Ministry of Forestry
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Study on The Effect of Fertilizer Application in Tung -Oil (*Aleurites montana* (Lour.) Wils) Plantation

By

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တန်းဆီပင် စိုက်ခင်းများတွင် ခါတ်မြေသြဇာကျွေးခြင်း၏အကျိုးသက်ရောက်မှုကို လေ့လာခြင်း

ဆွေဆွေထွန်း၊ သုတေသနလက်ထောက်–၂၊ သစ်တောသုတေသနဌာန
ဖြူဖြူဆွေ၊ သုတေသနလက်ထောက်–၂၊ သစ်တောသုတေသနဌာန
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စာတမ်းအကျဉ်း

ကမ္ဘာတဝှမ်းတွင်အဆီထွက်ပင်များနှင့်၄င်းတို့မှရရှိသည့်အဆီများအားလိုအပ်ချက်များပြားလာသည့် အတွက် အဆီပင်များအားအရှိန်အဟုန်မြင့်တိုးချဲ့စိုက်ပျိုးလာခဲ့ပါသည်။ရေရှည်တွင်တန်းဆီထွက်ရှိမှုအပေါ်မြေဆီ လွှာ အဆင့်အတန်းတိုးတက်စေရန်နှင့်နည်းပညာအချက်အလက်ထောက်ပံ့ပေးရန်အတွက် ရှမ်းပြည်နယ် မြောက်ပိုင်းရှိ သီပေါ၊ သိန်းနီ နှင့် မူဆယ်မြို့နယ်များရှိ တန်းဆီစိုက်ခင်းများတွင် ၂–နှစ် ဆက်တိုက် ခါတ်မြေသြဇာအချိုးအမျိုးမျိုးကျွေးခြင်းအပေါ်အကျိုးသက်ရောက်မှုအားလက်တွေ့စမ်းသပ် ဆောင်ရွက် ခဲ့ပါသည်။ ၂၀၀၈ခုနှစ်၊၄နှစ်သားတန်းဆီစိုက်ခင်းအား တစ်ပင်လျှင် ယူရီယား၊ တီစူပါ၊ ပိုတက် ခါတ်မြေသြဇာအချိုး (၁း၁း၁) –၉၃၈၈ဂရမ်နှုန်းနှင့် ၂၀၀၉ခုနှစ်၊ ၅နှစ်သားတန်းဆီစိုက်ခင်းအား တစ်ပင်လျှင် ယူရီယား၊ တီစူပါ၊ ပိုတက်ခါတ်မြေသြဇာအချိုး(၁း၀.၈း၁)–၁၁၃၄ဂရမ် နှုန်း ထည့်သွင်း ဆောင်ရွက်ခဲ့ပါသည်။ ခါတ်မြေသြဇာ အချိုးအမျိုးမျိုးထည့်သွင်းခြင်းဖြင့်နှစ်စဉ် တန်းဆီပင်၏ အပင်ကြီးထွားနှုန်း ကောင်းမွန် သည်ကို တွေ့ရှိရပါသည်။၄င်းအပြင်နှစ်စဉ်ခါတ်မြေသြဇာတိုးမြင့်ထည့်သွင်းပေးခြင်းဖြင့်အသီးထွက်ရှိမှုကောင်းမွန် သည်ကို တွေ့ရှိရပါသည်။သို့သော် ပိုမိုပြည့်စုံအကျိုးရှိသော ရလာဒ်များရရှိရန်အတွက် လူမှုစီးပွားရေး အကျိုးအမြတ်နှင့်ဂေဟစနစ်ဆိုင်ရာလေ့လာမှုများ ဆောင်ရွက်ရန်လိုအပ်မည်ဖြစ်ပါသည်။

Study on The Effect of Fertilizer Application in Tung –Oil (*Aleurites montana* (Lour.) Wils) Plantation

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Abstract

As World wise increase in demand for oil plants and their derivates, the cultivation of oil-producing plants have been accelerated and expanded. To provide some technical information and increase soil fertility for the long-term productivity of tung-oil, a field experiment for two consecutive years was conducted on three tung –oil plantations viz. Namma Reserved Forest (Thipaw Township), Mingli Unclassed Forest (Theinni Township) and Mingyu Industrial Raw Material Plantation (Muse Township) of Northern Shan State in response to differential applied NPK fertilizer. Fertilizer treatment was applied 938g/tree NPK (1:1:1) at 4 years old in 2008 and 1134g/tree NPK (1:0.8:1) at 5 years old in 2009. Results showed that the growth of tung-oil trees in these plantations was found significant. In addition, application of compound fertilizer by increasing application rate gives the better yield performance for tung-oil fruit. In order to obtain complete relevant results, it will also be necessary to conduct socio - economic and ecological impact studies.

Key Word: tung-oil , Soil fertility, fertilizer

Contents

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1. Introduction

Oil (or lipid)- containing plants are one of the most important resources in the tropics. Their oils, mainly contained in the seeds and fruits, have been used in a wide range of applications, including as food, fuel, illumination, pharmaceuticals, and industrial materials.

As a result of reducing petrochemical resources and environmental consciousness, the cultivation of oil-producing plants has been accelerated and expanded because of a worldwide increasing demand for oil plants and their derivatives as substitutes for petrochemicals in industrial applications, such as biolubricants, biofuels, nylon precursors and detergent feeds tocks.

However, the woody oil plants generally have limiting agronomic traits such as low yields, toxicity and the very limited geographical growing areas. In Myanmar, the expansion of *Jartropha curcas* cultivation has recently highlighted several issues concerning land resources management.

Tung-oil tree (genus of *Aleurites montana* and *Aleurites monocular*) plantations have been extensively planted in reforestation areas of cooler regions since 2000. Little information is available for growing of tung tree, particularly with regard to increasing their yield.

Considering the economic strength of the nation and forestry science progress, along with the effort to increase production and importation for adequate demand, great attention is needed to further improve fertilizer efficiency in tung - oil tree plantations.

2. Objectives

To increase soil fertility for long term productivity of tung-oil tree plantation
To evaluate the response of tung tree by differential fertilizer application
To provide technical information for the establishment of tung-oil tree plantation.

3. Literature Review

Tung (of the family Euphorbiaceae) showed great promise as the source of one of the world's best drying oils. Tung oil tree grows well in cooler climates but also does well under sub tropical conditions. The plant prefers light (sandy) and medium (loamy) soils and requires well-drained and lime free soil. Soil must be well drained, deep aerated and have a high moisture holding capacity to be easily penetrated by the roots. (Spurling, 1974)

Tung-oil tree usually begin bearing fruit in the third year after planting and are usually in commercially production by the fourth or fifth year, attaining maximum production in 10-12 years of age. Average life of tree in United States is 30 years. (Spurling, 1974)

Different rate of fertilizer application recommended for growing tung-oil tree plantation particularly with regard to increasing their fruit yields.

Early spring application of organic soil amendment and fertilizing with 6-6-6 for established tree. Seedling respond better to a fertilizer with more potassium and less phosphorus.

. Mineral NPK fertilizers should be applied as a basal dressing well mixed with the organic materials, followed by the two fertilizers top dressing annually thereafter in April and September. Tung-oil tree responds well to fertilization, especially with nitrogen fertilizer. Since the press cake that remains after oil expression is toxic as a feed, it is usually return to the field for fertilizer, often accompanied by the application of ammonium sulphate.

In China Szechuan Province, basal application of 30/t/ha organic manure with mineral fertilizer containing 60kg/ha N, 45kg/ha P_2O_5 , 90kg/haK_2O_5 was practiced on medium red soil.

Tree planted in 1941 on savannah very fine sandy loam soil at the Mississippi experimental tung farm, the high level were respectively per tree: 0.35lb of P_2O_5as trisodium phosphate, 0.27 lb of K_2O as potassium sulphate ,0.38 lb of Ca as a ground high-calcium limestone, and 0.05 lb of Mg as Epsom salt are applied in the first year and these rates were increased by equal amounts in each succeeding years. Matthew et.al,(1954) reported that a large response in yield and a large changes in the leaf content not only for P but also for N, K, Ca and Mg were affected by annual application of P to five tung clone from the time of planting until tree were 9 years old.

4. Materials and Methods

4.1 Study area

The study was conducted during two successive seasons of 2008 and 2009 at three tung-oil plantations including: Nannma Reserved Forest, N0.(8) in Thipaw Township (site 1), Mingli Protected Forest in Theinni Township (site 2) and industrial plantation in Musae Township (site 3). The plantations were established in 2005 with the original spacing of 6.7m x 6.7m.

At all sites within this research, the terrain is gently undulating, with slopes of less than 20%. Geologically, these areas consist primarily of metamorphic rocks including ,red shale, silt stone, sandstone, calcareous conglomerates and tat limestone from the Jurassic series(Bender,1983). Based on the food and Agricultural organization of the United Nations (FAO) classification of, the soils are Aerisols.

These sites enjoy subtropical monsoon and sub subtropical climate with the higher section of Indo Burma Ranges and of the Shan Massif, (Bender, 1983). Average precipitation between 2008 and 2009 was 245 mm with monthly peak that occur during South West monsoon of April and the North East monsoon of November and mean January temperature below 10·C and occasional frost during the winter months.

4.2 Experimental design

The experiment was arranged Randomized Complete Block Design(RCBD) with sites as main block. The sub –plots (treatments) were prepared and experiments were arranged in 6 replicates of two treatments (control plot and fertilizer plot). Each treatment of plot size was 50x50m^2.There were 12 treatment plots in every block with 6 trees per plot, giving a total of 216 trees. 938g of NPK fertilizer per tree was applied to each sub plot(except control) in two halve at age 4 in 2008 and 1134g of NPK fertilizer per tree was applied to each sub plot(except control) in two halve at age 5 in2009. Application time and the amount of NPK ratio are shown in the following.

Site	(2008)two times/year		(2009) two times/year	
	Fertilizer ratio	Amount of Fertilizer (g/tree)	Fertilizer ratio	Amount of Fertilizer (g/tree)
Thipaw Theini Muse	N:P:K (Urea: Tisuper: Potash) 1:1:1	312.6g:312.6g: 312.6g	N:P:K (Urea: Tisuper: Potash) 1:0.8:1	416g:302.6g: 416g

4.3 Fertilizer application

The 1st one was applied before rainy season and the 2nd one at the end of rainy season in both years.

4.4 Growth measurement

Tree height and diameter were measured in April 2009 and April 2010.

4.5 Soil sampling

Before application, composite soil samples from each study site were randomly collected at 0-10cm,40-50cm and 80-90cm.

4.6 Laboratory Analysis:

Total Nitrogen, Phosphorus, Potassium, pH, Organic matter and Texture of these soil samples were analyzed at the Forest soil Laboratory of Forest Research Institute.

4.7 Data Analysis

Tree growth data was analyzed by two-way analysis of variance using SPSS 4.1 version for window, and excel. Application rates were analyzed separately. Mean separation were performed by using the Fisher's Least Significant Difference (LSD) in Post Hoc test and T-test at the 0.05 probability level.

5. Results

5.1 Soil condition

The soils of these three sites are clay, loam and clay loam soil with acidic (pH4.7-5.9) soil condition. Site (1) and site (2) have medium bulk density and site (3) has high bulk density. Total nitrogen, available potassium level and organic matter are medium for normal the plant growth. These areas have pronounced deficiency of available phosphorous which are much lower than that in forest soil. (see appendix I)

5.2 The effect of fertilizer on tree growth

The result of the experiment clearly showed that height and diameter of tung-oil tree in all experimental sites and most of their response towards fertilizer treatments are found statically found highly significance($P<0.01$). The interaction between sites and fertilizer treatments are generally found significant. (see appendix II) .

According to Mean comparisons using T- test, compared value under each fertilizer treatment against control (see appendix III) showed that compound fertilizer with 938g NPK gave a significant difference for height and diameter at age 4 in 2008 .

Likewise increasing application rate of 1134g NPK gave a significant difference with control for both parameter at age 5 in 2009. Treatment effects on height growth were identical to treatment effects on diameter.

Average height and diameter of tung tree with control and fertilizer plot in 2008 and 2009 are shown in figure1. Differential fertilizer dose significantly increased tree growth compared with control. There is also a tendency to a better growth for tung tree with basal fertilizer doses. Height and diameter of tung tree ranged from 1.88m and 8.42 cm to 3.48 m and 14.28 cm respectively in 2008 and from 4.59m and 26.06 cm to 9.14 m and 47.28cm in 2009.

The growth of tung-oil tree is significantly influenced by fertilizer application, but the responses differed between sites.

For site 1, the highest growth (height= 4.52m, diameter = 6.0 cm) was obtained when 938 g NPK was applied at age 4 in 2008. A similar trend was found in site2: height and diameter were 3.95 m and 5.8 cm. However, these differences were not statistically significant. Site 3 has smaller diameter and height growth compared to these two sites.

An increasing application rate with 1134 g NPK at 5 years old in 2009, height and diameter of site 1and site2 (11.38m, 17.7 cm and 10.64 m, 17.0 cm respectively) were better than site 3 but these two sites were not significantly different.

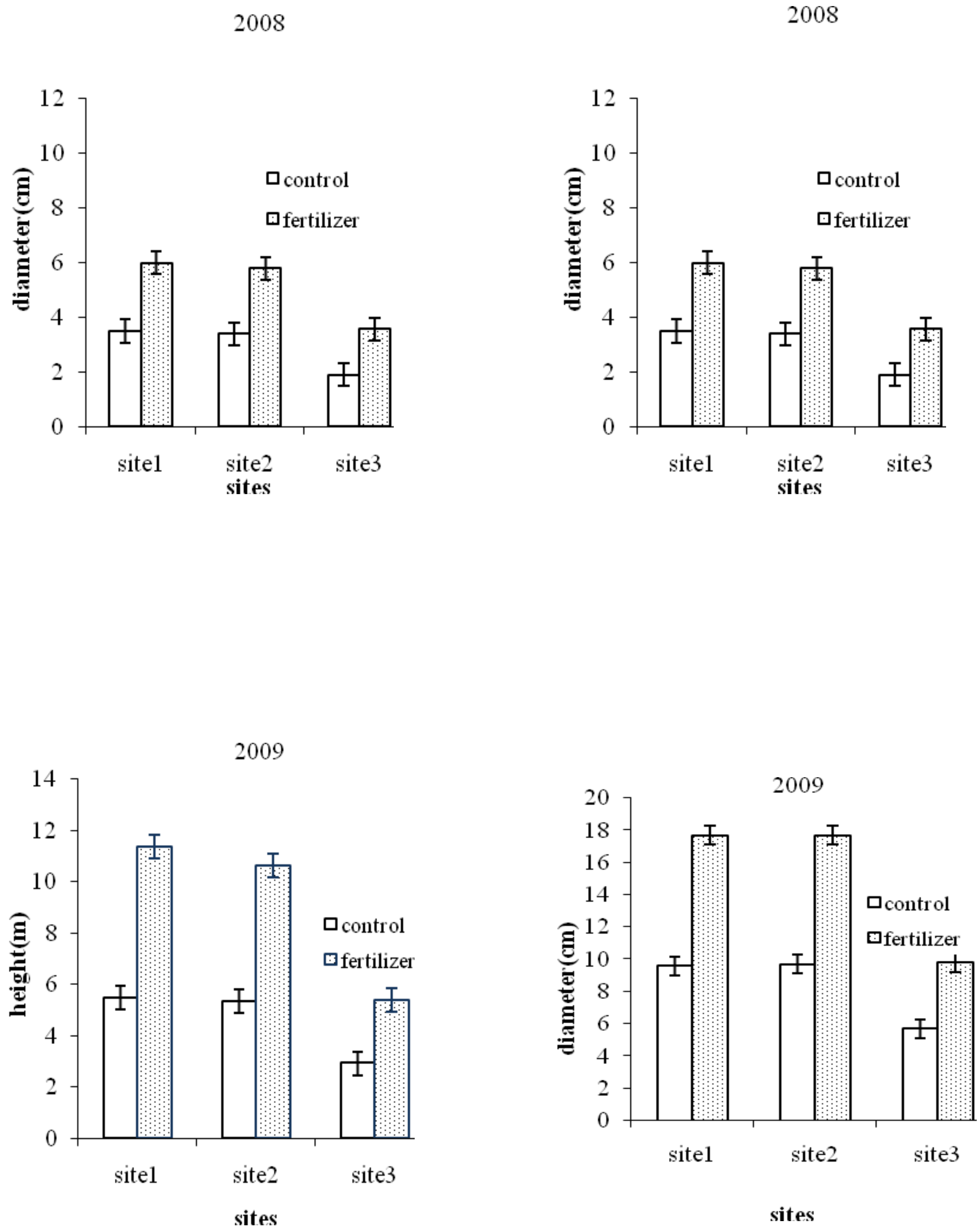

Fig.1 mean comparison of height and diameter of tung-oil tree between control and Fertilizer plot in 2008(at age 4) and in 2009(at age 5)

The results show that, fertilizer application effects increase of tree growth within two years experimental duration. Average height and diameter of tung-oil tree dramatically improved because of increasing the amount of applied fertilizer in all sites. Site 3 with fertilizer plot resulted in relatively low of tree growth. (see figure. 2)

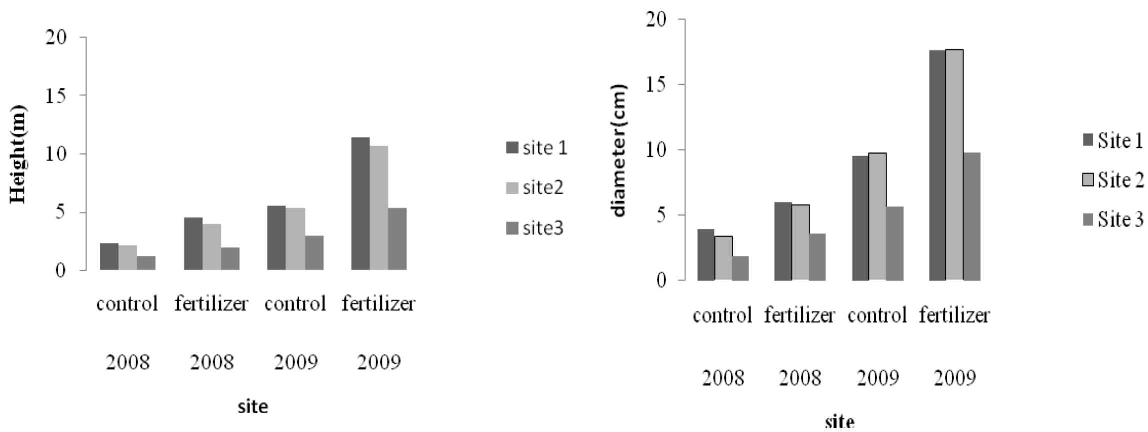

Fig.2 mean comparison of height and diameter of tung-oil tree after applications

5.3 The effect of fertilizer on fruit yield

After two-years experiment, fertilizer application was effective in increasing tung –oil fruit yield. Of the total yield, every fertilizer plots had better than control plots as shown in Appendix IV. Fruit yield ranged from 2143 to 2577 $Kgha^{-1}$ for fertilizer plots and from 857 to 1428 $Kgha^{-1}$ for control plots. Significant difference fruit yield observed among the sites. Site 1 and site 2 were higher yields than Site 3.

6. Discussion

Productivity of tung-oil plantation depends on climatic parameters (rainfall, temperature, humidity, etc.), properties of soil (pH, organic carbon, cation exchange capacity, etc), species varieties and major production inputs, such as irrigation and fertilizer management practices.

The best response in terms of productivity improvement is obtained from application of phosphorus, nitrogen and potassium combination fertilizers in tung-oil tree plantation.

Individual effects of low and high application of fertilizer produced significant height and diameter increase for tung –oil tree in 2008 and 2009 years. Current volume growth increment is shown in table 1 for each site. Increment data showed that tung-oil tree in fertilized plot had advantage over crop trees in control plot across all sites.

Table1. Current volume growth increment in 2008 and 2009

site	2008		Increment m^3ha^{-1}	2009		Increment m^3ha^{-1}
	Control m^3ha^{-1}	Fertilizer m^3ha^{-1}		Control m^3ha^{-1}	Fertilizer m^3ha^{-1}	
Thipaw	32	182	150	563	2256	1693
Theinni	28	142	121	562	2106	1544
Muse	2	8	6	141	628	488

Blackmon (1943) stated that using the same mixture of NPK: one pound per tree in younger age, with the amounts would be increased annually at the rate of $^1/2$to one pound for each additional year in tung-oil tree plantation could increase tree growth. Application of 938 g NPK resulted an increase in total volume growth of 6-150 m^3ha^{-1} over control plot at age 4 in 2008. Increasing application rate of 1134 g NPK also increased in total volume growth of fertilized trees above the level observed for the control treatment at age 5 in 2009. A significant increase in volume growth occurred for this treatment, with trees 488-1693 m^3ha^{-1} greater than trees in the control.

Marked differences in height and diameter increment were found among sites in consequences years. Height and diameter increment in site 1 was greater than or equal to site 2. Site 3 led to smaller height and diameter increment. Although the soil at the three sites belonged to the same chemical quality of soils, the different soil physical characteristics occurred at each site. The data indicated that site 3 has a high bulk density relative to other sites with tree growing. Mitchell et.al (1982) observed that bulk density of 1.4 g/cm^3 began to inhibit loblolly pine growth. So site 3 may have some impact on the uptake of nutrient for the tree growth.

Fertilized plots in tung-oil tree form substantially higher growth increments in all sites over control plots during the experiment. The increasing trend in annual growth increment with the increased fertilizer rates is linear. These increasing figures support the need of fertilizer rates to promote the growth and production to longer rotation.

NPK fertilizers play a vital role in enhancing tung-oil fruit yield. In this experiment, progressive application of fertilizers gives a large response in the fruit yield. Increasing application results in leave development, improvement of leaf area duration after flowering and overall growth assimilation (Brown 1945). Thus, it contributes to increasing seed yield. Maximum fruit yield was recorded in site 1 and site 2, while site 3 was minimum. Preexisting growth differences may be due to the important source of variation in the effect of fertilization on fruit production.

7. Conclusion and Recommendation

Based on the results of these field trials, it can thus be concluded that tung-oil tree response well to progressive increase in annual NPK fertilizer applications. An increasing tree volume growth across all sites on average of 92 m^3ha^{-1} is found after treating with 938g NPK and then this level significantly increased up to 1241 m^3ha^{-1} after increasing treatment with 1134g NPK. However, fertilization effects on the volume growth increment are site specific. The best volume growth increment is observed in Thipaw and Theinni sites. Muse site is a little lower than these two sites due to some impact on nutrient uptake for the growth. So soil working should be emphasized for this site to improve soil structure. In addition, application of compound fertilizer by increasing application rate gives the better yield performance for tung-oil fruit. In order to obtain more complete relevant results, it will be necessary to conduct socio-economic and ecological impact studies along with fertilized test in tung-oil plantation.

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APPENDIX I

Some physical and chemical properties of soil

Sr. no.	Particular	Depth (cm)	pH	Total N %	Ava. P %	Ex. K %	BD	OM %	Partical size distribution (%)			Texture
									Sand	Silt	Clay	
1	Thipaw	0-10	5.9	0.065	0.000038	0.00320	1.24	4.23	37	28	33	Clay-Loam
2		40-50	5.4	0.055	0.000027	0.00230		3.24	17	18	67	Clay
3		80-90	5.2	0.054	0.000020	0.00180		3.00	21	4	76	Clay
4	Theinni	0-10	5.0	0.093	0.000004	0.00033	1.25	3.88	32	28	37	Clay-Loam
5		40-50	5.2	0.073	0.000003	0.00260		3.00	14	37	48	Clay
6		80-90	5.5	0.068	0.000010	0.00180		2.99	11	34	56	Clay
7	Muse	0-10	5.1	0.077	0.000002	0.00220	1.48	4.11	44	36	19	Loam
8		40-50	4.7	0.068	0.000002	0.00200		3.77	27	36	34	Clay-Loam
9		80-90	4.7	0.066	0.000001	0.00160		3.22	25	30	52	Clay-Loam

APPENDIX II a

ANOVA for height in 2008

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	49.210(a)	5	9.842	30.045	.000
Intercept	257.924	1	257.924	787.387	.000
Township	23.261	2	11.631	35.506	.000
Treatment	22.817	1	22.817	69.654	.000
Township * Treatment	3.132	2	1.566	4.781	.016
Error	9.827	30	.328		
Total	316.960	36			
Corrected Total	59.037	35			

Multiple Comparisons of height in 2008

LSD

(I) Township	(J) Township	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
1.00	2.00	.3908	.23412	.105	-.0873	.8690
	3.00	1.7450(*)	.23412	.000	1.2669	2.2231
2.00	1.00	-.3908	.23412	.105	-.8690	.0873
	3.00	1.3542(*)	.23412	.000	.8760	1.8323
3.00	1.00	-1.7450(*)	.23412	.000	-2.2231	-1.2669
	2.00	-1.3542(*)	.23412	.000	-1.8323	-.8760

- The mean difference is significant at the .05 level.

ANOVA for height in 2009

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	338.751(a)	5	67.750	53.556	.000
Intercept	1696.067	1	1696.067	1340.733	.000
Township	132.516	2	66.258	52.377	.000
Treatment	186.232	1	186.232	147.215	.000
Township * Treatment	20.003	2	10.002	7.906	.002
Error	37.951	30	1.265		
Total	2072.769	36			
Corrected Total	376.702	35			

APPENDIX II b

Multiple Comparisons of height in 2009

	(I) Township	(J) Township	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
		2.00	-3.8233(*)	.45917	.000	-4.9553	-2.6914
LSD	1.00	2.00	.4550	.45917	.330	-.4828	1.3928
		3.00	4.2783(*)	.45917	.000	3.3406	5.2161
	2.00	1.00	-.4550	.45917	.330	-1.3928	.4828
		3.00	3.8233(*)	.45917	.000	2.8856	4.7611
	3.00	1.00	-4.2783(*)	.45917	.000	-5.2161	-3.3406
		2.00	-3.8233(*)	.45917	.000	-4.7611	-2.8856

ANOVA for diameter in 2008

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	168099.353(a)	5	33619.871	87.681	.000
Intercept	667761.361	1	667761.361	1741.531	.000
Township	114171.682	2	57085.841	148.881	.000
Treatment	45220.023	1	45220.023	117.934	.000
Township * Treatment	8707.649	2	4353.824	11.355	.000
Error	11503.004	30	383.433		
Total	847363.718	36			
Corrected Total	179602.357	35			

R Squared = .936 (Adjusted R Squared = .925)

APPENDIX II c

Multiple Comparisons of diameter in 2008

	(I) Township	(J) Township	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
LSD	1.00	2.00	6.5025	7.99410	.422	-9.8236	22.8286
		3.00	122.5817(*)	7.99410	.000	106.2555	138.9078
	2.00	1.00	-6.5025	7.99410	.422	-22.8286	9.8236
		3.00	116.0792(*)	7.99410	.000	99.7530	132.4053
	3.00	1.00	-122.5817(*)	7.99410	.000	-138.9078	-106.2555
		2.00	-116.0792(*)	7.99410	.000	-132.4053	-99.7530

* The mean difference is significant at the .05 level.

ANOVA for diameter in 2009

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	6941.922(a)	5	1388.384	161.400	.000	.964
Intercept	47716.034	1	47716.034	5547.000	.000	.995
Township	2807.521	2	1403.761	163.188	.000	.916
Treatment	3820.064	1	3820.064	444.083	.000	.937
Township * Treatment	314.336	2	157.168	18.271	.000	.549
Error	258.064	30	8.602			
Total	54916.019	36				
Corrected Total	7199.986	35				

Multiple Comparisons of diameter in 2009

	(I) Township	(J) Township	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
LSD	1.00	2.00	.2117	1.19737	.861	-2.2337	2.6570
		3.00	18.8383(*)	1.19737	.000	16.3930	21.2837
	2.00	1.00	-.2117	1.19737	.861	-2.6570	2.2337
		3.00	18.6267(*)	1.19737	.000	16.1813	21.0720
	3.00	1.00	-18.8383(*)	1.19737	.000	-21.2837	-16.3930
		2.00	-18.6267(*)	1.19737	.000	-21.0720	-16.1813