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NUTRITIONAL QUALITY OF TOMATOES, PEPPERS, AND
SNAP BEANS AS INFLUENCED BY CERTAIN GROWTH
REGULATORS APPLIED AS SPRAYS FOR IMPROVING
FRUIT SET

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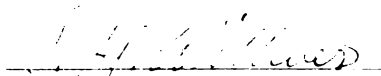
Nutritional Quality of Tomatoes, Peppers, and
Snap Beans as Influenced by Certain Growth Regulators
Applied as Sprays for Improving Fruit Set

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SNAP BEANS AS INFLUENCED BY CERTAIN GROWTH
REGULATORS APPLIED AS SPRAYS FOR IMPROVING
FRUIT SET

By

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NUTRITIONAL QUALITY OF TOMATOES, PEPPERS, AND SNAP
BEANS AS INFLUENCED BY CERTAIN GROWTH REGULATORS
APPLIED AS SPRAYS FOR IMPROVING FRUIT SET

INTRODUCTION

The use of various synthetic growth regulators for the purpose of improving fruit set during adverse weather has become of commercial importance with certain vegetables and is rapidly becoming a widespread practice with many growers. The morphological and physiological effects induced in the fruit by the so-called "hormone" sprays have been under study and observation for several years, but few investigations have been performed on the nutritional quality of the crop grown under field conditions. There is at present some restraint on the part of many commercial vegetable growers and processors in using growth regulators as sprays for improving fruit set as long as there is any question as to possible deleterious effects on the nutritive quality of the products produced. The objectives of the present investigations were to determine by carefully replicated analyses, the effects "hormone" sprays have when used as fruit setting aids, on the nutritional quality of field grown tomatoes, peppers, and snap beans.

REVIEW OF THE LITERATURE

Very little work has been performed on the nutritional quality of tomatoes, peppers, and snap beans as influenced by fruit set sprays when grown under field conditions. Holmes et al (10) carried out a study of blossom spray application on greenhouse-grown tomatoes. Janes (13, 14) used lanolin paste applications of indoleacetic and indolebutyric acids on tomatoes and sweet peppers and found that in treated tomatoes there was an increase in starch, while in peppers the total nitrogen in the pericarp was slightly higher in the true parthenocarpic fruit except when they were immature. The work on snap beans under field conditions by Murneek, Wittwer, and Hemphill (18) showed the chlorophyll content of the plant leaf tissue was greater on "hormone" treated plants. Further work of Wittwer (27) showed some variations of the ascorbic acid content of plant tissue when sprayed with growth regulators at various concentrations. During the course of preparing this manuscript an additional report by Holmes et al (11) has been published on "hormone" treated tomatoes grown under field conditions.

METHODS AND MATERIALS

TOMATOES: A good commercial strain (Stokes) of the Rutgers variety tomato was selected for study. The seeds were sown in flats on April 10 and the young seedlings were later transplanted to four inch pots. A few days before field planting the plants were removed from the greenhouse and allowed to "harden off" in coldframes. Field transplanting occurred on June 1. They were planted on a Hillsdale sandy loam soil which had received a previous application of 800 pounds of a 3-12-12 fertilizer and 10 tons of manure per acre. A total of four replications was used. Each replication consisted of two parallel rows with five tomato plants in each row. The rows were five feet apart with a three foot spacing between plants in the row. One member of each paired row was treated and the other served as a control. The treatment for the tomatoes was an adaptation of that used by Wittwer, Stallworth, and Howell (29), consisting of a water solution of 30 parts per million of para-chlorophenoxyacetic acid (ClPa-30) applied to the floral portions upon the initial appearance of flowers on the first cluster and subsequently, thereafter, at four to five day intervals during the early period of flowering and fruit set. The first treatment was applied on June 22 and spraying was terminated on July 7.

PEPPERS: The variety California Wonder (Corneli) was selected. The pepper seeds were sown in the greenhouse March

18 and these seedlings were later shifted to four inch pots. The plants were transplanted in the field on June 4. The soil was the same as that used for the tomato trials and had received the same treatment prior to the time the plants were set in the field. A total of four replications was used and each replication consisted of four rows of peppers with five plants per row. The individual rows were separated by a distance of three feet and the plants in the row were spaced two feet apart. Rows of Oakview Wonder peppers were planted alternately between the treated rows to serve as guards. The early blossoms were removed to prevent fruit set until all plants had attained sufficient vegetative vigor to support a good load of fruit.

BEANS: The snap bean investigations consisted of two commercially important varieties, Tendergreen and Stringless Black Valentine (Ferry-Morse). Four replications of each variety were used. Each block consisted of four differently treated rows of each variety. Additional guard rows of snap beans were planted alternately between those rows receiving the spray treatments. Rows were 20 feet in length. The snap beans were planted on June 1 and after the plants had emerged each row was thinned to 40 plants.

The peppers and snap beans received the same fruit setting hormone spray treatments which were as follows: (1) control (tap water); (2) naphthaleneacetic acid, 10 parts per million, hereafter designated by NA-10; (3) alpha-ortho-chlorophenoxypropionic acid, $2\frac{1}{2}$ parts per

million, hereafter designated as ClPP-2 $\frac{1}{2}$; and (4) para-chlorophenoxyacetic acid, 2 $\frac{1}{2}$ parts per million, hereafter designated as ClPA-2 $\frac{1}{2}$. All growth regulators were applied in aqueous solution with knapsack sprayers. A separate sprayer was used for each chemical to avoid contamination. A wetting spray was applied to all aerial parts of the bean and pepper plants. The initial treatment was sprayed on the bean plants at the time first blossoms appeared (July 13), and every week thereafter for three weeks until flowering ceased on August 3. The peppers were treated on the same initial dates as were the beans and the sprays continued at weekly intervals until August 17, thus the peppers received six hormone spray applications compared with four for the beans.

SAMPLING AND ANALYTICAL TECHNIQUE

TOMATOES: The fruit used in the analyses was harvested on August 13. A given sample of tomatoes consisted of 10 to 12 ripe fruit. All analyses were run in quadruplicate, each of the four samples for a given treatment being procured from one of the four plots, respectively. Thus, the four replications utilized in the analyses were sampled from the four respective field plots. Fruit in given comparative samples were selected for uniformity in color, size, and maturity. The tomatoes from treated plots were in most cases entirely seedless, or if seeds were evident

only a small fraction of the normal complement was present. The fruit were washed and within an hour after picking the various fresh fruit analyses were underway. For the ascorbic acid determinations the tomatoes were cut into eight segments and a slice sufficiently large taken from each segment to make a composite sample of 100 grams. The amount of ascorbic acid in the tomatoes was determined by the titration dye reduction method of Bessey and King (2) with modifications by Lucas (15). For the carotene analyses a composite sample consisting of four grams was obtained from the same segments from which portions were sampled in the vitamin C determinations. The method as developed by Petering, Benne, and Morgal (21) was utilized in the carotene determinations. After samples were removed for the ascorbic acid and carotene determinations the remaining portions of the tomatoes were weighed, sterilized in a dry heat oven at 130 degrees centigrade for 15 minutes, and then placed in a hot air oven at 55 degrees centigrade until thoroughly dry. This dried material was then weighed for the determination of total solids. The dry samples were ground to a 20 mesh sieve and preserved for carbohydrate, nitrogen, phosphorus, and calcium analyses which were run according to approved laboratory methods using the analytical techniques as recommended by the Association of Official Agricultural Chemists (1). Samples of the prepared dried material were sent to the National Spectrographic Laboratories, Inc., Cleveland, Ohio for analyses of

mineral constituents.

PEPPERS: The pepper samples which were used for the determinations were harvested on August 23. They showed no signs of parthenocarp due to the various treatments and resembled in every respect fruits which developed from normal pollination. As was the case with the tomatoes, four replicates were used in the analyses. These corresponded to the four replicated plots in the field. Following harvest the peppers were washed, the placenta and stem end removed from each and only the pericarp used for chemical analyses. Each sample weighed about 1000 grams and in each case consisted of 15 uniform fruit. The peppers were then chopped into half inch segments, mixed thoroughly, and 100 grams of this composite sample were used for the ascorbic acid determination, 10 grams for the carotene analysis, and 10 grams for the chlorophyll determination. The method employed for the chlorophyll determinations was the procedure developed by Petering, Benne, and Morgal (21). The methods for determining ascorbic acid, carotene, total solids, and nitrogen were the same as those described for tomatoes, but the pepper samples were ground to a fineness of a 40 mesh screen prior to the analyses of the dried tissue.

SNAP BEANS: The first harvest of snap beans lacked uniformity in maturity so were discarded and the second picking selected for analyses. These were harvested on August 2 and as was the case with peppers showed no signs of parthenocarp or other abnormalities, beans from the treated plants

resembled the controls in every respect. Pods from comparative treatments were approximately five to six inches in length and were uniform in maturity, shape, and color. Each sample for the analyses consisted of about 1000 grams of beans, as was the case with the tomatoes and peppers, the analytical replicates were obtained from respective field plot replications. The pods were washed and cut into segments of about one half inch. The segments were then thoroughly mixed and from this composite sample an aliquot of 100 grams was utilized for the ascorbic acid determination. For the carotene and chlorophyll determinations, 10 grams of fresh bean segments were sampled from this composite mixture. The chlorophyll analyses were the same as those used for peppers. The remaining portions of bean samples were weighed, sterilized, oven dried, and reweighed for the total solids determination as described for the tomato analyses. The dried samples were ground through a 40 mesh screen in preparation for the nitrogen determinations.

RESULTS

The data for the various analyses for the treated and non-treated tomatoes, peppers, and snap beans are assembled in tables I, II, III, IV, and V respectively. All values are expressed on a fresh weight basis.

In Table I a comparison of the values for tomatoes shows that for total solids the treated fruit had a

slightly higher percentage. The carotene contents of the treated and controls were similar with treated fruit giving an average of 55.0 parts per million compared with 52.7 for the controls, making a difference of only 2.3 parts per million. The ascorbic acid contents of both the treated and non-treated fruit were practically the same being higher in the treated fruit by only 0.5 milligrams per 100 grams of fruit. A comparison of the total nitrogen contents shows that the treated fruit were only slightly higher in this constituent. Differences great enough for statistical significance were not obtained since all differences reported in the various constituents were of insufficient magnitude to show any significance even at the five per cent level although the percentage of the various carbohydrate fractions showed some variability.

Nearly all the sugars present were reducing sugars with the treated fruit having 0.05 percent more reducing sugars than the controls. A consideration of the total sugar content also showed the treated fruit to have a higher percentage. The starch content showed the greatest variation (which was statistically significant on a dry weight basis only). Hormone treated tomatoes had 0.230 percent starch compared with only 0.148 percent for the controls.

The ash and mineral analyses for tomatoes showed consistent differences this time in favor of non-treated fruit in each replication but these differences again were not statistically significant. In percent of ash, the treated

fruit were lower by 0.014 percent, they also contained less phosphorus and calcium by 0.0017 percent and 0.0003 percent, respectively.

The results of the spectrographic analyses are assembled in Table II. The numerous elements analyzed showed few variations except for the potassium content of the treated tomatoes which had on the average 0.08 percent more potassium than the controls. These differences were not statistically significant.

Data showing the results of the pepper analyses are given in Table III. The various treatments produced only slight variations in the amounts of various constituents. The percentage total solids varied somewhat but showed no consistent trend that could be ascribed to treatment. The controls had 6.28 percent, NA-10 had 6.49 percent, ClPP-2 $\frac{1}{2}$ had 6.25 percent, ClPA-2 $\frac{1}{2}$ had 6.46 percent total solids. The carotene content of the treated and controls were all within one part per million range of each other with levels for the controls being at 3.9 parts per million. The chlorophyll analyses showed some variations but these were not significant, even in the case of NA-10 which gives a value of 17.3 milligrams per 100 grams, compared with 14.6 milligrams for the controls. The ascorbic acid analyses showed the most divergent values with the controls in each case having a higher level than any of the various treated fruits. These differences, however, were not statistically significant. The controls had 107.5 milligrams per 100

TABLE I

The comparative compositions of parthenocarpic Rutgers tomatoes resulting from the use of fruit setting sprays and those developing naturally from pollination and subsequent fertilization.

Plant constituent	Unit	Parthenocarpic ¹ fruit	Normal seeded fruit
Total solids	percent	6.91	6.79
Carotene	ppm	55.0	52.7
Ascorbic acid	mgs/100gms.	20.0	19.5
Nitrogen	percent	0.199	0.194
Reducing sugars	percent	1.99	1.94
Total sugars	percent	2.08	2.04
Ash	percent	0.632	0.646
Phosphorus	percent	0.0311	0.0328
Calcium	percent	0.0051	0.0054

1. Flower clusters sprayed with 30 parts per million of para-chlorophenoxyacetic acid.

TABLE II

The comparative compositions of parthenocarpic Rutgers tomatoes resulting from the use of fruit setting sprays and those developing naturally from pollination and subsequent fertilization.
(determined by spectrographic analyses)

Plant constituent	Unit	Parthenocarpic ¹ fruit	Normal seeded fruit
Calcium	percent	0.0086	0.0078
Iron	percent	0.0006	0.0007
Magnesium	percent	0.013	0.011
Manganese	percent	0.0002	0.0002
Molybdate	percent	0.00002	0.00003
Phosphorus	percent	0.033	0.034
Potassium	percent	0.37	0.29
Sodium	percent	0.0004	0.0003
Zinc	percent	0.0003	0.0004

1. Flower clusters sprayed with 30 parts per million of para-chlorophenoxyacetic acid.

TABLE III

Comparative amounts of some nutrient constituents in
California Wonder peppers resulting from the
use of various hormone chemicals used as aids
for improving fruit set.

Plant Constituent	Unit	No <u>treatment</u> (Control)	<u>Fruit setting chemical</u>		
			NA-10	ClPP-2 $\frac{1}{2}$	ClPA-2 $\frac{1}{2}$
Total solids	percent	6.28	6.49	6.25	6.46
Carotene	ppm	3.9	4.0	3.5	4.6
Chlorophyll	mgs/100gms	14.6	17.3	13.8	13.8
Ascorbic acid	mgs/100gms	107.5	94.7	97.3	90.7
Nitrogen	percent	0.13	0.15	0.13	0.13

grams, whereas ClPA-2 $\frac{1}{2}$ treated was lowest in ascorbic acid with 90.7 milligrams. The nitrogen analyses showed the NA-10 treated fruit to have 0.20 percent more nitrogen than the controls and the other two treatments compared favorably with the controls with ClPA-2 $\frac{1}{2}$ treated fruit being the same and the ClPP-2 $\frac{1}{2}$ treated fruit only slightly lower.

In Tables IV and V are presented the results of the analyses for the two snap bean varieties. Except for very slight variations of the total solids and ascorbic acid contents, there were no differences that could be ascribed to the various spray treatments. In each case for both varieties of beans the controls were higher in total solids than the treated beans. The Tendergreen snapbeans showed 10.73 percent total solids for the controls, 10.20 percent for NA-10 treated, 10.43 percent for ClPP-2 $\frac{1}{2}$ treated, and 10.55 percent for the ClPA-2 $\frac{1}{2}$ treated pods. The Stringless Black Valentine showed a greater variation in total solids with the controls having 11.05 percent, and the NA-10 treated pods having the lowest total solids at 9.93 percent. The carotene contents of both treated and non-treated pods of both varieties were very uniform and with the exception of their varietal differences all ranged within 0.2 parts per million of each other. The chlorophyll analyses showed no correlation between the two varieties and their respective treatments. The chlorophyll content of the controls for the Tendergreen variety was lowest while the chlorophyll

TABLE IV

Comparative amounts of some nutrient constituents in
Tendergreen snapbeans resulting from the use of
certain hormone chemicals used as aids for
improving fruit set.

Plant Constituent	Unit	No <u>treatment</u> (Control)	<u>Fruit setting chemical</u>		
			NA-10	ClPP-2 $\frac{1}{2}$	ClPA-2 $\frac{1}{2}$
Total solids	percent	10.73	10.20	10.43	10.55
Carotene	ppm	4.3	4.2	4.1	4.2
Chlorophyll	mgs/100gms	10.1	10.4	10.5	11.4
Ascorbic acid	mgs/100gms	28.6	28.3	27.3	27.3
Nitrogen	percent	0.29	0.30	0.30	0.29

TABLE V

Comparative amounts of some nutrient constituents in
Stringless Black Valentine snapbeans resulting
from the use of certain hormone chemicals
used as aids for improving fruit set.

Plant Constituent	Unit	No treatment (Control)	Fruit setting chemical		
			NA-10	ClPP-2 $\frac{1}{2}$	ClPA-2 $\frac{1}{2}$
Total solids	percent	11.05	9.93	10.6	10.06
Carotene	ppm	4.6	4.8	4.7	4.7
Chlorophyll	mgs/100gms	11.1	12.1	11.7	10.5
Ascorbic acid	mgs/100gms	29.2	28.3	27.6	26.7
Nitrogen	percent	0.31	0.28	0.30	0.29

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.	.	.	.

content of the Stringless Black Valentine was lowest in the ClPA-2 $\frac{1}{2}$ treated pods. This same treatment gave the highest chlorophyll values for the Tendergreen variety. The ascorbic acid contents were highest in each variety for the controls with the Tendergreen having 28.6 milligrams per 100 grams and the Stringless Black Valentine having 29.2 milligrams per 100 grams. The NA-10 treatments had the next highest amounts of ascorbic acid with the identical values of 28.3 milligrams per 100 grams. The lowest values for ascorbic acid in both varieties occurred in the ClPA-2 $\frac{1}{2}$ treated pods with the Tendergreen having 27.3 milligrams and the Stringless Black Valentine having 26.7 milligrams per 100 grams of pods. A study of the total nitrogen contents showed no consistent variations which could be attributed to the treatments applied.

DISCUSSION

Composition Studies With Tomatoes: The results of this study clearly show that there is very little loss or gain in the nutritional value of field-grown tomatoes when hormone sprays are used as aids for improving fruit set. A depression in nutrient value when it occurs is believed to be due to the absence of seeds (which normally have no nutritional value) within the treated tomatoes. The total solids of the non-treated tomatoes were slightly lower being at 6.79 percent compared with a value of 6.91 percent for the treated crop. These values were within the

limits of some of the nutritional tables studied such as those prepared by Chatfield and Adams (3), United States Department of Agriculture (25), the H. J. Heinz Company (19), and Winton and Winton (26). Holmes et al (10) under greenhouse conditions using the Waltham Forcing variety of tomatoes, treated with beta-naphthoxyacetic acid, reported the same trend, and in a recent publication by Holmes et al (11) with Pritchard variety of tomatoes under field conditions reported the same percent total solids for hormone treated and non-treated fruit. Janes (14) also growing the plants under greenhouse conditions, using John Baer tomatoes and lanolin paste applications of hormones pointed out that parthenocarpic tomatoes had a higher total solids content until they reached a stage of over ripeness. Saywell and Cruess (23) and Hamner and Maynard (9) emphasized that climatic conditions will vary the total solids content of tomatoes with a very hot dry climate producing a tomato crop with lower total solids and a cool moist climate producing one with a higher percentage of total solids.

The carotene content of the treated tomatoes was slightly higher but the difference was not significant and not consistent throughout all of the replications analyzed. The non-treated fruit had 52.7 parts per million and the treated fruit had 55.0 parts per million. These carotene values were higher than that reported by Ellis and Hamner (5) of 46.0 parts per million for Rutgers tomatoes grown

under field conditions in New York State. Ellis and Hamner also reported that an increase of soil nitrates will increase the carotene content but not significantly, while the addition of other macro-elements had no influence on the carotene content, with no correlation between fruit size and carotene content and no wide varietal variations. Smith (24) concluded that light will influence the carotene content of greenhouse as well as field-grown tomatoes, being lower under poor or dark light conditions.

Many investigators have carried out extensive work on ascorbic acid with particular emphasis on tomatoes. In the present study the ascorbic acid content of the treated fruits was very slightly higher than the controls, being 20.0 milligrams per 100 grams of fruit, compared with 19.5 milligrams for those not treated. The values for the ascorbic acid are lower in each case than the averages given in the previously listed nutritional tables. Holmes et al (10) on greenhouse tomatoes set by growth regulators, found the ascorbic acid content of the treated fruits considerably lower than the controls on the Waltham Forcing variety, but for Pritchard tomatoes set with growth regulators under field conditions (11) the ascorbic acid content for the hormone treated tomatoes was one milligram higher. Currence (4) in field trials at Minnesota on Rutgers tomatoes gave an average value of 19.9 milligrams per 100 grams of fresh fruit which compared favorably with the controls in this investigation. Hamner et al (7,8)

showed that light had the greatest influence on ascorbic acid of several factors studied including degree of ripeness, applications of nitrogen, relative humidity, and storage. The work of Maclinn, Fellers, and Buck (14) showed there was a varietal difference in the ascorbic acid content of tomatoes with Rutgers averaging 25 milligrams per 100 grams of fresh fruit. McCollum (17) found no correlation between the ascorbic acid content, total solids, and sugar content of tomatoes.

Variations in the nitrogen content were very slight and the values were about average compared with those of the several nutritional tables previously cited. The treated tomatoes showed a slightly higher nitrogen content. The data of Holmes et al (10) indicated a similar trend for greenhouse conditions but they reported a greater difference than that obtained in this study, meanwhile their data for tomatoes treated under field conditions (11) show the opposite trend with the controls having a higher nitrogen content than the hormone treated. Winton and Winton (26) concluded that the nitrogen content of tomatoes varied with their maturity, the percentage of nitrogen decreasing as the fruit became more mature, which is in accord with the findings of Sando (22).

The total sugars and reducing sugars herein reported were lower than the averages listed in the various nutritional charts and there were no significant variations due to the spray treatment. The treated fruit were 0.04 per-

cent higher in total sugars. The common observation that hormone treated fruit are "sweeter" was not borne out in the results of this investigation but this may be due to the change of acidity of the treated fruit rather than the total sugars. In this study no determinations were made of the total acidity of treated and non-treated fruit. Nearly all the sugars present were in the form of reducing sugars which was in accordance with the findings of several other investigators. Janes (14) under greenhouse conditions showed the same trends for treated and non-treated fruit of the John Baer variety. Saywell and Cruess (21) pointed out that nearly all the sugars present in tomatoes are reducing sugars. Sando (22) stated that reducing sugars in tomatoes increased with maturity and that there was no correlation between non-reducing sugars and maturity, that is, the relative percent of total non-reducing sugars was a constant level from the small green fruit and through subsequent stages of maturity.

The starch composition of treated fruit and those not treated showed the widest variation with a statistically significant difference on a dry weight basis which was not however significant when expressed on a fresh weight basis due to the percentage of total solids being higher in the treated fruit. Janes (12) reported the same findings, also bringing out that maturity altered the starch content of both treated and non-treated fruit, as fruit became more mature the starch content decreased.

Sando (22) reported similar findings for normal tomatoes grown under field conditions. It is believed that the seeds of the tomatoes exert an enzymatic activity during their development within the fruit of the tomato that converts the starch into other substances as needed. Due to the absence of seeds in the treated tomatoes therefore there may be a lack of starch conversion to other materials. The starch is thus retained in greater amounts during the development of the fruit.

The ash, phosphorus, and calcium contents of the tomatoes showed no statistically significant differences on a fresh weight basis, but the phosphorus on the dry weight basis did show a significant difference. The differences in ash, phosphorus, and calcium were believed due to the presence of seeds in the controls and the absence of seeds in the treated fruits. Sando (22) offers data on the composition of tomato fruit and tomato seeds. On an ash basis, the phosphorus content of the seed was 75 percent higher than the fruit and the calcium content of the seed was over 93 percent greater than in the fruit. Holmes (11) reported higher phosphorus and lower calcium in treated versus normal fruited tomatoes. The ash and phosphorus percentages of both hormone treated and non-treated tomato fruit are comparable to the earlier listed nutritional charts but the calcium content is lower than the average values given. Although the calcium content of both controls and treated fruits was much lower than the

averages reported by various workers, the spectrographic analyses indicated higher values (Table II) but the laboratory stated that at the time the spectrographic determinations for calcium were not yet standardized. The spectrographic data for calcium were not further considered in the present discussion.

In the spectrographic analyses the potassium content showed the widest differences with the controls in each replication analyzed having lower potassium. The phosphorus analyses show very close agreement with the findings as reported in Table I. The other minerals examined showed very few differences due to treatment.

Composition Studies With Peppers: The effects of the various fruit setting sprays on the resulting constituents examined in peppers showed few differences except in the ascorbic acid analyses which gave slightly higher values for the controls compared with the other treatments. The total solids were consistent within all treatments and the differences were not significant. Janes (13) reported the same findings on nitrogen and total solids for true parthenocarpic pepper fruit. In general, carotene and ascorbic acid contents of the peppers were lower than the average values listed in the nutritional charts (3), (19), and (25). The fruits were harvested while still green in color and it is believed that the concentration of carotene and ascorbic acid increases with the stage of maturity. Pepko-

witz et al (20) pointed out that the degree of maturation has a marked effect on the carotene and ascorbic acid content of sweet peppers and that when these ripen to a red color the carotene concentration increased approximately 3175 percent and the ascorbic acid content increased 49 percent above the average value for green peppers. Finch, Jones, and Van Horn (6) reported figures on a non-replicated treatment in which applications of nitrogen during plant growth increase the nitrogen content of the peppers but lowered the ascorbic acid content.

Composition Studies With Snap Beans: The study of the snap bean data for both varieties and the three treatments compared with a control failed to reveal any significant differences that could be attributed to either variety or "hormone" sprays. The concentrations of various constituents found are in agreement with those reported in the several nutritional charts (3), (19), and (25) except that the carotene content of the beans was slightly lower. Hibbard and Flynn (12) reported that as the beans become more matured the percent of moisture decreased and there was a depression in the carotene content; they further stated that maturity had little effect on the ascorbic acid content. In this study there were only small differences in the chlorophyll contents of the bean pods which were harvested from hormone treated plants compared with those receiving no treatment. Murneek, Wittwer, and Hemphill

(18) reported that applications of various growth regulators increased the chlorophyll content of the bean plant's green leaf tissue. No data however were given, pertaining to the pods themselves.

SUMMARY

An investigation was conducted under field conditions, using replicated plots, concerned with the effect of various hormone sprays on the nutritional quality of Rutgers tomatoes, California Wonder peppers, and Tendergreen and Stringless Black Valentine snap beans.

Parthenocarpic tomatoes (var. Rutgers) were caused to develop by the use of a spray consisting of 30 parts per million of para-chlorophenoxyacetic acid. The resulting tomatoes were compared in their chemical constituents with those produced from normal pollination. There were no statistically significant differences between any of the organic or inorganic constituents examined although the starch content of the treated tomatoes was considerably higher, and the phosphorus content lower.

California Wonder peppers, Tendergreen and Stringless Black Valentine snap beans were similarly treated with three whole plant hormone sprays to improve fruit and pod set. The resulting crops were analyzed for various constituents. The pepper fruit and bean pods produced were not seedless and showed no physiological effects from the treatments. Chemical analyses of their compositions in

terms of total solids, carotene, chlorophyll, ascorbic acid, and nitrogen showed no significant differences between the "hormone" treated produce and that not treated.

The data herein obtained, and that reported by other investigators, on the comparative nutritional values of hormone treated and normally pollinated fruit, are discussed.

LITERATURE CITED

1. Official and Tentative Methods of Analysis of the Association of Official Agricultural Chemists. 6th. Ed. Vol. I. Washington: Association of Official Agricultural Chemists. 1945.
2. Bessey, O. A., and King, C. G. The distribution of vitamin C in plant and animal tissues, and its determination. Jour. Biol. Chem. 103: 687-698. 1933.
3. Chatfield, C., and Adams, G. Proximate composition of American food material. U.S.D.A. Circ. 549, June 1940.
4. Currence, T. M. A comparison of tomato varieties for vitamin C content. Proc. Amer. Soc. Hort. Sci. 37: 901-904. 1940.
5. Ellis, G. H., and Hamner, K. C. The carotene content of tomatoes as influenced by various factors. Journ. Nutr. 25: 539-553. 1943.
6. Finch, A. H., Jones, W. W., and Van Horn, C. W. The influence of nitrogen nutrition upon the ascorbic acid content of several vegetable crops. Proc. Amer. Soc. Hort. Sci. 46: 314-318. 1945.
7. Hamner, K. C., Bernstein, L., and Maynard, L. A. Effects of light intensity, day length, temperature, and other environmental factors on the ascorbic content of tomatoes. Journ. Nutr. 29: 85-97. 1945.
8. Hamner, K. C., Lyon, C. B., and Hamner, C. L. Effect of mineral nutrition on ascorbic acid content of tomato. Bot. Gaz. 103: 586-616. 1942.
9. Hamner, K. C., and Maynard, L. A. Factors influencing nutritive value of tomato. U.S.D.A. Misc. Pub. 502. 1942.
10. Holmes, A. D., Spelman, A.F., Kuzmeski, J. W., and Lachman, W. H. Food value of hormone-treated tomatoes. Journ. Amer. Diet. Assoc. 23: 218-222. 1947.
11. Holmes A. D., Smith, C. T., Kuzmeski, J. W., and Lackman, W. H. Some results of hormone treatment of field grown tomatoes. Food. Tech. 2: 252-255. 1948.

12. Hibbard, A. D., and Flynn, L. M. Effect of maturity on the vitamin content of green snap beans. Proc. Amer. Soc. Hort. Sci. 46: 350-354. 1945.
13. Janes, B. E. A comparison of the chemical composition of artificially produced parthenocarpic fruits and normal seeded fruits of peppers. Proc. Amer. Soc. Hort. Sci. 40: 432-436. 1942.
14. Janes, B. E. Some chemical differences between artificially produced parthenocarpic fruits and normal seeded fruits of tomatoes. Amer. Journ. Bot. 28: 639-646. 1944.
15. Lucas, E. H. Determining ascorbic acid in large numbers of plant samples. Ind. and Eng. Chemistry 16: 649-652. 1944.
16. Maclinn, W. W., Fellers, C. R., and Buck, R. E. Tomato variety and strain differences in ascorbic acid (vitamin C) content. Proc. Amer. Soc. Hort. Sci. 34: 543-552. 1937.
17. McCollum, J. P. Some factors affecting the ascorbic acid content of tomatoes. Proc. Amer. Soc. Hort. Sci. 45: 382-386. 1944.
18. Murneek, A. E., Wittwer, S. H., and Hemphill, D. D. Hormone sprays on snap beans. Market Growers Journ. June 1944.
19. Nutritional Charts. H. J. Heinz Company, 12th. Ed. Pittsburg, Pa. 1946.
20. Pepkowitz, L. P., Russell, E. L., Gardner, J., and Owens, G. The carotene and ascorbic acid concentration of vegetable varieties. Proc. Amer. Soc. Hort. Sci. 44: 468. 1944.
21. Petering, H. G., Benne, E. J., and Morgal, P. W. Simplification of the Petering-Wolman-Hibbard method for determination of chlorophyll and carotene. Journ. of Ind. and Eng. Chemists. 13: 236-240. 1941.
22. Sando, C. E. The process of ripening in the tomato, considered especially from the commercial standpoint. U.S.D.A. D.P. Bull. 589. 1920.
23. Saywell, L. G., and Cruess, W. V. The composition of canning tomatoes. Calif. Agr. Exp. Sta. Bull. 545. 1932.

24. Smith, O. Effect of light on carotenoid formation in tomato fruits. Cornell Univ. Agric. Sta. Memoir 187: 1936.
25. Tables of food composition in terms of eleven nutrients. U.S.D.A. Mis. Pub. 572. 1945.
26. Winton, A. L., and Winton, K. B. The structure and composition of foods. (Vol. II) Vegetables, Legumes, Fruits. John Wiley and Sons, Inc. New York. Pp. 403-416. 1935.
27. Wittwer, S. H. Unpublished data. Mo. Agr. Exp. Sta. 1945.
28. Wittwer, S. H., and Murneek, A. E. Further investigations on the value of "hormone" sprays and dusts for green bush snap beans. Proc. Amer. Soc. Hort. Sci. 47: 285-293. 1946.
29. Wittwer, S. H., Stallworth, H., and Howell, M. J. The value of a "hormone" spray for overcoming delayed fruit set and increasing yields of outdoor tomatoes. Proc. Amer. Soc. Hort. Sci. 51: 371-380. 1948.

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