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Nutrient uptake studies on broccoli *(Brassica oleracea* L. var. *italica)* grown on peat

[Kajian pengambilan nutrien oleh brokoli *(Brassica oleracea* L. var. *italica)* di tanah gambut]

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Key words**:** broccoli, nutrient uptake, nutrient distribution

Abstrak

Penyerapan nutrien N, P, K, Ca dan Mg pada kadar 96, 19, 132, 44 dan 23 kg/ha telah diperoleh. Nisbah pengambilan nutrien yang didapati ialah 4:1:6:2:1 untuk N:P:K:Ca:Mg. Hanya 27% N, 22% P, 16% K, 6% Ca dan 10% Mg daripada keseluruhan pengambilan nutrien diserap oleh bahagian kepala brokoli untuk mengeluarkan hasil 5.6 t/ha. Nutrien yang lain diserap oleh bahagian yang tidak boleh dimakan iaitu daun, batang dan akar. Keperluan mikronutrien kurang daripada 0.5 kg/ha. Maklumat yang didapati boleh digunakan sebagai panduan untuk pembajaan brokoli yang ditanam di tanah gambut.

Abstract

Nutrient uptakes of N, P, K ,Ca and Mg at 96, 19, 132, 44 and 23 kg/ha respectively were obtained. Nutrient uptake ratio obtained was 4:1:6:2:1 for N:P:K:Ca:Mg. Only 27% N, 22% P, 16% K, 6% Ca and 10% Mg of the total nutrient uptake were removed in the edible head for an economic yield of 5.6 t/ha. The rest were found in the non-edible leaves, stems and roots. Micronutrient uptake was less than 0.5 kg/ha. Data presented can be used as a guide for formulating fertilizer needs of broccoli grown on peat.

Introduction

Broccoli, a new crop under lowland conditions, is not widely cultivated in Malaysia presently (Anon 1991). Recent research has shown there is economic potential of broccoli cultivation under rainshelter in the lowlands (Illias Mohd. Khir 1992). Variety 108 from Taiwan has been identified as one of the promising varieties.

As there is no information on the nutrient requirement of broccoli under local conditions, studies on the macro and micronutrient concentration, and uptake by broccoli grown on peat under rainshelter were conducted. The data presented serve as a guide for formulating fertilizer needs of broccoli under local conditions.

Materials and methods

Collection of samples

Four-week-old broccoli plants were transplanted on 1 m wide beds under rainshelter on peat soil at the MARDI Research Station, Jalan Kebun. The characteristics of the peat soil are given in

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Table 1. The planting distance used was 50 cm x 45 cm and the interbed space was 0.5 m. The planting density was 25 650 plants/ha. The plants were fertilized with NPK 12:12:17:2 ($N:P_2O_5:K_2O:MgO$) at 1 000 kg/ha.

At 12 weeks from sowing, 60 mature broccoli plants were randomly sampled for biomass and nutrient determination. Seventeen samples (50 plants/sample) at 4 weeks from sowing, 28 samples (6 plants/sample) at 6 weeks from sowing, 47 samples (2 plants/sample) at 8 weeks from sowing and 24 samples (2 plants/sample) at 10 weeks from sowing were also collected.

Treatment of sample

Mature plants were separated into heads, leaves, stems and roots while the 4, 6, 8 and 10-week-old plants were not separated. The roots were washed free of soil particles and the other plant parts were cleaned of adhering soil particles by wiping with a damp cloth. Fresh weights of head, leaves, stem and roots were obtained for each plant. The plant parts were then chopped and approximately 200 g samples were placed in cardboard trays, labelled and dried in a hot air oven at 70 °C to constant weight. The dry weight of each sample was obtained. The dried samples were then ground for nutrient analysis.

Chemical analyses

Nitrogen was determined by the micro-Kjeldahl method using an autoanalyser. For the other elements, 1–2 g of sample was weighed into a silica basin and dry-ashed in a muffle furnace at 500 °C (for 4–5 h) until ashing was complete. The ash was dissolved in a mixture of nitric and hydrochloric acids and allowed to evaporate on a water-bath. The residue was then washed with warm distilled water into a 100-mL volumetric flask. The nutrients P, K, Ca, Mg, Mn, Fe, Cu, Zn and B were determined using the ICP emission spectrophotometer.

Table 1. Soil characteristics of broccoli plot

Characteristic	Value
pH	5.80
Soluble P	300 ppm
Organic carbon	25.60%
Nitrogen	1.23%
CEC	119.40 meq./100 g
Exchangeable K	2.08 meq./100 g
Exchangeable Na	0.66 meq./100 g
Exchangeable Ca	66.90 meq./100 g
Exchangeable Mg	59.00 meq./100 g

Results and discussion

Biomass production

The total dry biomass production of the mature broccoli was 103.3 g/plant. The edible head had the lowest dry matter content of 10.0%, followed closely by the stem (10.6%) and leaves (11.5%). The roots had the highest dry matter content (21.4%). At a planting density of 25 650 plants/ha, an estimated economic (head) yield of 5.6 t of edible heads was obtained *(Table 2)*.

The leaves formed the major portion of the dry biomass (44%) followed by the stem (26%), head (21%) and roots (9%). The head (economic yield) comprised about 24% of the fresh weight of the broccoli plant and 21% dry weight, reflecting the lower dry weight of the edible head compared with the other plant parts.

The fresh weight and dry matter content of the immature broccoli plants at 4, 6, 8 and 10 weeks after sowing are shown in *Table 3*. The dry weight increased over 100-fold from 0.13 g/plant at 4 weeks to over 17 g/plant at 10 weeks.

Macronutrient composition

Results of chemical analysis *(Table 4)* showed that N content ranged from 1.77% in the roots to 4.76% in the edible head. This is lower than the critical N levels of 5.2–6.0% N reported by Munro et al. (1978). Phosphorus content ranged from 0.56% in the leaves to 0.88% in the stem which is comparable to the P levels reported by Munro et al. (1978). Potassium content

Table 2. Biomass production of mature broccoli components

Plant part	Biomass per plant (g)		Dry weight (%)	Biomass (t/ha)	
	Fresh	Dry		Fresh	Dry
Head	217.5 ± 7.7*	21.8 ± 0.7*	10.0	5.6	0.56
Leaves	397.5 ± 11.4	45.6 ± 1.2	11.5	10.2	1.17
Stem	253.0 ± 6.1	26.7 ± 0.7	10.6	6.5	0.69
Roots	43.0 ± 1.8	9.2 ± 0.3	21.4	1.1	0.24
Total	911.0	103.3		23.4	2.66

*S.E. of mean

Table 3. Biomass production by immature broccoli plants

Age (weeks)	Biomass per plant (g)		Dry weight (%)	Biomass (t/ha)	
	Fresh	Dry		Fresh	Dry
4	1.45 ± 0.05*	0.13 ± 0.01*	8.96	0.04	0.003
6	12.14 ± 0.40	1.04 ± 0.03	8.57	0.31	0.027
8	100.08 ± 5.00	9.08 ± 0.43	9.07	2.57	0.233
10	228.54 ± 27.50	17.06 ± 2.10	7.46	5.86	0.436

*S.E. of mean

Table 4. Macronutrient composition of mature broccoli plants

Plant part	Mean composition (%)				
	N	P	K	Ca	Mg
Head	4.76 ± 0.06*	0.73 ± 0.01*	3.83 ± 0.06*	0.50 ± 0.01*	0.39 ± 0.01*
Leaves	4.30 ± 0.08	0.56 ± 0.01	3.98 ± 0.14	2.83 ± 0.05	1.25 ± 0.02
Stem	2.12 ± 0.04	0.88 ± 0.04	8.12 ± 0.17	0.83 ± 0.03	0.68 ± 0.02
Roots	1.77 ± 0.04	0.79 ± 0.02	3.85 ± 0.06	1.11 ± 0.03	0.62 ± 0.04

*S.E. of mean

was highest in the stem (8.12%) and lowest in the head (3.83%). A high K content in stems was also reported for lettuce (Vimala and Cheah 1980), potato (Vimala et al. 1990), English cabbage (Vimala and Joseph 1977) as well as in Chinese cabbage and cauliflower (Vimala et al. 1980). The K content obtained was higher than that reported by Munro et al. (1978). The Ca content was highest in the leaves (2.83%) and lowest in the head (0.50%). The Mg content too was highest in the leaves and lowest in the head. The percentage of nutrients in decreasing order of magnitude was K > N > Ca > P and Mg.

The macronutrient composition at the earlier stages of growth are shown in *Table 5*. The N content generally decreased with the age of plant while K content showed an increase. No trend in P, Ca and Mg composition at the various stages of growth is evident.

Macronutrient uptake

An average of 3.7 g N, 0.7 g P, 5.1 g K, 1.7 g Ca, and 0.9 g Mg were taken up by each broccoli plant at maturity *(Table 6)*.

At a planting density of 25 650 plants/ha used in this study, the total nutrient uptake by broccoli were 96 kg N, 19 kg P, 132 kg K, 44 kg Ca and 23 kg Mg *(Figure 1)*. Magnifico et al. (1979) reported

Table 5. Macronutrient composition of immature broccoli plants

Age (weeks)	Mean composition (%)				
	N	P	K	Ca	Mg
4	6.42 ± 0.11*	0.78 ± 0.05*	4.55 ± 0.11*	1.90 ± 0.04*	0.91 ± 0.03*
6	5.95 ± 0.04	0.56 ± 0.01	4.63 ± 0.04	2.57 ± 0.02	0.88 ± 0.01
8	5.57 ± 0.03	0.60 ± 0.01	5.40 ± 0.05	2.87 ± 0.03	0.96 ± 0.01
10	3.55 ± 0.22	0.79 ± 0.03	8.00 ± 0.41	1.67 ± 0.10	0.91 ± 0.06

*S.E. of mean

Table 6. Macronutrient uptake by mature broccoli plants

Plant part	Mean uptake (mg/plant)					Total uptake (kg/ha)
	N	P	K	Ca	Mg	
Head	1 032 ± 32*	159 ± 5.7*	836 ± 29*	107 ± 3*	86 ± 2.2*	56.9
Leaves	1 970 ± 71	258 ± 9.6	1 802 ± 73	1 293 ± 43	573 ± 19.8	151.2
Stem	565 ± 18	233 ± 10.2	2 156 ± 59	219 ± 6	181 ± 4.8	86.0
Roots	160 ± 5	72 ± 2.7	351 ± 11	103 ± 5	58 ± 4.7	19.1
Total	3 727	722	5 145	1 722	898	

*S.E. of mean

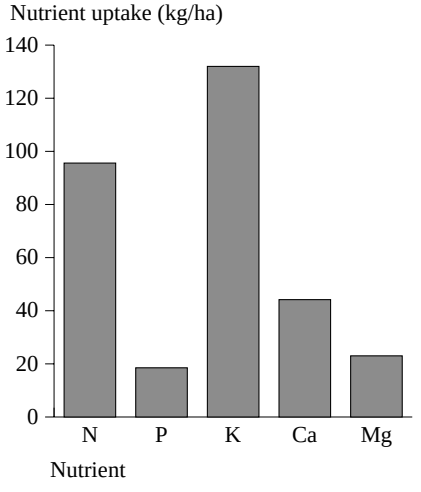

Figure 1. Total nutrient uptake by broccoli plants

N, P and K removals of 559, 23 and 723 kg/ha respectively. The lower N and K removals obtained in this study are attributed to the lower yields obtained.

The leaves removed the largest amount of nutrients followed by the stem, the head and the roots *(Table 6).*

About 27% N, 22% P, 16% K, 6% Ca and 10% Mg were removed by the edible head and are considered lost from the soil for the production of economic yield *(Figure 2)*. The rest of the nutrients for the production of non-economic yield (leaves, stems and roots) can be returned to the soil by incorporating the crop residue into the soil.

Macronutrients are removed at various stages of growth *(Figure 3*). The uptake of nutrients is negligible in the early stages of growth. In fact about 60% of the nutrient uptake occurs in the last 3 weeks before harvest. It is therefore important to ensure that sufficient nutrients are available to the plant at the later stages of growth.

Fertilizer recommendation must make allowance for the inherent soil fertility status, loss of nutrients through fixation, leaching, volatilization and surface runoff in addition to the absolute quantities of plant nutrients removed by the crop.

Micronutrient composition

The Mn content ranged from 14.2 to 32.7 ppm, Fe from 77.7 to 378.1 ppm, Cu from 3.6 to 9.3 ppm, Zn from 28.7 to 58.4 ppm and B from 21.2 to 32.7 ppm *(Table 7)*. The concentrations for Fe, Zn and B obtained in

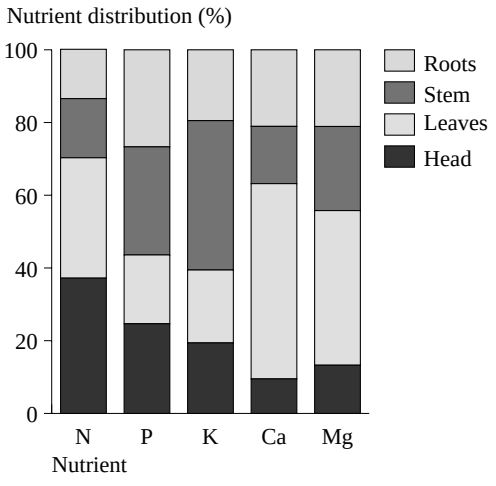

Figure 2. Distribution of nutrients in the broccoli plants

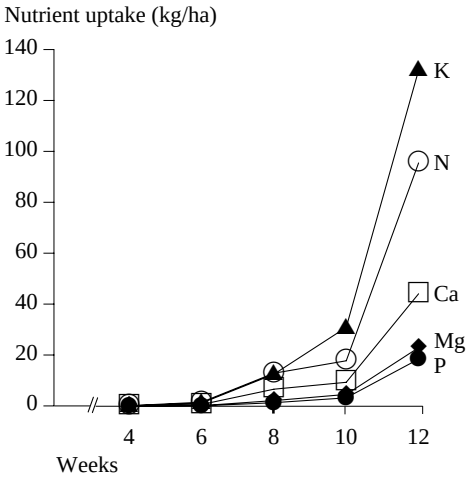

Figure 3. Major nutrient uptake by broccoli plants at various stages of growth

Table 7. Micronutrient composition of mature broccoli plants

Plant part	Mean composition (ppm)				
	Mn	Fe	Cu	Zn	B
Head	24.5 ± 0.6*	92.0 ± 2.8*	3.6 ± 0.5*	58.4 ± 0.8*	32.7 ± 1.3*
Leaves	32.7 ± 1.3	184.5 ± 3.5	4.6 ± 0.2	36.7 ± 0.8	21.2 ± 0.5
Stem	14.2 ± 0.5	77.7 ± 5.1	4.8 ± 0.2	28.7 ± 0.6	22.9 ± 0.6
Roots	21.9 ± 1.0	378.1 ± 33.8	9.3 ± 0.6	57.4 ± 4.7	21.9 ± 0.4

*S.E. of mean

this study are above the critical leaf concentrations reported by Scaife and Turner (1983). Maynard (1979) reported a Fe concentration of 100 ppm as being sufficient for normal growth of vegetables. However, Purvis and Carolus (1964) reported that the Fe content of normal plant tissue varied from 25 to 500 ppm, depending on plant part and species. The lower range of concentrations obtained for Mn and Cu in this study are below the critical values of 20 ppm for Mn and 5 ppm for Cu reported by Scaife and Turner (1983).

Micronutrient uptake

The micronutrient uptake per plant at maturity were 2.6 mg Mn, 16.1 mg Fe, 0.5 mg Cu, 4.2 mg Zn and 2.5 mg B. More than 50% of Mn and Fe, and about 40% of the other micronutrients were found in the leaves *(Table 8)*. Though removed at the rate of less than 0.5 kg/ha *(Table 9),* these micronutrients are essential for growth and must be available to the plants to ensure high yields.

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Table 8. Micronutrient uptake by mature broccoli plants

Plant part	Mean uptake (mg/plant)				
	Mn	Fe	Cu	Zn	B
Head	0.53 ± 0.02*	2.00 ± 0.1*	0.07 ± 0.01*	1.27 ± 0.04*	0.71 ± 0.03
Leaves	1.49 ± 0.07	8.38 ± 0.3	0.21 ± 0.01	1.66 ± 0.05	0.96 ± 0.03
Stem	0.38 ± 0.02	2.03 ± 0.1	0.13 ± 0.01	0.77 ± 0.03	0.61 ± 0.02
Roots	0.20 ± 0.01	3.68 ± 0.4	0.09 ± 0.01	0.53 ± 0.05	0.20 ± 0.01
Total	2.60	16.09	0.50	4.23	2.48

*S.E. of mean

Table 9. Micronutrient uptake by a hectare of broccoli plants

Plant part	Mean uptake (g/ha)				
	Mn	Fe	Cu	Zn	B
Head	13.6	51.2	1.9	32.5	18.2
Leaves	38.2	215.1	5.3	42.7	24.8
Stem	9.8	52.2	3.2	19.7	15.5
Roots	5.2	94.4	2.3	13.7	5.1
Total	66.8	412.9	12.7	108.6	63.6

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