J. Trop. Agric. and Fd. Sc. 44(1)(2016): 39 – 48

Precision nutrient management for export quality chrysanthemum: Soil nutrient status in relation to plant uptake

N. Dayang Safinah[1], A.B. Noor Haslizawati[2], M. Intan Nadhirah[2] and H. Abdul Razak[1]

[1]Crop and Soil Science Research Centre, MARDI Headquarters, Persiaran MARDI-UPM, 43400 Serdang, Selangor, Malaysia
[2]Crop and Soil Science Research Centre, MARDI Cameron Highlands, 39000 Tanah Rata, Pahang, Malaysia

Abstract
Two established farms that produce export quality chrysanthemum cut flowers at Kuala Terla and Ringlet, Cameron Highlands, Pahang were selected as the study area. Samplings of soils and plants at vegetative and reproductive stage were selected based on plants that show the best growth performance, so that the soil-plant nutrient status is considered to be at optimum level. This study was conducted to determine the relationship between soil nutrient status with plant nutrient uptake, and to monitor the translocation of nutrients from soils to the plants parts. Results obtained indicated that soil types and prevailing soil conditions can affect certain nutrient concentrations in the soils. This study also found that there is significant difference in nutrient requirement during vegetative and reproductive stage. It was shown that nutrients (N, P, K, Ca and Mg) tend to accumulate very high in the leaves for both Kuala Terla and Ringlet. Meanwhile, lowest nutrient accumulation is in the stem and root. The most mobile nutrient for chrysanthemum uptake is N, while Ca and Mg are the least mobile nutrients. To optimise the supply and demand of nutrients through soil-plant system, site-specific nutrient management should be implemented.

Keywords: soil nutrient status, plant uptake, accumulation, translocation

Introduction

Chrysanthemum (*Chrysanthemum morifolium*) which occupies a prominent place in ornamental horticulture is one of the commercially exploited flower crops. It is mainly grown for cut flower and loose flower for garland making, general decoration, hair adornments and religious function (Verma et al. 2011). In Malaysia, fresh cut flowers are one of the most profitable areas in horticulture sectors which could bring favourable foreign exchange. It is expected that from 2011 until 2020, total flower production will increase from 468 million in 2010 to 892 million potted or cuttings in 2020, with a growth rate of 6.2% per annum. Floriculture exports also projected to rise from RM449 million in 2010 to RM857 million in 2020. Meanwhile, flowers planted area is expected to stay on track at a rate of 3.8% per annum from 2400 ha in 2010 to 3,500 ha in 2020. Development of area for temperate flower such as chrysanthemum in the highlands will cover an area of 120 ha, including Tanah Tinggi Lojing, Kelantan, Tanah Tinggi Kinta, Perak, as well as in Sabah and Sarawak (MOA. 2011). In the floriculture

Article history
Received: 24.3.2015
Accepted: 6.4.2015

Authors' full names: Dayang Safinah Nayan, Noor Haslizawati Abu Bakar, Intan Nadhirah Masri and Abdul Razak Hamzah
E-mail: dayangsn@mardi.gov.my

industry, chrysanthemum has been identified as the most popular flower for the non-orchid industry (Ramlan et al. 2000).

Chrysanthemum requires large amount of nutrients especially during the first 7 or 8 weeks of growth to ensure quality foliage and blooms (Siti Aishah et al. 2001). Plant nutrition is known to have a great effect on growth, flowering and postharvest quality of horticultural crop products (Siti Aishah et al. 2000). The yield of a crop is affected by the nutritional environment of that crop, and the nutritional status can be monitored by plant analysis (Holcomb and White 1980). However, plant analysis does not always indicate the nutritional status of plants, and it may require soil testing. Soil tests will provide information on the nutritional environment of the plant roots, which relate to elemental composition of the plant. Even if soil test values are compatible to relate with the nutrient management in soil-plant system, there still remains the challenge of selecting a science-based nutrient management philosophy. Furthermore, the inappropriate application of fertiliser has become a common phenomenon in chrysanthemum export quality production and has led to nutrient imbalances, inefficient use of nutrient and large losses to the environment. In addition, *Dasar Agromakanan Negara* (DAN) also focus on strengthening the activities of research and development to develop competitive floriculture industry. Nutrient management is important to optimise the supply and demand of nutrients accordingly. But before that, study on differences in soil-plant system must be done. Hence, this research was conducted to determine the relationship between soils status with plant nutrient uptake, and to observe the translocation of nutrients from soil to other plant parts.

Materials and methods

Two established farms producing export quality chrysanthemum cut flowers in Kuala Terla and Ringlet, Cameron Highlands, Pahang were selected as study areas. Variety Mona Lisa is produced in Kuala Terla, whereas Barry More is produced in Ringlet. Fertilisation programme for both farms is similar since both are under the same management (*Table 1*). The agronomic practices followed a standard of procedure sets to ensure the export quality of cut flower achieved the specification (Mohd Ridzuan et al. 2003).

Selection of beds for plant sampling at vegetative and reproductive stages was based on the best growth performance. This method was used so that data on plant nutrient status are considered to be at an optimum level. Vegetative stage chrysanthemum was sampled at about 10 weeks old, and reproductive stage was sampled at budding period. On each selected bed, three points were marked and at each point, five healthiest chrysanthemum plants were harvested and composited as one sample. Therefore, three composite samples were collected for both vegetative and reproductive stages from each farm. The sampling layout is shown in *Figure 1*.

Soil samples at two different depths (0 – 15 cm and 15 – 30 cm) were collected adjacent to chrysanthemum sampling point. In the laboratory, the soil samples were air-dried and sieved through a ≤2.0 mm sieve. The soil chemical properties determined were the pH in water at soil:water of 1:2.5; cation exchange capacity (CEC) by leaching

Table 1. Common fertiliser management for chrysanthemum cultivation at Cameron Highlands

Time of application	Fertiliser types	Amount (t/ha)
Basal fertilisation before transplanting	Processed organic amendment (e.g. Amina)	1.5 – 3.0
4th week after transplanting	Granule fertiliser NPK 15:15:15	0.7 – 1.2
7th week after transplanting	Granule fertiliser NPK 12:12:17	0.7 – 1.2

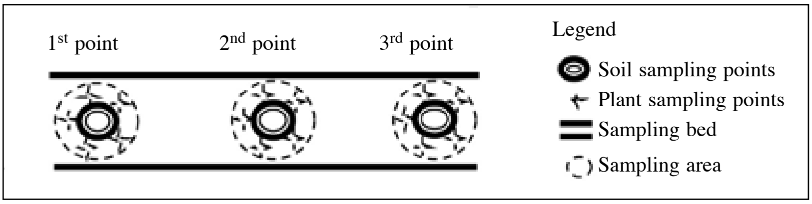

Figure 1. Sampling layout

with ammonium acetate (NH_4OAc), pH 7; organic carbon by Walkley and Black method; total N by Kjeldahl method; and total P, K, Ca and Mg by Aqua regia method.

After drying, all the plant parts (root, stem, leaf and flower) were subsampled and ground. Total P, K, Ca and Mg concentrations were determined by digesting about 1 g of oven dried plant sample using nitric acid and hydrochloric acid in a block digester at 110 °C. Digested solutions were filtered and made up to 100 ml with distilled water. The concentrations of P, K, Ca and Mg were determined using an Inductively Coupled Plasma (ICP). Meanwhile for N, 0.3 g of oven dried plant sample was digested with sulphuric acid along with Kjeldahl tablet at 350 °C and titrated with hydrochloric acid for N determination.

Statistical analysis

Data were analysed using the SAS 9.2 Software (Copyright © 2002 – 2008 by SAS Institute Inc. Cary, NC, USA). Analysis of Variance (ANOVA) was done to determine the significant difference of nutrient concentrations within soil depth, location and plant growth stage.

Observation of the nutrient translocation and accumulation in the plant parts were determined by the transfer coefficients (TC) of nutrients in the soil-plant system. The TC reflects the relative mobility of nutrients from soil to plant parts (Fauziah et al. 2004). Higher value of TC indicates the most mobile nutrient, meanwhile lower value of TC indicates the least mobile nutrient. It also describes the relationship between nutrient concentration in soils (NCs) and concentration in the plants (NCp). The TC is derived using the following formula;

$$TC = \frac{NCp}{NCs}$$

Results and discussion

Effect of soil depths, locations and growth stages on nutrient concentrations in soils and in chrysanthemum plant parts

The results of soil nutrient concentrations at two different depths (0 – 15 cm and 15 – 30 cm) from Kuala Terla and Ringlet are shown in Table 2. There are no significant differences in nutrient concentrations between the two depths of soil from Ringlet at vegetative as well as reproductive stages. Similar trend was observed in soil samples from Kuala Terla at vegetative stage. However, in contrast with soils from Ringlet, where there is a significant difference in N, K and Ca concentration within first depth and second depth at reproductive stage. It shows that similar agronomic practices not necessary produce the same result such as accumulative indigenous nutrient in soil. Other factors such as chemical properties (pH, organic carbon, CEC) of the soil also play an important role in determining nutrient concentrations which will affect nutrient supply and crop uptake.

Table 3 shows soil characteristics (pH, organic carbon and CEC) in soils from Kuala Terla and Ringlet. Based on the table, there is no significant difference in pH, organic carbon and CEC observed between soil depths. For reproductive stage, there is

Table 2. Nutrient concentrations (%) in soil samples from Kuala Terla and Ringlet at different depth

Soil depth (cm)	Vegetative					Reproductive				
	N	P	K	Ca	Mg	N	P	K	Ca	Mg
Kuala Terla										
0 – 15	0.14 ± 0.07a	0.45 ± 0.15a	0.39 ± 0.09a	1.24 ± 0.97a	0.51 ± 0.03a	0.17 ± 0.01a	0.40 ± 0.11a	0.38 ± 0.02b	1.81 ± 0.33a	0.49 ± 0.02a
15 – 30	0.17 ± 0.06a	0.49 ± 0.06a	0.36 ± 0.03a	1.40 ± 0.49a	0.48 ± 0.02a	0.10 ± 0.01b	0.22 ± 0.11a	0.42 ± 0.01a	0.57 ± 0.23b	0.50 ± 0.01a
Ringlet										
0 – 15	0.28 ± 0.01a	0.25 ± 0.03a	0.76 ± 0.22a	0.71 ± 0.38a	0.76 ± 0.17a	0.28 ± 0.03a	0.27 ± 0.06a	0.51 ± 0.04a	0.41 ± 0.06a	0.51 ± 0.03a
15 – 30	0.27 ± 0.04a	0.23 ± 0.06a	0.69 ± 0.09a	0.27 ± 0.03a	0.66 ± 0.09a	0.24 ± 0.01a	0.25 ± 0.03a	0.60 ± 0.12a	0.45 ± 0.10a	0.58 ± 0.12a

Values are the means of three samples ± SD. Values within a column followed by the same letter are not significantly different at $p > 0.05$

a significant difference observed in organic carbon for soil of Kuala Terla. This is one of the factors causing a significant difference for N, K and Ca concentrations in two soil depth of Kuala Terla during reproductive stage. As mentioned in Barber (1984), the bulk of N is present in the upper soil horizon where the bulk of organic matter is located, because organic matter which contains organic carbon has an average of 5% N (w/w).

Comparison of nutrient concentrations between locations has also been done. As observed in *Table 4*, there is a significant difference for N and K concentrations in soil samples between Kuala Terla and Ringlet at both vegetative and reproductive stages, with Ringlet having the highest concentration. Meanwhile, Ca shows a significant difference in concentration for reproductive stage, with Kuala Terla having the highest concentration. Soil characteristics of each location are shown in *Table 5*. It was found that there are significant differences in soil chemical characteristic for each location, with Kuala Terla has higher soil pH, whereas Ringlet has higher CEC and organic carbon. There is evident that these soil characteristics are the major factor influencing the nutrient concentrations in soil. Therefore, even though the fertilisation programmes are similar, the soil types and prevailing soil conditions still can affect a certain nutrient concentrations in the soil.

Comparison of nutrient concentrations between vegetative and reproductive stage for each location are shown in *Table 6*. Nutrient concentrations in chrysanthemum plant parts collected from Kuala Terla and Ringlet with Mona Lisa and Barry More variety respectively. All nutrient concentrations in stem at vegetative and reproductive stages show significant difference, with vegetative stage shows the highest values. Same result was also observed for stem samples from Ringlet (*Table 6*). Therefore, it shows that, nutrient requirements for stem growth during

Table 3. Soil characteristics in soil samples from Kuala Terla and Ringlet at different depth

Soil depth (cm)	Vegetative			Reproductive		
	pH	Organic carbon (%)	CEC (cmol (+)/kg)	pH	Organic carbon (%)	CEC (cmol(+)/kg)
Kuala Terla						
0 – 15	6.88 ± 0.25a	0.82 ± 0.44a	9.49 ± 0.36a	7.17 ± 0.02a	1.48 ± 0.22a	8.86 ± 0.40a
15 – 30	7.07 ± 0.23a	0.97 ± 0.33a	9.88 ± 0.68a	7.10 ± 0.06a	0.87 ± 0.30b	8.21 ± 0.66a
Ringlet						
0 – 15	4.48 ± 0.13a	2.43 ± 0.15a	12.01 ± 1.42a	5.04 ± 0.32a	2.17 ± 0.36a	11.99 ± 0.46a
15 – 30	4.75 ± 0.56a	2.18 ± 0.20a	11.11 ± 1.10a	5.28 ± 0.22a	1.85 ± 0.07a	12.26 ± 0.26a

Values are the means of three samples ± SD. Values within a column followed by the same letter are not significantly different at $p > 0.05$

vegetative stage are higher as compared to the reproductive stage.

Table 6 also shows that all nutrients except Mg in chrysanthemum leaves have a significant difference in concentrations. Nutrients in vegetative leaves show higher values, except for Ca that is higher in reproductive stage. A study by Siti Aishah et al. (2001) shows that older chrysanthemum leaves tend to accumulate higher amount of Ca than younger leaves. It is proven when leaf samples from Ringlet (*Table 6*) also indicate a similar trend. Meanwhile, for chrysanthemum roots, only N concentrations show a significant difference between vegetative and reproductive stage. High levels of N during the early growth stage are necessary to promote early root growth which will support the quality of above ground biomass at the later part of plant cycle (Siti Aishah et al. 2001).

While at Ringlet, it was found that P and Mg concentrations in chrysanthemum roots show a significant difference between vegetative and reproductive stages. And, for chrysanthemum leaves, only N, P and Ca concentrations show a significant difference between vegetative and reproductive stage (*Table 6*). Whereas, for the other nutrient, no significant difference in nutrient concentrations between vegetative and reproductive stage was observed. This indicated that the chrysanthemum variety has an impact on nutrient uptake during vegetative and reproductive growth stages. It was clearly shown in *Table 6*, when each location shows differences in terms of nutrient uptake between vegetative and reproductive stage.

Nutrient translocations and accumulation in soil-plant system

Table 7 shows nutrient partitioning in chrysanthemum parts collected from Kuala Terla. It was found that nutrients tend to accumulate very high in the leaves, except for P that accumulates very high in the flowers during a reproductive stage. Lowest nutrient accumulation during vegetative stage is in the roots. Meanwhile, during reproductive stage, lowest nutrient accumulation is in the stems for N, P and Mg. Whereas for K and Ca, lowest nutrients accumulation is in the roots.

Table 8 shows nutrient TC for chrysanthemum in the soil-plant system. High nutrient TC value indicated the most readily nutrients to be taken up by plant roots and translocate into the plant, meanwhile a lower value shows a vice versa. Based on *Table 8*, Kuala Terla farm shows that the most mobile nutrient taken up by roots, stems, leaves and flowers during vegetative and reproductive stages is N. Meanwhile, the least mobile nutrient for the system is Ca, except for the leaves during the reproductive stage with the least mobile nutrient is P. *Table 7* shows

Table 4. Nutrient concentrations (%) in soil samples from different locations

Location	Vegetative					Reproductive				
	N	P	K	Ca	Mg	N	P	K	Ca	Mg
Kuala Terla	0.14 ± 0.07b	0.45 ± 0.15a	0.39 ± 0.01b	1.24 ± 0.97a	0.51 ± 0.03a	0.17 ± 0.01b	0.40 ± 0.11a	0.38 ± 0.02b	1.81 ± 0.33a	0.49 ± 0.02a
Ringlet	0.28 ± 0.01a	0.25 ± 0.03a	0.76 ± 0.22a	0.71 ± 0.38a	0.76 ± 0.17a	0.28 ± 0.03a	0.27 ± 0.06a	0.51 ± 0.04a	0.41 ± 0.06b	0.51 ± 0.03a

Values are the means of three samples ± SD. Values within a column followed by the same letter are not significantly different at $p > 0.05$

nutrient partitioning in chrysanthemum plants collected from Ringlet farm. Except for P, the other nutrients tend to accumulate very high in the leaves at both vegetative and reproductive stages. Meanwhile for P, it tends to accumulate in the flower during reproductive stage. Results obtained was similar with the plant samples from Kuala Terla. Lowest nutrient accumulation during vegetative stage is in the root (except for Mg). Meanwhile during reproductive stage, lowest nutrient accumulation is in the stem, except for P with lowest nutrient accumulation is in the root.

Nutrient mobility at Ringlet is shown in *Table 8*. From the table, the most mobile nutrient for root, stem, leaf and flower uptake during vegetative and reproductive stages is N. Similar results were obtained for plant samples from Kuala Terla. This indicated that the N content of chrysanthemum increased linearly in response to increased N concentration in soils, as stated in Holcomb and White (1980). Meanwhile, the least mobile nutrient for root, stem and flower uptake at vegetative and reproductive stages is Mg. Soil pH might have an influence for the difference of the least mobile nutrients between Kuala Terla and Ringlet.

Soil pH at Ringlet was quite acidic compared to Kuala Terla (*Table 5*). A study by Chao et al. (2014) showed a decrease in the Mg concentrations in black pepper seedling roots under low pH conditions. It is believed that an increase in the hydrogen-ion concentration of the medium generally caused a decrease in the rate of cation absorption, probably as a result of competition between the similarly charged ions for binding and carrier sites (Alam et al. 1999).

Conclusion

Location and prevailing soil conditions can affect certain nutrient concentrations in the soils, even with similar fertiliser management. This study also found a significant difference in nutrient requirement

Table 5. Soil characteristics of soil samples from different locations

Location	Vegetative			Reproductive		
	pH	Organic carbon (%)	CEC (cmol (+)/kg)	pH	Organic carbon (%)	CEC (cmol (+)/kg)
Kuala Terla	6.88 ± 0.25a	0.82 ± 0.44b	9.49 ± 0.36b	7.17 ± 0.02a	1.48 ± 0.22b	8.86 ± 0.40b
Ringlet	4.48 ± 0.13b	2.43 ± 0.15a	12.01 ± 1.42a	5.04 ± 0.32b	2.17 ± 0.36a	11.99 ± 0.46a

Table 6. Nutrient concentrations in chrysanthemum plant parts from Kuala Terla and Ringlet

Plant parts	Growth stage	N	P	K	Ca	Mg
Kuala Terla						
Root	Vegetative	1.53 ± 0.18a	0.23 ± 0.09a	1.96 ± 0.74a	0.28 ± 0.16a	0.12 ± 0.06a
	Reproductive	1.11 ± 0.07b	0.26 ± 0.04a	1.38 ± 0.16a	0.20 ± 0.04a	0.09 ± 0.02a
Stem	Vegetative	2.46 ± 0.06a	0.31 ± 0.02a	4.20 ± 0.43a	0.35 ± 0.03a	0.23 ± 0.03a
	Reproductive	0.95 ± 0.02b	0.20 ± 0.04b	1.46 ± 0.04b	0.23 ± 0.03b	0.09 ± 0.01b
Leaf	Vegetative	5.13 ± 0.25a	0.49 ± 0.02a	5.65 ± 0.25a	1.11 ± 0.03b	0.55 ± 0.04a
	Reproductive	4.66 ± 0.11b	0.33 ± 0.02b	5.14 ± 0.06b	1.65 ± 0..00a	0.54 ± 0.09a
Ringlet						
Root	Vegetative	2.01 ± 0.17a	0.36 ± 0.01a	1.69 ± 0.10a	0.30 ± 0.02a	0.13 ± 0.01a
	Reproductive	1.77 ± 0.16a	0.19 ± 0.10b	1.32 ± 0.34a	0.30 ± 0.12a	0.08 ± 0.03b
Stem	Vegetative	2.47 ± 0.14a	0.36 ± 0.02a	3.44 ± 0.21a	0.39 ± 0.05a	0.12 ± 0.02a
	Reproductive	1.69 ± 0.10b	0.20 ± 0.02b	1.18 ± 0.13b	0.19 ± 0.01b	0.04 ± 0.00b
Leaf	Vegetative	5.53 ± 0.15a	0.51 ± 0.04a	5.69 ± 0.56a	1.09 ± 0.09b	0.27 ± 0.02a
	Reproductive	4.86 ± 0.06b	0.35 ± 0.04b	5.79 ± 0.67a	1.71 ± 0.10a	0.33 ± 0.07a

Values are the means of three samples ± SD. Values within a column followed by the same letter are not significantly different at $p > 0.05$

during vegetative and reproductive stages. Specifically for stem at vegetative, it requires higher nutrient levels as compared to other plant parts. Apart from that, chrysanthemum variety (Mona Lisa and Barry More) also had an effect on nutrients uptake, where it was clearly proven that each chrysanthemum variety shows different results in terms of nutrient uptake pattern during vegetative and reproductive stages. In terms of nutrient accumulation and translocation in soil-plant system, it was shown that nutrients tend to accumulate very high in chrysanthemum leaves from both Kuala Terla and Ringlet. Meanwhile, lowest nutrient accumulation is in the stems and roots. Based on nutrient TC, the most mobile nutrient for chrysanthemum uptake is N, while Ca and Mg are the least mobile. Due to these differences in soil-plant system, plant nutrient uptake and nutrient use efficiencies can be significantly increased by applying fertiliser on a field specific basis. Therefore, site-specific nutrient management is important to optimise the supply and demand of nutrients according to their differences. Site-specific fertiliser applications will be calculated by accounting for the nutrient supply, yield targets, nutrient demand as a function of the soil nutrient status and plant nutrient uptake.

Acknowledgement
The assistance rendered by Ms Aini Hayati Abdul Rahaman, Mr. Jamaluddin Ismail, Ms Hamidah Abdul Hamid, Mr Muhammad Hazwan Husaimi and others during sampling and laboratory analyses is greatly appreciated.

Table 7. Nutrient concentrations (%) in chrysanthemum plant parts from Kuala Terla and Ringlet (n = 3)

Plant parts	Vegetative					Reproductive				
	N	P	K	Ca	Mg	N	P	K	Ca	Mg
Kuala Terla										
Root	1.53 ± 0.18	0.23 ± 0.09	1.96 ± 0.74	0.28 ± 0.16	0.12 ± 0.06	1.11 ± 0.07	0.26 ± 0.04	1.38 ± 0.16	0.20 ± 0.04	0.09 ± 0.02
Stem	2.46 ± 0.06	0.31 ± 0.02	4.20 ± 0.43	0.35 ± 0.03	0.23 ± 0.03	0.95 ± 0.02	0.20 ± 0.04	1.46 ± 0.04	0.23 ± 0.03	0.09 ± 0.01
Leaf	5.13 ± 0.25	0.49 ± 0.02	5.65 ± 0.25	1.11 ± 0.03	0.55 ± 0.04	4.66 ± 0.11	0.33 ± 0.02	5.14 ± 0.06	1.65 ± 0.21	0.54 ± 0.09
Flower	–	–	–	–	–	3.23 ± 0.15	0.35 ± 0.02	3.23 ± 0.11	0.56 ± 0.03	0.28 ± 0.02
Mean total nutrient conc. in soil (%)	0.14	0.45	0.39	1.24	0.51	0.17	0.40	0.38	1.81	0.49
Ringlet										
Root	2.01 ± 0.17	0.36 ± 0.01	1.69 ± 0.10	0.30 ± 0.02	0.13 ± 0.01	1.77 ± 0.16	0.19 ± 0.10	1.32 ± 0.34	0.30 ± 0.12	0.08 ± 0.03
Stem	2.47 ± 0.14	0.36 ± 0.02	3.44 ± 0.21	0.39 ± 0.05	0.12 ± 0.02	1.69 ± 0.10	0.20 ± 0.02	1.18 ± 0.13	0.19 ± 0.01	0.04 ± 0.00
Leaf	5.53 ± 0.15	0.51 ± 0.04	5.69 ± 0.56	1.09 ± 0.09	0.27 ± 0.02	4.86 ± 0.06	0.35 ± 0.04	5.79 ± 0.67	1.71 ± 0.10	0.33 ± 0.07
Flower	–	–	–	–	–	3.34 ± 0.18	0.42 ± 0.03	3.16 ± 0.02	0.53 ± 0.02	0.23 ± 0.02
Mean total nutrient conc. in soil (%)	0.28	0.25	0.76	0.71	0.76	0.28	0.27	0.51	0.41	0.51

Table 8. Transfer factor (index soil-plant transfer) in the soil-plant system at Kuala Terla and Ringlet (n = 3)

	Vegetative					Reproductive				
	N	P	K	Ca	Mg	N	P	K	Ca	Mg
Kuala Terla										
Root	10.92	0.51	5.02	0.22	0.23	6.52	0.65	3.63	0.11	0.18
Stem	17.57	0.68	10.76	0.28	0.45	5.59	0.50	3.84	0.13	0.18
Leaf	36.64	1.08	14.48	0.89	1.08	27.41	0.83	13.52	0.91	1.10
Flower	–	–	–	–	–	19.00	0.88	8.5	0.31	0.57
Ringlet										
Root	7.18	1.44	2.22	0.42	0.17	6.32	0.70	2.59	0.73	0.16
Stem	8.82	1.44	4.52	0.55	0.16	6.04	0.74	2.31	0.46	0.08
Leaf	19.75	2.04	7.49	1.54	0.36	17.36	1.30	11.35	4.17	0.65
Flower	–	–	–	–	–	11.93	1.56	6.20	1.29	0.45

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Abstrak
Dua buah ladang yang menghasilkan bunga kekwa berkualiti eksport di Kuala Terla dan Ringlet, Cameron Highlands, Pahang telah dipilih sebagai kawasan kajian. Pensampelan tanah dan tumbuhan di peringkat vegetatif dan reproduktif telah dipilih berdasarkan tumbuhan yang menunjukkan prestasi pertumbuhan yang terbaik, dengan nutrien pada tanah-tumbuhan dianggap berada pada tahap optimum. Kajian ini dijalankan untuk menentukan hubungan antara status nutrien tanah dengan pengambilan nutrien oleh tumbuhan, dan untuk memantau translokasi nutrien dari tanah ke bahagian tumbuhan. Keputusan yang diperoleh menunjukkan bahawa jenis tanah dan keadaan tanah semasa boleh mempengaruhi kepekatan nutrien tertentu di dalam tanah. Kajian ini juga telah mendapati bahawa terdapat perbezaan yang signifikan dalam keperluan nutrien pada peringkat vegetatif dan reproduktif. Nutrien (N, P, K, Ca dan Mg) cenderung untuk berkumpul sangat tinggi di bahagian daun bagi kedua-dua kawasan iaitu di Kuala Terla dan Ringlet. Sementara itu, pengumpulan nutrien terendah adalah di bahagian batang dan akar. Berdasarkan pekali translokasi, didapati bahawa nutrien yang paling mudah untuk diambil oleh kekwa adalah N, manakala Ca dan Mg adalah nutrien yang sukar untuk diambil tumbuhan. Dalam usaha untuk mengoptimumkan penawaran dan permintaan nutrien mengikut perbezaan mereka melalui sistem tanah-tumbuhan, maka pengurusan nutrien secara jitu adalah penting dan perlu dilaksanakan.