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Procarbazone-sodium Effect on Rotational Crops and its Dissipation in Soils

Khalid F. Al Mutlaq[1] **Carol Mallory-Smith**[2] **Daniel A. Ball**[3].

ABSTRACT

Experiments were conducted at Corvallis and Pendleton, Oregon to study the effect of procarbazone-sodium on rotational crops and its soil bio-availability after a single application on winter wheat. Procarbazone-sodium was applied at three rates, 0.022, 0.044, and 0.089 kg ai/ha on February 25 and March 21, 1997, at Corvallis and Pendleton, respectively. The experimental rotational crops were spring barley, spring oat, spring-canola, green peas, and red lentils. Only spring oat was affected by the two heigher rates residues at pendelton. Procarbazone-sodium dissipation was monitored over time using a corn root bioassay to measure root growth in response to the herbicide residues. Procarbazone-sodium persisted longer in Corvallis soil with half-life time of 75 day compared to Pendleton where the half-life was 49 day.

Nomenclature: Procarbazone-Sodiume,(methyl 2-({[(4-methyl-5-oxo-3-propoxy-4,5-dihydro-1*H*-1,2,4-triazol-1-1)carbonyl]amino}sulfonyl)benzoate sodium salt; alfalfa, *Medicago sativa* L.;; green peas, *Pisum sativum* L.; spring barley, *Hordeum vulgar* L.; spring canola , *Brassica napus* L.; spring oats, *Avena sativa* L.; red lentils, *Lens culinaris* Medik; winter wheat, *Triticum aestivum* L.

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INTRODUCTION

Procarbazone-sodium is a sulfonylaminocarbonyl-triazolinone herbicide that has been introduced for weeds in wheat. Its structure as a typical sulfonamide herbicide that is similar to sulfonylurea and consists of an aryl group, a bridge, and a nitrogen-containing heterocycle. Its bridge is not saturated which causes a negative charge on the central nitrogen (Santel, 1998). It is formulated as a sodium salt herbicide. It is a post-emergence and soil active herbicide for use in winter wheat to control grasses, especially those belonging to the Bromus family and some selected broadleaf weeds (Feucht et al, 1999, Scoggan et al, 1999 and Bell, 1999). Procarbazone sodium acts by inhibiting the enzyme acetolactate synthase (ALS) in the biosynthetic pathway for branched chain amino acids (Santel, 1998). Persistence of herbicides in the soil and sensitivity of rotational crops to their residues are very important factors that influence damage to rotational crops (Monks and Banks, 1991; Hurle and Walker, 1980). Many herbicides persist in the soil and can affect crops planted several months after application (Abernathy and Keeling, 1979; Brewster and Appleby, 1983; Monks and Banks, 1991). Residues of chlorsulfuron {2-chloro-*N*-[[(4-methoxy-6-methyl-1,3,5-triazin-2-yl)amino] carbonyl] benzene-sulfonamide} applied at a rate of 35 g ai/ha in winter wheat *(Triticum aestivum* L.) injured snap beans (*Phaseolus vulgaris* L.), alfalfa (*Medicago sativa* L.), sweet corn (*Zea mays* L.), [illegible]

[illegible] (Brewster and Appleby, 1983). Burkhart and Fay (1985) reported that chlorsulfuron residues remained in soil with low moisture (precipitation of 50 mm/month) and high soil pH (7.8), thus restricting crop rotation options in Montana. Similar to chlorsulfuron, triasulfuron (2-(2-chloroethoxy)-N-[[(4-methoxy-6-methyl-1,3,5-triazin-2-yl)amino]carbony]benzene-sulfonamide) residues in a Montana soil (clay loam with 3.2% OM and pH=7.7) caused biomass reduction of sugar beet and alfalfa one year after application and reduced lentil biomass three years after application (Carda et al, 1991).

Herbicides from the same chemical family may have different soil persistence. For example, thifensulfuron (methyl 3-[[[[(4-methoxy-6-methyl-1,3-5-triazine-2-yl)amino]carbonyl]amino]sulfonyl]-2-thiophenecarboxylate) has a very short half-life in soil (Brown et al, 1987) while chlorsulfuron and triasulfuron have a longer half-life (James et al, 1988), and all are from the sulfonylurea family. The ideal soil-active herbicide should persist long enough in the soil to maintain weed control in the present crop but not so long as to cause injury to rotational crops. Factors such as the chemical and physical properties of herbicides (Tinsley, 1979), formulation (Hurle and Walker, 1980), soil properties (Baughman et al, 1996; Capri et al, 1995; Curran et al, 1992b; Smith and Aubin, 1992), climate (Vencill and Banks, 1994), and agronomic practices (Curran et al, 1992a; Reddy et al, 1995; Brown et al, 1996; Baughman et al, 1996) were affected on herbicide persistence in soils. Herbicide half-life in soil is measured as the time it takes for half of the initial amount of an herbicide to break down or to disappear. Despite the differences in dissipation time, the degradation of sulfonylurea herbicides in soil generally results from chemical hydrolysis and microbial breakdown (Brown et al, 1987; James et al, 1988). These degradation processes are dependent on soil pH, soil texture, moisture, and temperature, which vary widely among soils (Beyer et al, 1987). A herbicide bioassay is the measure of the response of a living organism to the presence of an herbicide in a given substrate (Stantelmann, 1977). According to Stantelmann (1977), bioassays are the best method to detect biological activity of herbicides because the detected amount by a chemical means does not necessarily reflect its bioactivity, while chemical and physical procedures are useful for identifying substances. Bioassays also can be used to study the herbicide persistence and movement in soils at an effective biological level.

Procarbazone-sodium is a sulfonamide herbicide and has similar properties of sulfonylurea, imidazolinones, and triazolopyrimidines herbicides (Hans Santel, personal communication, 1998). Procarbazone-sodium is a low pKa, weak acid herbicide, that is formulated as a dry flowable, sodium salt. The compound is highly water soluble; therefore, it is readily mobile and becomes bioavailable in soils. Microbial degradation is the main factor in the dissipation process of procarbazone-sodium (Hans Santel, personal communication, 1998). Chemical hydrolysis of the compound is possible, while no photodecomposition or vaporization is involved in the dissipation of procarbazone-sodium from the soil.

Procarbazone-sodium can be adsorbed by soil with high organic matter due to the partitioning of the compound molecules into the soil's organic matter. As soil pH decreases, the dissipation of procarbazone-sodium increases. Laboratory studies estimated the half-life at about 100 days in most U.S.A. soils, while field studies showed the half-life was between 25 to 100 days (Santel, 1988). The objectives of the present study were to determine the impact of procarbazone-sodium residues on rotational crops using a field bioassay and to detect procarbazone-sodium dissipation in two Oregon soils during one year following a single procarbazone-sodium application. Triasulfuron and Sulfusulfuron were included in this study as comparison products.

MATERIALS AND METHODS

Rotational Crops Studies.

Field experiments were conducted at Hyslop Field Laboratory, Corvallis and at the Columbia Basin Agricultural Research Center, Pendleton. Corvallis soil series was Woodburn (Silt Loam) consists of 69% silt, 9% sand, 22% clay and 2.38 % organic matter (OM) with pH of 6.1. Pendeltone soil series was Walla Walla (Silt Loam) consists of 68% silt, 16% sand, 16% clay and 1.93 % OM with pH of 6.1.

Average temperature and precipitation data for the study sites were obtained from the climate service at Oregon State University (Figures 1 and 2). Treatments included procarbazone-sodium at three rates (0.022, 0.044 and 0.089 kg ai/ha), triasulfuron at 0.018 kg ai/ha;

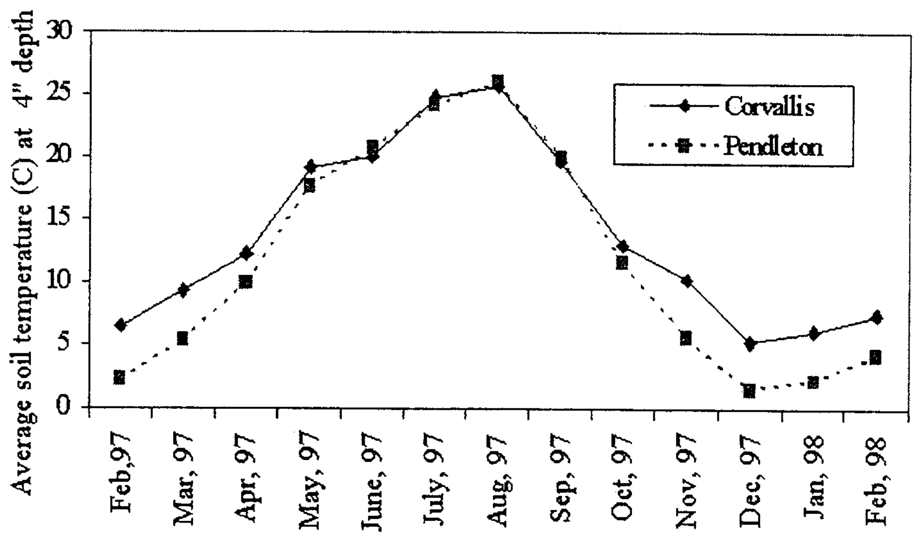

Figure 1. Average monthly soil temperature (C) during the study period.

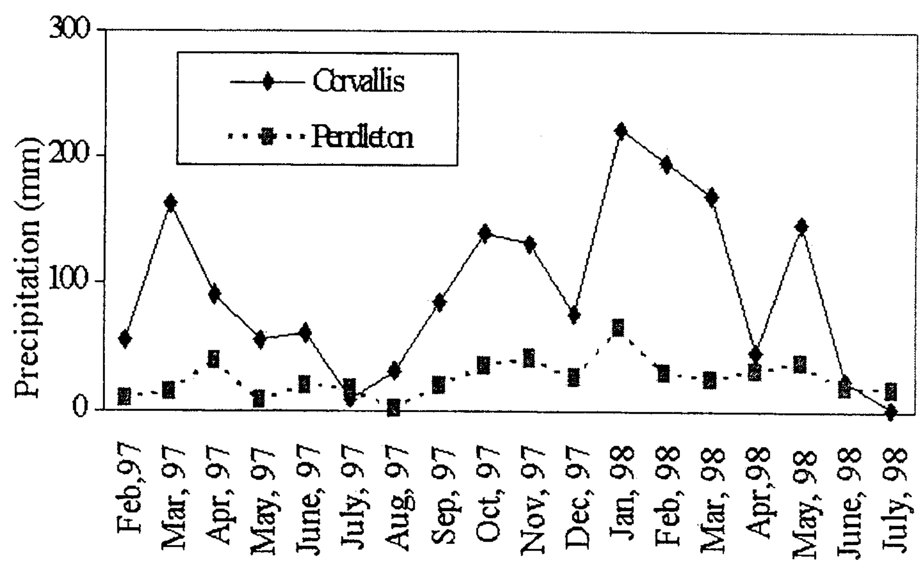

Figure 2. Average monthly precipitation (mm) during the study period.

sulfosulfuron at 0.036 kg ai/ha; and a control treatment (spray solution, water only, with no herbicide). In the Corvallis studies, the herbicides were applied using a backpack CO_2 sprayer calibrated to deliver 170 L/ha at 30 psi. In Pendleton, the herbicides were applied with a tractor sprayer calibrated to deliver 136 L/ha at 29 psi. No surfactant was included in any treatment. Winter wheat 'Rhohde' in Pendleton and 'Stephens' in Corvallis was planted on October 25, 1996 at both sites. After harvesting the wheat on July 25, 1997 at Corvallis and on July 10, 1997 at Pendleton, the fields were rototilled to a depth of 8 to 10 cm and left fallow until the rotational crops were planted.. The soil was fertilized with 18 *N, 22 P, 16 S* kg/ha and planted with the rotational crops on Aprial 16, 1998 at Corvallis and on March 16, 1998 at Pendelton The herbicide were applied to wheat at the 4 to 6 leaf stage on February 25 and March 21, 1997, at Corvallis and Pendleton, respectively. The plot size was 7.2 by 24 m at Corvallis, and 3.6 by 12 m in Pendelton.

The rotational crops (spring barley, spring oats , spring canola, and green peas) were planted randomly across the herbicide treatments in each replication. The width of each crop was 4.8 m in Corvallis and was 3.4 m in Pendelton. The experimental design was a randomized complete block with a strip treatments with four replications. The main plot treatments were herbicides and the strip plots were rotaional crops. Plots were kept weed-free by hand-weeding throughout the studies. Seedling dry weight and crop yield were collected from each plot. Crop seedlings were harvested 35 d after seeding at the soil surface from 1.8 m random sections of two rows in the center of each plot, oven-dried, and weighed. Rotational crops were harvested from an area 1.5 by 4.8 m in the center of each plot using a small plot combine on Augest 5, 1998 at Corvallis and on Julay 14 or 24, 1998 at Pendelton. Fisher's Protected Least Significant Difference (FPLD) test was conducted for means separation of herbicide treatment effects on the rotational crops using SAS (SAS 1991)

Corn Root Bioassay.

Field soils were collected one day before application in order to test the uniformity of the soil in each site (0-), immediately following application (0+), and 30, 90, 180, and 360 days after application (DAA). At each sampling time, 3.5-cm diameter soil cores were taken from each plot to a depth of 20 cm. Sixteen cores per plot were collected from Pendelton while 20 cores per plot were taken from Corvallis. The difference in sample numbers was due to different plot size among the sites, so representative soil samples were collected from each plot. The soil cores were taken randomly from each plot about 2.2 m from the plot edge and composited in a plastic bag. The soil samples were stored in a freezer at -5 C for one year until the bioassay was conducted. A dose-response curve was developed for each soil and herbicide to estimate the residue level in soil from field samples. The samples were air dried, ground, mixed, and screened through a 2-mm sieve. A subsample of 500 g was used for the dose-response curve. A greenhouse hood-sprayer calibrated to deliver 170 L/ha at 30 psi was used to apply the desired amount of the herbicide to the soil. Thus, the herbicide was uniformly distributed on the soil. The soil then was transferred to a plastic bag and thoroughly mixed. Concentrations of 0.0, 0.85, 2.7, 5.0, 8.5, 13.7, 16.9 ppb in dry soil were prepared for procarbazone-sodium, 0.0, 0.7, 2.7, 3.4, 5, and 6.8 ppb of triasulfuron, and 0.0, 2.4, 3.4, 6.8, 10.2, and 13.5 ppb of sulfosulfuron. The highest concentration corresponds to the applied rate of 0.044 kg/ha procarbazone-sodium, 0.018 kg/ha triasulfuron, 0.036 kg/ha sulfosulfuron.

A corn root bioassay was conducted twice for each herbicide rate and soils. The experimental design for each dose was a randomized complete block design with four replications. The corn root bioassay was conducted similarly to that described by Sunderland et al (1991). A strip (2.5 cm wide by 14 cm long) of a paper towel was placed along the bottom of a plastic Petri dish (10 cm diameter by 2.5 cm height), and one end of the strip (4 cm) was allowed to contact a water source that was provided in the lid of the Petri dish. Each Petri dish was filled with a 110 g dry soil, and the soil was gently tamped down by the lid until the lid was firmly in place, then the lid was removed. The lid was placed next to the dish and filled with water so that the strip of the paper toweling could be placed into the water. After 90% of the distance across the Petri dish was wet, the paper strip was cut. A line was drawn across the soil surface approximately 2.5 cm from the top. Five corn seeds, which had been germinated in the dark for 48 h at 26 C, were placed on the soil surface with the radical tip of each seed placed on the line. The lid was replaced, and the dish was placed in a dark chamber for 24 h at 30 C. The dish was placed face-down at a 45 angle so that the roots grew along the soil surface. After the 24 h incubation, the root length along the surface of the soil was measured beginning at the drawn line. The average of the four longest roots from each dish was taken for each herbicide concentration. The growth response of the corn root to each herbicide (procarbazone-sodium, triasulfuron, and sulfosulfuron) in the Woodburn and Walla Walla soils was similar.

The analysis of homogeneity of variance between Corvallis and Pendleton data was conducted by taking the ratio of error mean squares obtained from analysis of the variance of each data set and tested using the following equation (Gomez and Gomez, 1984):

F = larger error mean square/smaller error square Equation [1]

Homogeneity of variance between the two sites was obtained when the calculated F (F_c) was less or equal to tabular F (F_t) at p ? 0.05. The interaction of the soil types (Woodburn and Walla Walla) and the herbicide doses (independent variable) were tested. The mean square error (MSE) and the significance test of the parameter at p ? 0.05 showed no significant effect on the root response due to soil by herbicide interaction (Table 1). The response of the roots to each herbicide was similar and homogeneous in both soils (Table 1). Therefore, the data were combined, and the response of the root length to each herbicide (procarbazone-sodium, triasulfuron, sulfosulfuron) was calculated as a percentage of the control treatment and fitted by a regression model where Y is the root length as % of control, X is herbicide dose (ppb) (procarbazone-sodium Model [1], triasulfuron Model [2], and sulfosulfuron Model [3]):

Table 1. Parameters for homogeneity of variance and soil-dose interaction.

Herbicide	F_c	F_t	Soil Type Effect		Soil-Dose Interaction	
			MSE	p-value	MSE	p-value
Procarbazone-sodium	1.146	2.6	0.004	0.85	0.1	0.54
Triasulfuron	1.219	2.4	0.00001	0.99	0.001	0.99
Sulfosulfuron	1.025	2.4	0.04	0.30	0.003	0.99

$Y = 100.6 - 17.3*(X)^{1/2}$ $r^2 = 0.98$ Model [1]

$Y = 14.5 + 84.1*(1+X)^{-1}$ $r^2 = 0.99$ Model [2]

$Y = 20.4 + 79.6*(1+X)^{-1}$ $r^2 = 0.99$ Model [3]

The standard dose-response curves are presented in Figures 3, 4, and 5 for procarbazone-sodium, triasulfuron, and sulfosulfuron, respectively. The same bioassay procedure was conducted on the collected field soil samples. The root length response to each herbicide treatment was measured as the percentage of the root length response to the control treatment. The dose-response models (Models [1], [2], and [3]) were used to estimate the concentration (ppb) in the field samples. The estimated data of the procarbazone-sodium residues in the soil (ppb) were plotted as a % of the initial detected level of the herbicides at time 0 DAA and were fitted by a regression model (Model [4]).

$\% \text{ Dose} = A - B*(DAA)^{1/2}$ Model [4]

Where DAA = days after application; % Dose = herbicide concentration level as a % of the initial level at time 0 DAA; A= the estimated initial level (ppb); and B= rate of the decrease in dose over time. Standard diagnostic checking (Ott, 1993) of the model's residual did not reveal any gross violations of the assumptions underlying

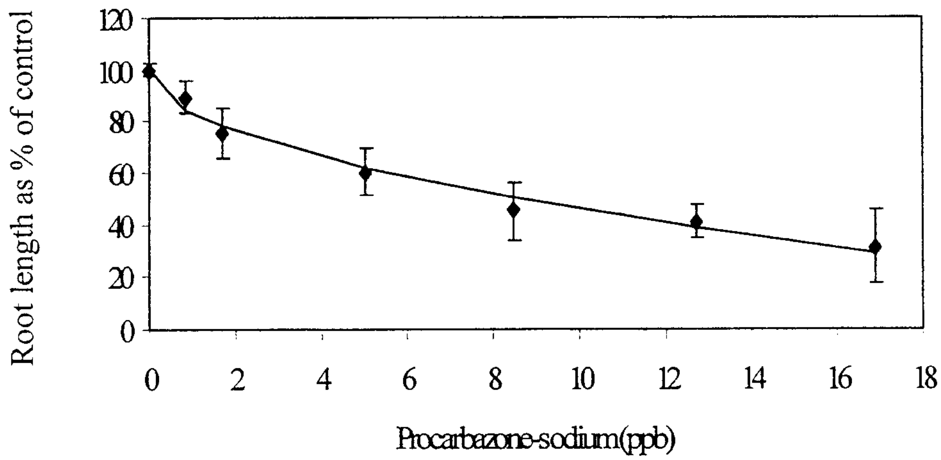

Figure 3. Corn root bioassay dose-response curve for procarbazone-sodium.

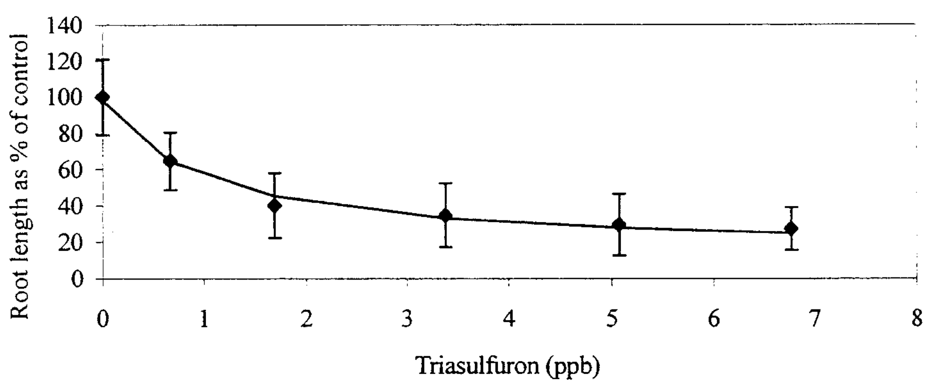

Figure 4. Corn root bioassay dose-response curve for triasulfuron.

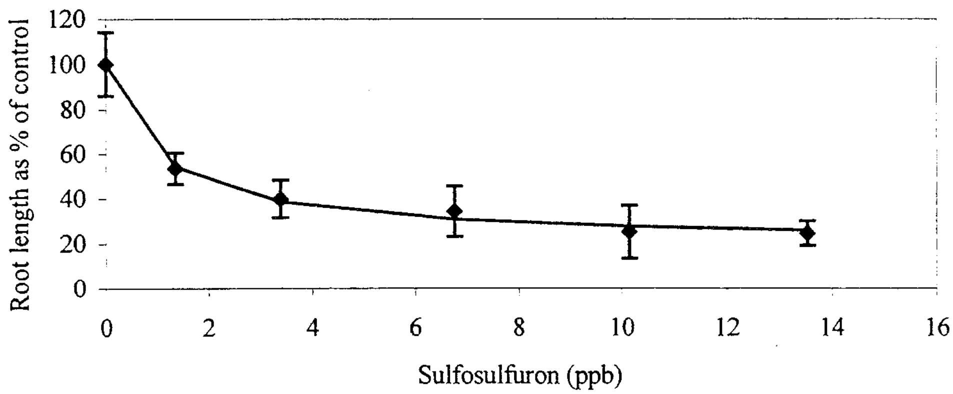

Figure 5. Corn root bioassay dose-response curve for sulfosulfuron.

normal linear regression. The half-life ($t_{1/2}$) time of each herbicide was measured by plotting the detected doses against time (DAA) for each replication. Then a horizonal line was drawn from the dose axis at 50% of the initial concentration and the intersection with the plotted curve determined the $t_{1/2}$. The $t_{1/2}$ data were subject to analysis of variance and mean separation test for least significant difference (LSD). All statistical analysis were performed using SAS (SAS,1991).

Mobility Study.

A thick layer technique (Weber and Peeper, 1977) was used to detect herbicide mobility in the soil. Shallow trays, 2 by 10 by 30 cm was filled with dry soil (500 g) and placed in a horizontal position. A soil treated with procarbazone-sodium (36 ppb), triasulfuron (36 ppb), or sulfosulfuron (36 ppb) was placed 2.5 cm from one end of the trays and connected to a water source by a strip of paper towel (3 cm wide by 15 cm long). Only 1.5 cm of the strip was placed in the treated soil and the rest was placed in the water source. After water diffused across the tray, and before it reached 2.5 cm from the other end, the paper towel was cut. After the moisture reached the other end, a line was drawn along on 30 cm edge of the tray, and 25 germinated corn seeds were placed on the line. The tray was covered and placed face-down at an angle of 45 degree in a dark growth chamber for 24 h at 30 C. Root length was measured, and the herbicide movement was detected by comparing root growth with the root growth of the control.

RESULTS AND DISCUSSION

Rotaional Crops Studies.

None of herbicide residues caused injury to the rotational crops seeded 13 months after herbicide application at Corvallis (Table 2). The residue of the highest rate (0.089 kg/ha) of procarbazone-sodium in the Pendeltone reduced spring oats biomass and yield (Table 3) while the residue in the Corvallis caused only slight visual injury (data not shown). At Pendeltone, spring oats yield was reduced by procarbazone-sodium, barley yield was reduced by the sulfosulfuron residue, and lentil yield was reduced by triasulfuron residue (Table 3).

Different environmental conditions especially the precipitation level that was higher in Corvallis compared to Pendelton (Figure 2) may have caused a faster dissipation of triasulfuron and sulfosulfuron in the Woodburn soil compared to the Walla Walla soil. Sulfonylurea herbicides dissipation increases as soil moisture increases (Beyer et al, 1987). Similar studies, conducted in Pendleton by other researchers, showed that sulfosulfuron reduced the biomass of barley, canola, and peas (Shinn et al, 1998). The authors also observed yield reduction on barley and peas after sulfosulfuron treatment. Similar herbicide treatments showed no effect on the rotational crops at Moscow and Endicott. Pendleton had the lowest precipitation, % OM and the highest soil pH, which may have caused a slower dissipation rate of sulfosulfuron at Pendleton compared to Moscow and Endicott (Shinn et al, 1998).

Procarbazone-sodium residues in the Woodburn soil were found to be safe to tested rotational crops. In the Walla Walla soil, the residue level of procarbazone-sodium was found to reduce the biomass and yield of spring oats (Table 3).

Table 2. Effect of herbicide residues on seedling dry weight and yield of rotational crops seeded 13 months after application at Corvallis site.

Data	Crop	Procarbazone- sodium 0.022	0.044	0.089 kg ai/ha	Triasulfuron 0.018 kg ai/ha	Sulfosulfuron 0.036 kg ai/ha	LSD p?0.05
Seedling dry weight as % of control	Barley	99a	112a	116a	115a	99a	27
	Canola	83a	80a	85a	101a	89a	27
	Oat	110a	95a	100a	107a	97a	22
	Pea	101a	98a	83a	95a	97a	21
Yield As % of control	Barley	111a	110ab	110ab	110ab	106ab	10
	Canola	110a	109a	109a	105a	102a	14
	Oat	103a	98a	92a	102a	102a	13
	Pea	102a	127a	110a	123a	110a	40

* The same letter within a row denotes no significant difference from control treatment at $p \leq 0.05$.

Table 3. Effect of herbicide residues on seedling dry weight and yield of rotational crops seeded 13 months after application at Pendelton.

Data	Crop	Procarbazone-sodium 0.02	0.04	0.08 kg ai/ha	Triasulfuron 0.018 kg ai/ha	Sulfosulfuron 0.036 kg ai/ha	LSD p?0.05
Seedling dry weight as % of control	Barley	108a	99a	98a	107a	94a	16
	Canola	101a	97a	104a	81a	118a	50
	Oats	98a	93a	64b	103a	101a	12
	Peas	94a	85a	89a	87a	93a	20
Yield As % of control	Barley	88ab	96ab	87ab	90ab	85b	13
	Canola	156a	108a	99a	112a	113a	64
	Oats	94a	77b	53c	95a	99a	17
	Peas	111a	101a	109a	105a	99a	22

* The same letter within a row denotes no significant difference from control treatment at $p \leq 0.05$.

Dissipation Studies.

The residue levels over time after a single application of procarbazone-sodium at three rates, triasulfuron and chlorsulfuron to winter wheat in Corvallis and Pendeltone are presented in Figures 6, 7, 8, 9 and 10 and the half-life values are presented in table 4. The dissipation curves of procarbazone were fitted by a linear regression (Table 5).

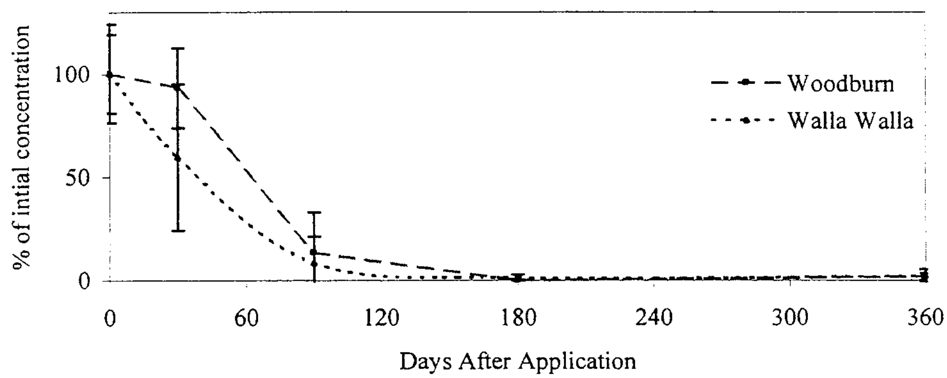

Figure 6. Soil dissipation of 0.022 kg ai/ha procarbazone-sodium.

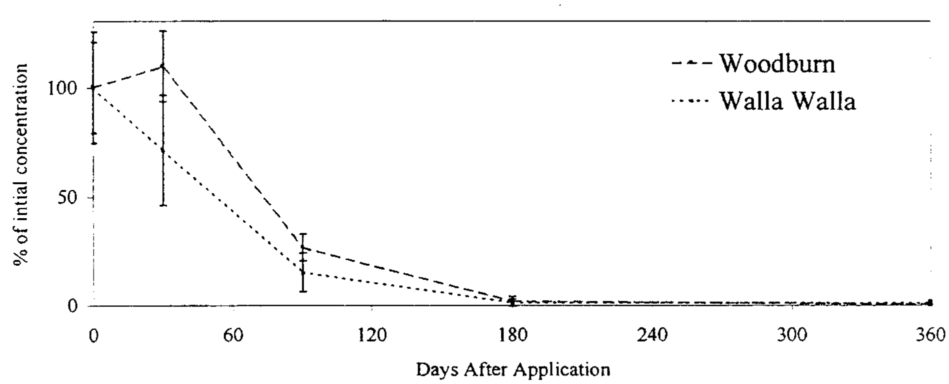

Figure 7. Soil dissipation of 0.044 kg ai/ha procarbazone-sodium.

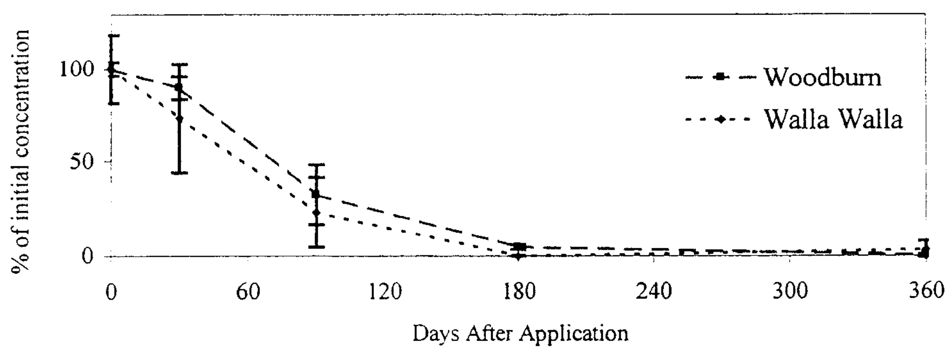

Figure 8. Soil dissipation of 0.089 kg ai/ha procarbazone-sodium.

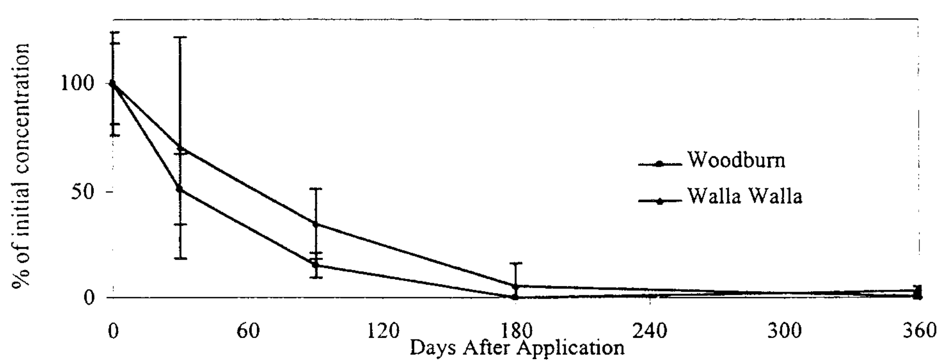

Figure 9. Soil dissipation of 0.018 kg ai/ha triasulfuron.

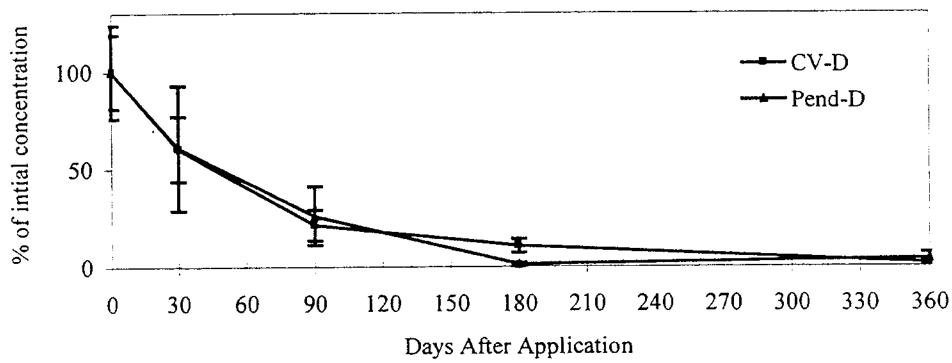

Figure 10. Soil dissipation of 0.036 kg ai/ha sulfosulfuron.

Table 4. Observed dissipation half-life of herbicide treatments in Corvallis and Pendeltone.

Soil type	Procarbazone-sodium			Triasulfuron	Sulfosulfuron	
	0.022	0.044	0.089	0.018	0.036	
	Kg ai/ha			kg ai/ha	kg ai/ha	
	(days)	(days)	(days)	(days)	(days)	LSD $_{=0.05}$
Woodburn	$64a^{2}$*	$75a^{1}$	$76a^{1}$	$36b^{4}$	$48a^{3}$	11
Walla Walla	$44b^{2}$	$49b^{2}$	$55b^{2}$	$73a^{2}$	$51a^{1}$	20
LSD $_{=0.05}$	12	23	14	29	23	

* The same letter within a column and the same number within a row denotes no significant difference at p 0.05.

Table 5. Linear regression model of soil dissipation of procarbazone-sodium and estimated half-life.

Site Procarbazone-sodium Rate	Estimated Parameter A	Estimated Parameter B	Parameter SE A	Parameter SE B	Estimated Half-life (day)	Obseved Half-life (day)
Woodburn						
(0.022 kg ai/ha)	98.8	- 6.1	9.16	0.79	64	64
(0.044 kg ai/ha)	105	- 6.3	7.8	0.68	76	75
(0.089 kg ai/ha)	102	- 6.3	6.5	0.50	75	76
Walla Walla						
(0.022 kg ai/ha)	86.1	- 5.5	9.2	0.80	43	44
(0.044 kg ai/ha)	92.5	- 5.7	7.2	0.63	53	49
(0.089 kg ai/ha)	97	- 5.7	8.2	0.72	59	55

The predicted half-life time was similar to the observed values. Moreover the dissipation rate of all three rates of procarbazone-sodium was similar within the site (Table 5). The half-life of procarbazone-sodium at the rates of0.022, 0.044 and 0.089 kg/ha in the Woodburn soil was longer than it was in Walla Walla soil (Table 4). This may be attributed to different environmental conditions between the two sites. The half-life of sulfusulfuron did not affected by the two site. Triasulfuron residue was found to be heigher in the Walla Walla soil, that received lower rain fall and had lower soil temperature versus the Woodburn soil (Figure 9). The half-life of triasulfuron in the Woodburn soil was significantly shorter than it was in the Walla Walla soil (p ? 0.05) (Table 4). This may due to microbial degradation that is increase as soil moisture increase. Iwanzik and Egli, (1989) found that with increasing soil % OM, triasulfuron injury to beets decreased due to substantial adsorption of triasulfuron. The half-life of triasulfuron in soil samples from different depths (0-20, 20-40, 40-60 cm) increased as soil depth increased due to slight increasing of soil pH from 6.5 to 6.8 to 7 and decreasing % OM from 4.01 to 3.03 to 2.17 (Sarmah et al, 1998).

The results with procarbazone-sodium were not as the same as the sulfonylurea herbicides. Although the soil temperature and rainfall were hiegher at Corvallis than at Pendeltone (Figures 1, and 2), procarbazone-sodium was found to persist longer in Corvallis. Another sulfonamide herbicide, fumetsulam with a pKa value of 4.6 was found to be more strongly adsorbed and persisted longer in the soil as the soil pH decreased from 7.1 to 5.9 (Fontaine, et al, 1991). This was attributed to the large proportion of the neutral form versus the anion forms as soil pH decreased which lead to more soil adsorption as % OM increased from 2.2 to 4.2. One possibility that may explain the longer persistence of procarbazone-sodium in the Woodburn soil compared to the Walla Walla soil, was that the lower soil pH in the Walla Walla soil may have caused a more rapid dissipation of procarbazone-sodium which might be due to larger proportion of neutral form of procarbazone sodium as soil pH decreased. Soil dissipation of procarbazone-sodium increases as soil pH decreases (Hans Santel, personal communication, 1998). Another possible explanation could be that the higher % OM in the Woodburn soil caused more exchange adsorption surfaces for the procarbazone-sodium, which led to a decreased rate of microbial degradation of the herbicide. In Woodburn soil, all three rates of procarbazone-sodium had a longer half-life compared to triasulfuron and sulfosulfuron (Table 5). In Walla Walla soil, the half-lives of the three rates of procarbazone-sodium were longer than triasulfuron but not significantly different from sulfosulfuron (p ? 0.05).

The mobility study showed that triasulfuron (Figure 11) is less soil mobile than sulfosulfuron (Figure 12) and procarbazone-sodium (Figure 13). Triasulfuron water solubility (815 mg/L) (Ahrens, 1994) is 50 % lower than sulfosulfuron (1626.8 mg/L) (Hatzios, 1998) at soil pH 7. Sulfosulfuron exhibited similar soil mobility to procarbazone-sodium. Since procarbazone-sodium persists longer or similarly to triasulfuron or sulfosulfuron which have lower or similar soil mobility, soil mobility of procarbazone-sodium dose not explain the persistence of procarbazone-sodium compared to the reference herbicides. Because triasulfuron, sulfosulfuron and procarbazone-sodium were shown to leach below 10-cm (Figures 11, 12, and 13), shallow rototilling may have no impact on soil dissipation of these herbicides.

Procarbazone-sodium persisted longer at Corvallis compared Pendeltone. The corn root bioassay was sensitive enough to detect bioactive residues of procarbazone-sodium. Factors that effect the physical and chemical properties of procarbazone-sodium in the soil need to be determined to know more about its environmental fate, dissipation and persistence in the soil as affected by soil environmental conditions.

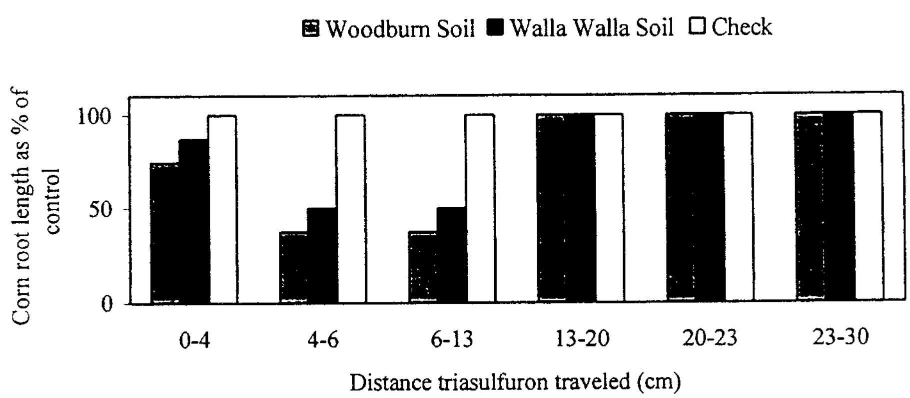

Figure 11. Triasulfuron movement after 15 h.

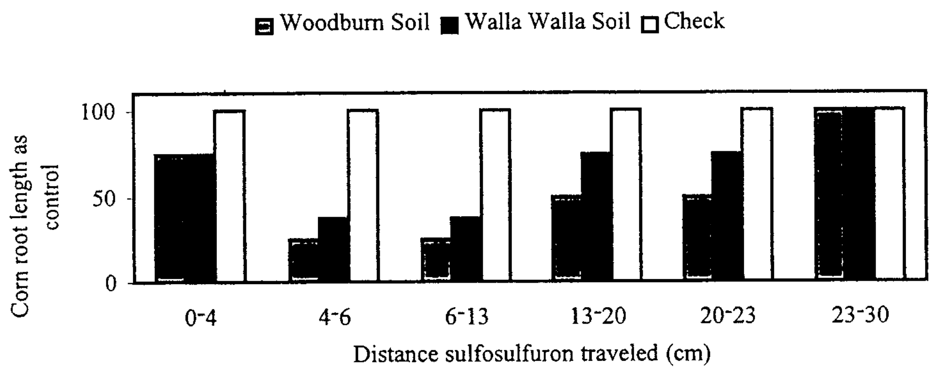

Figure 12. Sulfosulfuron movement after 15 h.

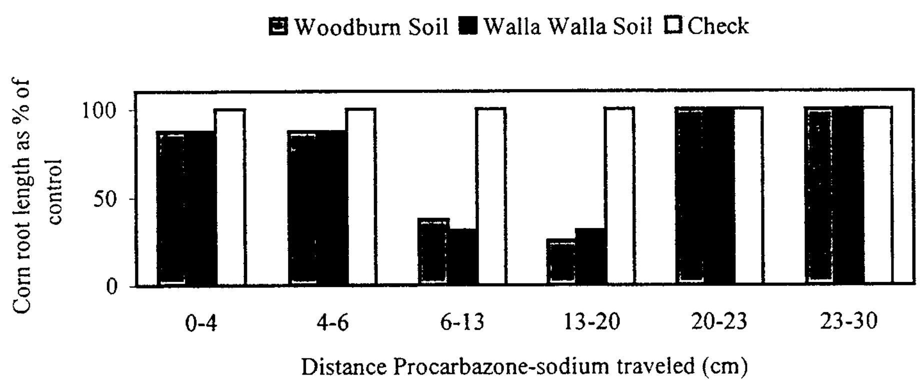

Figure 13. Procarbazone-sodium movement after 15 h.

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بحث رقم (١٢٠)، مركز بحوث كلية الزراعة، جامعة الملك سعود، ص (٥-٢٩) ١٤٢٤هـ

تأثير بروكاربازون – صوديوم على دورة المحاصيل الزراعية واختفاءه من التربة

خالد فرج آل مطلق[1] كيرول مالوري سميث[2] ادميثل بول[3]

الملخص

أجريت تجارب في مدينتي كورفالس وبندلتن في ولاية أورجون الأمريكية لدراسة تأثير البروتابازون – صوديوم على محاصيل الدورة الزراعية وبقاءه الحيوي بعد تطبيقه مرة واحدة على محصول القمح الشتوي. بروكاربازون طبق بثلاث معدلات: ٠,٠٢٢، ٠,٠٤٤، و ٠,٠٨٩ كجم مادة فعاله/هكتار في فبراير ٢٥ ومارس ٢١ عام ١٩٩٧م في مدينة تورفالس وبندلتن على التوالي. محاصيل الدورة الزراعية المختبرة كانت شعير ربيعي، شوفان ربيعي، كنولا ربيعي، بازلا ربيعي وعدس أحمر. تأثر فقط الشوفان الربيعي بمتبقيات المعدلين العاليين من البروكاربازون في بندلتن. أختفاء بروكاربازون صوديوم قيس مع الوقت باستخدام التقييم الحيوي لجذور الذرة بقياس استجابة طول الجذور لمتبقيات المبيد. بقاء بروتابازون صوديوم في مدينة تورفالس كان أطول حيث كان نصل العمر للمبيد في التربة ٧٥ يوم مقارنة بـ ٤٩ يوم في مدينة بندلتن.

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