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Effect of Groundnut Plant Residues on Germination and Radicle Elongation of Four Crop Species

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ABSTRAK

Pengeluaran hasil kacang tanah (Arachis hypogaea *L.) telah dilaporkan berkurangan melebihi 50% dengan penanaman yang berturutan. Hasil turasan sisa segar dan terhurai daripada pokok kacang tanah telah dibioasai untuk kesannya ke atas percambahan dan pemanjangan radikal empat spesies tanaman. Keputusan menunjukkan bahan perencat daripada sisa larut di dalam air; rawatan haba atau jangka masa penghuraian yang panjang dapat mengurangkan atau menghilangkan aktiviti perencatan. Pengeluaran perencat seolah-olah ada kitarnya dan mungkin berkaitan dengan perubahan pH hasil turasan sisa. Melewatkan tanaman yang berikutnya adalah dicadangkan sebagai langkah untuk mengelakkan kesan ke atas percambahan dan tumbesaran awal jika sisa digaulkan atau ditinggalkan di atas permukaan tanah.*

ABSTRACT

Groundnut (Arachis hypogaea *L.) yield has been reported to decrease by more than 50% with successive croppings. Filtrates from fresh and decomposed groundnut plant residues were bioassayed for their effects on germination and radicle elongation of four crop species. Results obtained indicated that the inhibitory substance(s) present in the residues is soluble in water; heat treatment or prolonged decomposition seemed to reduce or possibly eliminate the inhibitory activity of the residues. The production of the inhibitor(s) also seemed to follow a cycle and may also be associated with changes in pH of the residue filtrates. Delaying planting of the subsequent crop is suggested as a precaution against poor germination and early growth if plant residues were incorporated or left on the soil surface after harvest.*

INTRODUCTION

Groundnut yield was reported to decrease markedly with successive croppings on the same area despite the addition of fertilizers (Chan, 1968; Cheah, 1987). Yields of the subsequent second and third crops were reduced by more than 50% that of the first crop. In some cases, the yield reduction was attributed to increase in disease or pest damage or depletion of soil nutrients. However, substantial evidence has been accumulated to show that phytotoxic substances are produced in most crops and may be responsible for the reduced growth and yield (Cochran *et al.*, 1977; Elliot and Roy, 1982; Garcia, 1983; Guenzi & McCalla, 1962; Guenzi *et al.*, 1967; Kimber, 1973; Norstadt & McCalla, 1968; Robinson & Burdick, 1978; Yakle & Cruse, 1983, 1984).

Residue decomposition, either on the soil surface or incorporated into the soil, has been reported to retard growth and development of subsequent crop (Guenzi & McCalla 1962; Yakle & Cruse, 1983, 1984). Groundnut hulls, for example, were found to produce substance(s) that inhibit germination and shoot growth of cucumber (*Cucumis sativa* L.) seedlings (Robinson

& Burdick, 1978). In addition, increasing the number of years of groundnut cropping between succeeding tobacco (*Nicotiana tabacum* L.) crops resulted in decreased yield and grade of tobacco leaves (Elliot and Roy, 1982). These effects may be due to the release of phytotoxic substances as leachate during rainfall or through microbial breakdown. However, as the plant residues decompose, the inhibitory effects of the residues also decrease (Guenzi *et al.*, 1967; Kimber , 1973; Yakle & Cruse, 1983).

The objectives of this study were to determine the toxicity and the persistence of groundnut plant residues after periods of decomposition in the field using germination and radicle elongation of four crop species to bioassay for their effects.

MATERIALS AND METHODS

Phytotoxicity of Plant Residue

Groundnut plants (tops only) collected after harvest were rinsed with distilled water and then divided into three treatment groups as follows:

i) Freshly harvested plant materials were blended with distilled water in the ratio 1: 15 (w/v) and filtered
ii) Harvested plant materials were oven-dried at 60°C for 3 days and ground to pass through a 0.5 mm sieve before the filtrate was prepared
iii) Harvested plant materials were allowed to decompose in the field for 14 days, then oven-dried and ground as treatment (ii) above

The treatments were replicated four times and the filtrates from each of these treatments were bioassayed for phytotoxic activity according to procedures described by Guenzi *et al.* (1967) using a completely randomized design. Groundnut, maize *(Zea mays)*, mungbean *(Vigna radiata)* and okra *(Hibiscus esculentus)* were used as the bioassay crop.

Ten grams of the plant residue were extracted with 150 ml of distilled water by shaking for 2 h at room temperature (25-32°C). After filtering, the filtrates were tested for phytotoxicity by soaking the appropriate test seeds in the filtrate for 6 h and then incubated between two layers of Whatman No. 1 filter papers in petri dishes at room temperature for 72 h. Ten seeds in each of five petri dishes were used to evaluate the activity of each treatment. Six ml of the same filtrate in which the seeds had been soaked was added to each petri dish. As a control, a set of seeds of the test crop was treated in the same manner but using distilled water instead of the filtrate. After the incubation period, germination percentages were scored and radicle elongation was measured.

Persistence of Phytotoxic Substance in Decomposed Residue

Groundnut plants (tops only) collected directly after harvest were spread evenly on plastic mesh screens erected on frames 30 cm above the ground and left to decompose in the field. The residues were replicated thrice and residue toxicity was analysed at harvest and after 2, 4, 8, 12, 16, 20, 24 and 28 days of decomposition. Samples from each treatment were oven-dried, ground and tested for phytotoxicity using procedures described in (1) above.

RESULTS AND DISCUSSION

Phytotoxicity of Plant Residue

The phytotoxicity of groundnut plant residues to the germination and radicle elongation of four crop species is given in Table 1. Filtrates from the various residue treatments, in general, have an inhibitory effect on the germination and radicle elongation of the species bioassayed. The degree of inhibition, however, differs with the post-harvest treatments and the species tested. The filtrates of fresh residues have greater inhibitory effect on the germination of maize and okra. Only 16% and 70% of the seeds germinated, respectively. Germination of groundnut and mungbean, however, was not affected. Oven-drying or partially decomposing the residues seemed to reduce the inhibitory effect. For maize, germination increased to 60% and 76% for oven-dried and partially decomposed residues, respectively, compared to the fresh residues. Okra, however, were not affected by the oven-dried or partially decomposed residues. Guenzi and McCalla (1962) suggested that the substances affecting germination were probably heat sensitive. In addition, microbial activity and leaching by rainfall during decomposition probably reduced the phytotoxicity of the residues.

The effect of the filtrate on radicle elongation was more pronounced (Table 1). Both radicle

TABLE 1
Influence of different residue treatments on germination and radicle elongation of four crop species*

Residue treat- ments	Groundut		Maize		Mungbean		Okra	
	Germ. (%)	Length (cm)	Germ. (%)	Length (cm)	Germ. (%)	Length (cm)	Germ. (%)	Length (cm)
Fresh (blended)	100 a	3.0 d	16 d	0.7 b	94 a	1.9 c	70 b	0.7 c
Fresh (oven-dried)	100 a	4.1 c	60 c	1.0 b	94 a	5.1 a	86 ab	1.9 b
Partially decomposed	100 a	5.8 a	76 b	5.0 a	96 a	5.1 a	96 a	3.1 a
Control	98 a	4.9 b	92 a	5.3 a	98 a	3.9 b	92 a	2.5 ab

* All means in a column not followed by the same letter were significantly different from one another at 5% probability as determined by Duncan New Multiple Range Test (DNMRT).

elongation and morphological appearance of all the species were affected. Maize and okra were more sensitive to the fresh filtrate than groundnut or mungbean. The extent of inhibition differed from species to species. The order of increasing percent inhibition of fresh filtrate on radicle elongation of groundnut, mungbean, okra and maize was 39, 51, 72 and 87, respectively. This effect on growth appeared to be associated with the browning of the radicle tip in groundnut, maize and okra *(Plates, 1, 2* and *4)*. With mungbean, however, besides apical discolouration, the fresh filtrate stimulated profuse lateral roots on the hypocotyl and delayed emergence of the first pair of leaves *(Plate 3)*. Guenzi *et al.* (1967) also reported a slight stimulation in growth of wheat seedlings treated with extracts from oat and wheat straws. They also

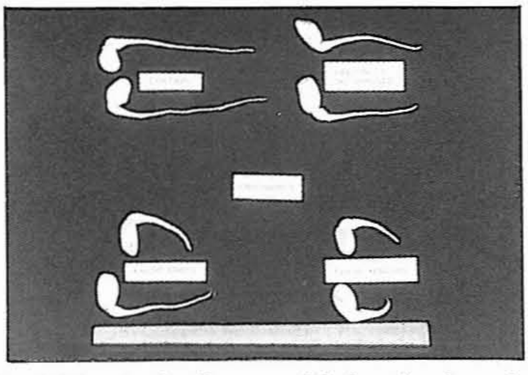

Plate 1: Effect of residue filtrate on radicle elongation of groundnut.

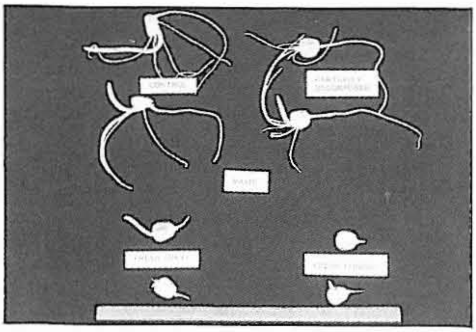

Plate 2: Effect of residue filtrate on radicle elongation of maize.

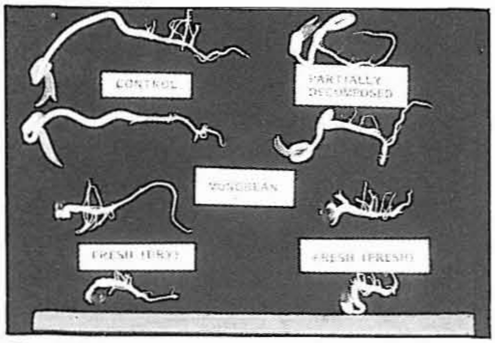

Plate 3: Effect of residue filtrate on radicle elongation of mungbean.

observed differences in tolerance to phytotoxic substances among species. Differences in the tolerance level observed in this study could possibly be due to the selective permeability of the seed coat to the inhibitory substance(s). Other possibilities include tolerance of the growing points to the inhibitory substance(s), seed size and seed surface area: volume ratio during imbibition of the filtrate.

Filtrates from the partially decomposed residues, however, were either stimulatory (groundnut and mungbean) or not significantly different from the control (Table 1). But, browning on the radicle and distorted elongation of the radicle were still present on mungbean and okra, respectively *(Plates 3* and *4)*. Substance(s) affecting the radicle not only restricted elongation but were also phytotoxic, as manifested by the browning and twisting of the radicle.

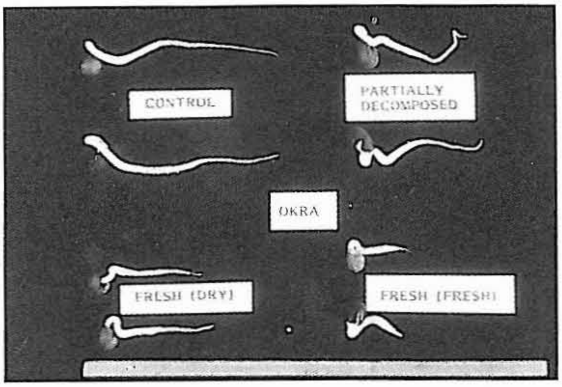

Plate 4: Effect of residue filtrate on radicle elongation of okra.

Persistence of Phytotoxic Substance in Decomposed Residue

Table 2 shows the influence of the residue filtrates taken from different decomposition periods on the germination and radicle elongation of the four species. Compared to the control, the highest reduction to germination was observed at two decomposition periods -4 days and 16 days of decomposition. According to Kimber (1973), the degree of inhibition varied with the time of residue decomposition. In wheat, for example, maximum inhibition was obtained after 2 to 6 days of decomposition. Norstadt and McCalla (1968) also observed that the phytotoxic activity of wheat residues peaked after 10 to 13 days and 26 to 29 days of decomposition. The two periods observed in this study were probably the peaks in the production or release of the inhibitory substance(s) by the groundnut plant residues. There was no correlation between germination and days of decomposition for all the species tested. In descending order of tolerance, groundnut appeared to be the most tolerant

TABLE 2
Influence of filtrates from different decomposition periods on germination and radicle elongation of the four crop species.

Decomposition periods (days)	Germination (%)	Length (cm)
	(Mean of 4 crops species)	
0	95 ab	3.3 de
2	92 bc	2.8 fg
4	87 c	2.5 g
8	94 ab	3.5 d
12	91 bc	3.2 def
16	88 c	2.9 efg
20	97 ab	3.5 d
24	92 bc	4.2 c
28	92 bc	4.6 b
Control	100 a	5.2 a

All means in a column not followed by the same letter were significantly different from one another at 5% probablity as determined by DNMRT.

followed by mungbean and okra; maize showed the least tolerance based on germination scores (Table 3).

TABLE 3
Influence of residue filtrates on germination and radicle elongation of four crop species

Crops	Germination (%)	Length (cm)
	(Mean of decomposition periods)	
Groundnut	98 a	3.2 b
Maize	83 c	3.4 b
Mungbean	94 b	4.9 a
Okra	94 b	2.8 c

All means in a column not followed by the same letter were significantly different from one another at 5% probability as determined by DNMRT.

There was an increasing inhibition to radicle elongation from day 0 to day 4 and from day 8 to day 16 compared to the control - from 37% to 52% and 33% to 44%, respectively (Table 2). After the 16th day, percent inhibition decreased with increasing periods of decomposition. In Table 1, however, the partially decomposed residue was not significantly different from the control; this was probably due to the increased

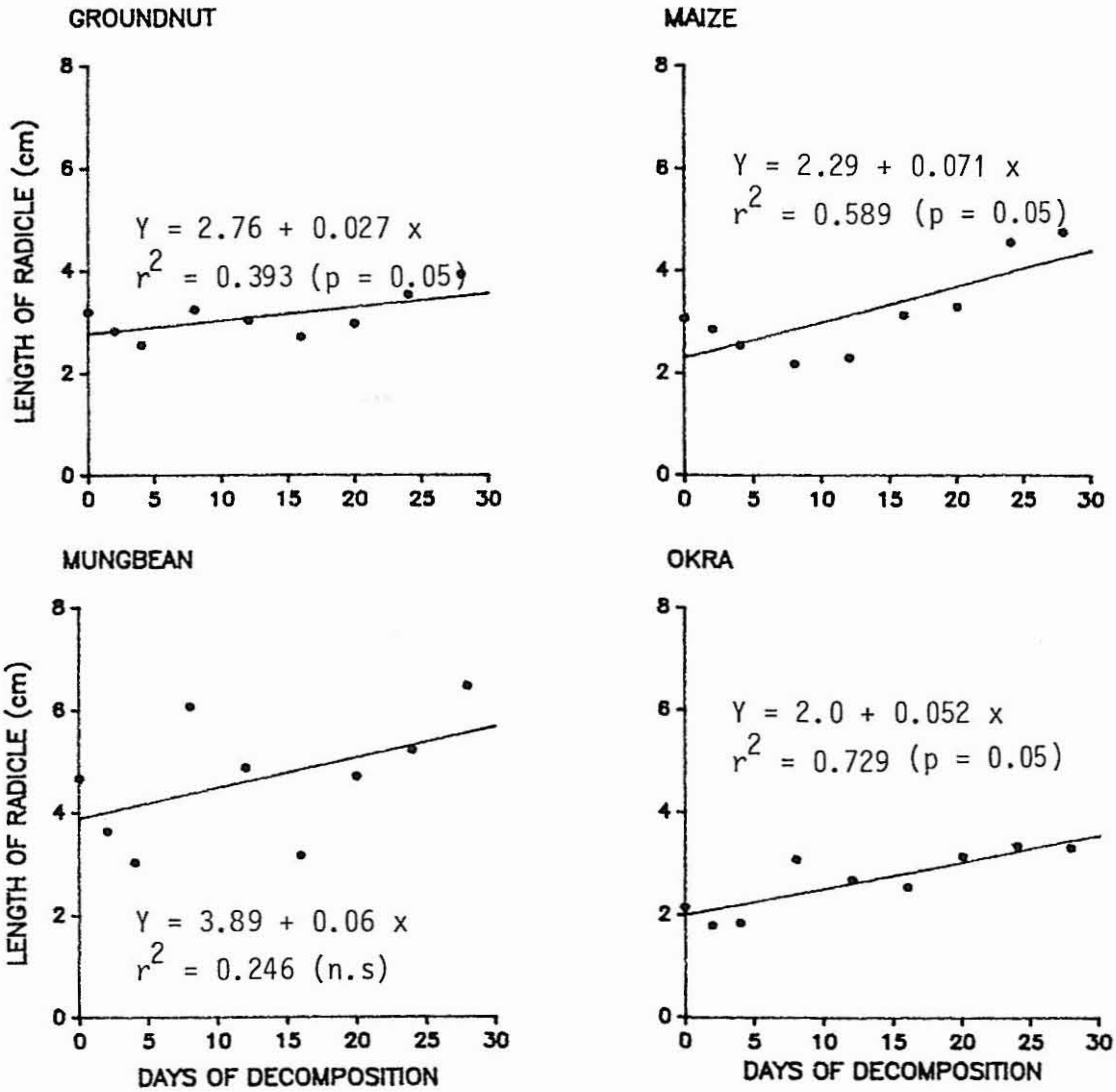

Fig. 1: Influence of residue decomposition periods on radicle elongation of four crop species.

microbial breakdown since the residues were in contact with the soil surface. Guenzi *et al.* (1967) and Kimber (1973) also reported that the inhibitory effect of the residues decreased with increased weathering and that the time taken to reduce the inhibitory substance(s) to tolerable levels also differed among plant species. In this study, radicle elongation of okra was inhibited the most while mungbean was the most tolerant to the residue filtrates (Table 3). In general, radicle elongation correlated well with days of decomposition for all the species tested except for mungbean *(Fig. 1)*. The results concur with the findings by other researchers that increasing the periods of decomposition reduced the phytotoxicity of the residues and that species differed in their susceptibility to the residues.

Cyclical and seasonal variation in the production of the inhibitory substances in residues were reported for wheat (Norstadt and McCalla, 1968; Cochran *et al.*, 1977) and maize (Garcia, 1983). The pattern of variation obtained in this study could imply a different rate of residue decomposition from the different parts of the plant as suggested by Guenzi *et al.* (1967). It is also interesting to note the decrease in acidity of the filtrates with increasing days of decomposition of the residues *(Fig. 2)*. Prolonged decomposition

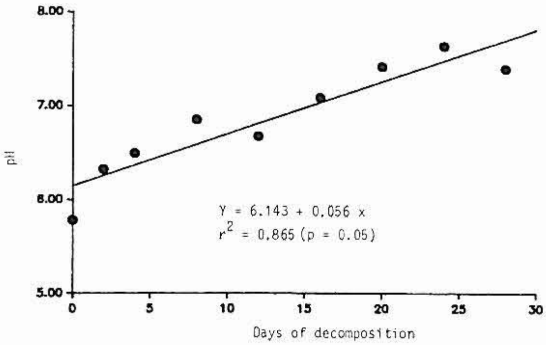

Fig. 2: Influence of residue decomposition periods on pH of filtrates.

produced a more alkaline filtrate. It is too conjectural to speculate the change in pH with decomposition time on the inhibitory effect of the residues. Nevertheless, the results do suggest that there were more than one substance or group of substances involved in restricting germination or radicle elongation. Besides being heat sensitive and biodegradable, the substance or group of substances were active at different pH ranges. Kimber (1973) also noted changes in acidity with different decomposition periods in wheat although there was no obvious correlation between toxicity and changes in acidity.

CONCLUSIONS

Groundnut plant residues may produce growth inhibitors that reduce germination and radicle elongation of groundnut and other crop species. The production of the inhibitor(s) seems to follow a pattern or cycle. The effect on germination and radicle elongation, however, appears to decline as the number of days of residue decomposition increased. The decrease in phytotoxicity may also be associated with the increase in pH of the residue filtrates. The inhibitor(s) seems to be active at different pH ranges, besides being heat sensitive and biodegradable. The filtrate from the fresh (green) plants was more toxic than filtrates from the oven-dried or partially decomposed residues. In general, germination of maize and radicle elongation of okra was inhibited the most by the residue filtrates. Groundnut and mungbean, however, showed some degree of tolerance to the inhibitor(s). Based on the results of this study, a period of at least 30 days is suggested before planting the next crop as a means to reduce or eliminate the inhibitory effect if groundnut plant residues were incorporated into the soil or left on the soil surface after harvest.

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