 100% NPK through fertilizers (NPK)	31.08	9.29	23.44
T-2, 100% N through VC	27.62	4.95	19.34
T-3, 100% N through compost	26.83	5.27	19.27
T-4, 75% NPK + 25% N through VC	32.43	7.63	23.12
T-5, 75% NPK + 25% N through compost	30.12	7.53	22.53
T-6, 25% NPK + 75% N through VC	28.53	5.31	21.67
T-7, 25% NPK + 75% N through compost	28.05	5.55	20.43
T-8, Control	16.19	7.13	12.26
$CD_{0.05}$	1.83	2.1	1.24

decrease in forking percentage was observed for treatments comprising of N substitution through organic manures (VC or compost) to the tune of 100% and 75% over those devoid of organic manures, *i.e.* 100% NPK through fertilizers or substituted at lower rate (25%) for N with 75% NPK through fertilizers and control. The decrease in forking percent with increased levels of N through organic manures in different treatments could be attributed to lower availability and uptake of N at root growth stage due to its control release besides, the improvement of soil environment such as lowered CI-due to addition of high quantity organic manure.

All the carrot quality attributes except TSS content that showed non-significant response to the treatments, were influenced significantly by application of different levels of organic, inorganic and combined sources of nutrient (Table 3). Application of 75% N through VC recorded higher ascorbic acid content which was on a par with 75 and 100% N substitution with compost and vermi-compost, respectively. It is reported by various researchers that organically fertilized soils generally produce plants with lower amounts of nitrogen than chemically fertilized ones because of which it would be expected that organic crops would have more vitamin C, less nitrates and less protein, and a higher chemical quality than conventional crops (Bear *et al.*, 2).

Substitution of 100% N through VC or compost (T_2 & T_3) resulted in significantly higher reducing and total sugars content in carrot over 100% NPK through fertilizer (T_1) and control (T_8). The response of 75% N through VC or compost with 25% NPK through fertilizers was statistically similar to that with 100% N substitution through manures for reducing and total sugar (Table 3). Such an increase in sugar content due to the application organic nutrient source was also reported by Hailu *et al.* (7). The improvement of nutrient quality attributes may be due to better availability and uptake of nutrients in combination of manures which might have lead to the balanced C/N ratio and increased activity of plant metabolism as suggested by Emura and Hosoya (4) in carrot.

Among the organic manures, the response of VC was superior to compost with respect to majority of yield and quality attributes in carrot, regardless of levels in treatment combinations; similar was reported by Prasad (10). The superior effect of VC may be due to higher level of various plant growth regulating materials and humic acids, produced by the increased activity of microbes (Arancon *et al.*, 1). The nutrient treatments influenced soil *p*H, organic C and FC moisture significantly, but their effect was non-significant on EC and CI (Table 4). In general, *p*H and organic C content increased but EC decreased over their initial values of 8.4, 0.19% and 0.29 dS m^{-1}, respectively. The increase in *p*H was significantly lower in treatments receiving higher quantity of organic manures, *i.e.*, 100% N through VC or compost (T_2 & T_3) compared to rest of the treatments, but was on a par with treatment receiving 75% N through VC with 25% NPK through fertilizers (T_6). The increase in soil *p*H over its initial value might be due to high *p*H (7.8) and EC (2.05 dS m^{-1}) of irrigation water and consequent of frequent irrigation led the accumulation of salts on upper soil surface. The milder increase in soil *p*H for higher rate of organic manure application may be ascribed to the formation of organic acids due to decomposition of organic manure and crop residues. Similar was the finding of Sur *et al.* (14), who have also reported the beneficial effects of organic manures over inorganic fertilizers in reducing soil *p*H. The soil EC increased with the amount of compost or VC, but the differences were non-significant. Our results reveal that the organic C content corresponds with the increase in

Table 3. Effect of different nutrient treatments on carrot quality attributes.

Treatment	TSS (°Brix)	Ascorbic acid (mg 100 g^{-1})	Reducing sugar (%)	Total sugars (%)
T1, 100% NPK through fertilizers (NPK)	9.31	10.16	3.48	7.23
T-2, 100% N through VC	9.48	12.89	3.85	7.45
T-3, 100% N through compost	9.35	12.47	3.68	7.39
T-4, 75% NPK + 25% N through VC	9.23	12.54	3.54	7.25
T-5, 75% NPK + 25% N through compost	9.32	11.56	3.58	7.29
T-6, 25% NPK + 75% N through VC	9.42	13.53	3.73	7.41
T-7, 25% NPK + 75% N through compost	9.36	13.27	3.67	7.37
T-8, Control	9.14	11.32	3.59	7.28
$CD_{0.05}$	NS	0.64	0.19	0.09

Table 4. Effect of different nutrient treatments on soil parameters in surface (10 cm).

Treatment	Soil *p*H	Soil EC (dS m^{-1})	Soil organic C (%)	Cone index (kg cm^{-2})	FC moisture (%)
Initial	8.30	0.29	0.19	-	-
T1, 100% NPK through fertilizers (NPK)	8.48	0.21	0.20	4.84	8.23
T-2, 100% N through VC	8.39	0.29	0.24	4.13	9.38
T-3, 100% N through compost	8.35	0.26	0.27	3.96	9.72
T-4, 75% NPK + 25% N through VC	8.44	0.22	0.21	4.53	8.35
T-5, 75% NPK + 25% N through compost	8.47	0.22	0.20	4.23	8.64
T-6, 25% NPK + 75% N through VC	8.46	0.25	0.23	4.31	8.83
T-7, 25% NPK + 75% N through compost	8.43	0.26	0.21	4.49	9.23
T-8, Control	8.51	0.23	0.19	5.18	8.14
$CD_{0.05}$	0.08	NS	0.03	NS	0.52

level of compost or VC in the treatments, and was maximum in 100% N through compost (T_3) followed by 100 and 75% N through VC, respectively (Table 4). Such an increase in organic C might be attributed to the direct addition of organic manures to the soil as also reported by Sur *et al.* (14) in different vegetable crops.

The penetration resistance, *i.e.* soil compaction denoted by CI was though not significantly influenced due to nutrient treatments but slight reduction was observed for treatments comprising of higher quantity of organic manures application, *i.e.*, 100% N substitution through compost and VC (Table 4). The decrease in CI due to application of organic manures alone or in combinations of these might be due to the beneficial effects of addition of organic manures that had helped in improvement of soil physical conditions. Ekwue and Stone (3) have also reported that decrease in penetration resistance with increase in organic matter due to addition of organic manure (FYM) and peat which support the results of present study.

The changes in FC moisture for treatments varied from 8.14 to 9.72%. It was significantly higher in the treatment receiving 100% N through compost (T_3) followed by its corresponding level through VC (T_2) and 75% N through compost (T_7) over rest of the treatments (Table 4). The minimum FC moisture content was recorded in control (T_8) followed by solely inorganic fertilized treatment, *i.e.*, 100% NPK through fertilizers (T_1) (Table 4). The increase in FC moisture with higher levels of compost or VC fertilized plots might be attributed to the beneficial effects of organic manures in conserving soil moisture due to improved soil structural condition. Similar finding was reported by Mamatha *et al.* (9) in onion.

From this study it is concluded that with the application of 75% NPK through fertilizer plus 25% N through VC or compost enhanced productivity of carrot as well as improvement in carrot quality attributes can be achieved. Furthermore, the combined application of nutrient sources help in improving the soil properties, which may thus help in sustaining higher yield and quality of carrot in long run in irrigated arid conditions.

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