チッソ、リンおよびカリウム肥料がベニバナボロギクの生長形質に及ぼす影響

Effects of N, P and K on Growth Characteristics of Redflower ragleaf (*Crassocephalum crepidioides*)

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Abstract: Redflower ragleaf (*Crassocephalum crepidioides*) is a weed as well as a functional vegetable in tropical and subtropical regions of the world. The experiment was conducted to evaluate fertilizer effects on growth characteristics of redflower ragleaf. The treatments were nitrogen (N), phosphorus (P), potassium (K), nitrogen plus phosphorus (NP), nitrogen plus potassium (NK), phosphorus plus potassium (PK), nitrogen plus phosphorus plus potassium (NPK) and control (Con, no fertilizer). Nitrogen, P and K were applied at 200 (1.0g/pot), 100 (0.5g/pot) and 100 kg/ha (0.5g/pot), respectively according to the experiment design. Redflower ragleaf grown with the application of N, NP, NK and NPK was greener, and had higher SPAD value than the plants grown with the P, K and PK. Leaf defoliation naturally started earlier in the plants grown without N application. Plant height, leaf number and branch number were highest in the plants grown with the NPK followed by NK or N. The plants grown without N application resulted in earlier flowering. Fresh and dry weight of the plants was the highest when grown with the NPK followed by NK and N. Phosphorous and K applied separately or together did not show any positive effect on growth parameters, fresh weight and dry weight of the plant, but showed positive effect when applied with the combination of N. Combined application of N, P and K resulted in the best effect on all growth parameters, fresh weight and dry weight of redflower ragleaf.

Keywords: Chemical fertilizer, medicinal plant, phenology, Redflower ragleaf, weed growth.

Introduction

Plants respond differently to different fertilizer elements. Proper fertilizer management for a plant species is important for increasing growth, yield and quality. Nitrogen (N), phosphorus (P) and potassium (K) are the three major nutrients, which individually and/or together maintain growth, yield and quality of plants (Mazid, 1993; Ivony et al., 1997). Nitrogen is involved in chlorophyll formation, and influences stomatal conductance and photosynthetic efficiency (Mazid, 1993; Ivonyi et al., 1997). Nitrogen increases crop yield up to 41% (Mazid, 1993; Maier et al., 1994, 1996).

Potassium plays catalytic roles in the plant rather than becoming an integral part of plant components. It regulates the permeability of cell walls and activities of various mineral elements as well as neutralizing physiologically important organic acids. Plants with an inadequate K show poor fruit or seed formation, yellowing leaves, poor growth, and low resistance to coldness and drought (Oya, 1972). Sufficient K promotes N uptake efficiency of plants. Phosphorous indirectly promotes plant growth and absorption of K as well as other nutrients (Oya, 1972).

Redflower ragleaf (*Crassocephalum crepidioides*), 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 and antimalarial properties (Aniya et al., 2005, 2007), and contains several minerals (Hossain et al., 2008a, 2008b).The tender and succulent leaves and stems of the plant are mucilaginous, and are used as a vegetable in Sierra Leone, Ghana, Benin, Nigeria, Cameroon, Uganda, Australia and Asian countries (Aletor and Adeogun, 1995; Kongsaeree et al., 2003; Dairo and Adanlawo, 2007; Hossain et al, 2008a, 2008b). 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.

Growth, yield and quality of a plant species vary with the soil types, nutrients, and management practices (Oya, 1972; Oya et al., 1977; Hossain and Ishimine, 2005; Akamine et al., 2007). 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 (data unpublished). It is found as a weed in many crops, vegetables, orchards and fallow lands in Okinawa and Kagoshima (personal survey). On the other hand it is an herb in Okinawa (Aniya et al., 2005; 2007). It is important to evaluate growth characteristics of this plant under different factors for developing management practices as a vegetable, herb and weed. Our previous study reported that seed germination, seedling emergence and growth of redflower ragleaf differ significantly with the different pH, temperature, moisture, sowing depth, seed maturity, seed storing and soil type (Nakamura and Hossain, 2009; Hossain et al., 2012). But no study has yet been conducted on this plant in relation to fertilizer response. Present study has been conducted to evaluate the effects of N, P and K alone or in combination on growth characteristics of redflower ragleaf.

Materials and Methods

A glasshouse experiment was conducted using dark-red soil (Shimajiri mahji) at the Subtropical Field Science Center, University of the Ryukyus, from July 19 to October 10, 2007. Plastic pots (size 0.05 m^2) were filled with 10 kg of air-dried soil each pot. Table 1 shows the chemical properties of soil. No organic fertilizer was added to soil for determining actual effects of chemical fertilizers on growth parameters of redflower ragleaf. Seeds were sown in planter filled with the same dark-red soil on July 19, 2007 for seedling preparation; and one seedling of 5-leaf stage (8-10 cm height) was transplanted in each pot on August 31, 2007.

The treatments were nitrogen (N), phosphorus (P), potassium (K), nitrogen plus phosphorus (NP), nitrogen plus potassium (NK), phosphorus plus potassium (PK), nitrogen plus phosphorus plus potassium (NPK) and control (Con, no fertilizer). Each treatment was consisted of five replications (5 pots). Nitrogen at 200 kg/ha (1.0g/pot), P at 100 kg/ha (0.5g/pot) and K at 100 kg/ha (0.5g/pot) were applied according to the experiment design on September 7, 2007 (6- to 7-leaf stage). Water was applied as required everyday for proper plant growth.

Data collection and statistical analysis

Leaf color was visually evaluated throughout the growing period, and SPAD value was measured using SPAD-502 (Minolta Co. Ltd., Japan) on October 9, 2007. Plant height, leaf number and branch number of redflower ragleaf were measured on October 10, 2007, and the plants were harvested on the same day. Fresh weight of aboveground shoots was measured. Plant shoots were cut into pieces and oven-dried at 80℃for 48 hours and measured dry weight. Mean and standard deviation (SD) of replications were determined using analysis of variance (ANOVA), and Fisher's protected least significance difference (LSD) test at the 5% level of significance was used to compare treatment means.

Results and Discussion

Redflower ragleaf grown with the N, NP, NK and NPK maintained greener throughout the growth period than the plants grown with the P, K and PK (Fig. 1). The SPAD value increased significantly and similarly when the plant was grown with the application of N, NP, NK and NPK (Fig. 2A). The plants grown without N application showed poorer vegetative growth (Fig. 1). The shoots were yellowish and leaf defoliation naturally started earlier in the plants grown without N application (data not presented). Similarly, Sarker et al. (2002) reported that deficiency of N fertilizer results in lower chlorophyll in leaves which causes earlier plant death.

Plant height was the highest when redflower ragleaf was grown with the NPK followed by N and NK (Fig. 2B). Nitrogen applied alone or in combination with the P, K or PK resulted in a significantly higher plant height, leaf number and tiller number (Fig. 2B, 2C, 2D). Combined application of P and K showed antagonistic effect and resulted in the lowest plant height. Number of leaves and branches was highest when the plants were grown with the NPK followed by NK and N. The plants with the P, K, PK or control resulted lower and similar number of leaves and branches (Fig. 2C, "D). Several studies reported that N is the principal nutrient of plant, which significantly increases vegetative growth parameters of plants (Akamine et al. 2007; Govind et al., 1990; Behura, 2001). No vegetative growth parameters of redflower ragleaf increased when grew with the P or K. Similarly, other studies reported that P or K is not individually significant for vegetative growth of

Table 1. Chemical properties of dark-red soil in Okinawa, Japan.

Na ($mg\,g^{-1}$)	K ($mg\,g^{-1}$)	Ca ($mg\,g^{-1}$)	Mg ($mg\,g^{-1}$)	Fe ($mg\,g^{-1}$)	P ($mg\,g^{-1}$)	S ($mg\,g^{-1}$)	Si ($mg\,g^{-1}$)	Mn ($mg\,g^{-1}$)	N (%)	C (%)	pH
0.35	0.54	0.28	0.14	0.000	0.004	0.19	0.02	0.0002	0.33	3.26	6.0

Note: Data are means of three replications.

Fig. 1. Growth of redflower ragleaf under different chemical-fertilizers.

plants (Behura, 2001; Govind et al., 1990; Maier et al., 1996; Razzaque and Hanafi, 2001). The combined application of P and K did not show positive effects on vegetative growth parameters. The fertilizer PK without N probably created nutrient imbalance in the soil, which inhibited absorption of necessary nutrients and resulted in lower vegetative growth. An imbalance or excessive nutrient prevents ion formation, which causes inhibition of nutrient absorption for the plant (Maier et al., 1994; Ivonyi et al., 1997). The plant grown without N application resulted in earlier flowering (data not presented). Similarly, Hossain et al. (2012) reported that capitula appeared earlier in the plants grown in red soil followed by dark-red soil due to lower N content in the soils.

Fresh and dry weight of the plants increased significantly with the N, NK and NPK, and they were highest in the plants with the NPK followed by NK and N (Fig. 3A, 3B). Nitrogen applied alone resulted in a remarkablely greater dry weight, whereas P, K or PK did not show any positive effect. However, P and K showed a slightly positive effect on growth and yield of redflower ragleaf when combined with N (Fig. 3A, 3B). The plants grown with N and NK obtained a similar fresh and dry weight. Nitrogen increased all vegetative growth parameters, which resulted in a higher shoot biomass. Our previous studies revealed that shoot biomass increased with the increasing plant height, leaf number and tiller number of turmeric plant (Hossain et al., 2005a, 2005b; Hossain and Ishimine, 2005c). The plants grown with N, NP, NK or NPK remained green much longer (Fig. 1), which contributed to longer photosynthesis and resulted in a higher shoot biomass. Sarker et al. (2002) reported that biomass increased in rice plants which remained green longer.

Phosphorus applied alone or in combination with K did not increase fresh and dry weight of the plant. Potassium applied alone did not have any effect on the plant, but NK increased the fresh and dry weight remarkably. This study indicates that K alone cannot increase yield but enhance N to improve the fresh and dry weight. Behura (2001) reported that K applied separately could not improve plant yield, but improved significantly when applied in combination with N and P. A similar result was reported in *Cannabis sativa* (Ivonyi et al., 1997). Application of PK did not show any

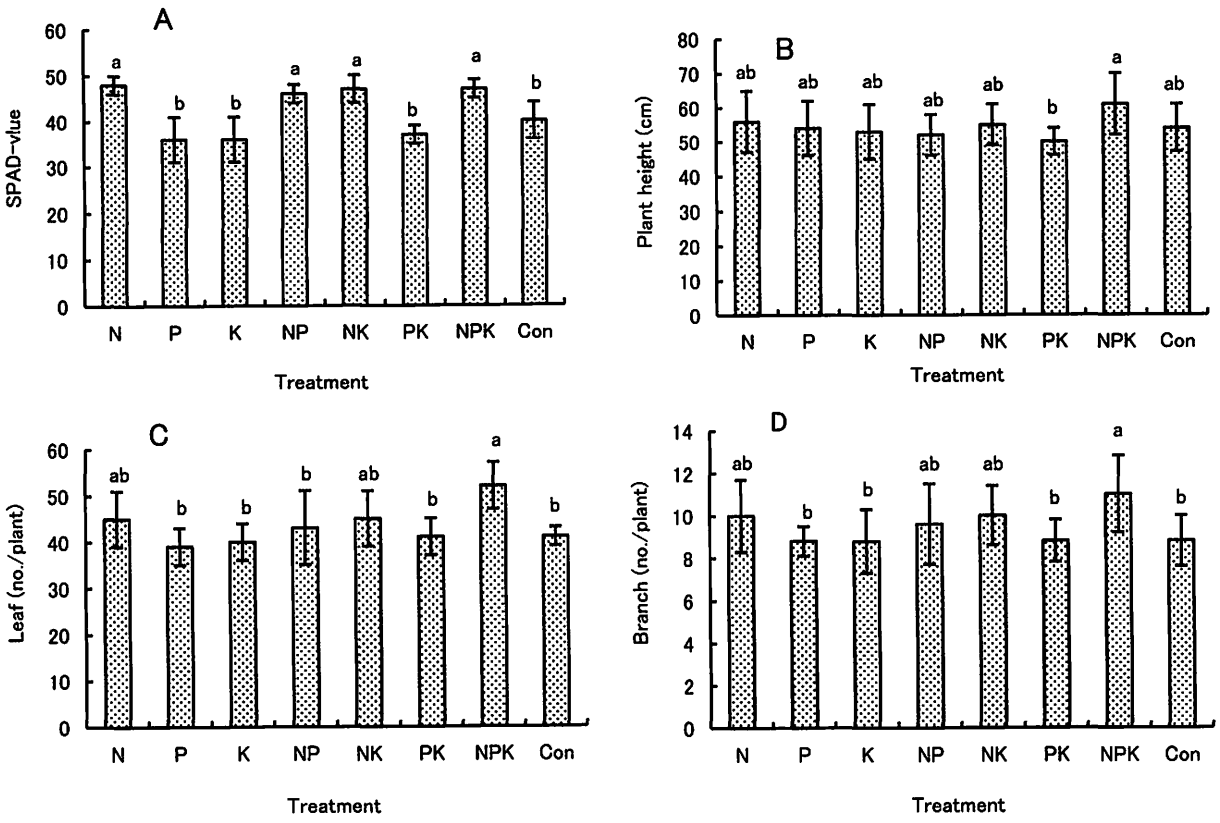

Fig. 2. Effect of Chemical fertilizer on SPAD-value (A), plant height (B), leaf number (C) and branch number (D) of redflower ragleaf. Treatment means with the same letter are not significantlydifferent at the 5% level, as determined by LSD test.

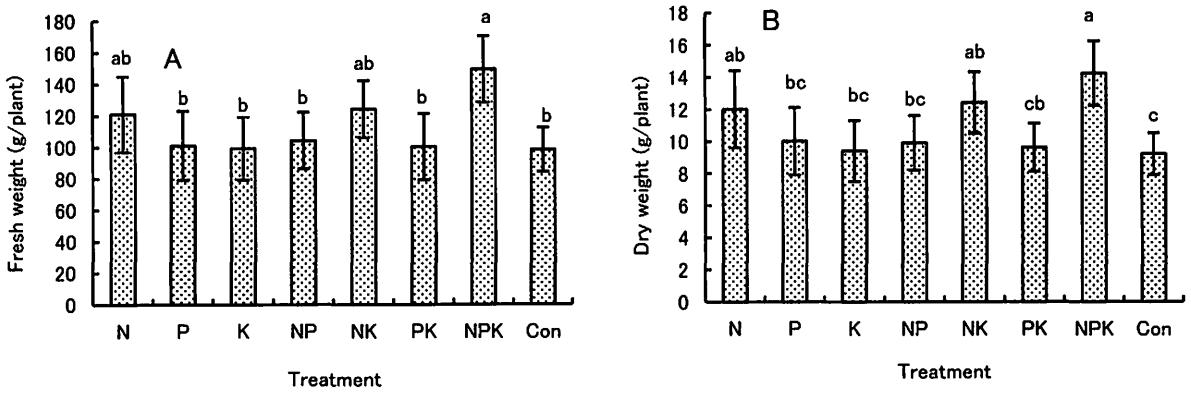

Fig. 3. Effects of chemical fertilizers on fresh (A) and dry (B) weight of redflower ragleaf. Treatment means with the same letter are not significantly different at the 5% level, as determined by LSD test.

effect on the plant. It was assumed that PK without N created a nutrient imbalance in the plants. Other studies reported that imbalance nutrients could not increase growth and yield of crops (Maier et al., 1994; Razzaque and Hanafi, 2001; Hossain and Ishimine, 2005c). Behura (2001) reported that chemical fertilizer of N and K applied in a certain ratio showed higher efficacy on plant yield. However, the ratio may differ with the soil nutrient status. N applied alone increased shoot biomass significantly. The above results indicate that N itself improves growth parameters and enhances the efficacy of P and K to improve biomass of the plant. Previous study (Hossain et al., 2012) reported that higher plant height, leaf number, branch number, leaf area, stem diameter and shoot biomass of redflower ragleaf increased in gray soil may due to higher N content in the soil. It was

reported that N is comparatively better than P or K for increasing growth of redflower ragleaf but varying with soil nutrient status (Reddy and Rao, 1978; Govind et al., 1990). Other studies reported that N fertilizer is responsible for 26 - 41% yield of many crops (Maier et al., 1994, 1996).

Conclusion

This experiment indicated that redflower ragleaf grown with the application of N, NP, NK and NPK was greener, and contained higher SPAD value in leaves than the plants grown with the P, K and PK. Leaf defoliation naturally started earlier in the plants grown without N application. The plants grown without N application resulted in earlier inflorescence. Phosphorous and K applied alone could not increase growth parameters, and fresh and dry weight of redflower ragleaf, whereas N applied alone increased all the growth parameters, and fresh and dry weight. Plant height, leaf umber, branch number, fresh weight and dry weight were highest in the plants grown with the NPK followed by NK or N. Nitrogen, P and K applied alone increased dry weight of redflower ragleaf by 30, 9 and 2%, respectively, and NP, NK, PK and NPK increased the dry weight by 8, 35, 4 and 54%, respectively (calculated from the Fig. 3b). These results indicated that P decreased efficiency of N when applied together, whereas K increased the efficiency of N. Phosphorous and K together increased efficiency of N significantly on the plant when applied together. Combined application of N, P and K resulted in the best effect on all the growth parameters, and fresh and dry weight of redflower ragleaf. Further studies are needed to evaluate the critical level and timing of N, P and K application on growth characteristics and biomass accumulation of redflower ragleaf.

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チッソ，リンおよびカリウム肥料がベニバナボロギクの生長形質に及ぼす影響

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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は機能性野菜として利用されている．本実験では，ベニバナボロギクの生長に対する化学肥料の影響を調査した．試験区は，チッソ(N)，リン(P)，カリウム(K)，チッソ＋リン（NP），チッソ＋カリウム（NK），リン＋カリウム（PK），チッソ＋リン＋カリウム（NPK）および無施肥（対照区）の8処理区とした．施肥量は，N，PおよびK，それぞれ20 Kg/ha（1.0g/ポット），100 Kg/ha（0.5g/ポット）および100 Kg/ha（0.5g/ポット）とした．葉におけるSPAD値は，N，NP，NKおよびNPK区においてP，KおよびPK区より高い値を示した．チッソ(N)を施肥しない区では，最も早く落葉が観察された．草丈，葉数および分枝数については，NPK区で栽培した植物体に次いでNKとN区の植物体で高い値を示した．チッソ(N)を施肥しない区の植物体は，より早く開花することがわかった．全新鮮重および全乾物重では，NPK区に次いでNK区，N区の順に高い値を示した．リン（P）およびK肥料の単独施肥またはPおよびKの混合施肥によって，全新鮮重，全乾物重および生長形質への影響は認められなかった．ベニバナボロギクの栽培においてN，PおよびKの組み合わせ施肥をすることが，生長形質や乾物重の増加に最も影響を及ぼすことがとがわかった．

キーワード：化学肥料，薬用植物，フェノロジー，ベニバナボロギク，雑草生長