Effect of nitrogen rate on okra and tomato in *Gliricidia* alley cropping system in South-western Nigeria

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ABSTRACT

The effect of nitrogen rate with hedgerow prunings applied as mulch in *Gliricidia sepium* alley cropping system on weed control and growth and yields of okra and tomato was studied in an on-farm experiment in South-western Nigeria in 1993 and 1994. The growth of the vegetables was increased by increasing nitrogen fertilizer rate up to 90 kg ha^{-1} with total hedgerow prunings applied as mulch, but this was not accompanied by a significant increase in fruit yields beyond 60 kg ha^{-1}. When averaged over the two years, however, application of 30 kg N ha^{-1} gave more economical yield than application of 60 kg ha^{-1}. With total foliage from hedgerow pruning applied as mulch, weed dry weight decreased significantly by 70-75% and 60-66% under okra and tomato, respectively, with and without fertilizer. It is concluded that application of small amount (about 30 kg ha^{-1}) of nitrogen fertilizer with hedgerow prunings applied as mulch can suppress weed growth and increase fruit yield of okra and tomato under *Gliricidia sepium* alley cropping system.

Keywords: Alley cropping, *Gliricidia sepium*, mulching, nitrogen, okra, weed.

INTRODUCTION

In tropical Africa, the importance of vegetables lies in their potential for raising nutritional levels adding proteins, vitamins and minerals to the starch-based diets of the people and in the role they play in the ecophysiology of traditional agriculture (Ikeorgu and Ezumah 1991; Olasantan 1992). They are also important for generating income for farmers, and for various medicinal and industrial purposes (Olasantan 1999b).

Vegetables are grown most often as intercrops with food crops in the tropics, although mixtures with tuber crops are the most common combinations in southern Nigeria. Vegetables are also grown occasionally as sole crops. In both systems, however, the practice of mulching, staking and fertilizer application in vegetable production are not common among farmers, since they are labour intensive and they increase production costs. The beneficial effects of these agronomic practices on soil properties and on okra and tomato production have often been reported (Sobulo *et al.* 1975; Shreastha 1983; Olasantan 1985,1999a).

Because of high population density and fast growing human population in Nigeria additional land for arable cropping is scarce and there is more extensive degradation of the environment. Attempts to increase food and vegetable crop production must, therefore, be based on the exploitation of mixed cropping and agro-forestry systems. This may reduce the usage of agro-chemicals including mineral fertilizers leading to reduced cost of production. Several studies have been carried out on agro-forestry, particularly alley cropping in the tropics (Kang *et al.* 1984; Siaw *et al.* 1991; Larbi *et al.* 1993). Alley cropping is an agro-forestry system in which food crops are grown in alleys formed by hedgerows of multipurpose trees and shrubs, perferably N-fixing leguminous species. The system reduces the long fallow periods characteristic of traditional shifting cultivation system and to sustain soil fertility and farm productivity. The system could also serve as a complementary biological method to suppress weeds and provide stakes and mulch needed in crop production. Agronomic and soil fertility aspects of alley cropping food crops and leguminous species have been extensively studied (Kang *et al.* 1984; Hulugalle and Kang 1990; Siaw *et al.* 1991). However, in alley cropping studies less attention has been given to vegetables which, in traditional agriculture, are as important as the food crops. Thus, growing vegetables in alleys formed by hedgerows of tree legumes deserves special attention. This paper reports an on-farm study of the effect of nitrogen application with hedgerow prunings applied as mulch on weed control and growth and yield of okra and tomato in alleys formed by hedgerows of *Glricidia sepium*.

MATERLALS AND METHODS

The on-farm experiment was conducted in two contiguous farms at Ila-Orangun, South-western

Nigeria (8° 0' N 4° 54' E) in 1993 and 1994. The soil of the experimental site was an Alfisol, classified as an oxic Tropudalf, with a pH of 5.6 (H_2O), 1.07% organic carbon, 0.104% total N, 6.4 mg kg^{-1} available P and 0.53 meq 100 g^{-1} of exchangeable K. The treatments consisted of two vegetables (okra cv. NHAe 47.4 and tomato cv. Ife 1) and four N-rates (0, 30, 60 and 90 kg ha^{-1}). A split-plot design with the vegetables as the main plot treatments and the N-rates as the subplot treatments was fitted into randomized complete-block layout with three replicates. The net plot size for the main treatments was 16 x 4.5 m, while that for the sub-treatments was 4.5 x 4.0 m. Total foliage from hedgerow prunings was applied as mulch to all plots.

Stem cuttings (1 m long) of *Gliricidia sepium* were planted in rows 4m apart at a spacing of 0.5 m within rows in yam plots in May 1988 and June 1989 in the first and second farms, respectively (Olasantan 1999a). The plots were left under fallow, with the leguminous trees being maintained occasionally, after yam harvest. The trees were first cut to a height of 0.5m above the soil 5 years after planting in each farm. The experimental site was prepared manually by clearing and tilling; planting was done on the flat. The hedgerows were pruned thrice during the experimental period in either year to reduce possible shading, starting 4 weeks after planting (WAP) the vegetable. At each occasion the prunings were weighed and spread uniformly on the surface of the soil in all plots. A proportion of the hedgerow branches was used as stake for tomato plants and for yam production in both 1993 and 1994.

Tomato seeds were sown in a nursery on 20 April 1993 and on 28 March 1994 and vigorous seedlings were transplanted five weeks later on the same day okra was seeded. Okra seeds were sown on 24 May 1993 and on 5 May 1994 in the first and second farms, respectively. Both vegetables were planted at a spacing of 90x30cm (43 000 plants ha^{-1}). Okra seedlings were thinned out to one per stand. In each year, a basal dressing of 30kg ha^{-1} each of P and K as single superphosphate and muriate of potash was applied to all plots receiving N fertilizer. The sub-plots selected randomly were then given either 0, 30, 60 or 90kg N ha^{-1} as urea drilled between rows 3 WAP. Tomato plants were staked to 120cm hight and the main stems and branches were subsequently trained regularly. As the stakes became weak or damaged by strong wind they were replaced with new ones. All plots were weeded by hoeing once, just before prunings were applied as mulch and subsequently by regular rogueing. At each occasion, samples were taken for dry matter determination. Okra plots were maintained free of foliar pests by applying Furadan 10% (Carbofuran).

Plant height and leaf or branch productions were determined at 50% flowering stage of the vegetables. Green immature pods of okra and ripe fruits of tomato were harvested every three days and their numbers and weights recorded. Healthy tomato fruits with a diameter of 2.5 cm and okra measuring 3.0 cm in length were regarded as marketable. All harvests were made from the centre four rows in all plots, guard rows were not considered. The results so obtained in both years were analyzed separately for a split-plot design in randomized block. After analyses of variance the differences between treatment means were separated by the least significant difference (LSD) test at 5 % probability values.

RESULTS AND DISCUSSION

Vegetative characters

The growth response of okra and tomato to N-application in 1994 followed a trend very similar to that in 1993 (Table 1.) Plant height and branch or leaf production in both vegetables increased significantly as the rate of N-fertilizer applied increased with total hedgerow pruning applied as mulch. N-application also had a significant effect on the number of days taken for harvest. Okra and tomato plants grown with additional N-fertilizer were ready for harvest between 4 and 9 and 2 and 5 days, respectively, earlier than the unfertilized ones. The vegetable x N-fertilizer interaction was not significant for branch production and time taken for the first harvest.

Table 1. Effect of nitrogen application on vegetative characters of okra and tomato with hedgerow prunings applied as mulch in *Gliricidia alley* cropping system in 1993 and 1994 in Nigeria.

Nitrogen Rate ($kg\ ha^{-1}$)	Plant height (cm)		No branches $plant^{-1}$		No. leaves $plant^{-1}$		Time taken for harvested (days)	
	1993	1994	1993	1994	1993	1994	1993	1994
Okra								
0	64	72	2.2	1.9	11	10	64	65
30	73	85	3.2	2.6	14	13	59	61
60	85	93	4.2	3.2	17	17	57	57
90	127	118	4.9	4.4	23	21	58	56
Mean	87	92	3.6	3.0	16	15	60	60
Tomato								
0	70	75	4.3	4.1	34	35	62	65
30	76	89	5.3	5.2	45	42	60	63
60	96	93	5.9	5.6	55	53	58	62
90	105	99	6.5	6.4	71	66	57	58
Mean	87	89	5.5	5.3	51	49	59	62
LSD (P=0.05)								
Vegetable	NS	NS	0.44	0.69	0.88	4.37	NS	NS
N rate	6.41	5.34	0.37	0.29	3.44	3.09	5.31	1.88
Vegetable	*	*	NS	NS	*	*	NS	NS

NS = Not significant. * Vegetable x N interaction was significant at P=0.05.

However, plant height and leaf production in both years was significantly affected. Tomato plants produced more branches and leaves than okra plants. This could be due to morphological and genetical differences of the two plant species. These results show that N-fertilization influenced phenology of both vegetables. Thus, it might be practical to apply

Table 2. Effect of nitrogen application on fruit yields and yield components of okra and tomato with hedgerow prunings applied as mulch in *Gliricidia* alley cropping system in 1993 and 1994 in Nigeria.

Nitrogen rate (kg ha⁻¹)	Fruit No. plant⁻¹		Weight fruit⁻¹ (g)		Fruit yield (g plant⁻¹)		Fruit yield t ha⁻¹	
	1993	1994	1993	1994	1993	1994	1993	1994
Okra								
0	7.3	8.3	16.3	15.7	128	131	4 7	4 6
30	10.8	11.3	17.0	16.3	178	185	6 7	6.8
60	9 3	12.3	16 0	16 0	142	197	5 3	7 3
90	8.3	8.7	16.0	15 7	133	137	4 9	5 1
Mean	8 9	10 2	16.3	15.9	145	163	5 4	6 0
Tomato								
0	9 3	9.7	38 4	37 3	361	372	13 3	13 9
30	11.8	13 7	41 9	43.0	497	588	18 6	21 8
60	12.7	11 5	41.1	42.3	524	480	19 3	17 8
90	10.3	10.3	40 0	41.3	415	428	15 3	15 8
Mean	10 9	11 3	40 3	41.0	449	467	16 5	17 3
LSD (P=0.05)								
Vegetable	0.36	0.95	1.81	1.29	28.7	20.5	1 36	1 09
N rate	1.23	0.94	1.28	1.05	36.4	23 2	1.29	0 88
Vegetable x rate	NS	*	NS	*	*	*	*	*

NS = Not significant, * Vegetable x N interaction was significant at P=0 05

Table 3. Effect of nitrogen application on total hedgerow prunings applied as mulch and on weed dry weight in alley cropping of okra or tomato with *Gliricidia sepium* in 1993 and 1994 in Nigeria.

Nitrogen rate (kg ha⁻¹)	Total weight of prunings (kg ha⁻¹)		Weed dry weight (g m⁻²) Before pruning (4 WAP)		Weed dry weight (g m⁻²) After pruning (8-12 WAP)	
	1993	1994	1993	1994	1993	1994
Okra						
0	13 7	14 0	234	238	59	67
30	13 8	14.6	258	269	65	74
60	13 4	13.7	339	338	80	88
90	14 1	13 9	350	378	94	98
Mean	13 3	14 1	295	306	75	82
Tomato						
0	14 1	13 8	243	248	79	81
30	14 5	14 8	260	288	86	99
60	14 6	14 3	353	331	118	123
90	14 9	15 7	368	390	127	149
Mean	14 5	14.8	306	314	103	113
LSD (P=0.05)						
Vegetable	NS	NS	NS	NS	17.4	19.2
N rate	NS	NS	25.2	25.7	10 5	12.1
Vegetable x N	NS	NS	NS	NS	*	*

NS = Not significant. * Vegetable x Ni interaction was significant at P=0 05

some N-fertilizer in combination with hedgerow prunings applied as mulch to enhance early growth and development of vegetables under alley cropping. An earlier harvest of fruits 2-9 days ensures a better market price during August and September, ensuring a low cost of production.

Fruit yield and yield components

The trend in yield pattern of the vegetables to N-fertilizer differed as compared with their vegetative characters in both years (Table 2). Although fruit production in both vegetables increased with the application of the highest level (90 kg^{-1}) of N and total hedgerow pruning applied as mulch, the results were consistently significant only at lower N-rates. The differences in fruit yields of the vegetables between 30 and 60 kg N ha^{-1} were not significantly different during the two years. Averaging the data for both years, application of 30 and 60kg N ha^{-1} significantly improved the pod yield of okra by about 40 and 35% and the fruit yields of tomato by 48 and 40% respectively, as compared with the no N applied treatment. Increasing the N-rate to 90kg ha^{-1}, however, did not result in an increased gain (5-15%) in fruit yield of the vegetables. Though application of 30 and 60kg N ha^{-1} with total hedgerow prunings applied as mulch increased fruit yield of the vegetables, more reliable and economically attractive area yields were obtained with the application of 30 than 60kg ha^{-1}. With the exception of fruit number per plant and weight per fruit in 1993, the vegetable x N interaction was significant in both years. This indicates that the response pattern of the vegetables and the choice of N-fertilizer rate to be applied for their production under alley cropping system differed each year.

Hedgerow prunings and weed dry weight

During 1993 and 1994, total weight of hedgerow prunings applied as mulch was not affected by either the vegetables, N-treatment or their interactions. However, dry weight of weeds was significantly affected by hedgerow prunings applied as mulch, vegetable type and N-treatment (Table 3). During the first four weeks of growth, before prunings were applied, there was no significant difference in weed dry weight for both vegetables with or without N application. However, following the application of hedgerow prunings at peak vegetative growth of the vegetables (i.e. at 8-12 WAP), the weed dry weight was significantly reduced by 70- 75% and 60-66% for okra and tomato, respectively. In both years, irrespective of prunings vegetable, plots with 60 and 90 kg N ha^{-1} produced the highest weed dry weight either before or after prunings were applied as mulch. Averaged across N rates, the weed dry weight was significantly higher by 35-40% in tomato than in okra plots, as suggested by the consistently significant vegetable x N interactions in both years. This indicates that growth response of weeds to N-treatment with prunings applied as mulch varied between the two vegetables during the peak vegetative growth; okra was more effective in the control of weeds than tomato. This is mainly due to the varying morphologies and growth habits of the two vegetables. The okra plant has a stronger upright stem and produces broader leaves than tomato plant. In smothering weeds, therefore, okra is likely to cover the soil more effectively and reduce the amount of solar radiation reaching the soil surface better than tomato.

The highly significant yield increase obtained from the application of 30 and 60 kg N ha^{-1} for both vegetables suggests that some external inorganic or organic fertilizer application is needed to sustain good yield of vegetables under alley cropping. A similar suggestion has been reported in alley croopping of maize and tree legumes by Evensen *et al.* (1991) and Larbi *et al.* (1993). Increased fruit yields of the vegetables at lower N-rates were likely due to the maintenance of soil fertility under alley cropping systems (Kang *et al.* 1981; Hulugalle and Kang 1990). It is also likely due to the nutrients released from the decomposed hedgerow prunings applied as muclch. Larbi *et al.* (1993) reported that soil organic carbon, nitrogen and available phosphorus increased as the proportion of *Leucaena* and *Gliricidia* hedgerow prunings applied as mulch increased. Furthermore, the basal dressing of 30 kg ha^{-1} each of P and K applied, particularly K, to all plots that received N-treatment might have contributed by enhancing availability of both native and added N; leading to a better balance of macro-nutrients.

CONCLUSION

The results show that alley cropping of okra or tomato and *Gliricidia sepium* can help to provide stakes and mulch, as well as part of the nitrogen needed by the vegetables. The hedgerow pruning applied as mulch, thrice during the experiment, were effective in reducing weed growth. The physical effects of the mulch, through reducing nutrient losses by surface erosion and decreasing soil temperatures and conserving moisture, may have contributed to increased vegetable yields. Furthermore, mulching may create a favourable habitat for soil organisms; this often improves soil structure (Hulugalle *et al.* 1986). The results also indicate that some supplemental nitrogen application is needed to sustain good yields in alley cropping of vegetable and tree legumes. The rate of 30kg N ha^{-1} appeared to be adequate in satisfying the nitrogen requirement of the vegetable crops with foliage from hedgerow prunings applied as mulch for soil fertility improvement and more sustainable productivity enhancement. One chemical effect of mulching on the performance of the vegetable in this study might be the release of nutrients, particularly N, from the decomposed hedgerow foliage. This is in addition to the nutrients released from the decomposed leaf litter and N fixed by the tree legume. Based on the results of this study, it is concluded that farmers can effectively control weed growth and obtain good vegetable yields in alley of tree legumes with hedgerow prunings applied as mulch. They can also reduce the cost of stakes and use of mineral nitrogen fertilizers in vegetable production; thus ensuring a low cost of production.

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