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Effect of soil application of NPK on yield traits and economics of radish (*Raphanus sativus* L.) cv. Kashi Hans under Bundelkhand region

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Abstract
The present investigation entitled "Effect of soil application of NPK on yield traits and Economics of Radish (*Raphanus sativus* L.) cv. Kashi Hans under Bundelkhand region" was conducted at Vegetable Research Farm at College of Horticulture, Banda University of Agriculture and Technology, Banda, Uttar-Pradesh during *Rabi* season of 2021. The experiment was laid out in Randomized Block Design with three replications. The treatments involved in the study were 10 in numbers *i.e.*,T_1 50:100:50 NPK/ha (control), T_2 100:100:50 NPK/ha, T_3 150:100:50 NPK/ha, T_4 200:100:50 NPK/ ha, T_5 50:150:50 NPK/ha, T_6 50:200:50 NPK/ha, T_7 50:250:50 NPK/ha, T_8 50:100:100 NPK/ha, T_9 50:100:150 NPK/ha and T_{10} 50:100:150 NPK/ha and they were applied with an objective to study the effect of NPK on yield traits and economics of radish. On the basis of result obtained and summarized from the present study, it can be concluded that all the observations taken for radish were found to be superior with the application of NPK. In the present study, it was observed that the application of 200:100:50 NPK/ha increased all the parameters [*i.e.* Length and diameter of root (cm), weight of root and leaves (g), root: shoot ratio, root yield per plot (Kg), total yield (q/ha) and B: C ratio] followed by 150:100:50 NPK/ha and 50:250:50 NPK/ha. Therefore among all the combinations of NPK applied 200:100:50 NPK/ha was found significantly most effective in increasing the yield and yield attributing traits. Hence, application of 200:100:50 NPK/ha may be suggested in radish plant in order to get higher yield of good quality roots as well as the maximum net return per hectare and B: C ratio under Bundelkhand condition.

Keywords: NPK, radish, yield and economics

Introduction
Among the major contributing vegetables, Radish *(Raphanus sativus* L. 2n=18.) is an important root crop. In India radish is an ancient root crop which was mentioned in the Ramayana, 1450 BC. It is also called 'Mooli, Mula or mullangi. Many ancient as well as modern names are known in many languages, indicating the long history of cultivation of radish. The species *R. sativus* was introduced into China more than 2400 years ago from the Eastern Mediterranean through the ancient silk route and then to Japan more than 1250 years ago. The area of maximum diversity of radish lies between the eastern Mediterranean and the Caspian Sea, which is probably the primary centre of origin for this species. This root vegetable extensively cultivated throughout India particularly in Uttar Pradesh, Bihar, West Bengal, Assam, Punjab, Haryana, Himanchal Pradesh, and Gujarat radish is one of the richest sources of iron, calcium, and sodium. Radish leaves have more calcium, phosphorus, vitamin C and protein than the roots. Per 100 g radish root has 94.4 percent moisture, 3.4 g carbohydrates, 0.7 g protein, 0.06 mg thiamine, 0.02 mg riboflavin, 15 mg vitamin C, 35 mg calcium and 0.04 mg iron (Choudhary, B.R. 2014) [9]. Radish roots are commonly used fresh for salad but sometimes cooked also. Its roots are also used for pickles. The edible part of radish is modified roots (fusiform) which develops from both primary roots and hypocotyls. There are also leafy radish varieties popular in some region of the world like China. It is largely used to as salad, especially the oriental types, and also picked in brine. The pickled radish is a staple item in diet of the Japanese. They are also used as a garnish for food dishes such as fish and poultry, sauteed or diced and added to soup and stews. Roots and leaves also served as an excellent fodder. Red coloured roots are also found which are higher in ascorbic acid content. The pungency in radish is due to the presence of volatile iso-thiocyanates and red colour is due to anthocyanin pigment (Bose *et al*, 2000) [8]. Radish leaves are eaten as vegetable especially in northern parts of country. The young pods of a variety *R. sativus* var. *caudatus* L known as Rat-tail radish or *mougri*, are also edibleas vegetable. *R. sativus* var.

oleifera Netz is used for fodder, vegetable oil and green manure. *Raphanus raphanistrum* L. is the most likely ancestor of the polymorphic *Raphanus sativus*. Radish has medicinal usedalso; it has refreshing and diuretic properties. It is used for neurological headache, sleeplessness, and chronic diarrhoea and especially preventing in case of jaundice, piles, stone formation in the urinary tract, increases appetite and problem of liver and spleen. Black radish juice has tonic and laxative action on intestine and indirectly stimulates the flow of bile. Radish has cooling effect and prevents constipation. The leaves of radish are good source for extraction of protein on a commercial scale and radish seeds are potential source of non-drying fatty oil suitable for soap making illuminating and edible purposes. Being a short duration and quick growing crop, the root growth should be rapid and uninterrupted. Radish is an popular vegetable and very much demanding throughout the year due to their enormous health benefits, therefore its proper cultivation is essential to maintain the quality and fulfil the consumer demand respectively. Cultivation involves several activities undertaken by farmers over a period. These activities or tasks are referred to as agricultural practices (Arshad, 2017) [2]. Cultivation of radish involves; preparation of soil, sowing, adding manure and fertilizers, irrigation, protecting from weeds, harvesting and storage etc. The preparation of soil is the first step before growing radish. One of the most important tasks is to turn the soil and loosen it. This allows the roots to penetrate deep into the soil (Arshad, 2017) [2]. The productivity of radish is influenced by several factors such as soil, varieties, fertilizer management and various agro-techniques used for growing crop. Nutrients play a vital role in functioning of normal physiological processes during the period of growth and development of plants. However, for obtaining higher economic yield, balanced supply of nutrients is one of the key factors (Singh, 1976) [30].Too low or high fertilizers levels can reduce the growth and development process of plants which may affect the crop yield.

Nitrogen is abundantly available (70-80%) in the atmosphere but the plants cannot take it directly from the atmosphere, hence nitrogen requirement of the plant is generally met out with the use of chemical fertilizers however, on the other hand, some microorganisms are available, which can fix atmospheric nitrogen in the plant roots. The balanced fertilization in radish is important factor to boost yield attributes. The application of nitrogen with different doses increases plant growth and yield of radish (Patel *et al.*, 1992) [23]. Deficiency of nitrogen first appears on older leaves due to high mobility of the element. Its deficiency causes interveinal yellowing, development of anthocyanin pigment, rolling of leaves, chlorosis, and necrosis (Singh and Srivastava, 1962) [32]. Phosphorus is indispensable constituent of nucleic acids, phospholipids and several enzymes. It is also needed for the transfer of energy within the plant system and is involved in its various metabolic activities (Yalwalker *et al*., 1962). It has its beneficial effect on early root development, plant growth, yield and quality. Indian soils have poor to medium status in available phosphorus for crops and remaining part is converted to insoluble phosphorus. Phosphorus plays a key role in the formation of energy bound phosphate (ADP and ATP). Potassium is one of the three major nutrient elements (N, P and K) required by plants. There are evidence of direct involvement of potassium in photosynthesis and its involvement in leaf tissues metabolic activities of chloroplast. It regulates transpiration through opening and closing of the stomata by affecting activities of guard cells. In these organelles, Potassium activates & the fat producing enzymes and thus enhances the oil content (Mandal and Chatterjee, 1973) [15]. Potassium also facilitates protein and starch synthesis and improves plant immunity to weather changes, diseases and nematodes in plants. Potassium is used to improve root growth and drought tolerance. It also enhanced the building of cellulose and thus reduces lodging. The work on this aspect was initiated with great enthusiasm in many parts of the World with positive results. Therefore, keeping in view of these above facts, the present investigation was carried out with prime objective to study the effect of NPK on yield traits of radish and to work out the economics of different treatments.

Materials and Methods

A field experiment was conducted at Vegetable Research Farm BUAT, Banda during Rabi season 20221 with the view to study the effect of different Doses of NPK on yield and economics of radish cv. Kashi Hans. The experiment was laid out in a Randomized Block Design with three replications and consisted of 10 treatments, namely i.e.,T1 50:100:50 NPK/ha (control), T2 100:100:50 NPK/ha, T3 150:100:50 NPK/ha, T4 200:100:50 NPK/ ha, T5 50:150:50 NPK/ha, T6 50:200:50 NPK/ha, T7 50:250:50 NPK/ha, T8 50:100:100 NPK/ha, T9 50:100:150 NPK/ha and T10 50:100:150 NPK/ha. Seeds were sown in recommended spacing of 20 x 10 cm between rows and plants. All the recommended agronomic practices and crop husbandry were followed to raise a good crop. A uniform dose of FYM @ 25 t/ha and different doses of NPK fertilizers (Nitrogen through Urea, Phosphorus through Single Super Phosphate and Potassium through Murate of Potash) according to treatments will be applied in all the treatments and replications. The entire dose of FYM, phosphorus and potassium and half dose of nitrogen will be applied at the time of last ploughing whereas, half dose of nitrogen will be applied at 25 days after sowing at the time of weeding-cum hoeing.. Five plants were selected randomly from each net plot to record the observation namely, Days Taken to harvest, length and diameter of roots (cm), weight of root (g), weight of leaves (g), Root shoot ratio, Root Yield/plot (kg), Root Yield (q/ha), Gross income (Rs/ ha), Total cost of cultivation (Rs/ ha), Net return (Rs/ ha) and cost: benefit ratio. The data recorded on different parameter during the year of investigation were statically analyzed as per the statistical methods described by (Panse and Sukhatme, 1985) [21].

Result and Discussion

a. Yield Parameters

1. Days taken to harvest

The Harvest time as minimum days (51 days) to harvesting was recorded with this treatment T_4 200:100:50 NPK followed by T_3 150:100:50 NPK (52.16 days) and T_7 50:250:50 (NPK 52.83 days) during experiments (Table-1). Harvesting was delayed in control plants (55 days). Similar findings have been reported by Bhuvneswri *et al.* (2016), Pathak *et al*. (2017) [24-25], Nargave *et al.* (2018) [20] and Kushwah *et al.* (2020) [14] in radish. The early harvesting might be due to positive action of supplied NPK on physiological regulation of root formation in the plant which reduces the timing of Harvesting (Das and Prusty, 1969) [10].

2. Lengthofroot (cm)

Among all the treatments, the maximum length of root (38.46

cm) at the time of harvesting was found with T_4 200:100:50 followed by T_3 150:100:50 NPK (36.96 cm) and T_7 50:250:50 (35.96 cm) Table- 1. However, the control plants had the minimum length of root in T_1 50:100:50 (27.73 cm) during investigation. Findings of present investigation, confirmed the results reported by Poudel *et al.* (2018) [27]. Nutrient levels had exerted very significant effect on length of root of radish. Mean values in relation to different nitrogen levels indicated significant superiority the 300kg/ha N over other treatments. 300 kg/ha N produced maximum and minimum root length was produced by treatment 100kg/ha i.e., 20.99cm. An increase in root length might be due to effect of environment, soil texture and on time and balanced manuring practices. Similar results were also recorded by Nargave K (2016) [19] that nitrogen level have significant influence on root length. These results are in accordance with Parthasarathy *et al.* (1999) [22] and Pervez *et al.* (2004) [26]. Mohammad *et al.* (2015), Jawad *et al.* (2015) [12], Verma *et al*, (2017) [34] and Kushwah *et al.,* (2020) [14] in radish. There could be attributed to the positive influence of nitrogen on cell division, cell elongation, cell expansion synthesis, of amino acids, enzymes and chlorophyll which might increase the root length. The results are in agreement with the findings of Houchmuth *et al*, (1999) who noted that the application of NPK fertilizer significantly increased the root length in radish.

3. Diameter of root (cm)

Significantly maximum diameter of root at the time of harvesting was recorded with T_4 200:100:50 NPK (4.46 cm) followed by T_3 150:100:50 NPK (4.36 cm) and T_7 50:250:50 NPK (4.26 cm), while the control plants were found to be minimum in diameter of root T_1 50:100:50 NPK (3.50 cm) during the investigation (Table-1). These findings are in agreement with those reported by Sharma *et al.* (2013) [29], Mohammad *et al.*(2015), Verma *et al.* (2017) [34] and Kushwah *et al.* (2020) [14] in Radish. The results entails that there is big difference in the effect of nitrogen on root diameter. The results are in conformity with Bloom (2006) [7] that the growth-promoting effect of N increase scytokin in production, which subsequently affects cell wall elasticity, number of meristematic cells, and cell growth. In contrary, higher application of soil N provided higher nitrogen to the plants and more space for the development of root which resulted in maximum diameter.

4. Weight of root (cm)

Among the treatments, it ranged from 90.00 g (control) to 124.66 g (T_4 200:100:50 NPK) during the study. Significantly maximum weight of root at the time of harvesting was recorded with T_4 200:100:50 NPK (124.66 g) followed by T_3 150:100:50 NPK (123.66 g) and T_7 50:250:50 NPK (121.13 g), while the control plants were found to be minimum in weight of root T_1 50:100:50 NPK (90.00 g) during the investigation (Table-1). Jilani *et al.* (2010) [13] studied the effect of different levels of nitrogen on yield of radish and the results showed that higher N levels gave better results for all studied parameters. Maximum root weight (139.28, 122.73 and 127.16 g) were recorded when N was applied @ 200, 250 and 150 kg per hectare, respectively. This could be due to the application of nitrogen higher dose which increase the fresh weight of root. Similar findings have been reported by Alsina *et al.* (2013) [1], Sumagaysay (2014) [33], Mohammad *et al.* (2015), Verma *et al.* (2017) [34] and Kushwah *et al.* (2020) [14] in radish.

5. Weight of leaves per plant (g)

Maximum weight of leaves per plant at the time of harvesting was recorded with T_4 200:100:50 NPK (198.80 g) followed by T_3 150:100:50 NPK (185.66 g) and T_7 50:250:50 NPK (180.20 g), while the control plants were found to be minimum in weight of leaves per plant T_1 50:100:50 NPK (139.86 g) during the investigation (Table-1). Jilani *et al.* (2010) [13] studied the effect of different levels of nitrogen on yield of radish and the results showed that higher N levels gave better results for all studied parameters. Maximum weight of leaves (160.67, 132.83 and 140.82 g) were recorded when N was applied @ 200, 250 and 150 kg per hectare, respectively. Corresponding to the findings of present investigation Pervez *et al.* (2004) [26], Jawad *et al.* (2015) [12], Mohammad *et al.* (2015) and Mehwish *et al.* (2016) [16] in radish. The increase in weight of leaves by the use of NPK may be due to beneficial influence of nitrification inhibition properties of nitrogen in the soil. Besides, it may also be due to rapid elongation and multiplication of cell in the presence of adequate quantity of nitrogen (Barman *et al.,* 2014) [4]. Similar results were reported by Singh *et al.* (2016) [31] and Verma *et al.* (2017) [34]

6. Root-shoot ratio

Maximum root and shoot ratio was recorded with T_4 200:100:50 NPK (1.60) followed by T_3 150:100:50 NPK (1.58) and T_7 50:250:50 NPK (1.55), while the control plants were found to be minimum in root and shoot ratio T_1 50:100:50 NPK (1.49) during the investigation (Table-1). Similar results were observed by Jawad *et al.* (2015) [12], Mohammad *et al.* (2015) and Mehwish *et al.* (2016) [16], Zeb *et al.* (2016) [36] and Pathak *et al.* (2017) [24-25] in radish. The higher root shoot ratio due to beneficial influence of nitrification inhibition properties of nitrogen in the soil. Besides, it may also be due to rapid elongation and multiplication of cell in the presence of adequate quantity of nitrogen Singh *et al.* (2016) [31]

7. Root yield per plot (kg)

Root yield per plot at the time of harvesting was recorded highest with T_4 200:100:50 NPK (24.93 kg) followed by T_3 150:100:50 NPK (24.73 kg) and T_7 50:250:50 NPK (24.22 kg) and minimum in the control T_1 50:100:50 NPK (18.00 kg) during the investigation (Table- 1). Similar results were observed by Baloch *et al.* (2014) [3], Sumagaysay (2014) [33], Mohammad *et al.*(2015), Verma *et al.* (2017) [34] and Kushwah *et al.* (2020) [14] in radish.

8. Root yield (q/ha)

Maximum root yield at the time of harvesting was recorded with T_4 200:100:50 NPK (415.55 q/ha) followed by T_3 150:100:50 NPK (412.21 q/ha) and T_7 50:250:50 NPK (403.76 q/ha), while the control plants were found to be minimum in root yield q/ha T_1 50:100:50 NPK (300 q/ha) during the investigation (Table-1). These findings are in agreement with those reported by Pervez *et al.* (2004) [26], Bilekudari *et al.* (2005), Baloch *et al.* (2014) [3], Jawad *et al.* (2015) [12], Mohammad *et al.* (2015) and Mehwish *et al.* (2016) [16], Arshad *et al.* (2017) [2] and Mishra *et al.* (2020) [17] in radish.

Table 1: Effect of NPK on yield parameters of Radish cv. Kashi Hans during Rabi 2021

Sl. No.	Treatments	Days to harvest	Length of root (cm)	Diameter of root(cm)	Weight of root(g)	Weight of leaves (g)	Root shoot ratio	Root yield per plot (kg)	Root Yield (q/ha)
1	T_1 50:100:50 (Control)	55.00	27.73	3.50	90.00	139.86	1.49	18.00	300.00
2	T_2 100:100:50	53.50	34.16	4.06	112.60	170.73	1.53	22.52	375.33
3	T_3 150:100:50	52.16	36.96	4.36	123.66	185.66	1.58	24.73	412.21
4	T_4 200:100:50	51.00	38.46	4.46	124.66	198.80	1.60	24.93	415.55
5	T_5 50:150:50	54.00	31.10	3.70	99.53	156.86	1.50	19.90	331.76
6	T_6 50:200:50	53.00	35.16	4.18	117.60	176.93	1.54	23.52	392.00
7	T_7 50:250:50	52.83	35.96	4.26	121.13	180.20	1.55	24.22	403.76
8	T_8 50:100:100	54.46	28.50	3.60	98.00	150.48	1.50	19.60	326.66
9	T_9 50:100:150	53.86	32.28	3.83	107.86	160.06	1.52	21.57	359.55
10	T_{10} 50:100:200	53.66	33.20	3.95	110.40	167.20	1.52	22.08	368.00
11	SEm±	0.31	0.41	0.04	2.44	2.88	0.09	0.39	0.256
12	CD	0.93	1.24	0.11	7.31	8.62	0.25	1.17	0.756

Economic parameter

Benefits: Cost ratio

The economics of cultivation of crop is having major impact and important factor, which is to be recorded in investigation. The data pertaining to benefit: cost ratio revealed that maximum benefit: cost ratio was obtained in that treatments, which fetched highest, gross returns. Treatments indicated significant effect on gross income, net return and B: Cratio. Highest B: C ratio was found with $T_4$200:100:50 NPK, (4.61) due to higher yield which was significantly superior over all other treatments followed by $T_3$150:100:50 NPK (4.57), $T_7$50:250:50 NPK (4.45). Whereas, minimum benefit: cost ratio was obtained in the treatment $T_1$50:100:50 NPK (3.05) (control) due to lesser yield. Finding corroborates with their results obtained by Reddy *et al.* (2011) [28] and Nargave *et al.* (2018) [20] The reason is that the higher yield compensates the cost of fertilizers which results in higher B:C ratio. (Table -2)

Table 2: Effect of NPK on economics of Radish cv. Kashi Hans during Rabi 2021

Sl. No.	Treatments	Total cost of cultivation (Rs/ha)	Gross income (Rs/ha)	Net return (Rs/ha)	Cost benefit ratio
1	T_1 50:100:50 (Control)	74070.52	300000.00	225929.48	3.05
2	T_2 100:100:50	74071.19	375330.00	301258.81	4.07
3	T_3 150:100:50	74071.83	412210.00	338138.17	4.57
4	T_4 200:100:50	74072.48	415550.00	341477.52	4.61
5	T_5 50:150:50	74075.21	331760.00	257684.79	3.48
6	T_6 50:200:50	74079.90	392000.00	317920.10	4.29
7	T_7 50:250:50	74084.59	403760.00	329675.41	4.45
8	T_8 50:100:100	74072.03	326660.00	252587.27	3.41
9	T_9 50:100:150	74073.53	359550.00	285476.47	3.85
10	T_{10} 50:100:200	74070.52	368000.00	293929.48	3.97

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