cated by the similar patterns of variability found in the residual soluble fraction.

Both simazine and amitrole affected the total RNA content, but this effect was not pronounced until the second period and, except for simazine at the higher rate, persisted throughout the study. Indications that amitrole does affect RNA were suggested in the studies of Carter and Naylor (1) who reported reductions in the free pool of the amino acids, glycine and serine, in beans treated with amitrole. Both of these amino acids are recognized as precursors of RNA. Sund et al. (8) gave additional evidence in their investigations, wherein they were able to alleviate the growth inhibition in amitrole treated tomato with adenine, guanine and hypoxanthine.

Our data also show that deleterious synergistic effects resulting from simultaneous use of simazine and amitrole did not occur. Some interaction was observed, but this appeared to be beneficial since simazine seemed to counteract some of the depressing influence of amitrole.

Literature Cited

1. Carter, M. C., and A. W. Naylor. 1961. The effect of 3-amino-1,2,4-triazole upon the metabolism of carbon labeled sodium bicarbonate, glucose, succinate, glycine and serine by bean plants. *Physiol. Plant.* 14:62–71.
2. Lowry, O. H., N. H. Rosebrough, A. L. Farr, and R. J. Randall. 1951. Protein measurement with the Folin phenol reagent. *J. Biol. Chem.* 193:225–272.
3. Luckwill, L. C., and S. H. Crowdy. 1950. Virus diseases of fruit trees. II. Rubbery wood, chat fruit and mosaic in apples. *Ann. Rep. Long Ashton Res. Sta.* 1949:68–79.
4. Ries, S. K., R. P. Larsen, and A. L. Kenworthy. 1963. The apparent influence of simazine on nitrogen nutrition of peach and apple trees. *Weeds* 11:270–273.
5. Millikan, D. F., and E. E. Pickett. 1964. A rapid method for the extraction and identification of RNA in plant leaf tissue. *Phytochem.* 3:667–670.
6. Saidak, W. J., and W. M. Rutherford. 1963. The tolerance of young apple trees to amitrole, diuron and simazine. *Can. J. Plant Sci.* 43:113–118.
7. Snedecor, G. W. 1956. Statistical Methods. Ed. 5. Iowa State College Press, Ames, Iowa. 534 p.
8. Sund, K. A., E. C. Putala, and H. N. Little. 1960. Reduction of 3-amino-1, 2,4-triazole phytotoxicity in tomato plants. *J. Agric. Food Chem.* 8:210–212.
9. Zucker, M., and H. T. Stinson, Jr. 1962. Chloroplasts as the major protein bearing structures in *Oenothera* leaves. *Arch. Biochem. Biophys.* 97:637–644.

Pre-emergence Weed Control in Young Deciduous Fruit Trees[1]

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Abstract. A number of pre-emergence soil residual herbicides were tested at 2 locations on varieties of young peach, plum, cherry, pear and walnut rootstocks. The greatest variation in response resulted from differences in location. Important differences in varietal response were also obtained with the various herbicides in light soils. Simazine appeared sufficiently safe to trees in heavier soil but gave variable weed control. Diuron gave about the same degree of weed control but more safety than simazine on young trees. Of the uracil herbicides tested, DP-733 was the least toxic to the fruit tree species tested, while bromacil and isocil were generally the most toxic, except to peach trees. Of the commercial uracil herbicides, only DP-732 (terbacil) was of sufficient interest for further study.

Introduction

WEED competition in the culture of deciduous orchards is most damaging during the first few years in the establishment of young trees. Most pre-emergence herbicides, labeled for use in orchards, restrict the use of soil herbicides for trees older than 3 years. The object of this study was to evaluate some of the more promising herbicides for preemergence weed control in orchards with young deciduous fruit trees.

A number of studies have been conducted on young deciduous fruit trees (3, 7). Benson and Degman (1) reported good weed control with diuron on young apple and pear trees, but insufficient safety with simazine. Larsen and Ries (6) reported adequate safety with simazine on apples but less safety on young pear trees. Fischer (2) reported good safety with isocil and bromacil on young peach trees. Trifonov (9) stated that simazine should not be used on the seed bed, or on 1- to 2-year-old apple, pear, plum, quince, peach, cherry and apricot trees.

The results reported here are a summary of 3 tests of a number of pre-emergent type herbicides on 9 different species of young deciduous fruit trees. These trials were conducted in 3 widely different climatic areas and soil conditions. The effects of the herbicide treatments were measured by the foliar conditions and growth measurements of the trees.

Materials and Methods

Young commercial nursery trees were lined out one foot apart in small 5 × 10-foot plots and treated shortly thereafter with a number of herbicides in aqueous solutions at 100 gal/A. During the application, no attempt was made to keep the herbicide spray off the dormant trees. At various periods during the spring and summer, foliar conditions were rated for phytotoxicity (0 = no effect, 3 = definite recognizable symptoms related to the herbicide, 5 = a striking symptom with marginal burn, 10 = all foliage dead). Tree diameters and circumferences were taken at all 3 locations. Fresh weights showed more variation than diameters and were therefore not included. Trees at the Kearney trial grew poorly and showed no significant differences in diameter; therefore only foliar phytotoxicity ratings are listed.

The herbicides used were simazine [2-chloro-4,6 bis (ethylamino)-*s*-triazine], atrazine (2-chloro-4-ethylamino-6-isopropylamino-*s*-triazine), prometryne (2,4-bis(isopropylamino)-6-methylmercapto-*s*-triazine), diuron [3-(3, 4-dichlorophenyl)-1,-1-dimethylurea], isocil [5-bromo-3-isopropyl-6-methyluracil], bromacil [5-bromo-3-*sec*-butyl-6-methyluracil], terbacil (3-*Tert*-butyl-5-chloro-6-methyluracil), DP629 (5-

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chloro-3-sec-butyl-6-methyluracil), DP-733 (5-bromo-3-Tert butyl-6-methyluracil), DP766 (5-chloro-3(α-ethylpropyl)-6-methyluracil, and DP767 (5-bromo-3(α-ethylpropyl)-6-methyluracil).

Sonoma county trials.

The Sonoma county trials included a number of tree species, but only 'Marianna 2624' and 'Myrobalan 3J' are reported here. Two trees of each species were planted per plot, replicated 3 times, on April 10, 1963, in a Dublin clay loam (organic matter 6.1%, sand 52%, silt 38%, clay 10%). The first application of herbicides was made on May 1, 1963, in 100 gal/A of water. Weed control and vigor ratings were made on June 5, 1963; phytotoxicity and vigor ratings on July 8 and September 11, 1963. The first diameter measurements were made on February 4, 1964. On March 18, 1964, the plots were resprayed with the same herbicides, with certain exceptions as noted in the tables. These plots were then rated for weed control, phytotoxicity and vigor on May 26 and July 23, 1964. Tree circumferences were again measured on December 4, 1964. The increase in diameters was recorded. These plots were again sprayed on January 29, 1965.

Trials at University of California, Davis.

The trees were planted on March 4, 1964, with 9 species in each plot; they were sprayed on April 27, 1964, with 5 herbicides (Table 3). Herbicides were applied at the rates listed in 100 gal/A of water using a small stainless steel sprayer adapted for constant pressure with an 8004 E nozzle, 30 psi.

The trees planted included 2 'Marianna' seedlings (1/2 inch and 3/8 inch), 3/8-inch 'Winter Nellis,' 1/2-inch 'Bartlett' on 'Domestic French,' 3/8-inch Black Walnut, 1/2-inch 'Bing' on 'Mahaleb,' 1/8-inch 'Mahaleb' liners and 1/8-inch 'Mazzard' liners. The soil had been previously fumigated with 1000 lb./A of a mixture of dichloropropane and dichloropropene. The area was sprinkle-irrigated. The soil series was Yolo clay loam composed of 5.8% organic matter, 24% sand, 64% silt and 12% clay. Each plot was replicated 6 times in a randomized block experiment design. Weed control ratings were made periodically, and 0–10 phytotoxicity ratings were taken on June 6, July 24, and November 7, 1964. Diameters were recorded on November 24, 1964.

Kearney Field Station trials.

With a similar plot layout, the same kinds of herbicides as used in the 1964 Davis trials were sprayed on April 28, 1964, on young trees planted April 1, 1964, at 12-inch spacings in a coarse sandy soil at the Kearney Field Station. This soil consisted of 0.6% organic matter, 67% sand, 24% silt and 9% clay. The trees used were 'Lovell' seedlings, 'Old Home' pear on French pear root (3/8-inch), 'Cardinal' grafted on 'Lovell' (3/8-inch), 'California' Black Walnut seedlings (1/2-inch), 'Blenheim' on apricot root (3/4-inch) and 'Myrobalan 29C' (3/4-inch). This trial was sprinkler-irrigated but not fertilized or pre-plant fumigated. Lack of uniform watering and of fertilizer affected the tree growth adversely. The differences in growth, therefore, did not show as readily as in the Davis trial even though the injury to the foliage was more severe. Weed control and phytotoxicity ratings were made on June 4, 1964, phytotoxicity ratings on July 15, and again on October 26, 1964. Diameter readings were taken on November 20, 1964, but showed no differences and therefore were excluded from Table 2.

Results

Sonoma trial.

Continued use of simazine at 6 lb./A showed increasing weed control over the three year period (Table 1). Prometryne and atrazine showed a decrease in weed control, although the rates of the latter were lower than with simazine (Table 1).

Diuron gave excellent annual weed control, particularly at the 6 lb./A rate. There was some year-to-year variation.

The uracil herbicides, bromacil, isocil, terbacil and the D.P. numbered compounds, generally gave outstanding weed control. The 4 lb./A rate of several appeared comparable to the 6 lb./A rate of diuron over the 3-year period.

The overall annual increase in tree size reflected the weed control. Those herbicides demonstrating the best control, i.e., diuron, isocil, bromacil, DP-629, and DP 733 were associated with the most substantial increase in diameter in both varieties of plum rootstock.

Minimal injury symptoms were observed in this trial, due probably to the high level of organic matter, 6.1% (5). The effect of herbicides on weed control was the predominant factor affecting growth; the high rates of herbicides apparently did not inhibit growth.

UC Davis trial.

Very little toxicity was noted on any of the species treated with herbicide rates of 1 and 4 lb. on this loam soil containing moderately high organic matter. The 'Lovell' peach trees showed marked resistance to both bromacil and isocil in the phytotoxic-

Table 1. The effect of several soil-applied, pre-emergence herbicides on foliar condition and growth as measured by trunk diameter after 2 years of applications.[a] Sonoma County trial.

Herbicide	Lb./A	Weed control[b]			Marianna 2624			Myrobalan 3 J		
		'63	'64	'65	Phytotoxicity[c] 5 months	Diameter	1-year increase[d]	Phytotoxicity[c] 5 months	Diameter	1-year increase[d]
		%	%	%	(0–10)	mm	mm	(0–10)	mm	mm
Simazine	3	30	10	56	0	54	8	0	42	5
Simazine	6	20	50	100	0	74	14	0	52	10
Atrazine	2	70	30	50	0	68	9	0	46	4
Atrazine	4	70	30	12	0.3	71	12	2.0	42	3
Prometryne	2	10	30	10	0	59	0	0	43	0
Prometryne	4	90	40	15	2.3	74	16	2.0	55	9
Diuron	3	80	17	90	0	81	17	2.0	55	12
Diuron	6	100	80	100	0	83	18	0	75	19
Bromacil	2	97	70	82	0	84	22	0	70	14
Bromacil	4	100	90	100	0	82	22	3.0	74	14
Isocil	2	90	70	98	0	71	15	0	57	14
Isocil	4	100	97	100	0	87	22	0	81	28
DP 629	2	100	70	68	0	81	16	0	62	16
DP 629	4	100	80	100	0.3	71	21	3.0	59	18
Terbacil	2	e	80	100	0	63	e	0	54	e
Terbacil	4	e	97	100	0	65	e	0	50	e
DP 733	2	e	90	98	0	57	e	3.0	42	e
DP 733	4	100	80	100	0	91	25	0	70	16
DP 766	2	e	50	17	0	66	e	0	42	e
DP 766	4	e	80	92	0	66	e	2.0	53	e
DP 767	2	70	50	18	1.3	69	10	0	63	11
DP 767	4	90	40	60	1.3	65	11	0	66	14
Check	0	0	0	0	0	49	6	0	40	6

[a]Average of 2 trees per plot, replicated 3 times.

[b]Average per cent weed control after 6 months based on a 0–10 weed control rating; 0 = no control, 10 = 100% weed control Weeds present include filaree (*Erodium cicutarium*), volunteer barley (*Hordeum murinum* L.), chickweed (*Stellaria media*), cheeseweed (*Malva parviflora* L.), mustard (*Brassica sp.*), bluegrass (*Poa annua L.*), prickly lettuce (*Lactuca scariola*), and bur clover (*Medicago hispida* Gaertn.).

[c]Phytotoxicity is based on a visual rating where 0 = no effect, 5 = severe chlorosis and marginal burn, 10 = all foliage dead.

[d]Increases in diameter over one year period of growth and final diameter after 2 years of herbicide application.

[e]Not included in first years treatment.

Table 2. The effect of several soil-applied, pre-emergence herbicides on the foliar condition and growth as measured by phytotoxicity ratings and trunk diameter after 7 months of growth. Sprayed April 27, 1964. Univ. of Calif. at Davis trial.

Herbicide	Lb./A	Weed[b] cont.	Lovell		Mar. 2624		Mazzard		Average[a] Mahaleb		Bing		W. Nellis		Bartlett		Bl. Walnut	
			Phyto	Diam	Phyto	Diam	Phyto	Diam	Phyto	Diam	Phyto	Diam	Phyto	Diam	Phyto	Diam	Phyto	Diam
		%	(0–10)	mm	(0–10)	mm	(0–10)	mm	(0–10)	mm	(0–10)	mm	(0–10)	mm	(0–10)	mm	(0–10)	mm
Simazine	1	30	1.0	33.0	0.7	30.2	0	14.2	0	11.3	0	17.2	0	17.5	0	17.2	0	15.5
Simazine	4	92	2.3	30.7	0.3	32.2	0.8	15.2	1.2	7.5	0	25.0	0.7	14.5	0	18.7	0	14.3
Diuron	1	53	1.0	32.5	0.2	31.8	0	14.5	0	10.8	0	21.0	0.3	16.7	0.5	16.1	0	18.8
Diuron	4	90	1.3	31.5	0.3	29.5	0	13.0	0	7.2	0	21.8	0	15.0	0	19.0	0	18.7
Prometryne	1	84	0	28.7	0	32.2	0	13.4	0	9.5	0.2	20.5	0	18.7	0.5	19.0	0	18.8
Prometryne	4	100	1.3	31.7	0.3	30.2	0	15.2	0	8.0	1.5	16.2	0	16.2	0	19.2	0	16.7
Bromacil	1	94	0	25.8	0.2	32.7	0.3	13.5	0	11.0	0	19.0	0	15.7	0	18.8	0.5	17.0
Bromacil	4	98	0.7	30.0	1.2	31.0	5.3	8.8	6.5	5.0	1.5	21.5	2.5	15.7	1.8	19.2	1.8	13.8
Isocil	1	90	0.3	31.2	0.3	30.2	0	16.5	1.7	7.2	3.0	17.7	1.0	14.7	0.7	19.3	0	15.3
Isocil	4	100	0.7	33.8	1.2	31.8	2.5	10.0	4.5	4.8	2.5	15.0	3.5	14.2	3.5	15.5	6.3	14.0
Check	0	21	0.3	24.0	0.3	30.2	0	14.0	0	10.8	0	20.8	0	18.0	0	18.3	0.8	14.2
L.S.D. 05				7.26		3.78		[c]		[c]		7.61		3.30		3.35		4.70
01				9.62		5.01						10.1		4.36		4.43		6.23
Coef var				20.9%		10.7%						33.1%		17.5%		15.8%		25.7%

[a]Average 6 replications.
[b]Per cent weed control based on rating where 0 = no control, 10 = 100% taken at 1 year after application. Weeds include pigweed (*Amaranthus* sp.), cheeseweed (*Malva parviflora* L.), knotweed (*Polygonum aviculare* L.), bluegrass (*Poa annua* L.), bur clover (*Medicago hispida* Gaertn.), and annual sunflower (*Helianthus annus* L.).
[c]Too many missing trees for statistical analysis.

ity readings (Table 2). Consistent with greenhouse studies (4), both pear varieties appeared to be sensitive to the uracils, isocil being somewhat more toxic than bromacil. Walnuts likewise showed considerable phytotoxicity from the applications of bromacil and isocil (Table 2). Cherry trees generally showed more toxicity from bromacil than isocil. Isocil appeared to be somewhat more toxic to 'Bing' and 'Mahaleb' than to 'Mazzard.' 'Marianna 2624' rootstocks showed very little toxicity from any of the herbicides in this trial.

At the Davis location, young deciduous fruit trees showed very little toxicity as a result of the 5 pre-emergence herbicides at 1 and 4 lb., with the exception of the more sensitive species. The soil at the Davis location is a highly productive Yolo loam and has been shown to be highly adsorptive (2). Phytotoxicity symptoms appeared to increase in intensity on the 'Winter Nellis' pear through the summer and into the fall, with isocil showing more foliar injury than bromacil to the young pear and walnut trees. The response of most rootstocks to simazine was intermediate. Diuron generally was the safest herbicide tested at the Davis location on all the species of the other herbicides tested.

UC Kearney trial.

A slightly different overall picture resulted from the trial at the Kearney Field Station, where the coarse sandy soil contained only 0.6% organic matter. Here, the 5 herbicides tested, at rates of 1 and 4 lb./A gave excellent weed control but caused severe foliar injury at the 4 lb. level (Table 3). Even diuron showed considerable phytotoxicity on peach trees. Isocil was the safer of the two uracil compounds tested, but it was almost as toxic as diuron early in the summer. By the fall, diuron and simazine were both considerably more toxic than isocil and bromacil on the 'Lovell' peach trees. Results on the 'Cardinal' grafted on 'Lovell' were slightly different although similar to those of 'Lovell.' A more reliable expression of phytotoxicity was obtained from the ratings than from tree diameters, because of poor growth under the conditions of this trial. Many of the plants in this test were weak and succumbed easily to the toxic effects of the herbicides; the more susceptible species were pear, walnut and cherry. The plum varieties showed some resistance, particularly to isocil. This resistance—whether due to uracil breakdown, leaching, etc.—became more apparent in the later fall readings at which time isocil, in particular, appeared to be as safe as simazine or diuron on plums. Diuron was safer on pears than the other herbicides in this test. Both diuron and simazine were safer on walnuts than the other herbicide. Bromacil was particularly damaging on walnut trees.

Table 3. The effect of several pre-emergence herbicides on foliar condition. Sprayed April 28, 1964. Univ. of California Kearney Field Station trial.[a]

Herbicide	Lb/A	Weed[b] Control	Lovell	Card. on Lov.	Myro-balan	S.R. on MAR	Ma-haleb	Apricot	Bartlett	Bl. Wal.
			Phyto	Phyto	Phyto	Phyto	Phyto	Phyto	Phyto	Phyto
		%	(0–10)	(0–10)	(0–10)	(0–10)	(0–10)	(0–10)	(0–10)	(0–10)
Simazine	1	97	4.0	2.1	4.8	3.8	6.1	4.1	0.5	0
Simazine	4	100	7.8	8.3	7.6	8.3	9.6	7.1	5.8	2.8
Diuron	1	100	3.0	3.2	0.8	1.5	5.0	5.5	1.5	0
Diuron	4	100	7.0	5.1	6.0	5.5	5.8	6.1	3.1	2.6
Prometryne	1	100	5.0	6.4	1.8	3.8	6.1	3.1	3.0	1.6
Prometryne	4	100	7.1	6.1	1.3	3.5	5.1	5.1	5.5	3.3
Bromacil	1	98	3.8	3.6	2.8	3.0	9.8	2.8	8.0	8.5
Bromacil	4	100	5.5	6.5	6.8	9.0	8.0	9.0	9.6	8.0
Isocil	1	100	0.3	1.6	0.6	0	6.0	4.8	7.0	1.6
Isocil	4	100	3.4	2.3	4.0	3.1	9.6	7.8	8.5	5.8
Check	0	10	2.6	1.1	0	1.5	3.1	3.1	1.6	6.6

[a]Average of 6 replications.
[b]Based on 0–10 rating where 0 = no control, 10 = 100% complete control at 1 year after herbicide application. Weeds present were purslane (*Portulaca oleracea* L.), pigweed (*Amaranthus* sp.), seedling Johnsongrass (*Sorghum halepense*), and yellow nutgrass (*Cyperus esculentus*).

Discussion

Most of the triazines, substituted ureas and uracil herbicides in these trials gave excellent weed control, although they varied greatly in toxicity by species and location. The higher organic matter of the Sonoma and Davis tests appeared to act as a buffer, reducing the phytotoxicity of the herbicides to trees even at very high herbicide rates. At the Kearney Station, the sandy soil with low organic matter and the poor growing conditions for trees resulted in maximum toxicity from the 3 classes of herbicides (triazines, substituted ureas, and uracil herbicides). The conclusions that might be drawn from these trials is that diuron, on a pound for pound basis, is generally safer with most species. An exception with peach appeared to exist in its resistance to the uracils.

Prunus species showed a degree of resistance to the uracils, particularly to isocil and DP-733. Quite the opposite occurred with walnuts and pears, which showed a high degree of susceptibility to the uracils. Likewise, the uracils do not show promise for use on cherry trees, although some differences in the uracil herbicides were noted. Of the uracils, isocil, terbacil and DP-733 should be further tested on species of *Prunus*.

The results reported here illustrate the significant roles that soil and orchard species play, and their influence upon recommendations for the use of pre-emergence, residual type herbicides. The differences among orchard species, or even among herbicides, are often relatively insignificant compared with location effects. The apparent resistance of the peach tree to some of the uracils and the apparent susceptibility of pear, walnut and cherry trees to these same herbicides illustrate factors to be considered in making decisions, concerning weed control in areas of mixed populations of deciduous fruit trees.

Literature Cited

1. Benson, N. R., and E. S. Degman. 1961. The use of herbicides around non-bearing pome fruit trees. *Proc. Amer. Soc. Hort. Sci.* 78:46–52.
2. Fischer, V. J. 1963. Weed control around young peach and apple trees with substituted uracils. *Proc. N. E. Weed Control Conf.* 18:188–192.
3. Hemphill, D. D. 1955. Weed control around newly transplanted apple trees. *Proc. North Central Weed Control Conf.* 12:49.
4. Lange, A. H., and J. C. Crane. 1967. The phytotoxicity of several herbicides to deciduous fruit tree seedlings. *Proc. Amer. Soc. Hort. Sci.* 90:41–55.
5. ———. 1967. Simazine and Diuron for weed control in California deciduous fruit orchards. WWCC Res. Rept., p. 55–57.
6. Larsen, R. P., and S. K. Ries. 1960. Simazine for controlling weeds in fruit tree and grape plantings. *Weeds* 8:676–677.
7. Leefe, J. S., and R. P. Longley. 1960. The control of weeds around young apple trees. *Weeds* 8:422–426.
8. Sheets, T. J., and A. S. Crafts. 1957. The phytotoxicity of four phenylurea herbicides in soil. *Weeds* 5:93–101.
9. Trifonov, D. 1962. The use of the herbicide simazine for control of weeds in fruit crops. *Selskostop. Nauka.* 1(7): 187–193.

Effects of High Temperature on Yield and Carbohydrate Composition of Bush Snap Beans[1]

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Abstract. The percentage set of blossoms and number and weight of pods of bush snap beans, *Phaseolus vulgaris* L. were reduced when plants were subjected to high maximum temperatures during bloom. Yields were reduced 0 to 65% in greenhouse and field tests. Perforated plastic-covered cages in the field produced maximum temperatures of 83 to 101°F while maximum temperatures for checks averaged 74 to 89°. High temperatures decreased carbohydrates in leaves, starch more than sugars, when compared to checks.

Introduction

FACTORS that have been reported to influence pod set and blossom drop of snap and lima beans include: high maximum temperatures, low minimum temperatures, moisture stress, low relative humidity, inadequate plant nutrition, and insects (1, 4, 6, 7, 25).

High temperatures during flowering may cause abortion and dropping of bean flowers and small pods, thus greatly reducing yields. Detrimental effects of high temperatures on pod set have been reported by many investigators in the United States (3, 5, 16, 19, 22) and in Japan (11, 12, 13, 14, 23).

Binkley (3) found that blossom and pod drop was associated with high maximum temperatures and varied between 44 and 76% for 6 varieties of beans tested in Colorado. Davis (5) in Michigan concluded that maximum temperature was the most important climatic factor affecting blossom development in pea beans. He found that average maximum temperatures exceeding 75°F for any 2 successive days caused a reduction of about 2% in the set of pods for each degree of temperature above 75°, up to 98°. However, he suggested that other climatic factors such as soil temperature, soil moisture, relative humidity, and light intensity, may decrease the accuracy of a single prediction factor. Lambeth (16) found that mean temperature above 78° for the 24 hr period following anthesis reduced pod set of 'Tendergreen' snap beans. Smith and Pryor (19) found that high temperature at blossoming time consistently reduced per cent set of 2 out of 3 varieties of field beans in California. Stobbe et al. (21) obtained a very low per cent set of 'Stringless GreenPod' in growth cabinets at day-night temperatures of 95–80° as compared to 85–70° and 75–60°. The fruit set at 95–80° contained no fully developed ovules; they were misshaped and small and many abscissed later.

Langridge (17) has summarized the limited work on effects of high temperature on biochemical composition of plants. Hewitt and Curtis (9) found that respirational losses of dry matter and carbohydrates (soluble sugar and starch) from leaves of bean, milk weed, and tomato plants increased as temperatures were increased from 39 to 104°F.

The present study was undertaken to determine the effects of high temperature on yield and carbohydrate composition of bush snap beans. The work was done in the greenhouse and in plastic cages in the field.

Materials and Methods

Field experiments. In 1963, 6 plantings of 'OSU 2065' bush snap beans were made at Corvallis at approximately 10 to 14 days intervals, from May 14 through July 12. 'OSU 2065' is a bush 'Blue Lake' type developed from a series of backcrosses to 'Blue Lake' pole beans. A planting of 'Tendercrop' bush beans was also made on the third date, June 11. During 1965, 7 plantings of 'OSU 2065' bush beans were made at 6 to 16 day intervals, from May 10 through July 2. Individual plots were single rows, 10 ft long, with rows spaced 3 ft apart. About 450 lb. 8–24–8 fertilizer per acre were banded at planting. Sprinkler irrigation was provided at intervals of 7 to 14 days. Plants were thinned to uniform stands of 5 to 6 per foot at the first trifoliate leaf stage.

Treatments were replicated 4 or 5 times and included a check which was

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