in agreement with other researchers (5, 6). SEM observations of digested *normal* and *wx* starch granules were similar to those pictured for these genotypes in a dent background (5, 6). Our SEM observations and data (Table 1) were similar to those of previous workers (5, 6, 7, 16, 17) who had examined some of these genotypes in dent maize backgrounds. Thus, the sweet corn background in which we studied these genotypes had little effect upon the digestibility of the isolated starch granules.

Clearly, *ae du wx* starch granules do not reflect the reduced digestibility associated with *ae* (Table 1, Fig. 2 & 3). In fact, *ae du wx* granules are digested more rapidly (Table 1). Thus, the value, as a source of carbohydrate, of cultivars homozygous for *ae du wx* is equal to or better than *normal* maize starch based on the susceptibility of isolated starch granules to enzymatic attack by amylases.

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Effects of Selected Photoperiods and Fertilizer Rates on Growth of *Pinus strobus* and *Pinus thunbergii* Seedlings[1]

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Additional index words. eastern white pine, Japanese black pine, dormancy, Osmocote

Abstract. **Eastern white pine (*Pinus strobus* L.) and Japanese black pine (*Pinus thunbergii* Parl.) seedlings were grown under 4 photoperiods with 5 rates of 18N-2.6P-10.0K (18N-6P_2O_5-12K_2O) Osmocote fertilizer applied at radicle emergence. Seedlings of both species grown under 16 and 20 hour photoperiods at fertilizer rates of 1.78 and 3.56 kg/m^3 were taller and had greater dry weight than seedlings grown under 8 and 12 hour photoperiods and higher rates of fertilizer (5.34 and 7.12 kg/m^3). With both species, short days inhibited height growth and dry weight accumulation and this effect could not be overcome by increasing the fertilizer rate.**

Induction of dormancy resulting in cessation of shoot extension and formation of a resting bud in woody temperate plants is the result of plant integration of several environmental signals, one of which is photoperiod. Photoperiod is the key environmental signal controlling dormancy induction (2, 3, 4, 7, 9), but nutrition, water stress and temperature may also be involved.

Under long-day conditions, dormancy in blue spruce *(Picea pungens)*, indicated by cessation of shoot extension and the formation of a resting bud, was induced by withholding N or water, whereas withholding P and K fertilizers had no effect (8). Bud break and the resumption of shoot extension occurred when the stress condition was relieved. Shoot extension was

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continuous under all temperatures studied and the maximum rates of shoot extension occurred at 25°C.

Fertilizer applications can stimulate shoot growth in resting buds of non-lammas species even under short days (6). Occasionally, eastern white pine seedlings grown in Raleigh, North Carolina under high fertilizer rates produce lammas growth.

It was proposed that the inhibiting effect of short days on shoot extension might be overcome if Japanese black pine and eastern white pine seedlings, 2 commercially important non-lammas species, were exposed to a continuous, optimum rate of slow release fertilizer from the time of radicle emergence. The interaction between photoperiod and nutrition on the growth of eastern white pine and Japanese black pine was studied by placing seedlings of both species under 4 photoperiods and 5 fertilizer rates at the time of radicle emergence.

Materials and Methods

Japanese black pine (JBP) seed and a Great Lakes strain of eastern white pine (EWP) purchased from a commercial source (F. W. Schumacher Co., Sandwich, Mass.) in September 1977 were stored at 3°C in sealed plastic bags. A 3-day stratification was begun on January 21, 1978 by placing JBP seed in a 3°C water soak. Following the 3-day soak, seed was placed between moist paper towels, enclosed in a sealed plastic bag and germinated at 21 ± 2°C. Within 10 days the radicles were about 1 cm long. At this time, 5 seeds were sown directly into 9.8 cm standard plastic pots containing a 3 pine bark:1 peat:1 sand medium (by volume) supplemented with 4.75 kg/m^3 dolomitic limestone, 1.19 kg/m^3 trebel superphosphate, 0.30 kg/m^3 elemental sulfur and 0.07 kg/m^3 FTE 503 trace element mix (5). The medium was amended with 0.00, 1.78, 3.56, 5.34 or 7.12 kg/m^3 18N-2.6P-10.0K (18N-6P_2O_5-12K_2O) Osmocote. The pots were placed in a greenhouse and temperatures maintained at 24°C (day)/18°C (night). Seedlings were thinned to 1 per pot on March 1, 1978. The seedlings were watered as needed.

Similarly, seeds of a Great Lakes strain of EWP were stratified (February 2, 1978), germinated (February 5, 1978), planted (February 15, 1978) and thinned (March 5, 1978). EWP seedlings were grown under the same conditions as the JBP seedlings.

Seedlings of both species were grown under 8, 12, 16 and 20 hr photoperiods. For each photoperiod, seedlings received 8 hr of natural light (0800-1600 hr). At 1600 hr black cloth was pulled on all benches and the photoperiod extended for the appropriate length of time by 4, 50-watt incandescent lamps located 104 cm above the bench and spaced 109 cm apart. The lamps provided a photon flux density of 0.21 $\mu Em^{-2} sec^{-1}$ (400-700 nm) at the top of the pots as measured with a Lambda LI-185 Quantum/Radiometer/Photometer.

After the seed was sown, pots were placed under 1 of the 4 photoperiods in a randomized complete block design. Photoperiods were considered main plots with fertilizer rates as subplots. Fertilizer rates were replicated 7 times with 3 plants per replication.

Initial shoot height was measured on March 5, 1978 and monthly during the experimental period. At the termination of the experiment, July 5, 1978, the medium was washed from the root systems. Seedlings were oven dried for 72 hr at 70°C. Plants within a replication were combined and the dry weight for each replication determined. Data for each species were analyzed by standard analysis of variance procedures.

Results

The fertilizer × photoperiod interaction for mean height and dry weight of both species was highly significant when tested using the fertilizer rate within photoperiod mean square as an error term. Thus, no tests of significance were done on the fertilizer or photoperiod main effects.

The 1.78 kg/m^3 fertilizer rate under the 20 hr photoperiod resulted in the tallest JBP seedlings while the tallest EWP seedlings grew at fertilizer rates of 1.78 and 3.56 kg/m^3 under the 16 hr photoperiod (data not shown).

The following equation [1.] derived through the General Linear Model Backward Elimination Procedure (1), accounted for 92% of the variation in height growth of JBP seedlings:

$$[1.] \quad HT = 1.0584 - 0.2334P + 0.02061 \times P^2 + 2.8889 \times F - 0.8927 \times F^2 + 0.09127 \times F^3 - 0.003021 \times F^4 + 0.04344 \times P \times F - 0.004531 \times P \times F^4$$

where HT was the total height increment (cm), P was the photoperiod, and F the fertilizer rate.

A plot of the predicted height increment for JBP seedlings was obtained by substitution of photoperiod and fertilizer values, within the experimental range, into equation 1 (Fig. 1). Maximum height increment for JBP seedlings predicted by the equation is between a 1.18 and 2.38 kg/m^3 fertilizer rate and a photoperiod greater than 20 hr.

Similarly, the following equation [2.] was derived for EWP seedlings:

$$[2.] \quad HT = 26.5835 - 6.4880 \times P + 0.5114 \times P^2 - 0.01245 \times P^3 - 0.4117 \times F + 0.1729 \times F^2 - 0.02867 \times F^3 + 0.001392 \times F^4 + 0.03243 \times P \times F - 0.002663 \times P \times F^2$$

where variables were the same as equation [1.].

The second equation accounted for 91% of the variation in height increment of EWP seedlings. A plot of the predicted height increment for EWP seedlings was obtained by substitution of photoperiod and fertilizer values, within the experimental range, into the equation (Fig. 2). Maximum height

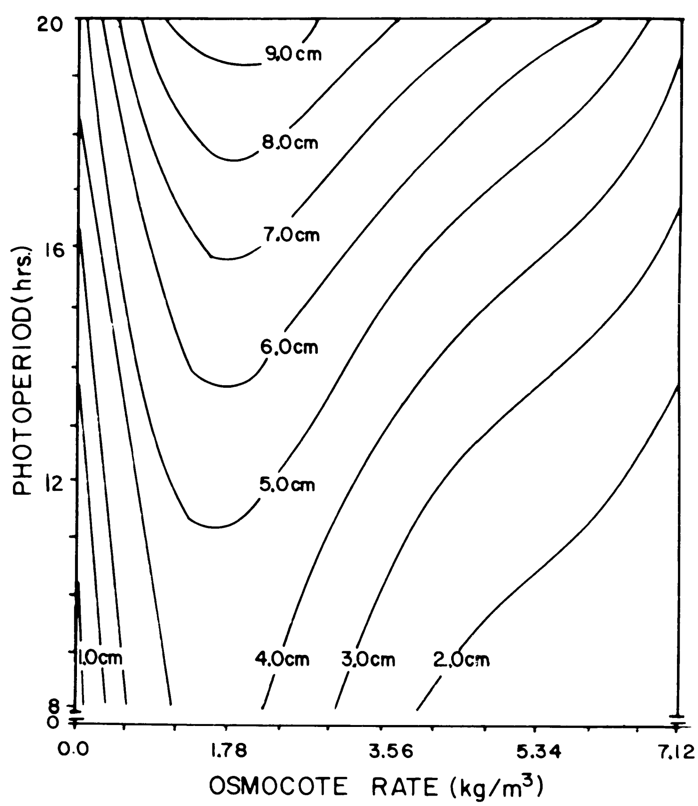

Fig. 1. Plot of predicted height increment for Japanese black pine seedlings. The plot was generated by substitution within the range of photoperiod and fertilizer values used in the experiment into the equation generated by a standard statistical program.

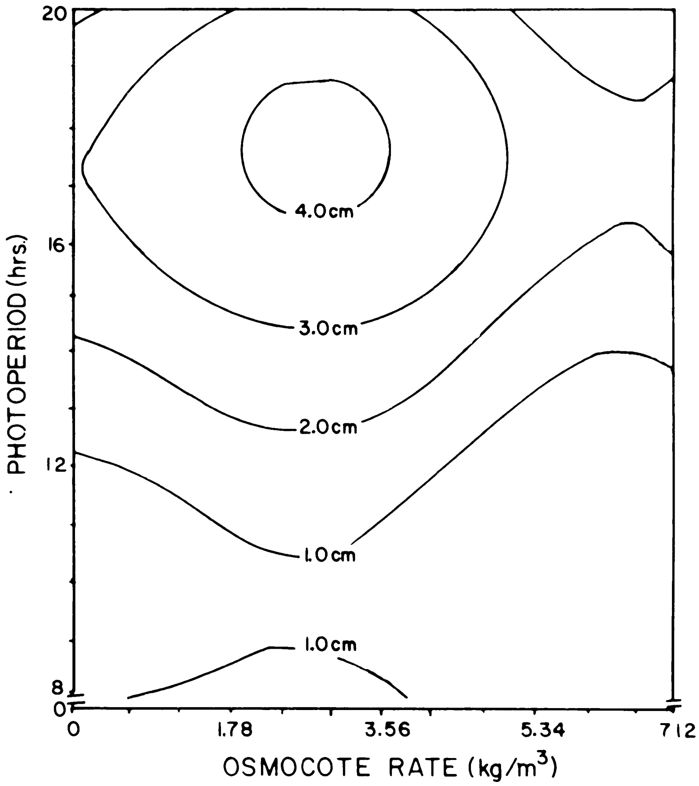

Fig. 2. Plot of predicted height increment for eastern white pine seedlings. The plot was generated in a manner similar to the Japanese black pine plot.

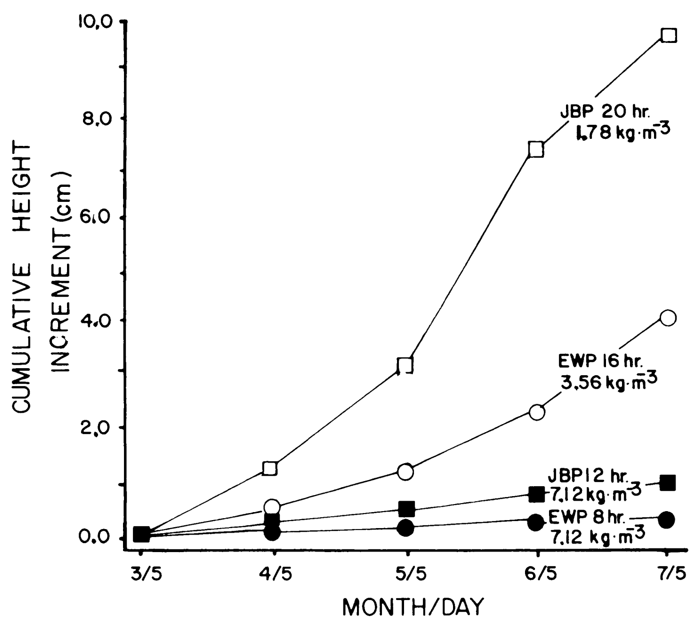

Fig. 3. Cumulative height increment for eastern white pine (EWP) and Japanese black pine (JBP) seedlings illustrating the most and least successful treatments used. Shoot extension for both species was continuous under 16 and 20 hr photoperiods, where under 8 and 12 hr photoperiods, a terminal resting bud was formed. Each point is the mean of 21 plants.

Table 1. Mean dry weight of eastern white pine (EWP) and Japanese black pine (JBP) seedlings 166 and 191 days, respectively, after sowing.[z]

Photoperiod (hr)	Fertilizer rate (kg/m^3)	Mean dry wt (mg) EWP	JBP
8	0.00	98b	135ab
	1.78	145cd	523d
	3.56	124bc	470d
	5.34	24a	307c
	7.12	13a	236bc
12	0.00	128bc	134ab
	1.78	227e	744e
	3.56	232e	897f
	5.34	98b	268c
	7.12	13a	282c
16	0.00	257e	98a
	1.78	464h	2397j
	3.56	453h	1141g
	5.34	425g	694e
	7.12	393g	514d
20	0.00	227e	139ab
	1.78	632j	1326h
	3.56	580i	1483i
	5.34	329f	455d
	7.12	177d	638e
	LSD 1%	36	107

[z]Each value represents the mean of 21 seedlings.

increment for EWP seedlings predicted by the equation is between fertilizer rates of 1.78 and 3.56 kg/m^3 and between photoperiods of 16.5 and 18.5 hr.

Mean cumulative height increment for the most and least successful treatments for EWP and JBP is given in Fig. 3. For both species, shoot elongation was continuous under the 16 and 20 hr photoperiods, whereas 8 and 12 hr photoperiods caused a terminal resting bud to form. Increasing fertilizer rates did not overcome the inhibition of short days on shoot extension. Also, within a photoperiod, fertilizer rate had no effect on the rate of bud formation. In general, JBP seedlings were taller than EWP seedlings under comparable treatments.

EWP seedlings at the 1.78 and 3.56 kg/m^3 fertilizer rates under the 20 hr photoperiod had the greatest mean dry weight (Table 1). The greatest mean dry weight of JBP seedlings was at the 1.78 kg/m^3 fertilizer rate under the 16 hr photoperiod. In general, JBP seedlings had greater dry weight than EWP seedlings under similar treatments.

Discussion

The inhibition of shoot extension by short days in EWP and JBP seedlings cannot be overcome by increasing the fertilizer rate, even if supplied from the time of radicle emergence. Fowler (2) incorporated 1, 2 or 3 parts pine forest loam as fertilizer treatments in a standard 4 part medium and reported similar results. Photoperiod apparently is the controlling environmental signal in seedling growth. Seedlings of both species had significantly greater dry weight under long days than under short days. This promotion of dry weight gain is a true photoperiodic response as all seedlings received 8 hr of natural (photosynthetic) light. Apparently, seedlings grown under long days have higher rates of net photosynthesis than seedlings grown under short days.

As reported by Hanover et al. (4) and Fowler (2) EWP seedlings do not respond as well to long day conditions as do other coniferous species. Similarly in this study, seedlings of

JBP were always larger than EWP seedlings under similar experimental treatments.

In this study caution must be taken when applying results of the predicted height increment plots to other experimental systems. Different optimums are to be expected when any component of the system is changed; i.e., seed source, temperature, light conditions, etc. Significant increases in height growth and dry weight accumulation can be expected when plants are given additional periods of photosynthetic light (4).

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Influence of Cultivar, Season, Irrigation, and Date of Planting on Thiocyanate Ion Content in Cabbages[1]

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Additional index words. Cruciferae, glucosinolates, goitrogens, natural toxicants

Abstract. **Tissue analysis of 14 cultivars of cabbage (*Brassica oleracea* L. Capitata group) in both 1974 and 1975 indicated that late maturing cultivars generally were higher in thiocyanate ion (SCN^-) content than early maturing cultivars. In both years, there was a significant positive correlation between SCN^- content of cultivars and days to maturity. While SCN^- content of late-planted (June 18, 1975) unirrigated 'Badger Market' and 'Storage Green' cabbages were more than twice as high as corresponding late-planted cabbages irrigated 5 times per week, the SCN^- content of early-planted (May 6) cabbages of both cultivars was not significantly influenced by irrigation treatment. In contrast, the marketable head fresh weight of both cultivars was lowest in late-planted, unirrigated plots. Head SCN^- content was negatively correlated with marketable head fresh weight and with total top weight of both cabbage cultivars.**

The association of goitre (enlargement of the thyroid gland) and consumption of plants of the Cruciferae family was first observed in 1928 by Chesney et al. (4) when rabbits were fed a diet with fresh cabbage leaves as the principle constituent and developed "cabbage goitre." Other studies have reported similar observations in animals (21, 23, 29, 30) but there is inconclusive evidence for this occurrence in humans (1, 19, 24).

Cruciferous plants contain a wide range of glucosinolates (thioglucosides) which yield various derivatives known to be potential goitrogens (8, 27, 29). Paxman and Hill (20) indicated that thiocyanate in kale leaves is largely responsible for thier goitrogenicity in rats. 3-indolylmethylglucosinolate (glucobrassicin) and N-methoxy-3-indolylglucosinolate (neoglucobrassicin) have been identified as the thiocyanate-yielding glucosinolates in cabbage (25), with 3-indolylglucosinolate making the major contribution (up to 68%) of glucosinolates in this species (26).

In view of concern for the content of natural toxicants in food plants (11), researchers have been studying the content, composition, and distribution of glucosinolates and their derivatives in cruciferous vegetable crops and cultivars (5, 7, 10, 16, 25, 26). We also have been studying the environmental and cultural factors influencing synthesis and accumulation of glucosinolate-derived toxins in cruciferous vegetables (2, 3, 18). In this study, we examine the influence of cultivar, season, irrigation, and planting date on thiocyanate ion (SCN^-) content in cabbages.

Materials and Methods

In 1974, 14 cultivars of cabbage (Table 1) were seeded on April 30 and grown in a greenhouse with a mean temperature of 22 ± 4°C at Macdonald College (45° 25'N; 73° 56'W). On May 28, seedlings were transplanted in the field 7 per row and within row spacing of 0.6m on a St. Bernard clay loam soil with rows 0.9m apart in a randomized block design with 3 replications. Standard recommendations for fertilizer, pesticide, and other cultural practices were followed. In 1975, the same cultivars were seeded on April 30, set in the same field on May 28, and similarly grown as the 1974 planting. In both years, 4 mature cabbages per row were selected randomly and the marketable head weight and total top weight (marketable head weight plus outer wrapper leaves) were recorded on a fresh weight basis. Thin cross-sectional wedges from each of 2 heads were removed and combined into a 100–150g sample for

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