the experiment almond seeds with longer chilling requirements were somewhat less likely to survive stratification and conditions suitable for germination than those with shorter chilling requirements. Previous experience in germinating almond seeds in breeding studies over a period of years has been similar. It could indicate a selective disadvantage against long chilling under these conditions and emphasizes the importance of obtaining high germination percentages in breeding programs for late bloom in almond.

'Nonpareil' bud-sports for late bloom. Two camparisons of 'Nonpareil' versus 'Tardy Nonpareil' as one parent in crosses with either CP 5-33 or 1-100W as the other parent are presented in Tables 1 and 2. The germination responses of seeds from 'Nonpareil' and 'Tardy Nonpareil' were almost identical in chilling requirements. This inability to transmit a longer chilling requirement to the seeds contrasts to what might be expected from comparing their bloom, which differed by 10 days. Other studies have shown that late bloom is transmitted by 'Tardy Nonpareil' to seedling offspring (5).

These differences between 'Nonpareil' and 'Tardy Nonpareil' are consistent with the conclusion reached earlier with inheritance studies involving 'Tardy Nonpareil' (5). Differences in time of bloom within populations may be quantitative and appear due to multiple factors; in this work, such differences between parental varieties are correlated with differences in seed chilling requirement. In contrast to this the mutation from 'Nonpareil' to 'Tardy Nonpareil', appears to be due to a major gene change, qualitatively distinct from the parent 'Nonpareil', and differences in time of bloom are not correlated to seed chilling. Seed germination responses may be useful to differentiate between these 2 systems.

Reciprocal crosses. Reciprocal crosses of varieties that differ in blooming time and seed chilling requirement are also compared in Table 2. The seed chilling requirements of seed lots from 'Tardy Nonpareil' × CP 5-33 and its reciprocal were essentially identical. Table 1 shows comparisons of 'Nonpareil' × 1-85W and 1-85W × 'Nonpareil'. In this case, the mean weeks for germination, where 1-85W was the seed parent, was slightly more than when 'Nonpareil' was seed parent but the difference was not significant when compared with the t-test.

The results provide additional evidence that embryo genotype is the determining factor in the chilling requirement of populations of almond seeds. If a maternal influence occurs it is small and is not discriminated in these studies.

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The Response of Pea Plants to Low Concentrations of Cycocel, Phosfon and B-Nine[1]

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Abstract. In 2 greenhouse experiments, 15-day old pea seedlings were sprayed with 1 or 100 ppm of Cycocel, Phosfon or B-Nine. The plants were grown to marketable maturity of peas.

Cycocel at 1 ppm increased plant height, internode length, pea yield and total dry matter, but decreased chlorophyll concentration as well as the ratio of chlorophyll a:b. Cycocel at 100 ppm decreased plant height, internode length and total dry matter, but had no significant effect on pea yield. Phosfon at 1 ppm had little effect on growth and yield, but 100 ppm markedly decreased plant height and pea yield while increasing chlorophyll concentration. B-Nine at both concentrations was relatively ineffective in altering the growth pattern of the pea plant.

Cycocel generally increased the concentrations of N, P and Mg in the pea vine. Phosfon generally increased P and Ca. B-Nine at 1 ppm decreased N and P while it increased both at 100 ppm. All 3 compounds generally decreased K.

Introduction

This study was initiated to determine whether the application of low concentrations of 3 growth retardant chemicals would enhance growth and yield of peas. The plant growth-regulating properties of (2-chloroethyl) trimethylammonium chloride, Cycocel (CCC) were reported for wheat by Tolbert (14) who found that concentrations ranging from 0.13 to 1300 ppm led to a reduction in size, which was accompanied by a darker green color than found in untreated plants. Adedipe et al. (1) found 1.3

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ppm to stimulate the growth of pea plants, to reduce the chlorophyll concentration of pea leaves, and to increase pea yield. Knavel (6) reported that Cycocel-treated tomato plants contained more N, P, Ca and Mg than other plants. Untreated plants contained more K than the treated plants.

2,4-dichlorobenzyl tributylammonium chloride (Phosfon) was reported by Preston and Link (11) to retard the growth of a large number of species including soybean, snapdragon, mungbean and sweet pea.

The growth-retarding capabilities of N-dimethylamino succinamic acid (B-Nine, Alar) have been reported by Jaffe and Isenberg (5) for petunias and cucumbers, and by Batjer et al. (3) for apples, pears and sweet cherries. Generally, concentrations between 500 and 2000 ppm were found to retard growth and to cause a marked increase in the amount of bloom on the fruit trees the following spring (3). Applications over 2 consecutive years were found to have no appreciable influence on the foliar levels of N, P, K, Ca, Mg, Mn, Zn and B, fruit set and total yield of apples (12), but Knavel (6) reported increases in N, P, and Ca in tomato plants. When applied to peas, B-Nine at a concentration of 2000 ppm reduced shoot length about 40% and acted as a general inhibitor of growth rather than suppressing growth of particular organs (13).

In comparative studies by Cathey and Stuart (4) with buckwheat and sweet pea, and by Moore (10) with cucumber hypocotyls, Phosfon was found to be more effective in growth retardation than quartenary ammonium compounds, including Cycocel. Growth retardation due to B-Nine did not persist as long as that due to Phosfon (8), and Cycocel was more effective than B-Nine for reducing tomato plant growth. Both Cycocel and B-Nine increased N, P and Ca and decreased K (6). These growth retardants have hitherto most frequently been used at high concentrations.

In the present study the effects of low level applications of Cycocel, B-Nine and Phosfon on growth characteristics, chlorophyll concentration and contents of 5 major elements were compared. Previous work had described the effects of only Cycocel on growth characteristics and chlorophyll concentration (1).

Materials and Methods

Seeds of pea, *Pisum sativum* L., cv. 'Dark Skin Perfection' were treated with a slurry of peat-base inoculum Nitragin and sown in 15 cm plastic pots containing a greenhouse soil, on May 15, 1967, and again on March 1, 1968. Seedlings were thinned for uniformity to one plant per pot 10 days later. Pots were placed in a randomized complete block design on a greenhouse bench with 6 pots (blocks) per treatment in both experiments. At the 5th to 6th node stage (15 days after seeding) (9) each plant was sprayed with 10 ml retardant containing 0.1% Triton B-1956 surfactant. Control plants were sprayed with the surfactant.

Chlorophyll and carotenoid determinations were carried out 2 days before harvesting on representative samples taken from fully expanded leaves at the 2 youngest nodes. Leaf samples were ground with acid-washed sand and $CaCO_3$ in cold acetone. Absorbance was read with a Beckman DU 2400 spectrophotometer. Concentrations of chlorophyll a and b were calculated according to MacKinney's specific absorption coefficients (7). von Wettstein's equation was used to calculate carotenoid concentration (15). Plants were harvested at estimated marketable maturity for green peas. Vines were dried in an oven at 65°C for 48 h, ground in a Wiley mill and dry-ashed in a muffle furnace at 500° for 6 hr. Chemical analysis of each plant was as follows: semi-micro Kjeldahl for N; P by phospho-molybdate colorimetry using a Beckman C colorimeter; Ca and Mg by atomic absorption; and K by flame emission photometry (2) using the Evans Electroselenium Atomic Absorption Flame Photometer. Amounts of elements in pea vine were computed from composition and weight data. Since statistical analysis showed no significant interaction of experiments with any treatment, the average values of the two experiments are reported.

Results

The effects of the 3 retardants on growth characteristics and mineral and pigment contents depended on the retardant and its concentration (Tables 1, 2, and 3). Cycocel at 1 ppm increased plant height, internode length, total dry matter and pea yield but did not affect number of peas. Chlorophyll a and the chlorophyll a:b ratio were significantly reduced while chlorophyll b was not influenced. N,

Table 1. Effects of Cycocel, Phosfon and B-Nine on growth and yield factors in peas.[x]

	Plant height (cm)	Mean internode length (cm)	Vine dry weight (g)	Total number peas (no.)	Pea fresh weight (g)	Pea dry weight (g)	Total dry matter (g)
Control	69.3b	3.63b	4.57ab	28.7a	15.38b	3.27b	10.30b
Cycocel, 1 ppm	75.5a	4.15a	4.86a	27.8a	20.46a	4.45a	11.94a
Cycocel, 100 ppm	62.8c	3.33c	3.96b	24.8a	13.77b	2.97b	9.17c
Phosfon, 1 ppm	73.6ab	3.90 a	4.49a	27.7a	16.86b	3.38b	10.17b
Phosfon, 100 ppm	38.3d	2.26d	2.94c	21.0a	9.75c	1.95c	6.66d
B-Nine, 1 ppm	69.9b	3.70b	4.16ab	26.5a	14.25b	3.15b	9.50b
B-Nine, 100 ppm	71.3ab	3.93a	3.97b	28.3a	14.71b	3.43b	9.53b

[x]Each figure is the mean of 12 plants. Figures followed by the same letter within a particular measurement are not significantly different at P = 0.05 according to Duncan's multiple range test.

Table 2. Effects of Cycocel, Phosfon and B-Nine on plastid pigment contents of pea plants.[x]

	mg/g fresh leaf				Ratio chlcro. a:b	Ratio chloro./ carot.
	Chloro. a	Chloro. b	Total chloro.	Carotenoids		
Control	1.90b	0.78b	2.68b	0.28a	2.44a	9.6a
Cycocel, 1 ppm	1.67c	0.73b	2.40c	0.24a	2.29b	10.0a
Cycocel, 100 ppm	2.00b	0.90a	2.90ab	0.27a	2.22b	10.7a
Phosfon, 1 ppm	1.79b	0.74b	2.53b	0.27a	2.42a	9.4a
Phosfon, 100 ppm	2.14a	0.91a	3.05a	0.29a	2.35a	10.5a
B-Nine, 1 ppm	1.89b	0.78b	2.67b	0.28a	2.42a	9.5a
B-Nine, 100 ppm	1.88b	0.78b	2.66b	0.23a	2.42a	11.6a

[x]Each figure is the mean of 12 plants. Figures followed by the same letter within a particular measurement are not significantly different at P = 0.05 according to Duncan's multiple range test.

Table 3. Mineral composition and total contents in pea plants as influenced by 2 concentrations of Cycocel, Phosfon and B-Nine.

	Mineral composition (% of dry matter)					Total mineral uptake (mg/plant vine portion)				
	N	P	K	Ca	Mg	N	P	K	Ca	Mg
Control	3.80b*	0.08e	4.46a	2.94b	0.76b	174a	3.7b	204a	134a	35ab
Cycocel, 1 ppm	4.05a	0.10c	4.22ab	2.95b	0.79a	197a	4.9ab	205a	143a	38a
Cycocel, 100 ppm	4.05a	0.13b	2.64c	3.07ab	0.80a	160b	5.1a	105c	122b	32b
Phosfon, 1 ppm	3.86b	0.13b	3.59b	2.99b	0.75b	173a	5.8a	161a	134a	34b
Phosfon, 100 ppm	3.89b	0.16a	4.35a	3.23a	0.74b	114c	4.7ab	128b	95c	22c
B-Nine, 1 ppm	3.56c	0.06d	4.07b	2.88b	0.80a	148b	2.5c	169a	120b	33b
B-Nine, 100 ppm	3.95a	0.11c	3.99b	2.90b	0.78ab	157b	4.4ab	158a	115b	31b

*Each figure is the mean of 12 plants. Figures followed by the same letter within a particular element are not significantly different at P = 0.05 according to Duncan's multiple range test.

P and Mg concentrations were higher than in control plants. Cycocel at 100 ppm caused a reduction in plant height, internode length and total dry matter production but did not affect pea yield. The reduction in total dry weight was largely a result of a decrease in vine weight. P, Mg and chlorophyll b concentration were increased and K decreased by this treatment.

Phosfon at 1 ppm increased internode length and the concentration of P but decreased K concentration. 100 ppm Phosfon caused a marked reduction in plant height, internode length, vine weight, pea weight and total dry matter but increased the concentrations of chlorophylls a and b, and P and Ca.

B-Nine at 1 ppm did not significantly affect growth and yield or plastid pigment content. N, P and K concentrations were reduced and Mg increased. B-Nine at 100 ppm increased mean internode length as well as N and P content. K was less than in control plants.

The total number of peas, carotenoid concentration and chlorophyll: carotenoid ratio were not significantly influenced by any of the treatments (Tables 1, 2). The relative magnitude of treatment effects on mineral composition depended on whether they were expressed on a per cent dry matter basis or expressed on a total uptake per plant on a vine portion basis (Table 3).

Discussion

Cycocel at 1 ppm was found to stimulate growth and to increase yield, while it decreased chlorophyll concentration as earlier reported by Adedipe et al. (1). Furthermore, Cycocel increased the levels of N, P and Mg but decreased K which agrees with Knavel's results (6), except that Ca was not affected in the pea plant as it was in the tomato.

While relatively high concentrations of B-Nine have been reported to retard the growth of fruit trees (3, 5), to increase the amount of bloom the following spring (3), and to reduce shoot length of pea plants by about 40% (13), our results show that the low concentrations of 1 and 100 ppm were ineffective in altering the growth pattern of pea plants. Concentrations of N and P were found to be increased and K decreased by 100 ppm of B-Nine in agreement with Knavel's (6) results for tomatoes but in contrast to the results of Southwick et al. (12) for apples.

The influence of the retardants on mineral nutrition depended on the unit of expression of nutrient amounts. For example, at 100 ppm Cycocel increased the concentration of N by about 6% when the level was expressed as per cent of dry matter. However, when the level was expressed as total element in the vine there was a decrease of about 8%. The 6% increase was thus due to a concentration effect resulting from smaller plants. Similarly, Phosfon at 100 ppm increased P by 100% when it was expressed as per cent of dry matter, but had much less effect on total P content in the vine. The use of both units of expression thus gives a better indication of net uptake while it also explains, if only partially, differences in element content of treated plants as compared to untreated plants.

On the basis of pronounced reduction in plant height and marked increase in chlorophyll concentration, Phosfon appears to be the most effective growth retardant, thus agreeing with the reports of Cathey and Stuart (4), Majumder (8) and Moore (10). At 1 ppm however, Cycocel stimulated growth, increased yield and levels of N, P and Mg while Phosfon at the same concentration did not have a significant effect on yield and increased the level of P only. Since 100 ppm Phosfon was perhaps too drastic, and 1 ppm had little effect, it may well be that growth stimulation may occur at less than 1 ppm.

It is concluded that B-Nine at a concentration of up to 100 ppm is ineffective in stimulating pea plant growth. Cycocel at 1 ppm is the most effective in terms of growth and yield stimulation. Phosfon at 100 ppm is the most effective in terms of growth retardation but decreases yield. Phosfon at concentrations lower than 100 ppm, perhaps less than 1 ppm, may stimulate pea growth and may be, like Cycocel, promising for use in increasing pea yield without deformative effects. This possibility should be investigated.

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