EVALUATION OF THE EFFECT OF HEDGEROW INTERCROPPING USING *Leucaena leucocephala* AND FERTILIZER APPLICATION ON GROWTH AND YIELD OF GARDEN EGGS (*Solanim melongena)*

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ABSTRACT
Field trials were conducted in Ghana to assess the effect of applying Leucaena prunings as mulch and N.P.K., 15-15-15 compound fertilizer on the growth and yield of garden eggs (Solanum melongena) during the 1993 minor and 1994 major cropping seasons. The crop was grown with or without Leucaena mulch as well as 0 kg/ha, 180 kg/ha and 360 kg/ha rates of fertilizer. The crop responded very well to the 15-15-15 compound fertilizer used, since plants without fertilizer had significantly reduced height; more days to flowering, fruiting and harvesting and produced yields far below the potential yield levels of the crop. In both seasons, applying the Leucaena mulch increased the mean yield by 21 percent over the no mulch treatments. Economic analysis of the various treatments showed that: producing the crop during the minor season with rainfall was not profitable; producing the crop during the major season was profitable when the half rate of fertilizer, mulched (F_1M_1); full rate fertilizer, mulched ($F_2 M_1$) and full rate fertilizer no mulch ($F_2 M_0$) treatments were applied, with the F_1M_1 ranking first as the most profitable option. This was shown by the comparative net income per hectare of: ¢1,215,000, ¢1,201,020 and ¢819,020 for the (F_1M_1), (F_2M_1) and (F_2M_0) respectively. Producing garden eggs with Leucaena mulch in hedgerow intercropping could reduce fertilizer requirement, at least by half. Hedgerow intercropping with garden eggs is therefore profitable and may become an attractive alternative to small-scale farmers as prices of inorganic fertilizer continue to increase over the years.

Keywords: *Leucaena mulch, 15-15-15 fertilizer, applications, hedgerow intercropping, Solanum melongena.*

INTRODUCTION

Garden eggs (S*olanum melongena*) is a fruit vegetable, which forms an important nutrient source in the daily diet of most West Africans (Sinnadurai, 1992). In Ghana, garden eggs is among the major vegetables sold at the market. The consumption of the crop is on the increase in developing countries like Ghana, due to increasing human population and better understanding of the nutrient values of the crop in the human diet.

Successful and increased production of vegetables rely greatly on the use of fertilizers; and garden eggs particularly has been identified to respond very well to commercial fertilizers as well as good amount of organic manure for good yield. Extensive dependence on chemical fertilizers for increased production of gardens eggs may not always be feasible in many developing countries, especially countries in Africa due to increasing cost of fertilizers and low income of rural farmers. Also, extensive use of agricultural chemicals, including fertilizers can pose risks to human health and to the environment (Quatara *et al.,* 1991).

To increase the production of garden eggs therefore, it is important to develop management practices that would lead to increased soil fertility and decreasing the extent of dependence on chemical fertilizers. Mulching with organic materials, among others, has the advantage of increasing the fertility levels of the soil through the supply of nutrient elements when the organic materials decompose. The most convenient way of obtaining mulch materials is by growing multi-purpose trees that produce a great deal of organic matter inside the field or by growing the crop in alley cropping (hedgerow intercropping) systems. Most studies with alley cropping have dealt with field crops (Palada *et al.*, 1992). In order to understand the principles and importance of the production of garden eggs in agroforestry (alley cropping) systems, it became necessary to evaluate/assess the performance of garden eggs growing in hedgerows of *Leucaena leucocephala*.

MATERIALS AND METHODS

Study Area and components of the study

The study was in two parts:

i) Laboratory Analysis on determination of dry matter yield and nutrient content of prunings and soil at the site. This was undertaken at the Soil Research Institute (SRI), Kumasi
ii) Field trials, which formed the main studies consisted of the production of the intercrop (garden eggs) at the Research farm of the Institute of Renewable Natural Resources (IRNR), KNUST, Kumasi. The field trials were conducted in the September – November 1993 minor season and repeated in the April – July 1994 major rainy season.

Soil and plant analysis

The studies began with chemical analysis of the surface soil (0-15cm depth) at the site. At the end of the second field trials, representative soil samples were taken at the 0-15cm depth, for end of cropping soil analysis. The soil samples taken before and at the end of the experiment were air-dried and analyzed for soil pH, organic Carbon, total N, P_2O_5, K_2O, Ca and Mg content of the soil.

During each of the three biomass harvests (cuttings) in each of the two cropping seasons, three *Leucaena* leaf samples were collected from each of the prunings. These leaf samples were oven-dried at 60°C until they attained constant weight and analyzed for N, P, K, Ca and Mg content of the leaf (plant). All the soil and plant analysis were carried out in duplicates at the Soil Research Institute (SRI) at Kwadaso – Kumasi.

Size of field of Study

The intercrop was planted in *Leucaena leucocephala* hedgerows planted at 4m inter-hedgerow and 0.25m intra-hedgerow spacing. Seedlings of the local cultivars of the garden eggs were planted at 0.95m inter-row and 0.90m intra-row spacing.

Design and Treatments

The experiment was replicated three times, and one replicate or block covered two alleys (hedgerows) with the size of 16m x 8m. The treatments within the blocks were set in a split-plot design, with the fertilizer application as the main-plot treatment and mulch application as the sub-plot treatment. Main-plot and sub-plot sizes were 8m x 5m and 5m x 4m respectively.

Each fertilizer treatment was applied in three split doses at 5-week intervals, with the first split application taking place at two weeks after transplanting. With 40 garden egg plants in each fertilizer treatment plot, the half rate (180 kg/ha) and full rate (360 kg/ha) plots received 6g and 12g of the 15-15-15 compound fertilizer per plant respectively, during each of the three times of fertilizer application.

There were 20 garden eggs plants in each *Leucaena* mulched treatment plot. The *Leucaena* hedgerows were cut (pruned) at 30cm above ground level, three times during the period of production at 5-week intervals. The first pruning was done two weeks after transplanting the intercrop. During the first cutting, prunings were weighed and evenly spread in the entire mulched plots. In subsequent cuttings, the prunings were weighed, equally divided into 20 and applied at the base of the individual garden egg plants in mulched plots.

Cultural practices
Appropriate cultural practices carried out include manual weeding, spraying insecticides against insect pests and applying furadan and dithane to control nematodes and fungal diseases respectively.

Assessment of some growth parameters of the intercrop
The following growth parameters of the garden eggs, planted in the various treatment plots were assessed: plant height at 60 days after transplanting; number of days to first and 50% flowering; number of days to first and 50% fruiting; and number of days to first harvest.

Assessments of yield and yield components
Fruits from sampled garden eggs plants were counted and weighed at each harvesting time. Yield values recorded for the various treatment plots were totals from the total number of harvests made during the maturity period of the intercrop. Data on yield and yield components of the intercrop was based on fruit size (g/fruit); number of fruits per plant; and fruit yield (tonnes/ha).

Analysis of Field Data
Data from field trials, which included growth parameters (plant height, days to 50% flowering, days to 50% fruiting and days to first harvest); yield and yield components (fruits size, number of fruits per plant, number of fruits per hectare) were analysed using the Analysis of Variance (ANOVA). Differences in treatment means were compared using the least significant difference (LSD) at 5% level of probability.

RESULTS AND DISCUSSION

Variation in soil characteristics
The chemical properties of the surface soil (0-15cm depth) at the site, at the start and end of the field trials are presented in Tables 1 and 2.

Table 1: Chemical properties of the surface soil (0-15cm depth) at the start of the trials

Characteristics	Level[1]
pH (H_2O)	5.71 (0.118)
Organic Carbon (%)	1.65 (0.118)
Nitrogen (%)	0.12 (0.009)
Phosphorus (ppm)	2.58 (0.225)
Potassium (ppm)	63.50 (0.707)
Calcium (meq/100g)	6.27 (2.407)
Magnesium (meq/100g)	2.67 (0.822)

The results indicated lack of significant change of pH, K and Mg levels in the soil at the end of the trials, generally in all the treatment plots although fertilizer and mulch were applied on the respective plots. Also, there was a general decline of organic Carbon and Ca levels in the soil by the end of the trials. The low initial fertility level of the soil may account for the lack of significant soil improvement even in plots mulched and/or treated with fertilizer. This confirms reports on a Leucaena alley cropping trials in Zam-

Table 2: Chemical properties of the surface soil (0-15cm) at the end of the trials

Treatment[a]	pH (H_2O)	Org. C (%)	N (%)	P (ppm)	K (ppm)	Ca (meq/100g)	Mg (meq/100g)
$F_0 M_0$	6.08	1.25	0.14	3.50	63.50	4.00	1.80
$F_0 M_1$	5.65	1.27	0.14	2.50	71.50	3.20	1.70
$F_1 M_0$	5.97	1.29	0.17	5.12	66.50	4.40	2.20
$F_1 M_1$	5.62	1.25	0.13	2.87	58.50	3.40	2.20
$F_2 M_0$	5.95	1.34	0.17	3.50	56.50	3.20	3.00
$F_2 M_1$	5.85	1.43	0.15	6.81	65.00	4.20	3.20
Mean[b]	5.85	1.31	0.15	4.05	63.58	3.73	2.32
	(0.168)	(0.064)	(0.015)	(1.481)	(4.987)	(0.442)	(0.579)

a $F_0 M_0$ = No fertilizer, no mulch
$F_0 M_1$ = No fertilizer, mulched
$F_1 M_0$ = 180kg/ha (half rate) 15-15-15 fertilizer, no mulch
$F_1 M_1$ = 180 kg/ha (half rate) 15-15-15 fertilizer, mulched
$F_2 M_0$ = 360 kg/ha (full rate) 15-15-15 fertilizer, no mulch
$F_2 M_1$ = 360 kg/ha (full rate) 15-15-15 fertilize, mulched
b Standard deviations of means are given in brackets.

bia by Matthews *et al.,* (1992), in which the authors remarked that it appears that soil improvement may occur where the soil fertility is already relatively high, but where it is low, then even further depletion occurs. The removal of the nutrient by the crop for vegetative growth and fruit formation might also contribute to the lower or constant level of nutrient elements at the end of the trials. Lal (1989b) in alley cropping trials in Nigeria found that soil organic matter, total N, pH and exchangeable bases declined in all treatments, although these trends were least marked in the *L. leucocephala* and *G. sepium* alley crop treatments.

There was however a slight increase in N levels and a significant increase in P levels at the end of the trials. This was probably due to the fact that the amount of nutrients contributed by the Leucaena prunings was far more than (Table 4) the amount required by the intercrop. And after the crop and the Leucaena plant itself had made use of their requirements the excess were left in the soil. Subbiah and Sundararajan (1990) have reported that the most suitable rates of fertilizer (nutrients requirements) for yield improvement were $N:P_2O_5:K_2O$ at 100:50:30 kg/ha for aubergines (garden eggs).

Dry matter and nutrient yields from the *Leucaena* prunings

Biomass (dry matter) yield was greater with the first prunings than in subsequent prunings in both years (Table 3) due to the longer interval between previous cropping and the next growing

Table 3: Dry Matter (biomass) yield (ton/ha) of hedgerow prunings of *L. leucocephala* intercropped with garden eggs

Cropping season	Prunings (Excluding woody stems)				
	1^{st}	2^{nd}	3^{rd}	Mean*	Total
1993	1.91^a	0.62^c	0.45^c	0.99 (4.64)	2.97
1994	1.02^b	0.65^c	0.52^c	0.73 (4.96)	2.20

**Values in brackets are Mean Annual Biomass Production (ton/ha)*
[a]DM yield over a period of 32 weeks
[b]DM yield over a period of 18 weeks
[c]DM yield over a period of 5 weeks

season, which allowed the *Leucaena* hedgerows to grow without disturbance.

The amount of nutrients contained or supposed to have been contributed (nutrient yield) by the *L. leucocephala* prunings (Table 4) were within the range of values reported in other studies (Palada *et al*., 1992). Assuming 20% nutrient use efficiency of N from prunings as observed with maize crop (Kang, 1987), the leucaena prunings could have contributed a total of 48 kg N/ha in 1993 and 56 kg N/ha in 1994.

Effect of the fertilizer and mulch on the growth and yield of the intercrop

The relatively large quantities of nitrogen added to the soil from the *L. leucocephala* prunings (Table 4) and the lack of significant change of N levels in the soil that received the half and full rate fertilizer, mulched treatments (Tables 1 and 2) would suggest that there was a more efficient release and uptake of N from these treatments. The low levels of almost all the nutrients in the soils with the half rate fertilizer, mulched treatments at the end of the trials (Table 2) can also be attributed to the efficient release of nutrients and the probable high uptake of the nutrients by the intercrop in these treatments.

In both years, plants (the intercrop) treated with full rate fertilizer, mulched, full rate fertilizer, no mulch and those treated with half rate fertilizer, mulched flowered at the same period, and were generally taller than those in the other treatments

Table 4: Nutrient yield (kg/ha/year) from *L. leucocephala* prunings used

Cropping season	Nutrient				
	N	P	K	Ca	Mg
1993	238.85	6.49	85.80	40.81	14.38
1994	279.84	6.95	91.79	47.14	14.88

Table 5: Effect of fertilizer and mulch on height of crop at 60 days after transplanting, days to 50% flowering and fruiting and days to first harvest

Treatment	Height (cm)	Days to 50% Flowering	Days to 50% Fruiting	Days to First Harvest
		1993		
No fert.., no mulch	28.0	82	90	85
No fert., mulched	36.7	68	79	82
Half rate fert., no. mulch	62.0	57	64	73
Half rate fert., mulched	62.3	56	61	74
Full rate fert., no mulch	70.0	56	62	72
Full rate fert., mulched	68.3	55	60	73
LSD (5%)	4.7	1	4.9	2.2
CV (%)	5.3	0.9	4.4	1.8
		1994		
No fert.., no mulch	32.0	67	73	81
No fert., mulched	57.3	58	64	77
Half rate fert., no. mulch	63.0	56	61	74
Half rate fert., mulched	71.0	55	61	74
Full rate fert., no mulch	61.0	55	61	71
Full rate fert., mulched	70.0	53	60	71
LSD (5%)	10.3	2	4	5.1
CV (%)	10.7	2.2	4.1	4.2

Table 6: Effect of fertilizer and mulch on fruit size, number of fruits and fruit yield (1993 and 1994)

Treatment	Fruit size (g/fruit)	No. of Fruits/ Plant	No. of Fruits (10^3/ha)	Fruits yield (ton/ha)
		1993		
No fert.., no mulch	28.2	4	37	1.0
No fert., mulched	41.5	10	100	4.2
Half rate fert., no. mulch	42.8	18	180	7.8
Half rate fert., mulched	47.0	23	235	11.0
Full rate fert., no mulch	47.3	23	230	11.0
Full rate fert., mulched	50.7	26	255	13.2
LSD (5%)	1.4	3.5	35.2	1.3
CV (%)	2.0	12.2	12.2	9.7
		1994		
No fert.., no mulch	29.4	17	163	4.8
No fert., mulched	40.7	27	268	10.9
Half rate fert., no. mulch	39.7	37	370	14.8
Half rate fert., mulched	48.3	54	535	25.8
Full rate fert., no mulch	46.7	42	422	19.8
Full rate fert., mulched	49.4	53	530	26.3
LSD (5%)	3.6	4.3	42.5	2.6
CV (%)	5.2	6.8	6.8	9.3

(Table 5). Plants treated with no fertilizer, mulched were taller ($P<0.05$) and also flowered and fruited significantly earlier than those with no fertilizer plus no mulch (Table 5).

There was lack of significant difference in fruit size and yield for plants treated with the half rate fertilizer, mulched treatment and the full rate fertilizer, mulched treatments, especially when there was adequate rainfall (Table 6). This indicates the efficiency of the half rate fertilizer, mulched treatments in promoting the growth and yield of the crop. This efficiency from the F_1M_1 treatment is probably due to:

i) The additional moisture conserved by the mulch material
ii) The Leucaena mulch enhancing the availability of nutrient elements from the fertilizer
iii) The more efficient release of nutrient elements from the mulch material as well as from the fertilizer due to adequate amount of moisture in the soil of this treatment.

Thus, by applying the mulch with the half rate fertilizer, the mulch could substitute for the half reduction in the fertilizer.

Effect of the mulch on the growth and yield of the intercrop

In both years, the significantly greater value of the fruit size, number of fruits and fruit yield from mulched plots than those from unmulched plots (Table 7) can be attributed to the positive effect of the mulch material in promoting growth and yield of the crop. As indicated in Table 4, there were large quantities of nutrients yield from the Leucaena prunings, which could contribute to the relatively high growth and yield of the crop in mulched plots. Also, it is probable that the mulch material could conserve enough moisture for regular use by the crop, and maintained a cool soil temperature which was a fa-

Table 7: Effect of *Leucaena leucocephala* mulch on fruit size, number of fruits and fruit yield of garden eggs (1993 and 1994 seasons)

Treatment	Fruit size (g/fruit)	No. of Fruits/ Plant	No. of Fruits (10^3/ha)	Fruits yield (ton/ha)
		1993		
No mulch	39.4	15.0	149.0	6.6
Mulched	46.4	20.0	197.0	9.5
LSD (5%)	0.8	2.0	20.3	0.7
CV (%)	2.0	12.2	12.5	9.7
		1994		
No mulch	38.6	32.0	318.0	13.1
Mulched	46.1	45.0	444.0	21.0
LSD (5%)	2.1	2.5	24.5	1.5
CV (%)	5.2	6.8	6.8	9.3

vourable condition for the root system of the crop, for a more efficient absorption of nutrient elements and water. Tindal (1983) has recommended mulching *Solanum melongena* to reduce high soil temperature which is injurious to the root system of the crop. The contribution of the mulch material is a positive development to Agriculture in Ghana and other developing countries because the results indicate that there can be significant reduction in the dependence of chemical fertilizers, which continue to increase in prices. Therefore low-income farmers in these countries can rely on Leucaena mulch materials for improved soil fertility and increased production of vegetable crops, especially garden eggs.

Effect of the hedgerow on the growth and yield of the intercrop

During the major rainy season (1994) cropping, plants grown in the middle of the alleys were significantly taller and produced more number of fruits and higher yield than those close to the hedgerows. This was probably due to competition for nutrients and water between the garden eggs close to the hedgerows and the Leucaena hedges. Atta-Krah (1983) has observed that when the prunings were put on the surface without soil disturbance, Leucaena coppices grew vigorously and competed with the associated maize crop, and reduced its yield. Tindal (1983) has observed that exposure of the local garden eggs to full sun is necessary since shaded conditions reduce growth.

Profitability of producing the intercrop with the various treatments

Economic analysis of the data showed that during the major rainy season, treatments that received the half rate fertilizer, mulched (F_1M_1); full rate fertilizer, mulched (F_2 M_1) and full rate fertilizer no mulch (F_2 M_0) were profitable, and the F_1M_1 ranked first. However, during the minor season, none of the combined fertilizer and mulch treatments was profitable, even though some appreciable net income per hectare were obtained for treatments that received the half and full rates fertilizer, with or without mulch (Table 8). The results indicate that fertilizer is a necessary requirement for economic production of the crop. However, with adequate water, the half rate fertilizer can be efficient particularly when combined with the *Leuceana* mulch material, which then becomes even more efficient, in promoting growth and yield than the full rate fertilizer, with or without fertilizer. The fact that the minor season (1993) cropping was not profitable for all the treatment combinations confirms the reason why farmers, especially in Ghana do not usually culti-

Table 8: Comparative Economic Analysis and ranking the profitability of the combined fertilizer and mulch treatments (1993 and 1994 cropping)

Treatments	Criteria					
	Gross Yield (kg / ha)	Total Costs per ha (TC)*	Net Income per ha (NI)*	Revenue on Investment (NI / TC)	Profitability**	Ranking
			1993			
No fert.., no mulch	1,250	438.00	-338.00	-0.77	NP (Loss)	6th
No fert., mulched	4,200	555.00	-217.00	-0.39	NP (Loss)	5th
Half rate fert., no. mulch	11,700	621.00	315.00	0.50	NP	1st
Half rate fert., mulched	11.000	719.00	161.00	0.22	NP	4th
Full rate fert., no mulch	11,220	675.00	223.00	0.33	NP	3rd
Full rate fert., mulched	13,200	773.00	283.00	0.36	NP	2nd
			1994			
No fert.., no mulch	6,000	568.22	-88.22	-0.16	NP (Loss)	6th
No fert., mulched	10,900	684.98	187.02	0.27	NP	5th
Half rate fert., no. mulch	17,000	750.98	657.02	0.87	NP	4th
Half rate fert., mulched	25,800	848.98	1,215.02	1.43	P	1st
Full rate fert., no mulch	20,300	804.98	819.02	1.02	P	3rd
Full rate fert., mulched	26,300	902.98	1,201.02	1.33	P	2nd

** Values are in thousands of cedis (¢'000)*
*** NP means Non-Profitable; and P means Profitable*

vate the crop on such high grounds, on commercial basis without irrigation during the minor rainy season. The results also mean that as the cost of labour and the price of fertilizer increase over the years or when there is no subsidies on fertilizer, it would be more economical for small-scale farmers to adopt the F_1M_1 treatment than the F_2M_1 treatment especially during the major rainy season. Nyambeki (1985) has observed that alley cropping appears to be a good land-conserving system, but with availability of subsidies on fertilizer and herbicides the system may become less attractive.

CONCLUSION

The local garden eggs (*Solanum melongena)* grown responded very well to the NPK: 15-15-15 fertilizer used. The *Leucaena* prunings applied as mulch yielded relatively large quantities of nutrients, with mean values of 259.35 kg N/ha, 6,72 kg P/ha, 88.80 kg K/ha, 43.98 kg Ca/ha and 14.63 kg Mg/ha during the two cropping seasons. The relatively large quantities of nitrogen added to the soil from the *Leucaena* prunings and the lack of significant change of N levels in the soil treated with the half rate fertilizer, mulched and full rate fertilizer, mulched treatments would suggest that there was a more efficient release and uptake of N from these treatments.

Applying the *Leucaena* mulch increased the mean yield by 21 percent over the no mulch treatments. Better growth and yield of the crop in mulched treatment plots were in part due to the significant amount of nutrients provided by the *Leucaena* mulch material and also the probable reduction of the soil temperature by the mulch material. During the major rainy season, the hedgerows could significantly reduce the number of fruits and fruit yield to the tune of 16 and 12 percent respectively. This was mainly due to shade effect and probable competition for nutrients and water between the garden eggs close to the hedgerows and the *Leucaena* hedges.

Economic analysis of the various treatments showed that:

i) Producing the crop during the minor season with rainfall was not profitable.

ii) Producing the crop during the major rainy season was profitable when the half rate of fertilizer, mulched (F_1M_1); full rate fertilizer, mulched (F_2 M_1) and full rate fertilizer no mulch (F_2 M_0) treatments were applied.

iii) Among the three treatments that were economical, the F_1M_1 ranked first as the most profitable option, followed by the F_2 M_1. This was shown by the comparative net income per hectare of: ¢1,215,000, ¢1,201,020 and ¢819,020 for the (F_1M_1), (F_2M_1) and (F_2M_0) respectively.

iv) Fertilizer is a necessary requirement for optimum growth and yield of the crop. However, with adequate rainfall (water), the half rate fertilizer can be efficient, particularly when combined with the *Leuceana* mulch material, which then becomes even more efficient in promoting growth and yield than the full rate fertilizer, with or without fertilizer.

The results thus indicated that producing the *Solanum melongena* with *Leucaena leucocephala* mulch in alley cropping during the major rainy season is feasible with lower inputs of fertilizer.

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