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Effect of nitrogen, boron and molybdenum on yield of root and leaf protein of radish (*Raphanus sativus*)

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Japanese White' cultivar of radish (*Raphanus sativus* Linn.) could produce 200–300 q roots/ha along with 200–250 kg extracted leaf protein/ha from the by-product tops (Bagchi, 1980). Roy and Seth (1971) and Maurya *et al.* (1977) reported an increase in yield and N content of radish with nitrogen and boron. Anderson (1956) stressed the role of molybdenum in protein synthesis. Hence a field experiment was conducted to determine the effects of N, B and Mo on the yield of root and leaf protein of radish.

Field trials were conducted with 'Japanese White' radish during winters of 1978–79 and 1979–80 at Calcutta. Adjacent fields of even topography and near-uniform fertility were selected. Soil samples (Jackson, 1973), had pH 6.9–7.1, organic carbon 0.442–0.490%, total N 0.038–0.042%, available N 248–284 kg/ha, available P 16.3–23.8 kg/ha, available K 174.2–211.7 kg/ha, water-soluble B 0.626–0.809 ppm and available Mo 0.122 ppm. The fertilizer treatments were 16, consisting of 4 doses of N (0, 60, 120 and 180 kg N/ha as urea) and 2 each of B (0 and 1 kg B/ha as borax) and Mo (0 and 1 kg Mo/ha as sodium molybdate) in 1978–79. In the second year 1 more B (2 kg B/ha) dose was included, making 24 treatments. These were replicated thrice and laid out in randomized block design. In both the trials basal dose of P and K @ 26 and 49.5 kg/ha respectively was applied to all the plots. The B and Mo were also given as basal dose, whereas two-third dose of N was applied at sowing and the remaining 20 days after. Seeds were sown at a spacing of 35 cm × 50 cm in 3 m × 2.1 m plots on 10 November 1978 and 13 November 1979. The crop was thinned after 20 days. Fifty days after of sowing, 4 randomly selected plant samples from each plot were collected for plant-wise weights of fresh and dry roots, and of

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top. Estimation of N and processing of plants for leaf-protein extraction and subsequent heat fractionation to green (chloroplast) and white (cytoplasm) protein together with calculation of extracted leaf protein were done following the standard methods (Pirie, 1978). *In-vitro* analysis of leaf protein concentrates was taken up according to the methods described by Singh and Venkatraman (1982).

The weights of top and root as also fresh-root yield showed maximum significant increase at 120 kg N/ha. For yield the optimum doses of N varied, indicating that response would vary greatly with fertility status and seasonal change (Maurya *et al.*, 1977). Boron @ 1 kg/ha significantly increased the total yield of both dried top and fresh roots but not individual plant weight, confirming the findings of Maurya *et al.* (1977). It also had an increasing effect at 0 or low N level, indicating its importance as a nutrient to the root crop (Gupta, 1979).

Data on N concentration (Table 1) suggested that compared with roots, in top the N content was affected more by N, but no such response was seen for B or Mo. Irrespective of the fertilizer dose, N uptake by top was 58–70% of the total, the highest being at 120 kg N/ha. This suggests that addition of N led to its higher recovery and thereby influence the yield.

Percentage of extractability of protein nitrogen from the by-product tops was 45–53% of total N, which was in the form of total or whole leaf protein. Out of this, 65–70% could be obtained as green or chloroplast protein and the remaining as white or cytoplasm protein. But N, B and Mo did not significantly affect the extractability percentage. Nearly one-third of the dried top yield was in the form of dry fibres and contained 34–39% of total N, suggesting its utilization as cattle feed (Mungikar and Joshi, 1976).

Application of N showed significant

Table 1. Effect of N, B and Mo on growth, yield, nitrogen content and extracted leaf-protein yield of radish (average data of 1978–79 and 1979–80)

Nutrients added (kg/ha)	Fresh-top weight (g/plant)	Fresh-root weight (g/plant)	Dry-root yield (kg/ha)	Fresh-root yield (q/ha)	Total N uptake by tops (kg/ha)	Total N uptake by roots (kg/ha)	Extracted leaf protein yield (kg/ha)
Nitrogen							
0	133.4	91.6	1,170	180.4	45.8	29.2	136.0
60	163.9	128.2	1,696	257.9	72.8	41.2	233.0
120	179.8	172.4	2,043	292.5	94.9	54.3	295.1
180	188.5	182.8	2,242	302.8	99.8	53.5	323.9
Mean	166.4	143.8	1,788	258.4	78.3	44.5	247.0
CD (P = 0.05)	15.8	20.25	285.0	21.2	10.35	10.2	29.1
Boron							
0	164.5	136.7	1,713	244.4	74.4	41.9	233.8
1	165.6	144.7	1,832	269.0	81.6	44.7	254.7
2	169.0	150.0	1,819	261.8	78.9	46.9	252.5
CD (P = 0.05)	NS	NS	97.4	16.3	6.20	NS	20.2
Mo as Na-molybdate							
0	165.6	139.4	1,767	258.6	78.0	42.0	248.6
1	167.5	148.1	1,808	258.1	78.7	47.0	245.9
CD (P = 0.05)	NS	NS	NS	NS	NS	NS	NS

linear increase in leaf protein with successive increase in N level up to 120 kg N/ha, resulting in a mean leaf-protein yield of 295 kg/ha (Byers and Sturrock, 1965). Boron up to 1 kg/ha also increased the leaf-protein yield significantly.

Laboratory analysis of freeze-dried samples of different leaf-protein concentrates indicates that cytoplamic protein had both highest protein content (89%) and digestibility (89%), followed by whole (protein 69% and digestibility 62%) and chloroplastic (protein 56% and digestibility 62%) leaf protein. The cytoplasmic fraction has been suggested as human food, whereas green or chloroplastic as poultry feed (Betschart, 1977). Pirie (1978), however, strongly recommended the use of whole-leaf protein for human consumption. Our study suggests strong potential of by-product tops of radish as a good protein source.

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