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Physiological and Biochemical Properties of Sweet Potato as affected by Agronomic Practices Under Sub-Tropical North Eastern Hills of India

M. R. Sahoo[1], S. S. Roy[1], N. Rakesh Singh[2], Y. Indrani Devi[1], N. Prakash[1] and S. V. Ngachan[3]

[1] ICAR Research Complex for NEH Region, Manipur Centre, Lamphelpat, Imphal 795 004, Manipur, India

[2] Central Agricultural University, Iroisemba, Imphal 795 004, Manipur, India

[3] ICAR Research Complex for NEH Region, Umroi Road, Umiam 793 103, Meghalaya, India

Corresponding author: M.R. Sahoo, e-mail: mrsahoo2004@rediffmail.com

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Abstract

The effect of spacing and nutrient management on physiological and biochemical properties of orange-fleshed sweet potato var. Gouri was studied under foot hill conditions of Manipur. The physiological parameters such as relative water content (RWC) and chlorophyll stability index (CSI); biochemical parameters such as protein content, total soluble sugar (TSS) and reducing sugar (RS) and NPK contents in leaves and tubers showed significant variation due to spacings (S_1: 60 x 20 cm and S_2: 60 x 30 cm) and NPK rates (F_1: 60:40:60 ; F_2: 75:50:75; F_3: 90:60:90 kg ha^{-1}). The RWC and CSI increased with increasing nutrient doses under spacing S_1 and decreased at spacing S_2. The NPK content, TSS and RS in leaf tissues increased significantly with increasing doses of NPK. The leaf protein content increased with increasing rates of NPK at wider spacing (S_2). The treatment combinations, S_1F_2 (33.0 t ha^{-1}) and S_2F_3 (32.7 t ha^{-1}) produced significantly higher tuber yield. The study revealed that NPK @ 75:50:75 kg ha^{-1} and spacing of 60 x 20 cm can be recommended for higher productivity and tuber quality of sweet potato under foot hill conditions of Manipur.

Key words: Nutrient management, spacing, sweet potato, physiological parameters, biochemical properties, tuber yield

Introduction

Sweet potato (*Ipomoea batatas* L.) is one of the important tuber crops, which ranks seventh among the food crops and second among the root and tuber crops in the world after potato. Orange-fleshed tubers are cheap and ready source of β carotene (10 mg 100 g^{-1} fresh weight), a precursor for the production of Vitamin A. The tubers of sweet potato serve as staple food, animal feed and to a limited extent as raw material for industrial purposes. The leaves are good source of minerals like Ca, K, Fe and P. The uses and advantages of sweet potato are well documented (Woolfe, 1993). The orange-fleshed sweet potato tubers of the variety Gouri are mostly preferred by the tribal population in North Eastern Hill (NEH) regions of India. The tender leaves and vines are widely used as fodder for livestock, in general and for pig feed, in particular. Despite being a staple crop, productivity of sweet potato is often threatened by nutrient stress under low/no input slash and burn cultivation practices in NEH region, especially in the state of Manipur. Sweet potato is gaining importance as a source of dietary energy amongst the tribal population of this region. However, low productivity has been realised due to low nutrient supplements either from inorganic or organic sources in this marginal, fragile and inaccessible agro-ecosystem. The reduced plant growth parameters in fields subjected to lower or no fertilizer can be attributed to deficiency of N in the soil and hence stunted plants (Ng Etich et al., 2013). Furthermore, the link between cultivation system and nutritional value of agricultural products remains missing (Lundegardh and Martensson, 2003; Hamouz et al., 2005). Reports on the effect of nutrient management on physiological and biochemical properties and NPK contents in leaf tissues and tubers of sweet potato under sub-tropical foot hill conditions of NEH region are scanty. Hence, the present study was conducted to investigate the effects of nutrient management and spacing on physiological and biochemical properties and NPK contents in leaf tissues and tubers of orange-fleshed sweet potato variety Gouri under foot hill conditions of Manipur.

Materials and Methods

Experimental site and design

A field experiment was laid out at the Langol Hill Research Farm (24°50' N latitude, 93°55' E longitude and altitude of 860 m above mean sea level), ICAR Research Complex for NEH Region, Lamphelpat, Imphal, India, during July-November in 2012-2013. The experiment was laid out in factorial randomized block design (RBD) with three NPK levels (F_1- 60:40:60, F_2- 75:50:75 and F_3- 90:60:90 kg ha^{-1}) as one factor and two spacings (S_1- 60 x 20 and S_2- 60 x 30 cm) as the other factor with four replications. A uniform dose of farmyard manure (FYM) @ 5 t $ha^{-1}$was applied in all the plots. Sweet potato var. Gouri was used for the present study. All other agronomic and crop management practices were followed as per the standard package of practices (Onwueme, 1977). The temperature during the crop growth period was 18.4 -29.3°C, bright sunshine hours 5.7 hours and total rainfall 543.4 mm. The organic C, available N, P and K contents were 2.5%, 275-325 kg ha^{-1}, 35-50 kg ha^{-1} and 45-75 kg ha^{-1} respectively. Statistical analyses were carried out using analysis of variance (ANOVA) for two factors in RBD (Gomez and Gomez, 1984).

Morphological, physiological and biochemical parameters

Morphological parameters such as vine length, number of leaves and leaf area were recorded at 45 and 90 days after planting (DAP). Leaf area was estimated following the procedure of Ramanujam and Indira (1978). The tuber yield was recorded at the time of harvest. Physiological parameters such as relative water content (RWC) and chlorophyll stability index (CSI) were also determined at 45 and 90 days after planting following the procedures of Perez et al. (2002) and Mohan et al. (2000) respectively.

The biochemical properties of leaves such as total soluble protein (TSP), total soluble sugar (TSS) and reducing sugar (RS) were estimated at 45 and 90 DAP. Protein concentration in the leaf tissues was determined following the procedure of Bradford (1976). The total soluble sugar was quantified following the anthrone method as described by Somogy (1952) and Roe (1955) and reducing sugar by the methodology of Nelson (1944).

The contents of N, P and K in leaf and tuber of sweet potato were estimated following standard methods (Bremner, 1965; Gupta, 2000).

Results and Discussion

Morphological and physiological parameters

Significant differences in the morphological and physiological parameters were observed in sweet potato grown under different levels of NPK and spacings. At 90 DAP, the vine length was significantly higher for the treatment, S_2F_3 (118.7 cm), which was on par with S_2F_1 (113.8 cm) and S_2F_2 (109.5 cm) (Table1). The treatment S_2F_3 also resulted in significantly higher leaf number (213.9), which was on par with that of S_2F_1. There was no significant difference in leaf area among the different treatments studied. The tuber yield was found to be significantly higher for the treatment S_1F_2 (33.0 t ha^{-1}), which was on par with that of S_2F_3 (32.67 t ha^{-1}). The lowest tuber yield was obtained in the treatment S_2F_1 (19.82) t ha^{-1} (Table1). The addition of chemical fertilizers increased the leaf area, growth parameters and ultimately tuber yield (Onwueme, 1977). Chemical fertilizers have a definite role in influencing the quality of sweet potato tuber (Kareem, 2013). Balanced application of N, P and K fertilizers at the correct amount and time is most important in deciding the quality of the produce. Imbalance in the application of NPK fertilizers will lead to decrease in tuber quality, delay in plant maturity and lower harvest index (Hashemidezfooli et al., 1998).

The physiological parameters such as relative water content (RWC) and chlorophyll stability index (CSI)

Table 1. Effect of nutrient management and spacing on growth and yield of sweet potato under foot hill conditions of Manipur

Treatments	Vine length (cm)		Number of leaves		Leaf area (cm^2)		Tuber yield
	45 DAP	90 DAP	45 DAP	90 DAP	45 DAP	90DAP	($t\ ha^{-1}$)
S_1F_1	31.3	109.3	29.7	148.1	141.9	289.7	23.15
S_1F_2	27.2	99.8	28.4	177.8	126.3	261.9	33.00
S_1F_3	30.3	105.2	28.5	171.9	117.3	242.8	24.21
S_2F_1	27.3	113.8	26.5	202.8	142.8	257.3	19.82
S_2F_2	28.4	109.5	22.2	175.9	148.8	257.6	25.29
S_2F_3	28.4	118.7	29.2	213.9	142.3	251.5	32.67
CD (0.05)	6.2	12.4	NS	34.2	NS	NS	7.66

DAP : Days after planting

showed significant difference among the treatments (Fig. 1). The RWC varied from 83.97 (S_2F_3) to 88.56% (S_1F_2) at 45 DAP and from 83.35 (S_1F_3) to 90.35% (S_2F_3) at 90 DAP. The RWC was found to increase with increasing rates of NPK at wider spacing (60 x 30 cm) and decrease with increasing dose of fertilizers at narrow spacing (60 x 20 cm) at 90 DAP (Fig. 1). The CSI increased with increasing rates of NPK at narrow spacing (60 x 20 cm) and decreased at wider spacing (60 x 30 cm). The highest CSI was obtained for the treatment, S_2F_1 (90.64), followed by S_2F_3 (90.44) at 45 DAP and the same was highest under S_1F_2 (88.79) and lowest under S_2F_2(81.36) at 90 DAP (Fig. 1). Chlorophyll content is known to be closely linked to N status of potato plants (Jones et al., 2013) and the CSI increased with increasing rate of NPK.

Biochemical characters

Biochemical parameters such as protein content, total soluble sugar (TSS) and reducing sugar (RS) content in leaf tissues at 45 and 90 DAP showed significant variation among the six treatment combinations tested. A negative relationship between protein content and nutrient levels has been demonstrated by Jones et al. (2013). The leaf protein content decreased with increase in NPK rates for the spacing S_1 and increased with increasing NPK rates for the spacing S_2. The leaf protein content was in the range of 9.51 (S_2F_2) to 15.23 mg g^{-1} (S_1F_1) at 45 DAP and 12.20 (S_1F_2) to 23.26 mg g^{-1} (S_2F_2) at 90 DAP (Fig. 2). The TSS in leaf tissues increased significantly with increasing NPK rates and spacing both at 45 and 90 DAP. The TSS ranged from 15.60 (S_1F_1) to 23.63 mg g^{-1} (S_2F_2) and 20.50 (S_1F_1) to 25.85 mg g^{-1} (S_2F_3) at 45

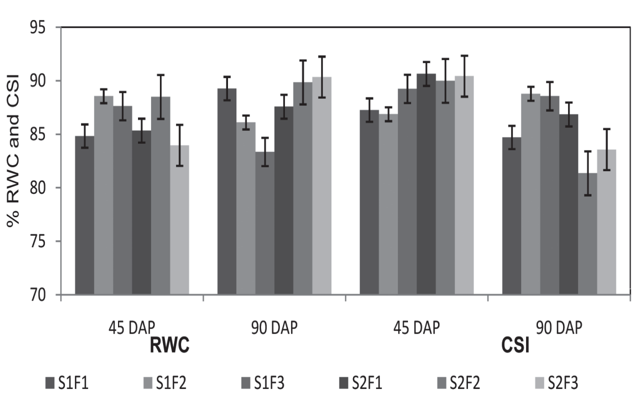

Fig. 1. Effect of nutrient management and spacing on relative water content (RWC) and chlorophyll stability index (CSI) of leaf tissues of sweet potato under foot hill conditions of Manipur

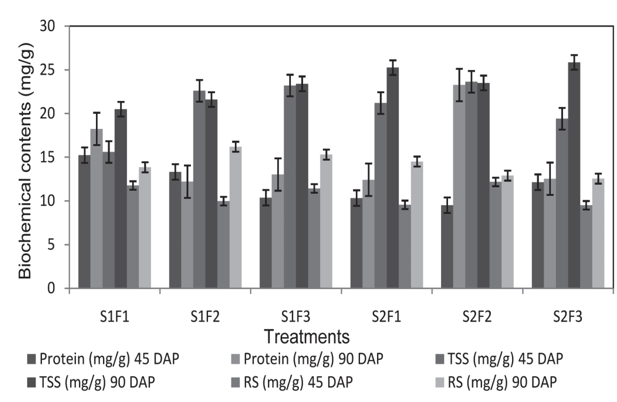

Fig. 2. Effect of nutrient management and spacing on protein, total soluble sugar and reducing sugar contents of leaf tissues of sweet potato under foot hill conditions of Manipur

and 90 DAP, respectively (Fig. 2). However, the RS content in leaf tissues at 45 and 90 DAP varied significantly from 9.50 (S_2F_3) to 12.18 mg g^{-1} (S_2F_2) and from 12.55 (S_2F_3) to 16.20 mg g^{-1} (S_1F_2) respectively (Fig. 2). The RS content in leaf tissues increased significantly with increasing NPK rates for the spacing S_1 and decreased with increasing NPK rates for the spacing $S_{1.}$ There is a direct relationship between energy and starch as well as carbohydrate content of the tubers as reported by Kareem (2013).

N, P and K contents

Significant variation among the N, P and K contents in tuber and leaf tissues of sweet potato were observed under the different treatments. The leaf N, P and K was in the range of 3.18-3.71%, 0.12-0.14% and 1.77-2.26%, respectively. The N, P and K contents in sweet potato tubers at harvest were in the range of 0.90-1.15%, 0.07-0.10% and 1.30-1.58%, respectively (Fig. 3). The N, P and K contents in leaf tissues and tubers increased with increasing rates of NPK under two

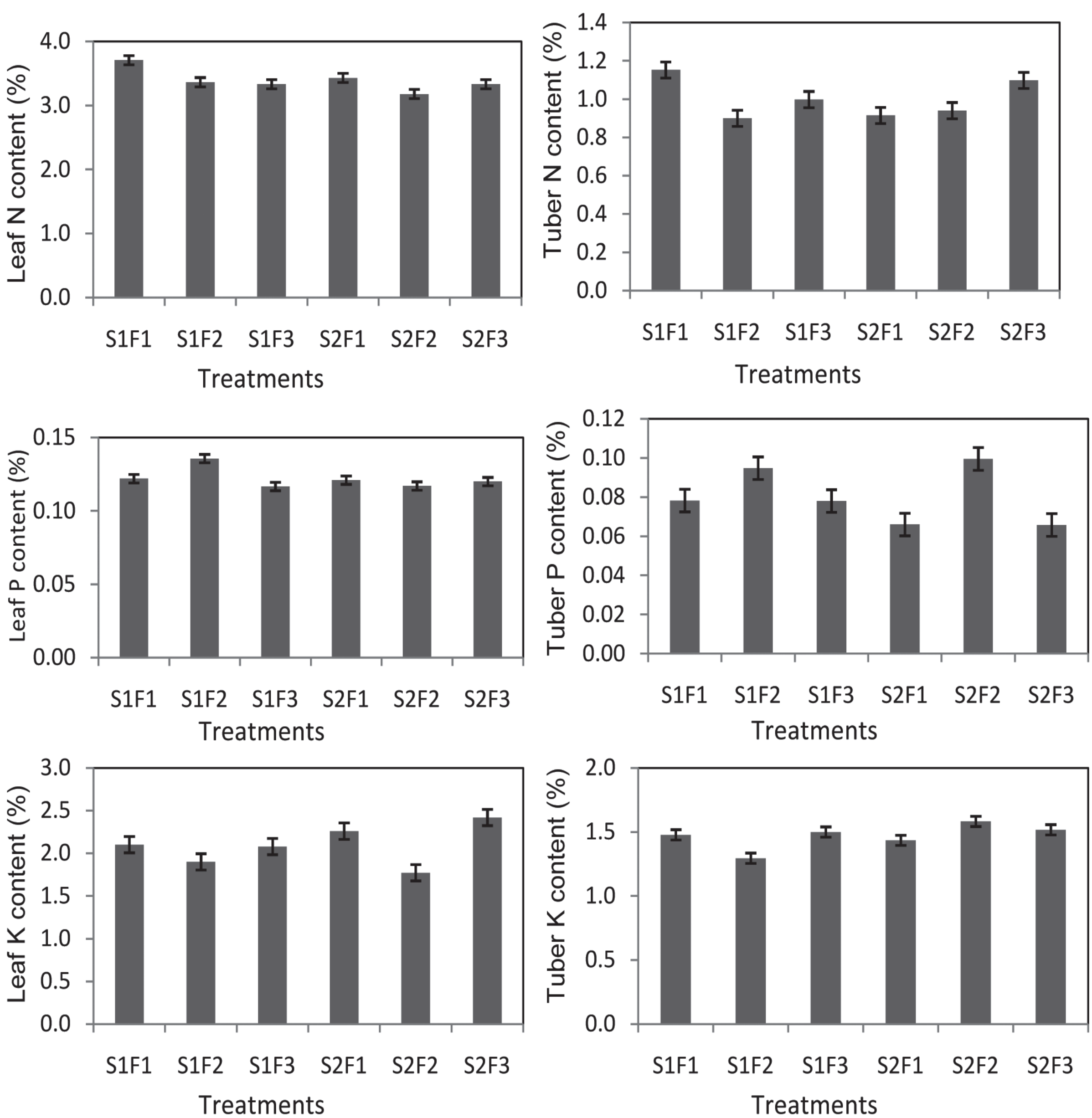

Fig. 3. Effect of nutrient management and spacing on N, P and K contents in leaves and tubers of sweet potato under foot hill conditions of Manipur

different spacing. The results of the present investigation are in accordance with that of Jones et al. (2013). The results showed that application of N, P and K at higher rates under narrow spacing resulted in significant increase in N content of sweet potato tubers, which was in agreement with the results of Love et al. (2005) and Haase et al. (2007). However, the increase in N rate decreased the P content of tubers. Potassium content of sweet potato tuber was significantly influenced by N fertilizer (Yourtchi et al., 2013). It has a role in the transportation of photosynthate complexes in leaves and it regulates the photosynthesis indirectly (Russell, 1973). The results of the present study clearly showed the importance of balanced application of NPK fertilizers and planting at proper spacing for higher yield and nutritional quality.

Conclusion

The present study indicated that a lower plant spacing of 60 x 20 cm and application of NPK @ 75:50:75 kg ha^{-1} resulted in higher tuber yield in sweet potato with less accumulation of NPK in the tuber and leaf tissues in the sub-tropical foot hills of Manipur. The above treatment combination had positive effect on vegetative growth, yield and biochemical properties of sweet potato.

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