FERTILIZER TRIALS ON TWO UPLAND SOILS FROM THE TRINITY MOUNTAIN AREA

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Range Management 198

January 22, 1963

TABLE OF CONTENTS

LIST OF TABLES, FIGURES, AND WORK SHEETS

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I. Introduction

The Trinity Mountain area is in need of more basic information about its soils. At the present time only a limited amount of soils work has been done. In 1949 the California Forest and Range Experiment Station reported 27,000 acres of Soil-Vegetation Survey work done in Trinity County. This was an overlap of work done in neighboring counties.[1] Since this time the Soil Conservation Service has surveyed soils on an additional 25,000 acres on privately owned lands. This work is on file as farm plans in the Weaverville office. During August 1958 a committee of six men from the Soil Conservation Service and the University of California examined 19 soils on an inspection tour of the county. Ten of these soils were reported to appear to be of a new series. A promise has been made that the Soil Vegetation Survey will start in Trinity in 1963.

There are more than two million acres of land in Trinity County. The writer is interested in helping to bring about a higher degree of rangeland improvement. In 1956 Love and Williams[2] pointed out that it was unwise to outline any

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1. W. W. Weir, 1954, Bibliography of Soil and Land Classification Surveys in California. 51 pp. mimeo.

2. R. M. Love and W. A. Williams, "Rangeland development by manipulation of the soil-plant-animal complex in the difficult environment of a Mediterranean-type climate," Proc. 7th Int. Grassl. Cong., 1956, pp. 509-17.

management objectives before the site potential is well understood. The purpose of this experiment then is to gain a better understanding of the fertilizing potential of two rangeland soils from the Trinity area.

II. Procedures Used

A. Gathering Soil

The soils selected for the experiment were of the Laughlin and Los Gatos series. These soils are considered to have a widespread distribution in the mountain range. In 1961, K. Gowan, L. Brown, and the writer, all of the U. C. Agricultural Extension Service, made soil monoliths of these soils and they are now on display in Weaverville as typical Trinity soils with the following description:

Laughlin Loam

Parent Material	Sandstone, Shale, Schist
Relief	Upland--moderate to steep
Reaction	pH 6.5 slightly acid
Profile Group	VIII (I)
Native Cover	Grass, Oaks
Use	Range

It is further rated as being light brown or light yellowish brown in color, good drainage, medium grazing rating but not suitable for conifer timber production. It is used as a good representative of an upland grass soil.

Los Gatos Gravelly Loam

Parent Material . . . . . Sandstone, Shale, Schist

Relief . . . . . Upland--steep and very steep

Reaction . . . . . pH 6.0 moderately acid

Profile Group . . . . . VIII[1] (II)

Native Cover . . . . . Shrubs, Manzanita, Ceanothus

Use . . . . . Brushland

This soil is further rated as being reddish brown in color, excessive poor drainage and grazing rating, and poor for timber. It is a droughty soil, very shallow and covered with sprouting brush species. It is used as a good example of an upland brush soil.

The soils used in this experiment were gathered by the writer in October 1962. They were taken from the same area as the soil monoliths of 1961. The Laughlin soil came from the Cliff Ross Ranch (2,000 elevation) on Brown's Creek in Central Trinity. The following plants were observed to be growing on this soil at the time the sample was taken:

Rhamus crocea var. ilicifolia (Redberry) heavily browsed

Quercus Garryanna--Oregon White Oak--scattered over field

Cheatgrass (Bromus tectorum) was the dominant grass in field

Stipa lemmonii (perennial) many small bunches

Sitanion jubatum--Big Squirreltail

Phacelia heterophylla--a useless forb--many small bunches

Arctostaphylos manzanita--a few plants

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1. Profile VIII indicates soils on upland areas underlain by consolidated sedimentary rocks.

The Los Gatos soil came from a higher elevation (2,400 feet) but within five miles of the first sample. Vegetation growing on this soil was mainly a brush cover as follows:

Arctostaphylos manzanita

Arctostaphylos viscida--Whiteleaf Manzanita

Arctostaphylos canescens

Ceanothus integerrimus--Deer Brush

Ceanothus cuneatus--Buckbrush--Wedge Leaf--also the most heavily browsed

Quercus kelloggii--California Black Oak (scattered trees)

Pseudotsuga menziesii--Douglas Fir (scattered trees)

B. Greenhouse Pot Tests

The surface samples of these two soils were brought to the University of California at Davis and pot tested for nitrogen, phosphorus, and sulfur deficiencies. They were set up in an arrangement illustrated on Figure 1, page 5.

Nitrogen (N) was mixed by adding 18.24 grams of NH_4NO_3 to 1 liter of water. Twenty-five cc of this solution added to 1,600 grams of soil was equivalent to adding 200# N/acre.

Phosphorus (P) was mixed by adding 10.44 grams of H_3PO_4 to one liter of water. Twenty-five cc of this solution added to 1,600 grams of soil was equivalent to adding 200# P_2O_5/acre.

Sulfur (S) was mixed by adding 32 grams of $Na_2SO_4.10\ H_2O$ to one liter of water. Twenty-five cc of this

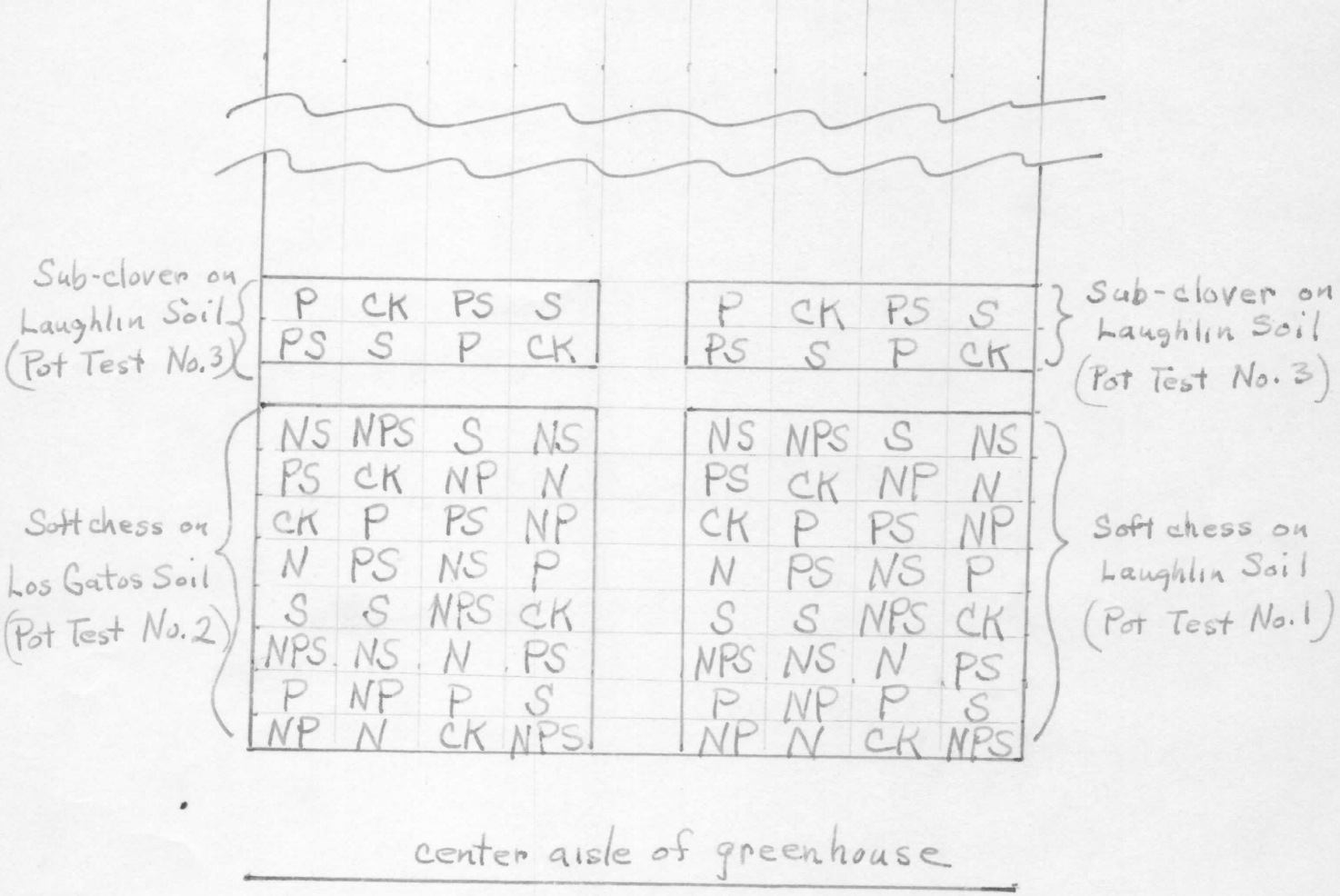

Figure 1. Showing arrangement of fertilizer trial pots in greenhouse. Arrangement was made from Table of Random Numbers on p. 54 of Experimental Methods for Extension Workers, University of California Agricultural Extension Service, 5/1962.

solution added to 1,600 grams of soil was equivalent to adding 100# S/acre.

Results of the tests were subjected to statistical analysis to indicate the deficiency patterns. (See work sheets, pages 12-20.)

Soft chess was used as the indicator plant because of its wide distribution on California range lands. According to Evans, Powell and Love, 1962, "The plant is easy to grow and reflects the soil nutrient level with respect to nitrogen, phosphorus, and sulfur."[1] The plot was set up in four replicated randomized blocks for each soil. Wherever nitrogen was indicated it was applied at the rate of 200# N/acre, phosphorus at the rate of 200# P_2O_5/acre, and sulfur at the rate of 100# S/acre.

Sub-clover was also used as an indicator plant on the Laughlin soil. This block was only used to test the deficiencies of phosphorus and sulfur. (See Pot Test No. 3, pages 17-19.)

Each pot was filled with 1,600 grams of air-dry soil that had been put through a one-fourth inch screen to remove pebbles and gravel.[2] Pots were paint ed on the inside and bottom with black asphaltum varnish and on the outside with aluminum paint. Pot saucers were painted with varnish on the inside.

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1. R. A. Evans, W. R. Powell, and R. M. Love, "Relation of Species Composition, Herbage Production, and Fertility on Millsap Soils," December 1962.

2. H. Jenny, J. Vlamis and W. E. Martin, "Greenhouse Assay of Fertility of California Soils." Hilgardia 20 (1): pp. 1-8.

Pot tests were conducted in the greenhouse under favorable growing conditions. Enough distilled water was supplied daily so that plants were never under moisture stress. Temperatures were also controlled. All softchess top growth was harvested and oven-dried seven weeks after planting. The sub-clover tops were harvested and oven dried nine and one-half weeks after planting. The oven was held at 95°-100° C for a twenty-four hour period.

In the sub-clover block (Pot Test No. 3) the plants were thinned to four plants per pot two weeks after planting. No thinning was done in the softchess blocks (Pot Test No. 1 and No. 2). A count was taken of softchess plants harvested. No pot had less than twenty plants or more than forty plants. The average was thirty plants per pot.

The early harvesting of the softchess blocks was due to poor germinating seed being used in the original planting. The first seeding of softchess was done with the sub-clover on November 12, 1962, but the seed did not germinate properly and had to be replanted on November 28, 1962. Test showed only 25-30 per cent of the seed germinated in fourteen days.

A question was asked about the possibility of the H_3PO_4 used as a source of phosphorus increasing the pH of the soil. On January 18, 1963, a sample of Laughlin soil was taken from a check pot and a pot with straight phosphorus added. Tests were run on the Beckman glass electrode pH meter in the agronomy laboratory. The soil from the CK had a pH of 6.8--the P had a pH of 7.0.

III. Findings from Tests

Results of the pot test are seen in picture form on pages 11, 14, and 17, and in the following table:

TABLE I

Table Showing Yields of Softchess and Sub-clover As Influenced by the Addition of Nitrogen, Phosphorus or Sulfur

Pot Test No. 1

Softchess on Laughlin

Treatment	Yield in gr.	Stat.[1] Sig.
CK	.27	a
S	.33	a
P	.37	a
PS	.48	a
N	.96	b
NS	1.18	b
NP	1.02	b
NPS	1.65	c

Pot Test No. 2

Softchess on Los Gatos

Treatment	Yield in gr.	Stat.[1] Sig.
CK	.16	a
N	.16	a
P	.21	a b
S	.24	a b c
PS	.30	b c
NS	.33	c
NP	.87	d
NPS	1.07	e

Pot Test No. 3

Sub-clover on Laughlin

Treatment	Yield in gr.	Stat.[1] Sig.
S	1.77	a
PS	1.90	a
CK	2.03	a
P	2.63	b

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1. Stat. Sig. means Statistical Significance.

Pot Test No. 1 had no significant difference between the check and applications of sulfur and phosphorus alone or sulfur and phosphorus together. Nitrogen, however, did give a significant response and this carried through both the NS and NP applications. Another significant increase came with the addition of NPS. It will be noted from the pictures that there is a staircase increase all the way from the CK to the NPS application. The important change came in the five-fold increase in using the NPS combination over the CK, S, or P applications and the more than double increase with the N application.

In Pot Test No. 2 the first thing that might be noted is the decrease in yield on the Los Gatos soil and the lack of response from the nitrogen. The picture indicates a sulfur response but the figures say it was not significant. The PS, NS, NP, NPS all had significant staircase responses. Certainly the adding of a single nutrient would not pay on this type of soil. Again we have a five- or six-fold increase with the NPS over CK, N, S, or P. The NP also brought a four-fold increase over the single applications.

Pot Test No. 3 showed no significant response from S and the figures indicate a slight decrease in yield over the check. Straight P, however, was significant and increased the yield by one-third.

show a general deficiency in all three nutrients (N, P, and S). Applications of single nutrients are not as apt to give as good a response as combinations. In some cases single nutrient applications are worthless. The best fertilizer to use is one that contains nitrogen, phosphorus, and sulfur. All three should be present.

These greenhouse pot tests should now be followed with field trials. Mr. Ross is a good cooperator. There is a good chance that just such a plot will be put out on Brown's Creek next fall.

Pot Test No. 1

Figure 2. Showing differential growth of softchess in response to various nutrient combinations added to Laughlin soil. CK indicates the check with no added nutrient. Nitrogen (N) and phosphorus (P) were applied at the rate of 200# per acre and sulfur (S) was applied at the rate of 100# per acre.

Pictures were taken by J. Street and D. Sumner.

Work Sheet

SOIL-VEGETATION SURVEY
Department of Agronomy, U.C. Davis

Soil Series Laughlin
~~Pot Test No.~~ Sample No. 1
~~Pot Test No.~~ Softchess
~~Pot Label I.D.~~ Bromus mollis

Date planted 11/28/62 by J C Borden
Date harvested 1/17/63 by J C Borden
Date weighed 1/18/63 by J C Borden

Replications

Treatments	grams I	II	III	IV	V	SX	$\bar{x}$	Duncan's Range Test *	Relative Yield
Check	0.28	0.38	0.23	0.18		1.07	0.27	a	16.4%
S	0.30	0.49	0.30	0.21		1.30	0.33	a	20.0
P	0.44	0.26	0.30	0.46		1.46	0.37	a	22.4
PS	0.71	0.40	0.41	0.39		1.91	0.48	a	29.1
N	0.61	1.01	1.23	0.98		3.83	0.96	b	58.2
NS	1.00	1.28	0.93	1.50		4.71	1.18	b	71.5
NP	1.10	0.92	0.90	1.15		4.07	1.02	b	61.8
NPS	1.69	1.41	1.96	1.52		6.58	1.65	c	100.0%
Rep. Totals	6.13	6.15	6.26	6.39		24.93	0.78		

* Treatments not having the same letter are significantly different at the 5% level.

Work Sheet for Pot Test No. 1 (Softakers or Laughlin Soil)

Source of Variation	Degrees of Freedom d.f	Sum of Squares SS	Mean Square MS	Observed F	Required F 5%	Required F 1%
Total	31	SS 7.70				
Rep's (Blocks)	3	SSB .00	.00			
Treatment	7	SST 6.91	.987	26.67	2.49	3.65
Error	21	SSE .79	MSE .037			

$$C = \frac{(\Sigma X)^2}{n} = \frac{T^2}{n} = \frac{24.93^2}{32} = \frac{621.5049}{32} = 19.42$$

$$SS = \Sigma X^2 - C = 27.12\cancel{33} - 19.42 = 7.70$$

$$SSB = \frac{\Sigma T_b^2}{n} - C = \frac{155.42}{8} = 19.42 - 19.42 = 0$$

$$SST = \frac{\Sigma T_t^2}{n} - C = \frac{105.33}{4} = 26.33 - 19.42 = 6.91$$

$$SSE = SS - SSB - SST = 7.70 - 0 - 6.91 = .79$$

$$MSE = S^2 = .037$$

$$S_{\bar{X}} = \sqrt{\frac{S^2}{n}} = \sqrt{\frac{.037}{8}} = \sqrt{.0046} = .068$$

Table for Least Significant Range $R_p = r_p(S_{\bar{X}})$

p	2	3	4	5	6	7	8
r_p	2.95	3.10	3.18	3.25	3.30	3.34	3.36
R_p	.201	.211	.216	.221	.224	.227	.228

Table for determining significant differences among treatments

Treatment	CK	S	P	PS	N	NP	NS	NPS
Mean Values	0.27	0.33	0.37	0.48	0.96	1.02	1.18	1.65
Duncan letter	a	a	a	a	b	b	b	c

$R_p = r_p(S_{\bar{X}})$

$2.95 \times .068 = .206$
$3.10 \times .068 = .211$
$3.18 \times .068 = .216$
$3.25 \times .068 = .221$
$3.30 \times .068 = .224$
$3.34 \times .068 = .227$
$3.36 \times .068 = .228$

Pot Test No. 2

Figure 3. Showing differential growth of softchess in response to various nutrient combinations added to Los Gatos soil. CK indicates the check with no added nutrient. Nitrogen (N) and phosphorus (P) were applied at the rate of 200# per acre and sulfur (S) was applied at the rate of 100# per acre.

Work Sheet

SOIL-VEGETATION SURVEY
Department of Agronomy, U.C. Davis

Soil Series Los Gatos
~~Pot Test No.~~ ~~Sample No.~~ 2
~~Pot Test No.~~ Softchess
~~Pot Label I.D.~~ Bromus mollis

Date planted 11/28/62 by J.C. Burns
Date harvested 1/17/63 by J.C. Burns
Date weighed 1/18/63 by J.C. Burns

Replications

Treatments	I	II	III	IV	V	SX	$\bar{x}$	Duncan's Range Test *	Relative Yield
Check	0.09	0.20	0.18	0.18		0.65	0.16	a	15.0 %
S	0.26	0.28	0.20	0.20		0.94	0.24	abc	22.4
P	0.14	0.28	0.10	0.30		0.82	0.21	ab	19.6
PS	0.40	0.30	0.18	0.30		1.18	0.30	bc	28.0
N	0.15	0.18	0.10	0.20		0.63	0.16	a	15.0
NS	0.29	0.24	0.35	0.42		1.30	0.33	c	30.8
NP	1.00	0.78	0.99	0.70		3.47	0.87	d	81.3
NPS	0.99	1.08	1.10	1.10		4.27	1.07	e	100.0 %
Rep. Totals	3.32	3.34	3.20	3.40		13.26	0.42		

* Treatments not having the same letter are significantly different at the 5% level.

Work Sheet for Pot Test No. 2 (Soybeans on Low Native Soil)

Source of Variation	Degrees of Freedom d.f.	Sum of Squares SS	Mean Square MS	Observed F	Required F 5%	Required F 1%
Total	31	SS 3.61				
Rep's/Blocks	3	SSB .01	.003			
Treatment	7	SST 3.44	.491	61.37	2.49	3.65
Error	21	SSE .16	MSE .008			

$$C = \frac{(\Sigma X)^2}{n} = \frac{T^2}{n} = \frac{13.26^2}{32} = \frac{175.83}{32} = 5.49$$

$$SS = \Sigma X^2 - c = 9.10 - 5.49 = 3.61$$

$$SSB = \frac{\Sigma T_b^2}{n} - c = \frac{43.98}{8} - c = 5.50 - 5.49 = .01$$

$$SST = \frac{\Sigma T_T^2}{n} - c = \frac{35.23}{4} - c = 8.93 - 5.49 = 3.44$$

$$SSE = SS - SSB - SST = 3.61 - .01 - 3.44 = .16$$

$$MSE = S^2 = .008$$

$$S_{\bar{x}} = \sqrt{\frac{S^2}{n}} = \sqrt{\frac{.008}{8}} = \sqrt{.001} = .032$$

Table for Least Significant Range $R_p = r_p(S_{\bar{x}})$

p		2	3	4	5	6	7	8
r_p		2.95	3.10	3.18	3.25	3.30	3.34	3.36
R_p		.094	.099	.102	.104	.106	.107	.108

Table for determining significant differences among treatments

Treatment	CK	N	P	S	PS	NS	NP	NPS
Mean Values	.16	.16	.21	.24	.30	.33	.87	1.07
Duncan letter	a	a	a	a				
			b	b	b			
				c	c	c		
							d	

e

$R_p = r_p(S_{\bar{x}})$

$2.95 \times .032 = .094$
$3.10 \times .032 = .099$
$3.18 \times .032 = .102$
$3.25 \times .032 = .104$
$3.30 \times .032 = .106$
$3.34 \times .032 = .107$
$3.36 \times .032 = .108$

Pot Test No. 3

Figure 4. Showing differential growth of sub-clover in response to various nutrient combinations added to Laughlin soil. CK indicates the check with no added nutrient. Phosphorus (P) was applied at the rate of 200# per acre and sulfur (S) was applied at the rate of 100# per acre.

Work Sheet

SOIL-VEGETATION SURVEY
Department of Agronomy, U.C. Davis

Soil Series Laughlin
Pot Test No. 3
~~Sample No.~~
~~Pot Test No.~~ Sub-clover
~~Pot Label I.D.~~ Trifolium subterraneum

Date planted 11/12/62 by JCBorden
Date harvested 1/17/63 by JCBorden
Date weighed 1/18/63 by JCBorden

Replications

Treatments	I	II	III	IV	V	SX	$\bar{x}$	Duncan's Range Test*	Relative Yield
Check	2.10	1.82	2.26	1.95		8.13	2.03	a	77.2%
S	1.66	1.73	1.70	2.00		7.09	1.77	a	67.3
P	2.96	2.50	2.48	2.59		10.53	2.63	b	100.0
PS	1.81	2.10	1.70	2.00		7.61	1.90	a	72.2%
N									
NS									
NP									
NPS									
Rep. Totals	8.53	8.15	8.14	8.54					

* Treatments not having the same letter are significantly different at the 5% level.

Source of Variation	d.f.	SS	MS	F	5%	1%
Total	15	SS 2.17				
Rep's) Blocks	3	SSB .04	.013			
Treatment	3	SST 1.74	.580	13.49	3.89	6.99
Error	9	SSE .39	MSE .043			

$$C = \frac{(\Sigma X)^2}{n} = \frac{T^2}{n} = \frac{33.36^2}{16} = \frac{1112.89}{16} = 69.55$$

$$SS = \Sigma X^2 - C = 71.72 - 69.55 = 2.17$$

$$SSB = \frac{\Sigma T_b^2}{n} - C = \frac{278.37}{4} - C = 69.59 - 69.55 = .04$$

$$SST = \frac{\Sigma T_T^2}{n} - C = \frac{285.16}{4} - C = 71.29 - 69.55 = 1.74$$

$$SSE = SS - SSB - SST = 2.17 - .04 - 1.74 = .39$$

$$MSE = S^2 = .043$$

$$S_{\bar{x}} = \sqrt{\frac{S^2}{n}} = \sqrt{\frac{.043}{4}} = \sqrt{.0107} = .103$$

Table for Least Significant Range $R_p = r_p(S_{\bar{x}})$

p	2	3	4
r_p	3.20	3.34	3.41
R_p	.330	.344	.351

Table for determining significant differences among treatments

Treatment	S	PSJ	CK	D
Mean Values	1.77	1.90	2.03	2.63
Duncan letter	a	a	a	b

$R_p = r_p(S_{\bar{x}})$

$3.20 \times .103 = .330$

$3.34 \times .103 = .344$

$3.41 \times .103 = .351$

LG Soft Chess Work Sheet — Weights of plants harvested 1/18/63 — 20

Los Gatos

	CK	# of Plants in pot	S	# of plants in pot	P	# of plants in pot	PS	# of plants in pot
1	0.09	29	0.26	24	0.14	35	0.40	35
2	0.20	40	0.28	32	0.28	34	0.30	24
3	0.18	26	0.20	22	0.10	28	0.18	28
4	0.18	26	0.20	24	0.30	30	0.30	29
		121		102		129		117

	N		NS		NP		NPS	
1	0.15	28	0.29	35	1.00	31	0.99	21
2	0.18	34	0.24	20	0.78	31	1.08	30
3	0.10	23	0.35	37	0.99	25	1.10	24
4	0.20	35	0.42	31	0.70	33	1.10	24
		120		123		120		99

Laughlin (Soft chess)

L

	CK		S		P		PS	
1	0.28	31	0.30	27	0.44	31	0.71	34
2	0.38	39	0.49	35	0.26	35	0.40	33
3	0.23	39	0.30	34	0.30	20	0.41	32
4	0.18	24	0.21	24	0.46	27	0.39	40
		133		120		113		139

	N		NS		NP		NPS	
1	0.61	25	1.00	25	1.10	33	1.69	33
2	1.01	30	1.28	31	0.92	24	1.41	21
3	1.23	34	0.93	28	0.90	30	1.96	30
4	0.98	39	1.50	37	1.15	29	1.52	27
		128		121		116		111

L

Laughlin Sub Clover

	CK	S	P	PS
1	2.10	1.66	2.96	1.81
2	1.82	1.73	2.50	2.10
3	2.26	1.70	2.48	1.70
4	1.95	2.00	2.59	2.00

V. Literature Cited

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