AN ABSTRACT OF THE THESIS OF

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Title: Seed Depth Influence on the Position of the Growing Point and Chemical Control of Wild Proso Millet (*Panicum miliaceum* L.)

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Abstract approved: ______________________

Myron Shenk

Wild proso millet (*Panicum miliaceum* L.) is a serious weed recently infesting sweet corn fields in the Willamette Valley of western Oregon. Field and greenhouse experiments were conducted to determine the importance of seed depth in the position of the growing point of wild proso millet seedlings and in the performance of five herbicides. The effects of atrazine (6-chloro-N-ethyl-N'-(1-methylethyl)-1,3,5-triazine-2,4-diamine) and tridiphane (2-(3,5-dichlorophenyl)-2-(2,2,2-trichloroethyl) oxirane) combinations and alachlor (2-chloro-N-(2,6-diethylphenyl-N-(methoxymethyl)acetamide) soil placement on wild proso millet control were also studied.

Shallow seed depths (0 and 3 cm) resulted in more seedlings with the growing point above the soil surface than deeper depths. Mesocotyl length was also directly influenced by seed depth. Wild proso millet emerged from the deepest seed placement which was 15 cm. Seedlings from seeds deeper than 6 cm emerged slower than from shallower seeds.

In the first field experiment, seed depth did not influence the performance of alachlor, atrazine, tridiphane, pendimethalin (N-(1-ethylpropyl)-3,4-dimethyl-2,6-dinitrobenzenamine), and EPTC (S-ethyl dipropyl carbamothioate). In the second field experiment, seed depth influenced the performance of these herbicides. Pendimethalin (2.0 kg/ha), atrazine + tridiphane (1.1 + 0.5 kg/ha), alachlor (2.2 kg/ha), and EPTC + dichlormid (3 kg/ha) were less effective at 1 cm than at 6 or 11 cm wild proso millet seed depth. Higher rates of the same herbicides were more effective on plants from seeds at 1 cm than from either 6 or 11 cm. This suggests that higher rates are needed to control wild proso millet from shallow seeds. Perhaps the growing point above the soil surface is reducing the effectiveness of soil applied herbicides on wild proso millet.

Early postemergence applications of atrazine (0.56, 0.84, 1.68, and 2.24 kg/ha) and tridiphane (0.28, 0.56, and 0.84 kg/ha) alone and in combinations decreased wild proso millet dry weight and height. Plants treated with atrazine or tridiphane alone did not differ in height or dry weight. There was synergism in the atrazine-tridiphane combinations.

Shoot exposure was more damaging to wild proso millet seedlings than root exposure at the three alachlor rates used (0.1, 0.5, and 1.0 ppm). Shoot or both shoot and root exposure caused equal reductions in height or dry weight of wild proso millet. These results indicate that alachlor should remain in the shoot region of emerging seedlings for best wild proso millet control.

Seed Depth Influence on Position of the Growing Point and Chemical Control of Wild Proso Millet (*Panicum miliaceum* L.)

by

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To my mother Emerita, Arturus, Jangly and Cesar, who made me appreciate the beauty of the life with their love.

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SEED DEPTH INFLUENCE ON POSITION OF THE GROWING POINT AND CHEMICAL CONTROL OF WILD PROSO MILLET

(*Panicum miliaceum* L.)

INTRODUCTION

Wild proso millet, a summer annual grass, began to present problems in the northern midwest of the United States in the 1970's. It has spread to the west and can be found in the Willamette Valley of western Oregon, infesting sweet corn fields.

The success of wild proso millet as a weed is partly due to its vigorous growth and prolific seed production. The seeds remain viable for several years and can germinate throughout the sweet corn season.

Herbicides registered for use in sweet corn do not provide consistent wild proso millet control. The best herbicides reported for wild proso millet control in the midwest of the United States are EPTC + dichlromid, pendimethalin, alachlor, atrazine, and tridiphane, applied alone and in combination. Erratic wild proso millet control has been attributed to the location of its growing point above the soil surface, thus escaping chemical control.

Research presented in Chapter 1 was undertaken to evaluate the effect of seed depth on the position of the growing point of wild proso millet seedlings and the performance of herbicides reported to control wild proso millet, although inconsistently. Chapter 2 reports studies on wild proso millet control with atrazine and tridiphane, alone and in combinations, applied early postemergence and the soil placement of alachlor.

CHAPTER 1. EFFECT OF SEED DEPTH ON THE POSITION OF THE GROWING POINT OF WILD PROSO MILLET (Panicum miliaceum L.) AND ON THE PERFORMANCE OF FIVE HERBICIDES.

Abstract. Greenhouse and field experiments were conducted to study the effect of seed depth on the position of the growing point in wild proso millet (Panicum miliaceum L.) seedlings and on the performance of five herbicides. Herbicides included were pendimethalin (N-(1-ethylpropyl)-3,4-dimethyl-2,6-dinitrobenzenamine), alachlor (2-chloro-N-(2,6-diethylphenyl-N-(methoxymethyl)acetamide), EPTC (S-ethyl dipropyl carbamothioate), atrazine (6-chloro-N-ethyl-N'-(1-methylethyl)-1,3,5-triazine-2,4-diamine), and tridiphane (2-(3,5-dichlorophenyl)-2-(2,2,2-trichloroethyl)oxirane).

In greenhouse experiments, shallow seed depths (0 and 3 cm depth) resulted in more seedlings with the growing point above the soil surface than at deeper depths. Wild proso millet emerged from 15 cm, the deepest seed placement tested. Mesocotyl length was directly influenced by seed depth. Seedlings from seeds deeper than 6 cm emerged slower than shallower seeds.

In the first field experiment, depths (1, 6, 11 cm) of wild proso millet seed did not affect control of this weed with the herbicides tested. In the second field experiment, however, a significant interaction between herbicide and seed depths was detected. Pendimethalin (2.0 kg/ha), atrazine + tridiphane (1.1 + 0.5 kg/ha), alachlor (2.2 kg/ha), and EPTC + dichlormid (3 kg/ha) were less phytotoxic to wild proso millet seeded at 1 cm than at 6 or 11 cm. Higher rates of the same herbicides were more effective on plants from seeds at 1 cm than from 6 or 11 cm. This suggests that

higher rates are needed to control wild proso millet from shallow seeds. Perhaps the growing point above the soil surface is reducing the absorption of soil applied herbicides by wild proso millet.

Lower stand counts were observed with pendimethalin (2 kg/ha) and alachlor (3.3 kg/ha) applied preemergence. Plants emerging from 1 cm seed depth were shorter than plants from 6 or 11 cm seed depth.

INTRODUCTION

Wild proso millet characteristics. Wild proso millet, a tall (up to 1.2 m) hairy (21), annual grass (31) is a rapidly spreading weed, becoming a problem in the northern midwest of the United States since 1970 (31). It is also found in southern Canada (5). In the early 1980's, wild proso millet appeared in sweet corn fields in the Willamette Valley of western Oregon, and it has spread rapidly. In 1985, it was estimated that 800 ha of sweet corn were infested. Only one year later, the weed had spread to 1620 ha (28). There are 125 ha with infestation sufficiently serious to reduce crop yields drastically (M. Silveira, pers. comm). It is unknown how wild proso millet was introduced to the Willamette Valley. Farm machinery is probably responsible for the rapid spread of this weed (24).

Seven weedy biotypes have been identified primarily by seed color (5). Oregon wild proso millet is of the black-seed biotype (21), which are the most difficult to control. Part of its success as a weed is its ability to form a long-term bank of viable seeds in the soil (5). A field infested for several years contained 1330 million seeds per ha (22). Coultas and Behrens (7) reported up to 522 plants/m^2 from May to June, in Minnesota. Striegel and Boldt (33) found that wild proso millet dormancy can be overcome by the absence of light during germination, or moist prechilled storage at 5 C, or 6 to 9 weeks of dry storage at 22 C. Light (180 $uE \cdot m^{-2} \cdot s^{-1}$) inhibited germination of seeds stored at 22 C. Germination occurred from 10 to 40 C, with 30 C being the optimum germination temperature.

Stump and Zimdahl (34) also studied burial effects. They found that after 12 months, seed losses were greater at 5 cm than at the 10 or 30 cm burial depth. Seed losses at 5 cm were primarily by in situ germination and at deeper depth by seed death. Wild proso millet emerged from as deep as 10 cm (7).

Carpenter and Hopen (6) studied some aspects of competition and found that increasing plant density of wild proso millet decreased height and dry wight, and slowed seedhead development. Shading increased germination and plant height and decreased dry weight, but did not affect the reproductive ability of wild proso millet. Coultas and Behrens (8) studied the effect of planting wild proso millet into a wheat crop and suggested that compounds associated with wheat roots suppressed wild proso millet growth.

Patterson et al. (27) suggested that wild proso millet will remain a serious problem only in the northern regions, because it has inferior competitive characteristics compared to Texas panicum (Panicum texanum L.) and other adapted grass weeds in the southern United States.

Chemical wild proso millet control. No herbicide registered for corn provides consistent control of wild proso millet. Results from initial studies showed excellent early season wild proso millet control with EPTC (32). In Wisconsin, EPTC mixed with either atrazine or cyanazine was one of the first herbicide treatments recommended to control wild proso millet (4, 17). Doersch and Harvey (10), Harvey et al. (19), and Rahman et al. (29) have reported reduced wild proso millet control with EPTC + dichlormid when the herbicide was used on the same fields for two successive seasons. Enhanced biodegradation of EPTC is suspected to be the cause for this reduced wild proso millet control in corn. Harvey et al. (19) confirmed that the extender, dietholate, slowed the biodegradation of EPTC in soils previously treated with EPTC + dichlormid but not with EPTC + dichlormid + dietholate. It could be that microorgamisms have adapted to degrade EPTC by an alternate pathway.

Pendimethalin, alone and in combination with other herbicides, has given effective wild proso millet control. Hartbug and Behm (15) and McNevin and Harvey (24) reported excellent wild proso millet control with pendimethalin + cyanazine applied preemergence or early postemergence. Boldt et al. (4), however, found that pendimethalin + cyanazine applied without EPTC preplant incorporated resulted in unacceptable wild proso millet control. Rainfall following pendimethalin treatment is essential for good wild proso millet control (15).

Alachlor has given excellent control in some years and in some states and no control at other times and places (3). Boldt et al. (4) reported good wild proso millet control with alachlor applied preemergence in Minnesota. Harvey (17), however, reported poor control of this weed with alachlor in Wisconsin. Strand and Behrens (31) reported that a single application of alachlor did not provide season-long control of wild proso millet.

Tridiphane appeared promising in several years in Wisconsin. In 1982, early season control was good but the late season regrowth of the weed was excessive. Tridiphane + atrazine was less effective than tridiphane + cyanazine in controlling wild proso millet, but was less phytotoxic to the corn (19). Tridiphane + cyanazine applied early postemergence, following a preemergence application of cyanazine or following a preplant incorporated treatment of a thiocarbamate herbicide, provided excellent season-long wild proso millet control (10). Tridiphane + atrazine is recommended as an early postemergence treatment (12), but this combination also is effective preemergence under certain soil moisture conditions (2). McReynolds and Vinal (26) reported good wild proso millet control with tridiphane + atrazine applied preemergence in sweet corn in the Willamette Valley, Oregon.

Growing point in wild proso millet seedlings. Location of the growing point (first node) varies among species and is determined by the length of the mesocotyl and the seed depth (1). After germination, the mesocotyl (first internode) of a grass seedling elongates pushing the growing point toward the soil surface (1). The length of the mesocotyl varies among grass species. In barley and rice, the mesocotyl remains short with the growing point located near the seed. In contrast, the mesocotyl of corn, oats, and barnyardgrass, elongates until the growing point is close to the soil surface (1). Wild proso millet differs from other grasses by often having the growing point above the soil surface (3). Adaptation to emerge from different depths in the soil can be explained by the etiolation syndrome (28): internodes elongate, leaves protected by the coleoptile do not expand, and chlorophyll does not develop. However, when the seedling reaches the light, internode elongation slows, leaves expand, and chlorophyll develops.

The growing point is the site of the shoot most susceptible to some dinitroaniline herbicides (9). Erratic wild proso millet control with soil applied herbicides may be partlially explained by the position of its growing point. If the growing point is an important site for herbicide absorption and if the growing point is above the soil surface, plants could escape chemical control because of limited herbicide absorption. Harvey, R. G. (in pers. comm. with R. William) suggested that alachlor kept in the top 2 cm of soil can control wild proso millet, however, if the herbicide leaches deeper than that, it has no effect on the weed.

Objectives. The objectives of these experiments were to determine the effect of seed depth on the position of the growing point in wild proso millet seedlings and on the performance of five herbicides.

MATERIALS AND METHODS

Greenhouse experiments. Mature wild proso millet seeds were collected in August and September 1985, in sweet corn fields in the Willamette Valley of western Oregon. Greenhouse experiments were conducted in March 1986, and in April 1987.

Seeds of wild proso millet were planted at six depths (0, 3, 6, 9, 12, 15 cm) using 3 L (15 by 17.5 cm) pots. Twenty- five seeds per pot were planted. Chehalis fine-silty (mixed, mesic Cumulic ultic Maploxerock) soil was used. Light intensity was 200 $uE \cdot m^{-2} \cdot s^{-1}$, temperature was 18 C day and 16 C night, and watering was by subirrigation in the first experiment. In the second experiment, light intensity was 250 $uE \cdot m^{-2} \cdot s^{-1}$, temperature was 21 C day and 16 C night, and watering was by subirrigation and sprinkling over the top of the pot.

A completely randomized block design with four replications was used. Position of the growing point and length of the mesocotyl of the seedlings were evaluated 2 weeks after planting. Speed of emergence was calculated by adapting Maquire's formula (23), in which the number of seedlings is divided by the number of days elapsed at each count. These proportions were summed.

Field experiments. Field experiments were established at Hyslop Research Farm, Corvallis, Oregon, to study the effect of depth of wild proso millet seed on the performance of five herbicides. The first experiment was established on May 29, 1986 and the second experiment on June 17, 1986. The soil was a Woodburn silt loam (fine-silty, mixed, mesic Aquultic Argixeroll), which has an organic matter content of approximately 3% and a pH of 5.4. A strip plot design with four replications was used. Main-plots were herbicides, and sub-plots, in strips, were seed depths. Plot size for the first experiment was 0.6 by 2.0 m, and for the second, 1.2 by 2.0 m.

Herbicide treatments included pendimethalin, alachlor, EPTC + dichlormid, atrazine, and tridiphane (Table 1.1). Preplant incorporated (PPI) treatments were applied and incorporated to 5 cm with a rototiller. Remaining plots were also rototilled for uniformity. Wild proso millet seeds were planted in double rows at each of three depths (1, 6, 11 cm) using Planet Jr. seeders mounted on the tool bar of a Farmall Cub tractor. Soil was mounded over the planted row to ensure the 11 cm depth. Preemergence (PRE) treatments were applied after seeding, followed by 3.5 cm of water applied with sprinkler irrigation. Postemergence (POST) applications were made on June 19 and July 3, 1986, for the first and second experiments, respectively, when the plants had six to seven leaves. The first experiment received a postemergence application of bromoxynil at 0.6 kg/ha to control broadleaf weeds. All herbicide treatments were applied with a unicycle sprayer equipped with compressed air and a 0.6 m boom. Herbicides were applied in 187 L/ha water at 124 kPa nozzle pressure. Sprinkler irrigation of 3.5 cm was made weekly.

Herbicide control was visually evaluated, using a scale where 0 was no control and 100 no emergence. Data were transformed using arc sine percentage in both experiments. Stand counts per 0.5 m of row and plant height were determined one month after planting for the second experiment.

Data from greenhouse and field experiments were subjected to an analysis of variance using Fisher's protected LSD (F-LSD) at the 0.05 level to compare treatment means.

RESULTS AND DISCUSSION

Greenhouse experiments

The percentage of seedlings with the growing point above the soil surface was higher for all the seed depths in the first experiment than in the second experiment, even though the two experiments showed the same trend; more seedlings with the growing point above the soil surface at the shallower seed depths.

In the first experiment, percentage of seedlings with the growing point above the soil surface differed significantly among seed depths. Shallow seed depths (at soil surface and 3 cm deep) resulted in 87.5% seedlings with the growing point above the soil surface (Figure 1.1). At the 9, 12 and 15 cm depths, the percentage of seedlings with the growing point above the soil surface decreased significantly to 27, 12 and 0%. Percentage of seedlings with the growing point above soil surface from 6 cm deep (11%) was not different compared to seedlings from 3 cm seed depth (15%) or deeper seed depths (0%).

In the second experiment, more seedlings with the growing point above soil surface were also observed in seedlings from 0 and 3 cm seed depths (36 and 15% respectively). Seedlings from the 6 cm seed depth did not differ in percentage of seedlings with the growing point above soil surface (11%) compared with seedlings from 3 cm and deeper seed depth (15 and 0%, respectively). At the 9 to 15 cm seed depth, all seedlings had the growing point below the soil surface.

Differences between the two experiments may be attributed to differences in light intensity. In the first experiment, seedlings showed etiolation, which may have influenced the moment when mesocotyls stopped elongating. Because of low light intensity, perhaps the mesocotyl did not stop developing until the growing point was above the soil surface, and received enough light to inhibit its development. In the second experiment, however, with an increase in light intensity, the mesocotyls may have been inhibited when the growing point reached the soil surface, resulting in fewer seedlings with the growing point above the soil surface.

We expected all of the seeds planted on the soil surface to produce seedlings with the growing point above the soil surface. Instead there was 92 and 36% of seedlings with the growing point above the soil surface, for the first and the second experiments, respectively. This also may be attributed to light inhibiting the development of the mesocotyl (15) placing the growing point at the soil surface.

Perhaps, seeds germinating from different depths and at different times in a developing crop, where light levels will vary as the crop grows, will influence the position of the growing point of wild proso millet seedlings during the season.

Seedlings with the growing point above soil surface arising from seeds at the soil surface had a green mesocotyl of 0.3 cm length

(Figure 1.2). Mesocotyl lengths from deeper seeds were also proportional to the seed depth.

Wild proso millet emergence was observed from all seed depths (0 to 15 cm) studied. Striegel and Boldt (33), however, reported emergence up to 10 cm seed depths for this weed. Time required for emergence of wild proso millet differed significantly among seed depths, in both experiments. In the first experiment, seedlings from 3 and 6 cm seed depths emerged faster than seeds at 0, 12 and 15 cm soil depth (Figure 1.3). In the second experiment, seeds on the soil surface germinated at about the same time that plants emerged from seeds at 3 cm soil depth. Seedlings from seeds at 6 cm soil depth or deeper, emerged at about the same time in both experiments.

The significant increase in germination percentage for seeds on the surface and in emergence time for seedlings from 3 cm seed depth of the second experiment compared to the first experiment, may be attributed to the sprinkler irrigation used in the second experiment, providing the appropriate moisture for germination at shallow seed depths. Response to moisture may help to explain partially the poor wild proso millet control in the midwest of United States. Flush of weeds after rain when no longer the herbicides are effective to control the wild proso millet, because of their leaching after the rains.

Field experiments

There were significant differences in wild proso millet control from different seed depths for the two field experiments; therefore the results were analyzed and reported separately for each experiment. In the first experiment, seed depths (1, 6, 11 cm) of wild proso millet did not affect chemical control of this weed with the herbicides tested (data not shown). The best herbicide treatments were pendimethalin at 2.0 kg/ha (97% control), atrazine + tridiphane at 2.2 + 0.5 kg/ha (99% control), and alachlor at 3.3 kg/ha (96% control) all applied preemergence (Table 1.2). These herbicides at the same rates did not control wild proso millet at the six to seven leaf-stage.

In the second experiment, however, a significant interaction between herbicides and seed depths was detected (data not shown). Two trends were observed in the interactions. With pendimethalin at 2.0 kg/ha, atrazine + tridiphane, and alachlor all applied preemergence, and EPTC + dichlormid applied preplant incorporated, all at the low rates, less control at 1 cm seed depth than at 6 or 11 cm wild proso millet seed depth was observed. Atrazine + tridiphane, alachlor applied preemergence, and EPTC applied preplant incorporated, all at the highest rate, provided better control at 1 cm than at 6 or 11 cm seed depth. No interaction was observed in the postemergence applications because of the lack of control at all seed depths (Table 1.3).

Control with alachlor at 3.3 kg/ha was 62% in contrast to 33% control at 2.2 kg/ha at the 1 cm seed depth. No differences in control between the two rates at 6 and 11 cm depth were observed (Figure 1.4). This suggests that a higher rate is needed to control seedlings from shallow wild proso millet seeds. These findings may be related to the greenhouse experiment results, where at shallow seed depths, more seedlings had the growing point above the soil surface. showed this could explain the lack of herbicide control because the most sensitive site of uptake is not in contact with the herbicide. These results are consistent with observations by Harvey (in pers. comm. with R. William) deficient wild proso millet control with alachlor when the herbicide leaches deeper than the top 2 cm of soil. Higher rates of the herbicide may control this weed, even though some leaching of the herbicide occurs.

In the second experiment, seed depth did not affect stand counts of wild proso millet, but herbicide treatments did affect then (Table 1.4). Stand counts were consistant with the wild proso millet control based on visual evaluations. Pendimethalin at 2.0 kg/ha and alachlor at 3.3 kg/ha applied preemergence had the lowest stand counts one and half months after emergence, and were the herbicides that controlled wild proso millet best in this experiment. Alachlor at 2.2 kg/ha applied preemergence, and EPTC + dichlormid + tridiphane applied preplant incorporated had lower stand counts than the check, but higher than pendimethalin at 2.0 kg/ha and alachlor at 2.2 kg/ha applied preemergence.

In the second experiment, seed depths and herbicide treatments affected the height of wild proso millet (Table 1.5). Differences in height of plants for different seed depths were observed only in the herbicide treatments applied postemergence and the check. Treatments with a significant herbicide-seed depth interaction followed the same trend; plants emerging from 1 cm seed depth were smaller than plants from 6 or 11 cm seed depth.

Control of wild proso millet with pendimethalin, was better when applied preemergence than postemergence, although opposite results have been reported (16). These experiments studied only one rate of pendimethalin, it was not possible to determine if different rates of pendimethalin followed different trends as observed in alachlor, where different rates resulted in different control in wild proso millet seedlings emerging from 1 cm seed depth and not from deeper depths. Perhaps the good control of pendimethalin can be attributed to its low water solubitily (Table 1.1). The herbicide remaines in the top layer of the soil longer and thus is available to the growing point during germination and shoot emergence. Further research is suggested to study the relationship between rates of pendimethalin and control of wild proso millet seedlings from shallow depths.

Alachlor, atrazine + tridiphane, and EPTC resulted in less control in the second experiment than in the first, perhaps due to differences in soil moisture. Atrazine + tridiphane applied preemergence resulted in good control of wild proso millet only in the first experiment. McReynolds and Vinal (26) also reported good control with the preemergence application of this combination. Perhaps the good control obtained in western Oregon with atrazine + tridiphane applied preemergence in the first experiment can be attributed to controlled irrigation after the application. No irrigation and uncertain rainfall in the midwestern United States, may not provide enough moisture to make the herbicide available to the seedlings. Heavy rains may cause sufficient leaching of the herbicide to result in the poor control.

Postemergence applications of atrazine + tridiphane did not control wild proso millet in either experiment, because were done at the wrong timing. Rain delayed application of postemergence treatments until wild proso millet had six to seven leaves, escaping the weed chemical control. With increasing plant maturity the glutathione-s-transferase levels increase, with a concomitant capacity for detoxifying atrazine (13). Thus, atrazine + tridiphane should be applied when wild proso millet has one to three leaves (12).

Wild proso millet control with EPTC was inferior to that obtained with pendimethalin, even though EPTC has been reported to provide good control of this weed in the midwestern United States. Erza et al. (14) suggested that tridiphane used in combination with EPTC, could improve wild proso millet control in corn. Tridiphane, however, did not seem to improve EPTC activity under field conditions in the Willamette Valley of western Oregon (Tables 1.2 and 1.3).

No herbicides registered in Oregon provide good wild proso millet control. Pendimethalin applied preemergence resulted in the best wild proso millet control in both studies. This herbicide is registered for use in sweet corn in Illinois, Minnesota, New York, and Wisconsin for preemergence and early postemergence application (35). Further research is suggested to verify the tolerance to pendimethalin of "Golden Jubilee", the sweet corn variety used in the Willamette Valley of western Oregon.

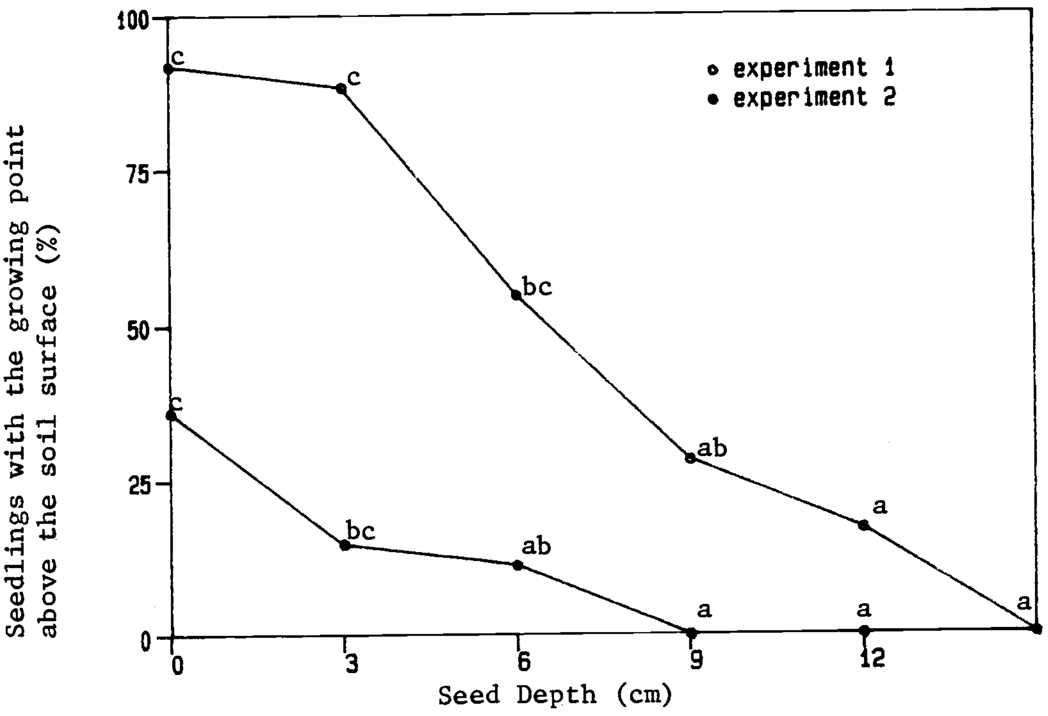

Figure 1.1. Percent of wild proso millet seedlings with the growing point above the soil surface.

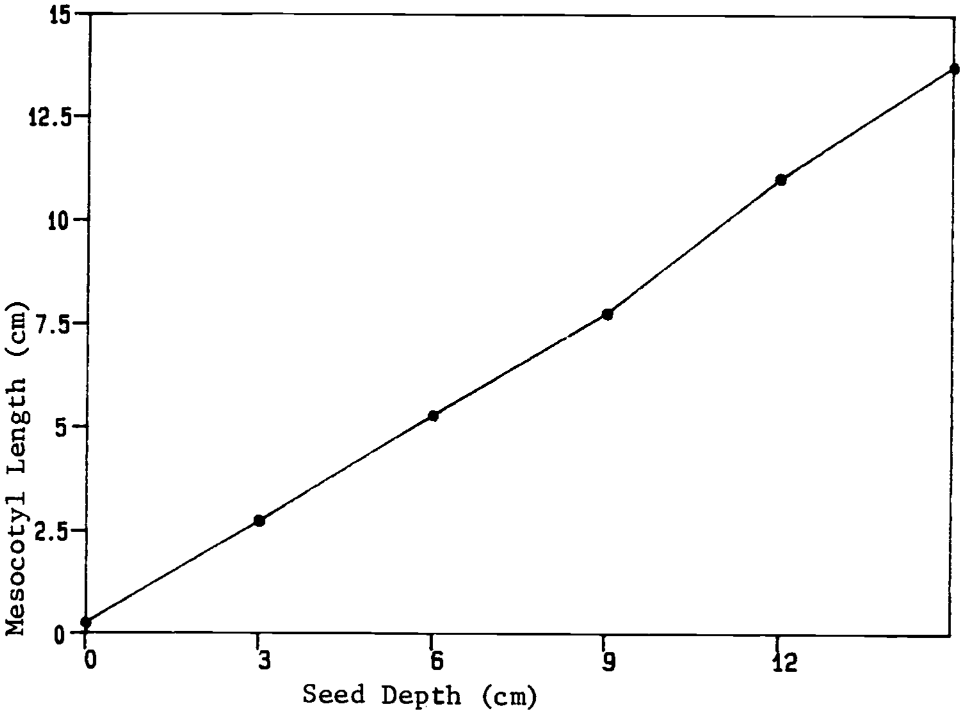

Figure 1.2. Mesocotyl length of wild proso millet from seed at different depths.

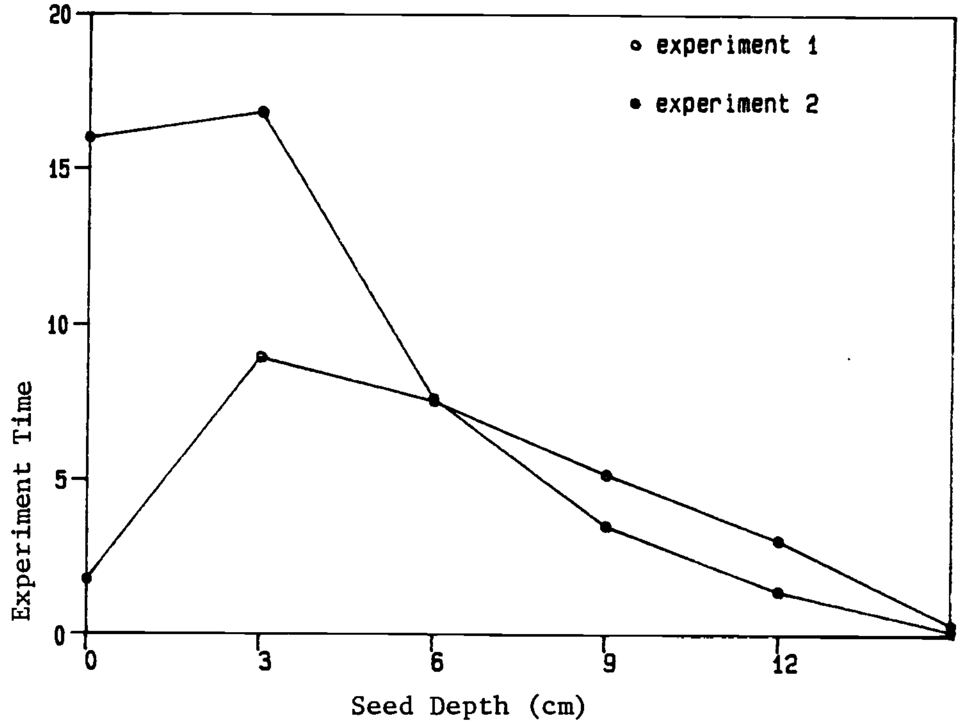

Figure 1.3. Emergence time of wild proso millet from different seed depths.

$$\text{Emergence Time} = \frac{\text{number of seedlings}}{\text{day of the first count}} + \cdots + \frac{\text{number of seedlings}}{\text{day of the last count}}$$

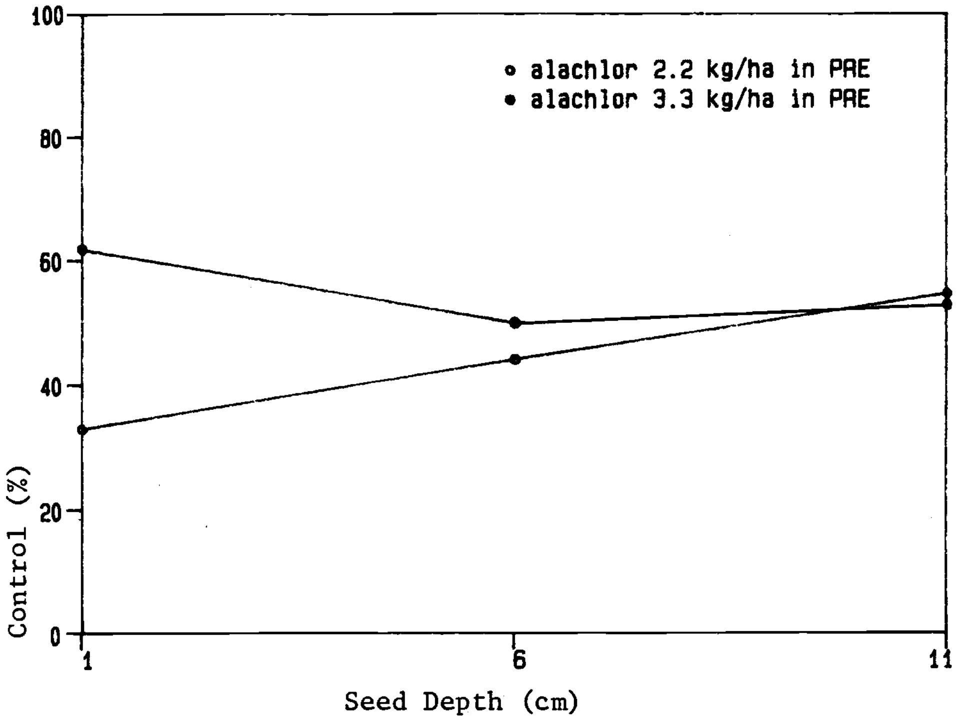

Figure 1.4. Percent control of wild proso millet with two rates of alachlor at three seed depths.

Table 1.1 Characteristics of five herbicides [a].

Herbicide	Adsorption	Soil Degradation	Vapor Pressure (mm Hg)	Water Solubility (ppm)	Absorption	Application
Pendimethalin	clay	oxidation	3.0×10^{-5}	0.5	shoot	PRE, EPOST
Alachlor	clay	microbes	2.2×10^{-5}	242.0	shoot	PPI, PRE, EPOST
EPTC + dichlormid	clay and organic matter	microbes	34.0×10^{-3}	370.0	shoot	PPI
Atrazine	clay	microbes	3.0×10^{-7}	33.0	root	PPI, PRE, POST
Tridiphane [b]	clay and organic matter	microbes	2.2×10^{-4}	1.8	shoot	EPOST, POST

[a] Source: Herbicide Handbook of the Weed Sci. Soc. of Amer. 1983. Fifth Edition.
[b] Source: Dow. 1982. Dowco 356, Experimental Herbicide. Technical information.

Table 1.2. Wild proso millet control with five herbicides at different rates and time of application. May-July 1986, Corvallis, Oregon[a].

Herbicide	Rate	Time	Control[b]
	(kg/ha)		(%)
pendimethalin	2.0	PRE	97 e
pendimethalin	2.0	POST	0 a
alachlor	2.2	PRE	88 de
alachlor	2.2	POST	4 a
alachlor	3.3	PRE	96 de
alachlor	3.3	POST	0 a
atrazine + tridiphane	1.1 + 0.5	PRE	42 b
atrazine + tridiphane	1.1 + 0.5	POST	5 a
atrazine + tridiphane	2.2 + 0.5	PRE	99 e
atrazine + tridiphane	2.2 + 0.5	POST	5 a
EPTC + dichlormid	3.0	PPI	67 c
EPTC + dichlormid	4.0	PPI	82 cd
EPTC + dichlormid + tridiphane	3.0 + 0.5	PPI	83 cd
tridiphane	1.0	POST	0 a
check			0 a

[a]Data subjected to the arc sin percentage transformation for statistical analysis. Actual (untransformed) percentages are reported. Data are average of four replications.

[b]Means followed by the same letter are not significantly different at the 5% level of probability as determined by the F-LSD.

Table 1.3. Wild proso millet control with five herbicides at three seed depths. June-August, 1986, Corvallis, Oregon[a].

			Control[b]		
			Seed depth (cm)		
Herbicide	Rate	Time	1	6	11
	(kg/ha)		(%)		
pendimethalin	2.0	PRE	98 E a	100 D b	100 D b
pendimethalin	2.0	POST	0 A a	0 A a	0 A a
alachlor	2.2	PRE	33 C a	44 C b	55 C c
alachlor	2.2	POST	0 A a	0 A a	0 A a
alachlor	3.3	PRE	62 D c	50 C b	53 C a
alachlor	3.3	POST	0 A a	0 A a	0 A a
atrazine + tridiphane	1.1 + 0.5	PRE	1 A a	4 AB c	2 A b
atrazine + tridiphane	1.1 + 0.5	POST	0 A a	0 A a	1 A a
atrazine + tridiphane	2.2 + 0.5	PRE	9 B c	7 B a	7 B a
atrazine + tridiphane	2.2 + 0.5	POST	0 A a	0 A a	0 A a
EPTC + dichlormid	3.0	PPI	1 A a	3 AB b	6 AB c
EPTC + dichlormid	4.0	PPI	5 AB b	8 AB b	3 AB a
EPTC + dichlormid + tridiphane	3.0 + 0.5	PPI	12 B b	7 AB a	8 B a
tridiphane	1.0	POST	0 A a	0 A a	0 A a
check			0 A a	0 A a	0 A a

[a]Data subjected to arc sin percentage transformation for statistical analysis. Actual (untransformed) data are reported.

[b]Data represent average of four replications. Means followed by the same letter are not significantly different at the 5% level of probability as determined by the F-LSD. Capital letters indicate main-plot; small letters, split-plot effects.

Table 1.4. Wild proso millet stand counts at different herbicide treatment. June-August, 1986, Corvallis, Oregon.

Herbicide	Rate	Time	Stand count[1]
	(kg/ha)		(per 0.5 m row)
pendimethalin	2.0	PRE	0
pendimethalin	2.0	POST	21
alachlor	2.2	PRE	7
alachlor	2.2	POST	22
alachlor	3.3	PRE	4
alachlor	3.3	POST	25
atrazine + tridiphane	1.1 + 0.5	PRE	22
atrazine + tridiphane	1.1 + 0.5	POST	22
atrazine + tridiphane	2.2 + 0.5	PRE	19
atrazine + tridiphane	2.2 + 0.5	POST	23
EPTC + dichlormid	3.0	PPI	24
EPTC + dichlormid	4.0	PPI	23
EPTC + dichlormid + tridiphane	3.0 + 0.5	PPI	16
tridiphane	1.0	POST	23
check			22
$LSD_{0.05}$			4.5

[1] Average of two rows and four replications.

Table 1.5. Effect of five herbicides and three seed depths on the height (cm) of wild proso millet. June-August, 1986, Corvallis, Oregon.

Herbicide	Rate	Time	Height[a] Seed depth (cm) 1	6	11
	(kg/ha)		(cm)		
pendimethalin	2.0	PRE	0.8	0.0	0.0
pendimethalin	2.0	POST	5.3	8.0	9.0
alachlor	2.2	PRE	1.0	0.6	0.7
alachlor	2.2	POST	6.4	7.5	8.4
alachlor	3.3	PRE	0.4	0.6	0.7
alachlor	3.3	POST	6.8	10.6	10.8
atrazine + tridiphane	1.1 + 0.5	PRE	2.8	3.0	3.4
atrazine + tridiphane	1.1 + 0.5	POST	6.8	9.5	9.9
atrazine + tridiphane	2.2 + 0.5	PRE	1.6	1.9	1.8
atrazine + tridiphane	2.2 + 0.5	POST	4.5	6.0	9.2
EPTC + dichlormid	3.0	PPI	3.0	3.0	3.6
EPTC + dichlormid	4.0	PPI	3.1	2.7	3.5
EPTC + dichlormid + tridiphane	3.0 + 0.5	PPI	2.5	2.2	1.7
tridiphane	1.0	POST	2.9	8.0	11.1
check			6.0	9.8	10.4

[a]Average of 10 subsamples in four replications.

LITERATURE CITED

1. Anderson, W. P. 1983. Weed Science: Principles. Second Edition. West Publishing Co., New York. Page 412.

2. Anonymous. 1982. Coming: Postemergence corn herbicide Tandem will be combined with atrazine Bladex for problem weeds. Agrichemical Age. 26:51c, 68.

3. Anonymous. 1984. Wild proso millet herbicide still sought. Crops and Soils Mag. 36(6):30.

4. Boldt, P. F., W. Christianson and W. Striegel. 1981. Wild proso millet control in sweet corn with thiocarbamates, acetanilide and dinitroaniline herbicides. Proc. North Cent. Weed Control Conf. 36:63.

5. Bought M., J. C. Colosi, and P. B. Cavers. 1986. The major weedy biotypes of proso millet (Panicum miliaceum) in Canada. Can. J. Bot. 64:1188-1198.

6. Carpenter, J. L. and H. J. Hopen. 1985. A comparison of the biology of wild and cultivated proso millet (Panicum miliaceum). Weed Sci. 33(6):795-799.

7. Coultas, J. S. and R. Behrens. 1984. Growth and development of wild proso millet (Panicum miliaceum L.) in Minnesota. Proc. North Cent. Weed Control Conf. 39:103.

8. Coultas, J. S. and R. Behrens. 1986. Wheat (Triticum aestivium) interference with the growth and development of wild proso millet (Panicum miliaceum). In press.

9. Cavers, P. B. and M. A. Bought. 1985. Panicum mileaceum: A crop and a weed. Pages 143-155. In White, J., ed., Studies on Plant Demography: A Festschrift for John L. Harper. Academic Press Inc., London.

10. Ditmarsen, S. C., B. R. Sheppard, and J. J. Velovitch. 1983. Post control of wild proso millet and wooly cupgrass with tridiphane in field corn. Proc. North Cent. Weed Control Conf. 38:120.

11. Doersch, R. E. and R. G. Harvey. 1982. Dealing with wild proso millet 1983. Univ. of Wisconsin. Dept. of Agronomy. Unpublished.

12. Dow. 1986. Tandem. Specimen Label 86-1893, date code 1285.

13. Dow. 1986. The mode of action of tridiphane-atrazine combinations. Unplublished.

14. Erza, G., J. Dekker, and G. Stephenson. 1985. Tridiphane as a synergist for herbicides in corn (Zea mays) and proso millet (Panicum miliaceum). Weed Sci. 33 (3):287-290.

15. Fischer, H. and R. G. Harvey. 1986. Herbicide combinations for wild proso millet (Panicum miliaceum). Weed Sci. Soc. of Amer. Abstr. 26:4-5.

16. Hartbug, T. J. and J. A. Behm. 1980. Control of wild proso millet (Panicum miliaceum) in field corn with pendimethalin. Proc. North Cent. Weed Control Conf. 35:72.

17. Harvey, R. G. 1978. Wild proso millet control in field and sweet corn. Proc. North Cent. Weed Control Conf. 33:94-95.

18. Harvey, R. G. 1979. Serious new weed threat: Wild proso millet. Crops and Soils. 37:10-13.

19. Harvey, R. G. 1982. Wild proso millet control in field and sweet corn. Proc. North Centr. Weed Control Conf. 29:30.

20. Harvey, R. G., G. R. McNevin, J. W. Albright, and M. E. Kozak. 1986. Wild proso millet (Panicum miliaceum) control with thiocarbamate herbicides on previously treated soils. Weed Sci. 34:773-780.

21. Hawkes, R., T. D. Whitson, and L. Dennis. 1985. A guide to selected weeds of Oregon. Oregon Dep. Agric., Oregon State Univ. Page 10.

22. Luellen, W. R. 1982. Wild proso millet: Will you recognize it before it is too late? Crops and Soils Mag. 34(7):9-11.

23. Maquire, J. D. 1962. Speed of germination- aid in selection and evaluation for seedling emergence and vigor. Crop Sci. 2:176-177.

24. McCanny, S. and P. B. Cavers. 1983. The dispersal of wild proso millet (Panicum miliaceum) by farm machinery. Weed Sci. Soc. of Amer. Abstr. 23:67.

25. McNevin, G. R. and R. G. Harvey. 1981. Wild proso millet in no-till field corn. Proc. North Centr. Weed Control Conf. 36:141-142.

26. McReynolds, B. and R. Vinal. 1985. Proso millet control in sweet corn field studies with tridiphane. Unpublished.

27. Patterson, D. T., A. E. Russell, D. A. Mortensen, R. D. Coffin, and E. P. Flint. 1986. Effects of temperature and photoperiod

on Texas panicum (Panicum texanum) and wild proso millet (Panicum miliaceum). Weed Sci. 34:876-882.

28. Petersen, K. L., R. B. McReynolds, and R. D. William. 1986. Wild proso millet control in sweet corn. Processing vegetable growers meeting. Salem, Oregon.

29. Salisbury, F. B. and C. W. Ross. 1985. Plant physiology. Third Edition. Wadsworth Publishing Co., California. Page 464.

30. Rahman, A., G. C. Atkinson, and J. A. Douglas. 1979. Erradicane causes problems. N. Z. J. Agric. 139 (39):47-49. In: Harvey et al. 1986. Weed Sci. 34:773-780.

31. Strand, O. E. and R. Behrens. 1981. Identification and control of wild proso millet. Ext. Bull. 1420. Univ. of Minnesota.

32. Strand, O. E., R. Behrens, and G. R. Miller. 1973. Wild proso millet (Panicum miliaceum) a new weed problem in Minnesota. Proc. North Cent. Weed Control Conf. 28:51-52.

33. Striegel, W. L. and P. F. Boldt. 1981. Germination and development of wild proso millet. Proc. North Cent. Weed Control Conf. 36:22.

34. Stump, W. L. and R. L. Zimdahl. 1983. The effect of depth and duration on burial of seed of Panicum miliaceum. Proc. West Soc. of Weed Sci. 97-98.

35. Weed Control Manual. 1987. Ag Consultant. Meister Publishing Co., Ohio. Page 212.

CHAPTER 2. EFFECTS OF ATRAZINE-TRIDIPHANE COMBINATIONS AND ALACHLOR SOIL PLACEMENT ON WILD PROSO MILLET (*Panicum miliaceum* L.) CONTROL.

Abstract. A greenhouse experiment was established to study the effect of atrazine (6-chloro-N-ethyl-N'-(1-methylethyl)-1,3,5-triazine-2,4-diamine) at 0.56, 0.84, 1.68, and 2.24 kg/ha and tridiphane (2-(3,5-dichlorophenyl)-2-(2,2,2-trichloroethyl)oxirane) at 0.28, 0.56, and 0.84 kg/ha, alone and in combination, applied early postemergence on wild proso millet (*Panicum miliaceum* L.). Atrazine + tridiphane decreased wild proso millet height and weight when compared with the untreated check. Plant height and dry weight did not differ when treated with atrazine or tridiphane alone. Synergism was oobserved in the atrazine + tridiphane mixture.

Another greenhouse experiment was conducted to study the effect of alachlor (2-chloro-N-(2,6-diethylphenyl)-N-(methoxymethyl)acetamide) soil placement on wild proso millet control. Shoot exposure was more damaging to wild proso millet seedlings than root exposure at the three alachlor rates used (0.1, 0.5, and 1.0 ppm). Seedlings with shoot exposure or shoot + root exposure did not differ height or dry weight of wild proso millet seedlings. These results suggest that alachlor should remain in the shoot region of emerging seedlings for best control of wild proso millet with alachlor.

SECTION 1. Control of wild proso millet with atrazine + tridiphane early postemergence application.

INTRODUCTION

Wild proso millet is a serious weed because it germinates throughout the season. Herbicides such as pendimethalin and cyanazine (16), EPTC + dichlormid alone or in mixture with either cyanazine or pendimethalin (6), have been reported to provide good short-term wild proso millet control. Early postemergence applications of pendimethalin (13), metolachlor, and cyanazine (14) have been used with good results in controling this weed. Repeated postemergence applications, however, are needed to obtain acceptable control throughout the season (18).

Tridiphane, a new selective postemergence herbicide in corn is recommended in mixture with atrazine or cyanazine to control wild proso millet (7). Tridiphane is a highly lipophillic compound that is ealisy absorbed by the cuticle (8). Crop oil should be added when tridiphane is applied with atrazine (1), to aid the atrazine foliar absorption (8). Tridiphane and atrazine which reach the soil may be expected to provide fourteen to twenty one days of residual weed control. Tridiphane is absorbed through the shoot of young seedlings. It moves in the soil in its vapor form for short distances (8).

Early postemergence application of tridiphane + atrazine or cyanazine following a preemergence application of cyanazine or a preplant incorporated application of a thiocarbamate herbicide has been reported to provide better wild proso millet control than only the postemergence mixture (5).

At least two mechanisms have been identified which partially explain the synergism observed with tridiphane triazine combinations. Tridiphane has been reported to be a meristematic inhibitor, and it also inhibits glutathione-S-transferase, interference with the conjugation of atrazine with glutathione in vivo (8, 15). The mechanisms through tridiphane stops cell division are not known (8). Lamoureux and Rusness (15) concluded that tridiphane would inhibit atrazine metabolism in vivo if tridiphane was metabolized in sufficient amounts to S-(tridiphane) glutathione, and this conjugate was sufficiently resistant to further metabolism.

Grass seedlings with one to three leaves are more easily controlled than mature plants because mature plants have higher levels of glutathione-s-transferase, and consecuently greater capacity to detoxify atrazine in the presence of tridiphane. Boydston and Slife (3) reported that delaying the application of tridiphane and atrazine reduced the control of giant foxtail (Setaria faberi L.). Two successive applications of tridiphane + atrazine provided good control of giant foxtail in the four to five leaf stage.

Lamoureux and Resness (15), studying corn and giant foxtail, postulated that the selectivity of tridiphane + atrazine in corn could be attributed to higher levels of glutathione in corn leaves than in the giant foxtail, or that glutathione-S-transferase in the weed, is more sensitive to inhibition by the conjugate S-(tridiphane) glutathione.

Erza et al. (10) studied the combinations of tridiphane with herbicides such as atrazine, EPTC, alachlor, and CDAA, which are known to be detoxified via enzymatic conjugation to glutathione, in corn and wild proso millet. In wild proso millet, EPTC and alachlor mixed with tridiphane were synergistic, while atrazine and CDAA mixed with tridiphane were not synergistic. Tridiphane + atrazine, however, have been reported to be synergistic in giant foxtail (3, 15).

McReynolds and Vinal (17) reported no phytotoxicity in "Golden Jubilee" sweet corn by tridiphane + atrazine applied pre- or postemergence. They reported good wild proso millet control with the preemergence application. The postemergence application, however, was done when wild proso millet plants were 22 to 25 cm high, which explains the poor wild proso millet control obtained with this late application. Several factors impact the reliability of preemergence control; tridiphane is tightly bound by soil organic matter and clay, sufficient precipitation must occur to place atrazine in the root zone, and application of tridiphane to wet soil will increase lost by volatilization (8).

The objective of this greenhouse experiment was to determine the control of wild proso millet by atrazine + tridiphane applied early postemergence.

MATERIALS AND METHODS

Wild proso millet seeds were germinated in petri dishes at 20 C with light intensity of 250 $uE \cdot m^{-2} \cdot s^{-1}$, for a week. Four seedlings at 1-leaf stage were transplanted on February 12, 1987, to 5 by 7.5 cm pots containing Chehalis fine-silty (mixed, mesic Cumulic ultic Maploxerock) soil. Watering was by subirrigation. Hoagland's nutrient solution (9) at 5% concentration was used.

Atrazine (0.56, 0.84, 1.68, 2.24 kg/ha) and tridiphane (0.28, 0.56, 0.84 kg/ha) alone and in combinations were applied when seedlings were in the two-leaf stage on February 18, 1987. Crop oil (2.34 L/ha) was added to all the treatments. Herbicides were applied uniformly to the seedlings and soil with a "Tee Jet" 8003 flat-fan nozzle on a track mounted sprayer moved across the pots by a motor driven chain. Compressed air at a pressure of 276 kPa was used to provide a spray volume of 350 L/ha. Water was used as a carrier.

A randomized block design with three replications was used. Two checks were included, one sprayed with crop oil alone, and the other untreated.

Height and dry weight were recorded 4 weeks after herbicides application. Data were evaluated by an analysis of variance, using Fisher's protected LSD (F-LSD), at 0.01 level to compare treatment means. Single degree of freedom contrasts were made at 0.05 level.

RESULTS AND DISCUSSION

Atrazine + tridiphane decreased wild proso millet plant height and weight when compared with the untreated check (Table 2.1). Plants in the untreated check were taller and dry weighted more than plants treated with the crop oil alone. In single degree contrasts, height and dry weight of plants treated with atrazine alone or tridiphane alone treatments did not differ (Table 2.2).

The mixture of tridiphane + atrazine caused height and dry weight reduction in wild proso millet seedlings when atrazine was applied at 0.56 and 1.68 kg/ha. However, when atrazine was applied at 2.24 kg/ha, the addition of tridiphane did not have an effect of wild proso millet height or dry weight (Table 2.2). Erza et al. (9) also reported no synergistic effects with atrazine at 5 and 10 kg/ha, and tridiphane at 0.05 kg/ha for controlling wild proso millet.

Further field experiments should be conducted to determine if the early postemergence application of atrazine at 2.24 kg/ha and atrazine + tridiphane combinations result in control of wild proso millet as observed under greenhouse conditions. Also evaluation of season-long control of wild proso millet with these treatments under the conditions in the Willamette Valley of western Oregon is suggested.

Table 2.1. Effect of early postemergence application of atrazine and tridiphane alone and in combination on height and dry weight of wild proso millet, greenhouse experiment, Corvallis, Oregon[1].

Treatment	Rate	Height	Dry Weight
	(hg/ha)	(cm)	(mg)
atrazine	0.56	6.4	7.7
atrazine	0.84	5.7	5.4
atrazine	1.68	5.8	5.9
atrazine	2.24	4.7	3.3
tridiphane	0.28	6.1	8.5
tridiphane	0.56	6.0	7.3
tridiphane	0.84	5.9	7.6
atrazine + tridiphane	0.56 + 0.28	4.5	2.8
atrazine + tridiphane	0.56 + 0.56	4.6	3.1
atrazine + tridiphane	0.56 + 0.84	4.3	5.0
atrazine + tridiphane	0.84 + 0.28	3.6	2.4
atrazine + tridiphane	0.84 + 0.56	4.2	2.8
atrazine + tridiphane	0.84 + 0.84	4.2	3.0
atrazine + tridiphane	1.68 + 0.28	4.8	3.0
atrazine + tridiphane	1.68 + 0.56	4.3	2.7
atrazine + tridiphane	1.68 + 0.84	4.5	2.7
atrazine + tridiphane	2.24 + 0.28	4.8	3.3
atrazine + tridiphane	2.24 + 0.56	4.5	3.3
atrazine + tridiphane	2.24 + 0.84	4.9	3.2
check		11.1	32.4
crop oil check		9.3	23.1
$F\text{-}LSD_{0.01}$		1.77	4.76

[1] Data represent the average of four subsamples in each of three replications.

Table 2.2. Single degree freedom contrast of atrazine and tridiphane alone and in combination, greenhouse experiment, Corvallis, Oregon.

Treatment comparision	Means	
	Height	Dry Weight
	(cm)	(mg)
1. atrazine vs.	5.69	5.58
tridiphane	6.06	7.80
2. atrazine 0.56 kg/ha vs.	6.44	7.70
atrazine (0.56 kg/ha) + tridiphane	4.49*	3.65*
3. atrazine 0.84 kg/ha vs	5.74	5.40
atrazine (0.84 kg/ha) + tridiphane	4.01*	2.76
4. atrazine 1.68 kg/ha vs	5.85	5.90
atrazine (1.68 kg/ha) + tridiphane	4.58*	2.86*
5. atrazine 2.24 kg/ha vs	4.76	3.30
atrazine (2.24 hg/ha) + tridiphane	4.76	3.30
6. tridiphane 0.28 kg/ha vs	6.14	8.50
tridiphane (0.28 kg/ha) + atrazine	4.46*	2.90*
7. tridiphane 0.56 kg/ha vs	6.00	7.30
tridiphane (0.56 kg/ha) + atrazine	4.45*	3.01*
8. tridiphane 0.84 kg/ha vs	5.96	7.60
tridiphane (0.84 kg/ha) + atrazine	4.52*	3.48*

* = Significant difference using t test at 5% level.

SECTION 2. Effect of alachlor soil placement on wild proso millet control.

INTRODUCTION

Alachlor is mainly absorbed by germinating plant shoots, and secondarily by roots (19). This general absorption pattern, however, varies depending on plant species (11). In corn and oats, alachlor uptake was greater through the shoot than the roots. Soybeans and cucumber absorbed higher amounts of herbicide through the roots. The growth of the two tolerant species, corn and soybeans, was reduced more when the herbicide was in the region of greatest uptake. Results for oats and cucumber, however, were the reverse. In oats, uptake of alachlor was greater through the shoots, but the plants were affected more with root exposure. Cucumber weight was more severely reduced by shoot exposure although root uptake was greater (11).

Hamill and Penner (12) reported that alachlor was translocated in the xylem to the tips of the older leaves in wheat. Chandler et al. (4) reported that wheat roots had greater accumulation of alachlor than the foliage. In soybeans, the stem accumulated more alachlor than the cotyledons or the growing point.

Harvey (2) suggested that wild proso millet plants are not controlled by alachlor because the growing point is above the soil surface, and the growing point is the site of greatest alachlor uptake.

The objective of this greenhouse experiment was to determine the effect of alachlor placement (root or shoot region) on the control of wild proso millet.

MATERIALS AND METHODS

Chehalis fine-silty (mixed, mesic Cumulic ultic Maploxerock) soil was used. Alachlor at 2.4, 1.2 and 0.24 mg alachlor/100ml water was applied to 2 kg dry soil in a tumbler sprayer, to obtain rates of 1.0, 0.5, and 0.1 ppm, respectively. Treated soil was placed: a) above the seeds only, b) below the seeds only, and c) above and below the seeds. A thin layer of charcoal was placed on the soil below the seeds to prevent the movement of the herbicide beyond the desired location. Six seeds were planted 3.75 cm deep, in 5.0 by 7.5 cm pots. Light intensity was 250 $uE \cdot m^{-2} \cdot s^{-1}$ and 24 C day and 18 C night temperatures were maintained. Watering was by subirrigation.

A randomized block design with five replications was used. An untreated check was included. Height and dry weight were recorded 4 weeks after planting. Data were evaluated in an analysis of variance, using Fisher's protected LSD (F-LSD), at 0.01 level to compare treatment means.

RESULTS AND DISCUSSION

Height and dry weight of wild proso millet were different when alachlor was placed in the root or in the shoot region (Figures 2.1 and 2.2). Shoot exposure was more damaging to wild proso millet seedlings than root exposure at the three rates of alachlor used (0.1, 0.5, and 1.0 ppm). Plants treated in the shoot or both shoot and root zones did not differ in height or dry weight.

Data suggest that if alachlor remains in the shoot region, it provides better wild proso millet control. Alachlor, however, with a water solubility of 242 ppm at 25 C, can leach out of the shoot region and lose its efectiveness in controlling this weed. Further research should be conducted to determine how time and amount of water influence the control of wild proso millet with alachlor. Sweet corn is grown with sprinkler irrigation in the Willamette Valley of western Oregon, and it may be possible to minimize leaching of alachlor by controlling intensity, duration and frequency of irrigations, thus, providing area farmers with a valuable tool in their fight against this weed.

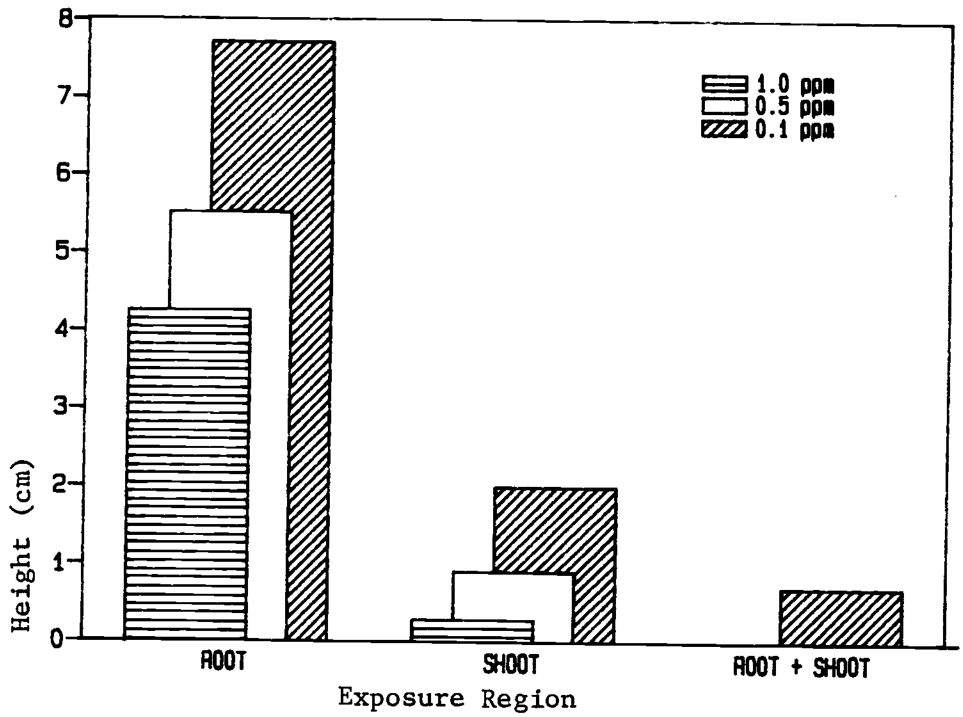

Figure 2.1. Height (cm) of wild proso millet seedlings exposed in the root, shoot or both regions, with alachlor at three rates, greenhouse experiment, Corvallis, Oregon.

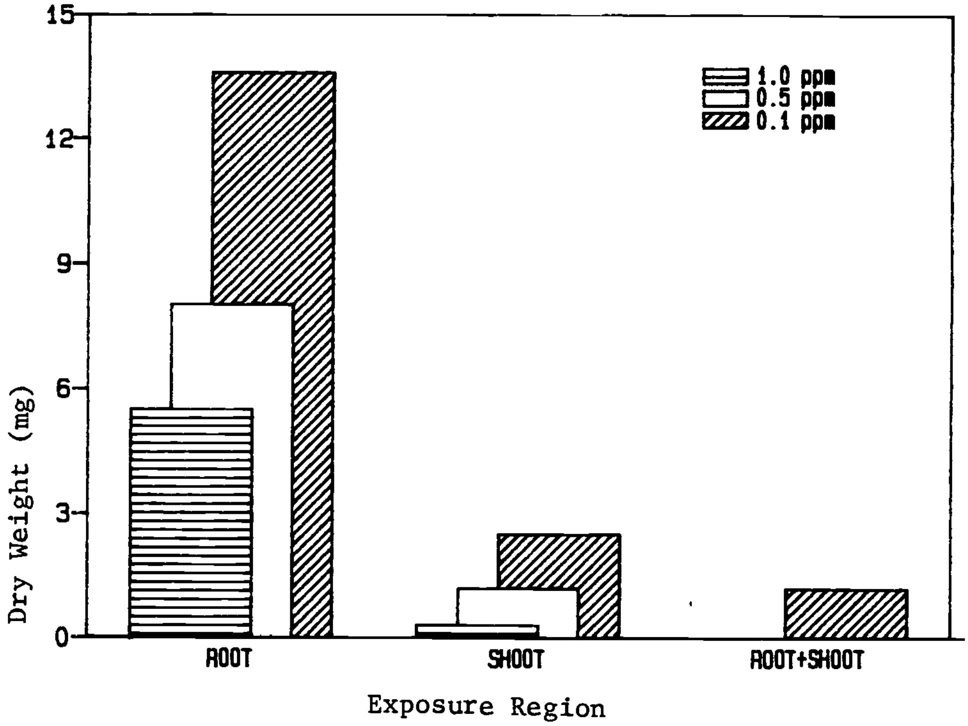

Figure 2.2. Dry weight (mg) of wild proso millet seedlings exposed in the root, shoot or both regions, with alachlor at three rates, greenhouse experiment, Corvallis Oregon.

LITERATURE CITED

1. Anonymous, 1982. Coming: Postemergence corn herbicide Tandem will be combined with atrazine Bladex for problem weeds. Agrichemical Age. 26:51c, 68.

2. Anonymous, 1984. Wild proso millet herbicide still sought. Crops and Soils Mag. 36(6):30.

3. Boydston, R. A. and F. W. Slife. 1987. Postemergence control of giant foxtail (Setaria faberi) in corn (Zea mays) with tridiphane and triazine combinations. Weed Sci. 35:103-108.

4. Chandler, J. M.k, E. Basler, and P. W. Santelmann. 1974. Uptake and translocation of alachlor in soybeans and wheat. Weed Sci. 22:253-258.

5. Ditmarsen, S. C., B. R. Sheppard, and J. J. Velovitch. 1983. Postemergence control of wild proso millet and woolly cupgrass with tridiphane in field corn. Proc. North Cent. Weed Control Conf. 38:120.

6. Doersch, R. E. and R. G. Harvey, 1980. Wild proso millet control in corn. Proc. North Cent. Weed Control Conf. 58-59.

7. Dow. 1986. Tandem. Specimen Label 86-1893, date code 1285.

8. Dow. 1986. The mode of action of tridiphane-atrazine combinations. Unpublished.

9. Downs, R. J. and H. Hellmers. 1975. Enviroment and the experimental control of plant growth. Academic Press, New York.

10. Erza, G., J. H. Dekker, and G. R. Stephenson. 1985. Tridiphane as a synergist for herbicides in corn (Zea mays) and wild proso millet (Panicum miliaceum). Weed Sci. 33:287-290.

11. Grwenwold, B. E. 1971. Mechanisms of uptake and some factors influencing the toxicity of 2-chloro-2',6'-diethyl-N-(methoxymethyl)acetanilide (alachlor) for selected plant species. Ph. D. Dissertation. Oregon State University, Corvallis.

12. Hamill,A. S. and D. Penner. 1973, Interaction of alachlor and carbofuran. Weed Sci. 21:330-335.

13. Harberg, T. J. and J. A. Behm. 1980. Control of wild proso millet (Panicum miliaceum) in field corn with pendimethalin. Proc. North Cent. Weed Control Conf. 35:72.

14. Harvey, R. G. and H. L. Fisher. 1986. Wild proso millet control in field corn study. Wisconsin Weed Control Results. 16:58-59.

15. Lamoureux, G. L. and D. G. Rusness. 1986. Tridiphane [2-(3,5-Dichlorophenyl)-2-(2,2,2-trichloroethyl)oxirane] an atrazine synergist: Enzymatic conversion to a potent glutathione-S-transferase inhibitor. Pest. Biochem. and Physiology. 26:323-342.

16. Mc. Nevin, G. R. and R. G. Harvey. 1982. Wild proso millet control in sod planted and no-till corn. Proc. North Central Weed Control Conf. 37:33.

17. McReynolds, B. and R. Vinal. 1985. Proso millet control in sweet corn field studies with tridiphane. Unpublised.

18. Strand, O. E. and R. Behrens. 1981. Identification and control of wild proso millet. Ext. Bull. 1420. Univ. of Minnesota.

19. Weed Sci. Soc. of Am. 1983. Herbicide Handbook. Fifth Edition. Weed Sci. Soc. of Amer., Illinois. Page 12-15.

BIBLIOGRAPHY

1. Anderson, W. P. 1983. Weed Science: Principles. Second Edition. West Publishing Co., New York. Page 412.

2. Anonymous. 1982. Coming: Postemergence corn herbicide Tandem will be combined with atrazine Bladex for problem weeds. Agrichemical Age. 26:51c, 68.

3. Anonymous. 1984. Wild proso millet herbicide still sought. Crops and Soils Mag. 36(6):30.

4. Boldt, P. F., W. Christianson and W. Striegel. 1981. Wild proso millet control in sweet corn with thiocarbamates, acetanilide and dinitroaniline herbicides. Proc. North Cent. Weed Control Conf. 36:63.

5. Bought M., J. C. Colosi, and P. B. Cavers. 1986. The major weedy biotypes of proso millet (Panicum miliaceum) in Canada. Can. J. Bot. 64:1188-1198.

6. Boydston, R. A. and F. W. Slife. 1987. Postemergence control of giant foxtail (Setaria faberi) in corn (Zea mays) with tridiphane and triazine combinations. Weed Sci. 35:103-108.

7. Carpenter, J. L. and H. J. Hopen. 1985. A comparison of the biology of wild and cultivated proso millet (Panicum miliaceum). Weed Sci. 33(6):795-799.

8. Chandler, J. M.k, E. Basler, and P. W. Santelmann. 1974. Uptake and translocation of alachlor in soybeans and wheat. Weed Sci. 22:253-258.

9. Coultas, J. S. and R. Behrens. 1984. Growth and development of wild proso millet (Panicum miliaceum L.) in Minnesota. Proc. North Cent. Weed Control Conf. 39:103.

10. Coultas, J. S. and R. Behrens. 1986. Wheat (Triticum aestivium) interference with the growth and development of wild proso millet (Panicum miliaceum). In press.

11. Cavers, P. B. and M. A. Bought. 1985. Panicum miliaceum: A crop and a weed. Pages 143-155. In White, J., ed., Studies on Plant Demography: A Festschrift for John L. Harper. Academic Press Inc., London.

12. Ditmarsen, S. C., B. R. Sheppard, and J. J. Velovitch. 1983. Post control of wild proso millet and wooly cupgrass with tridiphane in field corn. Proc. North Cent. Weed Control Conf. 38:120.

13. Doersch, R. E. and R. G. Harvey, 1980. Wild proso millet control in corn. Proc. North Cent. Weed Control Conf. 58-59.

14. Doersch, R. E. and R. G. Harvey. 1982. Dealing with wild proso millet 1983. Univ. of Wisconsin. Dept. of Agronomy. Unpublished.

15. Dow. 1986. Tandem. Specimen Label 86-1893, date code 1285.

16. Dow. 1986. The mode of action of tridiphane-atrazine combinations. Unplublished.

17. Downs, R. J. and H. Hellmers. 1975. Enviroment and the experimental control of plant growth. Academic Press, New York.

18. Erza, G., J. Dekker, and G. Stephenson. 1985. Tridiphane as a synergist for herbicides in corn (Zea mays) and proso millet (Panicum miliaceum). Weed Sci. 33 (3):287-290.

19. Fischer, H. and R. G. Harvey. 1986. Herbicide combinations for wild proso millet (Panicum miliaceum). Weed Sci. Soc. of Amer. Abstr. 26:4-5.

20. Grwenwold, B. E. 1971. Mechanisms of uptake and some factors influencing the toxicity of 2-chloro-2',6'-diethyl-N-(methoxymethyl)acetanilide (alachlor) for selected plant species. Ph. D. Dissertation. Oregon State University, Corvallis.

21. Hamill,A. S. and D. Penner. 1973, Interaction of alachlor and carbofuran. Weed Sci. 21:330-335.

22. Hartbug, T. J. and J. A. Behm. 1980. Control of wild proso millet (Panicum miliaceum) in field corn with pendimethalin. Proc. North Cent. Weed Control Conf. 35:72.

23. Harvey, R. G. 1978. Wild proso millet control in field and sweet corn. Proc. North Cent. Weed Control Conf. 33:94-95.

24. Harvey, R. G. 1979. Serious new weed threat: Wild proso millet. Crops and Soils. 37:10-13.

25. Harvey, R. G. 1982. Wild proso millet control in field and sweet corn. Proc. North Centr. Weed Control Conf. 29:30.

26. Harvey, R. G. and H. L. Fisher. 1986. Wild proso millet control in field corn study. Wisconsin Weed Control Results. 16:58-59.

27. Harvey, R. G., G. R. McNevin, J. W. Albright, and M. E. Kozak. 1986. Wild proso millet (Panicum miliaceum) control with thiocarbamate herbicides on previously treated soils. Weed Sci. 34:773-780.

28. Hawkes, R., T. D. Whitson, and L. Dennis. 1985. A guide to selected weeds of Oregon. Oregon Dep. Agric., Oregon State Univ. Page 10.

29. Lamoureux, G. L. and D. G. Rusness. 1986. Tridiphane [2-(3,5-Dichlorophenyl)-2-(2,2,2-trichloroethyl)oxirane] an atrazine synergist: Enzymatic conversion to a potent glutathione-S-transferase inhibitor. Pest. Biochem. and Physiology. 26:323-342.

30. Luellen, W. R. 1982. Wild proso millet: Will you recognize it before it is too late? Crops and Soils Mag. 34(7):9-11.

31. Maquire, J. D. 1962. Speed of germination- aid in selection and evaluation for seedling emergence and vigor. Crop Sci. 2:176-177.

32. McCanny, S. and P. B. Cavers. 1983. The dispersal of wild proso millet (Panicum miliaceum) by farm machinery. Weed Sci. Soc. of Amer. Abstr. 23:67.

33. McNevin, G. R. and R. G. Harvey. 1981. Wild proso millet in no-till field corn. Proc. North Centr. Weed Control Conf. 36:141-142.

34. Mc. Nevin, G. R. and R. G. Harvey. 1982. Wild proso millet control in sod planted and no-till corn. Proc. North Central Weed Control Conf. 37:33.

35. McReynolds, B. and R. Vinal. 1985. Proso millet control in sweet corn field studies with tridiphane. Unpublished.

36. Patterson, D. T., A. E. Russell, D. A. Mortensen, R. D. Coffin, and E. P. Flint. 1986. Effects of temperature and photoperiod on Texas panicum (Panicum texanum) and wild proso millet (Panicum miliaceum). Weed Sci. 34:876-882.

37. Petersen, K. L., R. B. McReynolds, and R. D. William. 1986. Wild proso millet control in sweet corn. Processing vegetable growers meeting. Salem, Oregon.

38. Salisbury, F. B. and C. W. Ross. 1985. Plant physiology. Third Edition. Wadsworth Publishing Co., California. Page 464.

39. Rahman, A., G. C. Atkinson, and J. A. Douglas. 1979. Erradicane causes problems. N. Z. J. Agric. 139 (39):47-49. In: Harvey et al. 1986. Weed Sci. 34:773-780.

40. Strand, O. E. and R. Behrens. 1981. Identification and control of wild proso millet. Ext. Bull. 1420. Univ. of Minnesota.

41. Strand, O. E., R. Behrens, and G. R. Miller. 1973. Wild proso millet (Panicum miliaceum) a new weed problem in Minnesota. Proc. North Cent. Weed Control Conf. 28:51-52.

42. Striegel, W. L. and P. F. Boldt. 1981. Germination and development of wild proso millet. Proc. North Cent. Weed Control Conf. 36:22.

43. Stump, W. L. and R. L. Zimdahl. 1983. The effect of depth and duration on burial of seed of Panicum miliaceum. Proc. West Soc. of Weed Sci. 97-98.

44. Weed Control Manual. 1987. Ag Consultant. Meister Publishing Co., Ohio. Page 212.

45. Weed Sci. Soc. of Amer. 1983. Herbicide Handbook. Fifth Edition. Weed Sci. Soc. of Amer., Illinois. Page 12-15.

APPENDIX

Appendix Table 1. Percent wild proso millet seedlings with the growing point above the soil surface at different seed depths. March 1986.

	Replication				
Seed depth	I	II	III	IV	Mean
(cm)	-----------------	-----	(%)	-----	-----------------
0	100	100	75	75	87.5
3	90	75	100	85	87.5
6	73	43	50	54	55.0
9	0	50	33	25	27.0
12	0	17	33	0	12.5
15	0	0	0	0	0.0

Appendix Table 2. Transformed percent wild proso millet seedlings with the growing point above soil surface using arc sin percentage. March 1986.

	Replication				
Seed depth	I	II	III	IV	Mean
(cm)	(%)				
0	87.44	87.44	60.00	60.00	73.72
3	71.56	60.00	87.44	67.21	71.55
6	58.69	40.98	45.00	47.29	47.99
9	2.56	45.00	35.06	30.00	28.16
12	2.56	24.35	35.06	2.56	16.13
15	2.56	2.56	2.56	2.56	2.56

Analysis of variance table for transformed percent data in Appendix Table 2.

Source of variation	df	SS	MS	F
Replication	3	363.5	121.2	
Seed depth	5	17230.0	3447.0	18.79**
Error	15	2751.0	183.4	

** = significant at 1% level.
cv = 33.8%

Appendix Table 3. Speed of emergence of wild proso millet seddlings at different seed depths. March 1986.

	Replication				
Seed depth	I	II	III	IV	Mean
(cm)	-----------speed of emergence-----------				
0	1.25	1.48	2.40	1.86	1.75
3	6.88	8.05	10.48	10.70	9.03
6	10.82	5.07	7.22	6.78	7.47
9	2.15	6.09	4.32	8.05	5.15
12	3.34	2.50	1.16	5.58	3.15
15	1.01	0.00	0.32	0.00	0.33

Analysis of variance table for speed of emergence data in Appendix Table 3.

Source of variation	df	SS	MS	F
Replication	3	8.95		
Seed depth	5	226.20	45.23	13.63**
Error	15	49.79	3.32	

** = significant at 1% level.
cv = 40.6%

Appendix Table 4. Mesocotyl length of wild proso millet seedlings at different seed depths. March 1986.

Seed depth	Replication I	II	III	IV	Mean
	(cm)				
0	0.35	0.35	0.28	0.20	0.30
3	2.13	2.79	3.47	2.24	2.66
6	4.90	4.90	5.76	5.78	5.34
9	8.20	7.10	7.96	7.93	7.80
12	11.40	11.28	10.80	10.54	11.01
15	13.23	-	14.40	-	13.82

Analysis of variance table for mesocotyl length data in Appendix Table 4.

Source of variation	df	SS	MS	F
Replication	3	37.44		
Seed depth	5	290.4	58.08	5.5*
Error	15	157.2	10.48	

* = significant at 5% level.
cv = 47.4%

Appendix Table 5. Percent wild proso millet seedlings with the growing point above the soil surface at different seed depths. March 1987.

	Replication				
Seed depth	I	II	III	IV	Mean
(cm)	---------------%---------------------				
0	21	45	47	32	36
3	13	8	17	23	15
6	33	11	0	0	11
9	0	0	0	0	0
12	0	0	0	0	0
15	0	0	0	0	0

Appendix Table 6. Transformed percent wild proso millet seedlings with the growing point above soil surface using arc sin percentage. March 1987.

Seed depth	Replication I	II	III	IV	Mean
(cm)	---------------	%	------------		
0	27.28	42.13	43.28	34.45	36.78
3	21.13	16.43	24.35	28.66	22.64
6	35.06	19.37	1.81	1.81	14.51
9	1.81	1.81	1.81	1.81	1.81
12	1.81	1.81	1.81	1.81	1.81
15	1.81	1.81	1.81	1.81	1.81

Analysis of variance table for transformed percent data in Appendix Table 6.

Source of variation	df	SS	MS	F
Replication	3	34.73	11.58	
Seed depth	5	4145.00	829.10	12.69**
Error	15	980.30	65.36	

** = significant at 1% level.
cv = 61%

Appendix Table 7. Speed of emergence of wild proso millet seedlings at different seed depths. March 1987.

Seed depth	Replication I	II	III	IV	Mean
(cm)	-----------speed of emergence-----------				
0	34.00	11.78	7.84	10.56	16.05
3	15.53	18.07	17.47	16.16	16.81
6	9.00	8.63	5.39	7.64	7.66
9	4.42	1.40	3.08	5.45	3.58
12	0.86	2.18	1.03	1.47	1.39
15	0.32	0.00	0.00	0.00	0.08

Analysis of variance table for speed of emergence data in Appendix Table 7.

Source of variation	df	SS	MS	F
Replication	3	81.83	27.28	
Seed depth	5	1070.00	213.90	8.5*
Error	15	378.40	25.23	

* = significant at 5% level.
cv = 66%

Appendix Table 8 Combined analysis of variance for transformed percent of wild proso millet seedlings with the growing point above soil surface in two greenhouse experiments. March 1986-87.

Source of variation	df	SS	MS	F
Replication	3	222.6	74.2	
Year	1	8472.0	8472.0	133.1**
Error (a)	3	190.9	63.6	
Seed depth	5	18650.0	3731.0	29.47**
Year x seed depth	5	3039.0	607.9	4.80*
Error (b)	30	3797.0	126.6	

*, ** = significant at 5 and 1% level, respectively.

Appendix Table 9. Combined analysis of variance for speed of emergence of wild proso millet seedlings in two greenhouse experiments. March 1986-87.

Source of variation	df	SS	MS	F
Replication	3	169.6	56.5	
Year	1	1591.0	1591.0	23.52**
Error (a)	3	202.9	67.6	
Seed depth	5	10530.0	2105.0	21.55**
Year x seed depth	5	5788.0	1158.0	11.85**
Error (b)	30	2931.0	97.7	

** = significant at 1% level.

Appendix Table 10. Wild proso millet control with five herbicides at different rate and time of application at different seed depths. Field experiment, May-July, 1986, Corvallis, Oregon.

Herbicide	Rate	Time	Control: Seed depth (cm) 1 R1	1 R2	1 R3	1 R4	6 R1	6 R2	6 R3	6 R4	11 R1	11 R2	11 R3	11 R4
	kg/ha		(%)											
pendimethalin	2.0	PRE	100	100	100	100	100	100	100	100	100	100	98	70
pendimethalin	2.0	POST	0	0	0	0	0	0	0	0	0	0	0	0
alachlor	2.2	PRE	80	80	95	70	80	90	100	75	80	100	100	100
alachlor	2.2	POST	0	0	0	0	0	0	0	0	0	0	0	50
alachlor	3.3	PRE	80	90	100	98	90	100	100	100	90	98	98	100
alachlor	3.3	POST	0	0	0	0	0	0	0	0	0	0	0	0
atrazine + tridiphane	1.1+ 0.5	PRE	15	10	50	60	10	50	60	25	0	60	60	50
atrazine + tridiphane	1.1+ 0.5	POST	0	0	0	0	0	0	0	0	0	0	0	60
atrazine + tridiphane	2.2+ 0.5	PRE	98	98	100	98	98	98	100	100	98	100	100	100
atrazine + tridiphane	2.2+ 0.5	POST	0	0	0	0	0	0	0	0	0	0	0	0
EPTC + dichlormid	3.0	PPI	50	60	10	50	60	80	95	70	50	98	95	100
EPTC + dichlormid	4.0	PPI	100	50	95	75	50	90	100	75	0	100	100	100
EPTC + dichlormid + tridiphane	3.0+ 0.5	PPI	80	80	95	98	80	20	95	100	80	80	98	100
tridiphane	1.0	POST	0	0	0	0	0	0	0	0	0	0	0	0
check			0	0	0	0	0	0	0	0	0	0	0	0

Appendix Table 11. Wild proso millet control with five herbicides at different rate and time of application at different seed depths. Field experiment, June-August, 1986, Corvallis, Oregon.

			Control											
			Seed depth (cm)											
Herbicide	Rate	Time	1				6				11			
			R1	R2	R3	R4	R1	R2	R3	R4	R1	R2	R3	R4
	kg/ha		(%)											
pendimethalin	2.0	PRE	100	95	100	100	100	92	95	100	100	100	100	100
pendimethalin	2.0	POST	0	0	0	0	0	0	0	0	0	0	0	0
alachlor	2.2	PRE	30	10	30	60	50	10	75	25	40	25	65	90
alachlor	2.2	POST	0	0	0	0	0	0	0	0	0	0	0	0
alachlor	3.3	PRE	85	75	55	30	75	75	30	20	85	50	50	25
alachlor	3.3	POST	0	0	0	0	0	0	0	0	0	0	0	0
atrazine + tridiphane	1.1+ 0.5	PRE	5	0	0	0	0	0	0	15	5	0	0	5
atrazine + tridiphane	1.1+ 0.5	POST	0	0	0	0	0	0	0	0	0	0	0	0
atrazine + tridiphane	2.2+ 0.5	PRE	5	10	5	20	5	10	5	20	0	5	5	20
atrazine + tridiphane	2.2+ 0.5	POST	0	0	0	0	0	0	0	0	0	0	0	0
EPTC + dichlormid	3.0	PPI	0	5	0	0	0	5	5	10	20	0	5	0
EPTC + dichlormid	4.0	PPI	0	5	5	15	0	5	0	30	0	0	0	10
EPTC + dichlormid + tridiphane	3.0+ 0.5	PPI	5	0	25	15	5	0	5	10	5	5	15	10
tridiphane	1.0	POST	0	0	0	0	0	0	0	0	0	0	0	10
check			0	0	0	0	0	0	0	0	0	0	0	10

Appendix Table 12. Wild proso millet height (cm) with five herbicides at different rate and time of application at three seed depths. Field experiment, June-August, 1986, Corvallis, Oregon.

			Height											
			Seed depth (cm)											
Herbicide	Rate	Time	1				6				11			
			R1	R2	R3	R4	R1	R2	R3	R4	R1	R2	R3	R4
	kg/ha		(cm)											
pendimethalin	2.0	PRE	0.0	3.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
pendimethalin	2.0	POST	6.4	7.5	5.5	1.9	8.3	9.1	7.4	7.3	7.3	9.0	12.7	7.9
alachlor	2.2	PRE	0.0	0.8	1.2	1.7	0.0	1.2	0.8	0.4	0.0	0.9	1.9	0.0
alachlor	2.2	POST	7.6	2.4	6.8	8.7	7.4	8.9	3.5	9.9	7.9	6.9	6.8	12.1
alachlor	3.3	PRE	0.0	0.0	0.9	0.8	0.0	0.0	1.5	1.2	0.0	0.0	1.1	1.7
alachlor	3.3	POST	6.1	5.6	9.7	5.8	10.1	11.3	9.8	10.9	7.3	10.7	11.9	13.3
atrazine + tridiphane	1.1+ 0.5	PRE	2.1	4.2	3.4	1.3	3.4	3.1	2.9	2.5	2.9	4.1	4.4	2.3
atrazine + tridiphane	1.1+ 0.5	POST	8.4	6.2	6.4	6.3	12.3	7.6	8.8	9.2	8.3	9.7	10.3	11.3
atrazine + tridiphane	2.2+ 0.5	PRE	1.1	1.8	1.8	1.6	1.2	2.6	1.5	2.5	1.4	1.6	3.1	1.2
atrazine + tridiphane	2.2+ 0.5	POST	4.7	4.3	1.8	6.9	6.2	5.4	5.0	7.5	6.8	11.1	8.8	10.2
EPTC + dichlormid	3.0	PPI	2.9	3.1	3.5	2.4	3.8	2.0	3.4	2.8	3.3	3.8	2.5	4.9
EPTC + dichlormid	4.0	PPI	5.2	3.2	2.5	1.4	4.5	3.5	1.9	0.9	5.2	3.8	2.5	2.5
EPTC + dichlormid + tridiphane	3.0+ 0.5	PPI	2.6	4.2	1.5	1.9	2.1	3.5	1.6	1.7	2.2	1.2	2.4	1.1
tridiphane	1.0	POST	4.4	6.6	7.8	4.9	7.2	7.3	7.1	10.5	7.6	11.5	14.0	11.2
check			4.1	6.5	9.6	3.9	7.5	10.5	9.5	11.9	7.3	10.2	11.8	12.2

Appendix Table 13. Wild proso millet stand counts with five herbicides at different rate and time of application at three seed depths. Field experiment. June 17, 1986. Corvallis, Oregon.

Herbicide	Rate	Time	Stand count: Seed depth (cm) 1				6				11			
			R1	R2	R3	R4	R1	R2	R3	R4	R1	R2	R3	R4
	kg/ha		(per 0.5 m row)											
pendimethalin	2.0	PRE	0	0	0	0	0	0	0	0	0	0	0	0
pendimethalin	2.0	POST	19	25	23	20	21	29	17	16	26	24	23	13
alachlor	2.2	PRE	0	17	6	0	0	6	29	9	0	7	6	4
alachlor	2.2	POST	14	27	20	18	21	25	23	20	19	21	32	28
alachlor	3.3	PRE	0	0	7	3	0	0	11	6	0	0	11	15
alachlor	3.3	POST	20	31	20	21	25	39	31	18	22	27	22	28
atrazine + tridiphane	1.1+ 0.5	PRE	17	26	33	24	22	25	24	13	16	19	15	26
atrazine + tridiphane	1.1+ 0.5	POST	26	20	15	24	13	32	22	11	16	28	23	28
atrazine + tridiphane	2.2+ 0.5	PRE	10	12	19	24	13	32	23	11	22	25	24	14
atrazine + tridiphane	2.2+ 0.5	POST	27	21	27	16	24	28	28	21	18	27	20	21
EPTC + dichlormid	3.0	PPI	23	21	20	23	22	33	26	27	13	31	16	26
EPTC + dichlormid	4.0	PPI	19	25	21	21	20	26	20	19	26	35	16	23
EPTC + dichlormid + tridiphane	3.0+ 0.5	PPI	15	21	11	11	14	25	18	20	11	20	7	21
tridiphane	1.0	POST	19	25	25	12	23	21	26	25	28	29	20	23
check			14	29	23	22	16	28	26	18	15	30	21	27

Appendix Table 14. Analysis of variance for transformed percent of control of wild proso millet with five herbicides at three seed depths. May-July, 1986.

Source of variation	df	SS	MS	F
Replication	3	2501.0	833.8	
Herbicide (herb)	14	214500.0	15320.0	73.58**
Error (a)	42	8747.0	208.3	
Seed depth	2	816.3	408.1	1.16
Error (b)	6	2105.4	350.9	
Herb x seed depth	28	4439.0	158.5	1.59
Error (c)	84	8357.1	99.4	

** = significant at 1% level.

cv (a)= 36.7%
cv (b)= 47.6%
cv (c)= 25.4%

Appendix Table 15. Analysis of variance for transformed percent of control of wild proso millet with five herbicides at three seed depths. June 17, 1986.

Source of variation	df	SS	MS	F
Replication	3	381.6	127.2	
Herbicide (herb)	14	95150.0	6796.0	55.5**
Error (a)	42	5144.0	122.5	
Seed depth	2	27.0	13.5	10.6*
Error (b)	6	7.6	1.3	
Herb x seed depth	28	724.9	25.9	69.6**
Error (c)	84	31.2	0.4	

*, ** = significant at 5 and 1% level, respectively.

cv (a)= 67.7%
cv (b)= 6.9%
cv (c)= 3.7%

Appendix Table 16 Analysis of variance for wild proso millet height with five herbicides at three seed depths. June 17, 1986.

Source of variation	df	SS	MS	F
Replication	3	9.51	3.17	
Herbicide (herb)	14	1940.00	138.60	36.6**
Error (a)	42	159.00	3.78	
Seed depth	2	103.10	51.54	9.1
Error (b)	6	33.64	5.60	
Herb x seed depth	28	152.40	5.44	3.7*
Error (c)	84	123.14	1.46	

*, ** = significant at 5 and 1% level, respectively.

cv (a)= 40.0%
cv (b)= 49.6%
cv (c)= 25.0%

Appendix Table 17. Analysis of variance for wild proso millet stand counts with five herbicides at three seed depths. June 17, 1986.

Source of variation	df	SS	MS	F
Replication	3	973.0	324.3	
Herbicide (herb)	14	10390.0	742.2	25.02*
Error (a)	42	1246.0	29.7	
Seed depth	2	105.1	52.5	1.02
Error (b)	6	307.9	51.3	
Herb x seed depth	28	550.2	19.6	0.84
Error (c)	84	1948.8	23.2	

* = significant at 5% level.

cv (a)= 29.8%
cv (b)= 39.2%
cv (c)= 26.4%

Appendix Table 18. Height of wild proso millet seedlings with early postemergence application of atrazine and tridiphane alone and in combinations. Greenhouse experiment. Corvallis, Oregon.

Treatment	Rate	Replication		
		I	II	III
	(hg/ha)		(cm)	
atrazine	0.56	6.2	6.4	6.7
atrazine	0.84	5.9	5.2	6.0
atrazine	1.68	5.5	5.7	6.2
atrazine	2.24	4.3	4.9	4.8
tridiphane	0.28	6.3	5.4	6.6
tridiphane	0.56	5.6	5.9	6.4
tridiphane	0.84	6.1	6.0	5.7
atrazine + tridiphane	0.56 + 0.28	3.5	3.7	6.3
atrazine + tridiphane	0.56 + 0.56	5.9	4.2	3.5
atrazine + tridiphane	0.56 + 0.84	6.3	3.1	3.5
atrazine + tridiphane	0.84 + 0.28	3.5	4.1	3.2
atrazine + tridiphane	0.84 + 0.56	3.8	4.6	4.2
atrazine + tridiphane	0.84 + 0.84	3.8	4.8	4.2
atrazine + tridiphane	1.68 + 0.28	4.8	4.8	4.8
atrazine + tridiphane	1.68 + 0.56	4.0	4.7	4.4
atrazine + tridiphane	1.68 + 0.84	4.6	4.0	4.9
atrazine + tridiphane	2.24 + 0.28	4.0	5.2	5.3
atrazine + tridiphane	2.24 + 0.56	4.7	3.7	5.1
atrazine + tridiphane	2.24 + 0.84	5.0	4.5	5.1
check		9.2	11.7	12.5
crop oil check		9.0	8.5	10.4

Appendix Table 19. Weight of wild proso millet seedlings with early postemergence application of atrazine and tridiphane alone and in combinations. Greenhouse experiment, Corvallis, Oregon.

Treatment	Rate	Replication		
		I	II	III
	(hg/ha)		(mg)	
atrazine	0.56	6.5	7.8	8.6
atrazine	0.84	5.5	4.6	6.2
atrazine	1.68	4.9	4.9	24.7
atrazine	2.24	3.3	3.6	3.0
tridiphane	0.28	9.4	7.4	8.6
tridiphane	0.56	7.0	7.6	7.4
tridiphane	0.84	8.0	7.8	6.9
atrazine + tridiphane	0.56 + 0.28	2.3	2.4	3.7
atrazine + tridiphane	0.56 + 0.56	4.3	2.9	2.1
atrazine + tridiphane	0.56 + 0.84	5.2	2.3	7.5
atrazine + tridiphane	0.84 + 0.28	2.4	2.6	2.2
atrazine + tridiphane	0.84 + 0.56	2.7	3.1	2.5
atrazine + tridiphane	0.84 + 0.84	3.2	2.9	2.9
atrazine + tridiphane	1.68 + 0.28	3.0	2.8	3.3
atrazine + tridiphane	1.68 + 0.56	2.6	2.9	2.8
atrazine + tridiphane	1.68 + 0.84	2.9	2.7	2.5
atrazine + tridiphane	2.24 + 0.28	2.6	3.8	3.5
atrazine + tridiphane	2.24 + 0.56	3.4	3.0	3.5
atrazine + tridiphane	2.24 + 0.84	3.3	2.9	3.5
check		25.0	42.0	30.2
crop oil check		24.6	23.3	21.6

Appendix Table 20. Analysis of variance for weight (mg) data in Appendix Table 19.

Source of variation	df	SS	MS	F
Replication	2	14.84	7.42	
Herbicide	20	3395.00	169.70	15.77**
Error	40	430.50	10.76	

** = significant at 1% level.
cv = 47.5%

Appendix Table 21. Analysis of variance for height (cm) for data in Appendix Table 18.

Source of variation	df	SS	MS	F
Replication	2	2.33	1.16	
Herbicide	20	190.00	9.50	14.75**
Error	40	25.76	0.64	

** = significant at 1% level.
cv = 14.6%

Appendix Table 22. Dry weight (mg) of wild proso millet seedlings with different rate and soil placement of alachlor. Greenhouse experiment, Corvallis, Oregon.

		Replication				
Exposure region	Rate	I	II	III	IV	V
	(ppm)	(mg)				
Shoot	0.1	3.5	3.1	2.0	2.2	2.2
Root	0.1	13.4	7.8	10.7	16.1	20.0
Shoot + root	0.1	0.0	1.3	1.6	1.6	1.4
Shoot	0.5	1.5	1.7	1.2	1.7	0.0
Root	0.5	4.8	10.3	9.1	11.3	4.7
Shoot + root	0.5	0.0	0.0	0.0	0.0	0.0
Shoot	1.0	1.6	0.0	0.0	0.0	0.0
Root	1.0	7.2	6.3	3.2	2.5	8.1
Shoot + root	1.0	0.0	0.0	0.0	0.0	0.0
Check		13.6	14.3	14.6	13.7	9.1

Analysis of variance table for dry weight data in Appendix Table 22.

Source of variation	df	SS	MS	F
Replication	4	23.46	5.860	
Treatment	9	1.27	0.140	28.66**
Error	36	0.17	0.004	

** = significant at 1% level.
cv = 15.3%

Appendix Table 23. Height (cm) of wild proso millet seedlings with different rate and soil placement of alachlor, greenhouse experiment, Corvallis, Oregon.

		Replication				
Exposure region	Rate	I	II	III	IV	V
	(ppm)			(cm)		
Shoot	0.1	2.0	2.5	1.7	1.7	1.9
Root	0.1	8.6	7.0	6.9	8.5	7.4
Shoot + root	0.1	0.0	1.4	1.2	0.0	0.8
Shoot	0.5	1.2	1.0	1.3	1.2	0.0
Root	0.5	2.8	7.3	5.8	7.5	4.1
Shoot + root	0.5	0.0	0.0	0.0	0.0	0.0
Shoot	1.0	1.4	0.0	0.0	0.0	0.0
Root	1.0	4.9	3.8	3.7	2.5	6.3
Shoot + root	1.0	0.0	0.0	0.0	0.0	0.0
Check		8.6	9.1	7.1	7.5	6.5

Analysis of variance table for height data in Appendix Table 23.

Source of variation	df	SS	MS	F
Replication	4	1.46	0.36	
Treatment	9	445.40	49.49	49**
Error	36	35.70	0.99	

** = significant at 1% level.
cv = 34%