Trans. Nat. Acad. Sci. & Tech. (Phils.)
1987.9:425-432

RESIDUAL EFFECTS OF CORN (*ZEA MAYS* L.) RESIDUES ON SUCCEEDING CROPS UNDER DIFFERENT TILLAGE LEVELS

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ABSTRACT

The growth and yield of corn, soybean and mungbean crops grown to a field previously planted to corn, and subjected to zero, minimum and conventional tillages were evaluated. Pot experiments using soil samples collected at 10, 17, 24, 31 and 52 days after corn residue application were also made. Favored growth and higher yield of the test crops were obtained when grown to a field with corn residues. Except for corn, tillage levels did not significantly influence the performance of the test crops. Stimulatory and inhibitory effects were observed with the pot experiments. The possible causal factors of corn residue inhibition or stimulation on growth of the test crops are discussed.

Introduction

Allowing crop residues to decompose in the field after harvest and the immediate planting of the subsequent crops in the same field has been a common practice by several farmers. The return of crop residues to the soil is beneficial to crop growth and development since this improves the soil organic matter. However, such practice sometimes results in deleterious effects of succeeding crops.

Well-documented evidences have shown that crop residues left on the field after harvest extremely reduce growth and development to succeeding crops. Decomposing crop residue releases organic substances inhibitory to the growth of the plants usually resulting to swollen seeds, abnormal radicle which lack root hairs and necrosis of the root tips (Patrick and Koch, 1958; Patrick, 1971; Chou and Patrick, 1976). Garcia (1983) has also reported that soils previously planted to corn and have corn residues left after harvest have strong allelopathic effects on the growth of succeeding corn seedlings. The effects are manifested in terms of shorter plants with chlorotic leaves and lower root, shoot and biomass weights.

Recognizing allelopathy as one of the constraints in crop production, there is a need to study the effects of corn residues left in the field after harvest on growth and yield performance of subsequent crops.

The objectives of the study were: 1) to determine the stimulatory or inhibitory effect of corn residues on the growth and yield of corn, mungbean and soybean; 2) to evaluate the effects of tillage on inhibitory or stimulatory effect of corn residues to subsequent crops; 3) to estimate the best time of planting subsequent crops such that inhibitory effect due to corn residues is no longer active.

Materials and Methods

Field experiment

The experimental area of 3,036 square meters which was plowed and harrowed once was divided into two main plots with an area of 1,516 square meters per plot. One of the plots was fallowed for one season while the other was planted to corn for the establishment of crop residues. At harvest, the stalks were chopped and spread on the soil surface. Thereafter, each mainplot was divided into four blocks and each block was subdivided into three subplots. Each subplot had an area of 26.25 square meters with seven furrows maintain at 0.75 meter between rows and 5 meters long. Zero, minimum and conventional tillages were established at random in each block. Corn residues were incorporated into the soil at various depths and proportion depending upon the tillage used. The experiment was arranged in a split-plot randomized complete block design with four replication. Corn residues application and tillages were assigned to the mainplot and subplot, respectively. Zero tillage means that planting was done directly into the field (drill method); minimum, only furrows were established before planting while conventional, one plowing, one harrowing before furrowing were made before planting. Agronomic characters and yield were recorded from corn, mungbean and soybean as test crops. The Duncan's Multiple Range Test at 5% level of probability was used to determine significant differences among treatment means.

Pot experiment

Soil samples were collected at 10, 17, 24, 31 and 52 days after corn residue application in the field. Soils including corn residues were randomly collected from four replicate plots at approximately 10 cm. depth from the soil surface for all tillages. Soils from each tillage represents a treatment. Soil samples were mixed with sieved river sand in a ratio of 50% soil samples and 50% sieved sand (v/v), placed in a clay pots (size 8) and bioassayed using corn, mungbean and soybean as test crops. Planting was done every after each sampling. Experimental units were arranged in a split-plot complete randomized design with ten replication having one pot one plant per replicate. The conventional, minimum, and zero tillages as the source of soil samples with corn residues and the control (fallow soil) were the main plots while days after corn residue application as the subplots. Weekly plant height was recorded. Four weeks after planting, plants were harvested. Dry root, shoot and biomass weights of each test plants were recorded and expressed as percent of control in order to compare the periodic response of test plants to different stages of corn residue decomposition.

Table 1. Corn, soybean, mungbean plant height planted to a field with or without corn residues

	Weeks After Planting																
		1			2			3			4			5		6	7
Treatments	C	S	M	C	S	M	C	S	M	C	S	M	C	S	M	C	C
With corn residue	25^{a}	12^{a}	12^{a}	45^{a}	21^{a}	20^{a}	74^{a}	32^{a}	32^{a}	109^{a}	46^{a}	48^{a}	1,500^{a}	60^{a}	65^{a}	201^{a}	238^{aa}
Without corn residue (control)	22^{a}	10^{b}	10^{b}	14^{a}	21^{a}	19^{a}	68^{a}	31^{a}	29^{a}	96^{a}	45^{a}	46^{a}	139^{a}	64^{a}	65^{a}	188^{a}	228^{a}

Means in a column with the same letter are not significantly different at alpha 0.05 using DMRT. This will be followed in succeeding tables unless otherwise specified.

C = corn S = soybean M = mungbean

Results and Discussion

Field experiment

There was no significant difference in plant height from the control five weeks after planting except for the first and fourth week for mungbean, soybean and corn, respectively (Table 1). The possible causal factors affecting the difference in soybean and mungbean plants might be due to the residual fertility of the soil previously cropped to corn crop that stimulated growth. The significant difference observed during the fourth week of corn growth could not be ascertained if it was due to the presence of corn residues or to other undetermined growth factor.

Table 2 shows that corn grain yield and its earlength were significantly higher when planted to a field with corn residues. This difference might be accounted for the presence of corn residues in the field since percent unfilled ear, percent barren plants and the average number of ears showed non-significant.

The number of plants harvested per plot was determined to possibly explain lower yields in plots with thin stand. As shown in Table 3, mungbean planted to a field with corn residues at thinner stand (560 plants) gave a significantly higher number of pods per plant as compared to mungbean planted to a field without corn residue at thicker stand (644 plants). This might be the reason why mungbean grain yield (760 kg/ha) at thinner stand is comparable to the yield (771 kg/ha) of mungbean without corn residue having thicker stand.

As to the effect of tillage, zero till influences significantly bigger mungbean seed formation and longer corn earlength as compared to conventional tillage. Minimum tillage effect, however, is non-significant with zero till (Table 4). Plant height and yield of test crops were not significantly affected by tillage used.

Pot experiment

Soil samples from the field previously planted to corn and with corn residues left after harvest with three tillages (conventional, minimum, zero) inhibited corn and mungbean growth as shown in shorter plants with conventional tillage which is comparable to those planted in a fallow soil having no corn or other plant residue at all. Stimulation, however, was observed in soybean plants from the three tillages as shown in taller plants (Table 5). Furthermore, the same soil with corn, soybean and mungbean crops currently growing sampled 10 days after corn residue application stimulated growth of the same crops whereas those sampled 17, 24, 31 and 52 days after residue application inhibited growth as evidenced by lower dry root, shoot and biomass weights.

It should be noted that during the 31 and 52 days sampling period, crops in the field were already one and two-month old, respectively. The inhibitory effect of 17, 24, and 31-day soil samples might suggests that corn residues in the field were already undergoing decomposition process and its products directly affecting root growth (Borner, 1960; Guenzi nd McCalla, 1966; Wang *et al.*, 1967; Chandramohan *et al.*, 1973; Chou and Patrick, 1976; Cochran *et al.*, 1977; Bhowmik and Doll,

Table 2. Corn earlength, percent barren plants, average number of ears and grain yield planted to a field with or without corn residue

Treatments	*Earlength (cm)*	*Percent unfilled Ear*	*Percent barren Plants*	*Average number of ears*	*Grain yield (kg/ha)*
With corn residues	16.74[a]	12[a]	13[a]	0.96[a]	3,046[a]
Without corn residues (control)	15.99[b]	15[a]	15[a]	1.01[a]	2,064[b]

Table 3. Number of plants per pot, pods per plant, 100-seed weight and grain yield of mungbean planted to a field with or without corn residue

Treatments	*Number of plants/ plot*	*Number of pods per plant*	*100-seed weight (gm)*	*Grain yield (kg/ha)*
With corn residue	560[b]	21[a]	3.8[a]	760[a]
Without corn residues (control)	644[a]	17[b]	3.9[a]	771[a]

Table 4. Corn earlength and 100 seed weight of mungbean grown in a field with corn residue subjected to different tillages

Tillages	*Corn earlength (cm)*	*Mungbean weight per 100-seeds (gm)*
Conventional tillage	15.8[b]	3.80[b]
Minimum tillage	16.3[ab]	3.85[ab]
Zero tillage	16.9[a]	3.93[a]

1982) resulting to inhibited plant growth and development. Inhibition might also due to the indirect effect of nitrogen immobilization by soil microorganisms (Henderson *et al.*, 1955; Norman, 1959; Kimber, 1973a; Turner and Rice, 1975).

The inhibitory effect of the soil sampled 52 days after residue application might be due to the allelopathic substances released by the currently growing corn, mungbean and soybean crops through root exudation or rain-leached substances from the above-ground plant parts (Guenzi and McCalla, 1962; Kimber, 1973b; Ballester *et al.*, 1982; Garcia, 1983), accumulated in the soil and were included in the bioassay.

Table 5. Corn, soybean and mungbean plant height (cm) from first, second, third and fourth week after planting to soils with corn residue subjected to different tillages

Treatments	*Plant height (cm)*											
	Week 1			*Week 2*			*Week 3*			*Week 4*		
	C	*S*	*M*	*C*	*S*	*M*	*C*	*S*	*M*	*C*	*S*	*M*
With corn residue												
Conventional till	10^{a}	6.4^{a}	8.3^{ab}	31^{bc}	15.2^{a}	14.5^{ab}	53^{b}	26.9^{a}	23.5^{bc}	73^{b}	38.9^{a}	35.2^{bc}
Minimum till	10^{a}	6.9^{a}	8.4^{ab}	34^{ab}	16.2^{a}	15.1^{ab}	59^{a}	27.1^{a}	24.4^{ab}	81^{a}	37.7^{a}	36.7^{ab}
Zero till	11^{a}	6.9^{a}	8.8^{a}	35^{a}	16.1^{a}	15.7^{a}	60^{a}	27.3^{a}	25.5^{a}	80^{a}	39.3^{a}	38.6^{a}
Without corn residue	10^{a}	4.9^{b}	7.7^{b}	30^{c}	12.5^{b}	13.7^{b}	53^{b}	22.4^{b}	22.2^{c}	75^{b}	33.1^{b}	33.4^{c}

The irregular growth pattern observed in dry root, shoot and biomass weights may suggest a periodic production of phytotoxic products of decomposition (Kimber, 1973b; Cochran *et al.*, 1977; Garcia, 1983) as influenced by the manner of tillage used (McCalla and Haskins, 1964; Doran, 1980).

The increasing growth expressed in terms of dry root, shoot and biomass weights when corn and mungbean were planted to soil sampled 52 days after residue application might be due to the mineralization effect (Tack *et al.*, 1972; Turner and Rice, 1975).

Conclusion

A field previously cropped to corn and had corn residues left after harvest favors growth in terms of plant height in corn, mungbean and soybean crops planted ten (10) days after residue application. This condition also increased yield and caused longer earlength in corn employing zero or minimum tillages. The favored growth and yield might be due to the stimulatory effect of corn residues.

Timing of planting, tillages to be used and kinds of crop to be planted are very important. To escape the inhibitory effect of corn residues in a field previously cropped to corn and had crops currently growing, the following may be observed:

a) Soybean should be planted 10 days after corn residue application in the field using zero, minimum or conventional tillages.
b) Mungbean can be planted 10 or 24 days after corn residue application using any of the tillages mentioned, 17 days after corn residue application using zero tillage.
c) Corn can be planted 10 or 52 days after corn residue application using zero or minimum tillages.

Acknowledgment

Sincere thanks to Dr. Arnulfo G. Garcia, Dr. Eduardo P. Paningbatan, Jr. and Dr. Joven S. Lales for the technical assistance and valuable suggestions in making this study a success and the Southeast Asian Regional Center for Graduate Study and Research in Agriculture (SEARCA) for financial assistance.

Literature Cited

Ballester, A., A. M. Vietez and E. Vietez. 1982. Allelopathic potential of *Erica vagans, Callauna vulgaris* and *Daboecia cantabrica. J. Chem. Ecol.* **8(5)** : 851-857.

Bhowmik, P. C. and J. D. Doll. 1982. Corn, soybean response to allelopathic effects of weed and crop residues. *Agron. Journal.* 74 : 601-606.

Borner, N. 1960. Liberation of organic substances from higher plants and their role in the soil sickness problems. *Bot. Review.* **26** : 343-424.

Chandramohan, D., D. Purushothaman and Kothandaraman. 1973. Soil phenolics and plant growth inhibition. *Plant and Soil.* **39** : 303-308.

Chou, C. and Z. A. Patrick. 1976. Identification and phytotoxic activity of compounds produced during decomposition of corn and rye residue in soil. *J. Chem. Ecol.* **2(3)** : 369-387.

Cochran, V. L., L.F. Elliot and R. I. Papendick. 1977. The production of phytotoxic from surface crop residues. *Soil Sci. Soc. Am. J.* **41** : 903-907.

Doran, J. W. 1980. Microbial changes associated with residue management with reduced tillage. *Soil Sci. Soc. Am. J.* **44** : 518-524.

Garcia, A. G. 1983. Seasonal variation in allelopathic effects of corn residue on corn and cress seedlings. Ph. D. Thesis. Agronomy. Iowa State University, Ames, Iowa.

Guenzi, W. D. and T. M. McCalla. 1962. Inhibition of germination and seedling development by crop residues. *Soil Sci. Soc. Am. Proc.* **26** : 456-458.

——————. 1966. Phenolic acids in oats, wheat, sorghum and corn residues and their phytotoxicity. *Agron. J.* **58** : 303-304.

Henderson, M. E. K. and V. C. Farmer. 1955. Utilization by soil fungi of p-hydroxybenzaldehyde, ferulic acid, syringaldehyde and vanillin. *J. Gen. Microbiol.* **12** : 37-46.

Kalantari, I. 1981. Stimulation of corn seedling growth by allelochemicals from soybean residue. Ph. D. Thesis. Iowa State University, Ames, Iowa.

Kimber, R. W. L. 1973a. Phytotoxicity from plant residues. III. The relative effect of toxins and nitrogen immobilization on the germination and growth of wheat. *Plant and Soil.* **38** : 543-555.

——————. 1973b. Phytotoxicity from plant residues. II. The effect of time of rotting of straw from grasses and legumes on the growth of wheat seedlings. *Plant and Soil.* **38** : 347-361.

McCalla, T. M. and F. A. Haskins. 1984. Phytotoxic substances from anaerobic soils containing plant residues. *Soil Biol. Biochem.* **10** : 131-135.

Nielsen, K. F., T. F. Cuddy and W. E. Woods. 1960. The influence of the extract of some crops and soil residues on germination and growth. *Can. J. Plant Sci.* **40** : 188-193.

Norstadt, F. A. and T. M. McCalla. 1969. Microbial population in stubble-mulched soil. *Soil Science.* **107**(3) : 188-193.

Norman, A. G. 1959. Inhibition of root growth and cation uptake by antibiotics. *Soil Sci. Am. Proc.* **23** : 369-370.

Papadakis, J. and A. I. Gix. 1978. Root toxins and crop growth: allelopathy. In U. S. Gupta (ed.) Crop Physiology. Bombay: Oxford and IBH Publishing Co. pp. 202-237.

Pareek, R. P. and A. C. Gaur. 1973. Organic acids in the rhizosphere of *Zea mays* L. and *Phaseolus aureus* plants. Short communication. *Plant and Soil.* **38** : 441-444.

Patrick, Z. A. and L. W. Koch. 1958. Inhibition of respiration, germination and growth by substances arising during the decomposition of certain plant residue in the soil. *Can. J. Bot.* **36** : 621-647.

—————— ., T. A. Toussoun and L. W. Koch. 1964. Effect of crop residue decomposition products on plant roots. *Rev. Phytopathology.* **2** : 267-292.

—————— . 1971. Phytotoxic substances associated with the decomposition in soil of plant residues. *Soil Science.* **3**(1): 13-18.

Tack, B. F., P. J. Chapman and S. Dagley. 1972. Metabolism of gallic acid and syringic acid by *Pseudomonasputida. J. Biol. Chem.* **247** (20) : 6438-6443.

Turner, J. A. and E. L. Rice. 1975. Microbial decomposition of ferulic acid in soil. *J. Chem. Ecol.* **1 (1)** : 41-58.

Wang, T. S., C. T. Yang and T. Chuang. 1967. Soil phenolic acids as plant growth inhibitors. *Soil Science.* **103** : 239-246.