COMPARATIVE RESPONSE OF TOMATO PLANTS TO NITROGEN RATES FROM UREA AND AMMONIUM NITRATE ON THREE SOIL TYPES

by
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1964

Submitted to the faculty of the Graduate School
of the Oklahoma State University in partial
fulfillment of the requirements
for the degree of
MASTER OF SCIENCE
May, 1965

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ACKNOWLEDGEMENT

During the course of this study the writer has had much help and guidance from several members of the faculty of the Oklahoma State University. He wishes to express grateful appreciation to Dr. J. Q. Lynd for his patient assistance and suggestions, in connection with this research study and in preparation of this thesis. Sincere thanks is also due to Dr. H. B. Cordner for his suggestions and criticism. Indebtedness is acknowledged to Mr. W. R. Kays, Head of Horticulture Department, for all his guidance, not only during the course of this study but also throughout his academic career.

A special thanks is due to Dr. Alexander Perumal for his constant guidance and encouragement.

Dedicated to
my parents

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CHAPTER I

INTRODUCTION

The effects of nitrogen fertilization on tomatoes is of major concern. Maximum production of high quality tomatoes cannot be achieved without an adequate supply of nitrogen. Oklahoma soils, in general, are deficient in organic matter and the problem of soil nitrogen is directly related to the status of soil organic matter. High levels of nitrogen fertilization are necessary for good production of tomatoes on most soils. Many sources of nitrogenous fertilizers are available and relative response of this crop is variable on different soils to those fertilizers.

The objective of this study was to determine the response of tomato plants to various rates and kinds of nitrogenous carriers on three soil types. A greenhouse experiment was used to obtain information on the dry weight and nitrogen content of tomato plants as influenced by levels of nitrogen supplied as urea and ammonium nitrate with phosphorus and potassium fertilization.

CHAPTER II

LITERATURE REVIEW

Few investigators have studied the effects of urea as a source of nitrogen for tomato plants in comparison to other nitrogenous fertilizers. Some investigations have been made on the use of urea as a foliage spray on horticultural crops. Lipman and McLean (15)* evaluated the effects of some of the newer nitrogenous fertilizer materials. Among these materials, ammonium phosphate, ammonium chloride and urea gave promise of usefulness. The high nitrogen content, nontoxicity and suitability for mixing with a wide number of fertilizer materials make urea particularly desirable among the synthetic nitrogen products.

Proebsting (23) also evaluated various commercial nitrogen materials and stated that urea and ammonia solutions have the advantages of: ease of application, no residue, high nitrogen percentage and are not fixed if irrigated before conversion to ammonium carbonate.

In Germany, (1) tests were conducted with ten different fertilizers on rye, potatoes, tobacco, and sugarbeets. They found that urea was best suited followed by ammonium nitrate, ammonium sulfate, and sodium nitrate. Urea gave the highest yield of potatoes and was recommended where cost permitted its use. In the United States (1) pot experiments with barley, rape, and sorghum showed that in all cases the use of urea resulted in better yields than ammonium sulfate.

*Figures in parenthesis refer to "Literature Cited".

Cooley (7) reported that a 1500 pound per acre application of fertilizer deriving half of the nitrogen from nitrate of soda and other half from cottonseed meal gave the highest yield per acre of tomatoes while urea and calcium nitrate, at the same rates, gave very good results.

Workers at the Georgia Coastal Plains Experiment Station (27) reported that fertilizer in which half of the nitrogen was derived from sodium nitrate, and other half from cottonseed meal was first in production of marketable tomatoes; cottonseed meal was second; and urea third. In 1933 and 1934, the Station reported similar results in their search for a use of ammonia for fertilization of tomatoes (28, 29).

It has been observed that urea is not a very good form of nitrogen for pasture plants. Burton and DeVane (3) reported relative yields of Bermuda grass with different sources and showed that urea was an inferior form of nitrogen for pasture plants.

Studies (10) have shown that urea applications at the higher rate (100 to 400 pounds per acre) increased the tomato tops than at the lower rates (50 to 100 pounds per acre). Total nitrogen uptake was influenced by the rate of nitrogen application.

Labanauskas et.al. (14) worked with orange trees and reported that urea alone at the rate of three pounds of nitrogen per tree per year increased yield and growth of trees appreciably over the check. Soil pH was not significantly affected. Urea treatments significantly increased manganese and iron concentrations in the leaves, whereas zinc, copper, and boron content of the leaves was unaffected.

Applications of urea and ammonium nitrate have somewhat varied effects on the pH of the surface soil and the subsoil. It was reported that where the heavy application of ammonium nitrate had been used for two years, the surface soil was more acid than where urea had been used at the same rate. For subsoil, the acidity was consistently less where urea was used than where ammonium nitrate was the source (30).

Wander (32) concluded that low soil pH is a serious problem in soils. In some cases deliberate selection of nitrogen sources to help prevent the development of low soil pH is desirable.

Volk (31) stated that urea is a physiologically alkaline form of ammonia. It is converted to ammonium carbonate by urease, an enzyme, which usually is available in abundance with microbial activity. Ammonium carbonate is unstable and releases ammonia which escapes to the atmosphere unless an effective ammonia absorbing mechanism such as soil cation exchange is present. The conversion of urea to ammonia is considered to be the result of the combined action of the urease enzyme accumulated in the soil and the activity of the microorganisms.

Conrad and Adams (6) showed that adsorbtion and thermolabile catalysis are perhaps largely responsible for the retention of nitrogen from urea by untreated soils.

In another investigation, Conrad (5) reported that cropping and cultural practices which added organic matter to the soil usually resulted in high catalytic activity especially in the surface soil. Practices which tended to deplete organic matter resulted in a lower and a more nearly constant activity.

Investigations on the effects of urea as a foliage spray have been less encouraging. Investigations undertaken at the Geneva Station in New York to determine the effectiveness of foliar sprays in supplying needed elements to vegetable canning crops indicated that nutritional sprays can be best used for overcoming acute deficiency symptoms (16).

Weinberger et.al. (33) concluded from his experiment that spray application of urea to foliage of peach trees was not effective to any significant degree.

Fleming and Alderfer (9) from their work on urea concluded that a urea containing spray failed to improve vigor or yield in either cultivated or Ladino clover sod block of a Concord grape vineyard. However, they suggested that such applications of urea may be beneficial where nitrogen deficiency exists.

Fisher et.al. (8) reported that urea sprays on apple trees resulted in slightly better fruit color than from soil application. Midsummer sprays of urea tended to increase the size of the fruit, but they also markedly reduced fruit color.

Montelaro, Hall and Jamison (16) tested urea sprays on field grown tomatoes at planting time and observed that plants during the early stages of growth responded more slowly to urea sprays at rates of 20-80 pounds per acre, than to soil applications of sodium nitrate at the same rates. When compared to side dressing with sodium nitrate, urea sprays did not significantly increase or decrease earliness of maturity, total weight or number of fruits harvested.

Cifferi (4) comparing the effects of urea and ammonium nitrate noted that when roots or leaves of tomato plants were immersed into 0.1 percent nitrogen solution of urea or ammonium nitrate, in Shive solution, gave a maximum growth with urea and absorption through the leaves which was superior to the ammonium nitrate absorption by either path and to urea intake by the roots.

Issacs and Hester (12) reported that urea spray with a suitable wetting agent applied to the foliage in the regular spray program for control of insects and disease proved very effective in supplying nitrogen to certain vegetable crops. Urea and ammonium nitrate in equal amounts can be used for certain vegetable crops at a greater concentration than either material alone.

The result of spray application of urea to foliage has not been very encouraging. The results in some cases are positive but they may have been, as pointed out by Hamilton et al. (11) due to other reasons. One proposal is that the spray material being very soluble may have washed to the ground due to rain and entered the plants through the roots. This statement cannot be supported strongly since the amount applied to each tree or plant was very low.

Ozaki and Carew (20) indicated that urea added to certain pesticidal sprays will be utilized by nitrogen deficient tomato and bean plants. Urea may be applied to plants as spray when soil applications are not feasible. Sucrose added to urea treatments prevented urea injury to the plants but it also reduced total fresh weight.

Urea spray, when used in high concentrations, has some injurious effects on the foliage. Mixing urea with other substances tends to reduce the injury to foliage. Montelaro et al. (17) tested a number of materials and discovered that sucrose and magnesium sulfate reduced the injury brought about by 0.3-0.5 M solutions of urea. The same authors (18) in another paper reported that an application of magnesium sulfate with urea sprayed on tomato leaves reduced the intake of urea from approximately 29 percent (urea alone) to approximately 6 percent (urea plus magnesium sulfate).

Klinker and Emmert (13) showed that 3 foliage sprays of urea, at 12.5 pounds and dextrose, at 44 pounds per 100 gallons of water produced a soluble nitrogen level in tomato plants equal to a side dressing of ammonium nitrate, at 200 pounds per acre. They concluded that foliage treatment is of practical value only as a supplement to soil applications of fertilizers.

CHAPTER III

METHODS AND MATERIALS

The objective of this experiment was to obtain information on the response of tomato plants to six levels of nitrogen application using two kinds of nitrogenous carriers. Determinations were made on the chemical composition and dry weight of Fireball variety of tomato plants grown on three soil types with these various nitrogen fertilization treatments.

Urea and ammonium nitrate were the two nitrogen carriers used. Reinach sandy loam from the Vegetable Research Station at Bixby; Bowie sandy loam from Idabel; and Norge sandy loam from the Experiment Station at Perkins were used in the study. The physical and chemical properties of the soils are presented in Table I.

Number 10 size tin cans were obtained and holes were punched in the bottom for drainage. The cans were lined with plastic bags which also had holes to allow for drainage.

Soils were first screened through a one fourth inch mesh screen and air-dried. Each can was filled with 4000 gms. of air dry soil. In case of Reinach soil, only 3800 gms. of air dry soil was placed in cans. This soil was fairly granular and the amount in cans was reduced to allow for sufficient space to permit watering. The fertility treatments were adjusted accordingly.

Either urea or ammonium nitrate was applied at levels of 0, 100, 200, 300, 400, and 500 ppm of nitrogen. Pots also received 200 ppm of phosphorus and potassium applied as potassium dihydrogen phosphate except for one check (no fertilizer) series with each soil.

TABLE I

SOME PHYSICAL AND CHEMICAL CHARACTERISTICS OF THE SOILS USED IN THE EXPERIMENT

	Reinach Sandy Loam	Bowie Sandy Loam	Norge Sandy Loam
Texture			
Sand %	62	74	74
Silt %	32	24	20
Clay %	6	2	6
pH	6.30	6.00	4.80
Organic Matter %	1.49	0.47	1.46
Total Exch. Capacity me/ 100g	8.05	4.45	5.50
Total Nitrogen %	0.16	0.063	0.15
Avail. Phosphorus lbs/ acre	11.77	4.38	5.96
Exchangeable Pottassium lbs/acre	280	160	480
Exchangeable Calcium lbs/acre	285	660	800
Exchangeable Magnesium lbs/acre	220	200	840

Following the fertilizer treatment, twenty tomato seeds (Fireball variety) were distributed in a circular pattern and covered with soil to a depth of one half inch. The cans were then watered to avoid splashing.

The design of the experiment was a randomized block design with three replications. There were two nitrogen carriers, three soil types, and six nitrogen rates which altogether involved one hundred and eight cans.

The experiment was carried out under a fiberglass covered section of the greenhouse on a ground bench where the day to night temperature was maintained between 60° and 75° F.

Following one week of growth the plants were thinned to ten per can. In some instances young seedlings had to be transplanted into certain cans in order to obtain a stand of ten plants. The plants were allowed to grow for six weeks during which time they were watered as needed. At the end of six weeks the plants were harvested just above the cotyledon scars on the stem. The harvested plants were oven dried in paper bags at 100° C for three days.

The dry weight of plant material was recorded and total nigrogen content determined by the Kjeldahl method.

Following the first harvest the plants in the cans were allowed to develop new growth. The plants began regrowth one week after the first harvest. Most of the plants had two lateral shoots emerge while some had only one. In some cases the plants died and were replaced by seedlings maintained in vermiculite. The second growth period was for seven weeks at which time the plants were harvested and dried as described for the previous harvest. Dry weights were recorded and the nitrogen content of the dry plants determined.

The data from both harvests were recorded, tabulated, and satistically analyzed. Comparisons were made between the two harvests, the various treatments, the three soils, and the two nitrogen carriers. The best nitrogen source for a given soil was determined on the basis of dry weight, nitrogen content, and the physical appearance of the plants.

Analysis of Soils

Samples from each of the three soils used in the greenhouse experiment were analysed. The results of the physical and chemical analysis are reported in Table I.

Soil texture was determined by the method of Bouyoucos (2). Soil pH was determined by the glass electrode method suggested by Peech and English (21). The exchange capacity was determined by the method described by Russell (24).

The available phosphorus was determined by the method of Olsen, Cole, Watanbe, and Dean (19). Exchangeable potassium, exchangeable calcium and exchangeable magensium were determined by the method described by Peech, Dean and Reed (22).

Statistical Analysis

Tomato plant yields and composition were analysed statistically. Analysis of variance of significant differences were determined by the methods outlined by Snedecor (25).

Analysis of Plants

Oven dried plants were ground through a 20 mesh screen and analysed for total nitrogen content by the use of Kjeldahl method (24).

CHAPTER IV

RESULTS AND DISCUSSION

Greenhouse experiments were conducted to determine the response of tomato plants to various nitrogen treatments from two nitrogen carriers. Three soil types, Norge sandy loam, Bowie sandy loam and Reinach sandy loam were used in the experiment and the response of tomato plants on these soils was recorded. The results reported are concerned with plant yield, nitrogen composition of plant and plant appearance as affected by various nitrogen treatment.

Plant Yield

Plant yield of both harvests are reported in Tables II and III. Individual pot yields are reported in Tables VI, VII, VIII and IX.

Yield results from the first harvest, reported in Table II, show no significant difference in yield due to the nitrogen treatments at various rates. Yield results do show a significant difference in replication at the 5% level. Yield results show a very high significant difference in case of soil types at both 5% and 1% level. Tomato plant yields were highest in case of Reinach soil while they were lowest in case of Norge soil. Significant difference in yield was not obtained by the use of two nitrogen carriers.

Results of tomato yields from the second harvest are reported in Table III. Significant difference in yield was not evident due to source of nitrogen treatment rates. There was a significant difference between the three soil types. Plants grown on Reinach soil had the highest yield while those grown on Norge soil had the lowest yield.

TABLE II

EFFECT OF UREA AND AMMONIUM NITRATE FERTILIZER TREATMENTS ON PLANT GROWTH OF FIRST HARVEST OF FIREBALL TOMATO PLANTS, ON THREE SOILS

	Urea					Ammonium Nitrate						
	ppm of Nitrogen Added With PK Treatment										PK	No
Soils	100	200	300	400	500	100	200	300	400	500	Only	Fertilizer
	gms.					gms.					gms.	
Reinach	8.64	9.38	9.40	10.26	8.09	10.90	9.52	9.60	10.68	9.47	8.84	7.85
Bowie	4.66	3.41	5.13	4.28	3.84	4.80	3.87	3.22	3.63	3.07	0.63	0.64
Norge	4.28	4.72	2.57	3.17	3.19	4.67	4.81	3.94	3.71	3.50	1.18	0.58

Each figure represents the mean of three replications. 200 ppm of P and 200 ppm of K added in PK treatment.

F values: Soils - 16.44 significant of 1% level.

TABLE III

EFFECT OF UREA AND AMMONIUM NITRATE FERTILIZER TREATMENTS ON PLANT GROWTH OF SECOND HARVEST OF FIREBALL TOMATO PLANTS, ON THREE SOILS

	Urea					Ammonium Nitrate						
	ppm of Nitrogen Added With PK Treatment										PK	Only
Soils	100	200	300	400	500	100	200	300	400	500	Only	Fertilizer
		gms.						gms.				gms.
Reinach	15.10	17.47	17.88	17.15	16.98	10.17	12.98	18.17	20.42	18.84	5.61	4.73
Bowie	7.44	18.15	16.22	19.46	13.78	13.28	13.26	16.43	13.16	16.95	7.50	4.58
Norge	11.09	11.40	10.35	9.18	6.02	9.12	12.33	11.89	10.40	10.20	5.07	4.72

Each figure represents the mean of three replications. 200 ppm of P and 200 ppm of K added in PK treatment.

F values: Replication - 3.23 significant at 5% level. Soils - 112.05 significant at 1% level.

Results from the two harvests show that plant yield was higher in second harvest than in the first. Plants grown on Reinach soil produced the greatest weight in both harvests. The F value for soil types was much higher in the first harvest than the second harvest. Replication differences showed significance in the first harvest at 5% level.

Nitrogen Percentage

Oven dried plants were analysed for total nitrogen by using the Kjedahl method. Results are presented in Tables IV and V for first and second harvests, respectively. Significant F values are also included with these tables. Individual pot results are reported in Tables XI, XII, XIII and XIV.

Plants of the first harvest showed a high nitrogen content. There were significant differences between the treatments as evidenced by the high F value. Percent nitrogen increased in plants as the rate of nitrogen increased. Plants grown in Norge soil showed a higher nitrogen percentage for all treatments followed by Bowie and Reinach soils. This was true for urea as a source of nitrogen but in the case of ammonium nitrate, plants grown on Bowie soil showed the least percent of nitrogen at 100 ppm instead of plants grown on Reinach soil (Figure 1). In Figure 2, the nitrogen content of the plants grown on Bowie soil was lowest at 100 ppm but was highest at 500 ppm than those grown on Reinach or Norge soils. In this case plants grown on Norge soil had a higher percent of nitrogen followed by those grown in Bowie and Reinach soils. Source of nitrogen did not show significant difference but soil type did.

In the second harvest, treatments resulted in significant differences. Percent nitrogen increased steadily with increasing nitrogen application as shown in figures 3 and 4. Soil types also showed significant difference with very high F value. Plants grown in Norge soil showed a higher percent

TABLE IV

EFFECT OF UREA AND AMMONIUM NITRATE FERTILIZER TREATMENTS ON PERCENT NITROGEN OF FIREBALL TOMATO PLANTS OF FIRST HARVEST, ON THREE SOILS

	Urea					Ammonium Nitrate						
	ppm Nitrogen Added With PK Treatment										PK	No
Soils	100	200	300	400	500	100	200	300	400	500	Only	Fertilizer
	% N					% N					% N	
Reinach	3.49	3.53	3.86	3.95	5.02	3.29	3.68	4.16	4.38	4.94	2.16	1.99
Bowie	3.98	4.23	4.16	4.66	4.65	2.59	4.27	4.56	4.97	5.87	2.58	2.64
Norge	4.11	4.52	5.02	5.35	5.68	3.80	5.01	5.06	5.22	5.72	2.77	2.73

Each figure represents average of three replications. 200 ppm of P and 200 ppm of K added in PK treatment.

F values: Soils - 26.40, Treatment - 31.20 significant at 1% level.

TABLE V

EFFECT OF UREA AND AMMONIUM NITRATE FERTILIZER TREATMENTS ON PERCENT NITROGEN OF FIREBALL TOMATO PLANTS OF SECOND HARVEST, ON THREE SOILS

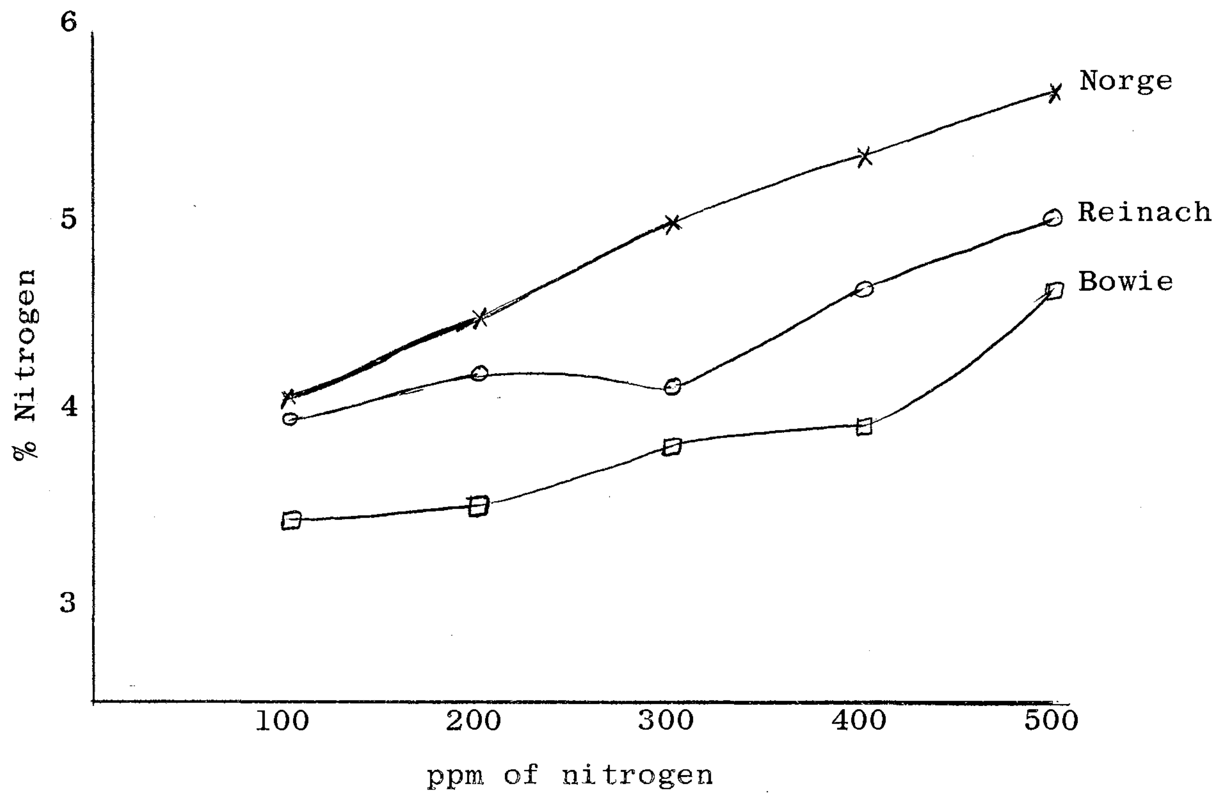
	Urea					Ammonium Nitrate						
	ppm Nitrogen Added With PK Treatment										PK	No
Soils	100	200	300	400	500	100	200	300	400	500	Only	Fertilizer
	% N					% N					% N	
Reinach	1.12	1.71	2.18	2.46	4.19	1.30	1.88	2.62	2.45	3.19	0.94	0.98
Bowie	0.81	0.84	1.00	1.68	2.39	0.85	1.09	1.13	1.43	1.60	0.86	0.48
Norge	1.65	3.34	3.78	3.88	3.37	1.43	3.24	3.40	4.16	4.48	0.62	1.04

Each figure represents the mean of three replications. 200 ppm P and 200 ppm K added in PK treatment.

F values: Soils - 92.08, Treatment - 27.22. Significant at 1% level.

FIGURE 1

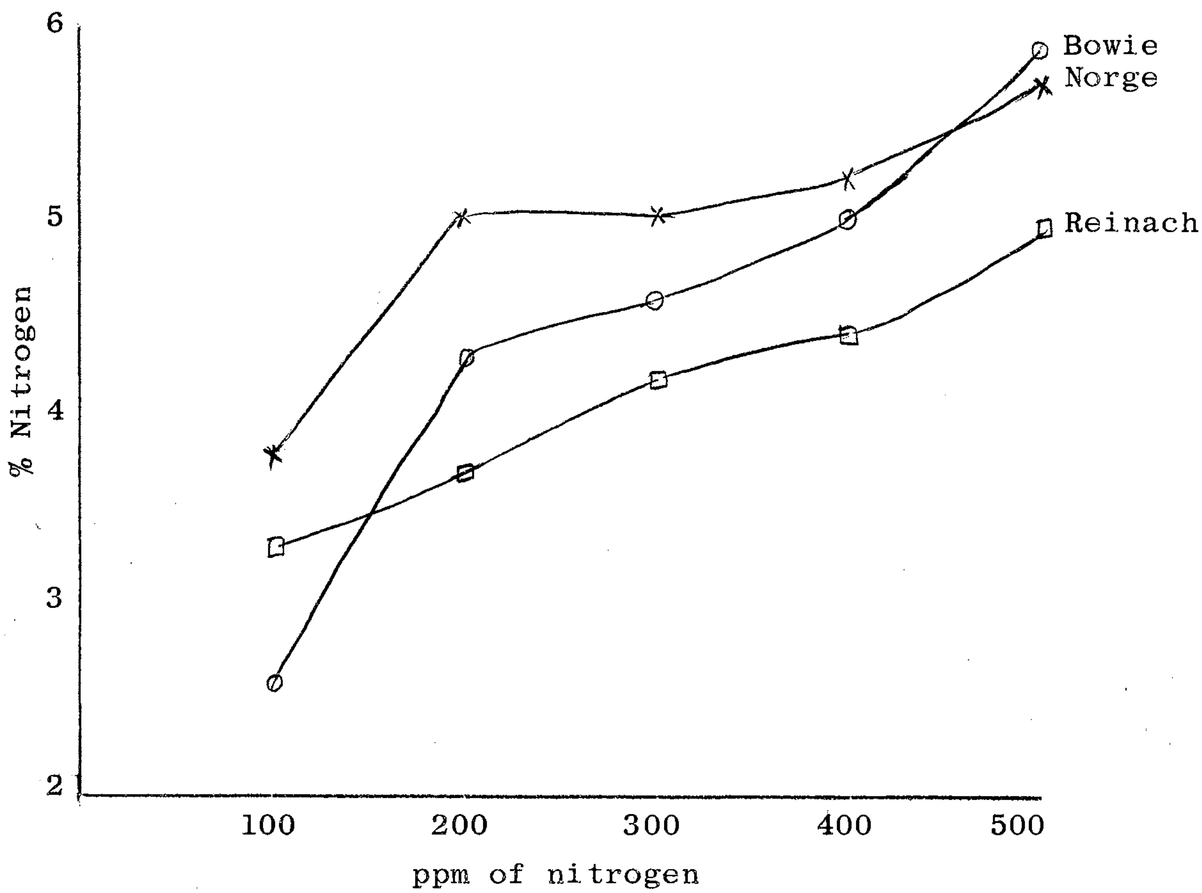
EFFECT OF UREA FERTILIZER TREATMENT ON PERCENT NITROGEN OF FIREBALL TOMATO PLANTS OF FIRST HARVEST, ON THREE SOILS



Each point represents the mean of three replications

FIGURE 2

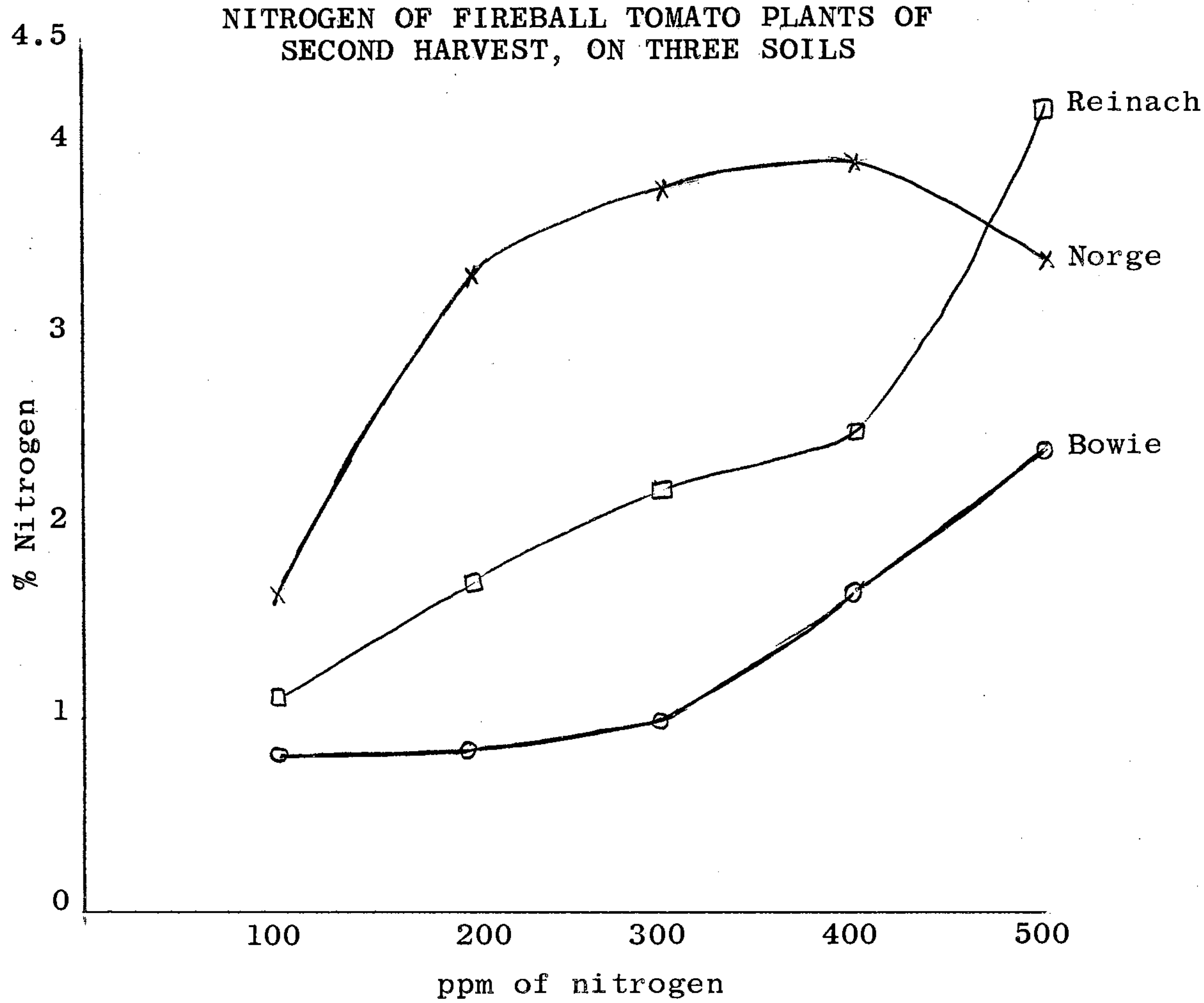
EFFECT OF AMMONIUM NITRATE FERTILIZER TREATMENT
ON PERCENT NITROGEN OF FIREBALL TOMATO PLANTS
OF FIRST HARVEST, ON THREE SOILS



Each point represents mean of three replications

FIGURE 3

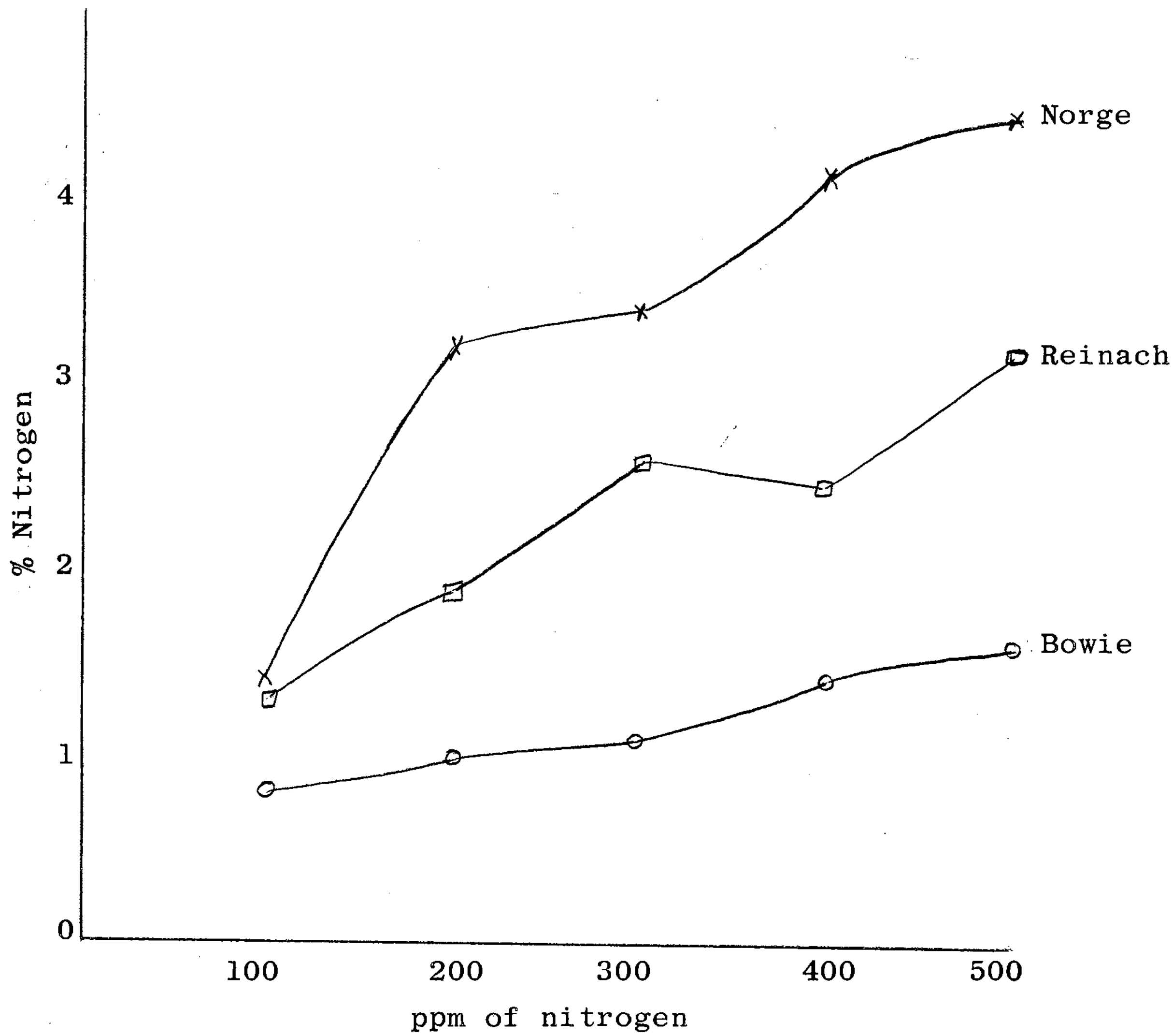
EFFECT OF UREA FERTILIZER TREATMENT ON PERCENT NITROGEN OF FIREBALL TOMATO PLANTS OF SECOND HARVEST, ON THREE SOILS



Each point represents the mean of three replications

FIGURE 4

EFFECT OF AMMONIUM NITRATE FERTILIZER TREATMENT ON PERCENT NITROGEN OF FIREBALL TOMATO PLANTS OF SECOND HARVEST, ON THREE SOILS



Each point represents the mean of three replications

of nitrogen than those grown on the other two soil types. In the case of urea treatment, plants grown in Norge soil showed a higher percent of nitrogen at 300 ppm with a lower percentage at 500 ppm (Figure 3). In the other cases the nitrogen percent increased with increasing treatments. Source of nitrogen did not show significant differences.

From the results, it appears that percent nitrogen for plants grown in the three soil types was higher in the first harvest than the second harvest. The trend of nitrogen content in plants was reversed in the two harvests. In the first harvest the highest percent of nitrogen was in plants grown on Norge soil followed by those grown on Bowie and Reinach soils. In the second harvest plants grown in Norge soil had the highest percent of nitrogen followed by those grown in Reinach and Bowie soils. Soil types gave a much higher significance in the second harvest than in first harvest. Neither replication nor source of nitrogen showed significant difference in either of the harvests.

Leaves clearly showed the effects of nitrogen fertilizer treatments. Plants receiving 500 ppm of nitrogen from urea or ammonium nitrate had large dark green leaves. As the treatment rate was reduced the intensity of the green color of the leaves decreased. In case of the no treatment and PK treatment the leaves were both quite small and light green in color while lower leaves prematurely turned yellow. In case of the second harvest the leaves were greater in size and the plants were considerably larger.

SUMMARY

This study was concerned with a comparison of the effects of two sources of nitrogen, applied at various rates, on Fireball variety of tomato plants grown on three soil types.

Tomato plants were grown in pots in the greenhouse. Uniform applications of potassium and phosphorus were applied to all pots except a check, (no fertilizer) treatment series for each soil. Urea and ammonium nitrate fertilizers were applied at rates equivalent to 0, 100, 200, 300, 400, and 500 ppm of nitrogen. Two harvests were taken from the experiment.

The following conclusions were based on results and statistical analysis of the data obtained from this experiment.

There were no significant differences between the two sources of nitrogen as far as effect on total plant top growth and percent nitrogen in plants were concerned.

There were significant differences between rates of application. An increase in percent nitrogen was observed with increasing rates of nitrogen application.

There were significant differences between the three soil types. Plants grown on Reinach soil produced the maximum amount of growth followed by those grown on Bowie and Norge soils.

Percent nitrogen was higher in plants of the first harvest than in the plants of the second harvest. Total dry weight was higher at the second harvest than at the first harvest.

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APPENDIX

TABLE VI

EFFECT OF UREA FERTILIZER TREATMENT ON PLANT GROWTH OF FIRST HARVEST ON FIREBALL TOMATO PLANTS, ON THREE SOILS

Treatment ppm of Nitrogen	Repl.	Reinach	Bowie	Norge
		gms. of oven-dry plants		
100	1	9.42	2.49	4.20
	2	7.68	2.41	6.80
	3	8.82	9.08	1.83
	av.	8.64	4.66	4.28
200	1	10.12	3.80	3.06
	2	9.21	5.62	4.72
	3	8.81	0.80	6.38
	av.	9.38	3.41	4.72
300	1	11.95	1.49	2.56
	2	10.00	7.51	2.50
	3	6.25	6.40	2.64
	av.	9.40	5.13	2.57
400	1	11.11	1.22	5.30
	2	11.20	4.70	3.45
	3	8.48	6.91	0.76
	av.	10.26	4.28	3.17
500	1	8.32	4.41	4.89
	2	10.70	6.38	2.95
	3	5.25	0.72	1.73
	av.	8.09	3.84	3.19

TABLE VII

EFFECT OF AMMONIUM NITRATE FERTILIZER TREATMENT ON PLANT GROWTH OF FIRST HAVEST OF FIREBALL TOMATO PLANTS, ON THREE SOILS

Treatment ppm of Nitrogen	Repl.	Reinach	Bowie	Norge
		gms. of oven-dry plants		
100	1	10.20	0.49	5.83
	2	11.70	5.70	5.72
	3	10.80	8.20	2.45
	av.	10.90	4.80	4.67
200	1	9.23	2.50	4.20
	2	10.50	3.30	5.20
	3	8.82	5.82	5.03
	av.	9.52	3.87	4.81
300	1	9.50	4.62	2.00
	2	9.40	4.32	3.53
	3	9.91	0.72	6.30
	av.	9.60	3.22	3.94
400	1	8.78	1.78	2.86
	2	11.61	6.41	4.30
	3	11.65	2.70	3.98
	av.	10.68	3.63	3.71
500	1	7.20	1.49	4.30
	2	11.00	4.32	3.95
	3	10.21	3.40	2.24
	av.	9.47	3.07	3.50

TABLE VIII

EFFECT OF UREA FERTILIZER TREATMENT ON PLANT GROWTH OF SECOND HARVEST OF FIREBALL TOMATO PLANTS, ON THREE SOILS

Treatment ppm of Nitrogen	Repl.	Reinach	Bowie	Norge
		gms. of oven-dry plants		
100	1	12.95	13.11	11.19
	2	17.74	3.51	6.12
	3	14.62	5.71	15.95
	av.	15.10	7.44	11.09
200	1	16.52	21.50	11.51
	2	18.68	18.91	13.49
	3	17.22	14.05	9.21
	av.	17.47	18.15	11.40
300	1	20.05	32.49	5.09
	2	18.83	5.35	13.48
	3	14.31	10.82	12.49
	av.	17.88	16.22	10.35
400	1	17.98	12.16	12.10
	2	17.99	14.31	7.08
	3	15.49	31.92	8.35
	av.	17.15	19.46	9.18
500	1	18.62	10.81	2.80
	2	18.85	11.21	9.25
	3	13.41	19.32	6.01
	av.	16.98	13.78	6.02

TABLE IX

EFFECT OF AMMONIUM NITRATE FERTILIZER TREATMENT ON PLANT GROWTH OF SECOND HARVEST OF FIREBALL TOMATO PLANTS, ON THREE SOILS

Treatment ppm of Nitrogen	Repl.	Reinach	Bowie	Norge
		gms. of oven-dry plants		
100	1	10.71	13.59	6.49
	2	10.81	4.01	10.18
	3	10.61	22.25	10.70
	av.	10.17	13.28	9.12
200	1	15.22	6.51	12.03
	2	12.22	12.21	11.75
	3	11.49	21.05	13.21
	av.	12.98	13.26	12.33
300	1	17.89	18.31	12.50
	2	19.11	12.81	12.22
	3	17.51	18.18	10.95
	av.	18.17	16.43	11.89
400	1	18.11	14.19	10.60
	2	24.10	7.85	8.21
	3	19.05	17.45	12.39
	av.	20.42	13.16	10.40
500	1	15.98	19.05	8.50
	2	20.16	19.45	10.20
	3	20.38	12.35	11.90
	av.	18.84	16.95	10.20

TABLE X

EFFECT OF P, K FERTILIZER TREATMENT AND NO TREATMENT ON PLANT GROWTH OF TWO HARVESTS OF FIREBALL TOMATO PLANTS, ON THREE SOILS

Treatment	Repl.	Reinach	Bowie	Norge
		gms. of oven-dry plants		
		FIRST HARVEST		
Check (No Fertilizer)	1	5.60	0.40	0.64
	2	9.25	0.71	0.35
	3	8.71	0.80	0.75
	av.	7.85	0.64	0.58
200 ppm of P, K	1	7.72	0.79	1.00
	2	10.10	0.90	0.54
	3	8.70	0.20	2.00
	av.	8.84	0.63	1.18
		SECOND HARVEST		
Check (No Fertilizer)	1	6.38	1.45	4.30
	2	3.81	9.24	5.12
	3	4.01	3.05	4.75
	av.	4.73	4.58	4.72
200 ppm of P, K	1	4.42	15.50	6.19
	2	5.51	1.51	5.21
	3	6.91	5.49	3.80
	av.	5.61	7.50	5.07

TABLE XI

EFFECT OF UREA FERTILIZER TREATMENT ON PERCENT NITROGEN OF FIRST HARVEST OF FIREBALL TOMATO PLANTS, ON THREE SOILS

Treatment ppm of Nitrogen	Repl.	Reinach	Bowie	Norge
		Percent Nitrogen		
100	1	3.43	4.58	4.38
	2	3.57	4.17	3.55
	3	3.48	3.20	4.40
	av.	3.49	3.98	4.11
200	1	3.40	5.19	4.65
	2	3.61	4.08	4.56
	3	3.58	3.41	4.36
	av.	3.53	4.23	4.52
300	1	3.76	4.51	4.84
	2	3.72	3.79	5.23
	3	4.11	4.19	4.99
	av.	3.86	4.16	5.02
400	1	3.96	3.83	5.36
	2	3.93	5.34	5.34
	3	3.95	4.81	5.35
	av.	3.95	4.66	5.35
500	1	6.52	4.63	5.80
	2	4.37	4.67	5.62
	3	4.18	4.65	5.61
	av.	5.02	4.65	5.68

TABLE XII

EFFECT OF AMMONIUM NITRATE FERTILIZER TREATMENT ON PERCENT NITROGEN OF FIRST HARVEST OF FIREBALL TOMATO PLANTS, ON THREE SOILS

Treatment ppm of Nitrogen	Repl.	Reinach	Bowie	Norge
		Percent Nitrogen		
100	1	3.35	2.60	3.41
	2	3.23	2.13	3.41
	3	3.29	3.05	4.59
	av.	3.29	2.59	3.80
200	1	3.58	3.93	4.56
	2	3.90	4.52	5.42
	3	3.56	4.35	5.04
	av.	3.68	4.27	5.01
300	1	4.19	4.66	5.09
	2	4.11	4.43	5.04
	3	4.18	4.58	5.05
	av.	4.16	4.56	5.06
400	1	4.37	5.32	5.13
	2	4.51	4.06	5.19
	3	4.27	5.53	5.34
	av.	4.38	4.97	5.22
500	1	4.76	5.76	5.94
	2	4.60	6.00	5.74
	3	5.47	5.84	5.49
	av.	4.94	5.87	5.72

TABLE XIII

EFFECT OF UREA FERTILIZER TREATMENT ON PERCENT NITROGEN OF SECOND HARVEST OF FIREBALL TOMATO PLANTS, ON THREE SOILS

Treatment ppm of Nitrogen	Repl.	Reinach	Bowie	Norge
		Percent Nitrogen		
	1	1.13	0.92	1.47
100	2	1.12	0.85	1.45
	3	1.11	0.67	2.02
	av.	1.12	0.81	1.65
	1	1.55	0.90	3.60
200	2	1.82	0.74	3.12
	3	1.77	0.90	3.29
	av.	1.71	0.84	3.32
	1	1.90	1.01	3.75
300	2	2.24	1.00	3.97
	3	2.39	1.01	3.63
	av.	2.18	1.00	3.78
	1	2.71	1.10	3.72
400	2	2.02	2.24	4.18
	3	2.65	1.64	3.73
	av.	2.46	1.66	3.88
	1	4.23	2.59	3.40
500	2	4.31	2.26	3.00
	3	4.03	2.31	3.72
	av.	4.19	2.39	3.37

TABLE XIV

EFFECT OF AMMONIUM NITRATE FERTILIZER TREATMENT ON PERCENT NITROGEN OF SECOND HARVEST OF FIREBALL TOMATO PLANTS, ON THREE SOILS

Treatment ppm of Nitrogen	Repl.	Reinach	Bowie	Norge
		Percent Nitrogen		
	1	1.95	1.59	1.49
100	2	0.87	0.93	1.40
	3	1.07	0.03	1.39
	av.	1.30	0.85	1.43
	1	1.17	0.87	3.09
200	2	2.01	1.30	3.85
	3	2.47	1.10	2.79
	av.	1.88	1.09	3.24
	1	2.85	1.01	3.42
300	2	2.43	0.86	3.31
	3	2.57	1.52	3.48
	av.	2.62	1.13	3.40
	1	2.97	1.65	4.20
400	2	1.54	1.12	4.37
	3	2.87	1.53	3.92
	av.	2.45	1.43	4.16
	1	3.27	1.45	4.14
500	2	3.24	1.75	5.34
	3	3.07	1.60	3.98
	av.	3.19	1.60	4.48

TABLE XV

EFFECT OF P, K FERTILIZER TREATMENT AND NO FERTILIZER ON PERCENT NITROGEN OF TWO HARVESTS OF FIREBALL TOMATO PLANTS, ON THREE SOILS

Treatment	Repl.	Reinach	Bowie	Norge
		Percent Nitrogen		
		FIRST HARVEST		
Check (No Fertilizer)	1	2.87	2.96	2.65
	2	1.48	2.56	3.10
	3	1.61	2.40	2.43
	av.	1.99	2.64	2.73
200 ppm of P, K	1	1.93	2.64	3.95
	2	2.35	2.35	1.90
	3	2.21	2.75	2.46
	av.	2.16	2.58	2.77
		SECOND HARVEST		
Check (No Fertilizer)	1	1.12	0.40	0.98
	2	0.86	0.83	1.07
	3	0.96	0.22	1.07
	av.	0.98	0.48	1.04
200 ppm of P, K	1	0.83	0.63	0.87
	2	0.97	1.10	0.90
	3	0.91	0.85	0.10
	av.	0.94	0.86	0.62

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