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Persistence of Chlorsulfuron in Sandy Loam Soil in Relation to Temperature

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ABSTRACT

The dry weight of maize shoot, the test plant increased significantly with each successive increase in temperature level from 15-35°C and incubation period from 0-120 days. Whereas increase in concentration of chlorsulfuron (0 to 40 ppb) caused significant reduction in dry weight of maize shoot. At 120 days of incubation, the GR_{50} (Growth reduction 50%) at 35°C was approximately 10 times higher than that at 15°C. The half-life of chlorsulfuron was 142, 93 and 80 days at 15, 25 and 35°C, respectively.

INTRODUCTION

Temperature is one of the most important factors influencing the rate of degradation of sulfonylurea herbicides which increases with increase in temperature (Vega *et al.*,1992). Both chemical and microbial degradations are enhanced by warmer temperatures (Beyer *et al.*,1988). At temperatures below 25-27°C, the contribution of microbial factors towards degradation exceeds that of chemical hydrolysis (Bondarev *et al.*,1990).

It may be possible to develop prescription for safe recropping of the treated area by quantitative estimates of rate of persistence under a range of temperatures prevailing during the season. Maize (*Zea mays* L.) is a sensitive crop to chlorsulfuron. The aim of the current investigation was to study the persistence of chlorsulfuron under different temperature conditions using maize as test plant.

MATERIALS AND METHODS

Thirty- six kg air- dried sandy loam sieved soil having 60.4% sand, 19.5% silt, 19.3% clay and 0.42% organic carbon with a pH of 8.0 was taken. Two kg of this soil was treated with 10.7 ml of 10 ppm stock solution of chlorsulfuron giving an initial concentration of 80 ppb. Thus, total 18 lots of 2 kg each (6 lots for each temperature 15, 25 and 35°C) and each temperature comprising six incubation periods (0, 7, 15, 30, 60 and 120 days) were prepared. These admixed soil samples were then transferred to steel jars (15 cm x 10 cm). These six steel jars having chlorsulfuron treated soil covered with silver foil were placed in each of three incubators maintained at 15, 25 and 35°C. Each jar was weighed accurately before keeping in the incubator and constant soil moisture was maintained by adding distilled water as and when needed to bring the soil to field capacity. The jars were removed from incubators after completion of the desired incubation period and were stored in deep freezer at -4°C in order to avoid further degradation of chlorsulfuron.

For bioassay studies, wicks of 30 cm length were wrapped with non-absorbent cotton in the centre (near about 15 cm). After sterilizing in the boiling water and drying, these wicks were fitted in the pipe of the conical pot in such a way that above cotton portion of wicks remained in pot and below cotton portion of wicks went down to the wide mouth water filled bottles placed below pots. Thus, the wicks served as capillaries as the water was supplied from below. Soil samples removed from deep freezer after completion of all incubation periods were dried in shade for 24 h and soil was well pulverized by crushing with a pestle and mortar. Each 2 kg soil (80 ppb concentration) of desired incubation period was mixed with fresh untreated 2 kg soil. Out of this 4 kg soil, 2 kg soil (40 ppb

Table 1. Dry weight (mg plant^{-1}) of maize shoot as affected by chlorsulfuron

Chlorsulfuron concentration (ppb)	Incubation period (days)						Temperature (°C)			Mean
	0	7	15	30	60	120	15	25	35	
0.0	550	550	550	550	550	550	550	550	550	550
2.5	203	249	263	293	345	377	188	309	368	288
5.0	172	215	227	260	311	343	155	274	335	255
10.0	122	153	177	204	24.5	289	98	216	280	198
20.0	65	102	121	155	178	234	63	158	207	143
40.0	29	58	80	120	146	172	18	130	155	101
Mean	190	221	236	264	296	327	179	273	316	
LSD (P=0.05)	Concentration 10		Period 11	Concentration x Period NS			Temperature 8	Temperature x Concentration 17		

Table 2. Visual phytotoxicity (%) on maize due to residues of varying concentrations of chlorsulfuron

Chlorsulfuron concentration (ppb)	Incubation period (days)						Temperature (°C)			Mean
	0	7	15	30	60	120	15	25	35	
0.0	4.05	4.05	4.05	4.05	4.05	4.05	4.05	4.05	4.05	4.05
	(0.5)	(0.5)	(0.5)	(0.5)	(0.5)	(0.5)	(0.5)	(0.5)	(0.5)	(0.5)
2.5	47.74	46.81	45.92	43.85	42.27	39.90	54.16	42.16	36.93	44.42
	(54.7)	(53.2)	(51.6)	(48.0)	(45.3)	(41.2)	(65.7)	(65.7)	(36.1)	(49.0)
5.0	57.78	55.04	53.61	51.96	49.73	46.98	61.42	49.89	46.24	52.52
	(70.0)	(67.1)	(64.8)	(62.1)	(58.2)	(53.4)	(77.1)	(77.1)	(52.1)	(63.0)
10.0	65.19	62.87	61.10	58.86	56.22	52.45	66.57	58.37	53.40	59.45
	(82.4)	(79.2)	(76.63)	(73.3)	(69.1)	(62.8)	(84.2)	(84.2)	(64.5)	(74.2)
20.0	70.72	68.52	66.29	63.61	59.67	55.85	69.19	63.27	59.87	64.11
	(89.1)	(86.6)	(84.8)	(80.3)	(74.5)	(68.5)	(87.4)	(87.4)	(74.8)	(80.9)
40.0	76.87	73.43	70.55	68.34	64.52	59.87	71.82	68.73	66.25	68.93
	(94.8)	(91.9)	(88.9)	(86.4)	(81.5)	(74.8)	(90.3)	(90.3)	(63.8)	(87.1)
Mean	53.72	51.79	50.25	48.44	46.07	43.18	54.53	47.24	44.45	
	(65.0)	(61.7)	(59.1)	(56.0)	(51.9)	(46.8)	(66.3)	(66.3)	(49.1)	
LSD (P=0.05) Concentration		PeriodTemperatureConcentration x period								
		0.58	6.63	1.10			1.42			

The data in parentheses are original, which have been transformed to arcsine transformation $\sin^{-1}\sqrt{x+0.5}$ replaced zero before transformation.

concentration) was used to fill four pots of 500 g each to be used as four replications and remaining 2 kg soil was used for further dilution with untreated soil in order to get the concentrations of 20, 10, 5 and 2.5 ppb, respectively. Untreated control was maintained for comparison by filling four pots with fresh untreated soil for each treatment. These pots were kept on wide mouth bottles with their wicks in the water. Ten seeds of maize (African tall) were sown at 5 cm depth on 21 February, 2001 just after filling the pots. Moisture content in the pots was maintained at constant by placing the pots on wide mouth bottles which were filled with water regularly .The data on shoot dry weight, visual phytotoxicity (0-100 scale) were recorded on 35 days after sowing (DAS). The average of three plants was taken for analysis. The data were analyzed using three-factor completely randomized design. The data on mean visual phytotoxicity were subjected to arcsine transformation and from these values probit regression analysis was made to find out GR_{50} values and half-life of chlorsulfuron. Half life of chlorsulfuron was calculated from herbicide (%) remaining in the soil after a particular period which was calculated as :

$$\text{Herbicide (\%) remaining in the soil after 't' days} = \frac{GR_{50}\text{ after 0 day}}{GR_{50}\text{ after 't' day}} \times 100$$

The herbicide remaining in the soil was plotted against the incubation period to obtain the curves for different situations.

RESULTS AND DISCUSSION

The dry weight of maize shoot increased significantly with each corresponding increase in the temperature level. The relative increase in shoot dry weight was 52 and 76% at 25 and 35°C as compared to 15°C (Table 1). Similarly, the increase in shoot dry weight at different incubation periods as compared to zero day incubation was 16, 24, 39, 56 and 72% at 7, 15, 30 , 60 and 120 days of incubation, respectively. The shoot dry weight decreased significantly with increasing concentration of chlorsulfuron. The relative decrease in shoot dry weight was found to be 48, 54, 64, 74 and 82% with 2.5, 5.0, 10, 20 and 40 ppb chlorsulfuron, respectively, as compared to untreated control. These results get full support from those of Duffy *et al.* (1987), Walker *et al.* (1989) and Kotoula-Syaka *et al.* (1993).

The visual phytotoxicity decreased significantly from 54% at 0 day incubation to 35% at 120 days incubation (Table 2). The phytotoxicity increased from 0 to 69% as the concentration increased from 0 to 40 ppb. As the degradation of chlorsulfuron was faster under higher temperature, the mean visual phytotoxicity increased from 44% at 35°C to 54% at 15°C. The GR_{50} values increased as the temperature increased from 15 to 35°C at all

Table 3. GR_{50} of chlorsulfuron and herbicide (%) remaining in soil incubated for different periods at 15, 25 and 35°C temperatures

Incubation period (days)	GR_{50} (ppb)			Herbicide (%) remaining in soil		
	15°C	25°C	35°C	15°C	25°C	35°C
0	0.48	2.40	3.39	-	-	-
7	0.51	2.67	3.82	94	90	89
15	0.53	2.79	4.48	91	86	76
30	0.61	3.32	5.15	79	72	66
60	0.68	3.98	6.00	71	60	57
120	0.87	5.58	8.91	55	43	38

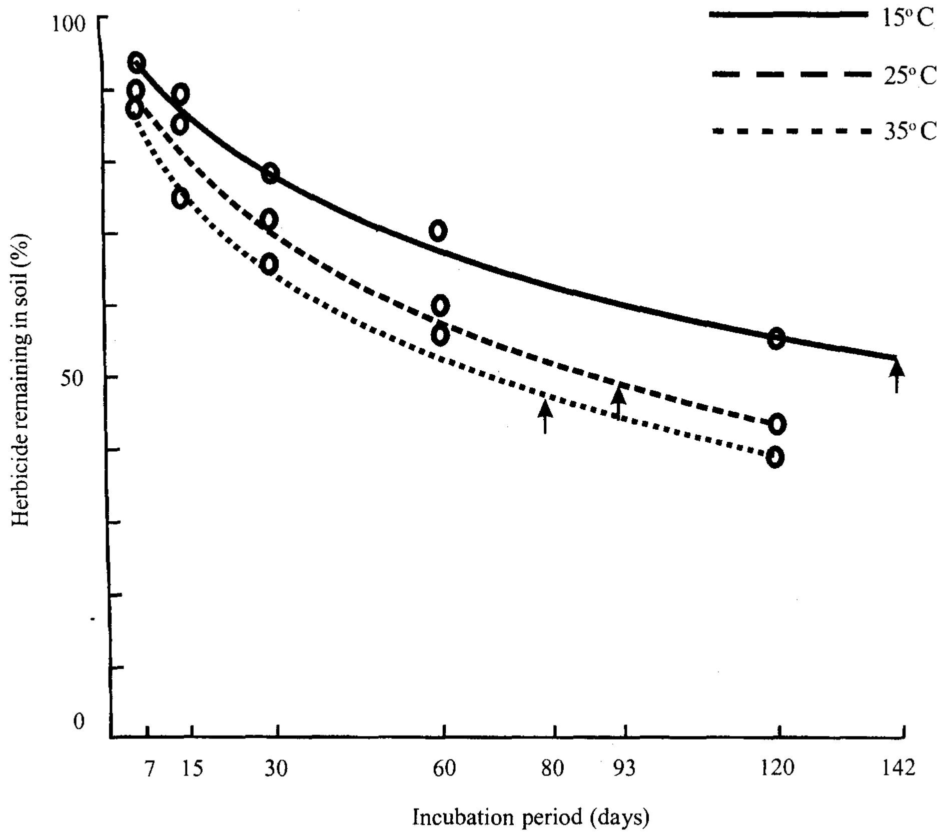

Fig. 1 Effect of temperature on degradation of chlorsulfuron.The arrow indicates half-life of chlorsulfuron.

incubation periods. Likewise, the GR_{50} increased with increase in incubation period at each temperature level (Table 3). At 120 days of incubation, the GR_{50} at 35°C was approximately 10.24 times higher than that at 15°C .Thus, it can be concluded that degradation of chlorsulfuron was faster at 35°C than 15°C .The half-life of chlorsulfuron also decreased with increasing temperature which was observed to be 142, 93 and 80 days at 15, 25 and 35°C temperature (Fig. 1), respectively. Similarly, James *et al.* (1999) also reported decreased half-life of chlorsulfuron as the temperature increased from 10 to 30°C.

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