they certainly are part of the growth regulator complex controlling fruit set and development.

Literature Cited

1. Bukovac, M. J. 1963. Induction of parthenocarpic growth of apple fruits with gibberellins A_3 and A_4. *Bot Gaz.* 124:191-195.
2. ——— and S. Nakagawa. 1968. Gibberellin-induced asymmetric growth of apples. *HortSci.* 3:172-174.
3. Crane, J. C. 1965. The chemical induction of parthenocarpy in the Calimyrna fig and its physiological significance. *Plant Physiol.* 40:606-610.
4. Davison, R. M. 1960. Fruit setting of apples using gibberellic acid. *Nature* 188:681-682.
5. Dennis, F. G., and L. J. Edgerton. 1962. Induction of parthenocarpy in the apple with gibberellin, and the effects of supplementary auxin application. *Proc. Amer. Soc. Hort. Sci.* 80:58-63.
6. Duncan, D. B. 1955. Multiple range and multiple F tests. *Biometrics* 11:1-42.
7. Jones, C. M. 1965. Effects of benzyladenine on fruit set in muskmelons. *Proc. Amer. Soc. Hort. Sci.* 87:335-340.
8. Letham, D. S. 1968. Regulators of cell division in plant tissues. VI. The effects of Zeatin and other stimulants of cell division on apple fruit development. *New Zealand Jour. Agric. Research* (In Press).
9. Varga, A. 1966. The specificities of apple cultivars and of gibberellins in the induction of parthenocarpic fruits. *Proc. Biol. and Med. Sci.* (Amsterdam) 59:641-644.
10. Weaver, R. J., J. van Overbeek, and R. M. Pool. 1965. Induction of fruit set in *Vitis vinifera* L. by a kinin. *Nature* 206:952-953.
11. Williams, M. W., and E. A. Stahly. 1968. Effect of cytokinins and gibberellins on shape of 'Delicious' apple fruits. *Proc. Amer. Soc. Hort. Sci.* 94:17-18.

Table 1. Effect of gibberellins and cytokinins on parthenocarpic fruit set of emasculated Sturmer apple flowers at Auckland, New Zealand, 1967.

	Average per cent fruit set[1]		
	No GA	GA_3 400 ppm	$GA_{4,7}$ 400 ppm
No cytokinins	0 a	1.7 a	12.8 bc
NPG 400	6.8 ab	6.2 ab	19.2 bc
NPG 800	3.9 ab	3.9 ab	26.4 c
SD8339, 400	8.0 ab	7.1 ab	42.8 d
SD8339, 800	10.8 ab	10.5 ab	40.0 d

[1]Means with different letters are significantly different at the 5% level (6).

Table 2. Effect of gibberellin and cytokinins on parthenocarpic fruit set of emasculated Sturmer, Starking Delicious and Golden Delicious apple flowers.

Treatment[1] and Concentration	Sturmer[2] per cent fruit set	Red Delicious[3] per cent fruit set	Golden Delicious[3] per cent fruit set
Open pollinated control	6.1	21.3	22.4
Emasculated control	0	0	0
GA_3 400 ppm	1.7	3.3	4.7
Zeatin 800 ppm	6.0	-	-
SD8339 400 ppm	8.0	2.0	8.0
GA_3 400 ppm + SD8339 400 ppm	7.1	9.3	5.0
$GA_{4,7}$ 400 ppm	12.8	41.0	1.7
$GA_{4,7}$ 400 ppm + Zeatin 800 ppm	14.5	-	-
$GA_{4,7}$ 400 ppm + SD8339 400 ppm	42.8	49.0	6.3
$GA_{4,7}$ 200 ppm + SD8339 200 ppm		46.5	8.0

[1]Three replicates with 100 flowers per replication.
[2]At Auckland, New Zealand, 1967.
[3]At Wenatchee, Washington, 1968.

Promotion of Leaf Abscission of Deciduous Tree Fruit Nursery Stock with Abscisic Acid[1]

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Following publication in 1965 (9) of the identity of Abscisin II isolated from cotton by Addicott's group, it was established that sycamore dormin and Abscisin II have the same structure (3). Abscisin II was later named abscisic acid (1). This and other research (4, 8, 10) shows that this is apparently a widely distributed compound.

In spite of early optimism, the possiblity of abscisic acid becoming a natural defoliant (2) has not been realized. Commercial synthesis is costly and has only recently been accomplished. Experimentation, as a result, has been limited. There is some evidence that abscisic acid may not be as useful a defoliant as previously supposed on the basis of its natural occurrence and on laboratory work with explants.[3] Recent information, however, published by Hartmann, *et al* on induction of olive fruit abscission showed that the force required to remove fruit on branches sprayed with 1,000 or 2,000 ppm abscisic acid was greater than the control, but complete defoliation occurred, which indicated that leaf abscission was stimulated but fruit abscission was not (5).

The purpose of the work reported here was to observe the effects of

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[3]Correspondence with R. Blondeau, Shell Development Company, 1966 and 1967.

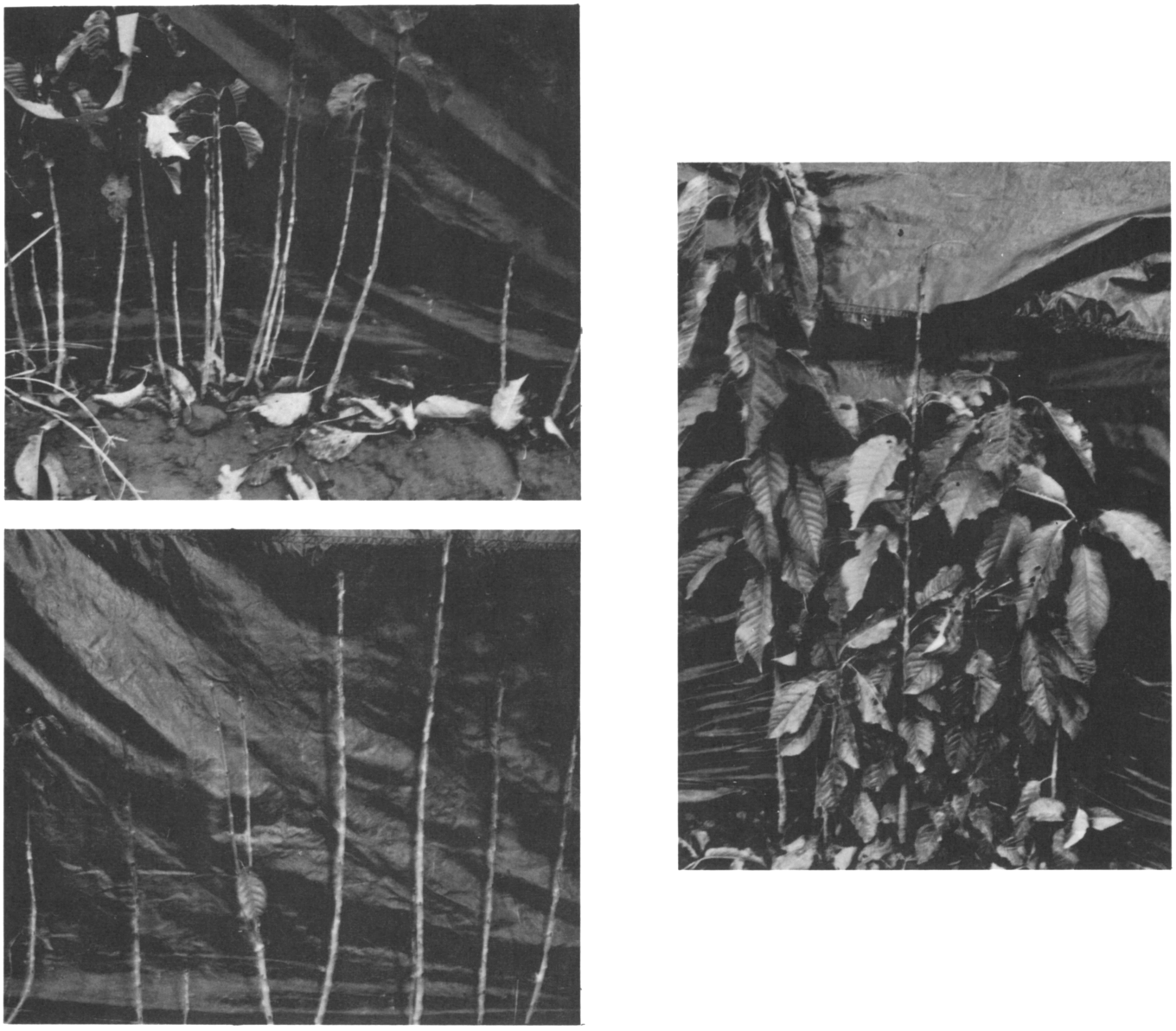

Fig. 1. Promotion of leaf abscission on *Prunus mazzard* cherry seedlings by abscisic acid. Upper left: 500 ppm; lower left: 2,000 ppm; right: control. Treated 10/17/68. Photo 11/8/68.

abscisic acid on leaf abscission of several cultivars of deciduous fruit tree nursery stock. A defoliant for nursery stock is needed in many parts of the world. In 1965, the author reported that hand-stripping costs were about $400–$450 per acre (6). Recent estimates by nurserymen in Washington indicate that hand-stripping costs of deciduous fruit trees are often $600–$800 and sometimes $1,000 per acre.

As part of a chemical defoliation research program at commercial nurseries, abscisic acid (50% *dl* – 5 – (1-hydroxy-2, 6, 6-trimethyl-4-oxo-2-cyclohexen-1-yl) 3-methyl-*cis, trans*-2, 4-pentadienoic acid, and 50% of the *trans, trans* isomer) was tested at 500, 1,000 and 2,000 ppm on *Prunus mazzard* cherry seedlings, on Spur Red Delicious, Golden Delicious, Red Rome, and McIntosh apples, and on Bartlett pear. Because of the high cost of the material, the entire trees, except with cherry seedlings, were not sprayed. Only the terminal foot of the main stem and lateral branches were treated. These areas are the most difficult to defoliate. Sprays were applied October 15, 1968 with one pint capacity hand sprayers. X-77 (principal active agents alkylarlylpolyethylene glycols) was included at 1,250 ppm. Six trees per treatment were used with 10 to 12 treated branches per tree. The control was untreated. An X-77 treated control was not included because X-77 was not observed to promote abscission in this or prior work. Leaf abscission was rated at weekly intervals following treatment until the plants were dug.

The results are shown in Table 1, and examples of the effects on mazzard cherry seedlings are shown in Fig. 1. This information indicates that abscisic acid does have promise for use as a defoliant. Since application was late in the season, it was not apparent whether abscisic acid would initiate abscission in the test plants or only stimulate the process once started. The appearance of treated leaves was more like those abscising naturally than were leaves

Table 1. Mean percent leaf abscission of several tree fruit cultivars and one seedling promoted by abscisic acid applied October 15, 1968 in the nursery.[1]

Plant	Concentration[2] (ppm)	Observation Date 10/29	11/7	11/14
Bartlett pear	500	90	90	100
	1,000	90	90	100
	2,000	90	90	100
	Control	0	23	90
Prunus mazzard cherry sdlg.	500	10	90	100
	1,000	30	95	100
	2,000	50	100	100
	Control	0	0	13
Red Rome apple	500	0	10	20
	1,000	0	20	50
	2,000	0	20	60
	Control	0	0	13
Spur Red Delicious apple	500	0	50	50
	1,000	20	50	90
	2,000	30	60	17
	Control	0	0	17
Golden Delicious apple	500	0	30	- -
	1,000	0	40	- -
	2,000	0	70	- -
	Control	0	0	- -
McIntosh apple	500	0	50	- -
	1,000	15	80	- -
	2,000	25	90	- -
	Control	0	0	- -

[1]Except for the cherry seedlings, which were completely sprayed, the data apply only to the terminal foot of the main stem and branches of the trees. Six trees per treatment were used with 10 to 12 treated terminals per tree.
[2]X-77 also included at 1,250 ppm.

treated with other defoliants, in that pigment changes were more similar. The yellow and red pigments, however, were somewhat more intense than on untreated leaves. The response of the treated plants was similar to plants treated with other test defoliants (7); that is, cherry and pear responded more readily than apple. Of the apple cultivars tested, Rome was the least responsive, as observed with other test defoliants. Also, in all cases, the leaves attached to the shoot tips were the last to absciss.

Further work is required to determine the usefullness of abscisic acid as a commercial defoliant and to explore the fundamental reactions associated with its use and the conditions influencing its effectiveness. Of particular interest in this regard is the work of Hartmann, *et al.*, which indicates that abscisic acid does not stimulate ethylene production in olive leaves (5).

Literature Cited

1. Addicott, F. T., J. L. Lyon, K. Ohkuma and W. E. Thiessen. 1968. Abscisic acid: A new name for Abscisin II (Dormin). *Science* 159:1493.
2. Anonymous. 1965. A natural defoliant. *Agr. Res.* (USDA). 14(5):11.
3. Cornforth, J. W., B. V. Milborrow and G. Ryback. 1965. Chemistry and physiology of dormins in sycamore. *Nature*. 205 (4978):1269-1270;
4. ———— . 1966. Indentification and estimation of (+) −Abscisin II ('Dormin') in plant extracts by spectropolarimetry. *Nature* 210:627-628.
5. Hartmann, H. T., A. J. Heslop and J. Whisler. 1968. Chemical induction of fruit abscission in olives. *Cal. Agr.* 22(7):14-16.
6. Larsen, F. E. 1965. Nursery stock defoliation: *Balls and Burlaps.* 15(6):3.
7. ———— . 1967. Five years' results with pre-storage chemical defoliation of deciduous nursery stock. *Proc. Internt. Plant Prop. Soc.* 17:157-172.
8. Milborrow, B. V. 1967. The identification of (+) -Abscisin II [(+)-dormin] in plants and measurement of its concentration. *Planta* 76:93-113.
9. Ohkuma, K., F. T. Addicott, O. E. Smith and W. E. Thiessen. 1965. The structure of Abscisin II. *Tetrahedron Letters* 29:2529-2536.
10. Pieniazek, J. and R. Rudnicki. 1967. The presence of Abscisin II in apple leaves and apple fruit juice. *Bul. De L'Academie Polonaise Sciences* Cl.V. – 15(5):251-254.

Germinating Response of the Tomato at High Temperature[1]

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Abstract. Differences in germination response at 35°C were found in tomato (*Lycopersicon esculentum* Mill.). Varieties with tolerance to germination at high temperature were characteristically cold-germinating types with the notable exception of the variety, Fireball. The ability to respond at high temperature was not found to be associated with earliness.

The existence of genetic differences in ability of tomato to germinate at cold temperature (henceforth referred to as GCT) has been reported by Smith (3), Kemp (1), Dolan, D. D. (unpublished), and Graham T. O. (unpublished). Because of the value of GCT in early season direct seeding when soil temperatures are low, breeding programs are in progress for the utilization of this trait. Evaluation of strains for GCT germination response involves a 2-to-4 week test period at 10°C. A study was initiated to determine if a comparable, but rapid, differential germination response occurs in GCT versus non-GCT strains at temperatures approaching the upper limiting temperature for tomato germination. Mancinelli (2) reported on high temperature effects on irradiated seed of the varieties Ace, Porte and Glamor; percentage germination for these varieties after 4 days at 30°C was respectively 75, 84 and 83 and at 35°C, 1, 0, and 2.

For part of this study, seed was used that had been extracted from fieldgrown fruit; seed so saved henceforth is referred to as experimental seed. In addition, commercial seed was used from an eastern Canadian and a western United States seed company. Of the 11 varieties reported on here, seven had been described by the previously referred to

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