The Effects of Ethephon on Saskatoon (*Amelanchier alnifolia* Nutt.) Fruit Ripening

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Abstract. Field experiments were conducted on two cultivars of saskatoon to test the effectiveness of ethephon in stimulating uniform fruit ripening without compromising fruit quality. Shrubs of cultivars Northline and Smoky were sprayed to runoff with ethephon (0, 250, 500, and 1000 mg·L⁻¹ for 'Northline'; 0, 500, and 1000 mg·L⁻¹ for 'Smoky') prior to fruit maturity. Fruit were harvested 4 to 8 days after treatment and sorted into ripeness categories by size, and the fully ripe fruit were evaluated for quality (surface color, firmness, mean fruit weight, soluble solids, and titratable acids). Ethephon significantly increased the percent ripe fruit per shrub (by up to 9.7%) in both cultivars, without a significant effect on fruit quality. At concentrations up to 1000 mg·L⁻¹, ethephon may be an effective ripening agent for saskatoon fruit without reducing fruit quality. Although there were significant differences in yield from year to year for both cultivars because of their biennial-bearing habit, ethephon treatments did not significantly affect total yields.

The saskatoon is an emerging North American fruit crop (St-Pierre, 1992) with widespread commercial potential. Somewhat similar to blueberry (*Vaccinium angustifolium* Ait.), it is nevertheless much better adapted to very cold winter temperatures and mildly alkaline soils (Finn, 1999). Most of the production occurs in the Prairie Provinces of Canada, with Alberta the current leader at 600 ha and 1.35 million kg. Demand (both domestic and international) has been expanding and production (up 5-fold in Alberta since 1999) has kept pace, as young orchards planted years ago reach their bearing age (Jeffs, 2003). Roughly half of the Alberta crop is processed into syrups and other products, partly because the freshly picked fruit is highly perishable. The need for quality fruit (both for processing and fresh consumption) has facilitated the introduction of specialized mechanical harvesters to counteract the high cost of hand-picking. Unfortunately, the nonuniform ripening pattern exhibited by saskatoon fruit (Green and Mazza, 1986) makes it difficult to maximize the yield of salable fruit with once-over mechanical harvesting. Ethylene is a naturally occurring ripening hormone in many fruits (Burdon and Sexton, 1990; Gross and Sams, 1984; Iannetta et al., 1999; McGlasson, 1985). The effects of endogenous and exogenous ethylene on various fruit-quality parameters have been studied in crops like apple [*Malus ×sylvestris* (L.) Mill. var. *domestica* (Borkh.) Mansf.] (Curry, 1994), grape (*Vitis vinifera* L.) (Powers et al., 1980; Roubelakis-Angelakis and Kliewer, 1986; Weaver and Montgomery, 1974), raspberry (*Rubus idaeus* L.) (Perkins and Nonnecke, 1992), and saskatoon (Rogiers and Knowles, 1997). However, the role of exogenous ethylene in influencing the time of ripening has been of particular interest to growers who rely heavily on once-over mechanical harvesters. Ethephon (2-chloroethylphosphonic acid) is an ethylene-releasing agent which has been used to synchronize ripening in a number of horticultural crops, including cherry (*Prunus cerasus* L.) (Olien and Bukovac, 1978), coffee (*Coffea arabica* L.) (Browning and

Cannell, 1970; Winston et al., 1992), olive (*Olea europaea* L.) (Tous et al., 1995), pepper (*Capsicum annuum* L.) (Batal and Granberry, 1982; Sims et al., 1974), and tomato (*Lycopersicon esculentum* Mill.) (Dostal and Wilcox, 1971). The objective of this study was to test the effectiveness of ethephon in stimulating uniform ripening of saskatoon fruit without negatively affecting fruit quality and yield.

Materials and Methods

Field experiments were conducted on mature 'Northline' and 'Smoky' saskatoon shrubs (all planted in 1988) during two seasons (1994 and 1995) at the Alberta Crop Diversification Centre North, Edmonton, Alberta, Canada. Three stands of each cultivar (three to five shrubs per stand) were selected for uniform shrub size. Four ethephon concentrations were applied to randomly selected 'Northline' shrubs (0, 250, 500, and 1000 mg·L⁻¹; three shrubs per treatment) and three to randomly selected 'Smoky' shrubs (0, 500, and 1000 mg·L⁻¹; three shrubs per treatment). Ethephon solutions were prepared from a stock solution of 480 g·L⁻¹ ethephon (Cerone; Union Carbide Agricultural Products Co., Calgary, Canada) diluted with distilled water (pH 5.6) to obtain the desired concentrations (250, 500, and 1000 mg·L⁻¹); distilled water was used for the control (0 mg·L⁻¹) solutions. Each treated shrub was sprayed once with a compressed-air sprayer to runoff when ≈70% of the "berries" were red (maturity class #7: Rogiers and Knowles, 1997) ['Northline' on 13 July 1994 (24.1 °C), and 19 and 21 July 1995 (27.3 °C and 22.2 °C, respectively); 'Smoky' on 13 July 1994 (24.1 °C) and 13 July 1995 (24.5 °C)]. Polyethylene baffles were erected between shrubs to prevent drift during application.

The saskatoon "berry" is actually a pome that may reach 20 mm or more in diameter when ripe; fruit size and shape vary among cultivars, but all commercial cultivars show a progression in fruit skin color from green through very dark purple as ripening proceeds. When ≈70% of the control berries were purple (maturity classes #8 and #9: Rogiers and Knowles, 1997) (4–8 d after treatment), fruit were harvested onto crushed ice ('Northline' on 19 July 1994, and 24 and 25 July 1995; 'Smoky' on 18 July 1994, and 19 and 21 July 1995). The total fruit per shrub or a 1-kg

sample of harvested berries was sorted on ice into nine maturity classes grouped according to fruit size and surface color (Rogiers and Knowles, 1997): #9 = mature, ripe, purple-blue fruit with average diameter of 14 mm; #8 = mature, purple-red fruit with average diameter of 14 mm; #7 = red fruit with diameter of 13 mm; #6 = pink fruit with diameter of 12 mm; #5 = pink and white fruit with diameter of 11 mm; #4 to #1 = green fruit, following in order of descending size (diameters of 11, 10, 9, and 7 mm, respectively; Fig. 1). To ensure consistent sorting of berries into the appropriate maturity classes, fruit surface color was quantified through the specimen port of a HunterLab Color/Difference Meter D25/L2 (Hunter Laboratory Associates, Fairfax, Va.) which had been calibrated according to factory values for the white, black, blue, and pink tiles (L, a, b values measured with 90° rotations of each fruit-filled petri dish; three replications per treatment). The L value indicates darkness or lightness of color, ranging from complete darkness (L = 0) to pure white light (L = 100). The a and b values are coordinates that indicate color directions: +a is the red direction, –a is the green direction, +b is the yellow direction, and –b is the blue direction. Chroma (C; saturation or vividness of color) and hue angle (h°; the basic tint of color) are derived from a and b and were calculated as described by McGuire (1992). As chromaticity increases, a color becomes more intense; as it decreases a color becomes more dull. For useful interpretation, h° should remain positive between 0° and 360° of the color wheel. As such, a h° of 0° is red-purple, 90° is yellow, 180° is bluish-green, and 270° is blue (McGuire, 1992). As saskatoon fruit mature from stage 7 (red) to stage 9 (bluish-purple), the h° values range from 20° (red), through 0° (red-purple), to 330° (bluish-purple). For unbiased statistical analyses, 360 was added to h° values <25° when performing analysis of variance (ANOVA) and orthogonal polynomial contrasts on these data.

The fresh weight of fruit per shrub in each maturity class was determined gravimetrically. The "ripe fruit" per shrub comprised the combined weights of maturity classes #8 and #9 and was expressed as a percentage of the total fruit weight per shrub. Category #9 fruit were used to obtain measurements for weight, firmness, soluble solids, and titratable acids.

Fresh-fruit firmness was determined using the 50-kg Kramer shear of the Instron Universal Testing System (model 4201; Instron Corp., Canton, Mass.) [13 fruit per replication; three replications (shrubs) per treatment].

Soluble solids concentration (SSC), expressed as percent sucrose equivalents, was determined using the refractometer method (AOAC, 2002a) with a Zeiss Abbe refractometer (Carl Zeiss Oberkochen, Wurtt, Germany) connected to a water bath (20 °C). Frozen fruit (50 g) was blended with 50 mL of distilled water for 3 min at high speed in a blender. The slurry was strained through two layers of cheesecloth, the liquid was centrifuged at 3500 g_n for 5 min, the collected supernatant was centrifuged again at 3500 g_n for 5 min, and the final supernatant was filtered through Whatman #4 filter paper. The percent SSC was determined from the filtrate [three replications (shrubs) per treatment], and corrected for the initial dilution.

Titratable acidity (TA), expressed as percent malic acid equivalents, was determined using the glass-electrode method (AOAC, 2002b) used by Green and Mazza (1986). Frozen fruit (30 g) was blended with 30 mL of distilled water for 3 min at high speed in a blender. An additional 50 mL of distilled water was added, and the slurry was boiled for 30 min while replacing water lost to evaporation. The boiled fruit slurry was brought to a final volume of 200 mL, strained through two layers of cheesecloth, and centrifuged at 14,000 g_n for 5 min; the supernatant was then filtered through Whatman #4 filter paper. Aliquots of filtrate (25
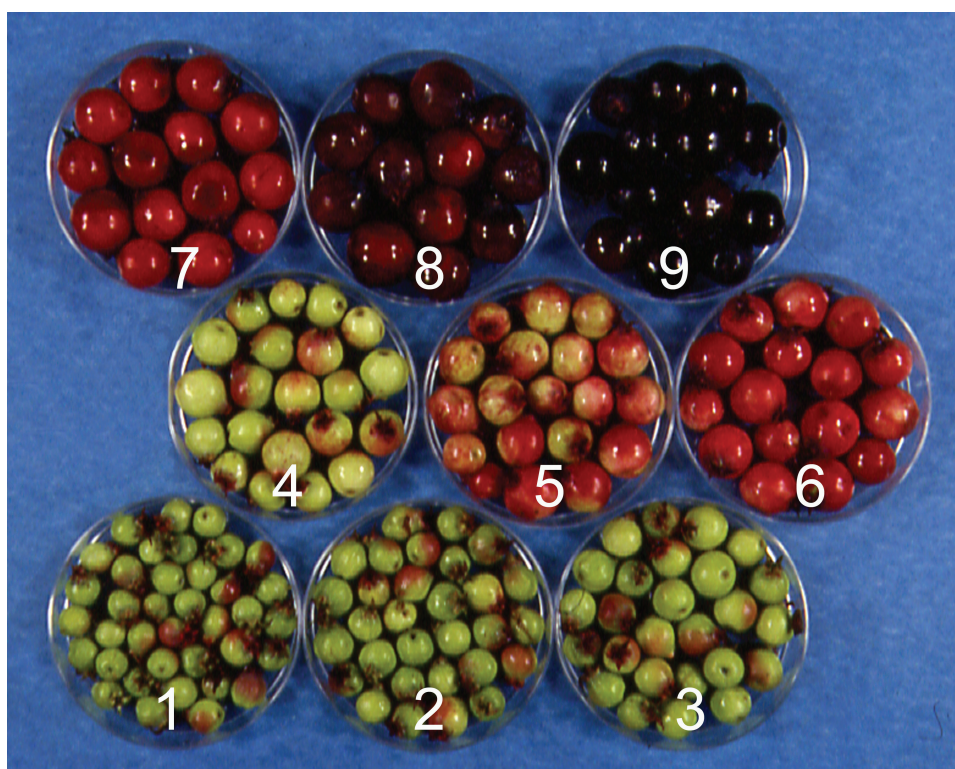

Fig. 1. Saskatoon fruit were separated into nine ripeness categories: #9 = mature purple-blue fruit; #8 = mature purple-red fruit; #7 = red fruit; #6 = pink fruit; #5 = pink-and-white fruit; #4 through #1 = green fruit, in order of descending fruit size ('Northline').

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mL) were titrated past the end-point (pH 8.1) with 0.01 M NaOH, and the volume of 0.1 M NaOH required to titrate 100 g of fruit at the end-point was calculated. Malic acid equivalents were determined from fruit filtrate [three replications (shrubs) per treatment] and expressed as grams of acid per 100 g of fruit.

The ethephon experiment was set up as a split-split-plot experimental design within each of the two cultivars. The data were analyzed using ANOVA. The sources of variation were set as shrub origin (micropropagated plants vs. transplanted suckers) and stand number (s = 3) nested within origin as the main plot, ethephon treatment as the split-plot, and year of treatment as the split-split plot.

Due to minimal yield of ripe fruit for 'Smoky' in 1994, only 1995 data were used to assess the effect of ethephon on the percent ripe fruit in this cultivar. These data were analyzed as a split-plot with sources of variation of origin and stands nested within origin as the main plot and ethephon treatment as the split-plot.

Orthogonal polynomial contrasts were used to determine if there were linear or quadratic trends in the dependent variables as a function of ethephon concentration.

The yield of the three control shrubs of 'Northline' and 'Smoky' were assessed in 1994, 1995, and 1996. These yield data were analyzed as a spilt-plot design with sources of variation of origin and stands within origin as the main plot and years as the split-plot.

For statistical analysis, the General Linear Model of the SAS 6.10 program (SAS Institute, Cary, N.C.) was used.

Results

When examined one cultivar at a time, the yield obtained from the control shrubs of 'Northline' and 'Smoky' varied significantly among years ($P \leq 0.01$). In 'Northline', the total fruit yield per shrub was significantly less in 1994 and 1996 than in 1995 (Table 1; $P \leq 0.05$). In 'Smoky', the total fruit yield per shrub was significantly different each year, with the least amount of fruit harvested in 1994, and the most fruit collected in 1995 (Table 1; $P \leq 0.05$). Ethephon did not significantly affect the yield from 'Northline' or 'Smoky' shrubs (Tables 2 and 3). Because of the minimal fruit yields obtained from 'Smoky' in 1994, the effect of ethephon on synchronizing ripening of 'Smoky' fruit was assessed in 1995 only.

Ethephon treatment significantly affected the percent ripe fruit per shrub in both cultivars (Fig. 2; $P \leq 0.05$). In 'Northline', the percent ripe fruit per shrub increased with increasing ethephon concentration (Fig. 2; 1994 and 1995; linear trend significant, $P \leq 0.01$), with a maximum increase of 7.5% attained with 1000 mg·L^{-1} ethephon. In 'Smoky', ethephon at 500 mg·L^{-1} elicited the greatest increase (9.7%) in percent ripe fruit per shrub (Fig. 2; 1995; linear trend significant at $P = 0.056$ and quadratic trend significant at $P \leq 0.03$).

Table 1. The fruit yields observed from 'Northline' and 'Smoky' saskatoon shrubs from 1994 to 1996.

Cultivar	Yield (kg/shrub)^z		
	1994	1995	1996
Northline	2.90 b^y	7.74 a	3.45 b
Smoky	0.32 z	10.14 x	2.09 y

^{z}Yields obtained from control shrubs.
^{y}Mean separation within rows (ab)(xyz) by the least significant difference test (LSD), $P \leq 0.05$.

In 'Northline', the year of treatment significantly affected fruit color development (Hunter L, C, and h° values), SSC, TA, and the ratio of SSC:TA (Table 2; $P \leq 0.01$). In 1994, the Hunter L values were lower, C values were higher, and tint of color (h°) more reddish-purple (than bluish-purple) than in 1995 ($P \leq 0.01$), indicating that fruit harvested in 1994 were darker, more intense, and more red-purple in color than fruit from 1995. Values for SSC and SSC:TA were significantly greater while TA values were significantly less in 1994 than in 1995 ($P \leq 0.01$). The year × origin interaction was significant for SSC, TA, and SSC:TA (Table 2; $P \leq 0.05$). In 1994, the SSC and SSC:TA were greater in fruits from micropropagated plants than plants derived from suckers; no difference was observed in 1995 (Table 2; $P \leq 0.05$). TA did not vary between origins in 1994; however, in 1995, TA was greater in fruit from micropropagated plants than from plants derived from suckers (Table 2; $P \leq 0.05$). In 'Northline', fruit firmness and fresh weight did not differ with respect to shrub origin or year of application (Table 2). Fruit firmness and h° decreased with increasing ethephon concentration (linear trend significant, $P \leq 0.05$) indicating fruit softened slightly and became more bluish-purple as ethephon concentration increased. Ethephon treatment did not affect the color characteristic L and C values, fruit fresh weight, SSC, TA, or SSC:TA of 'Northline' fruit (Table 2).

In 'Smoky', the year of treatment significantly affected fruit color development (Hunter L, C, and h° values), SSC, and SSC:TA (Table 3, $P \leq 0.01$). The Hunter L, C, and h° values were significantly greater in 1994 than in 1995, indicating that fruit harvested in 1994 were lighter, more intense, and more reddish-purple in color than fruit from 1995 ($P \leq 0.01$). Values for SSC and SSC:TA were significantly greater in 1994 than in 1995 ($P \leq 0.01$). In 'Smoky', fruit color characteristics, firmness, fresh weight, SSC, TA, and SSC:TA did not differ with respect to shrub origin (Table 3). Hunter b values and h° decreased with increasing ethephon concentration indicating that the fruit tint of color became more bluish-purple with increasing ethephon concentration (linear trend significant, $P \leq 0.05$). Ethephon treatment did not affect the Hunter L and C values, firmness, fresh weight, SSC, TA, or SSC:TA of 'Smoky' fruit (Table 3).

Discussion

The climacteric nature of saskatoon fruit is now established (Rogiers et al., 1998; Rogiers and Knowles, 1999). Uniform fruit ripening, essential for efficient mechanical harvesting, has been enhanced in many other fruit crops with applications of ethephon. In this study, saskatoon shrubs of cultivars Northline and Smoky treated with ethephon at the 70% "red-berry" stage (maturity class #7: Rogiers and Knowles, 1997) yielded greater proportions of ripe fruit per shrub with a single harvest. In general, the increases in ripe fruit were small (6% to 7%) but significant for both cultivars tested. Based on saskatoon industry information from Alberta Agriculture, Food and Rural Development (1998) and updated to 2003, a 4% estimated net increase in income for a 4-ha orchard would be realized as a result of ethephon application (assuming 5% increase in percent ripe fruit).

The success of ethephon in stimulating fruit ripening in field applications can be affected by numerous factors other than the cultivar (Bal et al., 1992; Cantliffe and Goodwin, 1975; Conrad and Sundstrom, 1987), including the stage of crop maturity (Cantliffe and Goodwin, 1975; Conrad and Sundstrom, 1987; Winston et al., 1992), the concentration of ethephon (Bal et al., 1992; Cantliffe

Table 2. The effects of ethephon treatment, year of application, and plant origin on fruit yield and quality parameters were determined for 'North-line' saskatoon.[z]

Year	Treatment (mg·L^{-1})	Yield kg/shrub	Fruit firmness (kg·g^{-1})	Fruit fresh wt (g)	SSC[x] (%)	TA[y] (% malic acid equivalents)	SSC:TA	Color characteristics[w] L	a	b	C	h°
1994	0	2.90	18.3	1.18	15.9	0.374	42.7	16.3	6.61	1.57	6.8	13.1
	250	1.67	17.5	1.10	15.5	0.371	41.9	15.9	7.23	1.63	7.4	12.6
	500	1.79	17.7	1.21	15.9	0.401	40.3	15.9	7.03	1.60	7.2	12.8
	1000	2.58	16.6	1.18	15.4	0.368	41.6	15.8	7.42	1.45	7.6	11.0
	mean	2.23 a[v]	17.5 b	1.17 b	15.7 a	0.379 a	41.6 a	16.0 a	7.08 a	1.56 a	7.3 a	12.4 a
1995	0	7.74	18.0	1.13	13.6	0.507	27.2	16.0	1.90	–0.72	2.0	339.8
	250	6.04	18.3	1.15	14.4	0.559	26.5	18.6	2.17	–1.00	2.4	336.0
	500	7.27	18.5	1.13	14.1	0.520	27.0	18.3	2.25	–1.00	2.5	335.4
	1000	5.86	17.9	1.18	13.8	0.495	28.8	19.0	2.15	–1.05	2.4	334.1
	mean	6.73 b	18.2 b	1.15 b	14.0 b	0.518 b	27.4 b	18.7 b	2.12 b	–0.94 b	2.3 b	336.3 b
Micro-propagated	1994 mean	1.62	17.4	1.17	16.5 a[u]	0.367 c	44.9 a	16.1	6.90	1.54	7.1	12.5
	1995 mean	6.00	18.1	1.11	13.7 c	0.540 a	25.6 c	19.0	2.18	–0.99	2.4	336.0
Sucker	1994 mean	2.85	17.6	1.18	14.8 b	0.390 c	38.3 b	15.9	7.25	1.58	7.4	12.2
	1995 mean	7.46	18.3	1.18	14.3 c	0.498 b	29.0 c	18.4	2.05	–0.89	2.2	336.7

[z]Quality parameters determined on stage 9 maturity fruits.
[y]TA = titratable acidity.
[x]SSC = soluble solids concentration.
[w]Color measurements of L (lightness of color), C (chroma, saturation or vividness of color), and h° (hue angle, tint of color; 0° = red-purple, 90° = yellow, 180° = bluish-green, 270° = blue); C and h° calculated from a and b values as described by McGuire (1992).
[v]Means followed by different letters (a, b) indicate significant difference between years by analysis of variance, $P \leq 0.01$.
[u]Mean separation within origin (abc) by least significant difference test (LSD), $P \leq 0.05$.

Table 3. The effects of ethephon treatment, year of application, and plant origin on fruit yield and quality parameters were determined for 'Smoky' saskatoon.[z]

Year	Treatment (mg·L^{-1})	Yield kg/shrub	Fruit firmness (kg·g^{-1})	Fruit fresh wt (g)	SSC[x] (%)	TA[y] (% malic acid equivalents)	SSC:TA	Color characteristics[w] L	a	b	C	h°
1994	0	0.324	---	---	17.6	0.190	93.4	17.2	7.17	–0.72	7.2	354.4
	500	0.840	---	---	16.2	0.229	70.6	16.5	7.87	–0.93	7.9	353.3
	1000	0.365	---	---	18.4	0.236	75.1	16.9	7.12	–1.12	7.2	351.1
	mean	0.510 a[v]	---	---	17.4 a	0.218 b	79.7 a	16.8 a	7.38 a	–0.92 a	7.45 a	352.9 a
1995	0	10.12	13.1	1.09	13.4	0.275	48.8	15.5	2.70	–0.47	2.8	350.5
	500	8.62	13.1	1.08	13.7	0.260	53.8	15.5	2.38	–0.40	2.4	350.0
	1000	9.39	13.4	1.03	13.2	0.236	57.2	15.5	2.90	–0.73	3.0	346.0
	mean	9.37 b	13.2	1.07	13.4 b	0.257 b	53.3 b	15.5 b	2.66 b	–0.53 b	2.73 b	348.8 b
Micro-propagated	1994 mean	0.324	---	---	17.9	0.228	73.7	17.6	7.17	–0.86	7.23	353.3
	1995 mean	8.79	13.3	1.05	13.3	0.267	50.1	16.0	2.43	–0.32	2.47	352.0
Sucker	1994 mean	0.695	---	---	16.8	0.208	85.7	16.1	7.60	–0.99	7.67	352.5
	1995 mean	9.96	13.1	1.09	13.6	0.248	56.4	14.9	2.89	–0.74	2.99	345.6

[z]Quality parameters determined on stage 9 maturity fruits.
[y]TA = titratable acidity.
[x]SSC = soluble solids concentration.
[w]Color measurements of L (lightness of color), C (chroma, saturation or vividness of color), and h° (hue angle, tint of color; 0° = red-purple, 90° = yellow, 180° = bluish-green, 270° = blue); C and h° calculated from a and b values as described by McGuire (1992).
[v]Means followed by different letters (a, b) indicate significant difference between years by analysis of variance, $P \leq 0.01$.

and Goodwin, 1975; Conrad and Sundstrom, 1987), the number of ethephon applications (Cantliffe and Goodwin, 1975; Conrad and Sundstrom, 1987), and the orchard temperature during (Bal et al., 1992) and after (Cantliffe and Goodwin, 1975; Conrad and Sundstrom, 1987; Olien and Bukovac, 1978) ethephon treatment. Our results indicate that applying ethephon to saskatoon shrubs when ≈70% of the berries are red can significantly increase the ripe fruit per shrub. Further experimentation will be required to test the effects of ethephon applied at earlier stages of saskatoon

fruit development. However, since the majority of the fruit size (mass and volume) in saskatoon is obtained during the last 2 weeks of development (McGarry et al., 1998), only a relatively small time window of application is possible without a dramatic reduction in fruit size and quality.

At elevated concentrations, the effectiveness of ethephon as a fruit-ripening agent diminishes, and ethephon instead stimulates excessive fruit abscission (Batal and Granberry, 1982; Cantliffe and Goodwin, 1975; Conrad and Sundstrom, 1987; Cooksey et al.,
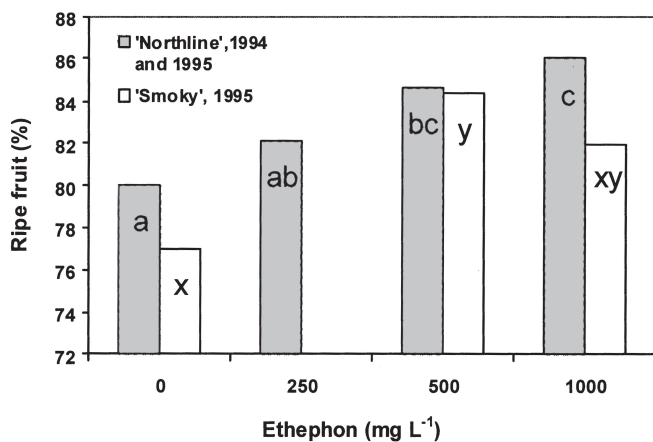
Fig. 2. The effect of ethephon on the percent of ripe fruit was determined for saskatoons 'Northline' (1994 and 1995) and 'Smoky' (1995). Mean separation among treatments was determined by the least significant difference test (LSD), $P \leq 0.05$, for 'Northline' (abc) and 'Smoky' (xy).

1994; Knavel and Kemp, 1973), defoliation (Batal and Granberry, 1982; Cantliffe and Goodwin, 1975; Conrad and Sundstrom, 1987; Cooksey et al., 1994; Martin et al., 1980), and accentuated alternate bearing (Wood, 1989). Thus premature fruit abscission occurs in pimiento and paprika peppers (*Capsicum annuum* L.) treated with 1500 to 3000 mg·L⁻¹ ethephon (Batal and Granberry, 1982), in tabasco peppers (*Capsicum frutescens* L.) sprayed with 5000 to 15,000 mg·L⁻¹ ethephon (Conrad and Sundstrom, 1987), and in olive treated with 2250 mg·L⁻¹ ethephon (Hartmann et al., 1970). Pecan [*Carya illinoinensis* (Wangenh.) C. Koch] trees suffer premature defoliation after exposure to 2000 mg·L⁻¹ ethephon (Martin et al., 1980). In 'Northline' and 'Smoky', ethephon (up to 1000 mg·L⁻¹) did not significantly stimulate the abscission of fruits. Testing of other saskatoon cultivars for ethephon-stimulated fruit abscission would be of value as they may differ in sensitivity to ethephon at the time of treatment.

With respect to saskatoon fruit quality (stage 9 maturity fruit), a small decrease in fruit firmness (in 'Northline') and a change in the tint of color (h°) of the fruit from reddish-purple to bluish-purple (in both cultivars) with increasing ethephon concentration was observed. Ethephon treatments did not affect the fruit fresh weight, SSC, TA, or SSC:TA values in 'Northline' or 'Smoky'. This suggests that ethephon applications at concentrations up to 1000 mg·L⁻¹ may enhance saskatoon fruit ripening without reducing fruit quality. Fruit flavor is attributed to the ratio of SSC:TA (Young et al., 1993). The SSC, TA, and SSC:TA values differed between 1994 and 1995, likely reflecting seasonal variations. However, the mean SSC, TA, and SSC:TA values across years ('Northline': 14.8% SSC, 0.45% malic acid, 34.7, respectively; 'Smoky': 15.4% SSC, 0.24% malic acid, 64.3, respectively) were very similar to those values reported by Green and Mazza (1986) ('Northline': 16.1% SSC, 0.45% malic acid, 35.5, respectively; 'Smoky': 16.3% SSC, 0.25% malic acid, 66.2, respectively). In general, these data show that fruit from 'Northline' and 'Smoky' contained similar quantities of sugars (SSC). The higher SSC:TA from 'Smoky' fruit in 1994 and 1995 was attributed to the reduced amount of acids (TA) present, in contrast to 'Northline' fruit.

The total fruit per shrub in cultivars 'Northline' and 'Smoky' varied significantly between years. In both cultivars, yields alternated in a typical biennial-bearing pattern. Analysis of fruit production in subsequent seasons will be required to establish the extent of biennial bearing in these cultivars. It will also be useful to evaluate the effect of ethephon treatments on alternate bearing. Indeed, further studies will be necessary to characterize the degree to which alternate bearing may be expressed in and influenced by ethephon in other saskatoon cultivars. Finally, the origin of the bearing shrubs (micropropagated plants vs. suckers) may interact differently with ethephon treatments in cultivars other than those studied here; if so, the commercial implications could be significant.

In summary, ethephon treatment promoted uniform ripening in saskatoon cultivars Northline and Smoky. The increase in percent ripe fruit per shrub obtained from each cultivar was small but significant. Ethephon treatment did not adversely affect saskatoon fruit quality, as determined by surface color, fruit firmness, fresh weight, soluble solids concentration, titratable acidity, or the ratio of soluble solid concentration to titratable acidity. Therefore, ethephon could be a potentially effective ripening agent for saskatoon fruits.

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