Ethephon and Mechanical Topping Influence Growth, Yield, and Lodging of Sweet Corn

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Abstract. Field experiments were conducted in 1986 through 1988 to evaluate the effects of rates and timing of ethephon application on growth, yield, and lodging of 'Jubilee' sweet corn (*Zea mays* L.). As a comparison, hand-topping was performed 10 days after early silking to simulate the commercial practice of mechanical topping to reduce lodging. Ethephon reduced plant height by 12% to 26%, with timing of application determining location of internode length reductions. There was greater reduction of ear height by ethephon applied at tassel elongation (TE) than at 1 and 2 weeks later. Effects of ethephon on husked yield varied from an 8% increase in yield to an 18% decrease, depending on rate, timing, and season. Topping reduced yield in one of the four experiments. Ear length was reduced by ethephon at 0.28 kg·ha⁻¹ in two of the four experiments. A helicopter fly-over resulted in 66% of topped plants lodging, compared to 87% of untreated plants. Lodging of plants that received an ethephon application of 0.28 kg·ha⁻¹ at TE averaged 51% for Expts. 2, 3, and 4. The amount of lodging tended to be least in those ethephon treatments with the largest reduction in plant or ear height. Chemical names used: 2-chloroethyl phosphonic acid (ethephon).

Wind and rainstorms can cause lodging and yield losses of sweet corn. Mechanical topping, which removes the upper portion of sweet corn stalks before harvest, is the current cultural practice used in the Pacific Northwest to reduce lodging. Topping has the additional advantages of increasing harvest efficiency and facilitating late-season movement of irrigation pipe, but mechanical topping has been shown to reduce yields by 5% to 25%, depending on timing and severity (Huelsen and Bemis, 1959; Mack, 1965).

Ethephon, a source of ethylene, is used commercially to promote floral induction, fruit abscission, and fruit ripening (de Wilde, 1971) and has been shown to control lodging, thus enhancing yields in small grains (Dahmouss et al., 1982; Green and McDonald, 1985).

In work with ethephon on field corn, Earley and Slife (1969) found reductions in plant height, leaf area, leaf efficiency, and yields

at rates of up to 2.24 kg·ha⁻¹ applied at several growth stages. Miller et al. (1969) noticed various degrees of stunting of sweet corn growth from ethephon at three concentrations made at the four-leaf stage of growth. Langan and Oplinger (1987) reported that plant and ear height of two field corn hybrids decreased with ethephon application at tassel elongation. Yield increased at low rates, but decreased at higher rates. Cox and Andrade (1988), Langan and Oplinger (1987), and Norberg et al. (1988) concluded that ethephon may enhance yields of field corn when lodging is a problem, but may decrease yields in the absence of lodging. However, response was dependent on ethephon rates, timing, plant populations, and cultivars.

With sweet corn, Gaska and Oplinger (1988a) found that a high rate of ethephon (0.42 kg·ha⁻¹) reduced lodging, plant height, and ear height by 87%, 16%, and 13%, respectively, and increased brace root development by 50%. Yields were reduced 13% with this high rate of ethephon applied at tassel elongation (TE) and TE + 4 to 6 days, but were not affected at TE + 9 to 13 days.

Our objectives were to 1) evaluate the effects of differential rates and timings of ethephon applications on sweet corn growth, and

2) compare yields and lodging tendency of plants sprayed with ethephon with those mechanically topped and with the untreated controls.

Four field experiments were conducted in 1986-88 on a mixed, mesic Cumulic Haploxerol (Chehalis silty clay loam) soil at the Oregon State Univ. Vegetable Research Farm, Corvallis.

Plots were overseeded with 'Jubilee' sweet corn in 91-cm rows and seedlings (10 to 15 cm high) were thinned to a uniform population of 62,750 plants/ha. Planting dates for the four experiments were 27 May 1986, 21 May and 14 June 1987, and 15 June 1988. Fertilizer (55N-75P-45K; kg·ha⁻¹) was banded on all plots at planting. Urea (125 kg N/ha) was sidedressed on all plots $\approx$ 2 weeks before tassel emergence. For weed control, alachlor at 0.90 kg a.i./ha and atrazine at 0.56 kg a.i./ha were applied pre-emergence. Hand-weeding supplemented chemical control. Plots were sprinkler-irrigated to field capacity at 7- to 10-day intervals, as needed, during the growing season, with total water applied ranging from 350 to 450 mm. Ethephon (0.48 kg·liter⁻¹ commercial formulation) was applied with a CO₂ backpack sprayer at 2.10 kg·cm⁻² pressure at rates and timings listed in Tables 1 and 2. All spray applications were directed into the top of leaf whorls. The earliest timing of ethephon application was at TE, which was determined by primordia measurements of plants in guard rows. TE was defined as the date when tassels had begun to rapidly elongate and reached an average length of 7 to 15 cm but were not visible externally. Subsequent applications of ethephon were based on the date of TE. Heat unit accumulations (10C base, air temperature) from planting to TE were as follows for Expts. 1, 2, 3, and 4: 329, 308, 341, and 404 degree days, respectively (41, 47, 40, and 46 days from planting to TE, respectively).

Plants were topped by hand, at two nodes above the ear attachment, 10 days after early silking to simulate mechanical topping.

Treatments for the four experiments are listed in Tables 1 and 2. All experiments used a randomized complete-block design. In Expt. 1 (1986), three treatments were replicated six times in single-row plots, 7.6 m long. In Expt. 2 (1987), six treatments were replicated four times in three-row plots (9.1 m long), while five treatments were replicated six times in six-row plots in Expt. 3 (1987). In Expt. 4 (1988), five treatments were replicated four times in four-row plots, with plots being separated by $\approx$ 3 m of un-

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Table 1. Effects of rates and timing of ethephon and of mechanical topping on plant height, ear height, and lodging of 'Jubilee' sweet corn at maturity.

Treatments	Experiment											
	1				2				3			
	Total plant height (cm)				Ear height (cm)				Plants lodged (%)			
Ethephon rate (kg-ha ⁻¹) and timing												
None (control)	239	264	283	214	97	85	99	81	89	90	83	
0.28, TE ¹	210	219	241	159	73	62	77	61	48	78	27	
0.28, TE + 1 week	---	223	238	162	---	75	81	72	88	72	47	
0.28, TE + 2 weeks	---	221	---	184	---	77	---	83	74	---	72	
0.56, TE + 1 week	---	---	212	---	---	---	74	---	---	58	---	
0.56, TE + 2 weeks	---	206	---	---	---	76	---	---	82	---	---	
Mechanical topping	---	153	162	140	---	85	97	88	61	70	66	
LSD 5 %	14	8	6	8	7	4	4	4	20	15	9	

¹TE = tassel elongation.

Table 2. Effects of rates and timing of ethephon and of mechanical topping on yield and ear length of 'Jubilee' sweet corn.

Treatments	Experiment							
	1				2			
	Yield of husked, acceptable ears (Mg-ha ⁻¹)				Ear length (cm)			
Ethephon rate (kg-ha ⁻¹) and timing								
None (control)	16.8	20.3	19.4	20.5	19.2	20.1	18.9	19.0
0.28, TE ¹	13.7	21.1	19.2	19.3	18.6	19.4	18.7	18.7
0.28, TE + 1 week	---	21.4	19.8	20.9	---	20.4	18.6	19.2
0.28, TE + 2 weeks	---	20.9	---	22.2	---	20.7	---	19.4
0.56 TE + 1 week	---	---	20.5	---	---	---	18.5	---
0.56, TE + 2 weeks	---	21.6	---	---	---	20.8	---	---
Mechanical topping	15.4	20.0	18.3	21.2	19.2	20.2	18.9	18.8
LSD 5%	1.4	NS	1.3	NS	0.3	0.5	NS	NS

¹TE = tassel elongation.

planted border on sides and at the ends. The heights of top ear node, ear base, flag leaf, and total height were measured randomly in each plot at maturity.

Ears were hand-harvested from single rows at $\approx 72\%$ kernel moisture and separated into good (acceptable for processing) and culls. Average lengths of individual good ears were from a five-ear subsample from each plot. Harvest dates for the respective experiments were 28 Aug. 1986, 25 Aug. and 9 Sept. 1987, and 20 Sept. 1988.

To induce lodging in Expts. 2, 3, and 4, wind turbulence was created by helicopter fly-overs parallel to rows at ≈ 4.5 to 6.0 m above the crop canopy. Plots were irrigated with 50 mm of water just before the lodging tests. Visual evaluation of lodging was based on nonharvested rows. Plants were considered as lodged when leaning more than $\approx 80^\circ$ from vertical.

Ethephon at 0.28 kg-ha⁻¹ reduced plant height 12% to 26% in the four experiments, compared to the control (Table 1). Height reduction was related more to rate of application of ethephon than timing in Expts. 2 and 3, with the higher rates causing more reduction in total plant height. Timing of application affected the location of reduced internode length, as reflected in ear height.

Early (TE) application caused internode shortening below the ear, but later application tended to decrease internode elongation above the ear. Mechanical topping reduced total plant heights 35% to 43%.

In Expt. 2, ear height was affected primarily by timing of ethephon application, where the 0.28 kg-ha⁻¹ rate at TE, TE + 1 week, and TE + 2 weeks resulted in ear height reductions of 25%, 10%, and 7%, respectively, compared to none applied. Plant height reductions from the same treatments were 17%, 16%, and 16%. A late ethephon application (0.56 kg-ha⁻¹, TE + 2 weeks) in Expt. 2 reduced ear height 10%, but plant height was reduced 22%. In the four experiments, application of ethephon at 0.28 kg-ha⁻¹ at TE caused ear height reductions of 22% to 27%, compared to the control (Table 1).

Lodging was highest in untreated plots (Expts. 2-4) compared to other treatments and averaged 87% for the three experiments. Topping of plants reduced lodging, and the average percentage of lodged plants was 66% in the three experiments. Amount of lodging from ethephon treatments varied, but, in some treatments, the percentage of plants lodged was equal to or less than in the topped treatment. The amount of lodging tended to be

least in those treatments with the greatest reduction in ear height or plant height. On average, 51% of plants had lodged for ethephon at 0.28 kg-ha⁻¹ applied at TE in Expts. 2-4.

Although the helicopter fly-over caused a more severe force and pattern of wind turbulence than would be expected from natural conditions, there were differential responses of the various treatments in this test, with the untreated plots showing the most lodging (Table 1). The main type of lodging was due to uprooting of plants, related to irrigation of plots just before the helicopter fly-over or during the fly-overs (Expt. 4), rather than from lodging due to stalk breakage. No measurements of brace roots were made, but Langan and Oplinger (1987) and Gaska and Oplinger (1988a, 1988b) reported that increasing ethephon rate increased brace root development. It is not clear in our study whether or not one of the above factors, or a combination of all, relates to enhancing the resistance of sweet corn to lodging.

Yields of husked, acceptable ears in Expt. 1 were significantly reduced by the 0.28 kg ethephon/ha rate at TE and by topping (Table 2). This ethephon treatment also significantly reduced ear length in Expts. 1 and 2.

Early application (TE) of ethephon resulted in greater yield reduction than later application (Gaska and Oplinger, 1988a); this trend was also evident in Expts. 1, 3, and 4. Earley and Slife (3) found that ethephon reduced leaf area per plant in some cases, but ethephon also reduced grain yield other than by restricting growth of leaves.

To make the choice between ethephon application and mechanical topping would require more information on reliability in reducing lodging and the economics of the two treatments.

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