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# Potential for Sunn Hemp (*Crotalaria juncea*) to Utilize Soil Potassium

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**Sunn hemp (*Crotalaria juncea* L.) is a tropical leguminous cover crop grown June through August in Florida. In organic production systems, efficient cycling of nutrients including K is critical to minimizing the high costs of compliant fertilizers. To determine the capacity of sunn hemp K uptake and the influence of K on aboveground biomass production, three rates of K (45, 90, and 180 kg·ha$^{-1}$) as potassium magnesium sulfate (22% $K_2O$) were compared to a control of 0 K. Treatments were randomized and replicated three times. Sunn hemp was seeded to 28 kg·ha$^{-1}$ on 15 May 2008 at Plant Science Research and Education Unit in Citra, FL. Percent K in sunn hemp stem tip tissue (top 15 cm) increased linearly with rate ($y = 0.004x + 1.98$; $r^2 = 0.12$) and declined linearly with time ($y = -0.44x + 3.57$; $r^2 = 0.73$). Total K in aboveground dry plant tissue increased with increasing K rate ($y = 0.005x + 1.92$; $r^2 = 0.58$) at 6 WAP. Potassium accumulation in aboveground tissues at 6 WAP was 68 kg·ha$^{-1}$, indicating the potential for some K provision to subsequent crops in short rotations.**

Sunn hemp (*Crotalaria juncea*) is a tropical to subtropical legume cultivated as a fiber crop in India and Asia and as multipurpose cover crop in North America. Sunn hemp as a cover crop is of great value to farmers because it offers many benefits to the farming system, including rapid growth, high biomass yield and efficient N fixation (Abdul-Baki et al., 2005), resistance to nematodes (Wang et al., 2008), weed suppression (Collins et al., 2008; Linares et al., 2008), and mitigation of pesticide residues (Holvoet et al., 2007). Sunn hemp fits easily into short rotations in vegetable systems throughout the southeastern U.S. and the tropics (Jeranyama et al., 2000; Schomberg et al., 2007).

Cover crops provide optimum benefits to the farming system when their production is carefully managed. Farmers pay careful attention to planting, termination, and soil incorporation but cover crops are rarely fertilized. Sunn hemp, as with many leguminous cover crop species, maintains a symbiotic relationship with soil bacteria *Rhizobium* spp. and is often included in rotation to provide N to following crops. Total N content in aboveground tissues can be substantial and can range from 112 to 336 kg·ha$^{-1}$ (Abdul-Baki et al., 2001; Balkcom and Reeves, 2005; Cherr et al., 2006).

While K is an essential nutrient for plant growth, it generally has received less attention than N and P in many crop production systems (Mikkelsen, 2007). Potassium is the seventh most abundant element on earth, and is absorbed in plants in larger amounts than any other nutrient except N (Havlin et al., 1999). It is a vital nutrient for plant growth. On many farms, the K balance is negative, which means that more K is being removed in harvested crops than replaced as soil amendments. In the U.S., an average of only 3 kg of K is replaced as fertilizer and manure for every 4 kg K removed in crops, and in Florida, 65% of soils require K to avoid yield loss (Potash and Phosphate Institute, 2002). Rain intensity and Ca are main determinants of soil solution K leaching in the soil (Kolahchi and Jalai, 2007). Exchangeable K does not adhere strongly to soil minerals and is easily displaced by Ca, a predominant element in our calcareous soils. Chronic underapplication of K ultimately results in a depletion of nutrients from the soil and increasing occurrences of deficiency.

Nutrient cycling efficiencies can improve when cover crops are used in crop rotations (Snapp et al., 2005). Frequently, cover crops are included in rotation following an income-producing crop to function as a "catch crop," meaning to utilize residual soil nutrients. This is especially prevalent in organic systems where efficient nutrient cycling is critical to minimize the high cost of compliant fertilizers. However, little research has been done to identify and improve the capacity of sunn hemp and other cover crop species to utilize residual soil K. The objectives of this experiment were to determine the capacity for sunn hemp to utilize residual soil K that might be available to subsequent vegetable crops and to evaluate the influence of K on height and aboveground biomass production.

## Materials and Methods

The experiment was located at the Organic Unit at the University of Florida's Plant Science Research and Education Unit in Citra, FL, on an Arredondo fine sand. Potassium fertilizer ($K_2SO_4 \cdot 2MgSO_4$) with an N–P–K analysis of 0–0–22 and compliant with the USDA's National Organic Program was soil incorporated to a depth of 15 cm at four rates of K: 0, 45, 90 ,and 180 kg·ha$^{-1}$. This range of K rates was selected to reflect the scenarios possible following termination of a vegetable crop. No added K per the control treatment represented termination of a vegetable crop well before a cover crop was planted, while the high rate (180 kg·ha$^{-1}$) was possible if an established vegetable crop was terminated due to crop failure. No additional inputs were provided. Treatments were arranged in a randomized complete-block design

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and replicated three times. Plots were 1.8 m wide and 6 m long and were separated by fallow drive rows 1.8 m wide.

On 15 May 2008 immediately following potassium fertilizer additions, sunn hemp was seeded at 28 kg·ha$^{-1}$ at 45-cm row spacing using a mechanical drill. Plant height was measured weekly from week 3 through week 12. Three plants per plot were measured to the height of their apical meristem. Soil samples were collected before planting (by replicate) and 6 weeks after planting (WAP) (by plot). Each soil sample was a composite of six cores from a 5-cm-diameter probe to a depth of 15 cm. Soil samples were submitted to Waters laboratory (Camilla, GA), and exchangeable K was determined with a Mehlich 1 extraction (Mehlich, 1953). Sunn hemp stem cuttings were collected at 4, 6, 8, 10, and 12 WAP by clipping the top 15 cm of the main stem. This practice was consistent with the treatment for a concurrent but separate experiment designed to evaluate the effect of cutting the main stem on floral initiation and seed production. In addition, aboveground plant tissue was sampled 6 WAP by cutting stems at the soil surface within a 1⁄4 m$^2$ sampling frame. All tissue was dried in a 160 °C oven until a constant weight was observed; then dry weight was recorded. Dry sunn hemp tissue was ground to pass using a 16-mm mesh screen and submitted to Waters laboratory. Potassium determination was by atomic absorption spectrophotometry (Hanlon, 1992).

Data were analyzed using General Linear Models (SAS, Cary, NC). When treatment differences were statistically different at $P \le 0.05$, means were separated using Duncan's new multiple range test. Data for K in plant tissue increase as a function of K fertilizer were fitted to a linear model using regression when significant at $P \le 0.05$. (SAS).

## Results and Discussion

**Sunn hemp height and biomass.** In this study, sunn hemp height and dry weight biomass increased linearly with time (data not shown) to over 2 m and up to 58,308 kg·ha$^{-1}$ in 12 weeks (Table 1). The aboveground biomass of sunn hemp observed in this study was greater than that observed in other studies (4500–9000 kg·ha$^{-1}$) (Abdul-Baki et al., 2001; Balkcom and Reeves, 2005; Cherr et al., 2006). The amount of preplant K fertilizer did not affect plant height or dry weight biomass from 4 to 12 weeks after planting (Table 1). When planted for fiber production, researchers observed that the addition of K and P fertilizer increased the yield of sunn hemp fiber, but the quantity of K applied and the biomass production were not included in that report (Chaudhury and Singh, 1978). The results produced by our research did not support the original prediction that greater amounts of K would significantly aid in the growth and development of sunn hemp.

**Soil potassium.** The Arredondo soil series is a well drained, rapidly permeable soil typically low in K. At the location of this experiment, the soil was composed of 95% sand, 2% silt, and 3% clay and has 1.5% organic matter. The soil K present before planting likely reflected the K available from decomposing bahia grass (*Paspalum notatum* Flugge) and miscellaneous weed species at the site following tillage events prior to sunn hemp seeding. Preplant soil K averaged 30 ppm and was not significantly different among replications. At 6 WAP, soil K was highest in the 180 kg·ha$^{-1}$ K treatment compared to remaining treatments (Table 2). In the first 6 weeks of the experiment, 8.8 cm of precipitation was received at the experimental site. Although K leaching was likely, it was not apparent in the data.

The inherent soil K was likely contributing to the soil K concentration (Table 2), since the sum of soil K and tissue K was greater than the K applied prior to sunn hemp seeding. Sunn hemp is known to have an extensive root system, and this additional K was likely utilized from depths greater than 15 cm. Additional soil sampling events and samples collected from lower depths would be required to more accurately account for soil K losses and gains.

**Sunn hemp K uptake.** Sunn hemp aboveground plant tissue accumulated the most K when provided the highest rate of K fertilizer (Table 2). Sunn hemp with the 180 kg·ha$^{-1}$ K treatment sequestered 26% more K in aboveground plant tissues than sunn hemp with the 0 K treatment. Sunn hemp aboveground tissue K accumulated 68.4 kg·ha$^{-1}$ K with the 180 kg·ha$^{-1}$ K treatment and 48.7 kg·ha$^{-1}$ K with control treatments (Table 2).

A General Linear Model analysis of sunn hemp stem tips using Duncan's new multiple range test revealed significant main effects of sample date and K rate; therefore K tissue data were combined over all dates. Averaged over all 12 weeks (n=5 dates), sunn hemp stem tips had the highest K concentration with the 180 kg·ha$^{-1}$ K treatment (2.7%), followed by the 45 and 90 kg·ha$^{-1}$ K treatments (2.3% and 2.2%, respectively). Stem tip K content was greater with all treatments compared to the control of no added K (1.9%) ($P < 0.0001$). The relationships between sunn hemp stem tip K and K rate and date are illustrated in Figure 1. Sunn hemp tips increased with K rate and fit a linear model ($y = 0.004x + 1.98$; $r^2 = 0.12$). Although the relationship was statistically significant ($P = 0.007$), little of the variation was accounted for in the model. Sunn hemp tips decreased in K concentration over time and also fit a linear model ($y = –0.44x + 3.6$; $r^2 = 0.73$). As biomass increased, the concentration of K in the main stem tips decreased. When whole, aboveground sunn hemp tissue was analyzed at 6 WAP, tissue K was observed to increase linearly with fertilizer K rate ($y = 0.005x + 1.917$; $r^2 = 0.5788$) (Fig. 2).

Sunn hemp stem tip K concentration was similar to aboveground tissue K concentration in the first 6 weeks. At 6 weeks after planting, plant and soil K were greatest with treatments receiving the

Table 1. Sunn hemp plant height and aboveground tissue dry weights as affected by K rate at selected weeks after planting (WAP) in 2008 at the University of Florida Plant Science Research and Education Unit in Citra, FL.

| K rate | Ht (cm) WAP | | | | Dry wt (kg·ha$^{-1}$) WAP | | | |
|---|---|---|---|---|---|---|---|---|
| (kg·ha$^{-1}$) | 4 | 6 | 8 | 12 | 4 | 6 | 8 | 12 |
| 0 | 24 | 78 | 132 | 237 | 1,718 | 14,013 | 36,632 | 44,085 |
| 45 | 25 | 76 | 137 | 234 | 2,411 | 16,611 | 43,425 | 58,308 |
| 90 | 26 | 79 | 139 | 238 | 2,224 | 17,063 | 32,103 | 47,024 |
| 180 | 27 | 76 | 138 | 229 | 2,197 | 16,211 | 35,832 | 44,787 |
| Significance | NS | NS | NS | NS | NS | NS | NS | NS |

NSNonsignificant.

Table 2. Content of K in soil and in sunn hemp aboveground plant tissue at 6 weeks after sunn hemp planting as affected by K rate in 2008 at the University of Florida Plant Science Research and Education Unit in Citra, FL.

| K rate | Soil K | | Sunn hemp tissue K[z] | |
|---|---|---|---|---|
| ($kg \cdot ha^{-1}$) | (ppm) | ($kg \cdot ha^{-1}$) | (%) | ($kg \cdot ha^{-1}$) |
| 0 | 42.3 b[y] | 96.8 b | 2.7 c | 48.7 |
| 45 | 53.7 b | 120.3 b | 2.9 bc | 64.2 |
| 90 | 50.7 b | 113.6 b | 3.0 bc | 65.5 |
| 180 | 80.7 a | 180.8 a | 3.4 a | 68.4 |
| Significance | $P = 0.003$ | $P = 0.003$ | $P = 0.02$ | NS |

[z]Plant tissue was analyzed on a dry-weight basis.
[y]Means followed by a different letter are significantly different by Duncan's new multiple range test.

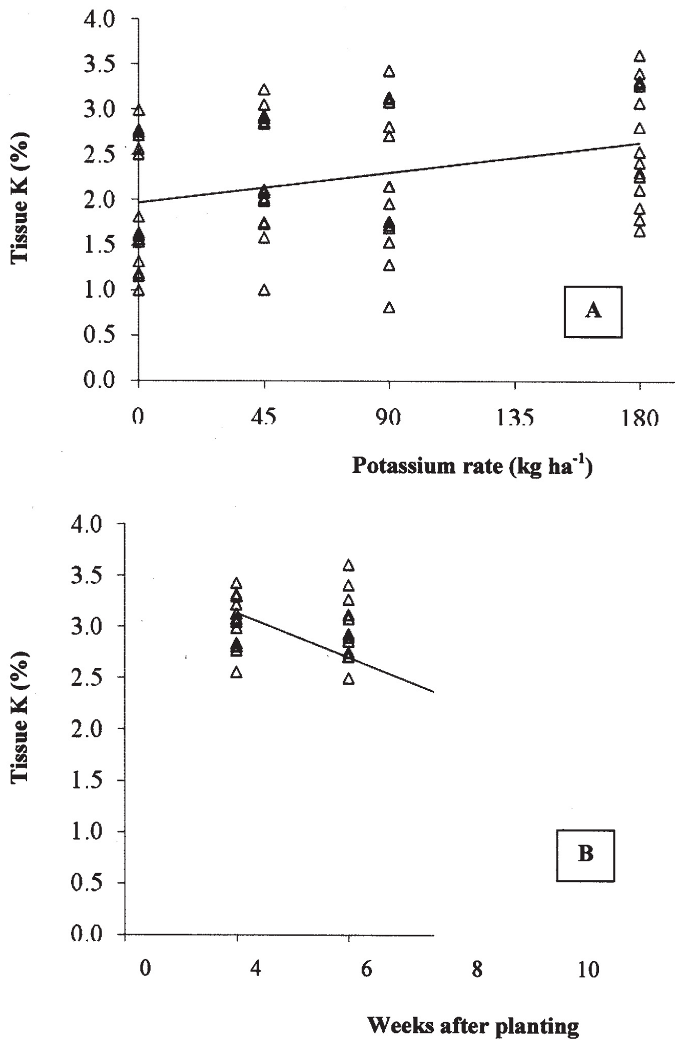


Fig. 1. Sunn hemp K stem tip content (main stem cut to 6 cm) at 6 weeks after planting as a function of K rates and sample dates. (**A**) Stem tip K tissue content with K rate fit to a linear model ($y = 0.004x + 1.98$; $r^2 = 0.12$) ($P = 0.05$) and (**B**) stem tip K tissue content with time fit to a linear model ($y = -0.44x + 3.6$; $r^2 = 0.73$) ($P = 0.01$).

most K (180 $kg \cdot ha^{-1}$). At this time, sunn hemp reached a height of 100 cm and was beginning to produce structural C in the main stem to support its rapid growth. After 6 weeks, the percentage of K in main stem tips declined as K was likely also directed to

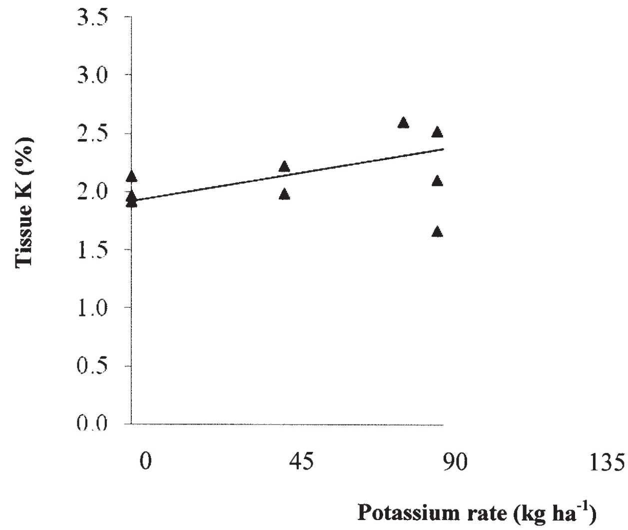


Fig. 2. Sunn hemp K tissue content (whole plant, aboveground) at 6 weeks after planting as affected by K rates. Tissue K content with K rate fit to a linear model ($y = 0.005x + 1.917$; $r^2 = 0.5788$) ($P = 0.05$)

emerging secondary stems associated with continuing growth. Sunn hemp is a fibrous crop and the main stems contain an increasing proportion of C to N as the crop develops (Abdul-Baki et al., 2001). In this experiment, the ratio of C to N was not different among treatments in the first 6 weeks, but the ratio of N:K was significantly affected by the main effects of K rate and sampling date ($P = 0.0001$). The lowest N:K ratios occurring with the 180 $kg \cdot ha^{-1}$ K treatment (1.18) and the highest N:K with the 0 $kg \cdot ha^{-1}$ K treatment (1.68). Cover crop decomposition and subsequent nutrient return to the soil solution was a bio-intensive process that decreases in efficiency as C:N ratios increase (Schomberg et al., 2007). Based on the results of this experiment, efficient return of K to the soil following sunn hemp termination and soil incorporation would occur at 6 weeks after planting.

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