Influence of soil mulches and method of crop establishment on growth and yields of pumpkins

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Waterer, D. 2000. **Influence of soil mulches and method of crop establishment on growth and yields of pumpkins.** Can. J. Plant Sci. **80**: 385–388. Management methods that speed crop establishment, growth and maturity are essential to the efficient production of warm season vegetable crops in regions with short, cool growing seasons. This study examined the influence of method of crop establishment and the use of plastic soil mulches on yields and crop maturity of two cultivars of pumpkins over two cropping seasons in central Saskatchewan. Transplanting did not improve stand establishment over direct seeding but enhanced yields without influencing crop maturity. Plastic mulches improved stand establishment and fruit yields relative to a non-mulched control. Clear mulch was superior to black plastic in some cases. Both cropping seasons were unusually favorable for pumpkin production, which may have obscured the benefits expected for transplanting or mulching.

Key words: Pumpkins, *Cucumis pepo*, seeding, transplanting, mulches, maturity, yields

Waterer, D. 2000. **Influence du paillage et de la méthode d'installation de la culture sur la croissance et le rendement de la citrouille**. Can. J. Plant Sci. **80**: 385–388. L'implantation d'une production rentable de légumes de saison chaude dans les régions à saison courte et fraîche exige, au préalable, la mise au point de méthodes de conduite susceptibles d'accélérer l'installation, la croissance et la maturation de ces cultures. Nous avons examiné l'influence de la méthode d'installation de la culture et de l'emploi de paillage plastique sur le rendement et sur la précocité de maturation de deux cultivars de citrouille, durant deux étés, dans le centre de la Saskatchewan. Le repiquage en pleine terre n'améliorait pas la densité de peuplement par rapport au semis en place, mais il procurait une augmentation du rendement sans, toutefois, influer sur la précocité de maturation. L'utilisation de paillis plastique améliorait la densité de peuplement et le rendement fruitier par rapport aux cultures non paillées. Le plastique transparent était dans certains cas supérieur au plastique noir. Le fait que les conditions climatiques aient été exceptionnellement favorables à la culture de la citrouille peut avoir masqué les avantages escomptés du repiquage ou du paillage.

Mots clés: Citrouille, *Cucumis pepo*, semis, repiquage, paillis, maturité, rendement

Pumpkins (*Cucumis pepo*) are a high-value horticultural crop widely grown for food and ornamental purposes. Pumpkins are adapted to warm growing conditions and have an indeterminant growth habit. Yields and maturity of the crop increase with the quality and duration of the growing season (Swiader et al. 1992). The short, cool growing season characteristic of the Canadian prairies is not well-suited to pumpkin production, resulting in poor yields of immature fruit unless appropriate crop management techniques are utilized. Pumpkins can be established by either direct seeding or via transplanting. Direct seeding represents the lower-cost option in terms of inputs; however, transplanting accelerates crop establishment (Lazin and Simonds 1981). This early start may be important when long season, frost sensitive crops such as pumpkins are grown in regions with a short frost-free season (Swiader et al. 1992). Transplanting may also improve stand establishment, as germination occurs within the controlled environment of the greenhouse, rather than the less than ideal conditions commonly found in the field. Plastic soil mulches are commonly employed in the production of high-value horticultural crops, but there are few reports on the use of mulches in pumpkin production (Welbaum and Wooge 1994; Birge et al. 1996). Plastic soil mulches have been demonstrated to enhance growth and yields of various crops by altering soil temperatures (Ashworth and Harrison 1983; Waterer 1999), conserving soil moisture (Bhella 1988) and reducing weed competition (Birge et al. 1996; Waterer 1999). Black plastic is most commonly used, as it provides excellent weed control, but clear plastic is more effective if the objective is to raise soil temperatures (Ashworth and Harrison 1983). For example, in Saskatoon, Saskatchewan, soil temperatures in the seeding zone (5 cm) at the typical time of planting (late May) average 10°C (Saskatchewan Research Council 1995), which is well below the 25–30°C optimal for germination of pumpkins (Swiader et al. 1992). Plastic soil mulches and particularly the clear form should enhance germination of direct-seeded pumpkins if they increase soil temperatures. The higher soil temperatures associated with mulches should also accelerate establishment of transplants and promote subsequent crop development, thereby increasing yields and/or promoting crop maturity at harvest (Argall and Stewart 1990; Farias-Larios et al. 1994). The benefits of mulch should be most apparent when slow-developing cultivars are grown or when growing conditions are less than ideal.

This project evaluated the influence of plastic soil mulches on establishment, yields and crop maturity of direct seeded and transplanted pumpkins during the 1997 and 1998 growing seasons in Saskatchewan.

Table 1. Environmental conditions for Saskatoon area, 1997, 1998 and 30 yr average (Saskatchewan Research Council 1995)

	Mean Temperature (°C)						Frost free	Growing degree
	April	May	June	July	Aug.	Sept.	season(d)	days[z]
1997	2.2	10.7	17.4	19.2	19.0	14.6	143	924
1998	7.2	13.0	14.5	18.7	20.0	13.3	127	813
30 year	3.5	11.2	15.6	18.4	17.2	11.5	118	696

[z]Calculated from 1 June to 30 September, Base 10°C.

MATERIALS AND METHODS

The trials were conducted at the Horticulture Field Research Station of the University of Saskatchewan in Saskatoon, Saskatchewan, Canada (latitude 52° 9′N). This site features a Sutherland series clay loam soil (pH 7.8, EC < 1.0 dS/m), which was fertilized to meet the requirements for pumpkins (100 kg N ha^{-1}, 120 kg P_2O_5 ha^{-1}, 150 kg K_2O ha^{-1}). Two ornamental-type cultivars were tested: Spirit, a relatively early-maturing semi-bush type cultivar, which produces small to medium-sized fruit; and Howden, a later-maturing cultivar with a vining growth habit, which produces large fruit with superior color and storage capabilities.

The mulch treatments were a) bare ground, b) black plastic mulch (1.25 mil) or c) clear plastic mulch (1.25 mil). The mulch (0.75 mm wide spaced on 3 m centers) was laid one week before crop establishment to allow soil warming. In accordance with locally accepted grower practices, the crop was established in the last week of May, by which time the risk of spring frost has abated in Saskatchewan. The crop was established either by direct seeding or by transplanting two week old seedlings. The transplants were grown in Jiffy-7 peat pots (Jiffy Products, Batavia, IL) under greenhouse conditions (25/23°C day/night, 200 μmol m^{-2} s^{-1} supplemental light, 16 h daylength). The seedlings had two true leaves at the time of transplanting. The seeds or transplants were planted into the field by hand on the same date, with 50 cm spacings between plants within each row. In the direct-seeded treatment, two seeds were placed in each planting hole. The cultivars were grown in separate plots, as Howden produces a much larger plant canopy than Spirit. Once the direct-seeded plants had developed two true leaves, the crop was thinned to one seedling/hole. The crop was protected with a floating row cover (Agryl P-17, McConkey Co., WA) until early July. Drip irrigation was used to maintain soil water potentials at 30 cm above –40 kPa throughout the growing season. The entire plot was harvested in the first week of October, by which time frost had killed the vines without damaging the fruit. Fruit free of blemishes or obvious defects were counted, weighed and evaluated for degree of maturity. Fruit were considered to be mature if at least 50% of the surface had turned from green to orange by the time of harvest. All fruit were sufficiently mature at harvest to fully ripen during subsequent storage.

The trial was conducted as a 2 × 3 factorial (crop establishment × mulching) using a randomized complete block design with four replicates. Each plot consisted of a single 5 m long row. Analysis of variance was calculated using the GLM procedures of SAS (SAS Institute, Inc., Cary, NC). The 2 test years were considered as random variables in the test model (Gomez and Gomez 1984). Bartlett's test was used to confirm the homogeneity of error variances for the 2 test years. All percentage data were normalized using arcsin conversion. Where significant treatment effects were detected, protected *T* or *LSD* (least significant difference) tests were used to compare treatment means. Single degree of freedom contrasts were used to compare mulched treatments to the non-mulched controls. All statistical tests were conducted at $P = 0.05$.

Table 2. Treatment mean squares for Spirit and Howden pumpkins grown using two crop establishment methods on various mulches in 1997 and 1998

		Yield		Avg. fruit	Fruit
	Stand	Wt.	No.	weight	maturity
Spirit					
Year (Y)	28.2*	40771**	444**	5.5*	28.2*
Mulch (M)	7.2*	9917*	122*	1.2	7.2*
No mulch vs. mulched	8.2*	24516**	291*	2.2	8.2*
Establishment method (E)	1.1	4648*	68*	0.4	1.1
M × E	0.3	4151*	26	0.9	0.3
Y × M	0.2	73	8	0.7	0.2
Y × E	0.3	1537	19	0.2	0.3
Y × E × M	1.8	11130**	21	0.7	1.8
CV%	16	22	17	13	18
Howden					
Year (Y)	9.6*	55815*	309**	19.5*	448
Mulch (M)	5.0*	4306*	47*	0.9	23
No mulch vs. mulched	9.9*	5382*	35*	0.5	6
Establishment method (E)	1.6	10337**	85*	2.0	70
M × E	0.1	2440	19	2.3	71
Y × M	1.6	10337**	85*	2.0	70
Y × E	1.3	1644	1	10.4*	2
Y × E × M	1.3	345	16	1.8	17
CV%	11	22	25	15	30

*,** Significant at $P = 0.05$ and $P = 0.01$ respectively.

RESULTS AND DISCUSSION

Both growing seasons were warmer than normal, with accumulated growing degree days (base 10°C) over the production season 33% and 17% greater than normal in 1997 and 1998 respectively (Table 1). In 1997, the first killing frost was 4 wk later than normal (Table 1). In 1998, April and May were exceptionally warm, resulting in substantial soil warming prior to planting.

The treatment mean squares are presented in Table 2, while the means for the main effects are presented in Table 3. Plant stands for both cultivars were more complete in 1998 than in 1997. The exceptionally early spring in 1998 produced conditions better suited to establishment of pumpkins than in 1997. Both crop establishment methods produced excellent stands, with no significant difference between transplanting and direct seeding for either cultivar.

Table 3. Main effect means for cv. Spirit and Howden pumpkins grown using two crop establishment methods on various mulches in 1997 and 1998

		Yield			
	Stand (%)	kg/m row	No. fruit/m	Avg. fruit weight (kg)	Mature (%)
Spirit					
Year					
1997	78	29.3	4.2	6.8	63
1998	94	41.2	5.4	7.5	84
LSD (0.05)	7	4.0	0.4	0.5	6
Mulch					
No mulch	80	32.9	7.4	7.0	72
Black	88	32.2	4.4	7.2	75
Clear	92	40.1	5.4	7.5	73
LSD (0.05)	8	4.9	0.5	0.6	8
Establishment method					
Direct-seed	88	33.3	4.4	7.1	70
Transplant	85	37.4	5.0	7.3	76
LSD (0.05)	7	4.0	0.4	0.5	7
Howden					
Year					
1997	82	24.4	3.0	8.3	46
1998	91	38.2	4.0	9.6	39
LSD (0.05)	5	4.2	0.4	0.8	7
Mulch					
No mulch	82	29.8	3.1	9.5	42
Black	86	31.4	3.6	8.5	45
Clear	92	32.6	3.8	8.8	42
LSD (0.05)	6	5.4	0.5	1.1	8
Establishment method					
Direct-seed	88	27.6	3.2	8.9	41
Transplant	86	34.8	3.8	9.0	45
LSD (0.05)	5	4.2	0.4	0.8	7

Transplanting may have been more advantageous if conditions prior to and after seeding had been less favorable. Double seeding also provided a margin for failure in the direct-seeded crop. For both cultivars, establishing the crop on plastic mulch improved the stand relative to the non-mulched control. Mulches conserve soil moisture and raise soil temperatures; changes beneficial to the establishment of both the direct-seeded and transplanted crops. For cv. Howden, the clear plastic mulch produced a better stand than the black plastic. Howden was slower to germinate than cv. Spirit, even under the relatively favorable greenhouse conditions used to establish the transplants (data not shown). This suggests that Howden may be relatively sensitive to unfavorable environmental conditions and might therefore benefit from the warmer soil temperatures typically provided by clear mulch (Ashworth and Harrison 1983).

Fruit yields (number and weight) in 1998 were substantially greater than in 1997 (Table 3). This was unexpected, as 1997 was warmer than 1998 and had an exceptionally long, frost-free fall. The 1998 crop produced a more complete stand than in 1997 and this may have contributed to the yield advantage observed in 1998. The transplanted crop out-yielded the direct seeded crop in both cultivars (Table 3). Since the two crop establishment methods produced comparable stands, the yield difference must have been linked to the transplants enhancing canopy growth and/or fruiting. Yield advantages from transplanting are mostly commonly observed when indeterminant crops like pumpkins are grown in regions with unfavorable spring conditions and/or limited growing seasons (Lazin and Simonds 1981; Swiader et al. 1992). For both cultivars, yields for the treatments grown with plastic mulch were significantly higher than for the non-mulched controls. Yield enhancement by mulches may be due to favorable changes in soil temperatures (Ashworth and Harrison 1983; Argall and Stewart 1990), soil moisture conservation (Bhella 1988) or reduced weed competition (Birge et al. 1996). Weed growth was minimal in this trial irrespective of mulching treatment. Although soil moisture levels were carefully monitored and maintained throughout the trial, it is possible that the non-mulched treatments may have experienced more moisture stress than the other treatments. No measurements of vegetative growth rates were taken, but the mulches appeared to enhance vegetative growth. This growth response to mulching was apparent early in the season, before weather conditions were conducive to the development of moisture stress. This suggests that the benefits of mulching were likely related to enhancement of soil temperatures.

Table 4. Fruit yields for cv. Spirit for 1997 and 1998 as influenced by mulch treatments and method of crop establishment[z]

Mulch treatment	Establishment method	Yield (kg m^{-1} row) 1997	1998
No mulch	Direct-seeded	29.6*bc*	38.7*b*
	Transplanted	21.7*cd*	39.0*b*
Black mulch	Direct-seeded	17.9*d*	38.4*b*
	Transplanted	34.8*b*	37.4*b*
Clear mulch	Direct-seeded	36.9*b*	38.6*b*
	Transplanted	33.1*b*	59.6*a*

[z]Values followed by the same letter are not significantly different ($P = 0.05$).

For cv. Spirit, the effect of the mulches on the weight of fruit harvested varied with the year and the method used to establish the crop (Table 2). In 1997, direct seeding produced the highest yields when no mulch was used (Table 4). On black plastic mulch, transplanting produced the best yield results, while on clear plastic, the method of crop establishment had no impact on yields. In 1998, the method of crop establishment had no effect on yields in the non-mulched and black plastic treatments, but when clear plastic was used, the transplanted crop produced more than the crop established by direct seeding. For cv. Howden, in 1997, the two mulched treatments produced comparable yields in terms of fruit number and weight and both mulched treatments out-yielded the control (Table 5). In 1998, yields obtained using clear plastic mulch were superior to both alternatives, and black plastic was no better than the control. In both these cases, the crop management variables that promoted growth (clear mulches and transplanting) were most effective when the growing season was limited. Even greater treatment effects could be expected during the short and cool summers that are typical of Saskatchewan.

The pumpkins were, on average, larger in 1998 than in 1997 (Table 3). Fruit number was less affected by year-to-year variability in growing season than overall productivity

Table 5. Fruit yields for cv. Howden in 1997 and 1998 as influenced by mulch treatments[z]

	Fruit Weight (kg m^{-1} row)		Fruit number (m^{-1})	
	1997	1998	1997	1998
No mulch	21.6*d*	36.0*b*	2.5*d*	3.7*b*
Black mulch	27.8*c*	36.6*b*	3.4*b*	3.7*b*
Clear mulch	26.2*c*	45.2*a*	3.0*c*	4.7*a*

[z]Values followed by the same letter are not significantly different ($P = 0.05$).

of the crop. In 1997, fruit from transplanted cv. Howden were larger than when the crop was direct-seeded (9.2 vs. 7.8 kg). This would be expected if transplanting had enhanced crop growth and yield potential without increasing the number of fruit produced by the crop. In 1998, transplanting again increased yields, but the yield effect was related to a significant increase in fruit number rather than to increased fruit size. These results illustrate the plasticity of cucurbits' yield response to differing production conditions and management practices (Argall and Stewart 1990; Waterer 1993; Reiner and Riggs 1999).

Where pumpkins are grown for ornamental use, complete degreening of the fruit is crucial to successful marketing. For cv. Spirit, a greater proportion of the fruit matured to orange prior to harvest in 1998 than in 1997 (Table 3). This was unexpected, as 1997 was warmer than 1998 and had a long, frost-free fall; both these factors should have been conducive to fruit ripening. The factors responsible for the higher yields observed in 1998 (i.e., complete stand) may also have accelerated crop maturity. Maynard and Scott (1998) observed that as plant populations of muskmelons increase, the resulting interplant competition may accelerate flowering and fruit maturity. Relatively few of the slower-growing cv. Howden fruit were mature by harvest time, irrespective of the year. Transplanting and mulching increased fruit yields, but contrary to expectations, these management practices did not significantly enhance the maturity of either cultivar (Table 3). By substantially increasing the fruit load on each plant, these management practices may have retarded the rate of development of each fruit, thereby effectively canceling out the expected advancement in maturity (Spencer and Waterer, unpublished). In regions with a short growing season, optimum management practices reflect a balance between the need to maximize yields while also enhancing crop maturity.

No single crop establishment method or mulch treatment was consistently superior in this 2-yr trial of pumpkin management practices. Transplanting had little effect on crop establishment or time to maturity, but usually improved yields. Mulching generally enhanced yields, with the clear mulch proving most beneficial when growing conditions were unfavorable. Production or purchasing of transplants and laying of mulch represent added production costs. Growers will need to evaluate the relative costs versus benefits before adopting either of these more intensive production practices. Selecting crop management practices that maximize yields may not represent the optimum approach in ornamental crops such as pumpkins, as fruit size and maturity may strongly influence marketability. Variables such as the growing season weather, which are beyond the growers' ability to predict or control, will also influence the relative effectiveness of any management practices adopted.

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Argall, J. F. and Stewart, K. A. 1990. The effect of year, planting date, mulches and tunnels on the productivity of field cucumbers in southern Quebec. Can. J. Plant Sci. **70**: 1207–1213.

Ashworth, S. and Harrison, H. 1983. Evaluation of mulches for use in the home garden. HortScience **18**: 180–182.

Bhella, H. S. 1988. Tomato response to trickle irrigation and black polyethylene mulch. J. Am. Soc. Hortic. Sci. **113**: 543–546.

Birge, Z. K., Weller, S. C. and Daniels, D. D. 1996. Comparison of herbicides, plastic mulch and cover crops for weed control in pumpkins. Proc. North Central Weed Science Society **51**: 153–156.

Farias-Larios, J., Guzman, S. and Michel, A. C. 1994. Effect of plastic mulches on the growth and yield of cucumber in a tropical region. Biol. Agric. Hortic. **10**: 303–306.

Gomez, K. A. and Gomez, A. A. 1984. Statistical procedures for Agricultural Research. John Wiley and Sons. New York NY.

Lazin, M. B. and Simonds, S. C. 1981. Influence of planting method, fertilizer rate, and within row spacing on production of two cultivars of honeydew melons. Proc. Fla. Hortic. Soc. **94**: 180–182.

Saskatchewan Research Council. 1998. Saskatoon Climatological Reference Station, Annual Summary.

Swiader, J. M., Ware, G. W. and McCollum, J. P. 1992. Producing vegetable crops. Interstate Publ., Danville, IL.

Reiners, S. and Riggs, D. I. M. 1999. Plant population affects yields and fruit size of pumpkin. HortScience **34**: 1076–1078.

Waterer, D. R. 1993. Influence of planting date and row covers on yields and economic value of muskmelons. Can. J. Plant Sci. **73**: 281–288.

Waterer, D.R. 1999. Effect of soil mulches and herbicides on production economics of warm season vegetable crops in a cool climate. HortTechnology **10**: 154–159.

Welbaum, G. E. and Wooge, J. D. 1994. Effects of black plastic mulch and drip irrigation of fruit number and size of three pumpkin cultivars. Proc. Natl. Agr. Plastics Conf. **25**: 230–232.