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Short Note

INTEGRATED NUTRIENT MANAGEMENT ON PRODUCTIVITY OF CARROT AND FERTILITY OF SOIL

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Carrot (*Daucus carota* L.) belongs to the family umbelliferae and is an important root vegetable grown throughout the world. Among various factors responsible for low production of carrot, nutrient management is of prime importance for maintaining higher yield and soil fertility. It has been reported that neither the chemical fertilizer alone nor the organic manure are able to sustain the crop productivity and soil fertility. The increasing use of chemical fertilizers to increase vegetable production has been widely recognized but its long run impact on soil health, ecology and other natural resources are detrimental which affect living organisms including beneficial soil microorganism and human being. The escalating prices of chemical fertilizers and its detrimental impact on the soil, environment and human health urged the farmer to adoption of integrated plant nutrient that offers the sustainable crop production and soil fertility (Sentiyangla et al., 2010). Besides fertilizers, there are several sources of plant nutrients like organic manures, biofertilizers etc. These nutrients sources not only reduce quantity of chemical fertilizers but also improve soil fertility (Chumyani et al., 2012). Use of organic manures in INM help mitigating multiple nutrient deficiencies. Application of organic manures to acidic soil reduces the soluble and exchangeable Al temporarily by forming complex and provides better environment for growth and development in addition to improvement in physical, chemical and biological properties of soil (Avitoli et al., 2012). Biofertilizers have also emerged as promising components of nutrient supply system. Application of biofertilizers which is environment friendly and low cost input, with organic and inorganic fertilizers as part of an integrated nutrient management strategy and play significant role in plant nutrition.

A field experiment was conducted during 2011 - 2012 at the Experimental Farm of SASRD, Medziphema campus, Nagaland University, Nagaland. The field is located at the altitude of 304.8 m above mean sea level with geographical location at 20º 45' 43" N latitude and 93 º 53' 04" E longitudes. The soil of the experimental site was sandy loam having soil pH 4.4, organic carbon 1.60 % and available N, P and K content of 305.76, 17.00 and 225.25 kg ha^{-1} respectively. The experiment was laid out in a randomized block design with three replications. Plot size measured 1.8 m x

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1.8 m and spacing was maintained at 30 x 10 cm. Seeds were sown on 5 October, 2011 and thinning was done 10 days after sowing to maintain spacing. The treatments consisted of T_1 - Control, T_2 - FYM @ 20 t ha^{-1}, T_3 - Pig manure @ 15 t ha^{-1}, T_4 - Vermicompost @ 5 t ha^{-1}, T_5 - 100% recommended dose of NPK (80:40:40 kg ha^{-1}), T_6 -50% NPK + 50% FYM, T_7 - 50% NPK + 50% Pig manure, T_8 - 50% NPK + 50% Vermicompost, T_9 - 50% NPK + 50% FYM + Biofertilizers, T_{10} - 50% NPK + 50% Pig manure + Biofertilizers, T_{11} - 50% NPK + 50% Vermicompost + Biofertilizers. N, P and K were given through Urea, SSP and MOP respectively. Full dose of P and K and half dose of N were applied at the time of transplanting and remaining half dose of N was given 45 days after transplanting. Manures viz., FYM, pig manure and vermicompost were incorporated as per treatment to respective plots prior to transplanting. Biofertilizers (*Azospirillum* and *Phosphotika*) were inoculated to seeds prior to sowing as seed treatment methods @ 500 g ha^{-1} each. Observations on plant height, number of leaves, root length, root diameter, root weight, root yield and carotene content were recorded at harvesting. Carotene content was determined by spectrophotometer method (Rangama, 1977) and expressed in mg 100^{-1}g.

Soil samples were collected before and after harvest of crop from different locations of the experimental plot to a depth of 15 cm with the help of screw type auger. The collected soil samples were mixed and reduced to 500 g, dried under shade and ground to pass 2 mm sieve. Soil samples were analysed for pH, organic carbon, available nitrogen, phosphorus and potassium which were determined by Digital pH meter, Walkley and Black Rapid titration method, Alkaline potassium permanganate method, Olsen's method, flame photometer method, respectively (Jackson, 1973). Statistical analysis was carried out as per standard procedure.

Economics of the treatments were calculated as per prevailing market price of input and output. Gross income was calculated by yield multiplied with whole sale rate of carrot (Rs. 10000 t^{-1}). Net income was estimated by deducting the total cost of cultivation (fixed cost + treatment cost) from gross income of the particular treatment. Cost-benefit ratio was worked out by dividing net return from total cost of cultivation.

Improvement in growth characters is considered to be a pre-requisite to increase the yield. NPK fertilizers with different organic manures along with biofertilizers alone or in combination were found to have significant effect on growth characters as compared to control (Table-1). All the treatments were found effective in increasing the plant growth over control. Application of 50% NPK + 50% FYM + biofertilzers (T_9) recorded maximum plant height (25.00 cm) and number of leaves (6.98). The lowest values of plant height and number of leaves were recorded with control. The increase in vegetative growth might be due to the role of nitrogen in promoting vegetative growth and enhancing cell division and elongation as well as greater chlorophyll synthesis, phosphorus is easily mobilized in the plant and translocated to the meristematic zone and increase the activity of leaf formation and

development in carrot and potassium activates many enzymes involved in respiration and photosynthesis. The added FYM in integrated nutrient management would have improved the physical, chemical and biological properties of soil which helps better nutrient absorption and utilization by plant resulting better plant growth. Rani et al. (2006) reported that application of neem cake and castor cake in combination with half the recommended dose of NPK recorded maximum growth characters in carrot. Sentiyangla et al. (2010) reported significant increase in plant height and number of leaves in radish when applied integrated application of chemical fertilizers, organic manures and biofertilizers (50% NPK + 50% FYM + biofertilizers). Subenthung et al. (2012) reported that combined application of 50% Pig manure + 50% NPK recorded maximum plant height (50.16 cm) and number of leaves (14.43), leaf area (185.86 cm^2) and root yield (522.51 t ha^{-1}) in turnip. These results are in conformity with the finding of Chumyani et al., 2012 in tomato and Vimera et al., 2012 in king chilli, they found that maximum growth characters with 50% NPK + 50% FYM + biofertilizers.

Integrated application of chemical fertilizers, organic manures and biofertilizers alone or in combination significantly increased the yield and yield attributing characters of carrot compared to control (Table-1). Application of 50 % NPK + 50 % FYM + biofertilizers (T_9) recorded maximum values of all yield attributing characters such as root length (18.88 cm), root diameter (4.14 cm), root weight (90.37 g). This result indicates positive effects of integrating NPK with manures as well as biofertilizers. Integrated application of organic manure and inorganic fertilizer increased the availability of NPK and also improved the fertility status of soil and productivity due to which yield attributing characters might have increased. Besides NPK, micronutrients might have played an important role in increasing the yield attributing characters of carrot as addition of FYM increased the availability of micronutrients. Also, biofertilizers might have played a vital role in increasing the yield and yield related attributes. Root yield per hectare was recorded highest (30.88 t) in the treatment combination of 50% NPK + 50% FYM + Biofertilizers (T_9) which was significantly superior over other treatment except T_{10} (50% NPK + 50% Pig manure + Biofertilizers) and minimum root yield was rcorded in control. Application of 50% NPK + 50% FYM + Biofertilizers produced 15% higher yield over 100% recommended doze of NPK. This might be due to corresponding response to increased growth and yield attributing characters attained previously under this treatment. Sagiv et al. (1994) reported that highest yield was obtained in carrot when organic manure, composted refuses and N fertilization was applied in combination. Rani et al. (2006) reported that application of neem cake and castor cake in combination with half the recommended dose of NPK recorded maximum root yield (25.860 t ha^{-1}) in carrot. Sentiyangla et al. (2010) observed maximum yield in radish by combination of NPK, FYM and biofrtilizers. Subenthung et al. (2012) observed that maximum root yield was obtained in the combined application of 50% pig manure + 50% NPK in turnip. Similarly Chumyani

et al. (2012) and Vimera et al. (2012) also conducted an experiment on integrated nutrient management and found that 50% NPK + 50% FYM + Biofertilizers recorded maximum yield in tomato and king chilli, respectively.

Quality of carrot is usually evaluated by carotene content. Various organic manures, inorganic fertilizers and biofertilizers and their combination had a beneficial impact on carotene content in roots. It is evident from table-1 that maximum carotene (3.41 mg 100^{-1}g) was recorded with 50 % NPK + 50 % FYM + biofertilizers (T_9). The comparative higher level of carotene might be due to the action of specific soil nutrients which might be made more readily available into the soil for plant absorption as a result of mineral fertilizer + lone organic manure 'or' with biofertilizers integration effect which might have activated specific enzymes for the synthesis of carotene in carrot. Nakagawa et al. (2003) reported that carotene content in roots was increased by application of organic fertilizers. Rani et al. (2006) reported that application of neem cake and castor cake in combination with half the recommended dose of NPK recorded highest carotene content (3.96 mg 100^{-1} g) in carrot. Sunandarani and Malareddy (2007) reported that Neem cake + 50% RD of NPK gave the highest carotene content (4.60 mg 100^{-1} g) in carrot.

Sustainability of a cropping system is being evaluated on the basis of crop yield as well as nutrient status of the soil after harvest of the crop. Different treatments alone and their combination with biofertilizers showed profound residual effect on soil fertility after harvest. However, their intensity varied considerably because of quantum variation (Table-2). Maximum available nitrogen (314.92 kg ha^{-1}), phosphorous (19.59 kg ha^{-1}) and potassium (250.42 kg ha^{-1}) was recorded with treatment 100% NPK (T_5) which was found at par with 50% NPK + 50% FYM + Biofertilizers (T_9), 50% NPK + 50% Pig manure + Biofertilizers (T_{10}), 50% NPK + 50% Vermicompost + Biofertilizers (T_{11}). Maximum available nitrogen phosphorous and potassium in treatment 100% NPK might be due to poor soil physical structure, lack of organic manures and microbial activities, thus resulting in poor utilization of NPK by plants. As such the applied NPK could bring about higher residual NPK in soil after harvest. Similar result was also reported by Vimera et al. (2012) who reported that application of 100% NPK fertilizers alone recorded maximum available NPK in soil after harvest in king chilli. Organic carbon of soil acts as a sink and source of nutrients for microbial population, which regulates the availability of different nutrients through microbial transformation. The net increase in organic carbon was much higher with organic manures in combination with biofertilizers and fertilizers over 100% NPK alone. Application of 50% NPK + 50 % FYM + biofertilizers (T_9) recorded maximum organic carbon (1.85 %) and soil pH (4.65) after harvest. Application of 50% NPK + 50 % FYM + biofertilizers recorded 16 % higher organic carbon over 100% NPK alone. This might be due to increased microbial activities in the root zone which decomposed organic manures and also fixed unavailable form of mineral nutrients into available forms in soil thereby substantiated crop requirements and improved organic carbon level and stabilized

soil pH. Chaudhary et al. (2005) reported that the incorporation of biofertilizers and FYM with inorganic fertilizers significantly improved the organic carbon content and pH of the soil in tomato. Similar results were also reported by Chumyani et al. (2012) in tomato who found maximum organic carbon and soil pH under treatment of 50% NPK + 50 % FYM + biofertilizers.

It is evident from table-3 that the integration of 50% NPK + 50 % FYM + biofertilizers (T_9) was found to be the most profitable treatment in carrot exhibiting highest net return Rs. 2,36,193 with cost benefit ratio of 1:3.65 followed by Rs. 2,21,723 with the application of 50% NPK + 50% Pig manure + Biofertilizers (T_{10}). The reason of high profitability in these two modes of integration can be due to lower cost of inputs and higher yield. Similar results were also reported by Chumyani et al. (2012) in tomato and Vimera et al. (2012) in king chilli. They found highest net return with the combined application of 50% NPK + 50% FYM + Biofertilizers.

It can be concluded from the experiment that integrated application of 50% NPK + 50% FYM + Biofertilizers was found optimum for getting maximum productivity of carrot without reducing fertility status of soil. This treatment reduced 50% chemical fertilizers without any compromise on yield of carrot and fertility of soil. Therefore, 50% NPK + 50% FYM + Biofertilizers may be recommended for sustainable yield of carrot and to nourish the soil fertility under foothills condition of Nagaland.

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Table 1: Effect of integrated nutrient management on growth, yield and quality of carrot

Treatments	Plant height (cm)	Number of leaves	Root length (cm)	Root diameter (cm)	Root weight (g)	Root yield (t ha^{-1})	Carotene content (mg 10^{1}g)
T_1 Control	17.93	6.13	14.99	3.20	35.65	11.86	2.22
T_2 FYM 20t ha^{-1}	20.93	6.77	15.69	3.53	41.29	13.73	2.51
T_3 Pig manure 15t ha^{-1}	20.73	6.70	16.04	3.42	43.04	14.31	2.50
T_4 Vermicompost 5t ha^{-1}	20.13	6.30	15.25	3.23	40.74	13.55	2.42
T_5 100% NPK ((80:40:40 kg ha^{-1})	21.93	6.67	16.59	3.87	78.37	26.09	2.69
T_6 50% NPK + 50% FYM	22.60	6.77	17.06	3.78	76.33	25.41	2.78
T_7 50% NPK + 50% Pig manure	21.67	6.70	17.01	3.71	72.60	24.17	2.76
T_8 50% NPK + 50% Vermicompost	21.53	6.67	17.00	3.68	70.77	23.56	2.64
T_9 50% NPK + 50% FYM + Biofertilizers	25.00	6.98	18.88	4.14	90.37	30.08	3.41
T_{10} 50% NPK + 50% Pig manure+ Biofertilizers	23.67	6.94	18.60	4.13	86.07	28.66	3.09
T_{11} 50% NPK + 50% Vermicompost+Biofertilizers	22.00	6.90	18.23	4.13	79.00	26.31	3.02
SEm+	0.81	0.8	0.47	0.10	1.45	0.47	0.07
CD (P=0.05)	2.47	0.24	1.49	0.34	4.39	1.46	0.21

Table 2: Effect of integrated nutrient management on the nutrient status of the soil after harvest

Treatments	Available N (kg ha^{-1})	Available P (kg ha^{-1})	Available K (kg ha^{-1})	Organic carbon (%)	Soil pH
T_1 Control	216.39	14.21	188.50	1.43	4.38
T_2 FYM 20t ha^{-1}	264.91	18.62	236.21	1.69	4.54
T_3 Pig manure 15t ha^{-1}	256.56	17.87	237.06	1.64	4.51
T_4 Vermicompost 5t ha^{-1}	266.16	16.82	230.21	1.59	4.48
T_5 100% NPK ((80:40:40 kg ha^{-1})	314.92	19.59	250.42	1.60	4.42
T_6 50% NPK + 50% FYM	301.84	18.60	238.90	1.77	4.59
T_7 50% NPK + 50% Pig manure	297.36	18.45	233.65	1.76	4.55
T_8 50% NPK + 50% Vermicompost	287.46	18.11	230.96	1.71	4.46
T_9 50% NPK + 50% FYM + Biofertilizers	309.17	19.40	246.18	1.85	4.65
T_{10} 50% NPK + 50% Pig manure + Biofertilizers	307.98	19.38	245.94	1.81	4.60
T_{11} 50% NPK + 50% Vermicompost + Biofertilizers	306.49	19.09	241.32	1.74	4.56
SEm±	3.70	0.29	3.46	0.03	0.01
CD (P=0.05)	11.13	0.90	10.40	0.11	0.05

Table 3: Effect of integrated nutrient management on economics of the treatments

Treatments	Fixed cost (Rs.)	Treatment cost (Rs.)	Total cost (Rs.)	Root yield (t ha^{-1})	Gross income (Rs ha^{-1})	Net income (Rs ha^{-1})	Cost benefit ratio
T_1 Control	55000	0	55000	11.86	118670	63670	1: 1.15
T_2 FYM 20t ha^{-1}	55000	10000	65000	13.73	137330	72330	1: 1.11
T_3 Pig manure 15t ha^{-1}	55000	10500	65500	14.31	143110	77610	1: 1.18
T_4 Vermicompost 5t ha^{-1}	55000	50000	105000	13.55	135550	30550	1: 0.29
T_5 100% NPK (80:40:40 kg ha^{-1})	55000	9273	64273	26.09	160880	96607	1: 3.06
T_6 50% NPK + 50% FYM	55000	9636	64636	25.41	164000	99364	1: 2.93
T_7 50% NPK + 50% Pig manure	55000	9886	64886	24.17	168440	103554	1: 2.73
T_8 50% NPK + 50% Vermicompost	55000	29636	84636	23.56	235550	150914	1: 1.78
T_9 50% NPK + 50% FYM + Biofertilizers	55000	9687	64687	30.08	300880	236193	1: 3.65
T_{10} 50% NPK + 50% Pig manure + Biofertilizers	55000	9937	64937	28.66	286660	221723	1: 3.41
T_{11} 50% NPK + 50% Vermicompost + Biofertilizers	55000	29687	84687	26.31	263110	178423	1: 2.10