T H E S I S

THE EFFECTS OF SOLUBLE SALTS AND SOIL MOISTURE ON CARNATION GROWTH AND QUALITY

Submitted by

John W. White

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WE HEREBY RECOMMEND THAT THE THESIS PREPARED UNDER OUR SUPERVISION BY JOHN W. WHITE ENTITLED THE EFFECTS OF SOLUBLE SALTS AND SOIL MOISTURE ON CARNATION GROWTH AND QUALITY BE ACCEPTED AS FULFILLING THIS PART OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCE.

Committee on Graduate Work

[redacted]

Major Professor

[redacted]

Head of Department

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Chapter I

INTRODUCTION

Of all the environmental factors that influence growth of greenhouse crops the one probably least understood by the commercial grower is the soil, and the nutrient balance connected with it. Many growers tend to overfertilize, which leads to an accumulation of fertilizer salts. In addition, some water supplies contain large amounts of salts which accumulate in greenhouse soils with continued irrigation.

Excess salts are known to affect the growth of many floricultural crops adversely by reducing plant height, flower size, and number of blooms. While carnations have been considered relatively tolerant to high salt conditions, recent studies indicate that both yield and the grade of blooms are significantly reduced at relatively low salt concentrations. Because of this recent work and a growing desire on the part of commercial carnation growers to know more about excess soluble salts, this investigation was designed.

Since soil moisture tension contributes to the total stresses put on plants, moisture levels covering the range usual to commercial carnation culture were incorporated in this investigation.

Chapter II

REVIEW OF LITERATURE

Recently production and research personnel in the field of floriculture have become concerned about soluble salts and their effects on floricultural plants. Experience with other agricultural crops has shown that plants grow best within certain ranges of concentrations of total salts in the soil moisture. These ranges have been determined for many agricultural crops (2,4,29), but not for all floricultural crops.

Experimental work conducted at the United States Salinity Laboratory, Riverside, California by Hayward and Spurr (10), Wadleigh and Ayers (28) and other workers has indicated that the rate of water uptake and growth of plants in saline soils is closely related to the osmotic pressure of the soil solution. Campbell and co-workers (6) found that in the range of electrical conductivity that will permit plant growth, the relation Osmotic Pressure = $0.36 \times EC_e \times 10^3$* can be used for estimating the osmotic pressure of soil solutions from conductivity measurements.

*Electrical conductivity of a saturation extract in millimhos per square centimeter.

Magistad and Reitmeier (21) reported that for a constant amount of salts, the concentration found in the soil solution at the wilting point is the maximum to which the plant will be subjected because of the general inverse relationship between concentration and moisture content. They also found that the relationship between plant growth and osmotic pressure of soil solutions was similar to and of the same order as that obtained in sand culture and solution culture experiments.

Wadleigh, Gauch and Strong (30) investigated root penetration and moisture extraction in saline soils by crop plants. They stated that as the salt content of the soil strata increased, the roots of various species showed a corresponding decrease in their ability to remove water. They also indicated that the supply of water available to the plant in the nonsaline or slightly saline part of the root zone is the main limiting factor to plant growth so far as salinity is concerned.

Eaton (7) concurred with the previous work and substantiated the conclusion that roots absorb more water from dilute than from concentrated salt solutions. Corn and tomato plants developed more roots in the dilute than in the concentrated solutions. The foregoing he found was irrespective of whether the differences in concentration were due to the addition of chloride or sulfate ions or additional nutrient salts. These findings indicated that osmotic pressure rather than specific ion effects were primarily involved.

Additional evidence presented by Wadleigh and Ayers (28) showed that plant growth was inhibited as the soil moisture tension at time of irrigation increased, even though in some of the treatments the soil moisture was always above the wilting range. The hyperbolic nature of the relationship between soil moisture percentage and moisture tension accounted for the findings that plants may not show changes in growth response while reducing the moisture percentage of the soil from field capacity to near the wilting percentage.

A study of the effects of soluble salts on plants must consider methods used in the determination of these salts on the soil moisture. In an experiment conducted by Schoonover, Wilhelm and Sciaroni (22), two greenhouse soils containing equal amounts of soluble salts were examined. One soil was sandy with a saturation percentage of 24 and the other a fine textured soil with a saturation percentage of 64. Saturation extracts of both gave conductivity readings of 8 mmhos/cm while a 1:2 suspension of the first gave 1.0 mmhos/cm and of the second, gave 4.5 mmhos/cm. By ordinary standards the first soil would have been considered safe and the second quite salty. Both were actually salty to the point that tender plants would have been damaged.

Further reasons for relying on the saturation extract as a measure of soil salinity are evident from data used by Wadleigh, Gauch and Kolisch (29) to determine the salt tolerance of orchard grass. In their experiment various methods of measuring soil salinity were used. They found that salinity estimates based on the conductivity of 1:1 and 1:5 extracts are convenient for rapid determinations, particularly if the amount of soil sample is limited, or when repeated samplings are to be made in the same soil to determine the change in salinity with time or treatment. However, the reliability of such estimates depends upon the kind of salts present. For chlorides, the results were only slightly affected by moisture content, but with sulfates or carbonates which have relatively low solubility, the apparent amount of soluble salts depends on the soil:water ratio.

The general effects of soluble salts on plants are many and vary with the crop and other environmental factors studied. Ahi and Powers (1) suggest that soluble salts may cause injury to plants by (1) preventing them from absorbing moisture, (2) causing a direct corrosive action or toxicity due to excess amounts of the salt or its ions or hydrolysis products, (3) inhibiting biological activities, (4) affecting germination, and (5) producing abnormal physical conditions in the soil.

Working with lettuce and tomatoes on a composted silt loam soil, Smith and Warren (23) used salts on an equal molar basis. Results of their experiments indicated that injurious amounts of various fertilizer salts, with the exception of sulfates, would be reflected in conductivities greater than approximately 2 mmhos/cm in a 1:2 soil water extract. With sulfate salts, injury did not occur until readings were above 3 mmhos/cm. Stunting of the plant was the chief symptom of excess soluble salts.

Work done by Wilhelm and Pyfrom (31) on _Gardenia jasminoides_ has shown that excessive accumulations of soluble salts in greenhouse soils usually can be traced either to excessive use of chemical fertilizers or to salts in the water supply. For _Gardenia_ these workers recommended holding the conductivity of the soil solution of a 1:2 extract below 1.5 mmhos/cm.

Data as to lists of the specific effects of soluble salts and the tolerance of floricultural crops to these salts are still in a very incomplete stage and leave much to be desired. Unpublished data by Kohl, Kofranek and Lunt (14) using _Saintpaulia ionantha_ indicated that they are rather sensitive to an increased total salt concentration in the soil solution. Growth as measured by fresh and dry weight of the tops increased to an optimum at a conductivity of about 0.58 mmhos/cm and showed a decrease at 0.76 mmhos/cm. Saintpaulias showed a high ability to accumulate sodium, especially in the older leaves. Sodium, chloride, sulfate, and calcium ions did not seem to exhibit specific toxic effects and at low nutrient concentrations, additions of sodium sulfate in moderate amounts increased growth.

Kofranek, Lunt and Kohl (15) studied *Euphorbia pulcherrima* growth as influenced by four solutions containing basic nutrients plus various amounts of calcium and sodium chloride. The effect of water high in boron was also studied. They reported that poinsettia pot plants are relatively sensitive to moderately high saline or boron levels. Plants grown at about 135 meq/l of salts abscised a majority of their leaves. Plant height and bract diameter were seriously reduced above this level and large quantities of chlorides were found to accumulate in the plant.

In a similar study with *Chrysanthemum morifolium*, Kofranek, Lunt and Hart (13) used nine salt treatments and, like other workers, started with a basic nutrient solution to which they added various fertilizer salts. The plants were grown in a loamy sand and the concentration of salts in the entire growing medium was adjusted to a reference level by nutrient solution additions every two to four days. These investigators summarize with the following statement:

> "Chrysanthemums of the Kramer variety are relatively tolerant to saline conditions when grown in sandy soil. Plant growth is satisfactory at EC_e of 6 mmhos per centimeter. Stem length is reduced but dry weight is not affected up to an EC_e of 6 if specific ion effects are not present. When salinity conditions are caused by an excess of ammonium or magnesium salts, stem length is greatly reduced. High levels of ammonia also greatly reduce the production of dry matter. The keeping quality of the blooms were adversely affected when all major nutrients were increased to high levels."

Concuring evidence was presented by Lunt, Kofranek and Hart (17) using Mathiola incana as the test plant. The exchange capacity of their soil was 6.0 meq/100 grams while the moisture content at field capacity was 10 per cent and at 15 atmospheres was 6 per cent. Using basically the same procedure as described by Kofranek and co-workers for poinsettias they found all varieties moderately salt tolerant. They also found that the basal leaves became chlorotic when grown in a soil with an EC_e of approximately 7 mmhos/cm and plants at that salt level were 25 to 30 per cent shorter than plants grown at an EC_e of around 2 mmhos/cm. Treatments had little or no effect on the dry weight or flowering date of the plants. The concentration of bases in plants grown at high salt levels was approximately 70 per cent greater than those grown at low salt levels. The tolerance of Mathiola to calcium and sodium chlorides appears to be related to the ability of the plant to accumulate appreciable quantities of sodium and chloride ions without suffering deleterious effects.

Lunt, Sciaroni and Bowles (18), working on general nutrition of carnations found that quality and yields of carnations are frequently reduced by salinity conditions resulting from overfertilization or improper irrigation practices. They advised growing carnations at EC_e values of less than 4 mmhos/centimeter.

Lunt and Kimball (16) report that for certain varieties of carnations, high salt levels reduced the number of blooms, but more frequently reduced flower size and stem length and caused development of chlorosis or even necrosis. They found that plant height decreases linearly with increases in soluble salts. They also found that by leaching the soil heavily when the variety Virginia Dare was being grown, (1) plant height was increased, (2) flower stem length was increased, (3) the quality response was good, and (4) no yield response was noted. Similar trials using the variety White Sim showed that (1) plant height was not increased, (2) flower stem length was increased, (3) there was a quality response and (4) there was a 17 per cent increase in yield. They concluded that leaching is the only practical method of removing excess salts from the soil. The amount of water necessary depends upon the kinds of ions present, the depth of the soil, the soil texture and permeability.

Lunt, Kohl, and Kofranek (19) tested the tolerance of carnations to saline conditions with treatments consisting of 60-120-180 meq/l of sodium chloride and calcium chloride plus 11 meq/l of a balanced nutrient solution. These investigators found that carnations will grow relatively well and produce fairly good quality blooms at very high soluble salt levels. Using 60 meq/l of equal amounts of sodium chloride and calcium chloride, they found a 71 per cent reduction in production and a 10 per cent reduction in grade. Their 60 meq/l treatment corresponded to an EC_e value of about 3.5 mmhos/cm of a saturated soil extract. They made no studies on the effect of salts on cut flower life.

They reported that carnations accumulate sodium and chloride ions and to a lesser extent calcium ions in the lower leaves of the plant. According to these workers, a more detailed study on specific salts will be required before it will be possible to show a general or a specific response to sodium, calcium or chloride. They conclude that it would be well to maintain EC_e values of saturated paste extract below 2.5 mmhos/cm.

Chapter III

METHODS AND PROCEDURE

Many investigators (7,9) feel that in greenhouses the problem of salt accumulation is greater than in the field due to frequent waterings, shallow soil, rapid evaporation, and year round concentrated production. To obtain information on the effect of various soluble salt and moisture levels on carnations grown in a greenhouse the following experiment was designed.

General procedure

Three greenhouse benches were separated by wooden dividers into 36 equal plots constructed in such a manner that intermixing of soil or soil water was at a minimum. The dimensions of each plot were 42 by 32 by 6 inches. A sandy loam soil was chosen to represent the major soil type used for carnation production in Colorado. This soil was obtained from the Table Mountain area near Golden, Colorado. In order to establish certain constants for reference, the soil tests shown in Table 1 were made.

Table 1.--BASIC SOIL TESTS.

Test	Method and reference	Result
Mechanical analysis	Hydrometer Bouyoucos (5)	16.5 per cent clay 18.0 per cent silt 65.5 per cent sand
Organic matter	Modified Walkley and Black:Smith and Weldon (24)	2.85 per cent
Saturation percentage	Volume of water added, Method 27b, Agricultural Handbook, No. 60 (26)	38.0 per cent
Exchange capacity	Chemical analysis, Method 19, Agricultural Handbook, No. 60 (26)	14.6 me per 100 g. soil
Moisture desorption curve	Oven dry weight compared with tensiometer readings	Fig. 1

Rooted carnation cuttings were planted at a spacing of 6 by 8 inches in all plots on June 13, 1956. As the plants became established the tops were broken out to promote lateral branching. Beginning on July 30, the terminals were removed from one-half of the lateral shoots. The employment of second pinching to give steady production was suggested by Holley (12) and involves "pinching" one-half or more of the original breaks as soon as they clear laterals. On June 20, plants of the

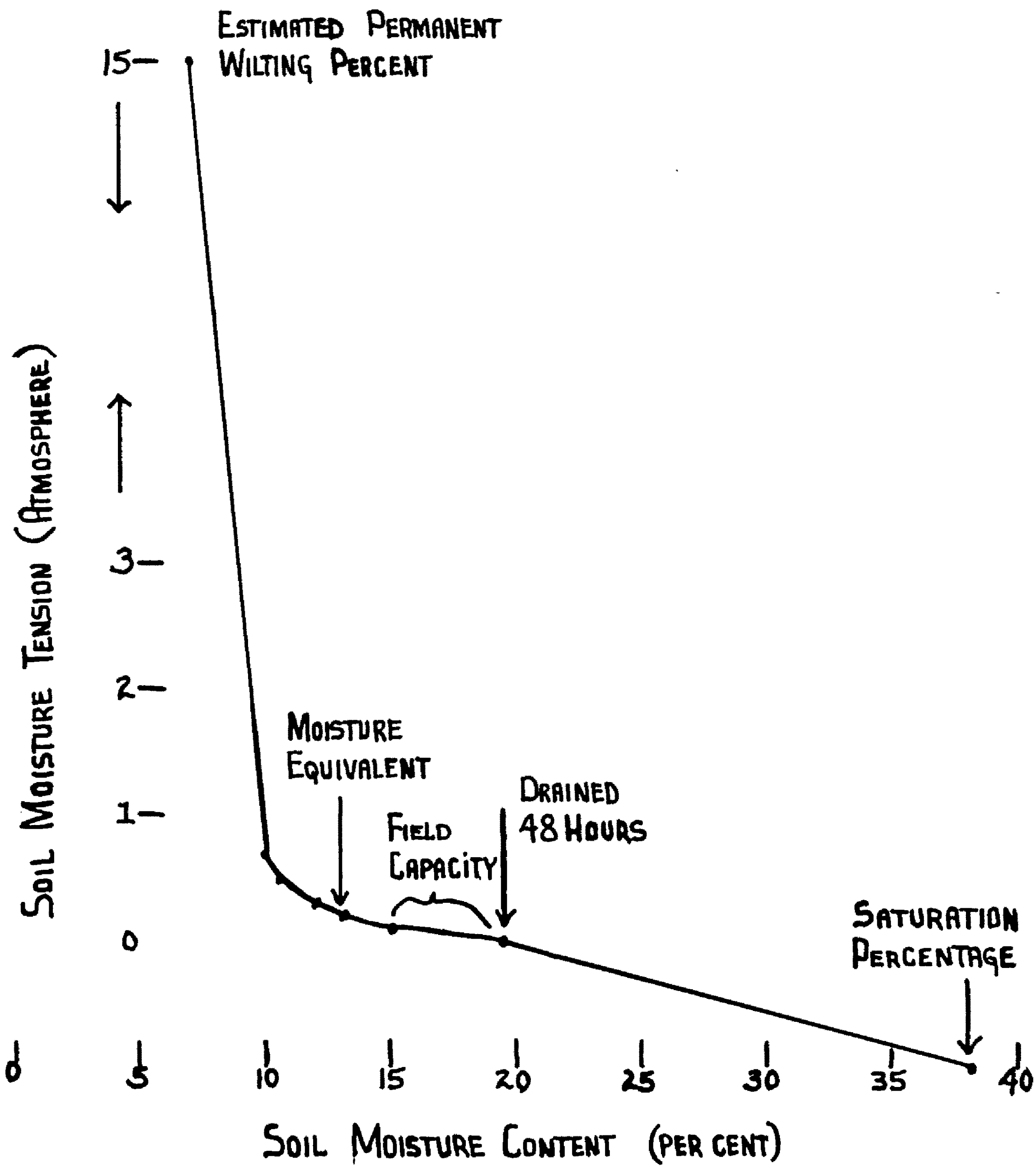


Fig. 1.--Moisture desorption curve.

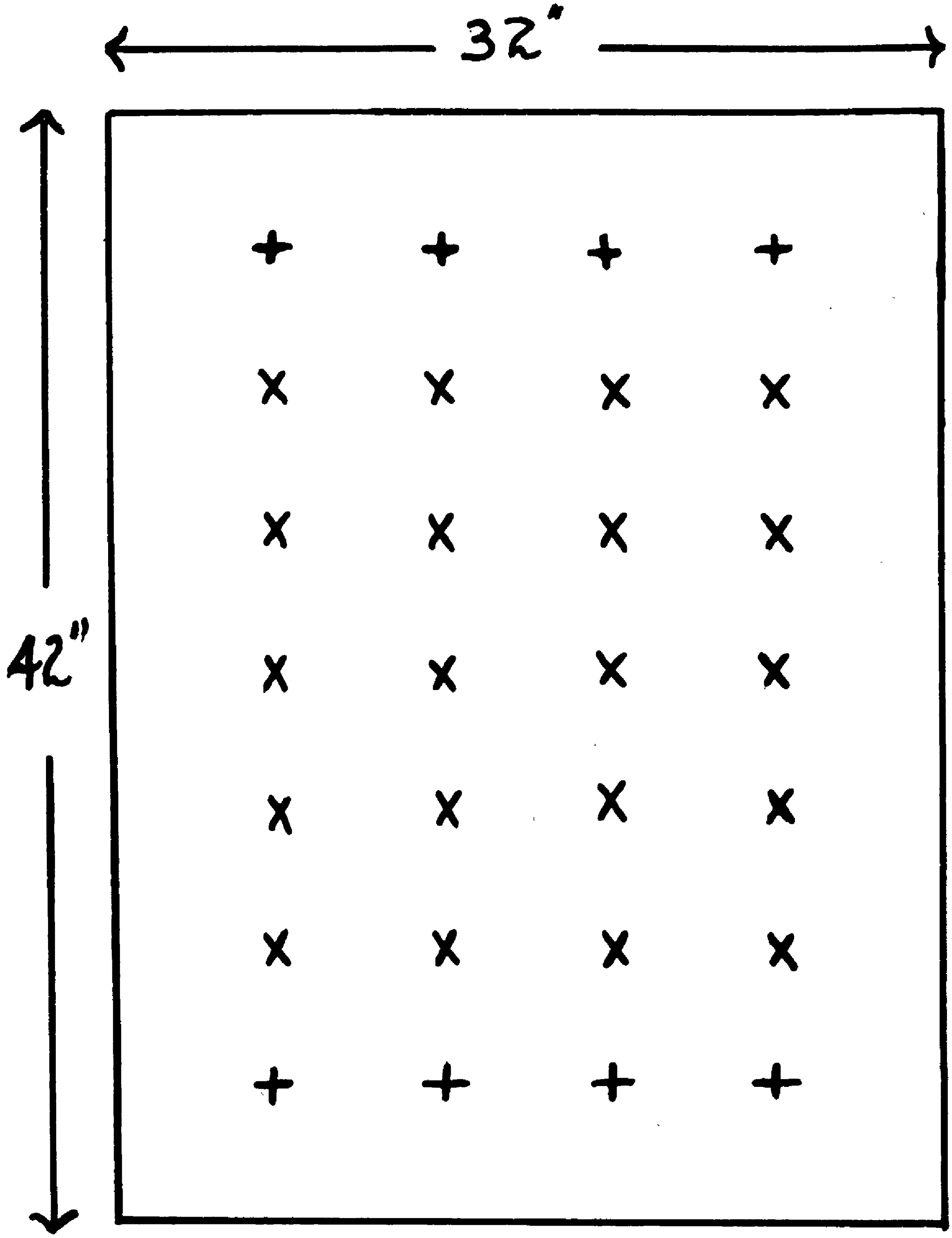


Fig. 2.--Position of test plants and buffer plants in each treatment plot.

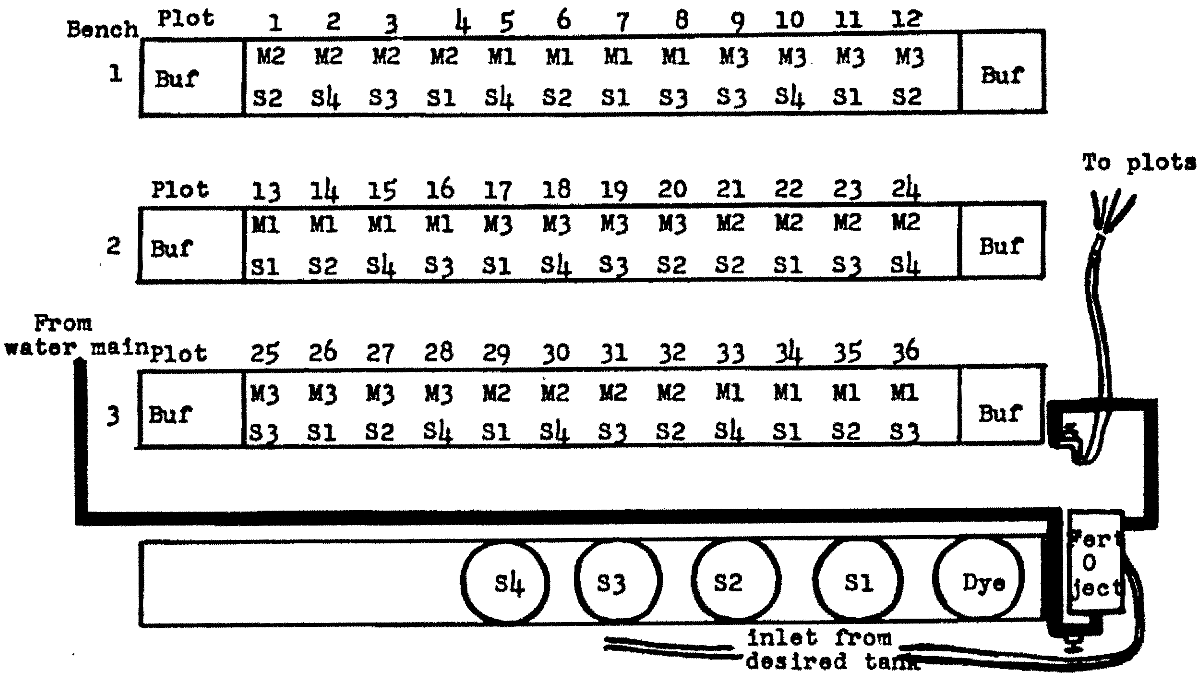
X Test plants --- White Sim

+ Buffer plants - Pink Sim

variety Brigadoon were transplanted from nursery beds to buffer plots on each end of the three benches.

Twenty-eight carnation cuttings, consisting of 20 test plants of the White Sim variety and eight buffer plants of the Pink Sim variety were used per plot. The position of test and buffer plants within each plot is shown in Fig. 2. The practice of using the outside rows in this manner to reduce the standard error per plot was suggested by Beach (3). The carnations were grown in a manner similar to that followed in commercial greenhouses with two exceptions: (1) various concentrations of chloride salts and various moisture levels were used, and (2) no mulch of any type was used on the soil surface. Optimum nutrient levels for quality carnation growth were maintained throughout the investigation.

Three soil moisture levels were arranged in a Latin square design. Within each moisture level, four soluble salt levels were arranged at random as shown in Fig. 3. The 12 treatments were replicated three times, making nine plots per salt level and 12 plots per soil moisture level. The plots were irrigated when the tensions reached 100, 300, and 500 centimeters of water measured by tensiometers placed in each plot. Tensiometers were so placed that the readings taken were consistent within and between plots for a given moisture level. These



Moisture levels maintained with tensiometers.
M1 - 100 centimeters of water tension
M2 - 300 centimeters of water tension
M3 - 500 centimeters of water tension

Concentrations of nutrients and soluble salts added in irrigation water.
S1 - Balanced nutrient solution - 11 meq/1
S2 - BNS + 10 meq/1 NaCl + 10 meq/1 $CaCl_2$
S3 - BNS + 20 meq/1 NaCl + 20 meq/1 $CaCl_2$
S4 - BNS + 30 meq/1 NaCl + 30 meq/1 $CaCl_2$

Fig. 3.--Position of the 12 plots within the three replicate benches; method of applying irrigation water; moisture levels and concentrations of nutrients and soluble salts added to the irrigation water.

moisture levels were chosen to encompass the moisture tensions normally used in commercial greenhouses. Moisture readings were made daily between 9 and 10 A.M. and plots registering the prescribed moisture tensions or higher were irrigated. The plots were thoroughly saturated during each irrigation.

<u>Application of irrigation water containing nutrients and soluble salts</u>

Beginning on July 18, soluble salts and nutrients were applied by injection into the irrigation water each time the plots were irrigated. The Fert-O-Ject proportioner model PR, a portable positive displacement type injector was used (Fig. 4). With this type of proportioner all of the irrigation water must pass through the water motor. The rate of injection is fixed so that regardless of the volume of water, the injection ratio remains the same. The proportioner machine used in this investigation was set to inject one gallon of stock solution per 34 gallons of water.

The method of applying irrigation water is shown diagramatically in Fig. 3. Four 20-gallon tanks were used for the stock solutions. A fifth tank containing malachite green solution was used as an indicator in determining when the irrigation line was clear of stock solution. A single irrigation house could be employed

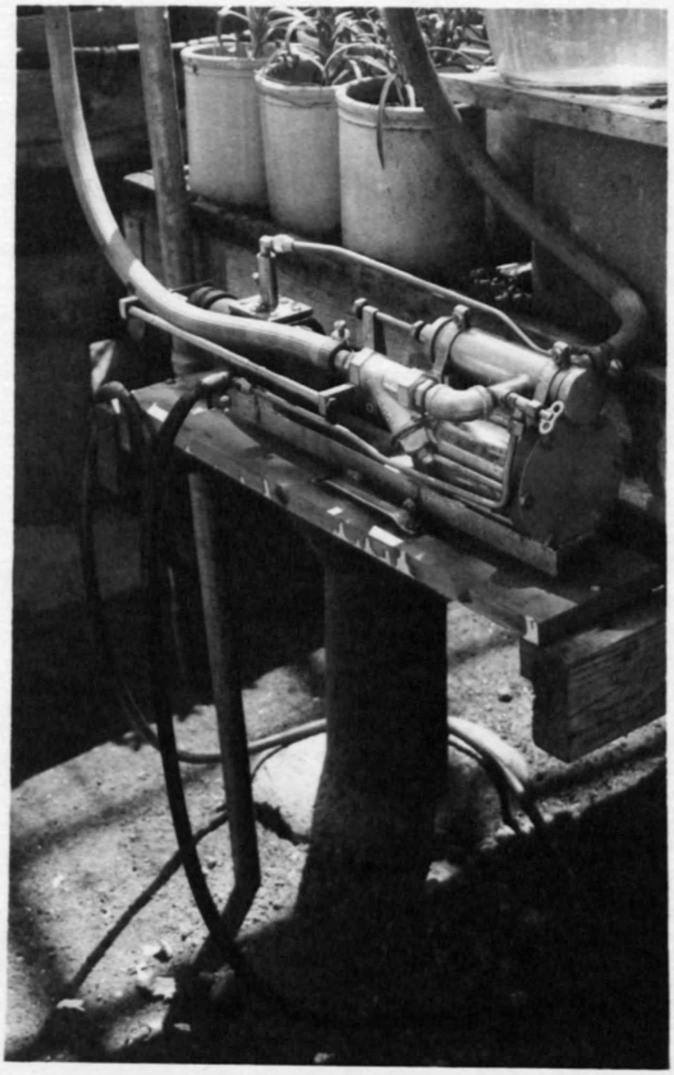


Fig. 4.--Fert-O-Ject proportioner machine.

for the addition of any of the stock solutions by changing the location of the solution intake line, flushing the line with dye solution, and refilling it with the next desired solution. The four stock solutions were prepared for injection into the irrigation water by adding the following salts in 20 gallons of water:

S1. Balanced nutrient solution (BNS) containing 1820 g. $Ca(NO_3)_2$, 95.3 g. $NaNO_3$, 476.7 g. KCl and 181.6 g. $MgSO_4$.

S2. BNS + 1477 g. NaCl + 1400 g. $CaCl_2$.

S3. BNS + 2953 g. NaCl + 2800 g. $CaCl_2$.

S4. BNS + 4430 g. NaCl + 4200 g. $CaCl_2$.

The treated irrigation water contained the concentrations of nutrients and soluble salts listed in Fig. 3. Due to their solubility, chloride salts were arbitrarily chosen for use in this investigation. The mean chloride levels maintained in these four groups were 35, 70, 140, 160 ppm, respectively.

Soil sampling

The soils in all plots were sampled and tested monthly. Samples of the entire depth from at least three locations within a plot were thoroughly mixed. After air drying, the samples were put through a 2 mm sieve in preparation for testing.

Preparation of soil extract

The soil extract was prepared by adding 13 ml of 0.018 N acetic acid to a level one-half teaspoon of soil. The solution was agitated for one minute and filtered. Using the Spurway (25) soil tests, the extracts were analyzed for nitrates, potassium, phosphorus, calcium, chlorides and sulphates.

Determination of soil reaction and specific conductance of a 5:1 extract

The soil reaction was determined by adding 10 grams of air dried soil to 50 ml of distilled water. This solution was stirred thoroughly for one minute, allowed to stand for 24 hours, stirred again and allowed to stand for one hour. The pH of the supernatant liquid was determined with the Bechman Model M Glass Electrode pH meter. The specific conductance of this 5:1 extract was measured by a Universal Solubridge, model RD-15, graduated to read in mhos 10^{-5} per centimeter, and equipped with a micro pipette type CEL G-2.

Determination of specific conductance by the saturation extract method (Fig. 5)

In preparing the soil pastes, based on the saturation percentage of this sandy loam soil, 66 grams of air dried soil was mixed with 25 ml of distilled water.

Fig. 5.--Suction filtering assembly used to make extracts of saturated soils.

The saturated soil pastes were stirred with a small spatula, and when thoroughly mixed, they displayed the following characteristics: (1) glistened as they reflected light, (2) flowed slightly when the container was tipped, (3) slid freely from the spatula, and (4) did not collect free water in surface depressions upon standing. The samples were allowed to stand for 30 minutes, stirred again, and allowed to stand for 3 hours. The saturated soil pastes were then placed in dry, clean Buchner funnels and filtered under slight vacuum. The specific conductance of the filtrate was determined by the use of the Solubridge.

Conductivity comparisons for 1:5 and saturation extracts were made for 108 soil samples during the course of this investigation. The straight line regression relation (Fig. 9) confirms work by Wadleigh, Gauch and Kolisch (29). These data show that an estimated saturation extract value can be obtained by multiplying a given 1:5 conductivity reading by ten. This multiplication factor, however, is less accurate in the lower conductivity range.

<u>Growth records</u>

The flowers were cut three times a week from September 30 to March 17 and graded on the basis of weight and stem length. A uniform procedure for cutting flowers was used to eliminate any possible variation resulting from the height of cutting. On the assumption that lower grades of flowers are less marketable in a competitive market, a mean grade was calculated by assigning the following numbers to the respective grades: five for fancy, four for standard, three for short and two for design. The number of flowers in each grade was multiplied by the number assigned to the grade. The sum of these products was divided by the total number of flowers in the lot to obtain a "quality index."

Measurement of cut flower life

To determine the keeping life of these experimental cut carnations, samples of five flowers from each plot were placed in containers of water of pH 7 ±0.2 and kept at a temperature of 68 ±2° F and 20-40 per cent relative humidity for the duration of testing interval. Flowers were considered to have reached the end of their useful life when the petals began curving inward, and loss of turgor was observed. The number of days of keeping life for each treatment was determined by finding the mean flower days for the three tests. Keeping trials of this type were conducted on January 18, February 15, and March 1, 1957.

Chapter IV

ANALYSIS OF DATA

This investigation was designed with fixed salt levels randomized within a Latin square for moisture levels. Due to fluctuations in the planned soluble salt levels, it was necessary to array them and to analyze the data from the standpoint of regression, correlation and covariance, rather than the conventional analysis of variance of a Latin square as originally planned.

The effects of position, moisture level, and soluble salt level on quality index, yield and mean cut flower life of White Sim carnation are presented in Table 2. The data in this table were used for all of the statistical computations made except for the miscellaneous tests. Scatter diagrams from these data (Fig. 6 and 7) show the trend of a unit change in salt level compared with a concomitant change in quality or yield. The data on these graphs indicate an inverse linear relation for the effect of salt on both yield and quality. However, because of a slight indication of deviation from linearity in the quality graph, Fig. 8 was prepared to show the effect of segregation of replicate positions.

Table 2.--THE EFFECTS OF POSITION, MOISTURE LEVEL, AND SALT LEVEL ON YIELD, QUALITY INDEX, AND MEAN CUT FLOWER LIFE OF WHITE SIM CARNATION.

Bench 1				Bench 2				Bench 3			
Mean/a salt level	Yield	Quality index	Mean days keeping	Mean salt level	Yield	Quality	Mean days keeping	Mean salt level	Yield	Quality	Mean days keeping
	Moisture 1				Moisture 1				Moisture 1		
25	114	4.43	10.1	44	101	4.11	8.7	44	113	4.33	9.9
45	120	4.09	9.7	63	113	3.75	10.6	70	116	4.01	10.3
86	106	4.03	10.3	105	117	3.19	9.0	122	113	3.83	9.9
117	97	3.90	9.1	124	98	3.34	9.3	123	92	3.74	9.4
Mean 68	109	4.11	9.8	84	107	3.60	9.4	90	109	3.98	9.9
Mean salt level	Moisture 2			Mean salt level	Moisture 2			Mean salt level	Moisture 2		
36	127	4.33	9.7	49	112	3.86	10.3	42	123	4.57	10.2
62	97	4.17	9.7	80	97	3.84	8.8	87	102	3.82	10.4
93	120	3.82	9.2	106	117	3.66	10.2	104	107	3.43	9.9
123	101	3.58	9.2	125	94	3.43	10.5	141	90	3.13	11.3
Mean 79	111	3.98	9.5	90	105	3.70	10.0	94	106	3.74	10.5
Mean salt level	Moisture 3			Mean salt level	Moisture 3			Mean salt level	Moisture 3		
59	101	4.36	10.6	35	127	3.94	10.6	50	112	4.16	10.3
59	100	4.34	10.8	89	112	3.82	10.4	94	116	3.99	10.7
94	95	3.94	10.9	99	100	3.43	9.0	101	98	3.77	9.2
98	103	3.74	9.7	121	100	2.91	9.6	119	83	3.30	9.8
Mean 78	100	4.10	10.5	86	110	3.53	9.9	91	102	3.81	10.0
Bench 1 Mean 75	107	4.06	9.9	Bench 2 Mean 87	107	3.61	9.8	Bench 3 Mean 91	105	3.84	10.1
Moisture 1 Mean 81	108	3.90	9.7	Moisture 2 Mean 87	107	3.80	10.0	Moisture 3 Mean 85	104	3.81	10.1

/a Salts expressed as ($K \times 10^5$) of a 1:5 soil water extract.

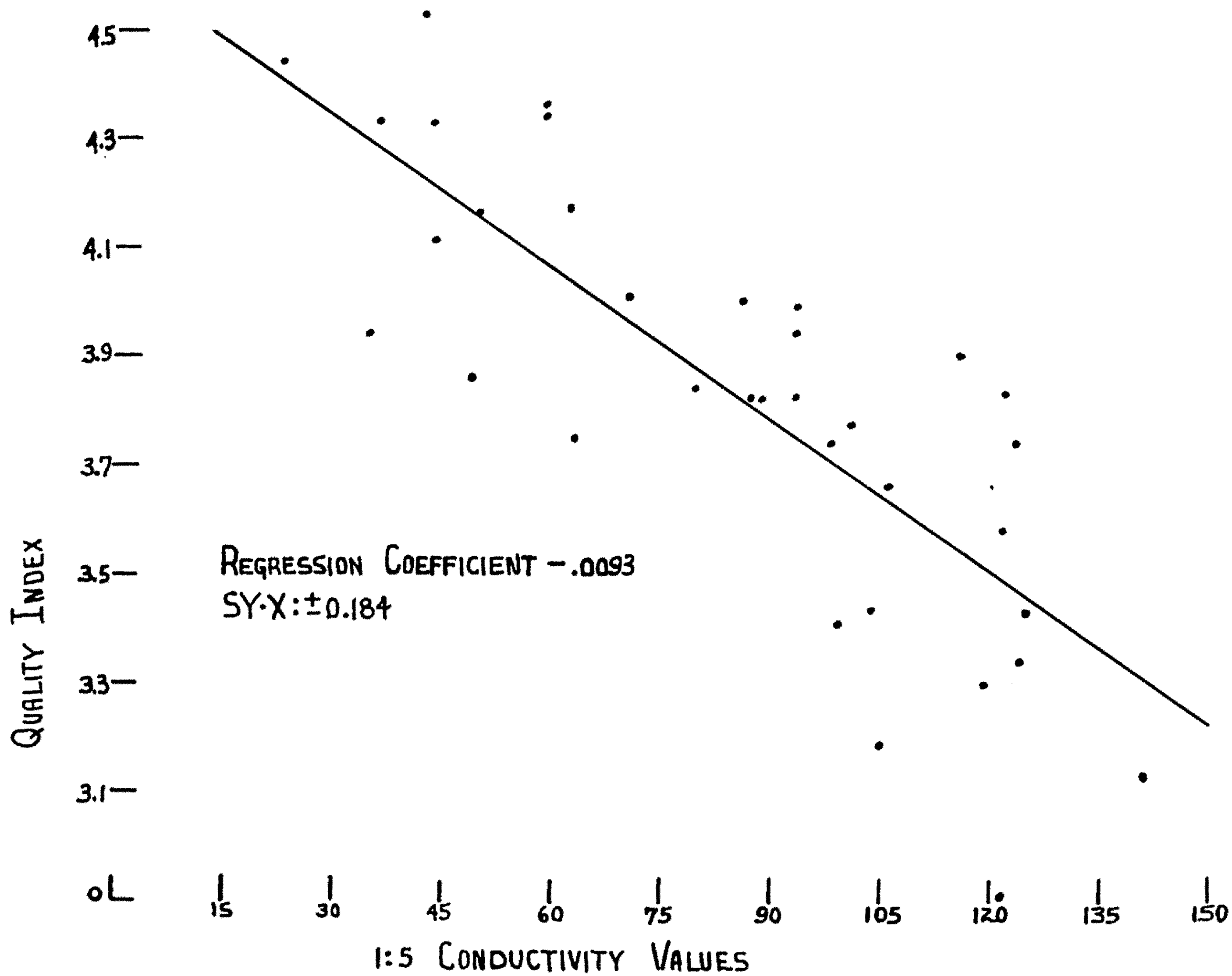


Fig. 6.--1:5 soluble salt specific conductance readings compared with the quality indexes of carnations.

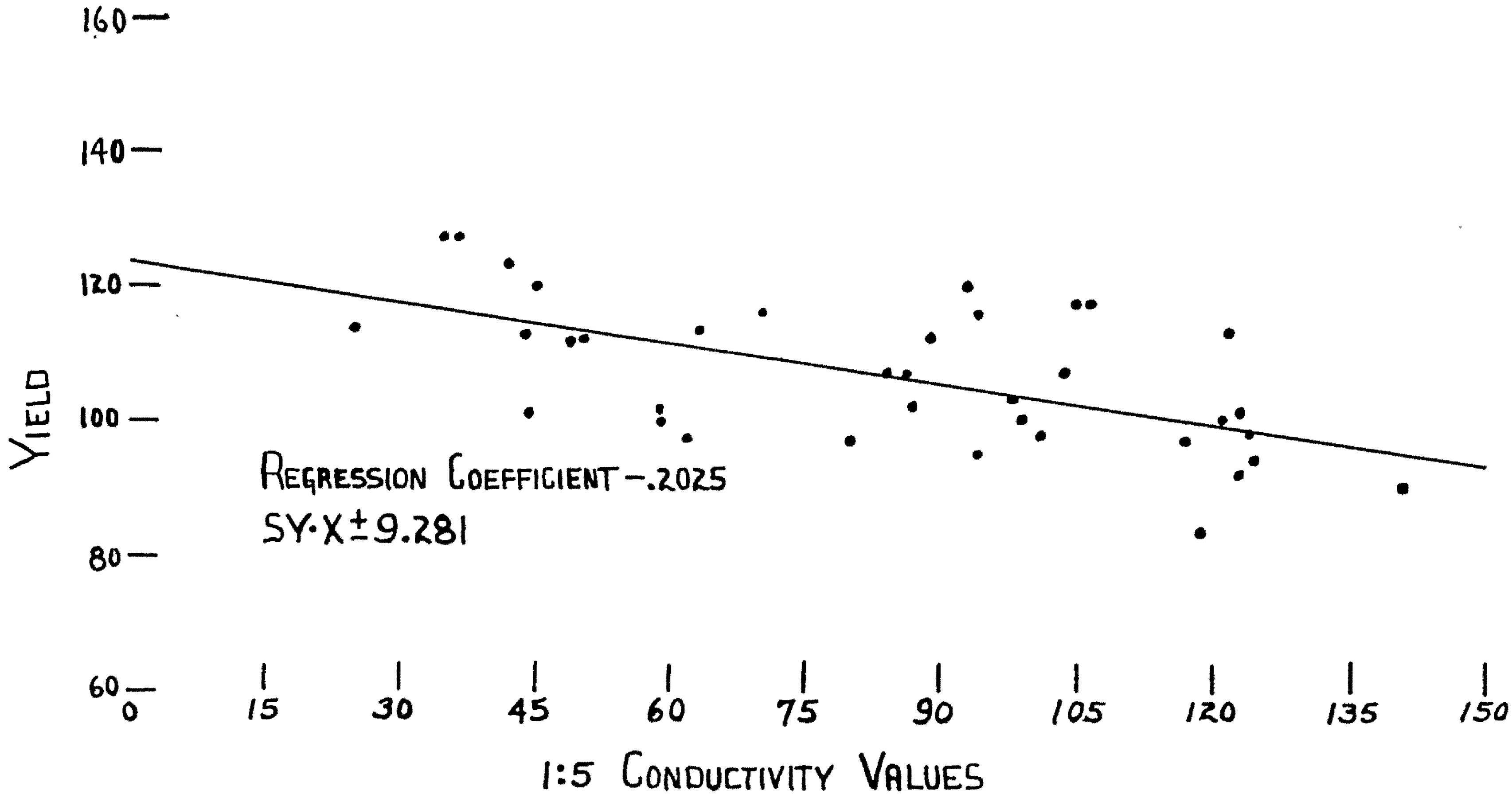


Fig. 7.--1:5 soluble salt specific conductance readings compared with the yield of carnations.

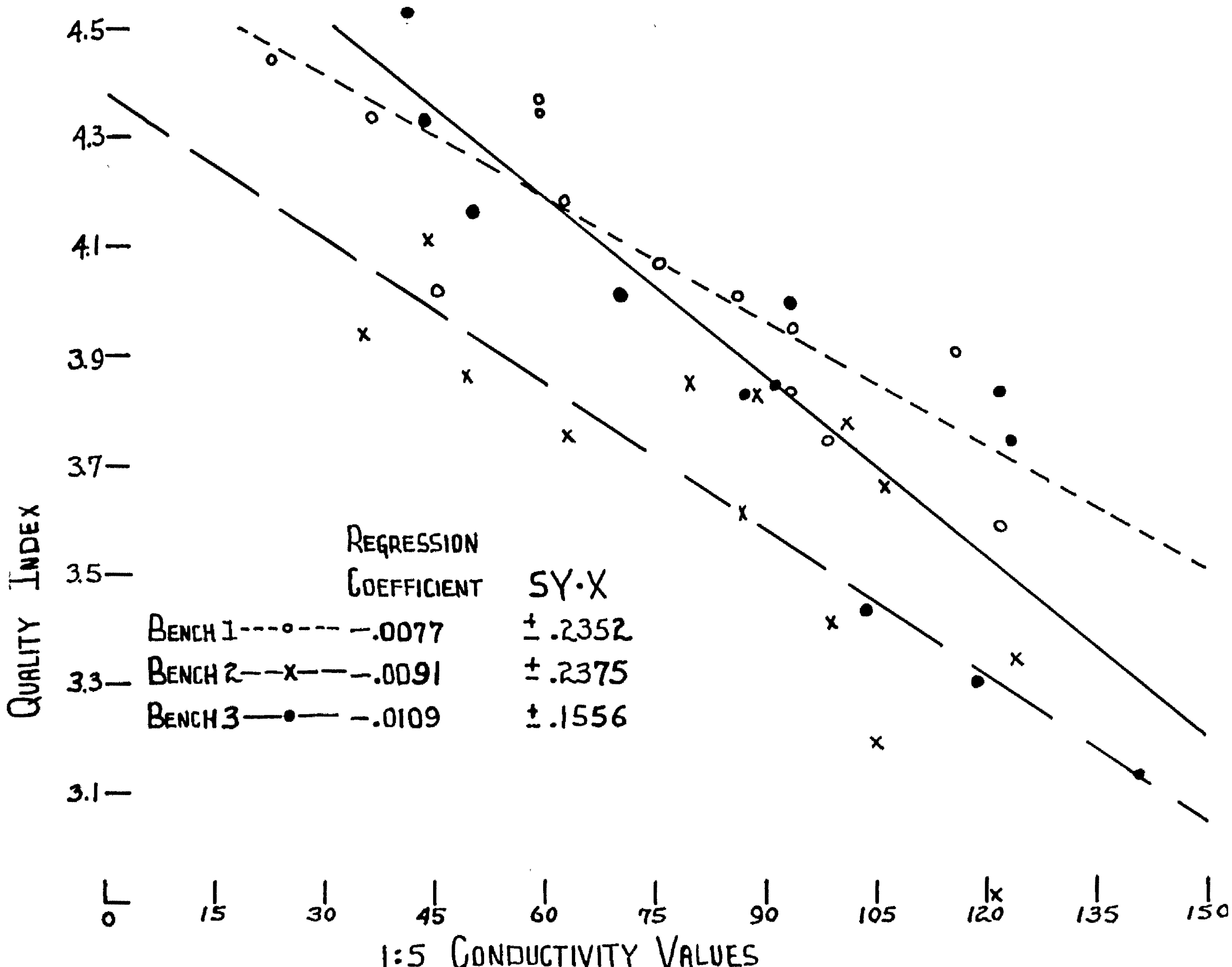


Fig. 8.--Scatter diagram and average regression lines of the effect of three bench locations on quality index of carnations for a range of soluble salt readings.

By grouping the data according to each bench, a new three level relation appeared which tended to remove the slight deviation from linearity that appeared in Fig. 6.

Assuming linearity, the average regression lines for quality index and yield were tested as shown in Tables 3A, 3B, and 3C. This test was used to determine whether the regression lines lay other than horizontal on the x abscissa. The F values for quality and yield were highly significant, which means that the departure from horizontal could have occurred by chance alone less than one time out of 100; or that there is a real effect of salt on quality and yield. The F test at the 5 per cent point for mean keeping life indicate weak evidence of a significant departure from horizontal. This means that the probability of soluble salts having any real effect on mean keeping life is very small for the moisture levels and positions used in this investigation.

Transposed on the scatter diagrams in Figs. 6 and 7 are the average regression lines based on data from Tables 3A, 3B and 3C and computed from the formula used to determine b, the regression coefficient:

$$b = \frac{Sxy - (Sx)\,(Sy)\,/\,N}{Sx^2 - (Sx)^2\,/\,N}$$

The regression lines formed by each combination of position and moisture level were tested for heterogenity

Table 3A.--TEST OF HETEROGENEITY OF REGRESSION BETWEEN TREATMENTS USING X FOR INDEPENDENT VARIABLE SALT, AND Y FOR DEPENDENT VARIABLE QUALITY INDEX.

b	Deviations due to regression b(Σxy)	Errors of estimate SS	Df	MS	F	5% level	1% level
-.0093	2.9715	0.8742	26	.0336	/b 87.4**	4.22	7.72
		0.4794	18	.0266	/a 1.857	2.51	
		0.3948	8	.0494			

Table 3B.--TEST OF HETEROGENEITY OF REGRESSION BETWEEN TREATMENTS USING X FOR INDEPENDENT VARIABLE SALT AND Y FOR DEPENDENT VARIABLE YIELD.

b	Deviations due to regression b(Σ xy)	Errors of estimate SS	Df	MS	F	5% level	1% level
-.2025	1409	2244	26	86.31	/b 16.32**	4.22	7.72
		1800	18	100.00	/a 0.555	2.51	
		444	8	55.50			

Table 3C.--TEST OF HETEROGENEITY OF REGRESSION BETWEEN TREATMENTS USING X FOR INDEPENDENT VARIABLE SALT AND Y FOR DEPENDENT VARIABLE KEEPING LIFE.

b	Deviations due to regression b(Σxy)	Errors of estimate SS	Df	MS	F	5% level	1% level
-.0037	0.481	9.869	26	0.3796	/b 1.27	4.22	-
		7.934	18	0.4408	/a 0.5488	2.51	
		1.935	8	0.5488			

/a Test hypothesis $\beta 1 \quad \beta 2 \quad \beta 3 \cdots\cdots \beta 9$

/b Test hypothesis β ave. 0

See appendix for computation tables of bench and moisture regression lines.

of regression as shown in Tables 3A, 3B and 3C. These tests were used to determine differences in the slope of the regression lines due to either moisture, position, or a combination of moisture and position. The F test shows very weak evidence of regression slope differences for bench, or moisture, or interactions, when considering soluble salts as an independent variable and quality index, or yield as dependent variables. This means that the effect of soluble salts on quality index and yield was the same for all moisture levels and benches. This test was not necessary for mean keeping life studies because of the lack of significant regression slope as previously indicated in Table 3C.

Covariance analysis to remove salt effect made on bench, moisture, and bench by moisture interactions, and their effects on quality index and yield are shown in Tables 4 and 5. The F values indicate weak evidence of any effect of moisture, bench, or interaction on yield. The F values also indicate weak evidence of any effect of moisture on quality index, however, there was a highly significant effect of bench - moisture interaction, and there was a significant bench effect on quality index. These F values mean that when moisture and position were considered independent of salts the probability of moisture, bench, or bench by moisture

Table 4.--ERRORS OF ESTIMATE FROM COVARIANCE ANALYSIS OF BENCH, MOISTURE, AND BENCH BY MOISTURE INTERACTION ON QUALITY INDEX INDEPENDENT OF SALT.

Source	Df	SS	MS	F	5% level
Bench x moisture ≠ moisture	5	22.755			
Bench x moisture (error)	3	16.267	5.422		
Adjusted moisture	2	6.488	3.244	0.599	9.55

Weak evidence of any moisture effect on quality.

Source	Df	SS	MS	F	1% level
Benches x moisture ≠ error	30	17.151			
Error	26	.874	.0336		
Adjusted bench x moisture	4	16.277	4.069	121.10**	4.14

Highly significant interaction effect on quality

Source	Df	SS	MS	F	1% level
Benches x moisture ≠ benches	5	140.048			
Benches x moisture (error)	3	16.267	5.422		
Adjusted benches	2	123.78	61.89	11.41*	30.82

Significant bench effect on quality

See appendix for complete covariance tables.

Table 5.--ERRORS OF ESTIMATE FROM COVARIANCE ANALYSIS OF BENCH, MOISTURE, AND BENCH BY MOISTURE INTERACTION EFFECTS ON YIELD, INDEPENDENT OF SALT EFFECT.

Source	Df	SS	MS	F	5% level
Bench x moisture ≠ moisture	5	426.44			
Bench x moisture (error)	3	299.37	97.79		
Adjusted moisture	2	127.07	63.54	0.6367	9.55

Weak evidence of any moisture effect on yield.

Source	Df	SS	MS	F	5% level
Bench x moisture ≠ error	30	3952.14			
Error	26	3653.14	140.51	0.5320	2.74
Adjusted bench x moisture	4	299.00	74.75		

Weak evidence of any bench x moisture effect on yield.

Source	Df	SS	MS	F	5% level
Bench x moisture ≠ bench	5	322.08			
Bench x moisture (error)	3	299.37	97.79	0.1161	9.55
Adjusted bench	2	22.71	11.35		

Weak evidence of any bench effect on yield.

See appendix for complete covariance tables.

Table 6.--ANALYSIS OF VARIANCE OF BENCH, MOISTURE, AND BENCH BY MOISTURE INTERACTION EFFECTS ON MEAN KEEPING LIFE WITHOUT CONSIDERING SALT AS A FACTOR.

Source	Df	SS	MS	F	5% level
Benches	2	77	38.5	.0596	19.25
Moisture	2	118	59.0	.0915	
Error	4	258	64.5		
Total	8	453			

Weak evidence of any bench or moisture effect on keeping.

Table 7.--REGRESSION COEFFICIENT AND ERRORS OF ESTIMATE FOR 1:5 ON SATURATION EXTRACT CONDUCTIVITY READINGS.

b	Deviations due to regression	Df	SS	MS	F	1% level
10.3	13,296,940	106	1,165,173	10,992	1210**	6.90

Highly significant regression for 1:5 on saturation extract conductivity comparisons.

interactions affecting yield, or moisture affecting quality index is very small, while there is a real effect of both bench and bench-moisture interaction on quality index.

An analysis of variance used to arrive at the F values shown in Table 6 was made on the effects of bench and moisture on the mean keeping life of the cut flowers. Salt was not considered as a factor in this test because of previous tests which showed no significant change in mean keeping life for a change in soluble salt level. The F values indicate weak evidence of any bench, moisture, or interaction effects on mean keeping life. This means that mean keeping life was not significantly affected by any of the salt levels, moisture levels, or positions used in this investigation.

A graphic comparison of results obtained with the 5:1 extract and the saturated soil extract method of estimating the salt content of the soil solution is presented in Fig. 9. Transposed on the scatter diagram is the average regression line determined from data shown in Table 7. The F value shows that there is a highly significant correlation between the two methods of estimating the salt content of the soil solution. All statistical computations were based on examples and theories presented by Goulden (8).

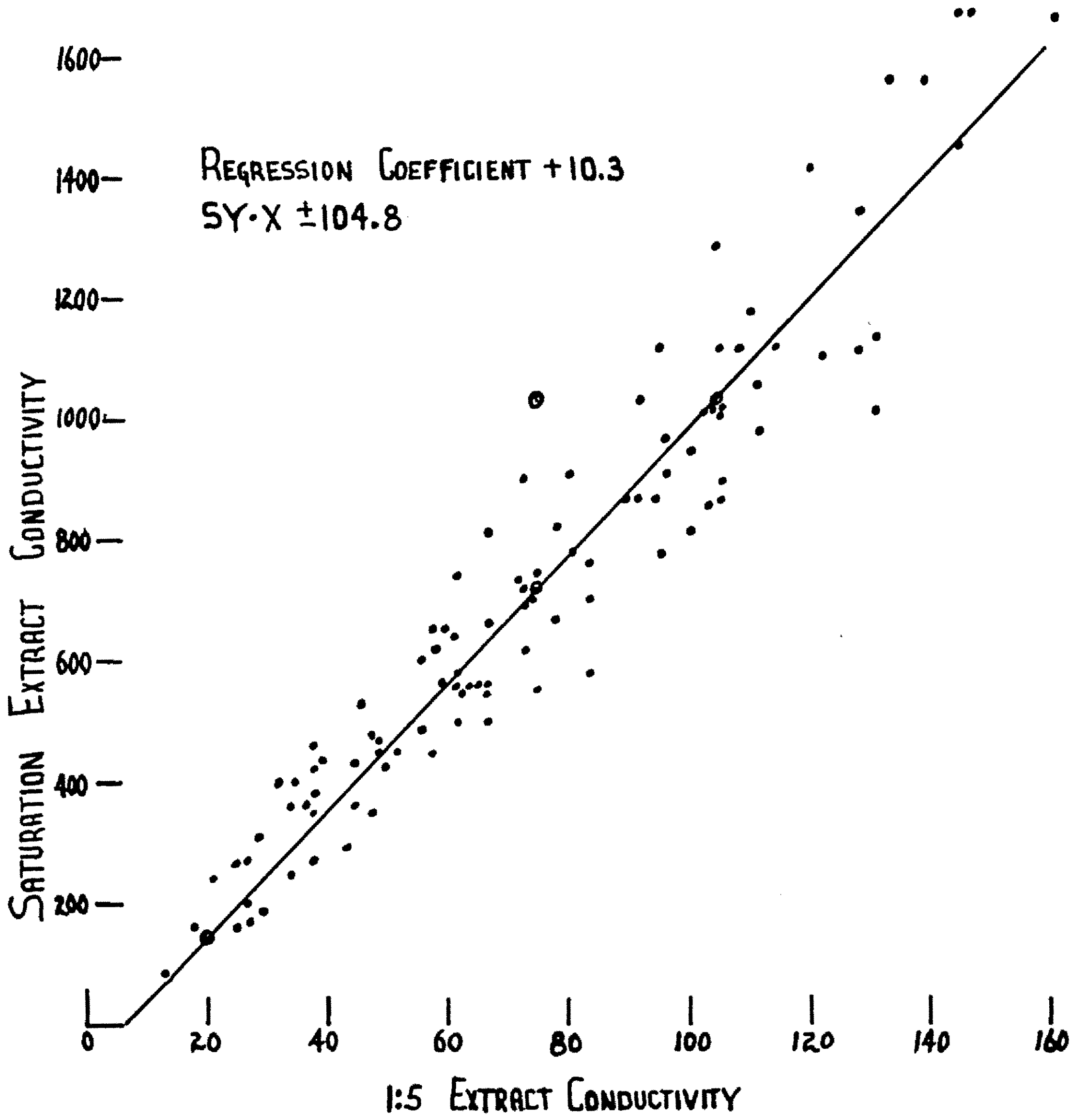


Fig. 9.--Comparison of 1:5 and saturation extract methods for estimating the specific conductivity of the soil solution.

Chapter V

DISCUSSION OF RESULTS

Salts are found in most irrigation water and are applied as fertilizers. An improper balance of nutrients and poor irrigation methods can allow these salts to build up to a concentration at which plant growth is seriously damaged. Carnation growth is restricted by moisture stresses above an optimum. Excess moisture stresses are thought to occur from the combined effect of osmotic pressure and moisture tension, or either one acting alone. In the following paragraphs, results of a study in which carnations were tested with various moisture stresses by combinations of moisture tension and soluble salt levels are discussed.

Although the addition of soluble salts by injection into the irrigation water is a convenient method of altering the total conductivity of the soil solution, the method did not lend itself well to the maintenance of fixed salt levels in the soil. Therefore data from this investigation were surveyed by the array of soluble salt levels rather than from fixed levels.

In Table 8 are presented the average salt levels (based on K x 10^5 conductivity readings of a 1:5 extract) maintained in the soil solution for each plot. These averages are based on seven months of irrigation using established moisture levels and applying the solutions S1, S2, S3 and S4 as indicated in Fig. 3.

Lunt and Kimball (16) point out that for certain varieties of carnations, high salt levels reduced the number of blooms, but more frequently reduced the flower size and stem length. They also found that height decreased linearly with increased soluble salts. The results presented in this thesis concur with the findings of the above workers. The mean grade of White Sim carnations grown in sandy loam soil decreased with an increase in soluble salt level (balanced nutrient solution plus various amounts of NaCl and $CaCl_2$ were used). Injury symptoms of the higher salt levels (90-140) were plainly visible and were characterized by stunting of the entire plant and reduced flower size (Fig. 10). To a lesser extent this was also true of the lower salt levels (30-90), but visible symptoms were not as plain. A straight line regression for the effect of salt on quality index was obtained as shown in Fig. 6. For each addition in soluble salts of 10 units of conductivity mean grade decreased 0.093 of a quality index unit.

Table 8.--AVERAGE SALT LEVELS BASED ON CONDUCTIVITIES ($K \times 10^5$) OF A 1:5 EXTRACT FOR EACH PLOT AFTER SEVEN MONTHS OF IRRIGATION.

Plot	M1 /a	Plot	M2	Plot	M3
1	25	4	36	17	35
13	44	29	42	26	50
34	44	22	49	11	59
6	45	1	62	12	59
14	63	21	80	20	89
35	70	32	87	10	94
8	86	3	93	27	94
16	105	31	104	9	98
5	117	23	106	19	99
36	122	2	123	25	101
33	123	24	125	28	119
15	124	30	141	18	121

/a M1 - 100 cm water tension
M2 - 300 cm water tension
M3 - 500 cm water tension

The standard deviation from the regression line is ± 0.184, which indicates that soluble salt conductivity readings can be used to predict a quality index response within the confines of this investigation.

Clearly evident is a tendency for yield to decrease with an increase in soluble salt level, but the standard deviation from regression (± 9.281) was high as shown in Fig. 7. For each addition in soluble salts of 10 conductivity units yield decreased 0.3 flower per square foot of bench area. On the basis of these data, one cannot accurately predict a yield response for a given soluble salt conductivity reading, although a general response could be expected.

Cut flower keeping life was not affected by the range of soluble salts used in this investigation. This is illustrated in Table 3C and by statistical tests which showed that for additions of soluble salt there was no change in cut flower keeping life. However, there is a suggestion of a salt effect on mean keeping life not brought out in the statistical analysis. The data in Table 2 indicate a trend for plants grown with lower salt levels to have longer cut flower keeping life. It is the opinion of the author that this effect would become more significant if more keeping life records were available.

High (120) Low (42) /a

Fig. 10.--Comparison of plant growth from two extremes of salt level.

/a Conductivity expressed as K x 10^5 of a 1:5 extract.

Moisture tensions used in this investigation did not significantly influence quality index, yield, or keeping life of the carnation flowers. This negative response can probably be attributed to the fact that the tensions used (100, 300, and 500 cm water) were probably all within the optimum range of moisture tension tolerated by carnations and also because moisture tensions made up a very small per cent of the total moisture stress (Table 19).

There was a salt-moisture interaction effect on quality and yield. That this interaction effect was due to salt alone was brought out when moisture was considered independent of salt (Tables 3A and 3B).

On the basis of reports from past workers with both carnations and other ornamentals and the added information gained from this study, it appears that total soluble salts should be maintained below ECe of 3.5 mmhos for White Sim carnations grown in a sandy loam soil, especially if chloride is thought to be the major anion.

Suggestions for further study

1. In light of a possible danger from unbalanced total soluble salt excesses and nutrient deficiencies it would be well to know more about plant response in the lower ranges of salts that were not encompassed in this study.

Table 9.--MOISTURE TENSION IN ATMOSPHERES EXPRESSED AS PER CENT OF TOTAL MOISTURE STRESS.

	Moisture tension /a atmospheres	Ostomic pressure from salts /b atmospheres	Total moisture stress of soil solution /c atmospheres	Per cent of total contributed to moisture tension
M1S1	0.1	1.08	2.36	4.2
M2S1	0.3	1.08	2.76	10.8
M3S1	0.5	1.08	3.16	15.8
M1S2	0.1	2.16	4.52	2.2
M2S2	0.3	2.16	4.92	6.1
M3S2	0.5	2.16	5.32	9.4
M1S3	0.1	3.24	6.68	1.5
M2S3	0.3	3.24	7.08	4.2
M3S3	0.5	3.24	7.48	6.7
M1S4	0.1	4.32	8.84	1.2
M2S4	0.3	4.32	9.24	3.2
M3S4	0.5	4.32	9.64	5.2

Based on conversion factors

/a 1 standard atmosphere = 1036 centimeters of water.

/b OP = 0.36 x ($EC_e \times 10^3$) based on saturation extract.
$EC_5 \times 10^5$ = ($EC_e \times 10 \times 10^3$)

/c OP at field capacity = OP saturation extract x 2 (approximation) (26).

M1 - 100 cm of water — S1 - 30 $EC_5 \times 10^5$

M2 - 300 cm of water — S2 - 60 $EC_5 \times 10^5$

M3 - 500 cm of water — S3 - 90 $EC_5 \times 10^5$

S4 -120 $EC_5 \times 10^5$

2. Because of the limitations imposed from the use of chloride salts, it would be well to know more about the effects of various specific ions and combinations of ions on carnation growth.

3. Experiments designed to explore the relative toxicity of various levels of balanced nutrient solutions would give the grower basic knowledge about his feeding program.

4. Laboratory techniques which involve the preparation of saturation extracts and field techniques which involve the addition of various salts should be developed and refined so that greater control may be had, and the personal equation reduced to a minimum.

Chapter VI

SUMMARY

White Sim carnations were grown for nine months in a sandy loam soil and subjected to soluble salts in such concentration as to give resultant conductivities of 25 to 141 ($K \times 10^5$) measured with a 1:5 soil extract. Basic nutrients were included in the soluble salts. Moisture tensions used were 100, 300 and 500 cm. of water. The cultural methods for growing these carnations were typical of those in use in Colorado.

Soluble salts affected both yield and grade according to an inverse linear relationship. For each addition in soluble salts of 10 ($K \times 10^5$) mean grade decreased 0.093 of a quality index unit and yield decreased 0.3 of a flower per square foot. Deviations from the regression line were high for yield responses and lower for the quality index values. Neither salt nor moisture levels significantly affected the cut flower life, however there was a trend for lower salt levels to produce flowers with greater keeping life. The moisture levels used did not significantly affect yield or mean grade.

It is suggested that for White Sim carnations grown in sandy loam soil, salt levels be maintained below

ECe of 3.5 millimhos per centimeter when chloride is a major constituent ion.

A comparison of 1:5 and saturation extract methods of estimating the conductivity of the soil solution showed a linear regression for a sandy loam soil. The 1:5 extract conductivity values for this soil can be multiplied by 10 for rough conversion to saturation extract conductivity values.

A P P E N D I X

APPENDIX LIST OF TABLES

Table A.--PROGRESSIVE SALT RECORD - 1:5 (K x 10^5).

Plot	Aug. 1 mo.	Sept. 2 mo.	Oct. 3 mo.	Nov. 4 mo.	Dec. 5 mo.	Jan. 6 mo.	Feb. 7 mo.	Mar. 1 ave. 7 mo.
1	45	73	101	78	60	50	25	62
2	97	157	168	137	121	106	73	123
3	75	81	146	123	105	62	60	93
4	22	40	49	31	37	43	27	36
5	112	95	185	143	129	75	81	117
6	49	54	62	47	39	38	25	45
7	36	27	18	31	29	18	13	25
8	78	92	114	84	75	106	52	86
9	86	94	157	105	72	92	81	98
10	36	97	85	146	146	60	90	94
11	43	29	48	106	73	49	64	59
12	50	45	75	56	67	67	54	59
13	41	41	58	60	34	38	34	44
14	52	62	76	95	58	56	45	63
15	119	129	213	142	105	92	67	124
16	74	114	160	151	84	73	78	105
17	28	37	49	48	32	27	27	35
18	72	108	157	162	162	112	134	121
19	72	116	132	132	129	49	62	99
20	75	72	108	118	112	72	67	89
21	36	52	101	118	73	95	84	80
22	36	54	39	84	45	48	34	49
23	73	101	114	146	106	103	101	106
24	106	125	179	146	96	115	106	125
25	73	94	123	118	96	106	97	101
26	39	37	50	76	62	56	29	50
27	60	83	103	106	106	73	58	84
28	83	123	168	140	132	78	109	119
29	38	54	41	36	50	58	35	42
30	101	125	213	168	148	112	123	141
31	64	116	132	123	146	58	92	104
32	64	74	112	109	106	62	84	87
33	125	132	213	125	140	62	67	123
34	43	36	52	71	65	21	20	44
35	62	69	92	87	74	46	63	70
36	90	121	157	157	134	101	97	122

Table B.--PROGRESSSIVE SALT RECORD - SATURATION EXTRACT.

Plot	Aug. 1 mo	Sept. 2 mo	Oct. 3 mo	Nov. 4 mo	Dec. 5 mo	Jan. 6 mo	Feb. 7 mo	Total	March 1 average 7 mo.
1	403	762	952	650	650	426	269	4112	588
2	896	1725	1792	1422	1423	1008	896	9162	1309
3	840	896	1456	1288	1290	582	560	6912	987
4	202	381	448	269	370	291	269	2230	319
5	1120	941	2016	1456	1345	549	784	8211	1173
6	493	347	650	470	415	347	157	2879	411
7	392	235	196	314	312	157	78	1684	241
8	784	896	1176	762	740	896	448	5702	815
9	896	885	1680	997	728	1030	907	7123	1018
10	347	896	952	1344	1458	560	874	6431	919
11	426	280	459	840	728	470	560	3763	534
12	504	504	896	470	660	806	560	4400	629
13	370	381	504	582	380	269	246	2732	390
14	493	672	840	784	616	493	358	4256	608
15	1187	1288	1926	1344	1008	874	504	8131	1162
16	706	1187	1456	1456	700	694	672	6871	982
17	202	381	403	381	404	202	168	2141	306
18	694	1120	1456	1568	1680	1060	1568	9146	1307
19	650	1232	1232	1322	1120	448	560	6564	938
20	650	616	1098	1086	1064	728	560	5802	829
21	420	538	896	1086	616	874	762	5192	742
22	493	515	336	773	426	347	358	3248	464
23	582	1120	1064	1344	1120	1008	952	7190	1027
24	896	1344	1658	1344	1142	1120	1120	8624	1232
25	436	840	1120	790	789	868	907	5750	821
26	314	280	470	650	504	602	179	2999	428
27	784	694	1008	874	1008	629	448	5445	778
28	784	1064	1456	1344	1120	824	1176	7768	1110
29	358	448	358	280	482	420	403	2749	393
30	1120	1120	2016	1512	1680	982	1120	9550	1364
31	683	952	1232	1232	1680	654	874	7307	1044
32	560	616	1053	986	1008	746	582	5551	793
33	1008	1120	1904	1064	1568	640	549	7853	1122
34	403	291	504	538	560	243	140	2679	383
35	650	672	918	694	695	533	549	4711	673
36	896	1098	1344	1400	1008	820	896	7462	1066

Table C.--TEST OF HETEROGENEITY OF REGRESSION BETWEEN TREATMENTS USING INDEPENDENT VARIABLE SALT FOR X AND INDEPENDENT VARIABLE QUALITY INDEX FOR Y.

Treatments	Df	ΣX^2	ΣXY	ΣY^2	b	b(Σxy)	Df	Y^2-(Σxy)	Df	MS
B1M1	3	5,103	- 25.03	.1533				.03065	2	
B1M2	3	4,269	- 38.16	.3441				.00448	2	
B1M3	3	1,377	- 19.27	.2803				.01245	2	
B2M1	3	4,082	- 42.56	.5183				.07568	2	
B2M2	3	3,262	- 18.05	.1197				.02042	2	
B2M3	3	4,004	- 43.04	.6465				.18167	2	
B3M1	3	4,627	- 29.42	.4165				.22821	2	
B3M2	3	5,061	- 75.50	1.1635				.03855	2	
B3M3	3	2,574	- 28.49	.2035				-.11274	2	
Totals	27	34,359	-319.52	3.8457	-.0093	2.9715	1	0.8742	26	.0336
								0.4794	18	.0266
								0.3948	8	.0494

Table D.--TEST OF HETEROGENEITY OF REGRESSION BETWEEN TREATMENTS USING INDEPENDENT VARIABLE SALT FOR X AND DEPENDENT VARIABLE YIELD FOR Y.

Treatments	Df	ΣX^2	ΣXY	ΣY^2	b	b(Σxy)	Df	Y^2-b(Σxy)	Df	MS
B1M1	3	5,103	-1,110	299				57.58	2	
B1M2	3	4,269	- 734	633				506.83	2	
B1M3	3	1,377	- 40	35				23.38	2	
B2M1	3	4,082	- 36	253				249.82	2	
B2M2	3	3,262	- 400	378				328.96	2	
B2M3	3	4,004	-1,341	452				2.90	2	
B3M1	3	4,627	- 758	369				244.84	2	
B3M2	3	5,061	-1,599	561				55.88	2	
B3M3	3	2,574	- 940	673				329.71	2	
Totals	27	34,359	-6,958	3,653	-.2025	1,409	1	2,244.00	26	86.31
								1,799.90	18	99.99
								444.10	8	55.50

Table E.--TEST OF HETEROGENEITY OF REGRESSION BETWEEN TREATMENTS USING INDEPENDENT VARIABLE SALT FOR X AND DEPENDENT VARIABLE KEEPING LIFE FOR Y.

Treatments	Df	ΣX^2	ΣXY	ΣY^2	b	b(Σxy)	Df	Y^2-b(Σxy)	Df	MS
B1M1	3	5,103	- 35.9	0.84				.5887		
B1M2	3	4,269	- 29.5	0.25				.0465		
B1M3	3	1,377	- 17.2	0.90				.6850		
B2M1	3	4,082	- 9.6	2.10				2.0770		
B2M2	3	3,262	20.4	1.81				1.6815		
B2M3	3	4,004	- 56.4	1.64				.8448		
B3M1	3	4,627	- 24.5	0.46				.3302		
B3M2	3	5,061	47.9	1.09				.6397		
B3M3	3	2,574	- 23.8	1.26				1.0410		
Total	27	34,359	-128.6	10.35	-.00374	.481	1	9,869	26	.3796
								7.934	18	.4408
								1.935	8	.5488

Table E.--RAW DATA COMPUTED FROM TREATMENT SUMS FOR QUALITY INDEX, YIELD, AND KEEPING LIFE USED FOR COVARIANCE ANALYSIS AND ANALYSIS OF VARIANCE STUDIES.

Moisture bench	Quality							
	M1		M2		M3		Total	
	X	Y	X	Y	X	Y	X	Y
B1	273	16.45	314	15.90	310	16.38	897	48.73
B2	336	14.39	360	14.79	344	14.10	1040	43.28
B3	359	15.91	374	14.95	364	15.22	1097	46.08
Total	968	46.75	1048	45.64	1018	45.70	3034	138.09
Mean	323	15.58	349	15.21	339	15.23	84	3.84

Moisture bench	Yield							
	M1		M2		M3		Total	
	X	Y	X	Y	X	Y	X	Y
B1	273	437	314	445	310	399	897	1281
B2	336	429	360	420	344	439	1040	1288
B3	359	434	374	422	364	409	1097	1265
Total	968	1300	1048	1287	1018	1247	3034	3834
Mean	323	433	349	429	339	416	84	106.5

Table F.--RAW DATA COMPUTED FROM TREATMENT SUMS FOR QUALITY INDEX, YIELD, AND KEEPING LIFE USED FOR COVARIANCE ANALYSIS AND ANALYSIS OF VARIANCE STUDIES.--Continued

	Keeping life				
	M1	M2	M3	Total	Mean
B1	39.2	37.8	42.0	119.0	39.7
B2	37.6	39.8	39.6	117.0	39.0
B3	39.5	41.8	40.0	121.3	40.4
Total	116.3	119.4	121.6	357.3	
Mean	38.8	39.8	40.5		

Table G.--ARRAY OF PLOTS 1-36 BY 1:5 SALT LEVELS (K x 10^5).

Plot	Salt	Yield	QI	Keeping life
7	25	114	4.43	10.1
17	35	127	3.94	10.6
4	36	127	4.33	9.7
29	42	123	4.57	10.2
34	44	113	4.33	9.9
13	44	101	4.11	8.7
6	45	120	4.09	9.7
22	49	112	3.86	10.3
26	50	112	4.16	10.3
12	59	96	4.36	10.6
11	59	100	4.34	10.8
1	62	97	4.17	9.7
14	63	113	3.75	10.6
35	70	116	4.01	10.3
21	80	97	3.84	8.8
8	86	106	4.03	10.3
32	87	102	3.82	10.4
20	89	112	3.82	10.4
3	93	120	3.82	9.2
27	94	116	3.99	10.7
10	94	95	3.94	10.9
9	98	103	3.74	9.7
19	99	100	3.43	9.0
25	101	98	3.77	9.2
31	104	107	3.43	9.9
16	105	117	3.19	9.0
23	106	117	3.66	10.2
5	117	97	3.90	9.1
28	119	83	3.30	9.8
18	121	100	2.91	9.6
36	122	113	3.83	9.9
33	123	92	3.74	9.4
2	123	101	3.58	9.2
15	124	98	3.34	9.3
24	125	94	3.43	10.5
30	141	90	3.13	11.3

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