205

EFFECT OF AUXINS ON HEAT RESISTANT AND SUSCEPTIBLE BEAN LINES

BY

PETER JOSEPH STOFFELLA

B.S., Delaware Valley College of Science and Agriculture, 1976

A MASTER'S THESIS

submitted in partial fulfillment of the

requirements for the degree

MASTER OF SCIENCE

Department of Horticulture
Kansas State University
Manhattan, Kansas

1977

Approved By

Major Professor

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LITERATURE REVIEW

Growth regulators used in the body of this literature review have many common names and abbreviations. A list of growth regulators with their common and chemical names is presented here for clarity (28, 31).

1. CCC, Chloromequat, Cycocel, Cycogan Extra
   (2-Chloroethyl)-trimethyl-ammonium chloride

2. Ethephon, Ethrel, Florel, Cepha
   (2-Chloroethyl) phosphonic acid

3. NAD, Amid-Thin W, Rosetone, NAAM
   Naphthalene-acetamide

4. NAA, Naphthalene, 1-Naphthaleneacetic Acid, Nu-Tone, Stafast, Tre-Hold, Stop-Drop, Alphaspra, ANA, Apple-Set, Parmone, Fruitone-N, Phyomone, Pimacol-Sol, Transplantone, Niagara-Stik
   Alpha-Naphthaleneacetic Acid

5. 2-NOA, Beta-Naphthoxyacetic acid
   (2-Naphthoxy)-acetic acid

6. Indolebutyric Acid, IBA, Indole Butyric, Hormodin, Jiffy Grow Hormex Rooting Powder, Rootone
   3-Indolebutyric acid

7. Silvex, 2,4,5/TB, Sta-Set, Fenoprop, Fruitone-T, Stikcol-D, Nu Set

2-(2,4,5-Trichlorophenoxy) propionic acid.

8. 4-CPA, Tomato Fix, CPA, PCPA, Tomatotone, Sure-Set

para-Chlorophenoxyacetic acid.

9. 2,4-D

2,4-Dichlorophenoxyacetic acid

10. Ethylene

Ethylene

11. 2,4,5-T

2,4,5-Trichlorophenoxyacetic acid.

12. CTBP

5-Chloro, 2-Thenyl, Tri-n-Butyl-phosphonium chloride

13. B-9, B-Nine, Daminozide, Alar, SADH, Kylar

Butanedioic acid mono (2,2-dimethyldrazide)

14. ABA, Abscisic acid Abscisin II, Dormin

3-methyl-5 (1'-hydroxy-4'-oxo-2',6,6-tri-methyl-2'-cyclohexen-1'yl)-<u>cis</u>, <u>trans</u>-2,4 pentadienoic acid.

15. Gibberellic acid, G.A., Gibberellin, Gib-Tabs, Gibrel, Brellin, Gib-Sol, Pro-Gibb, Berelex, Activol, Grocel, Cekugib.

2,4a,7-Trihydroxy-1-methyl-8-methylene gibb-3-ene-1,10-carboxylic acid-1-4 lactone.

16. TIBA

2,3,5-triodobenzoic acid.

EFFECTS OF AUXINS ON *PHASEOLUS VULGARIS* L. YIELDS

Several researchers have used auxins to increase yields of *Phaseolus vulgaris* L. The success of these experiments has been limited and dependent on environmental conditions, type of growth regulator, and rate and frequency of application prevailing during these experiments.

Wittwer and Murneek (37) increased green bush snap bean yields by 40 percent using five weekly spray applications of two ppm para-chlorophenoxyacetic acid (4-CPA) under hot, dry environmental conditions. There was an increase in pod set without increase in pod size and seed number. Under lower temperature conditions, yield gains were attributed to increased pod size as well as seed number. They concluded that yield increases of 10 to 25 percent could be achieved under favorable environmental conditions, although greater increases could be obtained under unfavorable conditions.

Murneek et al. (24) applied sprays every second day, beginning when flower buds first appeared, with 5 to 25 ppm alpha-naphthalene-acetamide (NAD) or beta-naphthoxyacetic acid (2-NOA) to 'Stringless Green Pod' bush beans under hot environmental conditions. They obtained 59 to 72 percent increase in yield due to greater pod number during hot summer weather. With five-day spray intervals during cool summer weather, yield decreases occurred, due to smaller pod weight.

Fisher et al. (13) dusted field-grown wax beans with alpha-naphthal-eneacetic acid (NAA) at 40 ppm and 80 ppm, resulting in a 24 and 12 percent yield increase, respectively. The yield increase was due to a greater number of pods, rather than to larger pods.

Randhawa and Thompson (25) observed that two ppm 4-CPA, applied biweekly on 'Tendergreen' snap beans, increased total yields. They also noted that 2 to 20 ppm 2,4,5-trichlorophenoxyacetic acid (2,4,5-T) decreased yields.

Hardenburg (15) decreased yields of pea beans by treating seeds with Rootone. He also obtained decreases in several field-grown bean yields by dusting with Parmone containing 70 to 140 ppm NAA. He concluded that under unfavorable conditions the yields were not significantly different. The auxin reduced pod set, although pods "filled" better on treated plants.

Mitchell and Marth (23) applied 4-CPA as a spray or dip treatment four days before snap bean fruits were harvested. They reported that 1000 ppm of the auxin retarded maturation. Although treated fruits were 14 percent heavier, the dry weight of seeds decreased 22 percent over the control. Spray applications of 250 to 1000 ppm to attached fruits decreased final yield of fresh fruit by 44 percent, but at 50 ppm yield did not significantly decrease.

Wedding et al. (33) reported spray applications of 2,4-dichlorophenoxyacetic acid (2,4-D), on lima and snap beans, altered yields from 70 percent to 75 percent decrease over different replications. They mentioned that most of this variability could be attributed to inadequate water supply at the end of the growing season, resulting in no increase or possible decreases in yield.

Stromme and Hamner (27) sprayed 2,4-D at nonherbicidal concentrations on red kidney bean plants. They reported that 100 ppm delayed maturity significantly with a slight decrease in pod number and seed yield.

There is much conflict in the literature regarding environmental effects on auxin-plant interactions. Brinkley (1) reported negative correlations between blossom and pod percent and yields per plant of several varieties of garden beans. He concluded that blossoming and pod setting periods appear to be very sensitive to wide variations in environmental conditions during plant growth.

EFFECTS OF OTHER GROWTH REGULATORS ON PHASEOLUS VULGARIS L.

Weigle et al. (34) applied several growth regulating herbicides (CTBP, DCT, Che 8570, and Bay 102614) at low concentrations to snap beans. They concluded that certain chemicals may increase pod set but not yields, especially when periods of environmental stress follow pod set.

Tompkins et al. (29) made single applications of CTBP to snap beans. They reported that yield increase varied for cultivars over seasons, but CTBP had no effect on 4- and 5-sieve pods regarding seed and fiber development, shear press value, or color. All treatments had no effect on Ca, Mg, P, and K level on 4-sieve, and 5-sieve, and deseeded 5-sieve pods. Campbell and Greig (2) reported similar results with several growth regulators on snap beans.

Wort (38) reported that naphthenates increase bean yields by 20 percent, due to larger pod size. Fattah and Wort (12) showed that at higher light intensity, regardless of temperature, naphthenate sprays increased plant height and pod weight. They found that pod number increased only under high light intensity coupled with high temperature. They concluded that vigorous pollen germination and decreased young fruit abscission may result in increased numbers of pods. Devlin and Yaklich (9)observed that 'Black Valentine' beans treated with 4-CPA absorbed and accumulated more naptalam.

Coyne (6) found that (2-chloroethyl)-trimethyl-ammonium chloride (CCC) promoted early flowering under long photoperiods in the short-day great northern bean, 'Nebraska No. 1 Sel. 27'. He suggested that CCC may be useful on short-day beans to promote early flowering. Butanedioic acid mono (2,2-dimethyldrazide) (B-9) was observed to cause the first flowers to open at higher nodes.

Jackson and Osborne (16) reported that distal application of ABA on explants of 'Canadian Wonder' beans induced early peaking of ethylene, increased cellulase activity, and promoted abscission. They proposed that abscission in explants is controlled at two levels:

1. "an auxin-dependent stage determining the duration of insensitivity to ethylene," and
2. "the timing of a rise in ethylene production in senescing tissue distal to the separation zone."

El-Beltagy and Hall (10) also reported that endogenous ethylene levels correlated with abscission of flowers or pods of broad beans (*Vicia faba* L.). They observed no correlation between endogenous auxin or inhibitor level and any developmental process.

Tucker et al. (30) reported no significant seed yield difference of 'Dark Red Kidney' beans treated with 300 to 2400 ppm ethephon. Webster et al. (32) had similar results, although at 1000 to 2000 ppm seed production, maturity, and size were decreased.

EFFECT OF AUXINS ON YIELD OF OTHER CROPS

Wester and Marth (36) used a 0.8 percent indolebutyric acid (IBA) and 0.2 percent 4-CPA mixture in lanolin paste on emasculated lima bean flowers. They obtained a 18.7 to 28.8 percent increase in the number of successful crosses. A significant increase from 1.95 to 2.43 times the average number of seeds per pod was reported.

Clore (4) applied Parmone (NAA) on lima beans at concentrations of 5 to 1000 ppm. Results showed that at high spray concentrations decreased pod size, seed set, and retarded maturity occurred on some varieties. They suggested that high temperatures together with low humidity, and possibly manner of application, contributed to lower yields. Wester and Marth (35) obtained similar results in lima bean, although they attributed failure of yield increase to unusually favorable temperatures occurring during bloom and setting periods. Cordner (5) reported that high air temperatures and dry atmosphere cause blossom drop of lima beans. He concluded that these factors are adverse to fruit set, the extent of their influence depending on duration and time of occurrence.

Marth and Wester (17) observed that 2,4,5-T applied at 1.5 and 3 ppm on bush lima beans during the early flowering period caused almost total flower drop. After plants resumed recovery, they yielded 18 to 35 percent more fresh marketable pods than untreated plants.

Mehrotra et al. (19) reported that 2-NOA and 4-CPA in combination or separately, gibberellic acid, or NAA increased the number of pods produced per plant on black gram mung beans. Plants sprayed with 2-NOA, p-CPA, p-CPA + 2-NOA, or 1-NAA increased grain yield by 48, 35, 32, and 27 percent, respectively. They conclude that under adverse weather conditions production of naturally occurring hormone may be lacking, resulting in incomplete pollination and fertilization and reducing pod set. This problem may be overcome by application of exogenous supply of synthetic growth regulators, substituting for endogenous supply, thus increasing pod set.

Randhawa and Thompson (26) increased total tomato yields by spraying flower clusters with 2-NOA (50 ppm), alpha-ortho-chlorophenoxy-propionic acid (2,4,5/TB) (50 ppm), 2,4,5-trichlorophenoxyacetic acid (2,4,5-T) (10 ppm), or 2,5-dichlorobenzoic acid (100 ppm). They concluded that tomatoes from treated plants were large in size, uniform, rich red in color, and were not altered in soluble solids and ascorbic acid content in comparison with control plants. Crane and Marks (7) applied 40 ppm solution of beta-naphthoxyacetic acid to emasculated pear flowers. Following pollination of these flowers by an apple variety, the auxin was once more applied. They obtained viable F_1 seeds and concluded that 2-NOA may be of value when distant crosses of plants are made.

Emsweller and Stuart (11) applied 0.1 to one percent IBA, NAA, NAD, 2-NOA, or mono-, di-, or tri-chlorophenoxy-acetic acid to the base of the style of several lily species in an attempt to overcome self-incompatibility. They reported that one percent NAD was most effective in delaying abscission of style and in increasing sugars and stimulating growth of young developing fruit. They concluded that hormones can be used to overcome incompatibilities caused by degeneration of the pollen tubes when they reach the ovules, since pollen action may lack hormonal activities needed for fruit formation.

McGraw (18) reported that in growth chamber studies with 'Early Set' pepper, application of 500 ppm CTBP gave greater yields than 30 ppm 4-CPA or 10 ppm TIBA. In greenhouse studies TIBA caused parthenocarpy, while CTBP was associated with early fruit set; yields of TIBA and 4-CPA treated plants were significantly lower than controls. In field experiments TIBA and 4-CPA increased early yields.

Clark and Wittwer (3) sprayed lettuce and celery plants with several auxins: 2,4-D, alpha-orthochlorophenoxypropionic acid, 2,3,5-triodobenzoic acid (TIBA), 4-CPA or NAA. They reported that seed stalk elongation was hastened, especially after repeated applications, but concluded that there was too much variability in plant response for these growth regulators to be recommended for practical control of seed stalk development.

MISCELLANEOUS EFFECTS OF AUXINS

Guyer and Kramer (14) reported that 4-CPA, applied at four percent seed stage of maturity, retarded seed and fiber development of snap beans. This effect was offset by a reduction in organoleptic test values for color, flavor, overall grade, and shape of pods; although there was no reduction in yield.

Randhawa and Thompson (25) obtained no significant differences in absorbic acid content of 'Tendergreen' snap beans sprayed with four ppm 4-CPA or four ppm ortho-chlorophenoxypropionic acid in comparison with controls.

Mitchell et al. (22) reported that bean leaves which were kept in the dark, then sprayed with one percent NAA accumulated less sugar, starch, and dextrin when placed in daylight, than untreated plants. This work is also supported by Mitchell (20) who obtained similar results with two percent lanolin mixtures of NAD or NAA.

Mitchell and Marth (23) reported that spray applications of 50 to 1000 ppm 4-CPA on attached bean fruits increased their water retaining capacity when harvested and stored. They also noted that rate of color changes during storage was retarded.

Mitchell at al. (21) sprayed 50 to 1000 ppm 4-CPA on commerically acceptable, attached snap bean fruits. They reported a significant maintenance of vitamin C content in storage for treated pods. No decrease in fruit size or yield was observed in both greenhouse and field studies when pod reached a marketable snap bean size.

LITERATURE CITED

1. Binkley, A.M. 1932. The amount of blossom and pod drop on six varieties of garden beans. Proc. Amer. Soc. Hort. Sci. 29:489-493.

2. Campbell, R.E., and J.K. Greig. 1974. Selected growth regulators increase yields of snap beans. HortScience 9 (1):71-72.

3. Clark, B.E., and S.H. Wittwer. 1949. Effect of certain growth regulators on seed stalk development in lettuce and celery. Plant Physiol. 24(4):555-576.

4. Clore, W.J. 1948. The effect of alpha-naphthalene-acetic acid in certain varieties of lima beans. Proc. Amer. Soc. Hort. Sci. 51:475-478.

5. Cordner, H.B. 1933. External and internal factors affecting blossom drop and set of pods in lima beans. Proc. Amer. Soc. Hort. Sci. 30:571-575.

6. Coyne, D.P. 1969. Effect of growth regulators on time of flowering of a photoperiodic sensitive field bean (*Phaseolus vulgaris* L.). HortScience (5):478-480.

7. Crane, M.B. and E. Marks. 1952. Pear-apple hybrids. Nature 170 (4337):1017.

8. Davis, J.T., J.P. Sterrett, and G.R. Leather. 1972. Ethephon-endothall as a chemical abscissor of bean leaves. HortScience (5):478-470.

9. Devlin, R.M. and R.W. Yaklich. 1972. Influence of two phenoxy growth regulators and the uptake and accumulation of naptalam by bean plants. Physiol. Plant. 27:317-320.

10. El-Beltagy, A.S. and M.A. Hall. 1975. Studies on endogenous plant levels of ethylene and auxins in *Vicia faba* L. during growth and development. New Phytol. 75:215-224.

11. Emsweller, S.L. and N.W. Stuart. 1948. Use of growth regulating substances to overcome incompatibilities in *Lilium*. Proc. Amer. Soc. Hort. Sci. 51:581-589.

12. Fattah, Q.A. and D.J. Wort. 1970. Effect of light and temperature on stimulation of vegetative and reproductive growth of bean plants by naphthenates. Agron. J. 62:576-577.

13. Fisher, E.H., A.J. Riker, and T.C. Allen. 1946. Bud, blossom, and pod drop of canning string beans reduced by plant hormones. Phytopath. 36:504-523.

14. Guyer, R.B. and A. Kramer. 1951. Objective measurements of quality of raw processed snap beans as affected by maleic hydrazide and para-chlorophenoxyacetic acid. *Proc. Amer. Soc. Hort. Sci.* 58:263-273.

15. Hardenburg, E.V. 1944. Effect of hormone dust on podset and yield in beans. *Proc. Amer. Soc. Hort. Sci.* 45:367-370.

16. Jackson, M.B. and D.J. Osborne. 1972. Abscisic acid, auxin, and ethylene in explant abscission. *J. Exp. Bot.* 23(76):849-862.

17. Marth, P.C. and R.E. Wester. 1954. Effects of 2,4,5-trichlorophenoxyacetic acid on flowering and vegetative growth of Fordhook 242 bush lima beans. *Proc. Amer. Soc. Hort. Sci.* 63:325-328.

18. McGraw, B.D. 1977. Physiological studies on fruitset in pepper (*Capsicum annuum*, L.) PhD dissertation, Kansas State University, 98 pp.

19. Mehrotra, O.N., H.K. Saxena, A.N. Roy, and S. Nath. 1968. Effects of growth regulators on fruiting and yield of black gram (*Phaseolus mungo*, Roxb.) in India. *Expl. Agric.* 4:339-344.

20. Mitchell, J.W. 1940. Effect of naphthalene acetic acid and naphthalene acetamide on nitrogenous and carbohydrate constituents of bean plants. *Bot. Gaz.* 101:688-699.

21. Mitchell, J.W., B.D. Ezell, and M.S. Wilcox. 1949. Effect of p-chlorophenoxyacetic acid on the vitamin C content of snap beans following harvest. Science 109:202-203.

22. Mitchell, J.W., E.J. Kraus, and M.R. Whitehead. 1940. Starch hydrolysis in bean leaves following spraying with alpha naphthalene acetic acid emulsion. Bot. Gaz. 102:97-104.

23. Mitchell, J.W., and P.C. Marth. 1950. Effect of growth-regulating substance on the water-retaining capacity of bean plants. Bot. Gaz. 112(1):70-76.

24. Murneek, A.E., S.H. Wittwer, and D.D. Hemphill. 1944. "Hormonal" sprays for snap beans. Proc. Amer. Soc. Hort. Sci. 44:428-432.

25. Randhawa, G.S., and H.C. Thompson. 1948. Effect of hormone sprays on yield of snap beans. Proc. Amer. Soc. Hort. Sci. 52:448-452.

26. Randhawa, G.S., and H.C. Thompson. 1950. Effect of application of hormones on yield of tomatoes grown in the greenhouse. Proc. Amer. Soc. Hort. Sci. 53:337-345.

27. Stromme, E.R. and C.L. Hamner. 1948. Delayed maturity of bean plants sprayed with solution of 2,4-dichlorophenoxyacetic acid of non-herbicidal concentrations. Science 107:170-171.

28. Thomson, W.T. 1976. Agricultural chemicals, book III-fumigants, growth regulators, repellents, and rodenticides. Thomson Publications, California.

29. Tomkins, D.R., W.A. Sistrunk, and J.W. Fleming. 1971. Yield of snap beans (*Phaseolus vulgaris* L.) as influence by 5-chloro, 2-thenyl, tri-n-butyl, phosphorium-chloride. *HortScience* 6(4): 393-394.

30. Tucker, C.L., M.D. Miller, and B.D. Webster. 1975. Effects of ethephon on seed yield of *Phaseolus vulgaris* L. *HortScience* 10(2):156-157.

31. Weaver, R.J. 1972. Plant growth substances in agriculture. W.H. Freeman & Co., San Francisco.

32. Webster, B.D., M.E. Craig, and C.L. Tucker. 1975. Effects of ethephon on abscission of vegetative and reproductive structures of *Phaseolus vulgaris* L. *HortScience* 10(2):154-155.

33. Wedding, R.T., J.B. Kendrick, Jr., W.S. Steward, and B.J. Hall. 1956. Growth regulators on beans. *Califor. Agr.* 10(4):4,12.

34. Weigle, J.L., M.L. Robbins, A.R. Beck, and K.M. Batal. 1973. Influence of growth regulators on pod set and yield in snap beans and related crops. *HortScience.* 8(1):35-36.

35. Wester, R.E., and P.C. Marth. 1947. Effects of some growth regulators on yield of bush lima beans. Proc. Amer. Soc. Hort. Sci. 49:315-319.

36. Wester, R.E., and P.C. Marth. 1949. Some effects of a growth regulator mixture in controlled cross-pollination of lima bean. Proc. Amer. Soc. Hort. Sci. 53:315-318.

37. Wittwer, S.H. and A.E. Murneek. 1946. Further investigations on the value of "hormone" sprays and dusts for green bush snap beans. Proc. Amer. Soc. Hort. Sci. 47:285-293.

38. Wort, P.J. 1969. Stimulation of vegetative and reproductive growth of bush bean plants by naphthenates. Can. J. Plant Sci. 49:791-796.

MANUSCRIPT

This manuscript is written in the style of and for publication in HortScience.

Effect of Auxins on Heat Resistant and Susceptible Bean Lines.[1]

P. J. Stoffella and C. D. Clayberg[2]

Department of Horticulture

Kansas State University, Manhattan, Kansas 66506

Additional index words: *Phaseolus vulgaris*, 4-chlorophenoxyacetic acid, (2-naphthoxy)-acetic acid.

Abstract: Beginning at half bloom stage, eight weekly applications of 1 ppm 4-CPA, 3 ppm 4-CPA, 5 ppm 2-NOA, and 10 ppm 2-NOA were applied to 'Bontoc' (heat resistant) and 'Oregon 1604' (heat susceptible) bean lines. Auxin applications significantly decreased percent daily flower abscission for 'Bontoc' but not 'Oregon 1604'. Five ppm 2-NOA increased pod and seed wt and seed no. for both lines, although not significantly so. Daily full bloom no. showed a positive linear response to maximum temperatures during the day before full bloom (DMAX) on both bean lines.

---

[1]Received for publication   Contribution No.
Kansas Agricultural Experimental Station

[2]Graduate student and Research Horticulturist.

Several researchers have used auxins to increase pod yields of Phaseolus vulgaris L., although few have reported seed yield increases. The success of these experiments has been dependent on environmental conditions, type of growth regulator, and rate and frequency of application used. Wittwer and Murneek (13) increased green bush snap bean yields by 40% using 5 weekly spray applications of 2 ppm 4-CPA under hot dry environmental conditions. Randhawa and Thompson (8) obtained similar results on 'Tendergreen' snap beans and reported that 2 to 20 ppm 2,4,5-trichlorophenoxyacetic acid decreased yields. Murneek et al. (7) found that 5 to 25 ppm alpha-naphthaleneacetamide or beta-naphthoxyacetic acid applied to 'Stringless Green Pod' bush beans increased yields by 59 to 79% during hot summer weather, while these same treatments led to a decrease in pod weight during cool summer weather. Fisher et al. (3) dusted field-grown wax beans with 40 and 80 ppm alpha-naphthalene acetic acid and obtained a 24 and 12% yield increase, respectively. Hardenburgh (4) reported decreases in several field-grown bean yields upon dusting with Parmone, containing 70 to 140 ppm alpha-naphthalene acetic acid, and concluded that under unfavorable conditions yields were not significantly different, although pods "filled" better on treated plants. Stromme and Hamner (9) found that 2,4-dichlorophenoxyacetic acid applied at nonherbicidal concentrations on red kdiney beans delayed maturity significantly with a slight decrease in pod number and seed yield. Wedding et al. (10) reported spray applications of 2,4-dichlorophenoxyacetic acid on lima and snap beans altered yields from 70% increase to 75% decrease over different replications. They attributed the yield variability mostly to inadequate water supply during the latter part of the growing period.

The use of synthetic growth regulators or hormones has been observed in other crops to increase (2,5,6,12) or decrease (1,11) pod and seed yields. This study was designed to determine if exogenous auxin applications would differentially increase seed yields of a heat resistant bean line in comparison with a heat susceptible line.

'Bontoc' (heat resistant) and 'Oregon 1604' (heat susceptible) bean lines were planted on May 26, 1977 followed by a second planting date 2 weeks later. A randomized complete block design was used with each treatment replicated three times. 'Taylor's Horticultural' bush beans were used as within plot guard plants to prevent border effect, since the amount of 'Bontoc' seed available was limited. Rows were planted .91 m apart and 'Williams' soybeans were planted in alternate rows to minimize spray drifts across rows. Auxins treatments of 1 ppm 4-CPA, 3 ppm 4-CPA, 5 ppm 2-NOA, and 10 ppm 2-NOA were sprayed at half bloom stage followed by 7 weekly applications. Ethanol, used to dissolve the auxins, plus water, was sprayed on control plants.

The auxins were applied with an 'Air-Plot' sprayer, at 281 g/sq. cm (40 psi) delivery pressure and a rate of 3.54 km per hr, using 3 disc-core cone spray nozzles, each with a .29 gpm capacity. Plant spacing was 15.43 cm except one randomly selected plant per plot was thinned to 30.48 cm spacing. Its flowers at full bloom were tagged daily for 43 consecutive days and counts recorded. Daily percent flower abscission was calculated by subtracting daily total pod no. from daily full bloom no. times 100. Beans were harvested starting August 4 and oven dried at 65° C. for 24 hrs. Total pod and seed wt and seed no. were obtained from untagged plants only.

Analysis of variance was performed on main effects and linear regression analysis on daily max. temp. the day before full bloom (DMAX) and daily total bloom no.

Daily full bloom no. was significantly increased on 'Bontoc' (Table 1) and decreased on 'Oregon 1604' (Table 2) by 2-NOA at 6.60 g/ha. Daily full bloom no. shows a higher positive linear response to DMAX for 'Oregon 1604' than for 'Bontoc' (Fig. 1). Auxin applications decreased daily percent flower abscission for both lines, but the decrease was significant only for 'Oregon 1604'. With an increase in daily full bloom no. and decrease in daily percent flower abscission on 'Oregon 1604', pod set should increase, especially under higher DMAX. A slight increase over control in pod wt, including seeded and parthenocarpic pods, was indeed observed for this cultivar (Table 3), although it was not significant. A similar trend occurred on 'Bontoc' (Table 1, 4) also at an insignificant probability level. Significance was not obtained due to high variation from common blight damage and from flooding that occurred during the first half of the growing season. These factors were also responsible for the lack of data for 'Bontoc' at high concentration of 2-NOA (Table 1).

Mehrotra et al. (6) concluded that under adverse weather conditions naturally occurring hormone may be lacking, resulting in incomplete pollination and fertilization. They suggested that exogenous applications of growth regulators could substitute for endogenous supply, thus increasing pod set.

Our data suggest that the type and concentration of auxin affects yield and daily full bloom no. on heat resistant and heat susceptible bean lines differently. Further studies on pollen tube growth and fertilization, under similar conditions would provide information on auxin's mode of action.

LITERATURE CITED

(1) Clore, W.J. 1948. The effect of alpha-naphthalene-acetic acid in certain varieties of lima beans. Proc. Amer. Soc. Hort. Sci. 51:475-478.

(2) Crane, M.B., and E. Marks. 1952. Pear-apple hybrids. Nature 170(4337):1017.

(3) Fisher, E.H., A.J. Riker, and T.C. Allen. 1946. Bud, blossom, and pod drop of canning string beans reduced by plant hormones. Phytopath. 36:504-523.

(4) Hardenburgh, E.V. 1944. Effect of hormone dust on pod-set and yield in beans. Proc. Amer. Soc. Hort. Sci. 45:367-370.

(5) Marth, P.C. and R.E. Wester. 1954. Effects of 2,4,5-trichlorophenoxyacetic acid on flowering and vegetative growth of Fordhook 242 bush lima beans. Proc. Amer. Soc. Hort. Sci. 63:325-328.

(6) Mehrotra, O.N., H.K. Saxena, A.N. Roy, and S. Nath. 1968. Effects of growth regulators on fruiting and yield of black gram (*Phaseolus mungo*, Roxb.) in India. Expl. Agric. 4:339-344.

(7) Murneek, A.E., S.H. Wittwer, and D.D. Hemphill. 1944. "Hormonal" sprays for snap beans. Proc. Amer. Soc. Hort. Sci. 44:428-432.

(8) Randhawa, G.S., and H.C. Thompson. 1948. Effect of hormone sprays on yield of snap beans. Proc. Amer. Soc. Hort. Sci. 52:448-452.

(9) Stromme, E.R. and C.L. Hamner. 1948. Delayed maturity of bean plants sprayed with solution of 2,4-dichlorophenoxyacetic acid of non-herbicidal concentrations. Science 107:170-171.

(10) Wedding, R.T., J.B. Kendrick, Jr., W.S. Steward, and B.J. Hall. 1956. Growth regulators on beans. Califor. Agr. 10(4):4, 12.

(11) Wester, R.E., and P.C. Marth. 1947. Effects of some growth regulators on yield of bush lima beans. Proc. Amer. Soc. Hort. Sci. 49:315-319.

(12) Wester, R.E., and P.C. Marth. 1949. Some effects of a growth regulator mixture in controlled cross-pollination of lima bean. Proc. Amer. Soc. Hort. Sci. 53:315-318.

(13) Wittwer, S.H. and A.E. Murneek. 1946. Further investigations on the value of "hormone" sprays and dusts for green bush snap beans. Proc. Amer. Soc. Hort. Sci. 47:285-293.

Table I. Effect of auxin on daily full bloom no. and daily percent flower abscission of 'Bontoc' grown under field conditions.[z]

Treatment	Conc. g/ha[y]	Bloom no.	% daily flower abscission
Control		2.37b	82.00a
4-CPA	1.32	2.92b	50.50a
4-CPA	3.96	2.42b	50.00a
2-NOA	6.60	4.02a	61.71a
2-NOA	13.19	3.98a	---

[z]Data are means of one plant and three replications over May 26 and June 6 planting dates.

[y]Mean separation in columns by LSD, 5% level.

Table 2. Effect of auxin on daily full bloom no. and daily percent flower abscission of 'Oregon 1604' grown under field conditions.^{z}

Treatment	Concn. g/ha^{y}	Bloom No.	% daily flower abscission
Control		5.82a	62.57a
4-CPA	1.32	5.41ab	51.37b
4-CPA	3.96	5.19b	50.00b
2-NOA	6.60	4.49c	49.71b
2-NOA	13.19	5.73ab	60.67ab

^{z}Data are means of one plant and three replications over May 26 and June 6 planting dates.

^{y}Mean separation in columns by LSD, 5% level.

Table 3. Effect of auxin on pod weight, seed weight, and seed number per plant of 'Oregon 1604' grown under field conditions (mean of six treatments).

Treatment	Concn. g/ha	Pod weight (g)[z]	Seed weight (g)	Seed no.
Control		7.21ab	3.86ab	31.25ab
4-CPA	1.32	4.67c	2.42b	18.25c
4-CPA	3.96	4.98bc	2.73b	19.63c
2-NOA	6.60	8.35a	4.68a	33.07a
2-NOA	13.19	5.62bc	3.03b	22.84bc

[z]Mean separation in columns by LSD, 5% level.

Table 4. Effect of auxin on pod weight, seed weight, and seed number per plant of 'Bontoc' grown under field conditions (mean of six treatments).

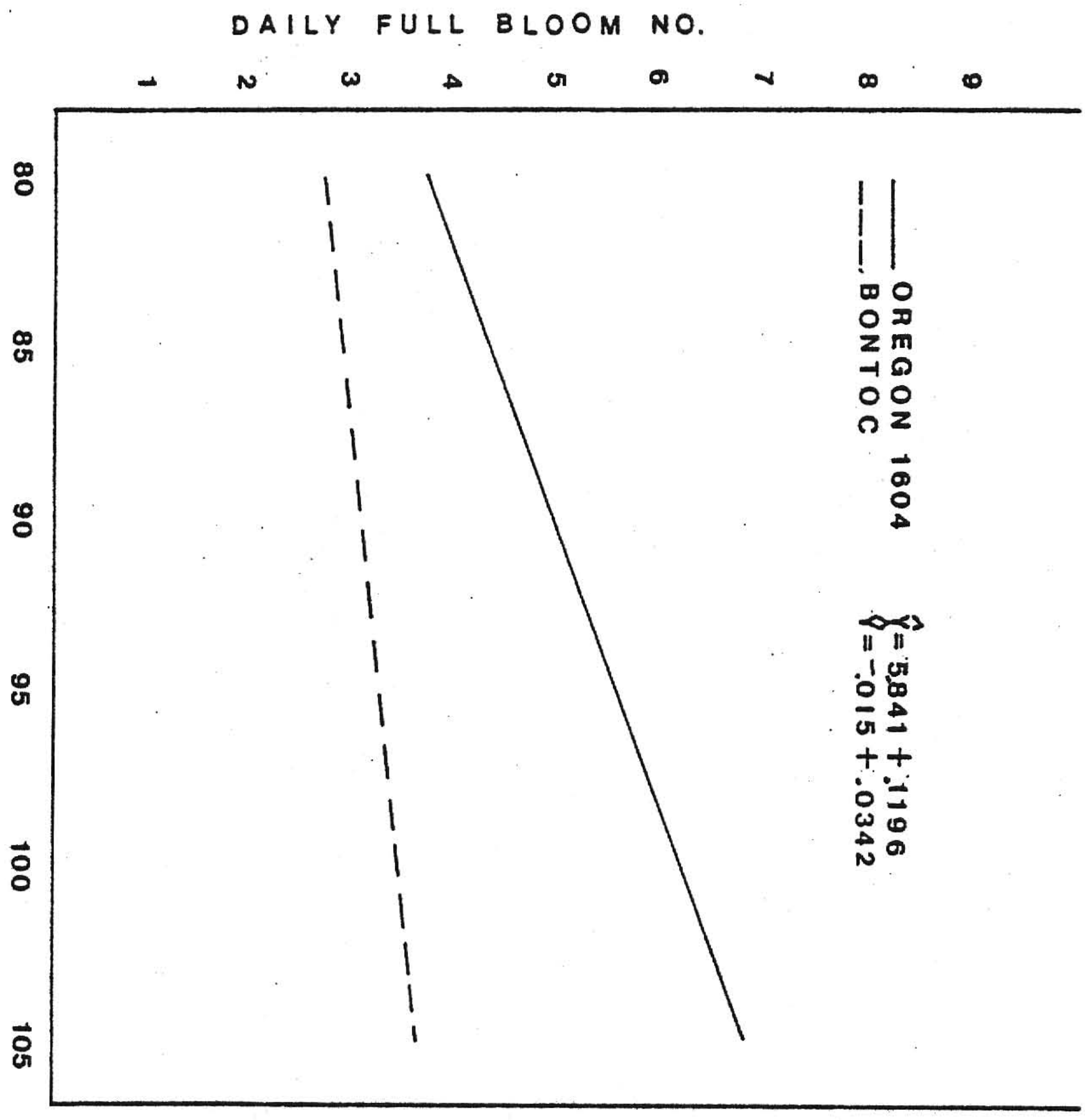
Treatment	Concn. g/ha	Pod weight (g)[z]	Seed weight (g)	Seed no.
Control		.21a	.09a	.63a
4-CPA	1.32	.56a	.28a	1.41a
4-CPA	3.96	.16a	.09a	.47a
2-NOA	6.60	.62a	.34a	1.54a
2-NOA	13.19	.20a	.20a	.11a

[z]Mean separation in columns by LSD, 5% level.

FIGURE 1: The effect of DMAX on the daily full bloom no. of 'Oregon 1604' and 'Bontoc'. Linear fits determined by least squares linear regression.

THIS BOOK CONTAINS NUMEROUS PAGES WITH DIAGRAMS THAT ARE CROOKED COMPARED TO THE REST OF THE INFORMATION ON THE PAGE.

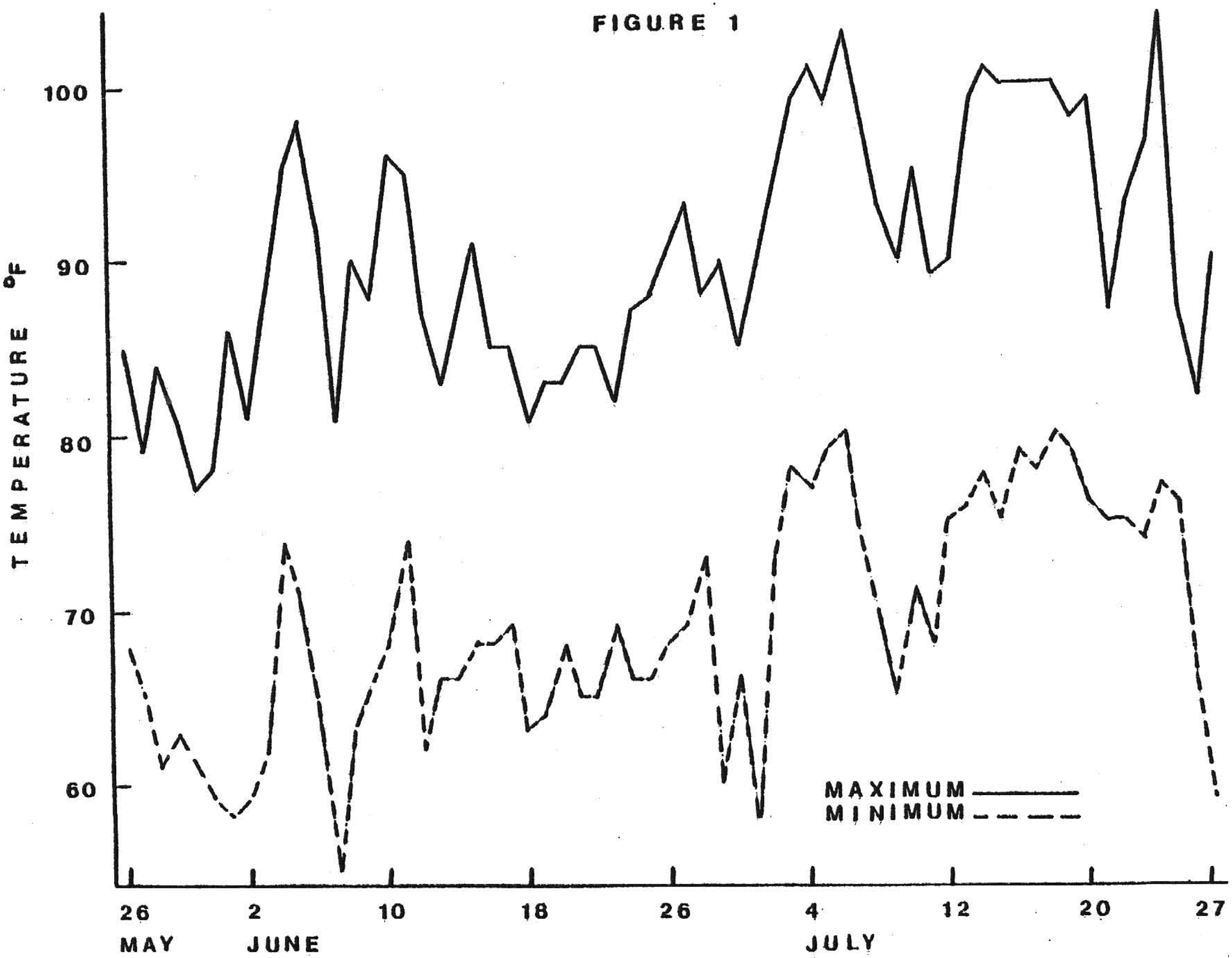
THIS IS AS RECEIVED FROM CUSTOMER.


DAILY FULL BLOOM NO.
1 2 3 4 5 6 7 8 9
DMAX
80 85 90 95 100 105
OREGON 1604 $\hat{Y}$ = 5.841 + .1196
BONTOC $\hat{Y}$ = -.015 + .0342

APPENDIX

Figure 1. Daily maximum and minimum temperatures at Manhattan, Kansas from May 26 to September 10, 1977.

FIGURE 1


100
90
80
70
60
TEMPERATURE °F
26
2
10
18
26
4
12
20
27
MAY
JUNE
JULY
MAXIMUM
MINIMUM

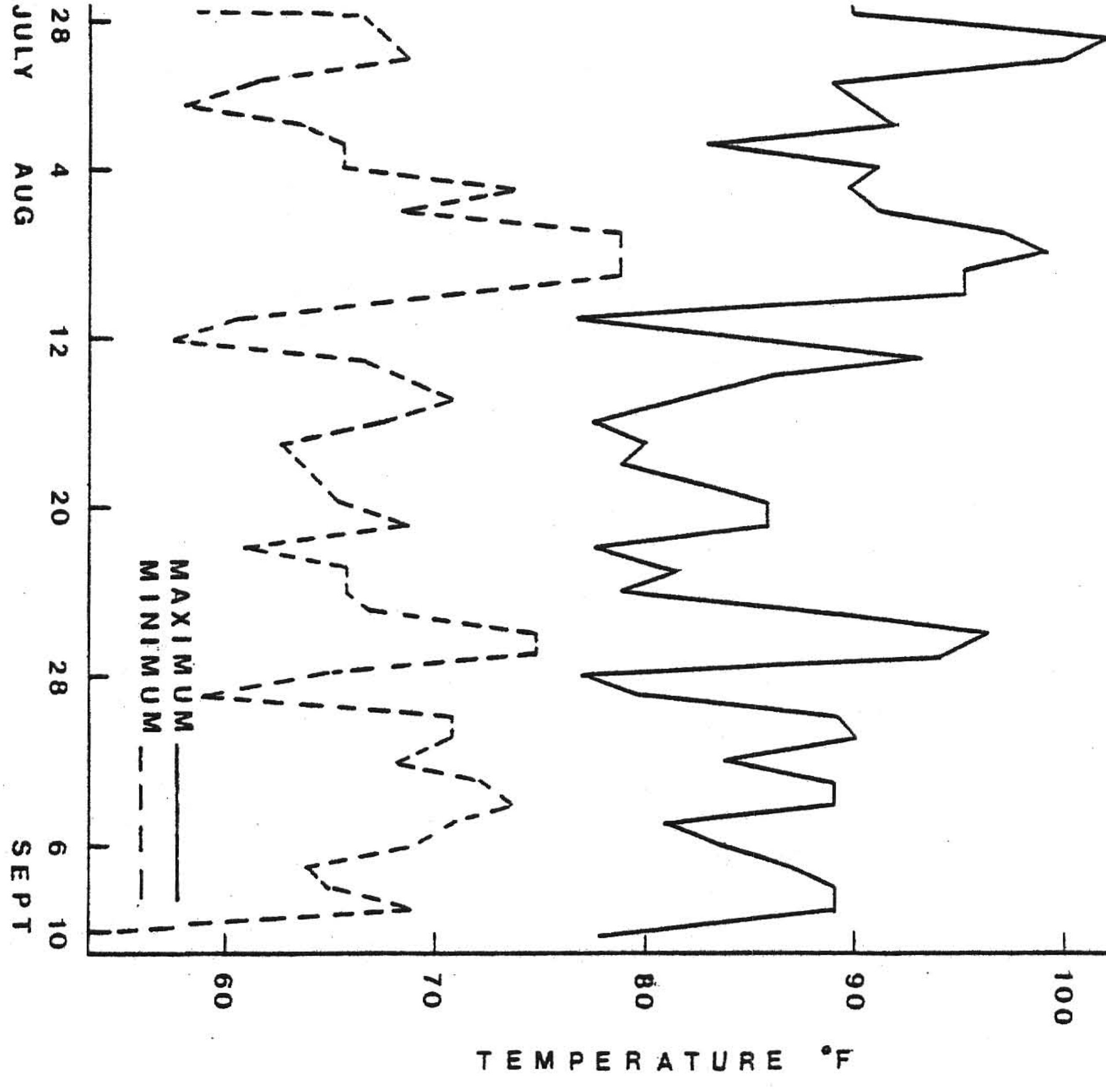


FIGURE 1 (CONT.)

Figure 2. Three day total rainfall data at Manhattan, Kansas from May 26 to September 10, 1977.

FIGURE 2

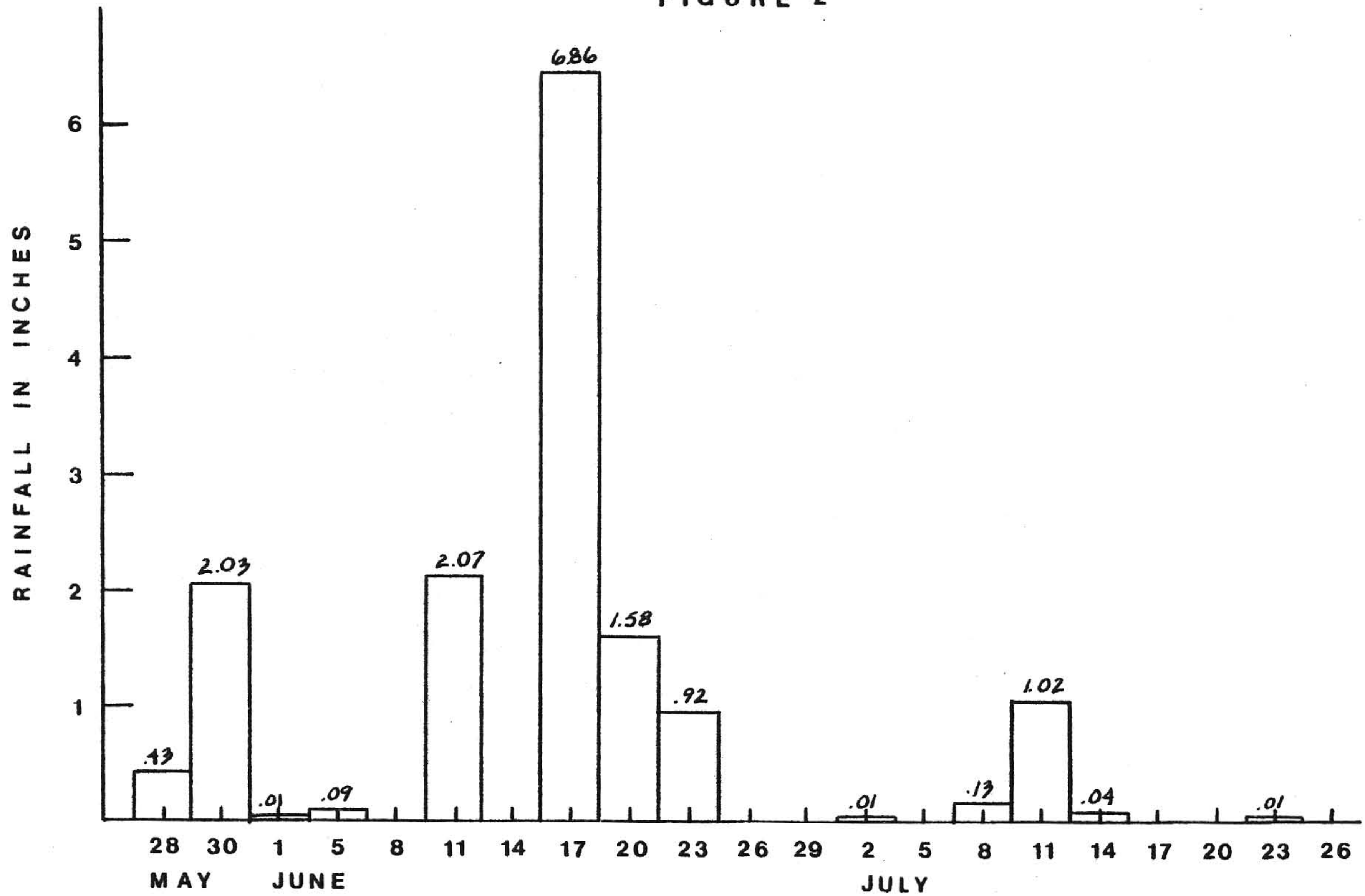

RAINFALL IN INCHES
1
2
3
4
5
6
.43
2.03
.01
.09
2.07
6.86
1.58
.92
.01
.13
1.02
.04
.01
28 30 1 5 8 11 14 17 20 23 26 29 2 5 8 11 14 17 20 23 26
MAY
JUNE
JULY

FIGURE 2 (CONT.)

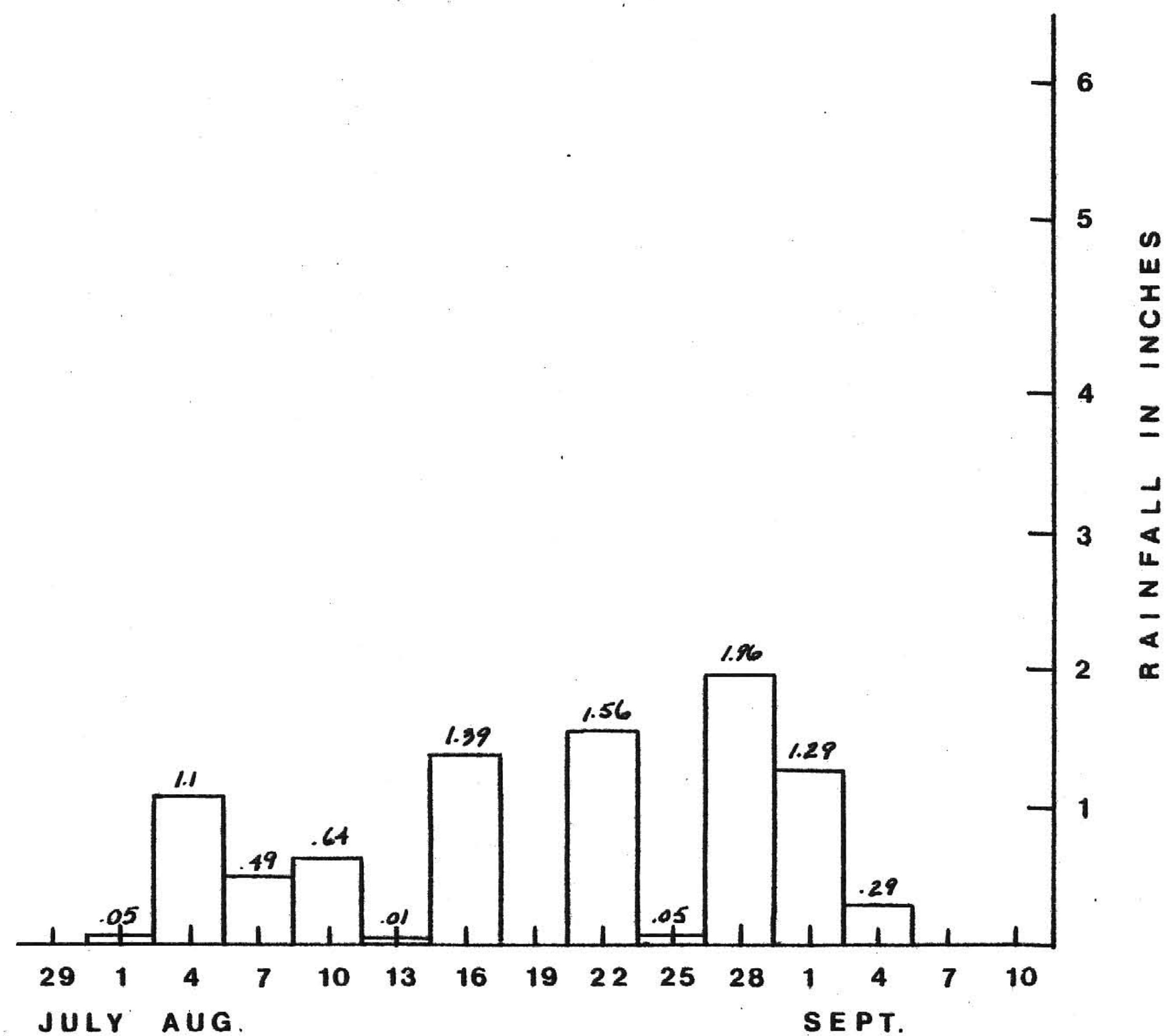


Table 5. Treatments, planting and auxin spray application dates of 1977 bean field experiments.

Treatments	Planting date	Auxin spray application dates
Control (ethanol + water)	May 26	June 29
1 ppm 4-CPA	June 6	July 6
3 ppm 4-CPA		July 12
5 ppm 2-NOA		July 20
10 ppm 2-NOA		July 27
		August 3
		August 10
		August 17

Table 6. Effect of auxin on pod weight, seed weight, and seed number per plant of beans grown under field conditions (mean of two lines, n = 12).

Treatment	Concn. g/ha	Pod weight (g)^z	Seed weight (g)	Seed no.
Control		3.72ab	1.98ab	15.94a
4-CPA	1.32	2.62a	1.35b	9.83a
4-CPA	3.96	2.57b	1.41b	10.05a
2-NOA	6.60	4.49a	2.51a	17.30a
2-NOA	13.19	2.91ab	1.57ab	11.71a

^{z}Mean separation in columns by Duncan's multiple range test, 5% level.

Table 7. Effect of cultivar on pod weight, seed weight, and seed number per plant of beans grown under field conditions (mean of 30 treatments).

Cultivar	Pod weight (g)^z	Seed weight (g)	Seed number
Oregon 1604	6.17a	3.34a	25.01a
Bontoc	.35b	.18b	.92b

^{z}Mean separation in columns by Duncan's multiple range test, 5% level.

Table 8. Effect of planting date on pod weight, seed weight, and seed number per plant of beans grown under field conditions (mean of 2 lines, n = 30).

Planting date	Pod weight (g)[z]	Seed weight (g)	Seed number
Date I (May 26)	3.48a	1.76a	13.59a
Date II (June 6)	3.04a	1.76a	12.34a

[z]Mean separation in column by Duncan's multiple range test, 5% level.

Table 9. Effect of cultivar on endogenous ethylene concentration (ppm) of beans grown under field conditions (n = 15).

Cultivar	Ethylene ppm/10 cm^2 leaf[z]
Oregon 1604	3.77a
Bontoc	3.23a

[z]Mean separation in column by Duncan's multiple range test, 5% level.

Table 10. Effect of auxin applications on endogenous ethylene concentration (ppm) of beans grown under field conditions (means of two lines, n = 30).

Auxin applications	Ethylene ppm/10 cm^2 leaf[z]
2 (July 7)	6.75a
4 (July 21)	.25b

[z]Mean separation in column by Duncan's multiple range test, 5% level.

Table 11. Effect of two weekly auxin applications on endogenous ethylene concentration (ppm) of 'Bontoc' grown under field conditions (mean of 3 treatments).

Treatment	Concn. g/ha	Ethylene ppm/10 cm^2 leaf[z]
Control		6.31a
4-CPA	1.32	7.10a
4-CPA	3.96	9.50a
2-NOA	6.60	2.32a
2-NOA	13.19	5.70a

[z]Mean separation in column by Duncan's multiple range test, 5% level.

Table 12. Effect of four weekly auxin applications on endogenous ethylene concentration (ppm) of 'Bontoc' grown under field conditions (mean of 3 treatments).

Treatment	Concn. g/ha	Ethylene ppm/10 cm^2 leaf[z]
Control		.32a
4-CPA	1.32	.31a
4-CPA	3.96	.16b
2-NOA	6.60	.33a
2-NOA	13.19	.25ab

[z]Mean separation in column by Duncan's multiple range test, 5% level.

Table 13. Effect of two weekly auxin applications on endogenous ethylene concentration (ppm) of 'Oregon 1604' grown under field conditions (mean of 3 treatments).

Treatment	Concn. g/ha	Ethylene ppm/10 cm^2 leaf[z]
Control		8.83a
4-CPA	1.32	8.91a
4-CPA	3.96	4.71a
2-NOA	6.60	4.21a
2-NOA	13.19	9.90a

[z]Mean separation in column by Duncan's multiple range test, 5% level.

Table 14. Effect of four weekly auxin applications on endogenous ethylene concentration (ppm) of 'Oregon 1604' grown under field conditions (mean of 3 treatments).

Treatment	Concn. g/ha	Ethylene ppm/10 cm^2 leaf[z]
Control		.29a
4-CPA	1.32	.19a
4-CPA	3.96	.23a
2-NOA	6.60	.25a
2-NOA	13.19	.21a

[z]Mean separation in column by Duncan's multiple range test, 5% level.

Table 15. Effect of planting date on pod and seed weight per plant of 'Taylor's Horticultural' beans grown under field conditions (mean of 30 treatments).

Planting date	Pod weight (g)[z]	Seed weight (g)
Date I (May 26)	8.55a	5.62a
Date II (June 6)	6.83b	4.38b

[z]Mean separation in columns by Duncan's multiple range test, 5% level.

Table 16. Effect of auxin on pod and seed weight per plant of 'Taylor's Horticultural' bean grown under field conditions (mean of 12 treatments).

Treatment	Concn. g/ha	Pod weight (g)[z]	Seed weight (g)
Control	.	7.55ab	4.93ab
4-CPA	1.32	7.02b	4.51b
4-CPA	3.96	7.42ab	4.77ab
2-NOA	6.60	7.90ab	5.14ab
2-NOA	13.19	8.55a	5.67a

[z]Mean separation in columns by Duncan's multiple range test, 5% level.

ACKNOWLEDGEMENTS

I would like to take this opportunity to express my appreciation to my major Professor, Dr. Carl D. Clayberg, Department of Horticulture, for his guidance, patience, and encouragement throughout my graduate study.

Sincere appreciation is also extended to Dr. Ronald W. Campbell, Head of the Department of Horticulture, Dr. James K. Greig, Professor of Horticulture, and Dr. George A. Milliken, Associate Professor of Statistics, for their advice as members of my academic committee.

Special thanks to Mr. Brian J. Feeney for drawing all figures in this study. I also wish to express my appreciation to all others who have helped me in this research in numerous ways at one time or another.

I wish to acknowledge the financial support provided by the Department of Horticulture.

Finally, I am forever indebted and grateful to my parents whose encouragement and sacrifice made my graduate studies possible.

EFFECT OF AUXINS ON HEAT RESISTANT AND SUSCEPTIBLE BEAN LINES

BY

PETER JOSEPH STOFFELLA

B.S., Delaware Valley College of Science and
Agriculture, 1976

AN ABSTRACT OF A MASTER'S THESIS

submitted in partial fulfillment of the

requirements for the degree

MASTER OF SCIENCE

Department of Horticulture
Kansas State University
Manhattan, Kansas

1977

Beginning at half bloom stage, eight weekly applications of 1 ppm 4-CPA, 3 ppm 4-CPA, 5 ppm 2-NOA, and 10 ppm 2-NOA were applied to 'Bontoc' (heat resistant) and 'Oregon 1604' (heat susceptible) bean lines. Auxin applications significantly decreased percent daily flower abscission for 'Bontoc' but not 'Oregon 1604'. Five ppm 2-NOA increased pod and seed wt. and seed no. for both lines, although not significantly so. Daily full bloom no. showed a positive linear response to maximum temperatures during the day before full bloom (DMAX) on both bean lines.