International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
IJCS 2018; 6(4): 3116-3119

Received: 22-05-2018
Accepted: 28-06-2018

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Root yield and nutrient uptake of Radish (*Raphanus sativus* L.) as influenced by the application of organic and inorganic sources of nitrogen and their combinations

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Abstract
A field experiment was conducted at v egetables block, College of Horticulture, Anantharajupeta, Andhra Pradesh to study the influence of organic and inorganic sources of nitrogen on growth and yield of radish (*Raphanus sativus* L.) during *Rabi*, 2018. The experiment consists of 14 treatments including recommended dose of inorganic fertilizers, FYM, vermicompost, neem cake in different combinations and absolute control. The experiment was laid out in a Randomized Block Design with three replications. The root parameters viz., root length, root diameter, fresh and dry weight of root, total biomass per plant, root shoot ratio and root yield at harvest were recorded. All the root parameters were significantly increased by the application of organic and inorganic sources of nitrogen, their combinations and recorded maximum with treatment T_7 i.e., 75% RDN + 25% N through neem cake. The highest total root yield and the uptake of N, P and K were maximum with 75% RDN + 25% N through neem cake. The study suggested that application of 75% RDN + 25% N through neem cake followed by recommended dose of inorganic fertilizers was found to be more beneficial and significantly improved growth and yield of radish.

Keywords: Radish, RDN, FYM, neem cake, vermi compost, nutrient uptake, yield

Introduction
Radish (*Raphanus sativus* L.) is a popular root vegetable in both tropical and temperate regions belongs to *Brassicaceae* family. Radish is grown for its young tender tuberous root which is consumed either cooked or raw. It is a good source of vitamin-c and minerals like calcium, potassium and phosphorus. It has refreshing and diuretic properties. It is also used for neurological headache, sleeplessness and chronic diarrhea. The roots are also useful in urinary complaints and piles. The leaves of radish are good source for extraction of protein on a commercial scale and radish seeds are potential source of nondrying fatty oil suitable for soap making illuminating and edible purposes. Availability of nitrogen is important for growing plants as it is a major indispensable constituent of protein and nucleic acid. The primary goal of integrated nutrient management is to combine old and new methods of nutrient management into ecologically sound and economically viable farming systems that utilize available organic and inorganic sources of nutrients in a judicious and efficient way. Radish being a short-duration and quick growing crop, the root growth should be rapid and uninterrupted. organic, inorganic and biofertilizers are essential (Dhanajaya, 2007) [5]. Further, due to higher cost of nitrogenous fertilizers and its ill effect on soil health and water, it is becoming imperative to go for alternative and cheaper sources like organic manures (Kumar *et al*., 2014) [9].

Material and Methods
The present field experiment was conducted at vegetables block, College of Horticulture, Anantharajupeta, Dr. Y.S.R. Horticultural University, Andhra Pradesh. The soil of the experimental field was sandy loam with a pH of 6.8. The experiment consists of 14 treatments laid out in a Randomized Block Design with three replications. Treatments include T_1- RDF (100:80:50 Kg NPK/ha), T_2-100% RDN through FYM, T_3-100% RDN through vermicompost, T_4-100% RDN through neem cake, T_5-75% RDN + 25% N through FYM, T_6-75% RDN + 25% N through vermicompost, T_7-75% RDN + 25% N through neem cake, T_8-50% RDN +

50% N through FYM, T_9-50% RDN + 50% N through vermicompost, T_{10}-50% RDN + 50% N through neem cake, T_{11}-25% RDN + 75% N through FYM, T_{12}-25% RDN + 75% N through vermicompost, T_{13}- 25% RDN + 75% N through neem cake and T_{14}-Absolute control. Nitrogen was applied in two equal splits at basal and 25 DAS as per the treatments. All the treatments except absolute control received uniform doses of 80 kg P_2O_5 and 50 kg K_2O ha^{-1} through SSP and MOP. FYM, vermicompost and neem cake were incorporated as per the treatments to respective plots prior to sowing on the basis of nitrogen percentage.

The seeds of radish cv. Japanese white were dibbled at a spacing of 30 x10 cm in ridge and furrow system. Thinning was done at 10 days after sowing by retaining one seedling per hill. The organic manures under study were FYM, vermicompost, Neem cake and inorganic manures were Urea, SSP and MOP. Both organic and inorganic manures were applied alone and in combinations. Organic manures were incorporated as basal dose during field preparation 15 days before sowing. The Nitrogen contents in FYM, Vermi compost and Neem cake was found to be 0.49%, 2.73%, and 1.08% respectively. The observations were recorded for yield parameters and nutrient uptake from the 5 randomly selected and tagged plants. The results were statistically analyzed using analysis of variance following the method of Panse and Sukhatme (1978) [14] and the mean values were computed at 5% level of significance.

Results and Discussion

Yield and yield attributes

Root length and root diameter

Root length of radish was recorded at harvesting stage (Table 1). Maximum length of root (31.17 cm) was observed in treatment T_7 - 75% RDN + 25% N through neem cake which was statistically on par with T_1 (29.05 cm. While the minimum root length (20.33 cm) was observed in T_{14}-absolute control. At harvest the highest root diameter of the radish was observed in T_7 -75% RDN + 25% N through neem cake (3.84 cm) followed by T_1 (3.76 cm) which were at par with each other but significantly superior to all other treatments. Absolute control has recorded the lowest root diameter (2.38 cm).

The increase in root length and root diameter of radish with 75 % RDN + 25 % N through neem cake might be due to higher P content (1.01%) in neem cake. Phosphorus stimulates root growth, greater absorption and translocation of nutrients. Phosphorus at early stages of growth might be involved in stimulation of root system. It is also a part of various enzymes, co enzymes and energy rich ATP resulting in increased root growth (Mangal, 1985) [12]. Phosphorus also brings about improvement in the physico- chemical characteristics of the soil (Schmidt, 1954) [16]. Organic manures play a direct role in plant growth as a source of all necessary macro and micro nutrients in available form during mineralization, improving physical and physiological properties of soil. Similar findings have been reported by Kumar *et al.* (2014) [9] in radish.

Fresh weight and dry weight of root

Significantly the highest fresh weight of root was noticed with T_7 with 75% RDN + 25% N through neem cake (306.54 gm) followed by T_1 (277.17 gm) and both of them were significantly superior over the rest of the treatments. The lowest fresh weight of root was obtained with T_{14} -absolute control (101.24 gm). The highest dry weight of root was obtained with T_7 - 75% RDN + 25% N through neem cake (16.89 gm) followed by T_1 (15.28gm) which were statistically on par with each other, but significantly superior over all other treatments. Whereas, lowest fresh weight of root (5.68 g) was observed in T_{14}-absolute control (Table 1).

Fresh and dry weight of root was increased with combination of organic and inorganic sources of nitrogen which might be due to increase in leaf number, leaf length and leaf area which ultimately results in maximum photosynthetic efficiency and better assimilation. Rapid synthesis and translocation of photosynthates from source (leaves) to sink (roots) might have contributed to increased fresh weight and dry weight of roots. Decrease in bulk density and increase in porosity and water holding capacity of the soil due to neem cake might have also contributed to the increase in yield attributes of the radish. Further it may be due to Solubilization of plant nutrients by addition of inorganic fertilizers and neem cake leading to increased uptake of NPK by the plant. These findings were in agreement with the findings of Kumar *et al.* (2009) [8], Uddain *et al.* (2010) [19] and Kumar *et al.* (2014) [9] in radish. Urea and S.S.P as a source of nitrogen and phosphorus respectively were found most effective in increasing the root weight of radish (Lakra *et al.*, 2017) [10]. Vijayakumari *et al.* (2012) [20] reported that treatment combinations consisting of NPK showed significant increase in fresh weight of root in radish. Otani (1974) [13] reported that fresh weight of root increased with nitrogen. Similar reports of significant effect of nitrogen on fresh weight of root was reported by Ali *et al.* (2006) [1] in carrot.

Total biomass per plant and root shoot ratio

The highest biomass per plant (541.11 g) was observed in T_7 treatment with 75% RDN + 25% N through neem cake followed by T_1-RDF (503.88 g). However both these treatments were on par with each other and significant over all other treatments. While, the lowest total biomass per plant was observed in T_{14} -absolute control (238.16 gm). The highest root shoot ratio was observed in T_7 (1.32 gm) with 75% RDN + 25% N through neem cake followed by T_1 (1.22) with RDF. Both the treatments were on par but significant than all other treatments. While minimum root shoot ratio (0.74) was observed in T_{14} - absolute control (Table 1).

The maximum total biomass weight per plant was recorded with 75 % RDN + 25 % N through neem cake (T_7). The total biomass is directly influenced by leaf number, leaf length, leaf area, fresh weight of leaves, root length, root diameter and root weight of plant. The positive influence of 75 % RDN + 25 % N through neem cake on growth parameters has subsequently reflected in improving the yield attributes. Decrease in bulk density and increase in porosity and water holding capacity of the soil due to neem cake might have also contributed to the increase in yield attributes of the radish. Solubilization of plant nutrients by addition of inorganic fertilizers and neem cake resulting in increased uptake of NPK and total biomass of the plant. These findings were in agreement with those reported by Sunandarani and Mallareddy (2007) [18], Kumar *et al.* (2009) [8], Kanaujia *et al.* (2010) [7], Uddain *et al.* (2010) [19] and Kumar *et al.* (2014) [9] in radish. The highest root to shoot ratio was recorded with 75 % RDN + 25 % N through neem cake which might be due to higher phosphorus availability from neem cake (1.87%) which happened due to application of manures on equal nitrogen basis and readily available nutrients from inorganic source of RDN.

Root yield (t ha^{-1})

The highest root yield (38.06 t ha^{-1}) was recorded in T_7 with 75% RDN + 25% N through neem cake which was significantly superior to all other treatments (Table 1). The next best treatments were T_1 followed by T_{10}, which were significantly superior to all other treatments. However lowest root yield t ha^{-1} (17.29 t ha^{-1}) was recorded with absolute control.

The increase in root yield might be due to cumulative effect of all the growth parameters *viz*., plant height, leaf area, fresh weight, dry weight of shoot and yield components *viz.*, root length, root diameter, fresh and dry weight of root with readily available nitrogen in 75% RDN + 25% N through neem cake treatment.

The slow release of nutrients from organic manures and readily available nitrogen from inorganic fertilizers in radish throughout the growing period might have resulted in higher root yield of radish. Similar results of increased yield with neem cake were reported in radish by Sharma *et al.* (1986) [17] and Amarendra *et al.* (1997) [2] in tomato. Increased yield due to better availability of nutrients and the balanced C: N ratio might have increased synthesis of carbohydrates which ultimately promoted greater yield (Jose *et al*., 1998). It can also be due to better accumulation of carbohydrates in the plants. The translocation of photosynthates from source (leaves) to sink (root) might have contributed to increased root length and root diameter resulting in root yield.

Nitrogen uptake (kg ha^{-1})

The highest nitrogen uptake (82.51 kg ha^{-1}) was recorded in treatment T_7 - 75% RDN + 25% N through neem cake followed by T_1 –RDF (70.24 kg ha^{-1}) both were significantly superior to all other treatments. The next best treatment was T_{10}-50% RDN + 50% N through neem cake. Lowest nitrogen uptake of (30.73 kg ha^{-1}) was recorded in absolute control (T_{14}).

Phosphorus uptake (kg ha^{-1})

Maximum phosphorus uptake of (18.50 kg ha^{-1}) was recorded in T_7 - 75% RDN + 25% N through neem cake which was statistically superior to all other treatments. Next best treatments were T_1 –RDF (16.95 kg ha^{-1}) and T_{10}-50% RDN + 50% N through neem cake both were statistically on par with each other. Absolute control (T_{14}) recorded lowest phosphorus uptake of (8.35 kg ha^{-1}).

Potassium uptake (kg ha^{-1})

Similar to nitrogen uptake, the highest potassium uptake of (89.51 kg ha^{-1}) was recorded in T_7 - 75% RDN + 25% N through neem cake which was statistically superior to all other treatments. Next best treatments were T_1 –RDF (80.24 kg ha^{-1}) and T_{10} – 50% RDN + 50% N through neem cake (76.57 kg ha^{-1}) both were statistically on par with each other. Lowest Potassium uptake of (38.23 kg ha^{-1}) was noticed in absolute control (T_{14}).

The increase in uptake was due to the increased availability of nutrients from the native, as well as from the mineralized neem cake manure which might have increased the concentration of NPK in the soil solution making it readily available for absorption. Nutrient uptake was a positive function of dry matter yield (Ramakal *et al*., 1998) [15]. This was in consonance with the findings of Chalapathi *et al*. (1997) [4] in stevia and Mallangouda *et al*. (1995) [11] in onion and garlic. Improvement of soil physical condition due to addition of organic manures might have resulted in better root growth so that the roots can explore more volume of soil and ultimately leads to higher uptake of the nutrients. Increased N uptake could be due to readily available N from inorganic and organic sources of nitrogen. The additional phosphorus present in neem cake might be one of the reasons for improving the uptake of P by the plants. Further, Budhawant, (1994) [3] found that phosphorus uptake increased with the application of organic manures, which may be attributed to the more solubilization of native P from the soil due to the action of various organic acids liberated during the decomposition of organic manures. Availability of K in soil might have influenced the potassium uptake. Availability of K uptake was influenced by increased availability of K in soil which might be due to K applied fertilizers and mineralization of organic manures. The uptake of NPK was increased significantly with the application of neem cake in black gram (Hakeem *et al.*, 2008) [6].

Table 1: Influence of organic and inorganic sources of nitrogen on root length, root diameter, fresh and dry weight of root, total biomass per plant, root shoot ratio and yield of radish.

Yield parameters / Treatments	Root length (cm)	Root diameter (cm)	Fresh weight of root (g)	Dry weight of root (g)	Total biomass plant^{-1} (g)	Root shoot ratio	Root yield (t/ha)
T_1-RDF (100:80:50 NPK Kg/ha)	29.05	3.76	277.17	15.28	503.88	1.22	34.17
T_2-100% FYM	24.70	2.75	150.79	8.31	323.91	0.87	24.23
T_3-100% VC	25.02	2.85	136.89	7.54	307.46	0.80	22.14
T_4-100%-NC	26.17	3.02	148.23	8.16	312.90	0.91	23.21
T_5-RDN+FYM (75%+25%)	28.40	3.40	187.57	10.34	373.28	1.04	25.76
T_6- RDN+ VC (75%+25%)	28.45	3.42	233.50	12.87	443.35	1.11	27.57
T_7- RDN+ NC (75%+25%)	31.17	3.84	306.54	16.89	541.11	1.32	38.06
T_8- RDN+ FYM (50%+50%)	27.61	3.27	176.56	9.73	347.79	1.03	25.28
T_9- RDN+VC (50%+50%)	28.00	3.35	151.52	8.35	317.89	0.91	25.12
T_{10}- RDN+ NC (50%+50%)	29.00	3.68	248.10	13.67	475.69	1.09	30.87
T_{11}-RDN+FYM (25%+75%)	27.50	3.08	197.28	10.87	391.73	1.01	25.98
T_{12}- RDN+ VC (50%+50%)	27.06	3.19	186.68	10.33	365.70	1.05	25.36
T_{13}- RDN+ NC (25%+75%)	28.17	3.37	187.10	10.31	375.51	0.99	25.88
T_{14}-Absolute control	20.33	2.38	101.24	5.68	238.16	0.74	17.29
S. Em. ±	1.01	0.11	9.58	0.74	16.39	0.06	0.88
C.D. at 5%	2.95	0.33	27.85	2.14	47.64	0.17	2.56

Table 2: Influence of organic and inorganic sources of nitrogen on nutrient uptake of radish at harvest

Treatments	Nutrient uptake at harvest		
	N (kg ha^{-1})	P (kg ha^{-1})	K (kg ha^{-1})
T_1 - RDF (100:80:50 Kg NPK/ha)	70.24	16.95	80.24
T_2 - 100% RDN through FYM	42.39	10.92	49.39
T_3 - 100% RDN through Vermicompost	37.24	9.03	46.24
T_4 - 100% RDN through Neem cake	39.17	9.73	44.17
T_5 - 75% RDN + 25% N through FYM	49.61	11.47	54.61
T_6 - 75% RDN + 25% N through Vermicompost	66.81	15.93	72.81
T_7 - 75% RDN + 25% N through Neem cake	82.51	18.50	89.51
T_8 - 50% RDN + 50% N through FYM	44.84	11.20	52.84
T_9 - 50% RDN + 50% N through Vermicompost	43.78	10.98	49.78
T_{10} - 50% RDN + 50% N through Neem cake	68.57	15.56	76.57
T_{11} - 25% RDN + 75% N through FYM	61.30	14.26	68.30
T_{12} - 25% RDN + 75% N through Vermicompost	46.90	11.38	52.25
T_{13} - 25% RDN + 75% N through Neem cake	53.54	12.19	58.94
T_{14} – Absolute Control	30.73	8.35	38.23
SEm±	1.70	0.49	1.93
CD (*P*= 0.05)	4.97	1.42	5.61

Conclusion

On the basis of the results obtained in the present investigation, it might be concluded that application of 75% RDN + 25% N through neem cake (T_7) followed by 100% RDF (T_1) can be considered as the best treatment for obtaining better yield and nutrient uptake in radish.

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