

# 琉球大学学術リポジトリ

沖縄県における島尻マージ土壤，国頭マージ土壤およびジャーガル土壤で栽培されたベニバナボロギク(*Crassocephalum crepidioides* (Benth.) S. Moore)の各生育段階における生育特性と収量およびミネラル含量

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**Growth Characteristics, Yield and Mineral Content of Redflower ragleaf  
(*Crassocephalum crepidioides* (Benth.) S. Moore) at Different Growth  
Stages, and in Dark-red soil, Red soil and Gray soil in Okinawa**

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**Abstract:** Redflower ragleaf (*Crassocephalum crepidioides*) is an herbal vegetable, animal feed as well as a weed in many countries of tropical and subtropical regions. Growth characteristics, yield and mineral content of redflower ragleaf were evaluated at different growth stages, and in dark-red soil (pH 5.5-6.5), red soil (pH 4.0-5.5) and gray soil (pH 6.5-7.3) in Okinawa to develop cultivation measures. Plant height, leaf number, leaf area and branch number increased slowly until 50 days after seed sowing (DAS) and rapidly from 50 to 70 DAS, thereafter slightly. Capitula appeared at 60 DAS and started maturity at 80 DAS. Yield at 70 and 80 DAS was almost similar, and 2-3 times greater than that at 60 DAS. All the plant growth parameters were significantly higher in gray soil, which resulted in around 3 times greater yield compared to those in dark-red soil or red soil. Capitula appeared earlier in red soil followed by dark-red soil. The plant contained higher Na, K, Ca, P, Al, Fe, S and Si within 60 DAS, and Mg with the longer growth period. Sodium, K and Mg in the plant were highest for the red soil followed by dark-red soil, whereas Ca was highest for the dark-red soil followed by gray soil, and P and S for the red soil followed by gray soil. Growth characteristics, yield and mineral content indicate that redflower ragleaf could be cultivated in gray soil and harvested at around 70 DAS for higher yield and better quality in Okinawa.

**Key words:** growth characteristics, herbal plant, mineral content, soil factors, yield.

## Introduction

Redflower ragleaf (*Crassocephalum crepidioides* (Benth.) S. Moore), a native to tropical Africa, grows as a weed, functional vegetable and herb in tropical and subtropical regions of the world (Ismail *et al.*, 2001; Dairo and Adanlawo, 2007; Nakamura and Hossain, 2009). This plant possesses antioxidant, antimutagenic and antimalarial properties (Aniya *et al.*, 2005, 2007). The tender and succulent leaves and stems are mucilaginous, and are used as a vegetable in Sierra Leone, Ghana, Benin, Nigeria, Cameroon, Uganda, Australia and Asian countries (Aletor and Adeogun, 1995; Kongsaree *et al.*, 2003; Dairo and Adanlawo, 2007). Redflower ragleaf is used to treat indigestion, upset stomachs, fresh wounds, headache and sleeping sickness in many countries (Zollo *et al.*, 2000). This plant is also used for livestock as a green fodder.

Yield and quality of a plant species differ with the growth stages (Howeler and Cadavid, 1983; Hossain, 2010). Harvesting a plant species in an appropriate time is important for increasing yield, quality and storability (Darby and Lauer, 2002; Boyhan *et al.*, 2004; Drake *et al.*, 2004; Mendonca *et al.*, 2004; Adler *et al.*, 2006; Farrer *et al.*, 2006). Yield and quality of a plant species also differ with the soil types, soil nutrient status, and management practices (Oya, 1972; Hossain and Ishimine, 2005; Akamine *et al.*, 2007).

Research on plant growth characteristics under the local climatic and edaphic factors is important for determining effective management measures (Hossain and Ishimine, 2005). Redflower ragleaf grows in different soils from seashore to mountain areas throughout the year, and a single plant produces up to 90,000 seeds in a single life cycle in Okinawa (data unpublished). Redflower ragleaf is found as a weed in many crops, vegetables, orchards and fallow lands in different soils such as dark-red soil, red soil and gray soil in Okinawa (personal survey). On the other hand it is an herb (Aniya *et al.*, 2005; 2007). Therefore, it is important to evaluate growth characteristics, yield and mineral contents of this plant under different climatic and edaphic factors for developing management practices as a vegetable, herb and weed. Our previous study reported seed germination and seedling emergence characteristics of redflower ragleaf under different pH, temperature, moisture, sowing depth, seed maturity and seed storing (Nakamura and Hossain, 2009). But no study has yet been conducted on this plant in relation to growth stages and soil types in Okinawa. Present study has been conducted to evaluate growth characteristics, yield and mineral content of redflower ragleaf at different growth stages and in different soils which could be helpful for developing cultivation and control strategies of this plant in Okinawa.

## Materials and Methods

### *Experiment 1: Growth and minerals of redflower ragleaf at different growth stages*

#### 1) Plant cultivation

A glasshouse experiment was conducted using dark-red soil (Shimajiri mahji, pH 5.5-6.5) from July 19 to October 10, 2007 at the Subtropical Field Science Center of the University of the Ryukyus, Okinawa, Japan. Each plastic planter (650 E) was filled with 12 kg air dried soil and 1 kg cow manure. Seeds were randomly sown on soil surface in 50 planters and water was applied three times a day for proper seed germination and plant growth. The plants were thinned to two healthiest stands per planter at 4- to 5-leaf stage, and inorganic fertilizer of 1.0g N, 0.5g P<sub>2</sub>O<sub>5</sub> and 0.5 g K<sub>2</sub>O were applied immediately.

#### 2) Data collection

Plants from 10 planters were harvested at 50, 60, 70 and 80 days after seed sowing (DAS), and plant height, leaf number, leaf area, branch number, and fresh and dry shoot (yield) were measured. Capitula appearance and maturity were monitored visually. Shoots of redflower ragleaf were dried at 40°C for 48 hr using forced convection oven (Advantec, DRLF23WA) and weighed. Some phenological characteristics were visually evaluated.

### *Experiment 2: Growth and minerals of redflower ragleaf in different soils*

#### 1) Soil collection

Dark-red soil (Shimajiri mahji: coarse sand 3%, fine sand 7%, silt 24%, clay 57%) and gray soil (Jagaru: coarse sand 4%, fine sand 31%, silt 24%, clay 33%) were collected from the upper 50 cm layer of fields at the Subtropical Field Science Center, University of the Ryukyus, and red soil (Kunigami mahji: coarse sand 17%, fine sand 44%, silt 27%, clay 31%) from the same layer of a field in northern part of Okinawa, Japan.

#### 2) Plant cultivation

The experiment was conducted in a glasshouse using dark-red soil, red soil and gray soil (Fig. 4B) from September 10 to December 30, 2007 at the Subtropical Field Science Center of the University of the Ryukyus. For each soil type, redflower ragleaf was cultivated in 10 Wagner pots (pot size: 0.05 m<sup>2</sup>) each containing 10 kg air dried soil and 1 kg cow manure (35% dry matter, pH 8.7). Cow manure was added to the soils for providing organic matter (Hossain and Ishimine, 2007). Cow manure was collected from the cattle farm of the University of the Ryukyus. One kilogram (1 kg) cow manure contained around 1.54 mg Na, 7.3 mg K, 0.42 mg Ca, 0.25 mg Mg, 0.2 mg Fe, 1.04 mg P, 1.34 mg S, 26200 mg N and 350000 mg C (Hossain and Ishimine, 2007) (Table 2). Total amount of the nutrients varied

significantly with the soil types (Table 2). Seedlings were grown in planters and 6 seedlings of 2- to 3-leaf stage were transplanted in a Wagner pot. The seedlings were thinned to three healthiest stands per pot 10 days after transplanting. Water was applied as required for proper plant growth, but no chemical fertilizers were applied.

### 3) Data collection

Capitula appearance was monitored. SPAD value, plant height, leaf number per main stem, leaf area per plant, largest leaf area, branch number per plant, largest branch length, and fresh and dry shoot (yield) per pot and per plant were recorded at 90 day after seedling transplanting. Plant shoot was dried at 40°C for 48 hr using the same oven and weighed.

### 4) Analysis of minerals, nitrogen, carbon and pH in soils and redflower ragleaf

Soil samples were dried at room temperature (25-28°C) for 5 days and ground finely. Shoots of redflower ragleaf were dried at 40°C for 48 hr, and ground finely. Powder of 10 plants was mixed together for each growth stage or soil treatment, and all the chemicals were determined three times. Mineral content of soil and redflower ragleaf was determined by using Inductively Coupled Plasma Spectrometer (ICPS-8100, Shimadzu Co. Ltd.). Total carbon and nitrogen content were measured by using Gas Chromatograph (Soil GS-8A, Shimadzu Co. Ltd.) and Sumigraph (NC-90A, Shimadzu Co. Ltd.). Soil pH in H<sub>2</sub>O was measured with TOA pH meter (HM-20S, Toa Electronic Ltd., Japan). Chemical properties of the soils and redflower ragleaf are presented in the Table 1, 2 and 3.

### 5) Data management and statistical analysis

Mean and standard deviation (SD) of 10 replications were determined using analysis of variance (ANOVA) for growth parameters, fresh yield and dry yield (shoot biomass) of redflower ragleaf. For each chemical property, mean values were calculated from three replications. All the means were separated by Fisher's Protected LSD (least significance difference) test at  $p < 0.05$ .

## Results

### *Experiment 1: Growth and minerals of redflower ragleaf at different growth stages*

#### 1) Vegetative growth and yield (fresh and dry shoot)

Plant height, leaf number and leaf area increased significantly with the delaying harvest until 70 DAS, and they were almost the same at 70 and 80 DAS (Fig. 1A, 1B, 1C). Branching appeared at 60 DAS (Fig. 2A, 2B), and increased to 13 per plant at 80 DAS (Fig. 1D). Capitula appeared from 60 DAS, some silky hair appeared from 70 DAS and seed maturity started from

80 DAS (visual observation). Fresh yield increased significantly with the delaying harvest until 70DAS and thereafter slightly, while dry yield increased significantly until 80 DAS (Fig. 3A, 3B).

#### 2) Minerals, nitrogen and carbon content

Sodium content was significantly highest at 50 DAS and decreased drastically at 80 DAS, on the other hand Mg content increased with the delaying harvest (Table 1). Potassium and P content was highest at 60 DAS followed by 70 DAS. Calcium, Al, Fe, S, Si and Mn content was higher from 50 to 60 DAS. The plant contained a similarly higher B at 60, 70 and 80 DAS than at 50 DAS. Nitrogen content was highest at 50 DAP and decreased significantly with the delaying harvest. Carbon content at 50 and 80 DAS was similar (Table 1).

### *Experiment 2: Growth and minerals of redflower ragleaf in different soils*

#### 1) Vegetative growth and yield (fresh and dry shoot)

Capitula of redflower ragleaf appeared earlier in red soil followed by dark-red soil (data not presented). The plants grown in gray soil was healthier, and had a larger stem diameter and longer internode than that grown in dark-red soil and red soil, but SPAD value did not differ with the soil types significantly (Fig. 4A, data not presented). The plant height was around two times greater in the gray soil than in the other soils, and was almost the same in dark-red soil and red soil (Fig. 5A). The number of leaves and branches was significantly higher in gray soil than in other soils (Fig. 5B, 5C), and no significant differences were found in leaf and branch between dark-red soil and red soil. Branch length was 3-4 times greater when the plant grew in gray soil than that in other soils, and it was smallest in red soil (Fig. 5D). Leaf area per plant and per leaf was significantly highest in gray soil followed by dark-red soil (Fig. 5E, 5F).

Dry leaf was higher in gray soil followed by dark-red soil (Fig. 6A, 6D). The plant in gray soil obtained 68-74% higher fresh yield compared to that in other soils, and the yield was around 19% higher in dark-red soil than in red soil (Fig. 6B, 6C). Almost similar trend was found in dry yield (shoot biomass) production (Fig. 6D).

#### 2) Minerals, nitrogen and carbon content

Potassium in redflower ragleaf covered 75-82% of total available minerals. The other major minerals were Na, Ca, Mg, P and S, which covered 15-23% together (calculated from Table 3). Aluminum, Fe, B, Si and Mn were the minor minerals in the plant. The content of Na, K, Mg and Mn was highest when the plant grew in red soil followed by dark-red soil. Calcium in the plant was highest for the dark-red soil followed by gray soil. Aluminum and Fe content was highest when the plant grew in the dark-red soil followed by red

Table 1. Mineral, nitrogen and carbon content of redflower ragleaf at different days after seed sowing (DAS).

DAS	Na mg/g	K mg/g	Ca mg/g	Mg mg/g	Al mg/g	Fe mg/g	P mg/g	S mg/g	B mg/g	Si mg/g	Mn mg/g	N %	C %
50	3.23a	72.34c	7.47b	1.45d	0.56a	0.68a	2.45c	1.85a	0.07b	0.71a	0.11a	4.47a	39.54a
60	2.46c	81.09a	7.89a	1.76c	0.30b	0.24b	2.77a	1.69b	0.16a	0.49b	0.10b	4.04b	38.16b
70	2.53b	74.10b	7.07c	1.86b	0.21d	0.18c	2.57b	1.08c	0.16a	0.44c	0.08c	3.66c	38.00b
80	1.45d	65.78d	7.13c	2.12a	0.26c	0.16c	2.44c	1.05c	0.17a	0.42c	0.08c	2.12d	40.15a

Ten plants were dried and grained together for each sampling date, and chemical properties were measured three times. Data with the same letter within each column are not significantly different at the 5% level, as determined by Fisher's Protected LSD test.

Table 2. Chemical properties of dark-red soil (DRS), red soil (RS) and gray soil (GS) in Okinawa, Japan.

Soil Types	Na mg/g	K mg/g	Ca mg/g	Mg mg/g	Fe mg/g	P mg/g	S mg/g	Si mg/g	Mn mg/g	N (%)	C (%)	pH
DRS	350a	540b	280a	140b	0b	4b	190b	20b	0.2a	0.33a	3.26b	5.5-6.5
RS	310a	1540a	180b	230a	3a	167a	320a	20b	0.2a	0.20b	1.65c	4.0-5.5
GS	130b	270c	100c	30c	0b	138a	80c	50a	0.0b	0.38a	3.95a	6.5-7.3

Note: Data were recorded on the dry weight basis. Data are means of three replications. Data with the same letter within each column are not significantly different at the 5% level, as determined by Fisher's Protected LSD test.

Table 3. Minerals, nitrogen and carbon content of redflower ragleaf cultivated on dark-red soil (DRS), red soil (RS) and gray soil (GS) in Okinawa, Japan.

Soil types	Na mg/g	K mg/g	Ca mg/g	Mg mg/g	Al mg/g	Fe mg/g	P mg/g	S mg/g	B mg/g	Si mg/g	Mn mg/g	N (%)	C (%)
DRS	1.00b	79.98b	11.52a	3.75b	0.21a	0.21a	5.85c	1.41c	0.07a	0.46c	0.23b	5.10a	38.38b
RS	1.28a	99.26a	5.09c	4.81a	0.16b	0.18b	8.66a	1.64a	0.07a	0.66b	0.29a	4.91b	36.79c
GS	0.58c	68.14c	10.53b	1.97c	0.11c	0.10c	7.14b	1.55b	0.07a	0.77a	0.05c	2.44c	39.63a

Note: Data are means of three replications (powder of redflower ragleaf cultivated in 10 pots was mixed and chemical properties were measured three times). Data were recorded on the dry weight basis. Data with the same letter within each column are not significantly different at 5% level, as determined by Fisher's Protected LSD test.

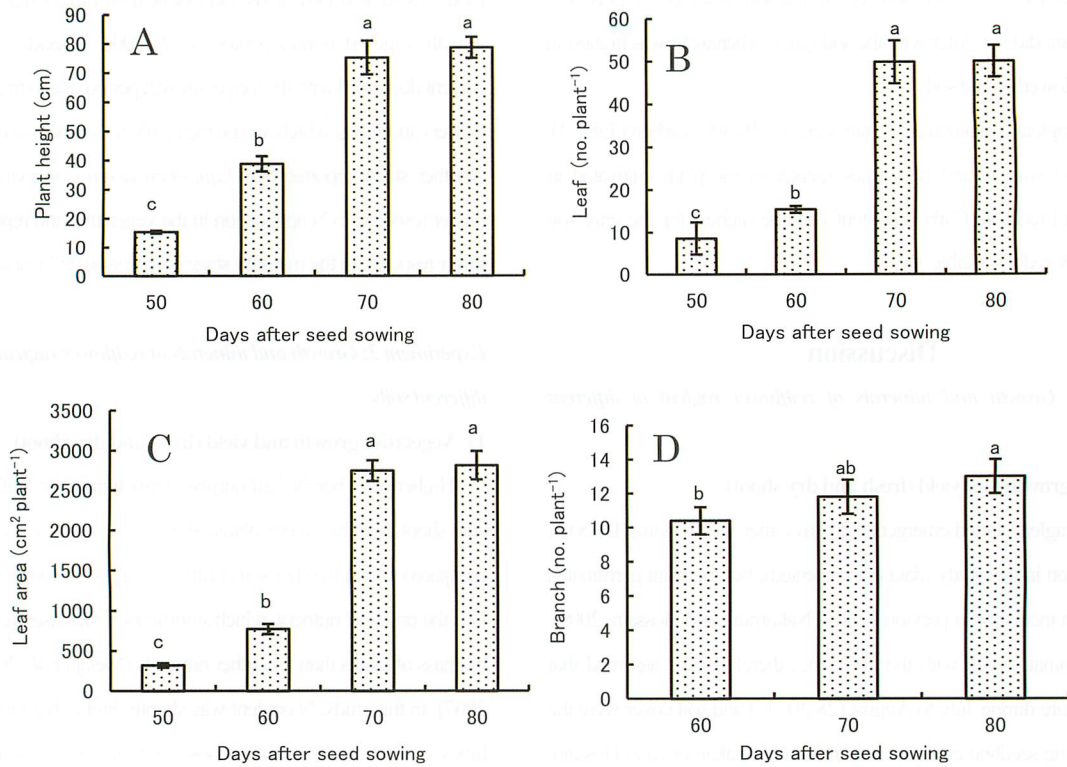


Fig. 1. Plant height (A), leaf number (B), leaf area (C) and branch number (D) of redflower ragleaf at different days after seed sowing. Data are means  $\pm$ SD of 10 replications. Treatment means with the same letter are not significantly different at the 5% level, as determined by Fisher's Protected LSD test.

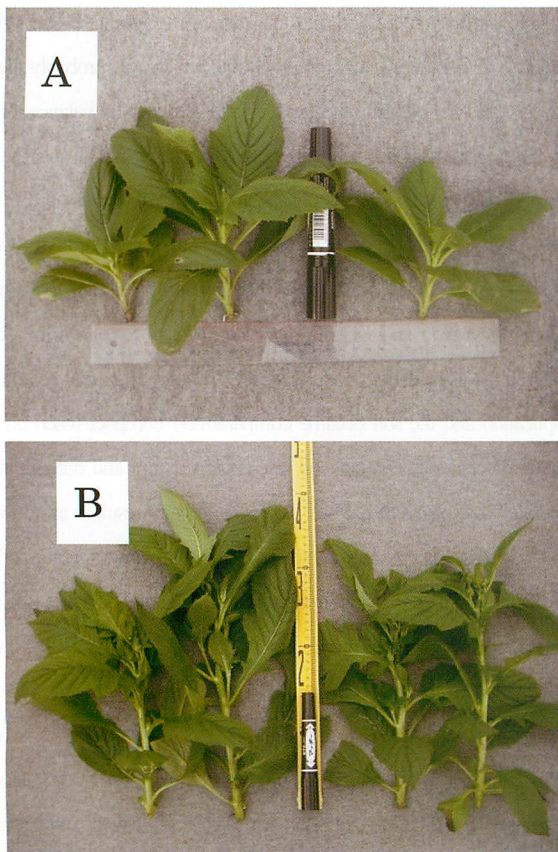


Fig. 2. Growth of redflower ragleaf at 50 (A) and 60 (B) day after seed sowing.

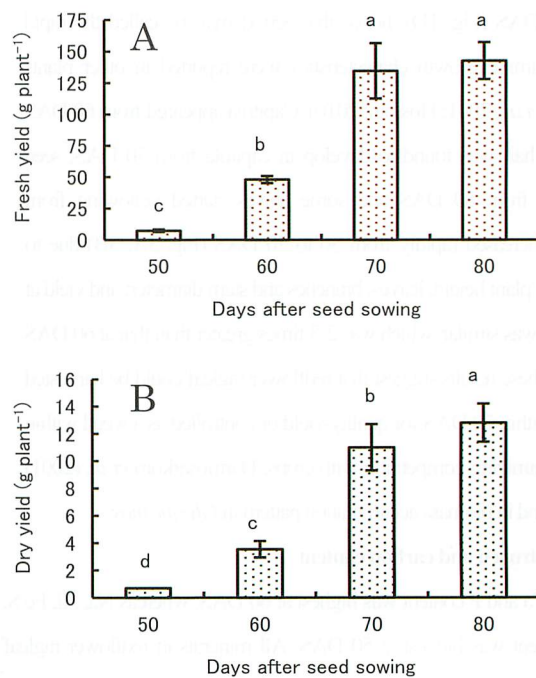


Fig. 3. Fresh (A) and dry (B) yield of redflower ragleaf at different days after seed sowing. Data are means  $\pm$ SD of 10 replications. Treatment means with the same letter are not significantly different at the 5% level, as determined by Fisher's Protected LSD test.

soil. Phosphorus and S were highest for the red soil followed by gray soil. Boron in the plant did not differ with the soil types, whereas Si was highest in the gray soil followed by red soil.

Redflower ragleaf contained 2-5% nitrogen and 36-40% carbon (Table 3). Nitrogen content was around two times greater in the plant cultivated in dark-red soil and red soil. Carbon content was the highest for the gray soil followed by dark-red soil (Table 3).

## Discussion

### *Experiment 1: Growth and minerals of redflower ragleaf at different growth stages*

#### 1) Vegetative growth and yield (fresh and dry shoot)

Redflower ragleaf started emergence 20 days after seed sowing (DAS) in ambient condition in this study (data not presented), but the plant germinated within 5 days in incubator in previous study (Nakamura and Hossain, 2009). This plant germinates well with the 20-25 °C, therefore it is assumed that higher temperature during July to August (28-30 °C) and soil cover were the causes of delaying seedling emergence in this study (Nakamura and Hossain, 2009). The plant height, leaf number and leaf area increased slowly until 50 DAS (Fig. 1A, 1B, 1C). This growth period may be called the establishment period. All the growth parameters increased rapidly and stem became thicker from 50 to 70 DAS (Fig. 1D), hence this period may be called the rapid growth stage. Similar growth characteristics were reported in other plants (Damosarkoro *et al.*, 2001; Hossain, 2010). Capitula appeared from 60 DAS (Fig. 2B), silky hair was found to develop in capitula from 70 DAS, seed maturity started from 80 DAS and some leaves started yellowing from 70DAS. Yield increased rapidly from 50 to 70 DAS (Fig. 3A, 3B) due to rapid growing of plant height, leaves, branches and stem diameter; and yield at 70 and 80 DAS was similar, which was 2-3 times greater than that at 60 DAS (Fig. 3A, 3B). These results suggest that redflower ragleaf could be harvested as a vegetable within 70 DAS for quality-yield or controlled as a weed within 60 DAP for minimizing competition with crops. Damosarkoro *et al.* (2001) found similar trend in biomass accumulation pattern in *Glycine max.*

#### 2) Minerals, nitrogen and carbon content

Potassium, Ca and P content was highest at 60 DAS, whereas Na, Al, Fe S, Si and Mn content was highest at 50 DAS. All minerals in redflower ragleaf tended to decrease at 70 DAS or later, except Mg and B (Table 1). Similarly, several studies reported that mineral content differ with the plant growth stages or harvest dates, and all the minerals do not follow the same pattern (Sims and Place, 1968; Adler *et al.*, 2006; Kobayashi *et al.*, 2007; Mirdehghan and Rahemi, 2007). Other studies reported that content of polyunsaturated fatty acids,

monounsaturated fatty acids and essential oil differs significantly with the plant growth stages (Chorianopoulos *et al.*, 2006; Msaada *et al.*, 2009). Nitrogen content decreased with the longer growth period due to the increasing maturity of flowers and seeds, which agreed the result in *Vicia sativa* (Caballero *et al.*, 2001). Another study reported that *Equisetum arvense* growing seasonally shows a higher response to N application in the vegetative and reproductive stages, and a lower response in the maturity stage (Andersson and Lundegårdh, 1999).

### *Experiment 2: Growth and minerals of redflower ragleaf in different soils*

#### 1) Vegetative growth and yield (fresh and dry shoot)

Higher plant height, leaf number, branch number, leaf area, stem diameter and shoot biomass were obtained in gray soil may due to the higher N compared to that in other soils (Table 2, Fig. 4, 5). Other studies reported that N is the principal nutrient, which significantly increases vegetative growth and biomass of plants than any other nutrients (Melaj *et al.*, 2003; Akamine *et al.*, 2007). In this study, N content was slightly higher but yield was around three times greater in gray soil than those in dark-red soil, which indicating that a certain combination of N and other nutrients is necessary for maximizing yield of redflower ragleaf, not only N. Gray soil contained highest N and lower Na, K, Ca, Mg and S, which was probably better combination for plant growth. On the other hand, red soil contained highest K (3-8 fold) and P (around 17%) but lowest N (around 40%) which was probably the cause of lowest yield. Similarly, other studies reported that a balanced nutrient is necessary for obtaining higher biomass of plants (Akamine *et al.*, 2007; Mazid, 1993; Hao and Papadopoulos, 2004).

Gray soil contained better moisture than other soils during the experiment (hand feeling), which was probably one of the factors to result greater vegetative growth and yield in this plant (Fig. 4, 5, 6). On the other hand, water-logging condition continued for sometime in red soil after water application and the soil became comparatively compact when dried, which might affected soil aeration, soil microbial activities and nutrient absorption. Therefore the plants in red soil were stressed and resulted in a lowest yield. Soil pH level was probably another factor for growth differences of this plant in different soils. Red soil is strong acidic which resulted in the lowest growth parameters. Similarly, turmeric growth differed with the soils with different pH levels (Hossain and Ishimine, 2005). Higher growth parameters of redflower ragleaf contributed to higher yield (Fig. 4, 5, 6), which is in agreement with the results in other plants (Melaj *et al.*, 2003; Hossain and Ishimine, 2005). Higher leaf area per plant and per leaf maybe resulted in higher photosynthesis per plant and subsequently contributed to a higher yield



Fig. 4. Growth differences of redflower ragleaf (A) in different soils (B) in Okinawa.

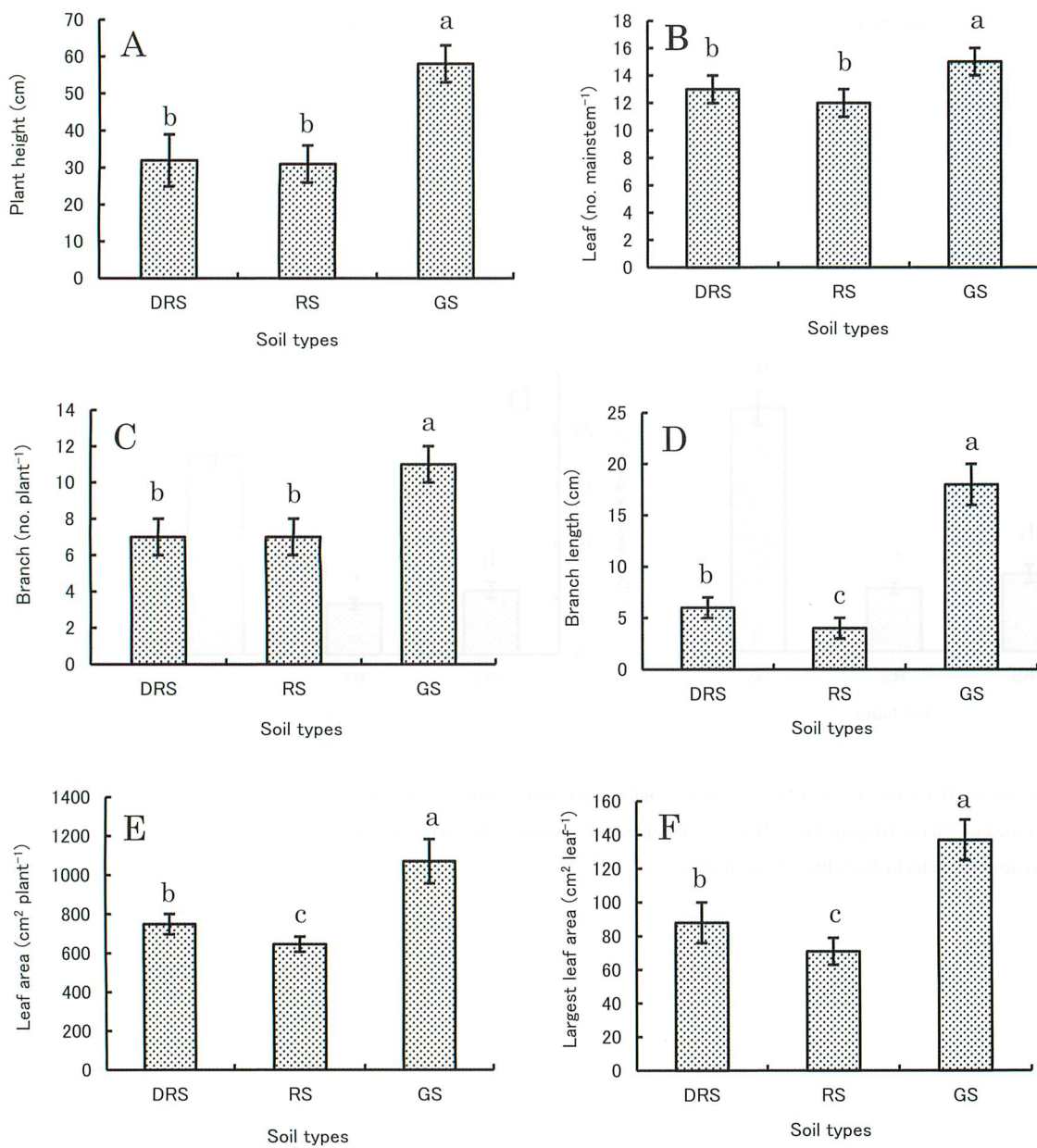


Fig. 5. Plant height (A), leaf number (B), brunch number (C), brunch length (D) and leaf area (E, F) of redflower ragleaf cultivated in dark-red soil (DRS), red soil (RS) and gray soil (GS). Data are means  $\pm$  SD of 10 replications. Bars with the same letter within each column are not significantly different at 5% level, as determined by Fisher's Protected LSD test.



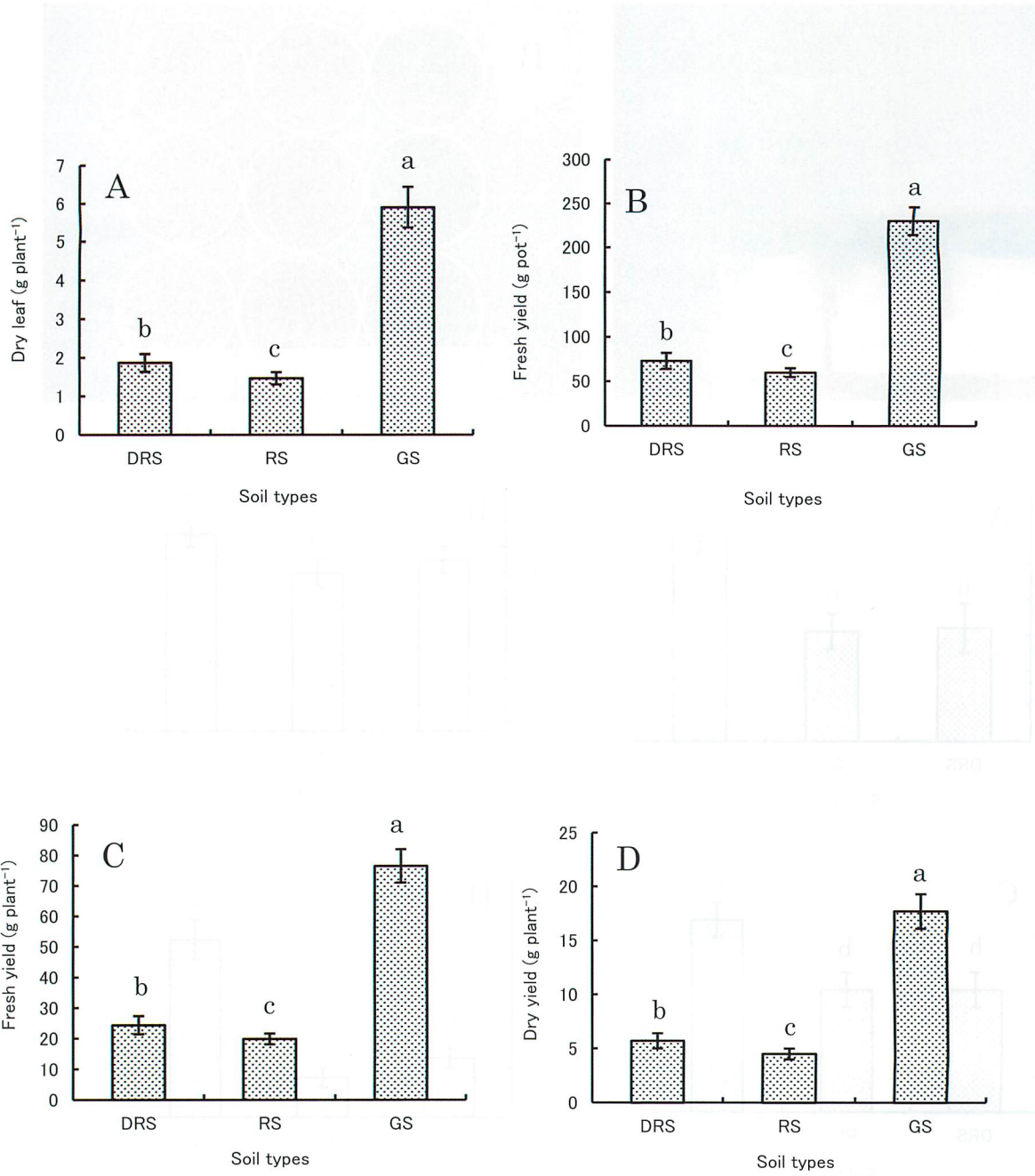


Fig. 6. Dry leaf (A), fresh yield (B, C) and dry yield(D) of redflower ragleaf cultivated in dark-red soil (DRS), red soil (RS) and gray soil (GS). Data are means  $\pm$  SD of 10 replications. Bars with the same letter within each column are not significantly different at 5% level, as determined by Fisher's Protected LSD test.

in gray soil. Similarly, Sarker *et al.* (2001) reported that leaf area is highly correlated with dry matter production in rice plant.

## 2) Mineral content of redflower ragleaf

Redflower ragleaf obtained highest Na, K and Mg in red soil followed by dark-red soil, Ca in dark-red soil, P in red soil followed by gray soil and Si in gray soil, may due to higher mineral content in the soils accordingly (Table 2, 3). Similarly, Johnson *et al.* (2003) found higher P in plant tissue with the increasing level of P fertilizer application. On the other hand, gray soil with the lowest Ca resulted in the second highest Ca in the plant, and red soil with the second highest Ca resulted in the lowest Ca in the plant. The S content was the highest in the plant cultivated in red soil with the highest S followed by gray soil with the lowest S. Aluminum and Fe content of the plant was the highest in dark-red soil though this soil did not contain highest mineral (Table 2, 3). Therefore, higher mineral in soils could not always increase mineral content in redflower ragleaf, which is in agreement with the result in other plants (Johnson *et al.*, 2003; Hossain and Ishimine, 2005). Clear relationship between the mineral content in soil and that in redflower ragleaf was not found. A certain level of minerals, a balanced fertilization and a specific soil pH are probably effective to increase mineral content of this plant. Omirou *et al.* (2009) reported that combined application of 150 kg ha<sup>-1</sup> S and 250 kg ha<sup>-1</sup> N resulted in a higher S in broccoli. Yan *et al.* (2008) reported that lower pH results in the lower Ca content in rice. Other studies reported that yield and quality of crops are positively and/or negatively correlated with the physical, chemical and nutrient status of soil (Oya, 1972; Miyazawa *et al.*, 2004).

Nitrogen content of redflower ragleaf was the highest in dark-red soil followed by red soil though these soils contained lower N, compared to those in gray soil (Table 2, 3). Similarly, Hossain and Ishimine (2005) found higher N in turmeric cultivated in dark-red soil with lower N, as compared that in gray soil with higher N. Nitrogen in dark-red soil and gray soil was almost the same, but yield was around three times higher in gray soil, which was probably the cause of lowest N in this plant. Flénet *et al.* (2006) reported that N concentration decreased with the increasing shoot biomass in *L. usitatissimum*.

## Conclusion

Redflower ragleaf grew slowly until 50 days after seed sowing (DAS) and rapidly from 50 to 70 DAS. Yield at 70 and 80 DAS was almost similar, which was around 2-3 times greater than that at 60 DAS. Capitula appeared from 60 DAS and matured from 80 DAS. All the growth parameters were significantly higher in gray soil, which resulted in around three fold greater yield as compared to those in dark-red soil or red soil. The plant in dark-red

soil obtained around 20% higher yield than that in red soil. Capitula appeared earlier in red soil than in other soils. Potassium (K) covered 75-82% of total minerals, and the other major minerals were Na, Ca, Mg, P and S in the plant. Potassium, Ca and P content was highest at 60 DAS, whereas Na, Al, Fe S and Si content was highest at 50 DAS and Mg increased with the longer growth period. Nitrogen content decreased with the longer growth period. Sodium, K and Mg content in the plant was highest in red soil followed by dark-red soil, whereas Ca was highest in dark-red soil followed by gray soil. Phosphorus and S content was highest for the red soil followed by gray soil. This plant contained highest N in dark-red soil followed by red soil. Considering growth characteristics, yield and mineral content, redflower ragleaf could be cultivated in gray soil and harvested between 60 and 70 day after seed sowing in Okinawa. The soil with higher N and pH (6.5-7.3) and lower Na, K, Ca, Mg and S may be suitable for better growth of this plant.

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沖縄県における島尻マーヅ土壤、国頭マーヅ土壤およびジャーガル土壤で栽培されたベニバナボロギク (*Crassocephalum crepidioides* (Benth.) S.Moore) の各生育段階における生育特性と収量およびミネラル含量

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## 要約

ベニバナボロギクは、熱帯・亜熱帯地域の国々で葉草や食用野菜として、あるいは、家畜飼料として利用されている。本試験では、ベニバナボロギクの生育特性と収量について、異なる生育段階ごとに評価し、さらに沖縄県内に分布する島尻マーヅ土壤 (pH5.5-6.5)、国頭マーヅ土壤 (pH4.0-5.5) およびジャーガル土壤 (pH6.5-7.3) を用いて栽培試験を行い、生育特性とミネラル含有量について調査した。

草高、葉数、葉面積および茎数については、播種後、50日目までは緩やかに増加したが、51日以降から70日目までは顕著な増加を示し、71日以降は、緩やかな増加を示した。播種後、60日目には頭状花序が出現し、80日目には成熟が始まった。播種後、70日目と80日目の収量は、ほぼ同様の値を示し、60日目の収量よりも2-3倍高い値を示した。ベニバナボロギクの生育に関する全ての測定項目について、ジャーガル土壤を用いた場合に顕著に高い値を示

し、収量については島尻マーヅ土壤あるいは国頭マーヅ土壤の値と比較して、約3倍高い値を示した。頭状花序の出現はジャーガル土壤が最も早く、次いで国頭マーヅ土壤、島尻マーヅ土壤の順であった。播種後60日目における植物体中のNa, K, Ca, P, Al, Fe, SおよびSi含量が最も高く、Mgについては、生育期間が長くなるにつれて増加した。Na, KおよびMgは、国頭マーヅ土壤で最も高く、次に島尻マーヅ土壤が高かったが、Caについては島尻マーヅ土壤で最も高く、次いでジャーガル土壤が高かった。PおよびSについては、国頭マーヅ土壤で最も高く、次にジャーガル土壤が高かった。

本試験により、沖縄県におけるベニバナボロギクの生育特性、収量およびミネラル含量について明らかとなった。特にベニバナボロギクは、ジャーガル土壤で最も良好な生育を示し、播種後70日目に収穫することが望ましいということが示された。また、ベニバナボロギクを雑草として着目する場合は、播種後70日以内に取除くことで、種子生産の抑制が可能であることが示唆された。