They fed sparingly on 'Top-Mark' seedlings and caused only slight damage to them. The beetles fed equally on reciprocal F_1 hybrid seedlings and caused moderately severe damage. The damage to F_1 hybrids was slightly less than but significantly different from that to 'Deserta Naja'. The controlled tests on seedlings in the greenhouse yielded results similar to the damage done to plants in field planting (Table 1).

Seedlings of 'PMR 45' and 'Hale's Best' muskmelon, like 'Top-Mark' were resistant to western spotted cucumber beetle in a free choice greenhouse test (Table 2). Seedlings of the American 'Golden Beauty' casaba, however, were as susceptible as 'Deserta Naja'. The performance of 'Golden Beauty' in the glasshouse (Table 2) contrasted sharply with its performance in the field test (Table 1).

Beetles confined to a single entry in the greenhouse caused injury to seedlings of 'Top-Mark' as severe as to 'Deserta Naja' and 'Golden Beauty' (Table 2). 'Hale's Best Jumbo' and 'PMR 45' were injured moderately and appeared to be more resistant than the other cultivars. The F_1 hybrid of 'Deserta Naja' was damaged more severly than were those of 'Top-Mark'.

In a separate no-choice test, seedlings of 'Deserta Naja' and 3 F_2 hybrids were severely damaged while 'Top-Mark' was only moderately injured (Table 2). The population means for severity of injury (beetle damage indices) indicated that strong preference for 'Deserta Naja' and its hybrids and nonpreference for 'Top-Mark' caused the observed differences in plant injury.

Chambliss and Jones (1), showed that a class of tetracycline triterpenoids called cucurbitacins found in the *Cucurbitaceae* were specific feeding attractants for cucumber beetles. Others (5, 6, 7) demonstrated resistance in cucurbits to cucumber beetles could also be attributed to environment, plant age, and free choice situations. We did not attempt to identify the nature of susceptibility of 'Deserta Naja' to cucumber beetle damage, but this report and those of Kishaba et al. (3), Kennedy et al. (4), and others demonstrate the desirability of a cooperative program to screen for all pests of exotic plants used as parents in plant improvement programs.

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Effects of No-tillage and Herbicides on Carrot and Onion Seed Production[1]

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Abstract. **Carrot roots (*Daucus carota* L.) and onion bulbs (*Allium cepa* L.) were planted in Kidman silt loam immediately after DCPA (dimethyl tetrachloroterephthalate), ethofumesate (2-ethoxy-2,3-dihydro-3,3-dimethyl-5-benzofuranol methanesulfonate), linuron (3-(3,4-dichlorophyenyl)-1-methoxy-1-methylurea), napropamide (2-(*a*-naphthoxy)-*N,N*-diethylpropionamide), or trifluralin (*a,a,a*-trifluoro-2,6 dinitro-*N,N*-dipropyl-*p*-toluidine) had been soil incorporated. In a second experiment, carrot roots and onion bulbs were planted in a conventionally-prepared seed bed or among vigorously growing wheat plants (7 to 10 cm tall). DCPA, linuron, and oryzalin (3,5-dinitro-N^4,N^4-dipropylsulfanilamide) plus glyphosate (*N*-(phosphonomethyl)glycine) were surface applied to these seedbeds after planting but prior to crop emergence. Methazole (2-(3,4-dichlorophenyl)-4-methyl-1,2,4-oxadiazolidine-3,5-dione) and nitrofen (2,4-dichlorophenyl-*p*-nitrophenyl ether) were applied postemergence. Chemical treatments significantly altered the seed yields within the no-tillage method. Carrots grown in the tilled plots exhibited no effect of chemical treatments on seed yield. Comparison of tillage methods indicated a highly significant reduction in carrot seed yield relative to the no-tillage plots. Those on the non-weeded control and no-tillage plots showed a highly significant reduction in seed yield. Many of the onion bulbs from male-fertile lines failed to develop seedstalks in the plots sprayed with linuron and napropamide and those that did were delayed in development. Linuron and ethofumesate reduced the numbers of onion flowers per umbel. Onions grown in the tilled plots exhibited no effect of chemical treatments on seed yield. Those on the non-weeded control and no-tillage plots showed a highly significant reduction in onion seed yield. Comparison of tillage methods indicated a highly significant reduction in onion seed yield relative to the no-tillage plots.**

Because of the continuing increases in production costs, minimum or no-tillage practices have gained widespread interest in agriculture (5, 6). Minimum tillage is not a specific set of cultural practices *per se,* but has the objective of reducing the number of trips over the field without loss of economic yield (1, 2, 3, 4). The literature provides no information on the application of this technique to the production of vegetable seeds such as carrots and onions. Seed production in carrots and onions is labor intensive. Also, both crops are poor competitors with weeds. Moreover, few herbicides are labeled for use in seedling onions and currently none are registered specifically for carrot and onion seed production. In an era of short energy supply and high production costs, some form of reduced tillage or no-tillage may be preferable to the conventional agronomic practices of seed production. This study addressed the question: can soil-applied herbicides, rather than conventional tillage practices, enhance the seed yields of carrots and onions?

Carrot roots, M5931 × M6000A (male sterile) and M5986B (male fertile) and onion bulbs, MSU2399A (male sterile) and MSU611C (male fertile) were planted in Kidman silt loam in a conventionally prepared seedbed or in an unprepared but fallow seedbed. Immediately prior to planting DCPA (9 and 13.4 kg/ha), ethofumesate (2.2 and 4.5 kg/ha), linuron (1.1 and 2.2 kg/ha), napropamide (4.5 and 6.7 kg/ha) or trifluralin (0.6 and 0.8 kg/ha) were soil incorporated. During the second year, these same inbreds

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were again planted in a conventionally prepared seedbed among vigorously growing wheat plants (7 to 10 cm tall). DCPA (9 and 13.4 kg/ha), linuron (1.1 and 2.2 kg/ha) or oryzalin (1.1 and 2.2 kg/ha) were surface-applied to plots after planting but prior to crop emergence. Glyphosate was foliary-applied to wheat to control it in the non-tilled plots. Methazole (1.7 and 3.3 kg/ha) and nitrofen (1.1 and 2.2 kg/ha) were applied postemergence to DCPA (9 kg/ha) plots. Hand- and non-weeded controls were maintained in the experiments during both years.

Carrot roots and onion bulbs were planted in 3-row plots with the rows 3 m long and 60 cm apart. Male-sterile inbreds were planted in the 2 outside rows, with the male-fertile inbred in the middle row of each plot for both carrots and onions. The experimental design was a randomized complete block with 3 replications. Irrigation was applied weekly for 6 hr at a flow rate of about 1.3 cm per hr. Weed control effectiveness, crop phytotoxicity, and seed yield were evaluated.

Carrots. DCPA provided relatively good weed control, although stinkgrass and witchgrass were not controlled in the plots (Table 1). Ethofumesate likewise gave good weed control except for lambsquarter. No apparent phytotoxicity to the carrots was observed. Linuron was weak in controlling annual grasses especially at the lower rate. Carrots appeared to be quite tolerant of linuron.

Of the herbicides tested, napropamide was the only one that appeared to be phytotoxic to carrot vegetative development (Table 2). Both carrot lines were equally susceptible to napropamide. Trifluralin provided fair weed control but, like napropamide, was ineffective in controlling the nightshades. There were also a few annual grasses in the trifluralin-treated plots.

Seed heads of the male sterile carrots were hand-harvested. The chemical treatments had no effects on carrot seed yield on the tilled plots (Tables 2 and 3). However, plants on DCPA 9 + nitrofen 2.2 plots and non-weeded control plots exhibited significantly lower seed yields when combined with no-tillage (Table 3). Carrot seed yields on conventionally-tilled plots were significantly higher than on the non-tilled plots regardless of chemical treatment.

Onions. The male-fertile onion inbred was much more sensitive to herbicides tested than was the male-sterile inbred. Many of the male-fertile bulbs failed to develop seedstalks in the linuron and napropamide-treated plots. Predominant weeds in all napropamide plots were mustards and the nightshades (Table 1).

Table 1. Effectiveness of weed control. Those weeds appearing in carrot and onion weedy check treatment and not in the herbicide plots were completely controlled in the treated plots; weeds listed in the treated plots were not controlled.

Chemical treatment	Common name	Scientific name
Weedy check	Black mustard	*Brassica nigra* (L.) Koch
	Cutleaf nightshade	*Solanum trifolium* Nutt.
	Foxtail barley	*Hordeum jubatum* L.
	Hairy nightshade	*Solanum sarrachoides*
	Lambsquarter	*Chenopodium album* L.
	Redroot pigweed	*Amaranthus retroflexus* L.
	Shephards purse	*Capsella bursa-pastoris* (L.) Med.
	Sow thistle	*Sonchus oleraceus* L.
	Stinkgrass	*Eragrostis cillianensis* (All.) Lutati
	Witchgrass	*Panicum capillare* L.
DCPA	Stinkgrass	
	Witchgrass	
Ethofumesate	Lambsquarter	
Linuron	Foxtail	
	Stinkgrass	
	Witchgrass	
Napropamide	Black mustard	
	Hairy nightshade	
	Cutleaf nightshade	
	Shepards purse	
Trifluralin	Hairy nightshade	
	Cutleaf nightshade	
	Foxtail	
	Stinkgrass	
	Witchgrass	
Oryzalin	Hairy nightshade	
	Cutleaf nightshade	
	Black mustard	

Table 2. Effects of herbicides on carrot and onion seed production in conventionally-tilled plots.

Treatment	Rate (kg/ha)	Weed control	Plant vigor[y]		Seed yield[y] (g/48m)	
			carrot	onion	M5931 x M6000A carrot	M2399A onion[y]
Hand-weeded CK	--	10.0	9.3	10.0	2552	907 bcd
Weedy CK	--	3.5	8.3	10.0	2608	723 cde
DCPA	9.0	8.0	9.4	9.9	1814	957 ab
	13.4	9.0	10.0	10.0	2608	943 abc
Ethofumesate	2.2	8.5	9.8	10.0	2722	695 de
	4.5	8.8	9.8	10.0	2183	666 e
Linuron	1.1	6.6	9.3	9.8	2268	790 bcde
	2.2	8.4	10.0	8.5	2835	652 e
Napropamide	4.5	7.8	7.5	8.8	1871	808 bcde
	6.7	8.1	5.0	6.3	1843	850 bcde
Trifluralin	0.6	7.8	9.5	10.0	2693	1148 a
	0.8	7.9	9.8	10.0	3119	985 ab

[z]Mean separation in columns by Duncan's multiple range test.

[y]Average visual ratings at 3 replications June 28, 1976, rated 0 (no weeds or no evidence of phytotoxicity) – 10.

Onion plots to which trifluralin and DCPA had been applied exhibited significantly higher seed yields (Table 2). Trifluralin-treated plots yielded the most seeds and were superior in all categories to all other treatments except DCPA. Ethofumesate, linuron, and napropamide each caused seed yield reductions. The ethofumesate plots were the most drastically affected, which was somewhat unexpected as the only indication of phytotoxicity had been a reduction in flower numbers and delay in maturity (Fig. 1). Seed reductions in linuron-treated onion plots could be correlated with a stunting of leaves and seed stalk. Male-fertile inbred seed stalk production in linuron and napropamide-treated plots was so sparse and anthesis so delayed that, on a whole field basis, commercial seed production would have been greatly reduced if not totally eliminated. The effects of asynchronous flowering of the male-sterile and male-fertile inbreds in these treatments was largely negated by the proximity of male-fertile onion plants in blossom in adjacent plots.

Onion seed yields from tilled plots were significantly higher than those from non-tilled ones (Table 3). There were no significant differences in seed yield due to chemical treatment with conventional tillage. However, seed

Table 3. Effect of no-tillage and herbicide treatment on carrot and onion seed yields.

Treatment (kg/ha)	Seed yield (g/48m)			
	Carrot		Onion	
	Till[z]	No-till	Till[x]	No-till
Hand-weeded check	379	174 bc[y]	210	13 c[y]
Weedy check	376	42 a	189	8 d
DCPA (9)	373	200 bc	228	13 c
(13.4)	342	174 b	249	28 a
(9) + Nitrofen (1.1)	428	207 c	215	26 a
(9) (2.2)	482	148 b	168	18 b
(9) + Methazole (1.7)	321	236 c	246	18 b
(9) (3.3)	417	236 c	210	18 b
Linuron (1.1)	511	218 c	182	21 b
(2.2)	404	197 bc	176	21 b
Oryzalin (1.1)	431	205 bc	236	23 b
(2.2)	431	223 c	244	21 b

[z]All treatments within the tilled method were significantly different from those in the no-till plot.

[y]Mean separation in columns by Duncan's multiple range test.

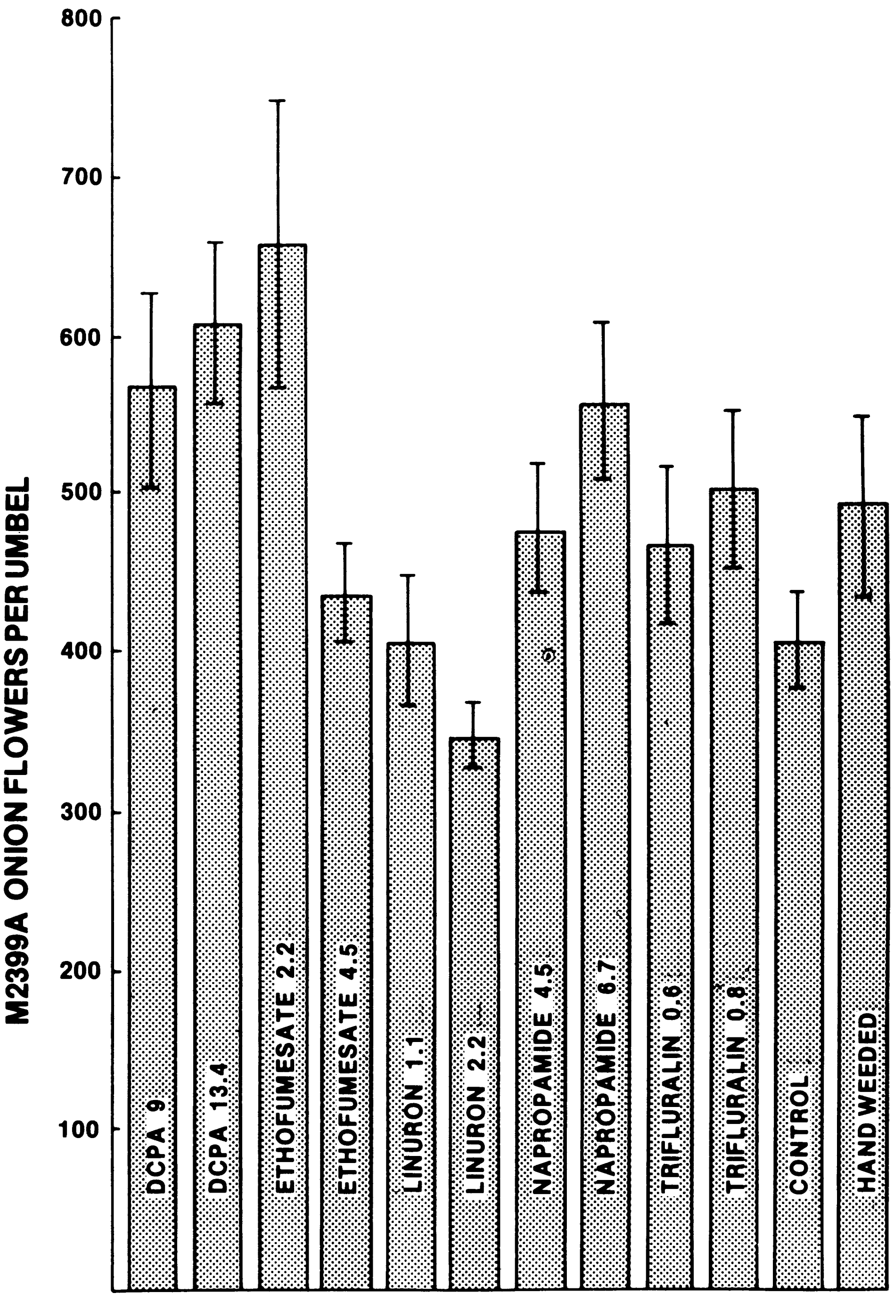

Fig. 1. The effect of various herbicides on the number of flowers per umbel in onion inbred, M2399A.

yields from non-weeded control plots were significantly lower than those from any other treatment with the non-tilled method DCPA 9 and hand-weeded control plots also resulted in significantly less seed production than the other treatments. DCPA 13.4 and DCPA 9 + nitrofen 1.1 produced significantly more seed than other treatments on the non-tilled plots.

The linuron treatment significantly reduced the number of flowers per umbel (Fig. 1) at its high rate, ethofumesate also reduced the number of onion flowers and the flowers present matured late. Further work is needed to define the phytotoxicity of herbicides to onions as the number of flowers per umbel and seed yield were reduced. The reduced number of flowers per umbel was probably the major cause of the lowered seed yields. On the linuron and napropamide plots, however, the male-fertile onion bulbs failed to develop seedstalks. If adequate pollination had not been provided from adjacent plots, seed yields of these onion plots would probably have been reduced considerably. Moreover, relatively little is known concerning the residual effects of the herbicides on megasporogenesis, microsporogenesis, pollen germination, or pollen tube growth.

The low seed yields in the non-weeded control plots are relatively easy to explain as the onion plant is shallow-rooted and thus a poor competitor with most weeds. However, this explanation does not account for the low seed yields in carrots.

Our primary goal in this study was to look at the potential for using the no-tillage method when producing carrot and onion seeds. Further research is needed to answer various questions: Is water conserved and is more efficient use made of available water? Do soils receive sufficient aeration? Does the value of energy saved from non-tillage culture compensate for the resulting seed reduction?

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