Table 2. Association between seed color and resistance during successive cycles of breeding and selection for resistance to Rhizoctonia diseases in snap beans.

		% resistant plants[z]			
		F_2		F_3	
Accession	Pedigree	colored	white	colored	white
	First cycle				
B4095	B3866 (c,r) x Provider (c,s)[y]	87	–	89	–
B4096	B3866 (w,s) x Provider (c,s)	80	0	94	0
B4116	B4000 (w,s) x B3866 (c,r)	62	0	85	0
B4120	B3999 (w,s) x P.I. 165426 (c,r)	77	0	89	0
B4129	B3999 (w,s) x Venezuela 54 (c,r)	71	0	88	0
B4130	Provider (c,s) x Venezuela 54 (c,r)	80	–	94	–
	Second cycle				
B4123	B3999 (w,s) x B4095 (c,r)	80	0	87	0
B4124	B3999 (w,s) x B4096 (c,r)	83	0	93	0
B4162	B4116 (w,s) x Contender (c,s)	not screened		86	0

Checks

Venezuela 54 (83% resistant)

Tendercrop (100% susceptible)

[z] 60 seeds of each entry screened each generation.

[y] w, white seed; c, colored seed; r, resistant; s, susceptible.

same as crosses between resistant and susceptible lines, producing approx 60% colored resistant, 15% colored susceptible, and 25% white susceptible. This closely approximates the 9:3:4 ratio of recessive epistasis, and although resistance is not simply inherited, the relationship between seed color and resistance is probably analogous to this form of epistasis.

The mechanism through which the epistatic effect is produced is not known, but there are indications that it is associated with the phenolic metabolism of the plant. Shikimic acid has been shown to be the source of the B ring in the flavonoids and related phenolic compounds (10). The source of the remainder of the molecule is not well established, but apparently all of the phenolic glycosides share several common precursors. The seed-coat pigments in beans are phenolic glycosides and the pigments seemed to segregate independently although the phenotypic ratios were often abnormal. In crosses between white- and colored-seeded lines, a much higher frequency of white-seeded plants were obtained than would be expected from a multifactor segregation. Prakken (7) indicated that the double recessive (*pp*) produced white seed, and we suspect that this gene blocks the pathway of phenolic synthesis near shikimic acid or one of the other precursors of the pigments. If the above hypothesis is correct, the synthesis of phaseollin, a phenolic which has been shown to inhibit the growth of *R. solani* (6, 13), may also be blocked. If this is indeed the case, it is unlikely that normal breeding methods will be effective in breaking the association between colored seed and resistance to diseases caused by *R. solani.*

Progress in breeding colored-seeded snap beans with resistance to Rhizoctonia diseases has been rapid using ordinary breeding methods. However, gaining acceptance of colored-seeded cultivars by industry remains a problem. If white-seeded cultivars are indeed essential, it may be possible to eliminate color by selection within resistant material. In such a plan, no white-seeded parents would be used to avoid the double recessive (*pp*). Instead, crosses would be made between resistant plants with light colored seed with subsequent selection for lighter colored seed. Using this approach, we have obtained tan-seeded lines with high levels of resistance, and it appears to be possible to develop resistant lines with white or near-white seed.

Literature Cited

1. Baker, K. F. 1970. Types of *Rhizoctonia* diseases and their occurrences. p. 125-148. *In* J. R. Parmeter (ed.) *Rhizoctonia solani,* Biology & Pathology. Univ. of Cal. Press.
2. Fassuliotis, George, J. R. Deakin, and J. C. Hoffman. 1970. Root-knot nematode resistance in snap beans: Breeding and nature of resistance. *J. Amer. Soc. Hort. Sci.* 95:640-645.
3. Leach, Lysle D., and R. H. Garber. 1970. Control of *Rhizoctonia.* p. 189-198. *In* J. R. Parmeter (ed.) *Rhizoctonia solani,* Biology & Pathology. Univ. of Cal. Press.
4. Lutrell, E. S., and K. H. Garren. 1952. Blights of snap bean in Georgia. *Phytopathology* 42:607-613.
5. McLean, D. M., J. C. Hoffman, and G. B. Brown. 1968. Greenhouse studies on resistance of snap beans to *Rhizoctonia solani. Plant Dis. Rptr.* 52:486-488.
6. Pierre, R. E., and D. F. Bateman. 1967. Induction and distribution of phytoalexins in *Rhizoctonia*-infected bean hypocotyls. *Phytopathology* 57:1154-1160.
7. Prakken, R. 1970. Inheritance of color in *Phaseolus vulgaris* L. II. A critical review. *Meded. Landbouwhogeschool Wageningen* 70:23.
8. Prasad, Krishna, and J. L. Weigle. 1969. Resistance to *Rhizoctonia solani* in *Phaseolus vulgaris* (snap bean). *Plant Dis. Rptr.* 53:350-352.
9. ———, ———. 1970. Screening for resistance to *Rhizoctonia solani* in *Phaseolus vulgaris. Plant Dis. Rptr.* 54:40-44.
10. Robinson, Trevor. 1963. The organic constituents of higher plants. Burgess Publishing Co., Minneapolis. p. 173-203.
11. Tisdale, W. B., and A. A. Foster. 1948. Damping-off of vegetable seedlings. *Fla. Agr. Expt. Ann. Rpt.* 1947, 48-94.
12. ———, and W. D. Moore. 1954. A new suggestion for control of damping-off and root-rot of snap beans. *Fla. Agr. Expt. Sta. Cir.* 575,
13. Van Etten, H. D., and D. F. Bateman. 1970. Isolation of phaseollin from *Rhizoctonia*-infected bean tissue. *Phytopathology* 60:385.
14. Zaumeyer, W. J., and H. Rex Thomas. 1957. A monographic study of bean diseases and methods for their control. *USDA Tech. Bul.* 868:31-34.

Effect of Herbicides on Weed Control and Nitrate Accumulation in Table Beets[1]

S. C. Phatak and D. J. Cantliffe[2]

Horticultural Experiment Station, Simcoe, Ontario, Canada

Abstract. **Good broadleaf weed control was achieved in table beets (*Beta vulgaris* L.) with cycloate, CNP, pebulate, lenacil, pyrazon (preplant application = pre), IMC 3950, TCA + pyrazon and pebulate (preplant incorporation = ppi) followed by pyrazone (postplant incorporation = post), while fair to good weed control was achieved with EPTC, propachlor and solubor. Poor weed control was obtained from CDEC, chlorpropham, pyrazon (post) and TCA. Yields expressed as $/ha or tons/ha were reduced by chlorpropham, lenacil, CNP and TCA. Nitrate-N was significantly increased in blades of beets by lenacil, pyrazon (pre) and CNP. The herbicides cyloate, CNP, EPTC, pebulate (ppi) – pyrazon (post), and TCA + pyrazon increased NO_3-N concentrations in petioles. TCA + pyrazon and CNP increased NO_3-N in beet roots, while CDEC, chlorpropham, solubor and pyrazon (post) decreased NO_3-N. Total N concentration in the leaf blades was not affected by any of the herbicide treatments. Total N in petioles increased when TCA, chlorpropham, lenacil and CNP were used. TCA, chlorpropham, lenacil and CNP increased root total N.**

---

[1] Received for publication December 4, 1974.

[2] Present address: Vegetable Crops Department, University of Florida, Gainesville, FL.

The present production of table beets requires effective weed control.

Several plant species have shown higher NO_3 levels when treated with herbicides (2, 5, 8, 9). Also, at sub-herbicidal levels, various weed killers have caused increased total N and protein in crop plants (7). Accumulation of high concn of NO_3-N can cause methemoglobinemia in humans (7). High concn of N in cooked beets can lead to bitterness (4). Our purpose in this study was to evaluate the effectiveness of several herbicides on weed control and to determine NO_3-N and total N accumulation in table beets.

'Detroit Dark Red' table beets were seeded in a sandy loam soil in June of 1972 and 1973 at Simcoe, Ontario. Rows were 60 cm apart with seeds dropped 5 cm apart with a Stanhay seeder. Individual plots consisted of 3 rows 7 m long. Each treatment was replicated 4 times. Fertilizer was broadcast and disked in before planting at rates equivalent to 161 kg N/ha, 56 kg P/ha, and 105 kg K/ha. Irrigation (2.5 cm) was applied following seeding and herbicide application to promote uniform germination.

Herbicide treatments included pebulate (S-propyl butylethyltiocarbamate), cycloate (S-ethyl N-ethylthiocyclohexanecarbamate), EPTC (S-ethyl dipropylthiocarbamate), TCA (trichloroacetic acid), CDEC (2-chloroallyl diethyldithiocarbamate), chlorpropham (isopropyl m-chlorocarbanilate), propachlor (2-chloro-N-isopropylacetanilide), lenacil (3-cyclohexyl-6, 7-dihydro-1 H-cyclopentapyrimidine-2, 4(3H,5H)-dione), IMC 3950 (S-(4-chlorobenzyl)-N, N-diethylthiolcarbamate), pyrazon (5-amino-4-chloro-2-phenyl-3(2H)-pyridazinone), CNP (2, 4, 6-trichlorophenyl-4-nitrophenylether), solubor (a material containing 20.5% B as $Na_2B_4O_2$). A non-herbicide, hand-weeded treatment was included. Rate and time of application can be found in Table 1. Preplant incorporated (ppi) treatments were applied immediately before seeding, preemergence (pre) treatments immediately after seeding and postemergence (post) 3 weeks after planting. The treatments were applied with an Oxford Precision Sprayer at a rate of 280 liters/ha at 2 kg/cm^2 pressure.

Weeds per 930 sq cm were counted 3 weeks after sowing when the crop was established. The primary weeds present were purslane (*Portulaca oleracea* L.), redroot pigweed (*Amaranthus retroflexus* L.), lambs-quarters (*Chenopodium album* L.) and shepherds purse (*Capsella bursa-pastoris* L.).

Four plants from the center row of each plot were harvested about 60 days after planting. The plants were washed in distilled water, separated into leaf blades, petioles, and roots then frozen and freeze dried. The tissue was ground in a Wiley mill and NO_3 determined using an Orion NO_3 ion electrode (1) and total N by Kjeldahl (3). The remainder of the plots was harvested on the same day. Roots were graded and priced according to Ontario Marketing Board Standards to the following sizes; <2.54 cm, cull; 2.54 to 3.18 cm, \$87/(metric) ton; 3.18 to 4.4 cm, \$52/ton; 4.4 to 6.4 cm, \$36/ton; 6.4 to 10.2 cm, \$17/ton; >10.2 cm, cull. The data for 1972 and 1973 were combined.

Compared with the hand-weeded check, broadleaf weeds were controlled best by using cycloate, CNP, lenacil, pyrazon (pre), pebulate (ppi)-pyrazon (post), IMC 3950, or TCA (pre) + pyrazon (pre) (Table 1). Other chemicals that gave fair to good broadleaf weed control were pebulate, EPTC, propachlor and solubor. Chlorpropham, pyrazon (post), CDEC and TCA gave poor weed control. Redroot pigweed and purslane were the 2 most difficult weeds to control. The population of grass species was not high enough in either year to determine significant differences between the hand-weeded check and the herbicide treatments.

Yields expressed as \$/ha were considerably lower than the hand-weeded check in the chlorpropham, lenacil, CNP and TCA treated plots (Table 1). Tons/ha were also considerably reduced by these 4 compounds, and pyrazon (post) and solubor. This reduction in yield resulted partially from ineffective weed control, but more to a reduction in plant stand due to herbicide toxicity. Chlorpropham severely reduced beet seed germination. There were no statistically significant differences in yield between the check and the other treatments.

Nitrate concn which were combined for both years in beet blades of the lenacil, pyrazon (pre) and CNP treatments were significantly higher than the weeded check (Table 2). Nitrates were higher in petioles of plants treated with cycloate, CNP, EPTC, pebulate (ppi)-pyrazon (post) and TCA + pyrazon. TCA + pyrazon and CNP increased root NO_3. Chlorpropham, CDEC, solubor and pyrazon (post) decreased the NO_3 concn of roots compared to the weeded check.

Total N in the blades was not affected by herbicide treatment in either year. CNP, TCA, chlorpropham and lenacil increased total N in petioles of the plants. Total N in the roots was significantly increased by TCA,

Table 1. Effect of herbicides on weed control and table beet yields.

Herbicide	Rate (kg/ha)	Time of application	No. weeds/930 sq cm			Yield	
			Redroot pigweed	Purslane	Total broadleaf weeds	Metric T/ha	\$/ha
Weeded check	–	–	0a[z]	0a	0a	12.3def	405cd
Pebulate	6.72	ppi[y]	2a	2abc	4ab	14.5f	308bcd
Cycloate	4.48	ppi	0a	1a	3a	10.3bdef	349cd
EPTC	2.24	ppi	2a	6cd	8abc	8.0bcdef	246bcd
TCA	8.96	pre	5ab	6cd	21d	5.4abc	174ab
CDEC	3.36	pre	11b	5bc	17cd	6.8bcde	244bcd
Chlorpropham	2.24	pre	11b	1a	14bcd	1.9a	86a
Propachlor	3.36	pre	3ab	5bc	8abc	6.4abcd	224abc
Solubor	28.00	pre	6ab	3abc	9ab	4.7ab	200abc
Lenacil	2.24	pre	1a	1ab	2a	5.4abc	149ab
IMC 3950	4.48	pre	1a	0a	1a	11.1cdef	369cd
Pyrazon	4.48	pre	0a	0a	1a	6.8bcde	220abc
Pyrazon	3.64	post	9b	10d	19cd	4.5ab	210abc
CNP	2.69	post	2a	0a	2a	4.3ab	167ab
Pebulate –	3.36	ppi	1a	2abc	3a	13.2ef	451d
Pryazon	3.36	post					
TCA +	6.72	pre	1a	0a	1a	8.1bcdef	305bcd
Pyrazon	3.36	pre					

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

[y] ppi = preplant incorporation, pre = preplant, post = postplant.

Table 2. Effect of herbicides on NO$_3$-N and total N concn of table beet leaf blade, petiole and root tissue.

Herbicide	%NO$_3$-N			% total N		
	Blades	Petioles	Roots	Blades	Petioles	Roots
Weeded check	.23a^{z}	1.35cd	.73cde	4.30a	2.22a	2.23a
Pebulate	.32abc	1.54de	.73cde	4.39a	2.38ab	2.38ab
Cycloate	.34abc	1.71ef	.72cde	4.40a	2.46ab	2.44abc
EPTC	.36abc	1.79f	.78efg	4.32a	2.51abc	2.57abc
TCA	.35abc	1.33cd	.65cd	4.14a	2.72bcd	3.24df
CDEC	.33abc	1.09ab	.47a	4.08a	2.42ab	2.62abc
Chlorpropham	.27ab	1.00a	.49a	4.42a	2.71bcd	2.79bcd
Propachlor	.24a	1.28bc	.62bc	4.15a	2.48abc	2.59abc
Solubor	.35abc	1.10ab	.54ab	4.33a	2.22a	2.60abc
Lenacil	.44c	1.22bc	.73cde	4.53a	3.06d	3.43f
IMC 3950	.26ab	1.34cd	.62bc	4.20a	2.51abc	2.62abc
Pyrazon (pre)	.44c	1.17abc	.74def	4.26a	2.60abcd	2.55abc
Pyrazon (post)	.32abc	1.14abc	.49a	4.44a	2.62abcd	2.66abc
CNP	.40bc	1.56e	.82fg	4.44a	2.90cd	2.88cdf
Pebulate-Pyrazon	.27ab	1.64ef	.71cde	4.19a	2.33ab	2.33a
TCA + Pyrazon	.31abc	1.67ef	.87g	4.30a	2.32ab	2.39ab

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

chlorpropham, lenacil and CNP.

There were 8 herbicides or herbicide combinations that provided acceptable weed control in table beets. Of these, CNP and lenacil led to reduced yields and to increased NO$_3^-$ and total N concn. An increase in root total N may seriously affect the quality of the processed product since bitter taste of cooked beets has been shown to be due to the formation of pyrrolidonecarboxylic acid from glutamine (4). Glutamine is known to accumulate in beets excessively fertilized with N (6). Therefore, neither of these 2 compounds appear promising for usage on table beets.

Pebulate, cycloate, and pebulate (ppi)-pyrazon (post) gave good weed control and had no detrimental affect on yield. Pyrazon (pre) and TCA + pyrazon gave good weed control but reduced yields by 4 to 5 tons/ha. They are presently recommended for weed control in table beets in most areas. With the exception of pebulate, all led to an increase in NO$_3$-N in one or more plant parts. Cycloate has been shown to lead to increased NO$_3$ concn over weeded and non-weeded checks of spinach leaf blades and petioles (2). Although some of the registered herbicides in the present experiment caused NO$_3$ concn to accumulate over weeded checks, there is little concern that NO$_3$ poisoning would occur since the levels reached were far below the minimum necessary for toxicity in humans (7, 8).

One new compound, IMC 3950, gave good weed control and good yields compared to a hand-weeded check. It did not cause an increase in tissue concn of either NO$_3$ or total N. This herbicide appears to be very promising for usage on table beets.

Other researchers have reported that sub-herbicidal levels of chlorophenoxy or triazine herbicides have increased N and protein levels of various crop plants (2, 7). In the present experiment, total N was increased in roots and petioles by some herbicidal treatments. With the exception of CNP, these herbicides were applied before the crop emerged from the soil. However, in no case was the total N concn in the blades significantly increased by herbicide application. Cantliffe and Phatak (2) observed similar results in spinach grown with preplant treatments of cycloate, lenacil or alachlor. Possibly, the increase in the NO$_3$ concn in the blades of the herbicide treated beet plants was due to a decrease in nitrate reduction, perhaps through a decrease in nitrate reductase activity.

Literature Cited

1. Cantliffe, D. J., G. E. MacDonald, and N. H. Peck. 1970. The potentiometric determination of nitrate and chloride in plant tissue. *N.Y. Food & Life Sci. Bul.* 3:1-7.
2. ———, and S. C. Phatak. 1974. Effect of herbicides on weed control and nitrate accumulation in spinach. *HortScience* 9:470-472.
3. Jackson, M. L. 1958. Soil chemical analysis. Prentice-Hall, Inc., p. 187.
4. Shallenberger, R. S., and J. C. Moyer. 1958. Relationship between pyrrolidonecarboxylic acid and an off-flavor in beet puree. *J. Agr. Food Chem.* 6:606-661.
5. Stahler, L. M., and F. I. Whitehead. 1950. The effect of 2,4-D on potassium nitrate levels in leaves of sugar beets. *Science* 112:749-751.
6. Vickery, H. B., G. W. Pucher, and H. E. Clark. 1936. Glutamine metabolism in the beet. *Plant Physiol.* 11:413-420.
7. Viets, Jr., F. G., and R. H. Hageman. 1971. Factors affecting the accumulation of nitrate in soil, water and plants. Agr. Res. Serv. U.S. Dept. Agr. Handb. 413.
8. Whitehead, E. I., and A. L. Moxon. 1952. Nitrate poisoning. *South Dakota Agr. Expt. Sta. Bul.* 424:1-24.
9. Willard, C. J. 1960. Indirect effects of herbicides. *Proc. North Central Weed Control Conf.* p. 110-112.

Insect Pollinators of Onion in New York State[1]

Dewey M. Caron[2], Robert C. Lederhouse[3], and Roger A. Morse[4]

Cornell University, Ithaca, New York

Abstract. **Honey bees and drone flies are the most common insects found on flowering onions in New York State; 1216 other insects, representing many species, were collected from 3 areas in the state.** ***Dialictus*** **sp. and** ***Halictus*** **sp. (Apoidea) and 3 Diptera species are common pollinators. The observed species are compared with those on onions in the western states.**

The production of hybrid onions has been possible since about 1940 when it was found that male-sterile lines, which produce no pollen, could be crossed with a second pollen producing line (3). Insects are needed to transport the heavy, sticky pollen grains (7). Some hybred seed is produced in cages using honey bees or flies (11, 7) but large scale production is undertaken in open field with rented colonies of bees placed in adjacent areas (10).

During the last 15 years, commercial onion seed production has become difficult due to inconsistent seed set (5, 14, 17). A high positive correlation between pollinator activity and seed set has been reported (2). Most previous investigations of onion pollination have emphasized the behavior of the principal pollinator, the honey bee (1, 6, 9, 10, 14, 17). The attractiveness of onion nectar in Arizona is reduced by high sugar concentrations (15) and by high potassium ion concentrations (15, 16). This may account for successful competition by wild flowers and other crops for honey bees provided for onion pollination. Where other species of insects have not been severely reduced by pesticide application (2, 5), they may become more important in the

---

[1] Received for publication May 11, 1974.

[2] Associate Professor of Apiculture, Dept. of Entomology, Univ. of Maryland, College Park, Maryland.

[3] Graduate Assistant, Div. of Biological Sciences, Cornell Univ., Ithaca, N.Y.

[4] Professor of Apiculture, Dept. of Entomology, Cornell Univ., Ithaca, N.Y.