Peanut Yield Potential as Influenced by Cropping System and Plant Density

P. E. Igbokwe* and N.V.K. Nkongolo[1]

ABSTRACT

This study was conducted on a Memphis silt loam at Alcorn State University in 1992 and 1993 and investigated row-intercropping as a low-input alternative to the conventional cropping system for peanut (*Arachis hypogaea* L.) production in southwestern Mississippi. Extractable P and exchangeable cations were significantly ($P \leq 0.05$) higher for vetiver-peanut row-intercropping in 1992. Extractable S and P were significantly ($P \leq 0.05$) higher for vetiver-peanut row-intercropping and conventional peanut monocropping, respectively, in 1993. Plant height, shoot dry weight, the number of yellow nutsedge (*Cyperus esculentus* L.) per row, insect lesions per leaflet, and rodent diggings per row were significantly ($P \leq 0.05$) higher for conventional peanut monocropping than when peanut was intercropped with vetiver grass [*Vetiveria zizanioides* (L.) Nash]. Peanut pod number, pod weight, seed number, and seed weight also were higher for conventional peanut monocropping. The seed mineral composition generally was not affected by cropping system and plant spacing. Peanut yield was higher for 15.2 cm within-row plant spacing compared to 10.2- and 20.3-cm spacings investigated in this study. Interaction between cropping system and plant spacing was significant for pod number, pod weight, seed number, seed weight, and seed Ca and Fe compositions in 1992, but only significant for seed number, seed weight, and seed Fe and Zn compositions in 1993.

Key Words: *Arachis hypogaea*, vetiver grass, *Vetiveria zizanioides*, row intercropping.

Soil erosion continues to be a problem on unprotected cultivated crop lands in Mississippi. An annual soil loss rate of nearly 26.88 mT/ha is reported in southwestern Mississippi where many small farmers earn a living on highly erosive Alfisols and Ultisols subjected to intensive crop productions. Despite massive expenditures, which have gone mainly to engineered soil conservation systems, the magnitude of the problem has increased (4). Greenfield (2) indicated that vetiver grass [*Vetiveria zizanioides* (L.) Nash] is used to stabilize rice paddy bunds and irrigation fields in Nepal, stop erosion on hill slopes in Philippines, trap silt at dam entrances in northern Ghana, and separate agricultural lands in Nigeria. In Trinidad, mango trees planted behind the vetiver hedge outgrew the trees planted away from it. Greenfield (2) also reported that vetiver grass planted in rows across hillsides in West Indies resulted in sediment deposits on the uphill side of the hedges and in elevation drops across the hedges. Whistler (9) indicated that vetiver planted on field or garden boundaries prevented the spread of weeds such as *Cynodon dactylon* (L.) Pers. Mulch crops such as rye traditionally have been planted to compete with weeds, cover the soil in winter, and improve soil tilth when they are plowed or disked in the spring (7). Vetiver is suspected to have an associated nitrogen-fixing symbiont, which would explain its green color throughout the year when grown in the tropics. Silica content in the leaves repel garden insects, while oil or the smoke from burning roots repel house pests and vectors of diseases (3). In the United States, the Agricultural Research Service (ARS) and Natural Resources Conservation Service (NRCS) scientists are investigating vegetative barriers for erosion control on hill slopes planted with such field crops as corn, soybeans, and cotton. In Mississippi, McGregor and Dabney (5) reported that stiff grass (*Miscanthus sinensis* Anders.) hedges dramatically reduced soil loss during the first growing season on conventional-till and no-till cotton plots as compared with similar plots with no hedges.

Peanut (*Arachis hypogaea* L.) is a popular garden crop in Mississippi, grown in a monocropping system, and considered important as such garden favorites as southern peas, okra, and lima beans (1). The cultivar Alcorn Pat was used in this study as the jumbo component of the Farmers' Varieties (differently sized peanuts), and was grown exclusively many years ago for fresh market in southwestern Mississippi. Although the cultivar was developed through selection for the fresh market, it also is being used for breeding purposes. Alcorn Pat has an excellent taste when boiled fresh in salt and has an average seed fresh weight of more than 1.4 g/seed. Producers on small farms could add as much as $2500 to their income by growing an acre of peanuts and dispensing of them raw and/or boiled fresh in salt (W. B. Patton, pers. commun., 1987). However, the most profitable and sustainable production practices for this crop are yet to be determined.

In recent years, there has been increased concern among growers, researchers, and consumers regarding the adverse effects of the extensive use of agricultural chemicals on human health and soil resources. Therefore, there are compelling reasons for farmers to consider switching from the current conventional (chemical-intensive) monocropping system to sustainable multiple cropping systems. Because of limited information on vegetative-hedge-vegetable intercropping on hill slopes, this study was initiated to determine the influence of low-input, vetiver-peanut row intercropping and plant density on soil characteristics, peanut growth, yield potential, seed mineral composition, and pest control.

Materials and Methods

Two field experiments were conducted using Alcorn Pat during the summers of 1992 and 1993 at the Alcorn Research Station, Lorman, MS. The soil type was a Memphis

[1]Assoc. Prof. and former grad. student, respectively, School of Agric., Res., Ext. and Appl. Sci., Alcorn State Univ., Lorman, MS 39096.

*Corresponding author.

silt loam (Typic Hapludalfs: fine silty, mixed thermic). A split-plot design was used in each experiment. The cropping systems (conventional and low-input) formed the main plots, and plant spacings (10.2, 15.3, and 20.3 cm) the subplots. Each spacing was replicated four times on rows 4.57 m long and 1.07 m wide, and seeds were hand-planted. Fertilizer applications were 89.60 kg/ha of P_20_5, 67.20 kg/ha of K_20, and gypsum was applied at the rate of 560 kg/ha at the time of pegging. Water was supplied by natural rainfall and with a single irrigation at pegging time. Methods for field preparation and pest control varied with the cropping system. Hairy vetch planted after the 1992 harvest was used for weed control, soil protection in winter, and soil tilth improvement for both cropping systems.

For the conventional cropping system, a tractor was used for disking (three times) and row preparation in 1992. The plot was on the uphill side of the first vetiver hedgerow which separated the two cropping systems. Alcorn Pat seeds were planted on 25 May 1992. Alachlor [2-chloro-2',6'-dimethyl-N-(methoxymethyl) acetanilide] preemergence herbicide was applied at the rate of 1.8 kg ai/ha, while bentazon [3-(1-methyl)-1 H-2,1,3-benzothiadiazin-4 (3H)-one 2,2-dioxide] postemergence herbicide was applied at the rate of 1.7 kg ai/ha. Chlorothalonil (tetrachlorisophthalonitrite) and carbaryl (1-napthalenyl methylcarbonate) were applied weekly for early leaf spot (*Cercospora arachidicola* Hori) and corn earworm (*Heliothis zea* Brodie) control, respectively. Applications were made at the rate of 0.71 L/ha and 2.24 kg/ha, respectively, with solo backpack sprayers. Foliage was sprayed until wet. These applications began 1 mo from seeding and were terminated 2 wk before harvest on 19 Oct. The same production practices were used in 1993.

For low-input row intercropping plots, field preparation was limited to single disking and row preparation. On 22 Apr. 1992, single tillers of vetiver grass accession 30230 were transplanted at a within-row distance of 20.3 cm on alternate rows. Skipped rows were seeded 1 mo later. Nutsedge control was limited to preemergence herbicide application during the first year, mulching with vetiver clippings, and hand removal. Mulching which was done after seeding for each growing season was generally 5.1 cm thick. Fungicides and insecticides were applied only once a month. Rate of application was as for the conventional cropping system in Mississippi. In 1993, row preparation between vetiver hedge regrowth was with rotary tiller and garden hoe. All other production practices were as in 1992, except that no preemergence herbicide was applied before rows were mulched after seeding.

Soil samples were collected at 0-20 cm soil depth from five randomly selected locations from each treatment row after each growing season and used to determine the influence of cropping system and peanut density on soil characteristics. Samples were analyzed for extractable nutrients, acidity, organic matter, and cation exchange capacity. Means were separated by Student's t-test ($P \leq 0.05$). Treatment effect on peanut growth was determined by the height and dry weight of the above-ground biomass of the randomly selected peanut plants. Treatment effect on pest infestations was based on the number of yellow nutsedge (*Cyperus escelentus* L.), rodent diggings, and insect lesions per leaflet from four uniform areas (0.33 m^2) from each block. The numbers of nutsedge and fresh diggings by rodents from each area were counted and the average reported per row. Five randomly selected leaflets from each area were counted also and the average reported per row. Pest infestation counts were taken during each week of the last month before harvest, thus giving four counts per growing season. At 135 d from seeding, harvests from four uniform areas (0.33 m^2) from each block were used to determine potential peanut yield and seed mineral composition for both the conventional and low-input cropping systems. Harvested pods were washed, fan-dried for 1 d, and used to determine fresh peanut yield and seed mineral composition. All data were analyzed by an analysis of variance, and means were separated by least significant differences.

Results and Discussion

The extractable nutrients P, K, Ca, Mg, and S were at higher levels for vetiver-peanut row intercropping than for conventional peanut monocropping in 1992. However, only extractable P was significant ($P \leq 0.05$) (Table 1). Soil acidity, soil organic matter, and exchangeable cations were also at higher levels for intercropping, but only exchangeable cation was significant ($P \leq 0.05$). In 1993, only Ca, Mg, and S were at higher levels in intercropping plots, whereas values for acidity were similar and soil organic matter and exchangeable cations were higher. However, only S level was significant ($P \leq 0.05$). Extractable P was significantly ($P \leq 0.05$) higher for conventional peanut monocropping. Data suggest that intercropping has more soil-building potential than the conventional cropping system. This could have been due to the nutrient recycling potential of vetiver grass (6).

In 1992, plant height, shoot dry weight, and the number of weeds per row were significantly ($P \leq 0.05$) higher in the conventional cropping system than when peanut was intercropped. However, only the number of weeds per row was influenced by plant spacing (Table 2). The number of weeds per row was highest (16.3) at the 20.3-cm plant spacing, but was not significantly ($P \leq 0.05$) different from the weed population in 15.2-cm plots. Interactions between cropping system and plant spacing were not significant for any parameter (data not presented).

In 1993, cropping system effects on shoot dry weight and the number of weeds per row were the same as for 1992. Plant height was signfiicantly ($P \leq 0.05$) higher in the intercropping system than for conventional peanut monocropping. Plant height was also highest (32.1 cm) at the 10.2-cm plant spacing but was not different from plants in 20.3-cm plant spacing plots. The number of weeds per row was lowest (8.8) at the 15.2-cm plant spacing. The average number of insect lesions per leaflet per row and rodent diggings per row also were significantly ($P \leq 0.05$) higher in the conventional cropping system. Only the number of insect lesions per leaflet was influenced by plant spacing. Number of lesions per leaflet was significantly ($P \leq 0.05$) lowest (8.0) at the 10.2-cm plant spacing. Interactions between cropping system and plant spacing were not significant for any parameter (data not presented). Results indicated that the conventional cropping system favors peanut growth more than row intercropping; however, the potential for the control of corn earworms, moles, and armadillos are greater in an intercropping system. The vetiver leaf

Table 1. Treatment effect on soil characteristics for peanut cropping systems[a].

Treatment	Extractable nutrient level P	K	Ca	Mg	S	Soil acidity	Soil organic matter	Exchangeable cations
	kg/ha					pH	%	c mol/kg
				1992				
Conventional	34.7 b	210.6 a	4202.2 a	785.1 a	249.8 a	7.1 a	1.6 a	12.5 b
Intercropping	42.6 a	230.7 a	5314.4 a	870.2 a	301.3 a	7.6 a	1.9 a	15.4 a
				1993				
Conventional	48.1 a	182.6 a	4429.6 a	864.6 a	183.7 b	7.2 a	1.2 a	13.3 a
Intercropping	39.2 b	168.0 a	4577.4 a	897.1 a	224.0 a	7.2 a	1.4 a	13.7 a

[a]Soil samples were taken for analysis at the end of each growing season. Data represent soil fertility level for each cropping system. Means within columns were separated by Student's t-test ($P \leq 0.05$).

Table 2. Treatment effect on plant growth and pest control for peanut cropping systems.

Treatment	1992 Plant height	1992 Shoot dry wt	1992 Weeds/row	1993 Plant height	1993 Shoot dry wt	1993 Weeds[a]/row	1993 Insect[b] lesions/leaflet	1993 Rodent[c] diggings/row
	cm	kg	no.	cm	kg	no.	no.	no.
Cropping system								
Conventional	33.8	0.16	16.7	27.9	0.11	13.1	12.8	5.1
Intercropping	27.4	0.10	12.8	32.7	0.08	8.8	7.8	2.8
LSD ($P \leq 0.05$)	4.3	0.02	3.1	4.2	0.02	1.2	2.8	1.2
Spacing								
10.2 cm	30.5	0.12	12.1	32.1	0.10	12.5	8.0	1.2
15.2 cm	31.2	0.16	15.6	27.5	0.10	8.8	10.9	4.3
20.3 cm	30.0	0.12	16.3	31.3	0.08	11.8	12.0	3.3
LSD ($P \leq 0.05$)	NS	NS	2.4	3.1	NS	2.4	2.4	NS

[a]The number of yellow nutsedge plants per row.
[b]The number of lesions caused by corn earworm per leaflet per row.
[c]The number of diggings by moles and armadillos.
NS = Nonsignificance at $P \leq 0.05$ level.

clippings used as mulch were effective in reducing yellow nutsedge infestation.

In 1992, peanut pod number, pod weight, seed number, and weight were higher in the conventional cropping system (Table 3). These parameter values also were highest in the 15.2-cm plant spacing but were not different from the corresponding value due to 10.2-cm plant spacing. Similar trends were observed in 1993 for both cropping system and plant spacing. However, values due to plant spacing were not significantly different in 1993. Interactions between cropping system and spacing were significant for all parameters in 1992, but only significant for seed number in 1993. Yield data suggest that the conventional peanut plot could have received additional nutrients from sediment deposit observed on the uphill side of the first vetiver grass hedgerow to support higher pod yield. Similar findings were reported by Greenfield (2). A change in the direction of water runoff from the monocropping plot was observed also, and similar findings were reported by Tiwari *et al.* (8). Sediment deposit on the conventional peanut plot could be prevented by separating both cropping systems with an uncultivated alley, 30.5 m or more wide. This measure will provide a better evaluation of the influence of both cropping systems on peanut yield and soil fertility building potentials. Partial shading from vetiver above-ground biomass also could have led to a reduction in photosynthesis and pod yield in the intercropped peanut plot.

In 1992, the effect of cropping system on seed mineral concentrations was significant for Cu only (data not presented). This higher average value of 7.9 ppm was attributed to the intercropping system. Plant spacing did not affect seed mineral concentration except for N, where the highest percentage (4.7%) was observed at the 15.2-cm plant spacing. Interaction effects between cropping system and plant spacing were significant for Ca and Fe only. In 1993, cropping system did not influence seed mineral concentrations except for Fe and Zn (data not

Table 3. Influence of cropping systems on fresh peanut yield.

Treatment	1992				1993			
	Pod	Pod weight	Seed	Seed weight	Pod	Pod weight	Seed	Seed weight
	no.	kg	no.	kg	no.	kg	no.	kg
Cropping system								
Conventional	77.6	0.48	121.3	0.22	53.4	0.25	89.8	0.12
Low input	47.2	0.28	81.0	0.14	34.3	0.19	53.8	0.07
LSD (P ≤ 0.05)	7.1	0.06	23.9	0.04	15.2	NS	11.6	0.03
Spacing								
10.16 cm	65.1	0.39	106.8	0.18	44.0	0.22	69.5	0.09
15.24 cm	67.4	0.43	110.5	0.20	49.6	0.25	78.6	0.11
20.32 cm	54.8	0.32	86.1	0.15	37.9	0.20	67.4	0.09
LSD (P ≤ 0.05)	9.0	0.07	17.6	0.04	NS	NS	NS	NS
Interaction	**	**	*	*	NS	NS	*	NS

[a]Pod values are average for marketable fresh pods harvested from a 0.33-m^2 area from each plot. Seed values are those that are edible, broken, or whole seed.

NS,*,**Denote nonsignificance, significance at $P \leq 0.05$ and $P \leq 0.01$ levels, respectively.

presented). A higher Fe value of 53.1 ppm was observed in conventional cropping system, whereas a higher Zn value of 41.3 ppm was observed in intercropping system. Plant spacing did not influence seed mineral concentrations except for Fe. The highest Fe value of 66.0 ppm was observed at 10.2-cm plant spacing. Interaction effects between cropping system and plant spacing were significant for Zn and Cu only. Data suggest that, despite possible competition for soil nutrients between vetiver grass and peanut, the seed quality (mineral composition) generally was not affected. This could relate to the nutrient recycling potential of vetiver grass, made possible by the huge spongy mass of strong and fibrous roots that tap into soil moisture far below the reach of most crops (NRC, 1993). The essential nutrients which vetiver absorbs with the soil moisture are brought also to the soil surface through the use of grass clippings as mulch and/or after the decomposition of the dead grasses.

Summary and Conclusions

Two field studies were used to investigate vetiver grass-peanut row intercropping as a low-input alternative to the current conventional, chemical-intensive monocropping system for growing Alcorn Pat peanut in southwestern Mississippi. Extractable nutrients, soil acidity, soil organic matter, and exchangeable cations generally were at higher levels for vetiver-peanut row intercropping than for conventional peanut monocropping. Plant height, shoot dry weight, the number of yellow nutsedge plants per row, insect lesions per leaflet, and rodent diggings per row were significantly ($P \leq 0.05$) higher for the conventional cropping system than when peanut was intercropped. Peanut pod number, pod weight, seed number, and seed weight also were higher for conventional cropping system. The seed mineral composition generally was not affected by cropping system. Peanut yield was higher for the 15.2-cm within-row plant spacing compared to 10.2- and 20.3-cm spacings. The interaction between cropping system and plant spacing was significant for pod number, pod weight, seed number, and Ca and Fe compositions in 1992, but only significant for seed number and Zn and Fe seed compositions in 1993.

Findings suggest the following: (a) Monocropping peanut on the uphill side of the first vetiver hedgerow will result in greater peanut growth and higher yield than vetiver-peanut row intercropping on the downhill side of the hedgerow. The observed sediment deposit on the monocropping plots could have provided additional soil nutrients and moisture to enhance productivity. (b) The depression of growth and pod yield of peanut intercropped with vetiver grass on alternate rows 1.07 m apart suggest possible competition for moisture and nutrient with vetiver and reduced photosynthesis due to partial shading by vetiver above-ground biomass. Intercropping on rows more than 1.07 m apart is therefore suggested for commercial production in southwestern Mississippi. (c) In general, both cropping system and plant spacing did not affect seed mineral compositions. (d) Peanut pests (yellow nutsedge, corn earworm, and rodents) which cause significant yield reductions in Mississippi would be better controlled in a vetiver-peanut row intercropping than in a monocropping system. (e) A within-row peanut spacing of 15.2 cm is considered more appropriate for higher Alcorn Pat peanut yield than the 10.2 and 20.3 cm spacings investigated in this study.

In conclusion, successful peanut production on hill slopes of highly erosive soils in southwestern Mississippi will require, among other things, the incorporation of vetiver grass hedgerows and other production practices outlined in this study into the farming operations.

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