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Conservation of Potassium in Young Slash Pine

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စလက်ထင်းရှူးအပင်ငယ် စိုက်ခင်းအတွင်း ပိုတက်စီယမ်ဓါတ် ထိန်းသိမ်းထားရှိခြင်း

ဒေါ်တင်တင်အုံး၊ B.Ag (Mddy.), M.S (U.F) ဒု-သုတေသနမှူး
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စာတမ်းအကျဉ်းချုပ်

ဓါတ်မြေဩဇာ အသုံးပြုရာတွင် အပင်အတွက် မည်သို့မည်ပုံ အကျိုးသက်ရောက်သည်ကို သိရှိနိုင်ရန် အတွက် ပိုတက်စီယမ်ဓါတ်မြေဩဇာ ကျွေးထားသော ထင်းရှူးပင်ငယ်စိုက်ခင်းများတွင် လေ့လာစမ်းသပ်ခဲ့ ပါသည်။ ၎င်းစိုက်ခင်းများမှ ထင်းရှူးပင်တွင်၎င်း၊ ပေါင်းပင်တွင်၎င်း၊ အပေါ်ယံ မြေလွှာအတွင်းတွင် ၎င်းကျွေး ထားသော မြေဩဇာ ပိုတက်စီယမ်ဓါတ် မည်မျှရရှိ ထိန်းသိမ်းထားနိုင်သည်ကို တွက်ချက် ဖော်ပြထားပါသည်။ ၂ နှစ်ခွဲအရွယ် ထင်းရှူးစိုက်ခင်းတွင် ပိုတက်စီယမ်ဓါတ် ၁၆၈ ကီလို/ဟက်တာ နှုန်း ကြဲပက်ထား ကျွေးထား သော ဓါတ်မြေဩဇာမှ ပိုတက်စီယမ်ဓါတ် ၁ မှ ၂ ရာခိုင်နှုန်းသည် ထင်းရှူးပင်တွင်၎င်း ၇ ရာခိုင်နှုန်းသည် ပေါင်းပင်တွင်၎င်း၊ ၉ မှ ၁၄ ရာခိုင်နှုန်းသည် အပေါ်ယံမြေလွှာတွင်၎င်း ရရှိကြောင်း တွေ့ရသည်။ ၅ နှစ်ခွဲသား စိုက်ခင်းတွင် ၉၅ ကီလို/ဟက်တာနှုန်း ပိုတက်စီယမ်ဓါတ် ကျွေးထားပြီး ၁နှစ်ခွဲအကြာတွင် ၎င်းမြေဩဇာ ၁၅ ရာခိုင်နှုန်းသည် ထင်းရှူးပင်တွင်၎င်း၊ ၁၄ ရာခိုင်နှုန်းသည် ပေါင်းပင်တွင်၎င်း နှင့် အပေါ်ယံမြေလွှာတွင် ၂၅ ရာခိုင်နှုန်းပါရှိကြောင်း တွေ့ရှိရပါသည်။ တွက်ချက်မှုများအရ ၎င်းပေါင်းပင်၊ အပေါ်ယံမြေလွှာ၊ ထင်းရှူးပင် ၃ မျိုးတို့ထဲတွင် ပါဝင်သော ပိုတက်စီယမ်ဓါတ် စုစုပေါင်း၏ ၃၉ မှ ၇၂ ရာခိုင်နှုန်းတို့သည် မြေဩဇာမှ ရရှိကြောင်း တွေ့ရှိရပါသည်။

Conservation of Potassium in Young Slash Pine

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Abstract

The fate of fertilizer K broadcast on young slash pine plantations was examined to estimate the amount taken up by the plants or retained in the surface soil. Two and a half years after application of 168 kg/ha K to two new planting, it was found that about 4 to 7%, 1 to 2% and 9 to 14% of applied fertilizer were observed in the above ground vegetation, the pine seedling and in the surface 15 cms of the soil respectively. In 5✐ year old plantation, which has been fertilized by 95 kg/ha since 1✐ years ago, about 14% of applied K was absorbed by the groundvegetation. 15% by the pine and 25% was retained by the surface soil. It was calculated that 39 to 72% of K in pines, vegetation and surface soil was derived from the fertilizer.

Contents

1. Introduction

1.1 Slash pine (Pinus elliottii Engelm var. elliottii) is a major commercial species in the lower south of the united State of America. It is now well known that phosphorus fertilization may greatly incresase the growth of slash pine on certain soils in Florida and Georgia, notably on some of those within Cooperative Research in Forest Fertilization (CRIFF) soil groups A and B (Comerford et al. 1983). Less striking but often economically important respones to either phosphorus (P) or nitorgen (N) alone or the two in combination also occur widely on a variety of other soils, mostly within CRIFF gropus C and D.

1.2 Responses to application of the third major macronutrient, potssium (K), have been investigated less thoroughtly. Nevertheless, an increasing number of statistically significant responses to K are not being detected in field experiments and many of thes responses are also large enough to be economically significant. Usually response is not evident from application of K alone but appears in the superiority of NPK treatments over NP treatments.

1.3 In several instances this superiority has remained evident or even had increased for serveal years after a single K application made at the time of planting or soon there after. The fact that K persists in these acid, sandy, ill-drained soils in sufficient quentity to benefit subsequent tree growth seems surprising. The total biomass of the widely spaced-pine seedlings in their first and second years is far too small for appreciable storage of any element. Accordingly, the present study was undertaken to examine whether either the surface soil horizon or the ground vegetation could serve as a major reservoir of applied K for subsequent use by the developing stand. It was anticipated that sampling errors would be high and might obscure any mass increase in soil or plant K. Therefore the study also employed the rubidium-potassium (Rb/K) reverse tracter technique (Hafez and Stout, 1973) as a means of identifying K derived from the fertilizer addition.

Table 1. Characteristics of the four slash pine experiments sampled in this study.

Experiment	Cooperator & Location	CRIFF soil group	Age		Tree hight	Fertilizer treatments compared	Measure-ment plot area (Replications)	Ground- cover subplot area
			Fertilized	Sampled				
			----- yr------		m	kg ha^{-1}	-----m^2-----	
A101	ITT-Rayonier Atkison Co., Ga	C	0	2½	1.7±0.3	p56+k168 vs p^{56}	214 (4)	1.2-1.6
A105	Brunswick P.L. Brantly Co., Ga	D	0	2½	1.7±0.3	p56+k168 vs p56	214 (6)	1.2-1.6
3-16A	ITT Rayonier Nassau Co., Fla	C	4	5½[1]	6.0±0.3	N42+p47+K95 vs 0	220 (4)	5
30-PRY-29	ITT Rayonier Nassau Co., Fla	D	1	16	14.6	N50+p56+K106 vs N60+p56	167 (5)	none

[1]Understory vegetation samples were taken in July 1985; tree samples were in February 1986

2. Materials and Methods

2.1 Study Areas

2.1.1 The present study was based on selected plots from four pre-existing field experiments, which had been established by University of Florida Cooperative Research in Forest Fertilization program A and cooperating of U.S.A, to test the response of slash pine plantations to various combination of N, O and K. Table 1 summarizes the relevant characteristics of the four experiments.

2.1.2 All areas had been site prepared and bedded before planting. In all cases, the P carrier was either concentrated (triple) superphosphate or diammonium phosphate, and the K carrier was potassium chloride.

2.1.3 Experiment A 101 and A 105 have the same basic design with 5 treatments (O, P, Pk, Pk + micronutrients, NPK) and 6 replications, completely randomized, occupying a minimum arrea of 6 ha.

2.1.4 Experiment 3-16 A entailed an operational ground application of complete NPK fertilizer applied to alternate 12 row (¯45 m) bands across a 4.8 ha plantation. Measurement plots had been established in the interior four rows of each band. For the present study, the first two plots in each of four altermnate bands were sampled, excepting that first polt in one band was rejected because of excessively heavy shrub cover.

2.2 Field Methods

2.2.1 Procedures for sampling ground vegetation differed between 3 - 16 A and the two A-100 series experiments. In 3-16 A, requirements of the original experiment precluded removing ground cover within the measurement polt. Accordingly, two subplots, 1 m wide by 5 m long, were arbitrarily located between the right-had rows at either and of each plot (as approached from tha access road). All vegetation was clipped about 5 am above soil level, using a 1 m wide sickle bar mower designed for use in agricultural experiments. Although the machine was effective, it proved extremely difficult to handle on moist irregular ground, and had to be manhandled over stumps and the "beds" on which the trees were planted.

2.2.2 All clipped vegetation from the 5 m^2 plots was baggesd with no separation of species. It was subsequently dried at 70 C, weighed, ground in a large hammer mill, then reground in a wiley mill to pass a 1 mm mesh. The bulk sample was then reduced using a sample splitter.

2.2.3 A composite soil sample representing the upper 0 to 15 cm depth was collected from each ground vegetation subplot. Ten 2 cm diameter cores from each subplot were composited, and subsequently air dried before analysis.

2.2.4 Removal of sample trees within the measurement plot was also precluded, as was creation of large gaps in the border rows. Accordingly, a single tree was removed from an arbitrarily defined position, that is, in the border row immediately outside the right hand proximal corner, relative to approach from the access road. The selection was further restricked to exclude unusually large or small trees. This procedure was devised to allow characterization of Rb/K ratios in 2 + year old saplings where total tree mass was obviously small and growth response was too small for detection without large samples. Trees were out at the ground line, chopped, and bagged, and subsequently treated as described for ground vegetation. The large woody stems from Experiment 3-16 had to be sectioned and split before hammer-milling of the entire tree.

2.2.5 In Experiment A 101 and A 105, two subplots for ground cover samples were randomly located within each selected measurement plot. Each plot was 1 m wide, and extended the proportionated areas of bed, bordering furrow, and undisturbed interbed space. All non - tree vegetation, living and recently dead, was clipped close to the ground, collected, and treated as described above.

2.2.6 Recovery of vegetation in the field was estimated to be between 90 and 95 %. Soil samples were taken from each vegetation plot after clipping, and a single pine seedling was sampled, as described above.

2.3 Laboratory Methods

2.3.1 Potassium in soil and plant extracts was determined with an atomic absorption spectrometer with a hollow cathods lamp at wavelength 766.5 nm with an air-acetylene flame. Rubidium was also determined by atomic absorption, using an electrode-less discharge lamp at wavelength 780 nm, also with an air acetylene flame.

2.3.2 Tissue samples were extracted by 0.1 M HNO_3 with 1 hr shaking time and a sample - to extractant ratio of 1: 20. The soil sample was extracted by double acid (Mehlich 1). Since the Rb concentration in the double acid extract was very low, the solution was concertrated 5 times by evaporating to dryness in an oven and taking up again in 0.1 M HNO_3 . Strontium chloride solution was added to the sample solutions to make a final concentration of 2000 mg Kg^{-1} Sr when determing K, and Rb of both soil and tissue samples.

2.3.3 Data from soil and ground vegetation samples were analyzed by a three-stage nested ANOVN procedure.

6 (A)

Table.2 Summary of k, Rb, and Rb/K in three ecosystem components of three young plantations. (*, ** denote significance at p > 0.05 and p>0.01, respectively, between control and fertilized values within location; other differences within pairs are non-significant.)

Location and Components	Dry Weight		Concentration				Mass						K derived from fert.	Calc K from fert.
	Cont	fert	K		Rb		K		Rb		Rb	K		
			Cont.	fert.	Cont.	fert.	Cont.	fert.	Cont.	fert.	Cont.	fert.		
A101	kg	ha $^{-1}$	-------	-----mg	kg $^{-1}$----	------	kg	ha $^{-1}$	g	ha $^{-1}$	mmol	mol	%	kg ha $^{-1}$
Veg						-								
Tree	4600	5200	2900 *	3800	13.2**		13.2	18.6	59	* 39	2.15 **	0.91	58	10.7
Soil[1]	700	1300	2600 *	3700	8.9	7.6	1.6	4.8	6.2	8.7	1.62 **	0.93	43	2.1
			11.23 **	17.39	0.04	7.4	22.5 **	34.8	68	52	1.33 **	0.72	46	16.0
A105						0.03								
Veg														
Tree	4500	5200	2500 **	3400	6.8		10.6 *	17.8	32	29	1.32 **	0.81	39	6.9
Soil[1]	1200	1200	2700 **	4600	8.0	5.9	3.1	5.5	8.6	6.9	1.46 **	0.61	58	3.2
			11.26 **	15.8	0.04	6.2	23.2 **	31.6	76	68	1.61 **	0.92	43	13.6
3-16A						0.03								
Veg														
Tree	3300	4900	2000 **	3800	9.6 **	5.8	6.1 **	18.2	32	28	2.40 **	0.72	72	13.1
Soil[1]	9000	1000	1800	2000	8.2 **	4.1	17	21	74	44	2.15 **	0.93	57	12.0
			9.1 **	18.1	0.05 **	0.03	18.1 **	36.2	92 **	68	2.54 **	0.87	64	23.3

1 Double acid extrect values; weight of 0-15 cm soil layer assumed to = 2x 10^6 kg ha $^{-1}$

2.3.4 Calculation of Potassium Derived from Fertilizer

The proportion of K in soil or plant derived from the fertilizer application was calculated from the Rb/K ratios, as outlined by Hafez and Stout (1973) :

% of K derived from fertilizer = 100 (Su - Sf) / Su

Su = Rb/K in unfertilized soil plant or tissue.

Sf = Rb/K in fertilized soil plant or tissue.

3. Results

3.1 Mass, K and Rb concentrations, Rb/K ratios and calculated values for the three components of the yound plantations are summerized in Table 2.

3.2 Ground Vegetation

3.2.1 The ground vegetation in all three young stand consisted of many distinct clumps of gallberry, waxmyrtle, blackberry and tall grass, with intervening areas of lower shrubs and grasses. This pattern of biomass distribution was coarse-grained relative to the size of 1.2 to 5 m subplots used to sample ground vegetation (Table 1). In consequence, variability within treatment was high.

3.2.2 Dry weight of understory vegetation were similar at sites A 101 and A 105. Although weights from the treated plots were 13 to 16 % greater than those of the controls, the differences were not significant even at the 10 % level.

3.2.3 In experiment 3-16 A, dry weight of understory vegetation from the treated plot was 48% higher than that of the control although this difference also was not significant different at the 10% level. Mean K concentrations of the fertilized vegetation ranged only narrowly, o.34 to 0.38% (3400 mg Kg^{-1} - 3800 mg Kg^{-1}) and were singificantly higher than those of the controls, which varied from 0.20 to 0.29%. The calculated mass of K in above ground vegetation of the fertilized treatment was 6 to 12 kg ha^{-1} greater than in controls. Only that at A 1o1 was not significantly different.

3.2.4 At all these sites, both Rb consentration and Rb mass decreassed in vegetation of the fertilized plots. Concentration was significantly lower only at A 101 and 3-16A, and mass only at A101.

3.2.5 Difference in Rb/K retios were significant at the 1% level at all these locations. Calculations from these ratios indicated that 39 to 72% of the total K content had been derived from the added fertilizer.

3.3 Tree

3.3.1 The estimated mean biomass was based on only four to six trees per treatment; henxe, none of the treatment difference were significant.

3.3.2 In the two younger plantations (A 101 and A 105), trees in the fertilized plots had significantly higher K concentrations than their respective controls. In contract, the much larger trees of Experiment 3-16A differed only slightly with treatment. The much greater proportion of woody tissue at 3-16A presumably accounted for the lower K concentrations there. The large variability in tree mass at all these locations in no significant difference in K content between treatments.

3.3.3 Trees on fertilized plots had lower Rb concentrations than the controls, but the difference was significant at only 3-16A. Treatment differences in Rb content, however, were not significant at any location.

3.3.4 As also found with the ground vegetation, Rb/K ratios in trees from the fertilized plots were significantly and markedly lower than the controls. Calculated percentage of K derived from fertilizer ranged from 43 to 58.

3.4 Soil

3.4.1 Mean extractable K concentration of the controls varied from 9 to 11 mg kg^{-1} , which may be compared with "critical range" of 8 to 12, tentatively suggested by Comerford and Pritchett (1981). Soil K concentrations in treated plots were significantly higher than those of the controls in all cases. Because of the assumption of constant soil mass, difference in K mass follow those in extractable K.

3.4.2 As in plant tissue, Rb/K ratios from the fertilized plots were significantly lower than those of the controls. Somewhat surprisingly, these soil ratios were generally similar to the respective plant ratios (Table 7). Calculation from Rb/K ratios indicated some 43 to 64% extractable soil K was attributable to the fertilizer applied 1 1/2 to 1 1/2 - years previously.

4. Discussion

4.1 Mean K contents of fertilized ground vegetation (above ground only) at the three experimental sites appear remarkbly similar, 18 to 19 kg ha^{-1}, 1 1/2 to 2 1/2 seasons after fertilization (Table 2). At the A101 and A105 locations, the fertilizer was broadcast soon after site preparation and planting when vegetation was still sparse and its capacity for K uptake was limited. In contrast, at 3-16A the application was on a well - established plant cover, but at a rate of only 96 Kg ha^{-1} K, rather than 165 as at A101 and A105.

4.2 Allowance for K contained in root systems plus a small percentage of tops not harvested would increase total plant content probably by no more than 20 to 25%, suggesting an effective K storage capacity of only 25 Kf ha^{-1} , 2 ½ years after application. Calculation from Rb/K ratios (Table 2) indicated that fertilizer K occupied some 40 to 70% of this capacity. Hence, opportunities for storage of added K are limited in sites such as these. Some areas of similar age after site preparation are seen to have a much denser cover to tall grasses or shrubs, however, and presumably have a substantially greater K - storage potential.

4.3 The total K storage capacity of widely - spaced pine seedlings in their first years obviously is limited, and sampling procedures were not designed to examine differences in K content. In fact, although none of the biomass or K mass differences proved significant, the 2 ½ year - old seedlings contained ✁ to ✂ as much K as did not the respective ground cover components in three of four possible comparisons (Table 2). The contents of the older trees of Experiment 3-16A equalled or exceeded those in the ground vegetation (Table 2). In all three plantations, Rb/K ratios demonstrated significant uptake of fertilizer K.

4.4 At all tree experimental sites, surface soil provided the greatest storage for added K. The amounts were not large, however, ranging from 14 to 24 kf ha $^{-1}$ (Table 3). It is not known how much of the 19 to 23 kg ha $^{-1}$ extractable K in the unfertilized soil is actually available for plant uptake.

4.5 The present study did not investigate availability of native soil K below the 15 cm depth, nor the possibility that fertilizer K leached below this depth might be retained in the deeper layers.

5. Summary and Conclusion

5.1 The fate of fertilizer K broadcast on yound slash pine plantations was examined, using the Rb/K reverse tracer technique to estimate amounts taken up by plants or retained in the surface soil.

5.2 Two and a half years after application of 168 kg ha $^{-1}$ to two new plantings on site-prepared land, about 4 to 7% was in above - ground herbaceous and shrubby vegetation, where only 1 to 2% was in the 1.7 m tall pine seedlings, and 9 to 14% was still in extractable from in the surface 15 cms of soil. Thus the total fertilizer K accounted for ranged from 24 to 29 kg ha $^{-1}$. A small additional amount was present in roots of ground vegetation and pine seedlings, and some unknown fraction may have been retained in the soil below the 15 cm depth. The remainder would have been moved from the site by downward or lateral leaching.

5.3 One and a half years after application of 95 kg ha $^{-1}$ K to a four-year old plantation with a well established ground cover, about 14% of the K was in the ground vegetation, 13% in the 6 m tall pines, and 25% in the surface soil. The total accounted for was 48 kg ha-1. The fate of the remainder presumably was similar to that in the younger stands.

5.4 The amounts of K from fertilizer, 24 to 49 kg ha $^{-1}$, in the surface soil-plant system one and a half to two and a half years after application, represent appreciable fractions of the 57 to 85 kg ha $^{-1}$ reported as total in the above-ground stands of 13 to 26 year old plantations by other investigations. Thus on initial retention of only 20 to 50 kg ha $^{-1}$K, followed by efficient recycling as the stand developed, could lead to increased growth in otherwise K-deficient sites.

Table 3. Apparent uptake or retention[1] of applied potassium, calculated by Rb/K methods.

Component and experiment	K mass from fertilizer calc. from Rb/K
Ground Vegetation	-----------kg ha^{-1}--------------
A101	
A105	10.7
3-16A	6.9
	13.1
Tree	
A101	2.1
A105	3.2
3-16A	12.0
Soil[2] (0-15 cm)	
A101	16.0
A105	13.6
3-16A	23.2

[1]Differences between fertilized and control were significant at P (.05 expect as indicated by n.s.

[2]Extractable K.

References

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