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culture-propagated strawberries (var. Selva)**

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San Jose State University, 1993

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INTRA-CLONAL CROP PERFORMANCE AND STABILITY
OF MERISTEM CULTURE-PROPAGATED STRAWBERRIES
(VAR. SELVA)

A Thesis
Presented to
The Faculty of the Department of Biological Sciences
San Jose State University

In Partial Fulfillment
of the Requirements for the Degree
Master of Arts

by
Steven Douglas Nelson
December 1993

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ABSTRACT

INTRA-CLONAL CROP PERFORMANCE AND STABILITY OF MERISTEM CULTURE-PROPAGATED STRAWBERRIES (VAR.SELVA)

by Steven D. Nelson

The field performance of meristem culture-propagated strawberry plants (cv. Selva) was evaluated following vegetative propagation at the screenhouse increase level. Significant variability of yield among clones was observed. In order to determine if this variability was conserved, three high yielding clones were compared to three low yielding clones following a subsequent year of vegetative propagation at the field foundation nursery level. Yield performance was consistent with 5 of 6 clones. Most significant was that two low yielding clones produced less than approximately 10% of the yield that the high yielders produced. All clones evaluated in this study were confirmed to be "virus negative" cv. Selva through grafting. As demonstrated by this study, somaclonal variation, the recovery of genetic changes in plants regenerated from tissue culture, offers plant breeders an opportunity to unlock natural variability and use such variability for the development of new varieties. However, it should be noted that most variants produced as a result of somaclonal variation are of no commercial value.

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Chapter I

INTRODUCTION

Commercially grown strawberry (*Fragaria ananassa*) cultivars are derived almost exclusively from (*F. chiloensis* x *virginiana*). Original hybrids occurred as natural outcrosses in the 1750's in private gardens near Brest, Brittany. Since that time, hobbyists and professional plant breeders have continued their search for improved cultivars. California is the country's leading producer of fresh strawberries, due in large part to ongoing successful plant breeding efforts. California strawberry growers produce approximately 75% of all the fresh strawberries produced in the United States. Annual production of fresh market strawberries in California is approximately 100 million trays, over 500,000 tons. Annual farm gate value for California strawberries is approximately 675 million dollars. Strawberries in California are grown as an annual crop from dormant root stock.

Nursery plants are grown at high elevation nurseries (1,300+ meters). The nursery plants become dormant in the fall due to cool temperatures and shorter day lengths. When the plants are adequately dormant they are mechanically dug, hand trimmed, and packed. Dormant plants are then transported to the fruiting fields for planting. Harvest begins within approximately 4 months of planting and continues for 5-8 months.

Strawberry plants are susceptible to many pests and diseases including birds, slugs and snails, insects, mites, fungus, bacteria, and virus. Successful strawberry pest management

requires an integrated approach which relies on mechanical controls, biological controls (predators and parasites), and chemical controls. Viral infection is not treatable in the commercial field (although pests which vector viruses are monitored and measures may be taken to control their populations) (29). Infection may be simple (involving a single virus) or complex (involving two or more viruses). The effects of viruses are generally synergistic. Symptoms can range from slight yield loss to total necrosis. The most common virus of strawberries in California is Mild Yellow Edge. Other common viruses are Mottle and Crinkle (11,12). The presence of virus in strawberry is determined by grafting a petiole of a cultivated variety to a highly sensitive indicator variety, which if positive will produce symptomology to indicate a single latent virus (4,19).

In strawberry, viruses are eliminated through tissue-culture of meristems following heat treatment (which reduces virus titer within the plant) of the mother plants (1,19,21,24). The clean plants developed are referred to as "virus-negative" as compared to "virus-free" due to the inability to isolate and positively identify all virus forms. Meristem derived, virus negative clones are commonly more vigorous than non-meristem stock, even in cases where no disease symptoms are evident (5,6,18,27).

Micropropagation, the clonal propagation of plants in vitro, is used commercially for rapid propagation of strawberries, especially in breeding programs to increase new material (7). If virus-negative plants are used to initiate the cultures, micropropagation (as opposed to field developed stock) offers the advantage of producing "disease-free"

plants. Micropropagated strawberry plants can also provide an extensive repository of germplasm in a very small space (2,3,20). Although plant tissue culture is useful for virus elimination and mass propagation, there is the risk of unexpected somaclonal variants differing in both appearance and performance from the parent. Somaclonal variation is the general term used to describe the complete range of variation within a plant population which has been regenerated from in vitro cultures of callus, cells or protoplasts. Variants can be either of obvious or of discrete symptomology (10, 13, 14, 15, 17, 23, 25, 26). Obvious phenotypic variants include white streak, dwarfism, and yellow variants. Discrete variants can only be measured by their yield performance, runner performance, or another subtle quantitative measure.

Currently, the primary commercial use of tissue culture-propagated (TC) strawberry plants is in the screenhouse nursery. Screenhouses are used during the first year of nursery plant propagation, following in vitro culture. Their purpose is to protect the very susceptible young plants from insects, such as aphids, which are virus vectors. Nursery plants are replanted in the foundation nursery, the year following screenhouse increase. At the foundation nursery plants are propagated in open fields by clone. It has been suggested that TC plants could be of benefit at the foundation nursery level (27). Benefits include increased runner production (approximately 60%) and the reduction of propagation time by 1 year which would reduce their exposure to pathogens. However, the use of TC plants at the foundation level would double propagation costs for the foundation nursery although the increased production (as much as 60%) could more than offset the cost

increase (8). Of greatest concern would be the potential for TC off-types (variants) to enter the nursery cycle undetected. One off-type TC mother plant, at the foundation level, if allowed to multiply, could lead to approximately 6,000 off-type plants in the commercial fruiting field two years later. Thus, it is critical to understand and detect any off-types in order to eliminate the possibility of these plants being planted by the commercial grower.

Somaclonal variants arising from tissue culture are classified in two major categories, genetic and epigenetic variants. Genetic changes associated with somaclonal variations include altered chromosome number, ploidy level changes, single gene changes, cytoplasmic gene changes, chromosome rearrangements, mitotic crossing over, expression of previously suppressed genes, copy number changes of repetitive DNA, and tissue specific changes (10). Epigenetic variation or transient changes often induced by tissue culture conditions may be of benefit for asexually propagated plants, if shown to be conserved. Epigenetic variations are generally not of significant value for sexually reproduced plants, as changes are not expressed in sexual progeny. Such variants are generally growth habit related (juveniles, dwarfs, and other morphological exceptions).

Reports have been published regarding strawberry varietal improvement through somaclonal variation. From Japan, researchers report two lines of strawberries resistant to the fungal wilt disease, caused by Fusarium oxysporum sp. fragariae, which were selected from 1,225 regenerants initiated from leaf-derived callus tissues of strawberry (cv. Hoko-wase). Daughter plants produced through runner

production were also tested over three generations. The stability of the resistant trait was confirmed by directly inoculating the daughter plants with the pathogen and planting them in a pathogen - infested soil. All control plants were infected and died within 30 days. The two variant clone lines grew and developed runners even after direct inoculation (28). Researchers in Hungary published preliminary notes of crop improvement through somaclonal variations of strawberry (cv. Pocahontas). Approximately 1000 plantlets obtained from callus derived from anther culture were evaluated for various agronomic traits. Among the somaclones, there were selections made based upon valuable variants regarding earliness, ease of calyx removal, ripening rate, and mildew tolerance (25).

Somaclonal variation has been used successfully with crops other than strawberries for crop improvement in conjunction with conventional breeding programs. Current breeding applications include selection from regenerated plants or their progeny for incremental improvements over existing varieties. For instance, a high solids tomato variety (DNAP-9) was a selection derived from clones that were regenerated from leaf explants of a commercial tomato (*Lycopersicon esculentum*) variety (UC 82B). This variation was confirmed in field trials and shown to be stable over several generations (9). A second tomato variety (DNAP-17) was selected from the same population of 230 regenerated plants that yielded DNAP-9. In the R_3 generation, lines with good agronomic performance were screened for resistance to several diseases. Seedlings of DNAP-17 are virtually indistinguishable from UC82B but express resistance to Fusarium Race 2 (10). A third example is Bell Sweet, a yellow bell pepper (*Capsicum frutesceus*) variety which was

identified as a variant among plants regenerated from anther culture. Bell Sweet contains a mean of nine seeds per fruit compared to a mean of 330 seeds per fruit contained by the parent variety, Yolo Wonder (10).

The above literature review suggests a novel approach to strawberry varietal improvement through somaclonal variation. Through identification and selection of variants, it may be possible to unlock natural and induced variations associated with tissue culture propagated plants (16). Plants obtained by this method can originate from single cells, therefore they would be pure mutant type, thus avoiding the traditional chimeric phenomena typically associated with mutation breeding studies (22,28).

Prominent strawberry researchers Swartz, Galletta and Zimmerman (1981) conducted work to study the feasibility of using tissue culture propagated strawberry plants as foundation nursery mother plants. They noted production of somaclonal variations which were largely limited to one meristem-tip line. They concluded that, "if the superior meristem tip-lines consistently maintain their advantages, nursery stock improvement through clonal selection should be worthwhile" (27).

The purpose of this author's research was to determine if meristem cultures of the U.C. strawberry variety Selva produced high and low yielding clonal lines and whether such variations were conserved through one year of asexual nursery propagation. If high and low yielding clones did exist and if such variations were stable, nursery stock improvement through clonal selection would indeed be worthwhile.

Chapter II

MATERIALS AND METHODS

Plant Culture and Propagation

In the fall of 1986, mother plants of the U.C. strawberry variety Selva were planted into 15 cm clay pots with a sterilized (steam treated) soil medium. The mother plants then were kept at 38°C for 21 days. Atmospheric levels of CO₂ were enhanced to 1200 ppm in order to facilitate plant survival under extreme heat conditions.

Mother plants with runners were transferred to a greenhouse following heat treatment. Plant meristem culture was carried out by Dr. J. Hansen at Plant Sciences, Inc.®, Watsonville, CA. Runners were removed and meristem cells were aseptically removed under a dissection scope. The meristem culture was accomplished by Plant Sciences, Inc.® personnel using standard meristem culture techniques (19). All meristem cultures were grown on media containing Knop's solution (1). Meristem-culture derived mother plants were then planted into a high elevation commercial nursery screenhouse, in Susanville, CA. (1,300+ meters) for reproduction through asexual means (runner production).

In October of 1987 the plants were hand dug. The original mother plants were discarded and the daughter plants were allocated as follows: three plants were stored at 1°C for approximately 30 days until they were adequately chilled and could be planted into a commercial fruiting field in Watsonville for type testing; two plants were set into 10 cm plastic pots and returned to Plant Sciences, Inc.® for

virus indexing purposes (grafting); all virus positive clones were discarded; the remaining plants, 50-200 per clone, were held at -3°C until they could be replanted as nursery stock in April of 1988.

This last group of plants was replanted, by clone, into the foundation nursery in April 1988, at Susanville, CA. (at 1,300+ meters elevation). The foundation nursery was dug in October of 1988. At that time, 300 plants from each of the 6 clones selected for further study (3 high yielding and 3 low yielding) were hand dug and bagged separately.

Plot Design and Plant Care

Type test 1987-88 - The study clones were planted into a commercial strawberry field for the purpose of selecting 3 high yielding and 3 low yielding clonal lines. Each clonal plot consisted of 3 plants (plots were not replicated). Plots were planted into raised beds with 117 cm centers on November 25, 1987, with two lines of plants per bed and down the row spacing at 30 cm (plant population density was the equivalent of 56,190 plants per hectare).

Replicated 6 clone test 1988-89 - The study clones were planted into a commercial strawberry field. The test plot consisted of 6 clonal lines (3 high yielding clones, and 3 low yielding clones) replicated 6 times (randomized complete block design); each replicate consisted of forty plants. Plots were planted into raised beds with 117 cm centers on November 25, 1988, with two lines of plants per bed and down the row spacing at 30 cm (plant population density was the equivalent of 56,190 plants per hectare).

The grower performed all commercial cultural practices such as irrigation, fertilization, and pest management, on an as-needed basis.

Data Collection

Type test 1987-88 - The 3 plant plots were harvested by clone. Marketable fruit, by weight (grams) was recorded at each harvesting, which occurred at a frequency of 2-3 times per week. Harvest began in April 1988 and continued through October 1988. All harvesting was performed by experienced field labor.

Replicated 6 clone test 1988-89 - Each replicate plot was harvested. Marketable fruit, by weight (grams) was recorded at each harvesting, which occurred at a frequency of 2-3 times per week. Harvest began in April 1989 and continued through October 1989. All harvesting was performed by experienced field labor.

Data Analysis

No statistical analysis was performed on data which were taken from the non-replicated type test of 1987-88. The 3 high yielding and 3 low yielding clones were selected based on numerical data from the type test of 1987-88.

Data which were taken from the replicated 6 clone test were compiled on a monthly basis by clone. Statistical analysis of the marketable fruit yields from the 3 high and 3 low yielding clones was performed on a monthly and season totals basis by analysis of variance with an LSD of 0.05. Data were subjected to Duncan's New Multiple Range Comparison.

Chapter III

RESULTS

Plant Culture and Propagation

Mother plants produced an adequate number of runners required to yield over 150 individual clonal lines. Plantlets developed without difficulty and were available for planting in the screenhouse (April 1987). The plantlets (now referred to as screenhouse mother plants) produced more than adequate numbers of runners, with an average of 100 daughter plants per clone. Daughter plants accumulated adequate chilling at the nursery (450 hours below 7°C) by October 25, 1987. Plants were then dug, and cold stored at -3°C and 1°C. The plants held at -3°C were used for nursery replants, and the plants held at 1°C were used for test plots in the fruiting field. The 1988 nursery (foundation level) also produced more than adequate numbers of plants. They received adequate chilling (430 hours below 7°C) by October 15, 1988 at which time plants were dug and cold stored at 1°C.

Virus Indexing

Virus indexing of 2 test plants of each clone was carried out by Bill Colfer and his staff at Plant Sciences, Inc.®. Several clones were indexed as viral positive and rogued out. All six clones (3 high yielding, and 3 low yielding) selected for this research project were confirmed to be viral negative.

Type Test Performance (1987-88)

Routine evaluations of overall vigor, fitness, and growth identified 136 "normal clones". Twelve off-types were flagged and later rogued from the program . The off-types included 3 dwarf clones, 6 highly vegetative clones, 2 yellow streak clones, and 1 generally weak clone.

Yield data were gathered per clone. Yields ranged from 147 grams to 3,600 grams per 3 plant plot. From the 136 healthy clones, the 3 highest and 3 lowest yielding clones were selected for further study in order to determine if the yield trend would remain consistent following another year of nursery reproduction (Table 1).

Replicated Six Clone Test (1988-89)

Clonal performance yield comparisons are illustrated in Figures 1-8. Five of six clones showed yields consistent in 1989 with the previous year's (1988) yields. The three high-yielding clones remained high yielding. However, only two of the three low yielding clones remained low yielding. Clone 5 (10108-1) was identified as a low yielder in the type test; however, in the expanded clonal performance test, its performance was not statistically different from all of the high yielding clones (Table 2).

In the month of April, clones 1-5 produced yields with no significant difference (Figure 1). In May, clones 4 and 6 produced significantly less yield than all others (Figure 2). That trend continued through June and July (Figures 3 & 4). In September, clone 5 produced a significantly greater yield than all other clones, and

clones 4 and 6 continued to produce significantly less than all other clones (Figure 6).

In October, clones 4 and 6 continued to produce significantly less yield than all other clones (Figure 7). Clonal performance for the 1989 season is summarized in Figure 8. ANOVA's and Duncan's New Multiple Range of Treatment Means Comparison were performed monthly (Appendix A) and for the season totals (Table 2). Yield data at season end followed closely the expected trend. The three high yielding clones of 1987-88 were also high yield producers in 1988-89. Of the three low yielding clones, yields for two of three were consistent with the expected trend. However, clone number 5 (10108-1) produced yields statistically equal to the high yielding clones.

All six clones were evaluated for phenotypic variations throughout the season. Clones 1-3 and 5 all grew and produced normally (Figures 9-14, 17 and 18). Clones 4 and 6 did show abnormalities. Clone 4 (7107) produced very few flowers compared to all other clones (Figures 15 and 16). Clone 6 (9048-1) produced many flowers; however, the quality of the fruit set was very poor (Figures 19 and 20).

Chapter IV

DISCUSSION

The use of tissue culture-propagated plants has resulted in better plant uniformity, improved field survival, and increased yields both of fruits and runners (i.e. by both sexual and asexual reproduction). This increased yield is due in large part to virus eradication both of known and probably some of unknown identity. All certified commercial strawberry nurseries rely on tissue culture - propagated stock for their screenhouse mother plants. As reported, some researchers have recommended that the use of TC plants be expanded to the foundation nursery level. The bases for such a recommendation indicate increased plant vigor would be of benefit for low runner producing varieties; reduction of field nursery years by one, gives the nursery more flexibility in planning and reducing the plant's exposure to insects, viruses, and other plant pathogens. On the other hand, the use of TC plants at the foundation level nursery would require very close inspection of each clonal line in order to identify and rogue any off-types. Such a program would not be feasible for most California nursery operations which grow an average of 12 or more acres of foundation nursery. The time requirement to evaluate each clone individually would be very costly, and farming costs would increase significantly due to the plant spacing requirements in order to prevent mixing of runners (and clones) which would further complicate the evaluation and rogueing process.

As demonstrated by this research, high and low yielding clones may be conserved and maintained over time, through successive years of asexual reproduction (by runners). Therefore, it is critical that all clonal lines be tested to determine if they are free of any detrimental somaclonal variations (e.g., low yield, off-type, and male sterile). The literature and this study, strongly suggest that the use of somaclonal variation could be a valuable approach to crop improvement by producing and identifying higher yielding clones. Such improvement could benefit the profitability of production at both the nursery (plant production) level and the fruit production level. The use of somaclonal variation allows for exploitation of both natural and induced variation associated with tissue culture-propagated plants. Induced variation, such as chemical mutagenesis, has been reported to produce a four fold increase in somaclonal variation (16). Somaclonal variation can be exploited in plants which are highly adapted or where sexual reproduction is disturbed or not available. The use of somaclonal variation does also have the obvious advantage in that the techniques involved are simpler than those of recombinant DNA, and have been free of the regulatory and public acceptance problems that products of recombinant DNA have experienced.

As with any agronomic tool, tissue culture-propagated plants will not solve all of our plant health problems, nor does somaclonal variation provide the answer to all plant breeding hurdles; rather, they are both useful tools that can and should be applied where feasible in order to promote healthy, safe, abundant food and fiber for all.

Table 1. Clonal lines (representing the 3 highest and 3 lowest yielding clones) of the strawberry variety Selva selected from the 1987-88 type test of 136 clones.

HIGH YIELDING CLONE MERISTEM NUMBERS:

1. 9737-2
2. 7145
3. 9036-3

LOW YIELDING CLONE MERISTEM NUMBERS:

1. 7107
2. 10108-1
3. 9048-1

Table 2. Statistical analysis of variance for strawberry (cv. Selva) marketable fruit yields in grams. Intra-clonal study, Borina Ranch, 1989.

Treatment No.	Clonal No.	Mean Wt. (g)	Std. Dev.
1	9737-2	37371.83 a	2720.996
2	7145	36326.17 a	3882.209
3	9036-3	37548.50 a	1656.144
4	7107	3766.33 b	496.906
5	10108-1	38395.50 a	1338.800
6	9048-1	1801.17 b	475.511

LSD (0.05) = 2571.905

ANOVA significant - All treatment means not equal.

**YIELD PERFORMANCE OF SIX MERISTEM
CULTURED STRAWBERRY CLONES (CV. SELVA)
BORINA RANCH, WATSONVILLE, CA
APRIL, 1989**

**YIELD PERFORMANCE OF SIX MERISTEM
CULTURED STRAWBERRY CLONES (CV. SELVA)
BORINA RANCH, WATSONVILLE, CA
MAY, 1989**

YIELD PERFORMANCE OF SIX MERISTEM CULTURED STRAWBERRY CLONES (CV. SELVA) BORINA RANCH, WATSONVILLE, CA

JUNE, 1989

YIELD PERFORMANCE OF SIX MERISTEM CULTURED STRAWBERRY CLONES (CV. SELVA) BORINA RANCH, WATSONVILLE, CA

JULY, 1989

YIELD PERFORMANCE OF SIX MERISTEM CULTURED STRAWBERRY CLONES (CV. SELVA) BORINA RANCH, WATSONVILLE, CA

AUGUST, 1989

**YIELD PERFORMANCE OF SIX MERISTEM
CULTURED STRAWBERRY CLONES (CV. SELVA)
BORINA RANCH, WATSONVILLE, CA
SEPTEMBER, 1989**

YIELD PERFORMANCE OF SIX MERISTEM CULTURED STRAWBERRY CLONES (CV. SELVA) BORINA RANCH, WATSONVILLE, CA OCTOBER, 1989

YIELD PERFORMANCE OF SIX MERISTEM CULTURED STRAWBERRY CLONES (CV. SELVA) BORINA RANCH, WATSONVILLE, CA YEAR TOTALS

Figure 9. Strawberry plants (Var. Selva, clone 9737-2) located in the replicated field study plot, September 1989, Borina Ranch, Watsonville, CA.

Figure 10. Strawberry plants (Var. Selva, clone 9737-2) located in the replicated field study plot, September 1989, Borina Ranch, Watsonville, CA.

Figure 11. Strawberry plants (Var. Selva, clone 7145) located in the replicated field study plot, September 1989, Borina Ranch, Watsonville, CA.

Figure 12. Strawberry plants (Var. Selva, clone 7145) located in the replicated field study plot, September 1989, Borina Ranch, Watsonville, CA.

Figure 13. Strawberry plants (Var. Selva, clone 9036-3) located in the replicated field study plot, September 1989, Borina Ranch, Watsonville, CA.

Figure 14. Strawberry plants (Var. Selva, clone 9036-3) located in replicated field study plot, September 1989, Borina Ranch, Watsonville, CA.

Figure 15. Strawberry plants (Var. Selva, clone 7107) located in the replicated field study plot, September 1989, Borina Ranch, Watsonville, CA.

Figure 16. Strawberry plants (Var. Selva, clone 7107) located in the replicated field study plot, September 1989, Borina Ranch, Watsonville, CA.

Figure 17. Strawberry plants (Var. Selva, clone 10108-1) located in the replicated field study plot, September 1989, Borina Ranch, Watsonville, CA.

Figure 18. Strawberry plants (Var. Selva, clone 10108-1) located in the replicated field study plot, September 1989, Borina Ranch, Watsonville, CA.

Figure 19. Strawberry plants (Var. Selva, clone 9048-1) located in the replicated field study plot, September 1989, Borina Ranch, Watsonville, CA.

Figure 20. Strawberry plants (Var. Selva, clone 9048-1) located in the replicated field study plots, September 1989, Borina Ranch, Watsonville, CA.

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Appendix A

Statistical analysis of variance for strawberry (cv. Selva) marketable fruit yield, in grams. Intra - clonal study, Borina Ranch, 1989.

APPENDIX A

PSI SELVA CLONAL\BORINA RANCH\WT\GRMS\MARKET

APRIL 1989

Printed on ==> 10-03-1993 a 10:42:34

	SUM	DEGREES	MEAN	F	CRIT VALS
	SQUARES	FREEDOM	SQUARE	RATIO	
TREATMENT	2.368438E+07				
		5	4736877	19.2012	2.6
BLOCK	1529008	5	305801.6	1.239584	2.6
ERROR	6167424	25	246697		
TOTAL	3.138082E+07				
		35			

STANDARD ERROR OF A VARIETAL MEAN = 222.1247

LSD(0.05) = 590.7292

LSD(0.10) = 489.7891

ANOVA SIGNIFICANT -- ALL TREATMENT MEANS NOT EQUAL

ANOVA NOT SIGNIFICANT -- ALL REPLICATION MEANS STATISTICALLY EQUAL

FILE SAVED IN FILE : SCLNAP89.ANV

ORIGINAL DATA STATISTICS

TR NO	TREATMENT NAME	MEAN	STD DEV
1	CLONE #9737-2	2615.167	426.0585
2	CLONE #7145	2552.333	456.3477
3	CLONE #9036-3	2401	880.8026
4	CLONE #7107	2457.833	335.9554
5	CLONE #10108-1	2633.5	358.6794
6	CLONE #9048-1	366.6667	363.5633

BLOCK NO	MEAN
1	2494.333
2	2280.167
3	2238.5
4	2091.333
5	1820.833
6	2101.333

Duncan's New Multiple Range Comparison Table

2633.50 2615.17 2552.33 2457.83 2401.00 366.67

a a a a a b

PSI SELVA CLONAL/BORINA RANCH/WT/GRMS/MARKET

MAY 1989

Printed on ==> 10-03-1993 @ 10:49:16

	SUM SQUARES	DEGREES FREEDOM	MEAN SQUARE	F RATIO	CRIT VALS
TREATMENT	1.374108E+07				
		5	2748216	31.67111	2.6
BLOCK	527568	5	105513.6	1.215964	2.6
ERROR	2169340	25	86773.6		
TOTAL	1.643799E+07				
		35			

STANDARD ERROR OF A VARIETAL MEAN = 131.7373

LSD(0.05) = 350.3486

LSD(0.10) = 290.4832

ANOVA SIGNIFICANT -- ALL TREATMENT MEANS NOT EQUAL

ANOVA NOT SIGNIFICANT -- ALL REPLICATION MEANS STATISTICALLY EQUAL

FILE SAVED IN FILE : SCLNMY89.ANV

ORIGINAL DATA STATISTICS

TR NO TREATMENT NAME

1 CLONE #9737-2
2 CLONE #7145
3 CLONE #9036-3
4 CLONE #7107
5 CLONE #10108-1
6 CLONE #9048-1

MEAN	STD DEV
1615	362.2883
1656.333	252.8622
1763.667	258.992
471.5	234.7788
1365.833	460.6899
181.5	98.77601

BLOCK NO

MEAN

1 1252.667
2 1401.167
3 1171.333
4 1092.167
5 1091.5
6 1045

Duncan's New Multiple Range Comparison Table

1763.67 1656.33 1615.00 1365.83 471.50 181.50

a a a a b b

PSI SELVA CLONAL/BORINA RANCH/WT/GRMS/MARKET

JUNE 1989

Printed on ==> 10-03-1993 @ 10:44:17

	SUM SQUARES	DEGREES FREEDOM	MEAN SQUARE	F RATIO	CRIT VALS
TREATMENT	2.521108E+07				
		5	5042215	99.94242	2.6
BLOCK	250088	5	50017.6	.9914056	2.6
ERROR	1261280	25	50451.2		
TOTAL	2.672244E+07				
		35			

STANDARD ERROR OF A VARIETAL MEAN = 100.4502

LSD(0.05) = 267.1421

LSD(0.10) = 221.4945

ANOVA SIGNIFICANT -- ALL TREATMENT MEANS NOT EQUAL

ANOVA NOT SIGNIFICANT -- ALL REPLICATION MEANS STATISTICALLY EQUAL

FILE SAVED IN FILE : SCLNJJN89.ANV

ORIGINAL DATA STATISTICS

TR NO TREATMENT NAME

1 CLONE #9737-2
2 CLONE #7145
3 CLONE #9036-3
4 CLONE #7107
5 CLONE #10108-1
6 CLONE #9048-1

MEAN	STD DEV
2520.5	233.6572
1502.333	376.5439
1345.833	220.0592
87	78.31985
1225.667	157.7047
136.8333	162.6732

BLOCK NO

MEAN

1 1164.5
2 1150.167
3 1287
4 1080.167
5 1015.5
6 1120.833

Duncan's New Multiple Range Comparison Table

2520.50 1502.33 1345.83 1225.67 136.83 87.00

a

b

b

b

c

c

PSI SELVA CLONAL/BORINA RANCH/WT/GRMS/MARKET

JULY 1989

Printed on ==> 10-03-1993 @ 11:07:18

	SUM SQUARES	DEGREES FREEDOM	MEAN SQUARE	F RATIO	CRIT VALS
TREATMENT	1.711138E+09	5	3.422276E+08		
				325.4203	2.6
BLOCK	4315648	5	863129.6	.82074	2.6
ERROR	2.62912E+07	25	1051648		
TOTAL	1.741745E+09	35			

STANDARD ERROR OF A VARIETAL MEAN = 458.6171

LSD(0.05) = 1219.668

LSD(0.10) = 1011.259

ANOVA SIGNIFICANT -- ALL TREATMENT MEANS NOT EQUAL

ANOVA NOT SIGNIFICANT -- ALL REPLICATION MEANS STATISTICALLY EQUAL

FILE SAVED IN FILE : SCLNJY89.ANV

ORIGINAL DATA STATISTICS

TR NO	TREATMENT NAME	MEAN	STD DEV
1	CLONE #9737-2	13486.67	1401.188
2	CLONE #7145	14660.17	1671.228
3	CLONE #9036-3	14383.83	1010.893
4	CLONE #7107	25.16667	40.89214
5	CLONE #10108-1	15810.67	583.6862
6	CLONE #9048-1	37	25.78372

BLOCK NO	MEAN
1	9884.333
2	9944.333
3	10183
4	9482
5	9114.667
6	9795.167

Duncan's New Multiple Range Comparison Table

%15810.67 %14660.17 %14383.83 %13486.67 37.00 25.17

a a
b b b
c c

PSI SELVA CLONAL/BORINA RANCH/WT/GRMS/MARKET
AUGUST 1989

Printed on ==> 10-03-1993 @ 11:07:57

	SUM	DEGREES	MEAN	F	CRIT VALS
	SQUARES	FREEDOM	SQUARE	RATIO	
TREATMENT	4.829316E+08	5	9.658632E+07	115.451	2.6
BLOCK	3105984	5	621196.8	.7425252	2.6
ERROR	2.091501E+07	25	836600.3		
TOTAL	5.069526E+08	35			

STANDARD ERROR OF A VARIETAL MEAN = 409.0478

LSD(0.05) = 1087.841

LSD(0.10) = 901.9578

ANOVA SIGNIFICANT -- ALL TREATMENT MEANS NOT EQUAL

ANOVA NOT SIGNIFICANT -- ALL REPLICATION MEANS STATISTICALLY EQUAL

FILE SAVED IN FILE : SCLNAG89.ANV

ORIGINAL DATA STATISTICS

TR NO	TREATMENT NAME	MEAN	STD DEV
1	CLONE #9737-2	8983.333	1542.93
2	CLONE #7145	7389.667	1024.629
3	CLONE #9036-3	8091.667	762.7737
4	CLONE #7107	218.5	154.7123
5	CLONE #10108-1	7282.5	865.498
6	CLONE #9048-1	295.5	137.4202

BLOCK NO	MEAN
1	5965.5
2	5075.5
3	5453.667
4	5382.833
5	5246.333
6	5137.333

Duncan's New Multiple Range Comparison Table

8983.33 8091.67 7389.67 7282.50 295.50 218.50

a a b b c c

PSI SELVA CLONAL/BORINA RANCH/WT/GRMS/MARKET
SEPTEMBER 1989

Printed on ==> 10-03-1993 @ 11:08:31

	SUM SQUARES	DEGREES FREEDOM	MEAN SQUARE	F RATIO	CRIT VALS
TREATMENT	3.437752E+08	5	6.875503E+07		
BLOCK	3392128	5	678425.6	178.8135	2.6
ERROR	9612672	25	384506.9	1.764404	2.6
TOTAL	3.5678E+08	35			

STANDARD ERROR OF A VARIETAL MEAN = 277.311

LSD(0.05) = 737.4943

LSD(0.10) = 611.4758

ANOVA SIGNIFICANT -- ALL TREATMENT MEANS NOT EQUAL
ANOVA NOT SIGNIFICANT -- ALL REPLICATION MEANS STATISTICALLY EQUAL

FILE SAVED IN FILE : SCLNSP89.ANV

ORIGINAL DATA STATISTICS

TR NO	TREATMENT NAME	MEAN	STD DEV
1	CLONE #9737-2	6463.333	628.8937
2	CLONE #7145	6345.167	1308.399
3	CLONE #9036-3	7166.5	544.3033
4	CLONE #7107	425	295.973
5	CLONE #10108-1	7643.667	319.5591
6	CLONE #9048-1	402.8333	87.12151

BLOCK NO	MEAN
1	4232.167
2	4677.833
3	5090.667
4	4961.667
5	4485.667
6	4998.5

+++++
Duncan's New Multiple Range Comparison Table
+++++

7643.67 7166.50 6463.33 6345.17 425.00 402.83

a a b b c c
b b c c

PSI SELVA CLONAL/BORINA RANCH/WT/GRMS/MARKET
OCTOBER 1989

Printed on ==> 10-03-1993 @ 11:09:13

	SUM SQUARES	DEGREES FREEDOM	MEAN SQUARE	F RATIO	CRIT VALS
TREATMENT	3.376657E+07	5	6753314	50.04163	2.6
BLOCK	1012608	5	202521.6	1.500672	2.6
ERROR	3373848	25	134953.9		
TOTAL	3.815302E+07	35			

STANDARD ERROR OF A VARIETAL MEAN = 164.2887

LSD(0.05) = 436.9174

LSD(0.10) = 362.2597

ANOVA SIGNIFICANT -- ALL TREATMENT MEANS NOT EQUAL
ANOVA NOT SIGNIFICANT -- ALL REPLICATION MEANS STATISTICALLY EQUAL

FILE SAVED IN FILE : SCLNOC89.ANV

ORIGINAL DATA STATISTICS

TR NO	TREATMENT NAME	MEAN	STD DEV
1	CLONE #9737-2	1953.333	296.1866
2	CLONE #7145	2220.167	727.158
3	CLONE #9036-3	2396	436.4649
4	CLONE #7107	81.33334	69.41373
5	CLONE #10108-1	2433.667	222.7415
6	CLONE #9048-1	380.8333	125.9784

BLOCK NO	MEAN
1	1219.167
2	1600.667
3	1572.833
4	1670.333
5	1718.5
6	1683.833

Duncan's New Multiple Range Comparison Table

2433.67	2396.00	2220.17	1953.33	380.83	81.33
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a	a	a	a	b	b
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PSI SELVA CLONAL/BORINA RANCH/WT/GRMS/MARKET

SEASON TOTAL (10-15-89)

Printed on ==> 10-03-1993 a 11:09:49

	SUM	DEGREES	MEAN	F	CRIT VALS
	SQUARES	FREEDOM	SQUARE	RATIO	
TREATMENT	9.616681E+09	5	1.923336E+09		
				411.2998	2.6
BLOCK	2.051072E+07	5	4102144	.8772314	2.6
ERROR	1.16906E+08	25	4676240		
TOTAL	9.754098E+09	35			

STANDARD ERROR OF A VARIETAL MEAN = 967.0822

LSD(0.05) = 2571.905

LSD(0.10) = 2132.434

ANOVA SIGNIFICANT -- ALL TREATMENT MEANS NOT EQUAL

ANOVA NOT SIGNIFICANT -- ALL REPLICATION MEANS STATISTICALLY EQUAL

FILE SAVED IN FILE : SCLNST89.ANV

ORIGINAL DATA STATISTICS

TR NO	TREATMENT NAME	MEAN	STD DEV
1	CLONE #9737-2	37371.83	2720.996
2	CLONE #7145	36326.17	3882.209
3	CLONE #9036-3	37548.5	1656.144
4	CLONE #7107	3766.333	496.9062
5	CLONE #10108-1	38395.5	1338.8
6	CLONE #9048-1	1801.167	475.5112

BLOCK NO	MEAN
1	26212.67
2	26129.83
3	26997
4	25661.67
5	24493
6	25715.33

Duncan's New Multiple Range Comparison Table

%38395.50 %37548.50 %37371.83 %36326.17 3766.33 1801.17

a a a a b b