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Dipika Vardam
M.Sc. Agriculture, Department of SSAC, College of Agriculture, Dr. BSKKV, Dapoli, Maharashtra, India

Pooja Sawant
Associate Professor, Department of SSAC, College of Agriculture, Dr. BSKKV, Dapoli, Maharashtra, India

PB Sanap
Vegetable Specialist, Vegetable Improvement Scheme, Central Experimental Station, Dr. BSKKV, Dapoli, Maharashtra, India

NH Khobragade
Assistant Professor, Department of SSAC, College of Agriculture, Dr. BSKKV, Dapoli, Maharashtra, India

NA Meshram
Scientist (S-1), AICRP on agroforestry, Dr. BSKKV, Dapoli, Maharashtra, India

Nayyar Syeda
M.Sc. Agriculture, Department of SSAC, College of Agriculture, Dr. BSKKV, Dapoli, Maharashtra, India

Pranita Chimate
M.Sc. Agriculture, Department of SSAC, College of Agriculture, Dr. BSKKV, Dapoli, Maharashtra, India

Corresponding Author:
Dipika Vardam
M.Sc. Agriculture, Department of SSAC, College of Agriculture, Dr. BSKKV, Dapoli, Maharashtra, India

Effect of levels of nitrogen and calcium nitrate spray on growth and yield of radish leaves (*Raphanus sativus* L.) Var. Pusa Chetki under Konkan agro-climatic conditions

Dipika Vardam, Pooja Sawant, PB Sanap, NH Khobragade, NA Meshram, Nayyar Syeda and Pranita Chimate

Abstract
A field experiment was undertaken during *Rabi* season, 2021-22 to study the effect different levels of soil applied nitrogen (0, 60, 80 and 100 kg N ha^{-1}) and foliar application of calcium nitrate (0, 0.5, 1.0 and 1.5%) on growth and yield of the radish (*Raphanus sativus* L.) leaves at Central Experiment Station, Pangari Block, Wakawali, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli, Dist. Ratnagiri in factorial randomized block design. The highest dose of nitrogen (100 kg N ha^{-1}) as well as the lowest concentration of calcium nitrate recorded the significantly highest growth and yield parameters *viz.*, number of leaves, height of the plant, fresh weight of leaves, leaf yield and dry weight of leaves. Thus, application of nitrogen @ 100 kg N ha^{-1} along with foliar application of 0.5% calcium nitrate spray significantly increased the height of the plant (45.81 cm), fresh weight of leaves (59.51 g plant-1) and leaf yield (67.44 q ha^{-1}) in lateritic soil of Konkan.

Keywords: Radish, nitrogen, calcium nitrate, growth, yield

Introduction
Radish (*Raphanus sativus* L.) belongs to the genus Raphanus, family Brassicaceae or Cruciferae originating from Central and Western China and India, locally called muli (Hindi) or mula (Marathi). It's grown for the soft young root that can mostly eaten raw as a crunchy salad vegetable with a pungent flavor or cooked. Radish is high in vitamin C and minerals such as calcium, potassium, and phosphorus. Although, it is not one of the traditional green vegetables, the leaves contain more vitamins, minerals, phosphorus, and protein than the radish itself. The leaves are laxative, diuretic, and antiscorbutic. The leaves are high in protein and they are also used as chicken feed and in cooking, as this is a short-term and fast-growing annual or biannual herb suitable for both temperate and tropical climate.

Nitrate ($NO3^-$) is easily absorbed by plants at high rates. Unlike urea or ammonium, it is immediately available as a nutrient. Nitrate is highly mobile in the soil and reaches the plant roots quickly. Applying nitrogen as calcium nitrate provides an instant nutrient supply. Calcium is known to exert important consequence on several physiological processes in plants like ion transport, translocation of carbohydrates, proteins, and their storage during seed formation and other enzymatic activities. Calcium has been reported to inhibit Na^+ uptake and thereby reduce its adverse effect on seed germination (Nayyar, 2003) [6] as well as increase plant growth (Munns, 2002) [5].

Among macro nutrients nitrogen plays a vital role in the growth and development of plants. It is an essential constituent of metabolically active compounds like protein, nucleic acids, chlorophyll and enzymes etc. Nitrogen fertilization is widely adopted to enhance crop production and improve nitrogen utilization all over the world. Among the factors deciding about successful cultivation of this vegetable nitrogen fertilization is of a special meaning and application level of this element should be targeted not only on the yield size, but, first of all, yield. Deficiency of nitrogen in soil results into poor crop yield with low quality, while excessive use of nitrogen negatively affects the quality as well as yield of agricultural crops. Nitrogen is very essential for leafy vegetable production. Its application upholds the overall growth, yield and quality of radish leaves.

With these points in view, an experiment has been undertaken to ascertain the response of radish leaves (Pusa Chetki) to different levels of nitrogen through soil application and calcium nitrate Ca(NO3)2 through foliar application in lateritic soil of Konkan.

Material and Methods

The field experiment was conducted during *Rabi*, 2020-21 in sandy loam soil at Central Experiment Station, Wakawali, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli. The treatments comprising of four levels of nitrogen (0, 60, 80 and 100 kg ha^{-1})] with recommended dose of P and K (50 kg ha^{-1}) through soil application and calcium nitrate (0, 0.5, 1.0 and 1.5%) through foliar application. In the soil application, half split dose of nitrogen along with complete dose of P and K applied as basal dose and remaining half nitrogen dose applied at 20 DAS, while foliar application was done at 25 DAS and 35 DAS. The seeds were sown in the 1st week of November with line sowing maintaining 45 cm distance between the rows in plots of 4 x 3 m2 with application of FYM @ 10 t ha^{-1}. The experiment was laid in a factorial randomized block design with three replication and sixteen treatment combinations *viz*., N0C0 (00 N:50 P_2O_5:50 K_2O kg ha^{-1}), N0C1 (00 N:50 P_2O_5:50 K_2O kg ha^{-1}+0.5% calcium nitrate spray), N0C2 (00 N:50 P_2O_5:50 K_2O kg ha^{-1}+1.0% calcium nitrate spray), N0C3 (00 N:50 P_2O_5:50 K_2O kg ha^{-1}+1.5% calcium nitrate spray), N1C0 (60 N:50 P_2O_5:50 K_2O kg ha^{-1}), N1C1 (60 N:50 P_2O_5:50 K_2O kg ha^{-1}+0.5% calcium nitrate spray), N1C2 (60 N:50 P_2O_5:50 K_2O kg ha^{-1}+1.0% calcium nitrate spray), N1C3 (60 N:50 P_2O_5:50 K_2O kg ha^{-1}+1.5% calcium nitrate spray), N2C0 (80 N:50 P_2O_5:50 K_2O kg ha^{-1}), N2C1 (80 N:50 P_2O_5:50 K_2O kg ha^{-1}+0.5% calcium nitrate spray), N2C2 (98 N:50 P_2O_5:50 K_2O kg ha^{-1}+1.0% calcium nitrate spray), N2C3 (80 N:50 P_2O_5:50 K_2O kg ha^{-1}+1.5% calcium nitrate spray), N3C0 (100 N:50 P_2O_5:50 K_2O kg ha^{-1}), N3C1 (100 N:50 P_2O_5:50 K_2O kg ha^{-1}+0.5% calcium nitrate spray), N3C2 (100 N:50 P_2O_5:50 K_2O kg ha^{-1}+1.0% calcium nitrate spray), and N3C3 (100 N:50 P_2O_5:50 K_2O kg ha^{-1}+1.5% calcium nitrate spray).

The Ca(NO3)2 solution @ 0.5%, 1% and 1.5% was prepared by dissolving the respective weight of Ca(NO3)2 i.e. 5, 10, 15 g L-1 in water by continuous stirring and were applied in the pertinent treatments. Dilute solutions of nutrient salt as per treatments were applied @ 500 litter water ha^{-1} at 25 DAS and 900 litter water ha^{-1} at 35 DAS as a foliar spray with the help of a Knapsack sprayer. Nitrogen, phosphorus and potassium were supplied through urea, single super phosphate and muriate of potash, respectively. For estimation of growth and yield of radish leaves, observations were recorded at harvest from five randomly selected and labeled plants from each treatment plots. Plant heights were measured with a meter scale from ground level to the tip of the main stem. Fresh weight of leaves obtained by weighing all leaves immediately after harvest and yield was count from the fresh weight. Dry matter of plants were estimated by weighing all leaves, branches after being dried them in a hot air oven (at 65 °C to 70 °C) till the constant weight were obtained.

Result and discussion effect of nitrogen levels

Graded increase in growth and yield parameters of radish leaves with graded increase in dose of nitrogen, where the highest dose of nitrogen N3 (100 kg N ha^{-1}) significantly recorded the highest number of leaves (13.73), plant height (43.87 cm), fresh weight of leaves (54.83 g plant-1), leaf yield (62.14 q ha^{-1}) and dry weight (5.75 q ha^{-1}) at harvest of crop which was significantly superior over the lower doses of nitrogen and followed by treatment N2 i.e. 80 kg ha^{-1}. From the data it is observed that the leaf yield of radish increased by 15.20% with the application of 60 kg N ha^{-1}, 65.14% with the application of 80 kg N ha^{-1} and 92.74% with the application of 100 kg N ha^{-1}.

This clearly supports the fact that higher application of nitrogen has a vital role in the betterment of plant physiological processes such as cell division, and cell elongation along with timely metabolic processes. The increase in fresh and dry weight of leaves, stem and root and total dry matter of the plant could be due to higher uptake and accumulation of the greater amount of photosynthates leading to an increase in the number of leaves, plant size and fresh biomass, which in turn yields higher dry matter content. The leaves are the plant factories, manufacturing carbohydrates. Photosynthesis occurs in leaf cells and carbohydrates are formed there. Therefore vegetative growth was increased. Plant height is an indicator of vegetative growth. Minimum plant height might be due to the result of the unavailability of nitrogen and other nutrients required by the plants for their normal growth and development. It was observed that an increase in nitrogen levels positively affected the plant height character. Similar results have been quoted by Baloch (2014) [1] in all growth parameters of radish. The higher leaf yield due to increased nitrogen fertilization have been reported by Ramchandra (1978) [8] in amaranthus and Thakral *et al*. (1992) [13] in coriander leaves.

Effect of calcium nitrate levels

The treatment receiving a lower concentration of calcium nitrate i.e. C1 (0.5% Ca(NO3)2) showed a highly significant effect on the number of leaves (13.73) and plant height 45.81, fresh weight of leaves (45.41 g plant-1), yield (51.47 q ha^{-1}) and dry weight of leaves (5.14 q ha^{-1}), where C1 was at par with C2 in cases of number of leaves and plant height. From the data it is observed that the leaf yield of radish increased by 24.11% with the foliar application of 0.5% calcium nitrate, 17.55% with the foliar application of 1.0% calcium nitrate and 4.10% with the foliar application of 1.5% calcium nitrate.

These results may be because of calcium activating enzymes for cell mitosis division and elongation (Jonnes, 1999) [4]. It can be inferred that when nutrients applied through foliar spray, might have accelerated the metabolic and physiological activity of the plant and put up more growth by assimilating more amount of major nutrients and increasing the leaf area of the plant which ultimately increases leaf fresh weight (Guvence and Badem 2001) [3]. Sarkar and Pal (2006) [10] also reported that foliar application of nitrate at 50 per cent flowering showed a beneficial effect on growth parameters and yield attributing in green gram.

Interaction effect

The treatment receiving 100 kg N ha^{-1} with 0.5% Ca(NO3)2 spray showed significantly highest plant height (45.81 cm), highest fresh weight (59.51 q ha^{-1}) and yield (67.44 q ha^{-1}) and which was at par with N3C2 (100 kg N ha^{-1} with 1.0% Ca(NO3)2 spray) and N2C1 (80 kg N ha- 1 with 0.5% Ca(NO3)2 spray). The number of leaves and dry weight of radish leaves showed non-significant results by the interaction effect of different levels of nitrogen and calcium nitrate spray.

A stimulating effect of Ca on vegetative growth and N absorption by roots indicates that Ca addition to foliar urea sprays enhanced N absorption in apples (Taylor *et al.* 1985) [12]. Calcium (Ca2+) may substantially increase N and P uptake and this may prove to be helpful in promoting root growth (Friessen *et al*. 1980) [2]. Similar results have been quoted by Sarkar and Mallick (2009) [9] in sunflower and Raj and Mallick (2017) [7] in mustard.

Table 1: Effect of levels of nitrogen and calcium nitrate spray on growth and yield of radish leaves

Treatments	Growth and Yield contributing characters				
Nitrogen levels (kg ha^{-1}) (N)	No. of leaves	Plant height (cm)	Fresh weight of Leaves (g plant-1)	Leaf yield (q ha^{-1})	Dry weight (q ha^{-1})
N0	10.08	34.73	28.44	32.24	3.75
N1	11.30	38.58	32.8	37.23	4.22
N2	12.35	41.96	46.98	53.24	5.31
N3	12.90	43.87	54.83	62.14	5.75
‘F’ Test	SIG	SIG	SIG	SIG	SIG
SE (m) ±	0.14	0.37	0.81	0.92	0.13
CD at 5%	0.43	1.06	2.35	2.67	0.36
Ca(NO3)2 levels (%) (C)					
C0	10.99	37.38	36.59	41.47	4.50
C1	12.15	41.89	45.41	51.47	5.14
C2	12.03	40.93	43.01	48.75	5.03
C3	11.46	38.94	38.09	43.17	4.36
‘F’ Test	SIG	SIG	SIG	SIG	SIG
SE (m) ±	0.14	0.37	0.81	0.92	0.13
CD at 5%	0.43	1.06	2.35	2.67	0.36
Interaction (NXC)					
N0 C0	9.57	34.11	27.99	31.72	3.59
N0 C1	10.27	35.28	28.99	32.86	3.72
N0 C2	10.03	35.41	28.54	32.34	4.01
N0 C3	10.47	34.11	28.26	32.03	3.67
N1 C0	10.60	35.46	28.25	32.02	3.63
N1 C1	11.70	42.33	38.27	43.37	4.92
N1C2	11.60	39.66	34.54	39.15	4.44
N1 C3	11.30	36.86	30.34	34.38	3.90
N2 C0	11.70	38.43	40.96	46.42	4.83
N2 C1	12.90	44.12	54.88	62.20	5.79
N2 C2	12.88	43.69	51.45	58.31	5.72
N2 C3	11.92	41.60	40.63	46.04	4.88
N3 C0	12.10	41.52	49.17	55.72	5.94
N3C1	13.73	45.81	59.51	67.44	6.12
N3 C2	13.60	44.96	57.53	65.20	5.96
N3C3	12.17	43.19	53.13	60.21	4.99
‘F’ Test	NS	SIG	SIG	SIG	NS
SE (m) ±	0.29	0.74	1.63	1.84	0.27
CD at 5%	-	2.13	4.71	5.34	-

Conclusion

From the experiment, it was reveal that effect of 100 kg N ha^{-1} and foliar spray of 0.5% calcium nitrate either alone or in combination resulted in maximum number of leaves (13.73), the height of the plant, fresh weight of leaves, leaf yield and dry weight of leaves. Thus, it can be concluded that application of nitrogen @ 100 kg N ha^{-1} in combination with foliar application of 0.5% calcium nitrate spray was found to be most effective in increasing radish leaf production in lateritic soil of Konkan.

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