Interplanted Barley and Rye in Carrots and Onions

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Summary. Carrots *(Daucus carota* L.) or onions *(Allium cepa* L.) were interplanted with barley *(Hordeum vulgare* L.) or rye *(Secale cereale* L.) seeded at 0, 0.5, 1.0, or 2.0 bushels/acre (0, 43.5, 87, and 174 liters-ha-i). Barley was killed at heights of 4, 8, 12, or 16 inches (10, 20, 30, or 40 cm), and rye was killed at 4, 6, 7, or 8 inches with a postemergence graminicide. Barley and rye killed at 4 inches did not reduce onion yield. If barley exceeded 8 inches and rye exceeded 7 inches when killed, onion yields were reduced. Carrot yield was reduced only by 2 bushels of barley killed at 16 inches. One bushel of barley per acre killed at 4 inches appeared to be optimal in giving good soil protection and minimal crop competition.

Carrots and onions are grown primarily on organic (muck) soils in Michigan. These crops are planted in April and May, as soon as fields are dry enough to be tilled. The surface of muck soil dries out quickly and is very susceptible to wind erosion. A strong wind may remove 1 to 2 inches (2 to 5 cm) of soil from the surface in 1 or 2 h, taking with it herbicides, insecticides, fertilizer, and seed. Before interplanting small grains became a routine cultural practice, growers often replanted 20% or more of their acreage each year as a result of wind erosion.

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Carrots and onions germinate slowly in cold soils and emerge in 2 to 3 weeks. Their cotyledons and early true leaves are very small and susceptible to wind injury and soil abrasion. Onions often are cut off at the soil surface by moving soil particles. Carrots may be sheared off or their taproots broken, resulting in stubbed or forked carrots at harvest.

For several years after the droughts of the 1930s, willow *(Salix* sp.) or other woody species were planted for windbreaks. The majority of these windbreaks were oriented north to south, about 100 yards apart, to break the predominant southwest winds. During the past 30 years, most of these windbreaks have been removed to increase tillable acreage.

Small-grain windbreak strips have been planted along with carrots and onions for many years. The strips usually were planted between every two, three, or four rows of carrots or onions. Barley commonly has been used because of its upright growth habit and ability to survive mowing. Growers mowed it several times to keep it short, then removed it with a rotovator. Because these rows are planted in the same direction as the crop, they only give protection from cross-winds. Thus, even with these strips, many carrot and onion crops have been lost due to wind erosion.

In 1978, BASF Corp. (Research Triangle Park, N.C.) introduced the herbicide sethoxydim (Poast) into the United States market. In 1981, ICI Americas, Inc. (currently Zeneca Corp., Wilmington, Dela.) introduced fluazifop (Fusilade). These postemergence graminicides kill only emerged grasses and can be sprayed over carrots and onions to kill interplanted small grains. Limited research has been reported on the use of interplanted small grains in carrots and onions. Therefore, the experiments described here were conducted to determine seeding rate and killing stage of barley and rye for optimum carrot and onion yields.

Onk. An experiment was established at the MSU Muck Research Farm, Laingsburg, in 1986 to evaluate barley ('Bowers') and rye ('Wheeler') as interplanted cover crops in onion. Each small grain was broadcast at 0, 0.5, 1.0, or 2.0 bushels/acre and disked in on 25 Apr. 1986. Onions ('Spartan Banner') were sown 28 Apr. Plots were 25 ft (7.6 m) long by 5.25 ft (1.6 m) wide, with three onion rows spaced 20 inches (5 1 cm) apart per plot. Eighteen onion seeds were planted per foot of row.

The barley and rye were sprayed with 0.25 lb a.i. fluazifop-P (Fusilade 2000) plus 1 qt crop oil concentrate (COC) in 30 gal of water per acre (0.28 $kg \cdot ha^{-1}$ in 280 $liter \cdot ha^{-1}$) 26, 33, or 35 days after seeding, when barley was 8, 12, and 16 inches (20, 30, and 40 cm) tall, and rye was 6, 7, and 8 inches (15, 18, and 20 cm) tall, respectively. Ten onion plants were pulled randomly from each plot and weighed on 25 June. Onions were harvested by hand and weighed on 16 Sept.

In 1988, a similar study was conducted using only barley interseeded at 0.5 or 1.0 bushel/acre. Barley was broadcast and disked in on 4 May. Onions ('Spartan Banner 80') were seeded on 5 May. The respective plots were sprayed with fluazifop-P when the barley was 4, 8, 12, or 16 inches (10, 20, 30, or 40 cm) tall. Ten onion plants from each plot were weighed on 20 June. The onions were harvested and weighed on 8 Sept.

Carrots. Carrot experiments were established at the MSU Muck Research Farm in 1987 and 1988. In 1987, 'Bowers' barley was broadcast and disked in at 0, 0.5, 1.0, or 2.0 bushels/acre on 5 May. 'Caropak' carrots were seeded on 6 May. In 1988, barley was seeded at 0, 0.5, and 1.0 bushel/acre on 10 May. 'Six Pak II' carrots were seeded 12 May. Plots were 25 ft (7.6 m) long by 5.25 ft (1.6 m) wide, with three carrot rows spaced 20 inches (51 cm) apart per plot. Twenty carrot seeds were planted per foot of row. In 1987, barleywas sprayed with 0.25 lb a.i. fluazifop plus 1 qt (0.95 liter) COC/acre (0.28 $kg \cdot ha^{-1}$) 17, 22, 25, or 28 days after seeding, at 4, 8, 12, and 16 inches (10, 20, 30, and 40 cm) tall, respectively. In 1988, barley was sprayed 14, 19, 23, or 27 days after seeding, when heights were similar to 1987 heights. On 7 July 1987 and 5 July 1988, 10 carrot plants were pulled from each plot and weighed. Carrots were harvested and weighed 6 Aug. 1987 and 16 Aug. 1988.

Onions. Onion fresh weight on 25 June 1986 was reduced by all barley and rye treatments (Table 1). Increasing the seeding rate of barley or rye from 0.5 to 2.0 bushels/acre caused increasingly lower onion fresh weights. Onion response to barley and rye was similar. In 1988, barley sprayed at 4 inches (10 cm) had no effect on onion fresh weight. Barley reaching 8 inches (20 cm) or taller reduced onion fresh weight (Table 1). Onion plant stands were not affected by any of the cover crop treatments.

Onion yield in 1986 was reduced when barley or rye was seeded at 2 bushels/acre, regardless ofkilling size, or allowed to grow to 16 inches (40 cm) tall regardless of seeding rate (Table 2). Although early onion fresh weight was reduced with the 0.5- and 1.0-bushel seeding rates of barley or

Table 1. Onion plant fresh weight after interplanted barley and rye were sprayed at different heights with fluazifop-P.

Small grain	Seeding rate (bushels/acre)	Small grain ht when sprayed (inches)[z] 4	8(6)	12(7)	16(8)
		25 June 1986			
				gr/10 plants	
None	0.0		80	87[y]	
Barley	0.5		51	50	
Rye	0.5		60	50	
Barley	1.0		41	26	
Rye	1.0		36	29	
Barley	2.0		21	11	
Rye	2.0		42	17	
LSD (0.05) = 15 for all means					
		20 June 1988			
None	0.0	85	89	94	82
Barley	0.5	83	64	76	20
Barley	1.0	79	49	11	7
LSD (0.05) = 13 for all means					

[z]Rye height is in parentheses.
[y]Data for 16-inch small grain in 1986 are not available.

Table 2. Onion yield after interseeded barley and rye were sprayed at different heights with fluazifop-P.

Small grain	Seeding rate (bushels/acre)	Small grain ht when sprayed (inches)[z] 4	8(6)	12(7)	16(8)
		1986			
			Onion yield (kg/plot)		
None	0.0		27.0	25.0	27.9
Barley	0.5		26.2	26.6	22.5
Rye	0.5		27.4	24.3	27.3
Barley	1.0		24.1	22.0	23.2
Rye	1.0		25.4	26.2	18.9
Barley	2.0		21.1	17.5	2.5
Rye	2.0		26.2	19.5	11.5
LSD (0.05) = 4.3 for all means					
		1988			
None	0.0	22.9	27.3	23.3	19.7
Barley	0.5	23.5	21.7	22.3	6.8
Barley	1.0	22.4	19.8	8.5	1.9
LSD (0.05) = 7.1 for all means					

[z]Rye height is in parentheses.

rye, onion yield was not different from yields with no barley or rye unless the barley exceeded 12 inches (30 cm) and the rye exceeded 7 inches (18 cm) when sprayed. In 1988, onion yield was reduced significantly with 0.5 bushel/acre of barley only when it was allowed to grow to 16 inches (40 cm). Yields were reduced 27%, 64%, and 90% by 1 bushel of barley/acre when sprayed at 8, 12, and 16 inches (20, 30, and 40 cm) tall, respectively.

Carrots. In 1987, carrot fresh weight on 7 July was reduced only when 2 bushels of barley was allowed to grow to 12 or 16 inches (30 or 40 cm) tall (Fig. 1) Carrot yield was reduced only when barley was planted at 2.0 bushels and killed at 16 inches (40 cm) (Fig. 2). Results in 1988 were similar.

Carrots and onions can be interseeded effectively with small grains to minimize wind erosion and protect the young seedlings. In our experience, barley is a better choice than rye due to its upright growth habit. Studies conducted in 1986, 1987, and 1988 found that seeding barley at 1 bushel/acre gives sufficient plant density (10 to 12 plants/ft^2) for good wind protection. Spraying interseeded barley with a graminicide when it reaches 4 to 5 inches (10 to 12 cm) in height will minimize potential reductions in onion and carrot yields. After it is sprayed, barley continues to provide protection from wind for 2 to 3 weeks as it deteriorates. Carrots appear to be less-affected than onions by interplanted barley.

Growers have continued to test various small grains and planting rates in carrots and onions. Barley is interseeded most commonly in carrots and onions in -western Michigan; oats is favored in eastern Michigan. Wheat and rye are used occasionally. Barley and oats appear to be popular because of their rapid emergence and upright growth habit. Wheat emerges slowly, and thus gives less protection from wind. Rye emerges rapidly, but has a horizontal growth habit for the first few weeks. Under some conditions, it may compete or interfere with crop plants. In our experience, rye is also the most difficult of the small grains to kill with fluazifop or sethoxydim.

Most growers currently interseed 0.75 to 1.0 bushel of small grain/acre. Higher seeding rates give quicker protection from wind, but a densely

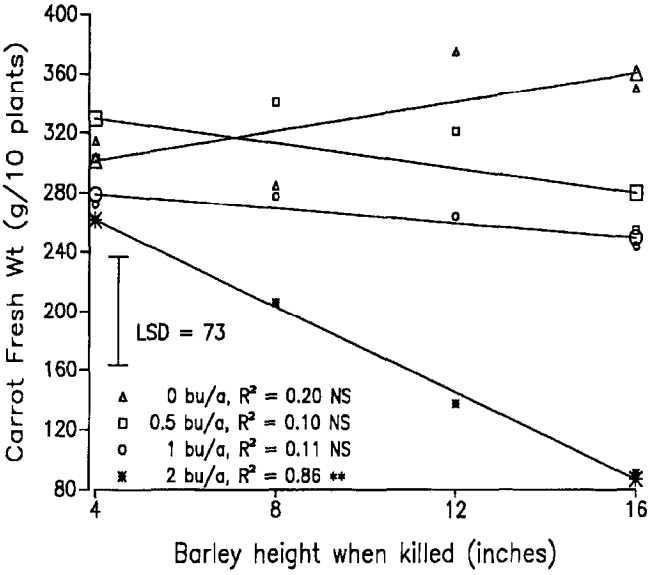

Fig. 1. *Carrot fresh weight 7 July 1987 after spraying interplanted barley at 4, 8, 12, or 16 inches (10, 20, 30, or 40 cm).*

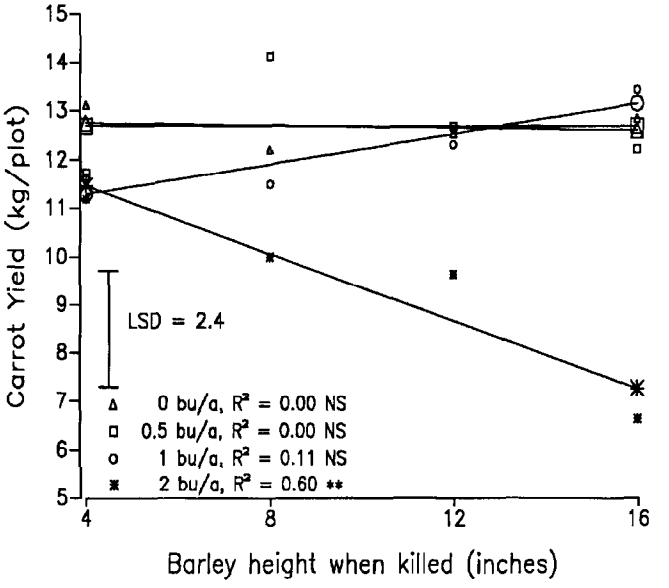

Fig. 2. *Carrot yield after spraying interplanted barley at 4, 8, 12, or 16 inches (10, 20, 30, or 40 cm).*

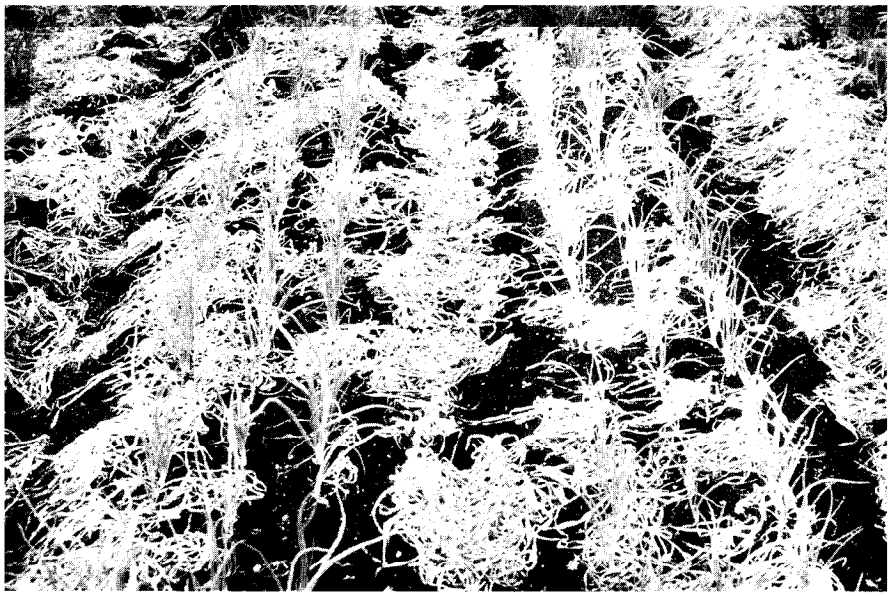

Fig. 3. Onions growing on muck soil 2 weeks after spraying the barley cover crop with a postemergence graminicide.

planted small grain can compete with the crop very early in the season. A crop that has been stunted by competition from a cover crop may suffer irreversible yield reduction.

The small grains interseeded with carrots and onions usually are killed when they are 4 to 5 inches (10 to 12 cm) tall (Fig. 3). Chlorosis appears ≈1 week after graminicide application; 1 to 2 weeks later the cover crop collapses, thus giving 2 to 3 weeks of protection after spraying. Growers sometimes allow the interseeded small grain to grow a little longer, but, by doing so, they risk serious crop competition and yield loss.

The highest recommended rate of a graminicide should be applied to ensure complete kill of the small grains. The small grains tend to be more difficult to kill with these graminicides than many weedy grasses (Harker, 1992), and they become more tolerant of the herbicides as they mature. Inclusion of crop oil concentrate or another approved adjuvant in 10 to 20 gal/acre of spray solution will improve control.

The small grains should be seeded <5 days prior to seeding carrots and onions to avoid having to kill the small grain too early. This will extend protection as long as possible. The grain seed should be broadcast and disked, dragged, or rolled into the soil. Some growers mount a whirling spreader on the rear of their plow and in front of a roller or drag (Fig. 4). Others mount the spreader on the front of the tractor pulling the seeder. The disturbance of the soil by the seeder is enough to cover the grain seed.

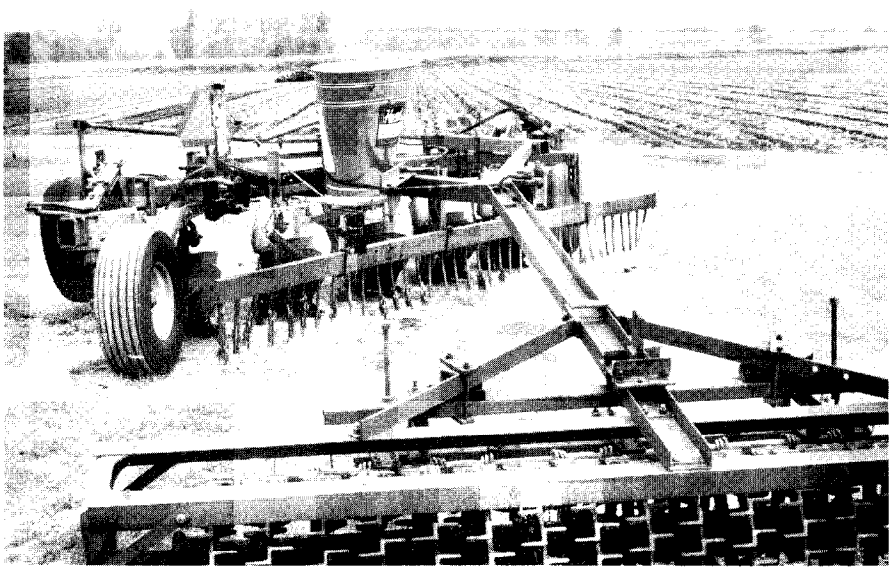

Fig. 4. A feed spreader mounted on a plow for broadcasting small grain seed before planting carrots and onions.

When the small grain emerges, it is difficult to see the crop rows for subsequent field operations. Some growers plant a solid row of small grain in one of the wheel tracks or in the middle of a bed. An extra seeding unit is mounted on the planter for this purpose. Tractor drivers use this row as a guide until the small grains are killed-and carrots and onions are visible.

When small grains are planted with carrots and onions, growers should apply preemergence herbicides so as not to kill the small grains prematurely. In carrots, linuron (Lorox, DuPont Agricultural Products, Wilmington, Dela.) applied preemergence may reduce the small grain stand, but will not kill it completely. In onions, pendimethalin (Prowl, American Cyanamid Co., Princeton, N. J., used under a Section 18 Specific Exemption in Michigan) usually does not injure the small grain as long as the seed is coveredwith some soil. Waiting at least 1 week after seeding the small grain before applying a preemergence herbicide will reduce risk of injury to the small grain.

Broadleaf weeds that emerge before the onions emerge can be killed without injuring the small grain by applying 0.25 lb/acre (0.28 $kg \cdot ha^{-1}$) bromoxynil (Buctril, Rhone Poulenc AgCo., Research Triangle Park, N.C.). Some growers apply their preemergence herbicide plus bromoxynil just before onions emerge. This extends the effective time of the preemergence herbicide and reduces the potential for stunting the small grain.

The graminicides are usually the first postemergence herbicides applied each season (to the carrots and onions). Carrots are usually in the one- to two-leaf stage, and onions in the flag- to one-leafstage at the time of application. Because graminicides have no adverse effects on these crops, their timing should be based only on the size of the small grain. At present,

Fusilade 2000 is labeled for carrots and onions and Poast is labeled for onions.

Small grain cover crops have become an integral part of carrot and onion culture in Michigan. The development of graminicides makes it possible to use interplanted small grain crops to prevent wind erosion, protect crops, and reduce movement of pesticides and fertilizer from point of application. Interseeded small grains and herbicides are an essential part of sustainable vegetable production on muck soil.

The mention of specific herbicides in this paper is not intended to be a recommendation. It is likely that, over time, recommended herbicides will change. However, the principles and factors relative to cover crop protection are not likely to change.

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