Effect of Intercropping and Residue Management on Soil Water Depletion, Plant Biomass and Grain Production

S. Some W.L. Hargrove, and D.E. Radcliffe[1]

ABSTRACT

Intercropping is an alternative cropping strategy with potential for fostering agricultural sustainability. However, the compatibility **of** many crops for intercropping, especially under different crop residue management systems, has not been established.

During the summer of 1991, we investigated the effect of intercropping and residue management on soil water depletion, plant biomass and grain production. Our results clearly show the yield advantage of crop association. Contrary to some reports, the legume crops yielded significantly more in mixed than in pure stands. The advantage of the intercropping systems was attributed to reduced competition among plants. Velvetbean biomass production was interestingly high, suggesting its integration into cropping systems for soil improvement. However, velvetbean appeared to depress sorghum grain yield when both were grown in mixture.

INTRODUCTION

Numerous factors affect crop performance in mixed stands (3, 4, 9, 11, 12). The complexity of their potential interactions (6. 10), compounded by a scarcity of data, make it difficult to predict the performance of untested intercrop mixtures. Reports on legume/cereal intercropping especially are contradictory (3, 4, 5, 11, 12) and call for additional field work to determine which species to intercrop, when, where, and how. Among the factors influencing crop performance in mixtures, the effect of tillage and crop residue management practices has not been well investigated.

MATERIALS AND METHODS

Grain sorghum [Sorghum bicolor (L.) Moench, **CV.** 'Pioneer 8230'] was intercropped with velvetbean Mucuna aterrima (Piper and Tracy) Merr.] or groundnut [Arachis hypogaea L., cv. 'Southern Runner'] on a Cecil sandy clay loam at Griffin, Georgia during the summer of 1991. The field experiment was laid out as a split-plot design in randomized complete blocks with three replications. The main-plot treatments were conventional tillage (CT) no-tillage with residue left on surface (NTR) and no-tillage with residue removed immediately after harvest (NTNR), a common practice in West Africa. Sub-plot treatments were pure stands of unfertilized sorghum (S)fertilized sorghum (SF), velvetbean (V), groundnut (G), and mixed stands of sorghum/velvetbean (SV) and sorghum/groundnut (SG). Crops in mixtures were planted in alternating double rows (binary basis). Rows were 34 inches apart and 40 feet long. Plant populations for all crops averaged 200,000 and 100,000 plants/ha in pure and mixed stands respectively.

The soil moisture content was measured at different time intervals at six depths ranging from 6 to 36 inches in the middle of rows by means of a time domain reflectometer (TDR). Plant biomass was harvested over two randomly located 1-square meter (velvetbean) or 1-meter row (groundnut and sorghum) samples, dried, and weighed. The same sampling procedure was used at harvest for seed yield estimation.

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[1]Agronomy Department, University of Georgia, Athens, GA 30602.

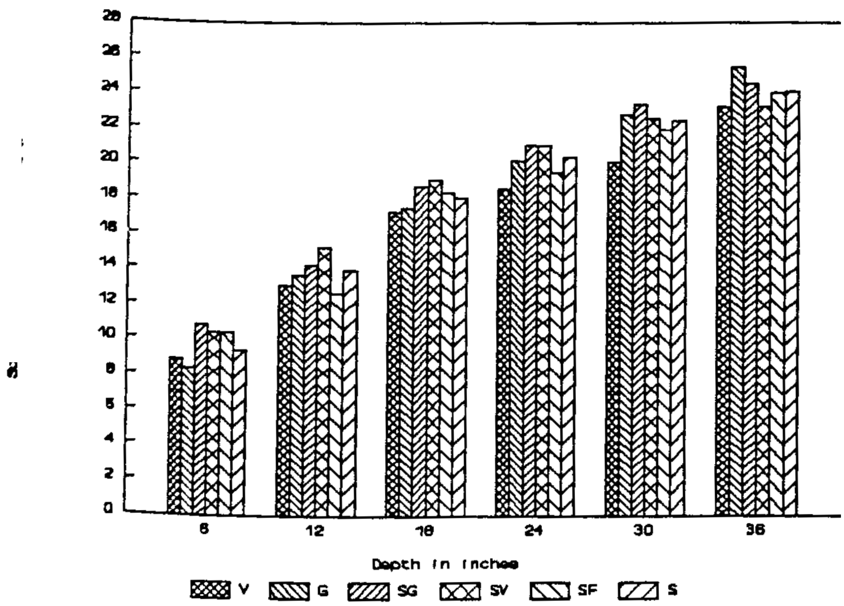

Fig. 1. Effect of intercropping on soil moisture content in the soil profile.

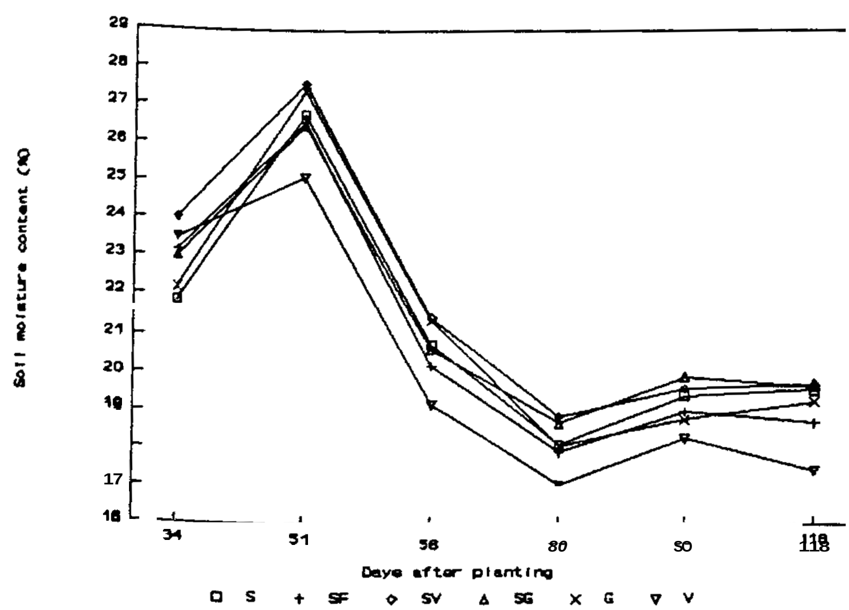

Fig. 2. Effect of intercropping on the depletion of soil moisture

RESULTS AND DISCUSSION

The mean soil moisture content increased with depth with little difference among crop treatments (Fig. 1). However, when summed over depth, soil moisture was more depleted in pure stand velvetbean (Fig. 2), but SV mixture unexpectedly resulted in the highest moisture content for much of the season. The other crop treatments resulted in intermediate soil moisture contents.

Soil moisture content was lower for CT, in contrast to its response under no-tillage (NTNR and NTR; Fig. 3). Loosening of the soil by tillage may have favored more extensive root growth resulting in higher water uptake under CT. The residue mulch with *NTR* resulted in greater soil moisture conservation, as is often reported (7, 8, 10). In contrast, residue removal with NTNR favored more rapid water loss by evaporation.

Under all the residue management systems, ranking of crop treatments for final biomass yield in decreasing order was V, SV, S, SF, SG, and G (Table 1). Intercropping velvetbean with sorghum significantly reduced overall biomass production. In contrast, SG produced significantly more biomass than a sole crop of groundnut. The high water uptake by velvetbean may justify its rapid growth ater 61 days post planting, i.e., in August, where rainfall was abundant (Fig. 4).

Comparison among residue management systems showed no significant difference in both biomass (Table 1) and grain yield (data not included), suggesting that additional years with these tillage/residue management systems in place are required before these treatments will express significant differences.

A closer analysis (Table 2) shows that intercropping did not significantly affect crop biomass production. However, sorghum grain yield decreased significantly in mixture with velvetbean, but not when intercropped with groundnut. In contrast, both legumes yielded significantly higher in mixed than in pure stands (Table 2).

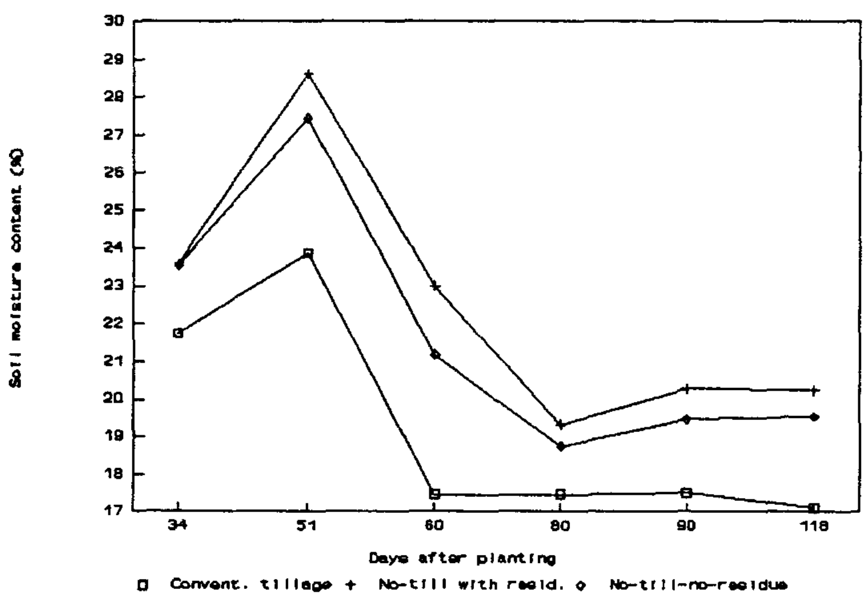

Fig. 3. Effect of residue management practices on soil moisture content.

Several authors have reported reduced yields of legumes when intercropped with cereals, which they attributed to a shading effect (9) or competition for nutrients (4, 11, 12) by the cereal crops. In particular, yield of groundnut has consistently been reported to decrease when intercropped with cereals (1, 2). Our results are not in agreement with these reports. Three explanations appear plausible. First, sorghum variety used averaged only 1.45 m full height, which limited its ability to shade the intercropped legumes. Shading was further reduced by adopting the binary system of planting. Second, high relative humidity in the dense pure stand canopy may have favored disease development, resulting in lower yields for monocropped legumes. This was particularly true for velvetbean; an extensive flower and fruit abortion was observed in the pure stand. Finally, intense intraspecific competition in the pure stand may have resulted in legume yield depression. In general, land equivalent ratios for both biomass and seed yield averaged 2 in each intercropping situation.

CONCLUSION

Our experiment clearly showed the yield advantage of intercropping. Contrary to some reports, the legume crops yielded significantly more in mixed than in pure stands. The advantage of the intercropping systems is attributable to reduced competition among plants. Velvetbean biomass production was interestingly high, suggesting its integration into cropping systems for nutrient replenishment. However, velvetbean may depress sorghum grain yield in mixtures.

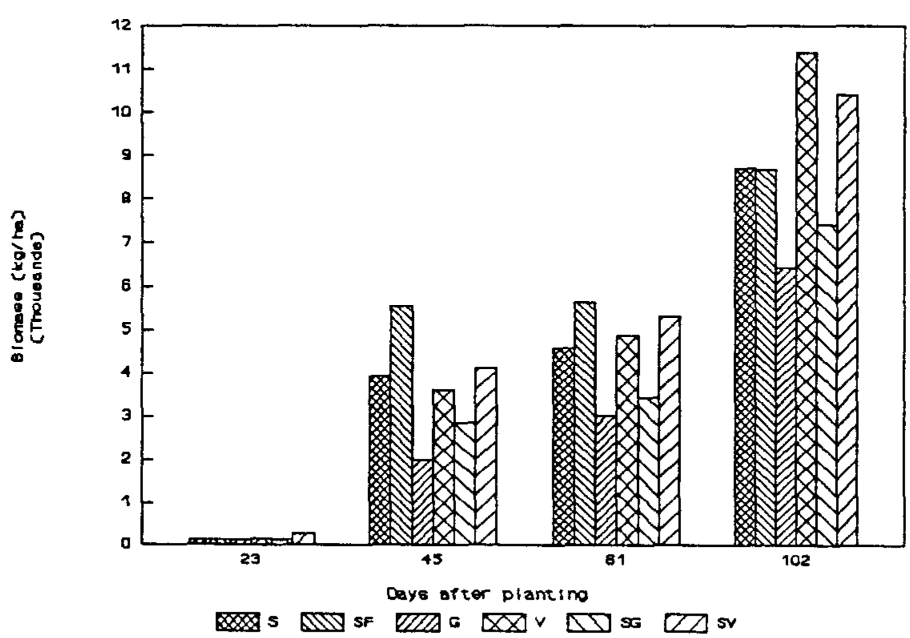

Table 1. combined final biomass yield of crops under different residue management practices. Values for intercrops are combined means.

Crop Treatment	CT	NTR	NTNR	Overall Mean
	....	kg ha^{-1}	----------------------	
V	12020 a*	11443 a	10717 a	11393 a
SV	11622 a	10527 b	9059 b	10403 b
S	8543 b	9015 c	8626 b	8728 c
SF	8747 b	8862 c	8469 b	8693 c
SG	7339 c	7259 d	7664 c	7421 d
G	6058 d	7130 d	6058 d	6416 e
Overall Mean	9055	9039	8432	8842

* Means within a column followed by the same letter are not significantly different (P= 0.05).

Table 2. Effect of intercropping and crop residue management on plant final biomass and seed yield.

Sorghum		Groundnut		Velvetbean	
Means of biomass yields (kg ha^{-1})					
S	8093 a*	G	6415 a	V	11393 a
SF	8728 a	SG	6021 a	SV	12640 a
SG	8821 a				
SV	8165 a				
Means of grain or pod yields (kg ha^{-1})					
S	4800 b	G	2757 b	V	3150 b
SF	5665 a	SG	3838 a	SV	4772 a
SG	4774 b				
SV	4077 c				

* Means within a crop followed by the same letter are not significgntly different (P= 0.05).

CITATIONS

1. Koli, S.E. 1975. Pure cropping and mixed cropping of maize and groundnuts in Ghana. J. Agric. Sci. 8:23-30.

2. IRAT. 1978. Rapport Annuel. 1977. IRAT. Paris.

3. Lai, T.M., and K. Lawton. 1962. Root competition for fertilizer phosphorus as affected by intercropping. Soil Sci. Soc. Amer. Proc. 26:58-62.

4. Mt. Pleasant, J. 1982. Corn polyculture systems in New York. M.S. Thesis. Cornell Univ., Ithaca, NY.

5. Murray, G.A., and J.B. Swensen. 1985. Seed yield in Austrian winter field peas intercropped with winter cereals. Agron. J. 77:913-916.

6. Nyambo, D.B., T. Matimati, A.L. Komba, and R.K. Jana. 1980. Influence of plant combinations and planting configurations on three cereals (maize, sorghum, millet) intercropped with two legumes (soybean, green-gram). In: Keswani, C.L. and B.J. Ndunguru (eds.) Intercropping. Proceedings of the Second Symposium on Intercropping in Semi-Arid Areas, Morogoro, Tanzania.

7. Okigbo, B.N. 1969. Maize experiments on the Nsukka plains: III, effects of different kinds of mulch on the yield of maize in the tropics. L' Agron. Trop. 28:1036-1047.

8. Okigbo, B.N. 1990. Sustainable agricultural systems in tropical Africa. p. 323-352. In: C.A. Edwards, R. Lal, P. Madden, R.H. Miller, and G. House (eds.) Sustainable agricultural systems. Soil and water conservation society, Ankeny. Iowa.

9. Reedy, M.S., and R.W. Willey. 1980. The relative importance of above- and below-ground resource use in determining yield advantages in pearl millet/groundnut intercropping-Summary. p. 70-71. In: L. Keswani and B.J. Ndunguru (eds.) Intercropping. Proceedings of the Second Symposium on Intercropping in Semi-Arid Areas, Morogoro, Tanzania.

10. Russelle, M.P. and W.L. Hargrove. 1989. Cropping systems: Ecology and management. P. 277-317. In: R.F. Follett (ed.) Nitrogen management and ground water protection. Elsevier, New York, NY.

11. Wolfe, E.C., and A. Lazenby. 1973. Grass-white clover relationships during pasture development. I. Effect of superphosphate. Austr. J. Expl. Agric. Anim. Husb. 13:367-574.

12. Wolfe, M.S., P.N. Minchi, and S.E. Slater. 1982. Barley mildew. p. 92-95. In: Annual report of plant breeding institute, 1981. Plant Breeding Institute, Cambridge, United Kingdom.