MARDI Res. J. 18(2)(1990): 267–272

Nutrient removal studies on potato *(Solanum tuberosum)*

[Pengambilan nutrien oleh ubi kentang *(Solanum tuberosum)*]

P. Vimala*, N. H. Yeong* and N. Shukor**

Key words : potato, nutrient uptake, nutrient distribution

Abstrak

Kandungan dan pengambilan nutrien oleh ubi kentang (varieti Famosa) telah dikaji. Kadar nutrien N, P, K, Ca dan Mg yang diserap oleh ubi kentang dengan hasil 27 t/ha ialah 78, 11, 154, 31 dan 7 kg/ha. Nisbah pengambilan nutrien yang didapati ialah 11:2:22:4:1 untuk N:P:K:Ca:Mg. Lebih kurang 50% N, K, dan Mg, 70% P dan 8% Ca telah diserap oleh bahagian ubi dan yang lain diserap oleh daun dan batang pokok ubi kentang. Mikronutrien yang diserap adalah lebih kurang 1 kg/ha. Maklumat yang didapati boleh diguna sebagai panduan untuk pembajaan ubi kentang.

Abstract

Nutrient contents and removal by potato (Famosa variety) were investigated. Nutrient removal rates of 78, 11, 154, 31 and 7 kg/ha of N, P, K, Ca and Mg respectively were obtained for a yield of 27 t/ha. Nutrient removal ratio obtained was 11:2:22:4:1 for N:P:K:Ca:Mg. About 50% of N, K and Mg, 70% P and 8% Ca were removed by the tubers and the remainder by leaves and stems. About 1 kg/ha of each micronutrient was removed. Data presented can be used as a guide for formulating fertilizer needs of potato.

Introduction

Presently, potato is not widely cultivated in the highlands of Malaysia. Less than 1% of the area under vegetable cultivation is reported to be grown with potato. However, efforts are being made to introduce potato cultivation to farmers in Cameron Highlands as well as in the lowlands. Through varietal evaluation studies several potential varieties have been identified. Famosa was found to be the most promising variety in Cameron Highlands (Shukor and Saharan 1986).

As information on the nutrient requirements of potato under local conditions is unavailable, studies on the removal of macro and micronutrients by potato (Famosa variety) grown under Cameron Highlands conditions were conducted.

The data presented serve as a guide for formulating fertilizer needs of potato and as a basis for future research on the nutrient needs of potato.

Materials and methods

Collection of sample

Sixty-seven mature disease-free potato plants were randomly collected from a potato plot containing 300 plants, in Cameron Highlands. The plants were grown on clay-loam soil fertilized with chicken-dung at 10 t/ha and chemical fertilizer (12:12:17:2) at 2 t/ha was applied

*Division of Horticulture, MARDI Jalan Kebun, P.O. Box 186, 41720 Kelang, Malaysia
**Division of Horticulture, MARDI Cameron Highlands, 39000 Tanah Rata, Malaysia
Authors' full names: Vimala Purushothaman, Yeong Nam Hin and Shukor Nordin

Table 1. Mean fresh and dry weight of potato plant

Plant part	wt. (g/plant)		Dry (%)
	Fresh	Dry	
Leaves	215.2 ± 10.39*	18.8 ± 0.95*	8.7 ± 0.31*
Stems	225.0 ± 9.23	20.6 ± 0.96	9.1 ± 0.16
Tubers	964.1 ± 38.08	139.1 ± 5.56	14.4 ± 0.12

* S.E. of mean

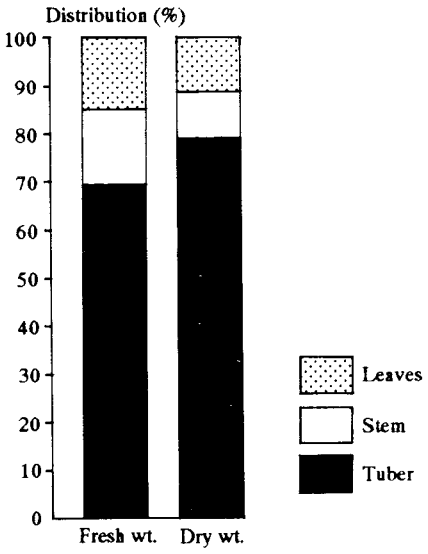

Figure 1. Distribution of fresh and dry weights of the potato plant

in three equal split applications.

Treatment of sample

In the laboratory, the plants were separated into leaves, stems and tubers. The tubers were washed and the other plant parts were cleaned of adhering soil particles. Fresh weights of the leaves, stems and tubers were obtained for each plant. Each plant part was then chopped up separately, mixed thoroughly and approximately 200-g samples were obtained. These 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 analyses.

Chemical analyses

Nitrogen was determined by the micro-Kjeldahl method using the 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.

Results and discussion

Mean fresh weight and dry-matter content

From *Table 1,* the tubers showed the highest dry-matter content (14.4%) compared with the stems (9.2%) and the leaves (8.7%). In Australia, a dry-matter content of 20% was reported for tubers (Darley 1975).

Distribution of edible and non-edible components

In *Figure 1,* the edible tubers comprised 69% of the fresh weight and 78% of the dry weight of the potato plant. The non-edible leaves and stem formed the remaining 31% of the fresh weight or 22% of the dry weight. The leaves and stem can be returned to the soil possibly after composting.

Macronutrient composition

Results of the chemical analyses *(Table 2)* showed that nitrogen content ranged from 1.04% in the tubers to 4.74% in the leaves. Phosphorus content varied from 0.21% in

Table 2. Macronutrient composition of potato plant

Plant part	Mean composition (%)				
	N	P	K	Mg	Ca
Leaves	4.74 ± 0.04*	0.35 ± 0.01*	5.83 ± 0.08*	0.40 ± 0.01*	3.08 ± 0.07*
Stems	2.23 ± 0.05	0.22 ± 0.01	8.53 ± 0.10	0.27 ± 0.01	2.16 ± 0.05
Tubers	1.04 ± 0.02	0.21 ± 0.01	1.91 ± 0.03	0.09 ± 0.002	0.06 ± 0.001

* S.E. of mean

Table 3. Macronutrient removal by potato plant

Plant part	Mean removal (mg/plant)				
	N	P	K	Mg	Ca
Leaves	889.8 ± 45.17*	66.6 ± 4.00*	1 116.7 ± 62.62*	77.4 ± 5.18*	576.7 ± 29.58*
Stems	452.1 ± 22.70	46.5 ± 3.62	1 733.3 ± 80.05	55.0 ± 3.16	436.3 ± 21.21
Tubers	1 431.5 ± 59.61	283.4 ± 12.05	2 632.2 ± 104.75	122.7 ± 5.15	86.0 ± 3.89

* S. E. of mean

the tubers to 0.35% in the leaves. Potassium content was highest in the stem (8.53%) followed by the leaves (5.83%) and tubers (1.91%). According to Lorenz (1965) the deficiency levels for potatoes would be 0.6% NO_3-N, 0.08% PO_4-P and 7% K. Though not directly comparable, as total N and total P were determined in this study, it can be assumed that the nutrient composition of the potato plants sampled was in the sufficient range. No deficiency symptoms were observed and yields (27 t/ha) were also high. Only very low levels of calcium (ca) were found in the tubers (0.06%) compared with that in the leaves (3.08%) and stem (2.16%). Magnesium content ranged from 0.09% to 0.40%. The percentage of nutrient in decreasing order of magnitude was K>N>Ca>P>Mg.

A similar trend in nutrient composition was obtained for other highland vegetables (Vimala and Joseph 1977; Vimala and Cheah 1980; Vimala et al. 1980).

Macronutrient removal

About 5.5 g K, 2.8 g N, 1.1 g Ca, 0.4 g P and 0.3 g Mg were removed by each of the potato plants *(Table 3)*. About 50% of N, K and Mg, 70% P and 8% Ca were removed by the tubers *(Figure 2)* and are considered lost from the soil for production of economic yield. The rest of the nutrients for the production of non-economic yield (leaves and stem) can perhaps be gainfully returned to the soil by incorporating the crop residue into the soil.

At a planting density of 28 000 plants/ha and a yield of 27 t/ha, the total nutrients removed by the leaves, stems and tubers were 78 kg N, 11 kg P, 154 kg K, 31 kg Ca and 7 kg Mg/ha *(Table 4)*. Splittstoesser (1974) in U.S.A. reported a removal of 67 kg N, 29 kg P, 77 kg K per ha for a potato yield of 20 t/ha. In Australia, removals of 168 kg N, 28 kg P and 224 kg K were reported (Darley 1975). In France, Loue (1977) reported removals of 113 kg N, 19 kg P, 157 kg K, 5 kg Ca and 8 kg Mg for a yield of 37 t/ha. Motta Macedo (1976) reported removal of 55-81 kg N, 10-18 kg P, 94-154 kg K, 4-10 kg Ca and 2-4 kg Mg for six varieties in Brazil. For a yield of 40 t/ha removals of 175 kg N, 34 kg P and 248 kg K/ha have been reported (Anon. n.d.). The varying quantities of nutrients reported could be attributed to the differing yields obtained.

Fertilizer recommendation must make allowance for the inherent soil fertility status, loss of nutrients through fixation, leaching, volatilization and surface run-off,

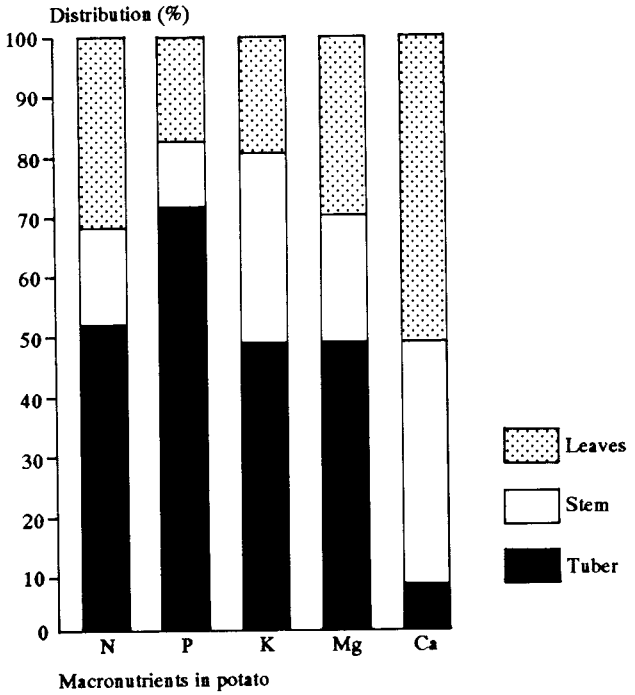

Figure 2. Distribution of nutrients in the potato plant

Table 4. Macronutrient removal by a hectare of potato plant

Plant part	Removal (kg/ha)				
	N	P	K	Mg	Ca
Leaves	24.91	1.86	31.27	2.17	16.15
Stems	12.66	1.30	48.53	1.54	12.22
Tubers	40.08	7.94	73.70	3.42	2.41
Total	77.65	11.10	153.50	7.13	30.78

Table 5. Micronutrient compostion of potato plant

Plant part	Mean composition (ppm)				
	Mn	Fe	Cu	Zn	B
Leaves	1 216.8 ± 26.42*	1 540.4 ± 54.87*	11.4 ± 0.97*	157.3 ± 3.31*	27.1 ± 0.54*
Stems	368.3 ± 10.31	583.2 ± 25.36	12.6 ± 1.66	84.8 ± 1.79	22.6 ± 0.22
Tubers	6.8 ± 0.21	48.2 ± 1.41	1.3 ± 0.10	12.1 ± 0.32	4.3 ± 0.13

* S. E. of mean

in addition to the absolute quantities of plant nutrients removed by the crop. These losses must be added to the nutrient removal values to ensure that sufficient nutrients are available for crop growth. This approach is particularly useful in areas where field trials are either lacking or costly and when immediate fertilizer recommendation is needed.

The amount of chemical fertilizer (12:12:17:2 at 2 t/ha) presently applied for potatoes in Cameron Highlands would

Table 6. Micronutrient removal by potato

Plant part	Mean removal (mg/plant)				
	Mn	Fe	Cu	Zn	B
Leaves	23.15 ± 1.35*	28.84 ± 1.65*	0.21 ± 0.01*	2.98 ± 0.17*	0.52 ± 0.03*
Stems	7.34 ± 0.36	11.68 ± 0.69	0.23 ± 0.02	1.69 ± 0.07	0.46 ± 0.02
Tubers	0.92 ± 0.40	6.70 ± 0.35	0.17 ± 0.01	1.64 ± 0.07	0.59 ± 0.03
Total	31.41	47.22	0.61	6.31	1.57

* S. E. of mean

Table 7. Micronutrient removal by a hectare of potato plant

Plant part	Removal (g/ha)				
	Mn	Fe	Cu	Zn	B
Leaves	648.2	807.5	5.88	83.4	14.6
Stems	205.5	327.0	6.44	47.3	12.9
Tubers	25.8	187.6	4.76	45.9	16.5
Total	879.5	1 322.1	17.1	176.6	44.0

provide 240 kg N, 103 kg P, 272 kg K, 24 kg Mg and about 100 kg Ca. These macronutrients applied are therefore in excess of the nutrient removal values of 78 kg N, 11 kg P, 154 kg K, 7 kg Mg and 31 kg Ca obtained in this study. This is more so if the nutrients available from the chicken-dung (10 t/ha) which was applied as basal, are also considered. As a rough guide, only two-thirds of applied nitrogen, one-third applied phosphorus and one half applied potassium is available for plant uptake. Using this as a guide the N and P applied can be reduced by 50%. However, field response studies are suggested to substantiate this estimate.

Micronutrient composition

Among the micronutrients Mn (1 216 ppm), Fe (1 540 ppm), Zn (157 ppm) and B (27 ppm) were highest in the leaves while Cu (12.6 ppm) was highest in the stem. All the micronutrient contents were lowest in the tubers, compared with the leaves and stems *(Table 5)*.

Micronutrient removal

The total micronutrient removal per plant was 47.22 mg Fe, 31.41 mg Mn, 6.31 mg Zn, 1.57 mg B and 0.61 mg Cu *(Table 6)*. For a hectare, the micronutrients worked out to be 880, 1 322, 17, 177 and 44 g for Mn, Fe, Cu, Zn and B respectively *(Table 7)*. Though removed at the rate of about 1 kg/ha or less of each, these micronutrients are essential for growth and must be available to the plant to ensure high yields.

Acknowledgement

The authors are grateful to the Central Analytical Services Division, MARDI for the plant analysis. They would like to thank Dr Saharan Hj. Anang for his comments on the paper. Mr Azizan and Mr Ngaspan Sardan are gratefully acknowledged for field assistance.

References

Anon. (n.d). *General recommendation for the application of BASF nitrophoska complex fertilisers*

Darley, E. C. (1975). Potato growing. New South Wales Dept. of Agriculture. Div. of plant industry Bulletin. p. 1-32

Lorenz, O. A. (1965). *Plant Food Review 11 (2):* 2-4. Quoted by Jan G. de Geus. (year) in *Fertiliser guide for the tropics and sub tropics* Zurich : Centre d'I'Azote

Loue', A. (1977). Fertilisation et nutrition minerale de la pomme de terre. Experimentation et'etudes agronomiques. SCPA. Mulhouse. 147 p.