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PERSISTENCE OF S-METOLACHLOR IN SOUTHERN GUINEA SAVANNA, OGBOMOSO NIGERIA

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ABSTRACT

The persistence of S-metolachlor was monitored under maize plots during two growing seasons in Southern Guinea Savanna soil of Ladoke Akintola University of Technology, Ogbomoso, Teaching and Research Farm and a farm settlement in Ogbomoso in two growing seasons in the using Spectronic 2ID for residue analysis of samples. The treatments applied were 1.6 l/ha, 1.2 l/ha, and 0.8 l/ha and two controls of hand weeding alone and zero weed control and replicated thrice. S-metolachlor residue from the soil decreased faster during the first four weeks after application; followed by a slower rate of disappearance four to eight weeks after application. The disappearance time (DT) values showed that 10% (DT_{10}) of the initial concentration was lost by 9.7, 10.1, and 13.2 days after application for 1.6, 1.2, and 0.8 l/ha rates respectively. At 80.1 days after application, 75% (DT_{75}) of S-metolachlor at the usual recommended rate of 1.6 l/ha had disappeared; at 55.4 days after application, 50% (DT_{50}) of this rate had disappeared. Weed control assessment at this period showed a relatively inadequate control of weeds due to the loss of the applied S-metolachlor. This indicated that adequate weed control cannot be expected by eighth week after application and beyond. S-metolachlor was found to be moderately persistent in this zone.

KEY WORDS: *Disappearance time, DT_{50}, Persistence, S-metolachlor residue, maize plot*

INTRODUCTION

Herbicides are the main class of pesticides used extensively in home gardens and farms all over the world (Coelho-Moreira *et al*., 2013; Luchian et al, 2019). An area of concern in chemical weed control is that of herbicides persistence. S-metolachlor (mixture of 80–100% 2-chloro-*N*-(6-ethyl-*o*-tolyl)-*N*-[(1*S*)-2-methoxy-1-methylethyl] acetamide and 20–0% 2-chloro-*N*-(6-ethyl-*o*-tolyl)-*N*-[(1*R*)-2-methoxy-1-methylethyl] acetamide) is one of the herbicides commonly used for weed control in maize and sorghum. *S*-metolachlor is a chiral compound comprised of 88% S-enantiomer and 12% *R*-enantiomer. At the same application rate level, *S*-metolachlor is

1.4-1.6-fold more active than the Metolachlor (50% S-enantiomer and 50% *R*-enantiomer) (Grichar *et al.*, 2001; Peter *et al*., 1998).

The mean half-life of S-metolachlor was 23 days in distillation studies at different European field sites. At use rates and with highly concentrated formulations containing up to 90% (W/V) a. i. the use of S-metolachlor will result in a substantial reduction of risk to applicators, consumers and the environment (Grichar *et al*., 2001). Very adsorptive soil requires high rates of application.

There is no universally accepted classification of pesticide environmental persistence. However, Roberts (1996) used a classification based on the mean half-life of the pesticide in the soil: i) Impersistent [or "non-persistent"], $DT_{50}<5$ days; ii) slightly persistent, DT_{50} = 5-21 days; iii) moderately persistent, DT_{50} = 22-60 days; and iv) very persistent, $DT_{50}>60$ days. Any estimate of field dissipation half-life or comparable index of persistence is dependent on a variety of factors. For example, DT_{50} values tend to be shorter in warm, moist climates compared to cooler, drier soils. Alkaline soils tend to prolong persistence for certain herbicide classes, notably sulfonylureas and triazines. Thus, although a single value may be reported for DT_{50}, for an herbicide, it usually represents a range, often very wide.

Efforts to reduce the rates of herbicide application are often associated with reduced efficacy (Berti & Zanin,1997; Muyonga *et al*., 1996) and therefore, added economic risk to the farmer. In contrast, the development of S-metolachlor provides a valuable opportunity, by virtue of its reduced application rate, to substantially reduce chemical load to the environment whilst maintaining biological performance. In Nigeria, Ayeni (1991) observed that many a time the herbicides are not within the reach of the farmers who are also both technically deficient to apply them correctly and economically poor to afford the high prices that the herbicides command. In addition, there is limited information on the safety of the chemicals in the Nigerian environment, as the only information available as regards these chemicals are reports from other parts of the world.

Soil type effects on persistence *per se* have been shown to better be compared in field experiments due to the complicating influences of climate, especially rainfall and temperature Sheets (1970). It is therefore desirable to establish the persistence of a given herbicide within similar edaphic and climatic regions where the information is intended to be used. The choice of which crops will immediately follow maize in a rotation within one year where pre-emergent herbicides have been applied for weed control depends largely on knowledge of their persistence in the environment (Akinyemiju *et al.*, 1986). The objective of this study was to trace the disappearance of S-metolachlor in Southern Guinea Savanna zone of Nigeria and to relate the persistence to the effectiveness of weed control in treated field.

MATERIALS AND METHODS

The experiment was conducted at Ladoke Akintola University of Technology, Ogbomoso, Teaching and Research Farm and a farm settlement in Ogbomoso in two growing seasons. Both sites were located on Latitude 80°10[1,] Longitude 4°10[1]E and Altitude of 700m.

Land preparation, experimental design and treatments application. The site in each of the two locations was disc ploughed twice and manually leveled. The experiment was laid out in a Completely Randomized Block Design (CRBD) with five treatments: three levels of S-metolachlor 1.6 l/ha, 1.2 l/ha, and 0.8 l/ha and two controls of hand weeding alone and zero weed control (weedy check) and replicated thrice. Each block contained five (5) beds of 5 m by 5 m, spaced at 2 m apart.

Weed assessment. Weed density was assessed three weeks after spraying {21 days after spraying (DAS)} using 0.025 m x 0.025 m quadrats at two spots per plot, also, in the same way harvestable weeds was taken at eight weeks after spraying. Weed biomass were measured by oven-dried the collected fresh weeds at 80°C in JP SELECTA, S. a. CE V230 Cod: 2000209 Serial number 0446955 at 80°C to constant weight and weighed for dry matter evaluation using Gibertini TM 1600 Max.1600, d=0.01 Top Loading balance.

Assessment of herbicide persistence in treated field plots. Eight samples of the treated soils were taken at a usual depth of 15 cm using soil auger. The first samples were taken within 24 hours of application. Two other samples were taken at weekly intervals while the remaining five samples were collected at two weekly intervals (Akinyemiju *et al.*, 1986).Three samples were taken per plot, mixed together to form a composite sample and taken in polyethylene bags to the laboratory for Spectronic 2ID analysis of the S-metolachlor residue.

Extraction of Herbicide Residues. Five (5 g) of soil sample was weighed using a Metler top loading balance and 25 ml of Ethyl acetate was added in the presence of anhydrous Sodium sulphate (10 g) and Sodium chloride (10 g). They were homogenized on shaker at a high speed for 3 minutes. The homogenate was filtered through a Whatman No. 1 filter paper. The filtrate was left to pass through activated charcoal, (i.e. the activated charcoal was put on filter paper when the solution was then poured) to remove certain impurities. The standards were prepared using S-metolachlor at 0.5 ppm, 1.0 ppm, 1.5 ppm, 2.0 ppm. The clear filtrate was then read on the Spectronic 21D at 420 nm wavelength. The standard curve was plotted to obtain the slope (AOAC (2005); Miller *et al*. (1981). **Calculation:**

$$\text{Absorbance x Slope x Dilution Factor}$$

$$\text{Slope for S – metolachlor} = 0.148$$

Statistical analysis. Data from persistence soil analysis were subjected to regression analysis and regression curves obtained. Weed values were expressed as percentage of the weedy check.

RESULTS AND DISCUSSIONS

The weather records obtained during the 2008 and 2009 growing seasons are shown in Table 1. Mean temperature, rainfall and sunshine were generally higher in 2008 than in 2009.

TABLE 1. Monthly weather data of Nigerian Meteorological Agency, Ilorin Airport

Meteorological data during the experiment (2008 (Year A) & 2009 Year B)

Date (months)	Temp(ºC) Max Min	Mean T(ºC)	Relative Humidity (%)	Sunshine (Hrs.)	Rainfall (mm)	No of Rainy days	Pitch Evaporimeter
Year A							
July	29.8 21.8	25.8	87	5.4	318.6	18	2.6
August	28.921.7	25.3	89	4.8	226.3	19	2.8
September	30.1 21.7	25.9	88	4.5	270.3	21	2.3
October	32.3 21.8	27.1	83	7.5	224.5	11	3.4
November	34.9 21.3	28.1	75	8.1	4.8	1	7.2
Year B							
July	30.0 21.8	25.9	90	4.7	313.4	16	2,7
August	27.3 22.0	24.7	90	3.8	209.1	13	2.4
September	30.5 21.9	26.2	86	2.3	185.7	19	2.3
October	31.4 22.0	26.7	85	5.3	122.8	13	2.7
November	33.4 20.2	26.8	67	7.5	4.4	2	3.7
December	33.2 19.2	26.2	-	-	0	nil	-

Figures 1 and 2 showed the disappearance of S-metolachlor with time for 2008 and 2009 respectively. In general, there was a decrease in the concentrations of S-metolachlor residues in the soil from the day of application irrespective of the rate. The disappearance time for S-metolachlor was initially low at the highest concentration (1.6 l/ha) except in 2009 at Ogbomoso Farm Settlement where the reverse was the case. As the concentration of the herbicide got reduced with days, the disappearance time no longer followed the level of application. Generally, about 90% (DT_{90}) of S-metolachlor applied at their respective concentrations disappeared between 80-100 days. Fifty per cent (DT_{50}) of the herbicide disappeared between 44-59 days, that is, about 6^{th} to 8^{th} weeks after application. Ten per cent (10%) (DT_{10}) of S-metolachlor had disappeared in less than 15 days after application. Between 0-28 days after soil application, about 4.5 mg/kg to 5.7 mg/kg had disappeared and the rate of disappearance kept decreasing as the concentrations in the soil decreased until 85-98 days when less than 1mg/kg of the herbicide disappeared.

In 2008 at LAUTECH Farm, the three rates controlled the weed in the same pattern while at LAUTECH farm and Ogbomoso farm settlement in 2009, 0.8 l/ha gave a significantly lower weed control than the 1.2 and 1.6 l/ha rates which were in turn not significantly different in their weed control ability.

The weed control assessment eight weeks (56 days) after herbicide application revealed that, though the weedy check gave significantly higher weed biomass than the herbicide sprayed plots, the weed control was not so adequate. In 2008, at the sites, the three rates and even the hoe weeded plots gave less than 40% weed control. The record of 2009 was a bit better as the herbicide recorded between 40.44% to 69.41% weed control. LAUTECH farm recorded a better percentage weed control (67.6-69.6) than Ogbomoso farm settlement (50.9-57) in 2008.

About 50% of the herbicide had disappeared at about eight weeks (56 days) after application. By the 8^{th} week after herbicide application, 1.6 l/ha S-metolachlor gave 37.45% weed control at LAUTECH farm in 2008. Percentage weed control of less than 45% was recorded for the herbicide in Year B at Ogbomoso Farm settlement. The weed control was better in 2009 in which at both plots location 50.2 to about 70% weed control was recorded.

The initial weed control was high at 3 weeks (21 day) after spraying as shown in Table 2 in which the percentage weed control was calculated based weed population 3 weeks after planting. The table indicated great disparity in weed control ability of the herbicide between 3 and 8 weeks after spraying. At the three weeks after spraying when weed density was estimated, more than 75% of S-metolachlor remained in the soil while more than 50% of the herbicide had disappeared before the eighth week of the experiment during which the weed biomass was taken. The percentage weed control at LAUTECH Farm was the best in 2009 for the herbicide at 8th week.

Table 3 shows the characteristics of S-metolachlor in the Southern Guinea Savanna zone as summarized from the results. The applied rates were within the same range in terms of DT_{50} but the mean percentage weed control indicated that the highest rate (1.6 L/ha) which disappeared fastest was the best.

There was no apparent initial lag phase during which no appreciable loss of the herbicides occurred (Akinyemiju *et al*. 1986). S-metolachlor was more effective in 2009 than in 2008 at both sites. The herbicide adequately controlled the weeds 3 weeks after planting due to higher quantity present in the soil at this period. In 2008, the sites recorded serious weed problem which is indicative of less control efficacy of the herbicide. This suggested that the herbicide might have lost some of its efficacy before 8weeks after planting due to factors such as degradation, leaching, runoff, volatilization and soil (and related meteorological) characteristics (Feria-Reyes *et al*., 2011). Some important factors may limit the biodegradation of herbicides in the environment including soil and water and its limited availability to the microorganisms (Abigail & Nilanjana, 2012).

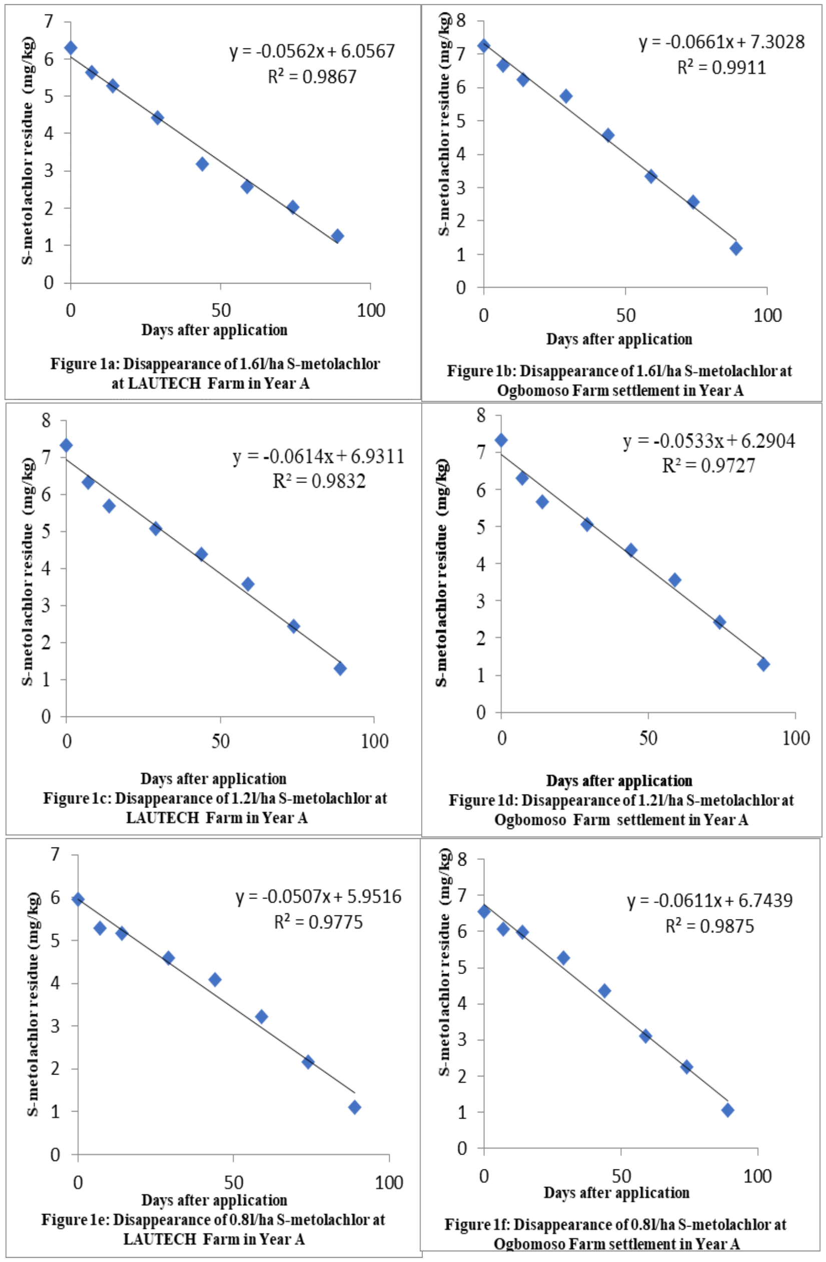

Figure 1a: Disappearance of 1.6l/ha S-metolachlor at LAUTECH Farm in Year A

Figure 1b: Disappearance of 1.6l/ha S-metolachlor at Ogbomoso Farm settlement in Year A

Figure 1c: Disappearance of 1.2l/ha S-metolachlor at LAUTECH Farm in Year A

Figure 1d: Disappearance of 1.2l/ha S-metolachlor at Ogbomoso Farm settlement in Year A

Figure 1e: Disappearance of 0.8l/ha S-metolachlor at LAUTECH Farm in Year A

Figure 1f: Disappearance of 0.8l/ha S-metolachlor at Ogbomoso Farm settlement in Year A

FIGURE 1. The disappearance of S-metolachlor with time in the southern guinea savannah zone in Year A (2008)

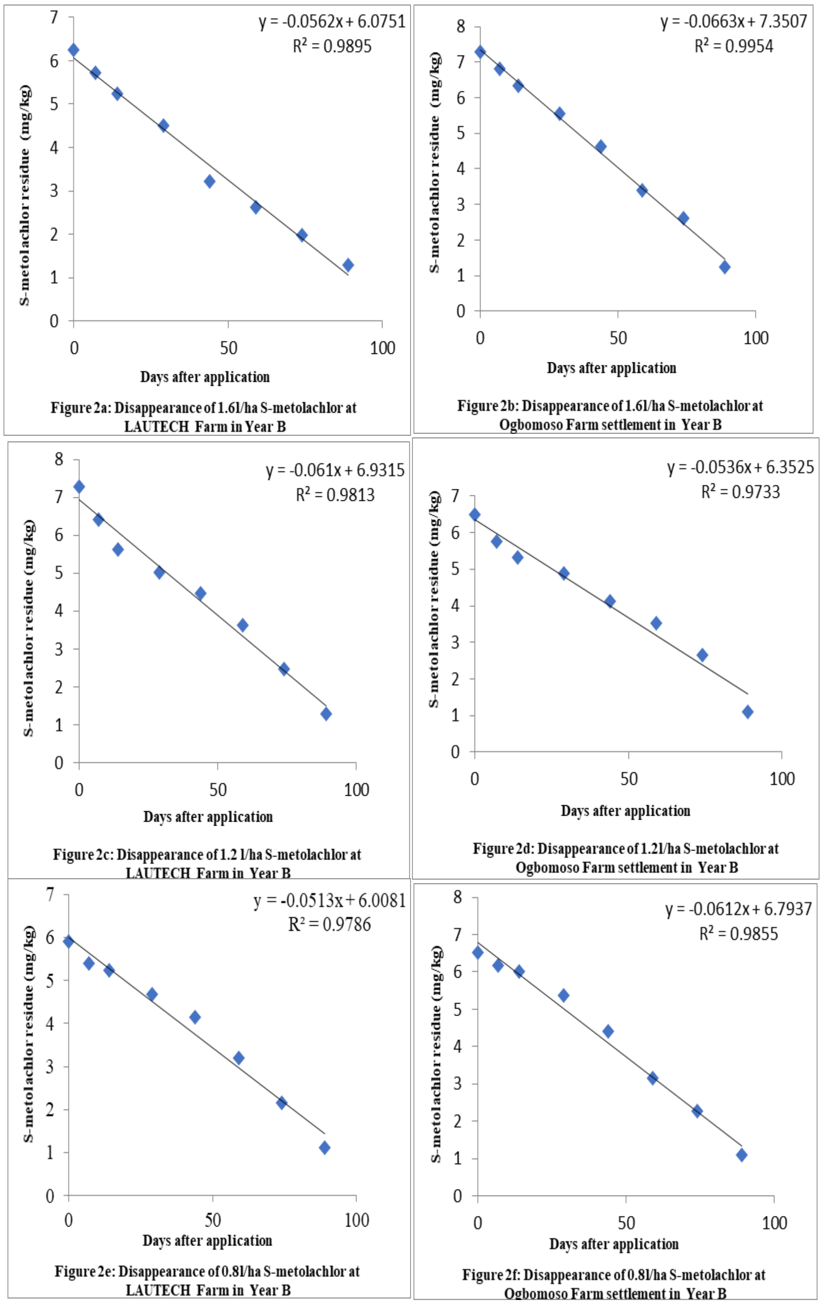

Figure 2a: Disappearance of 1.6l/ha S-metolachlor at LAUTECH Farm in Year B

Figure 2b: Disappearance of 1.6l/ha S-metolachlor at Ogbomoso Farm settlement in Year B

Figure 2c: Disappearance of 1.2 l/ha S-metolachlor at LAUTECH Farm in Year B

Figure 2d: Disappearance of 1.2l/ha S-metolachlor at Ogbomoso Farm settlement in Year B

Figure 2e: Disappearance of 0.8l/ha S-metolachlor at LAUTECH Farm in Year B

Figure 2f: Disappearance of 0.8l/ha S-metolachlor at Ogbomoso Farm settlement in Year B

FIGURE 2. The disappearance of S-metolachlor with time in the southern guinea savannah zone in Year B (2009)

TABLE 2. Effect of S-metolachlor on weed density three weeks after spraying, and weed biomass eight weeks after spraying at the sites during 2008 and 2009 seasons

Application rate (l/ha)	Weed density (% of control)	Weed biomass (%of control)
LAUTECH Farm 2008		
1.6	52.9	37.5
1.2	52.4	37.09
0.8	48.6	28.9
Hoe Weeding	22.4	37.5
Ogbomoso farm settlement 2008		
1.6	76.2	43.9
1.2	77.6	38.7
0.8	68.3	35.8
Hoe Weeding	8.8	41.4
LAUTECH Farm 2009		
1.6	80.5	69.6
1.2	77.6	67.6
0.8	50.2	69.4
Hoe Weeding	-	58.7
Ogbomoso farm settlement 2009		
1.6	81.8	57
1.2	80.3	55
0.8	73.3	50.9
Hoe Weeding	6.0	52.4

TABLE 3. Characteristics of S-metolachlor in Southern Guinea Savanna zone of Nigeria

Rate L/ha	1.6	1.2	0.8
Mean DT_{50}	55.4	53.8	53.4
Mean % Weed control 56DAS	52	49.6	46.3
Mean % Residue. 89DAS	18.5	17.3	17.6
Disappearance rate mg/kg:			
DAS:			
0-28	5.0	5.1	5.0
29-56	3.2	3.4	3.6
57-84	1.5	1.6	1.3
85-98	0.5	0.7	0.6

Source: Year A and Year B Results
Key: Wd = Weed, DAS = Day after spraying, Res. = Residue.

Long *et al*. (2014) reported that the degradation rate of S-metolachlor in sterilized soil was 3.3 times slower than in corresponding unsterilized soil, indicating that microbial degradation was the predominant contributors to dissipation of *S*-metolachlor in soil. The degradation rate of *S*-metolachlor decreased as the initial concentration increased. The disparity in meteorological data during the cropping seasons could be attributed to the difference observed in weed control and herbicide disappearance. There are many reports of herbicides and other pesticides dissipating more rapidly in tropical than in temperate climates (Racke *et al.*, 1997*;* Laabs *et al.*, 2002), which is more likely related to higher mean soil temperature in tropical and subtropical areas. Metolachlor is an herbicide for which vapor phase loss can be large during the first 48 h after application, depending on the climatic conditions. S-metolachlor with a vapor pressure of $2.8x10^{-5}$mmHg at 25^{o}C is likely to vaporize more during 2008. Health Canada (2004) reported that leaching may occur under conditions of excessive rainfall or irrigation, thus S-metolachlor could have leached seriously during 2008 heavy rain. Such leached chemical no longer contribute to weed control and has lessen persistence in the zone relevant to crop production.

There is direct correlation between persistence and the potential for runoff loss, particularly when the chemical remains within the upper 1 cm of surface soil. Runoff is triggered by rainfall, and the highest pesticide loss occurs during the first major runoff-producing event (Waucope, 1978; Leonard, 1988; Leonard, 1990).While herbicide transport by runoff represents an important mechanism for potential environmental contamination of surface waters, the process itself generally removes <5% of total applied chemical and for most pesticides, <0.3% (Waucope,1978). These would lead to loss of the active ingredient from the soil. The loss in phytotoxicity and inability of S-metolachlor at the recommended rate of 1.6 l/ha to control weeds adequately beyond eight weeks (56 days) after application was due to the low level of the herbicide in the soil at this period. The remaining concentration in the soil from this period was not enough to appreciably control the weeds hence the weediness observed after eighth week. The diminishing quantity of the herbicide in the soil in this zone which adversely affected weed control will definitely translate to yield reduction in maize. S-metolachlor was moderately persistent in this zone based on this study.

CONCLUSIONS

All the rates of s-metolachlor applied were moderately persistent in the southern guinea savannah of Nigeria thus put to rest the fear of environmental pollution but the rates were not very effective in weed control. The rate of disappearance decreased with decreasing residue concentration in the soil.

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