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Response of Growth and Leaf Yield of Adansonia Digitata Seedlings to Soil Amendments and Harvesting Regimes

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***Abstract*—Experiment on leaf biomass production of *Adansonia digitata* L. was carried at the Faculty of Agriculture, University for Development Studies at Nyankpala in the Northern Region of Ghana. The experiment was to determine the effect of rate of NPK fertilizer, leaf defoliation and their interaction on growth and leaf production. The treatments included zero-manure (control), organic manure (sheep manure, poultry manure, and cow dung) which were mixed with soil at the rate of 226.8g/pot before sowing of seeds whilst NPK fertilizer at 11.5g NPK/pot was applied at two weeks after planting (2WAP) and combined with leaf picking every 2, 3 week and zero-harvest (control) starting 6 weeks after transplanting. These treatments were arranged in a 3 x 5 factorial design in three replications. Baobab seeds were direct seeded in pots. Firstly, the response of the parameters to soil amendments followed the gradient: Cow dung > Poultry manure > Sheep manure > NPK > Control. Furthermore, cow dung influenced both plant height and stem girth. Among the fertilizer treatments, 11.5g NPK/pot gave total low yield. Harvesting baobab leaves every three weeks recorded the highest leaf yield. The application of cow dung combined with harvesting regime every 3 weeks supported regular leaf yield of baobab. The findings are in line with the purpose to domesticate baobab seedlings to market garden plants for commercial cultivation. Further studies on the effect of intercropping, plant spacing and integrated pest control on leaf yield and retention should be investigated.**

Keywords—Cow dung, Poultry manure, Sheep manure, NPK, Leaf retention, Baobab, soil amendment

I. INTRODUCTION

Among indigenous tree crops, the demand for *Adansonia digitata* L. globally has increased enormously dramatically in more sectors, such as the medical industry, food industry and cosmetic industry. For instance, the discovery of pharmacological properties as well as the multiple medicinal purpose uses of the whole plant in many part of the world [1], particularly Africa, places the plant at a higher pedestal. proceedings.

Adansonia digitata L. is a perennial plant mostly regarded as a fruit-bearing forest tree. Known as baobab tree in both English and French, it belongs to the Malvaceae family and very characteristic of the Sahelian region [2]. It is a multipurpose and widely-used species with medicinal properties, numerous food uses of various plant parts, and bark fibres are used for a variety of purposes [3, 4]. Even though the tree can live up to 1000 years or more the trees are generally deciduous, shedding its leaves every dry season. For the past years, baobab leaves have been a major component in traditional diets. The leaves which are rich in iron and other vitamins are commonly used as a leafy vegetable. The leaves can be eaten fresh or in the form of dry powder. In countries like Nigeria, Togo and Ghana the dried leaves are called “kuka” and are used to make delicious vegetable soup [4]. The dry pulp of the fruit, after separation from the fruits and fibres is eaten directly mixed into porridge or milk. The seeds of baobab can be used as thickener for soup. The seeds may be fermented into seasoning, roasted for direct consumption or pounded to extract vegetable oil. The tree also provide source of fibre, dye and fuel. The indigenous use baobab as source of water and food [1, 5].

In spite of the numerous benefits of baobab particularly the leaves in diet, it has never been under cultivation like the other indigenous vegetable species in northern Ghana. The few baobab trees found in northern Ghana are naturally regenerated plants. For this reason, fresh leaves available only in the wet season (3-4months). Observations showed that even during the wet season few fresh baobab leaves are seen on the market compared to other numerous leafy vegetables, while in the dry only the dry processed forms are readily available. However, consumers prefer fresh vegetables to the dry processed form. In this regards, mostly women and children are found scouting for fresh leaves in the wild during the dry season. This practice turns to be laborious, time demanding and in most cases lead the destruction of branches to obtain few leaves. Like the other leafy vegetables, baobab leaves production are affected by several factors including pests and diseases, extreme temperatures, erratic rainfall pattern, long drought and low soil fertility. Women and children mostly engage in wild leaves harvesting are exposed to snake bites, scorpions, among others. There have instances where children have been victims of severe injuries from broken trees branches. Therefore, it is commendable to search for alternatives to makes fresh baobab leaves available in quality and quantity all year around through garden cultivation.

In recent years, poor soil fertility, low levels of available mineral nutrients in soil, inappropriate nutrient management strategies, as well as lack of plant genotypes with high tolerance to nutrient deficiencies or toxicities are major bottlenecks contributing to food insecurity, malnutrition and eco-system degradation [6]. In general, investigations into plant nutrition can provide highly valuable information that can be used to negate the constraints outlined earlier. This will eventually result in increased productivity, sustained food and nutrition security with eco-friendly strategies. Several authors indicated that at least 60% of cultivated soils have problems limiting plant growth, that are attributed to mineral-nutrient deficiencies and toxicities, and approximately 50% of the world population has micronutrient deficiencies, thus presenting research into plant nutrition a promising area to augment global demand for sufficient food production and raise nutritional value [7-9]. It is estimated that high increase in world fertilizer consumption may hit as much as 200 or even 300 million tons in 2020, which prompts concerns due to low nutrient use efficiency and poor soil management [10]. For that matter, study of element and nutrient balances at various stages such as on-farm, nursery, and soil system balance, has remain generally preferred as an approach to sustainable agriculture productivity. However, there still are inadequate information in soil amendment for indigenous leafy vegetables.

Nowadays, commercial and traditional farming in Ghana are choosing to use of organic fertilizers for growing vegetables crops due to the many benefits to the soil, water and living organisms. Compared to inorganic fertilizers, organic manure can serve as alternative practice for soil structure improvement [11] and less cost to the poor farmer. However, to the best of our knowledge, adequate information on agronomic practices on both soil amendment and harvesting to domesticate the production of baobab leafy vegetable are completely lacking. However, efforts toward establishing standards for intensive cultivation of baobab seedlings to produce fresh leaves during the dry season as well are most appropriate. The specific objectives of the present study include; to determine the effect of different types of soil amendments on leaf yield, to determine the most appropriate harvesting frequency that affect leaf retention to maintain baobab seedlings growth as garden plants.

II. MATERIAL AND METHODS

Description of Experimental Site

A pot experiment was carried out in the plant house of the Faculty of Agriculture, UDS at Nyankpala near Tamale. The experimental site lies within the interior Guinea Savanna of Ghana which falls on latitude 9^{o} 25' 141", longitude O^{o} 58' 142" and at an altitude of 183m above sea level. The natural vegetation is grasses, shrubs and few trees that are scattered. The soil is brown in colour, moderately drained with sandy loam texture, derived from voltaian sandstone and classified as Nyankpala series (Plinthic Acrisol). The rainfall pattern is monomodal and erratic and associated with prolonged drought. The area has the total annual monomial rainfall of about 1022mm which falls mainly between May and September each year. The area has an average minimum temperature of 25 ^{o}C and maximum average temperature of 35 ^{o}C. During the experiment the Plant House recorded a mean minimum temperature between 22.5 ^{o}C and 32.0 ^{o}C with relative humidity between 34.8 % and 48.2 %.

Experimental Design

A 3 x 5 x 3 factorial in a Randomized Complete Block Design (RCBD) was used. There were five different soil amendments: cow dung (cow manure)/sheep manure/poultry manure/NPK 15-15-15 and zero-manure (control). Approximately10t/ha of various organic manure each at 226.8g/pot and 200kg NPK/ha at 11.5g NPK/pot were used to treat sandy loam soil. The rates of organic manures and NPK used were based on earlier work done on cabbage in the study area. Harvesting regimes of leaves consisted of the following: every 2 weeks harvest, every 3 weeks harvest and zero-harvesting (control). Leaves of control plants were retained and harvested only at the 4th harvest. A total of 15 treatment combinations were used. Ninety pots measuring 18 x 15cm were laid in 3 blocks with 30cm between blocks.

Different organic manure was mixed with soil before filling and sowing of the baobab seeds. NPK (15-15-15) fertilizer was applied to the seedlings two weeks after germination whiles the control received no fertilizer treatment. Three seeds were sown and subsequently thinned to one seedling in each pot at the 7th days after germination.

Data collection and statistical analysis

Data was collected on the following parameters; plant height, stem girth at 5cm above ground, number and leaf weight were recorded at weekly interval. During harvesting, three leaflets were left on each plant after every harvest to help the plants in photosynthesis.

Data collected were subjected to analysis of variance (ANOVA) using the computer software GENSTAT (sixth edition) and the least significant difference (LSD 0.05) were used to separate the means.

III. RESULTS AND DISCUSSION

Effect of soil amendments and harvesting on vegetative growth: The results showed that interaction between the soil amendments and harvesting regimes did not significantly (P >0.05) affect plant height although soil amendments alone significantly (*P* <0.05) affected plant height at 2, 4, 6, 8, 10 and 12 WAP. The results on comparison between amendment type was as follows Cow dung > Poultry manure > Sheep manure > NPK > Control (Table 1). Harvesting of baobab leaves at 4 WAP (Figure 1) and 8 WAP (Figure 2) showed a significant difference (P < 0.05) in plant height although plant height at 2, 6, 10 and 12 WAP were not significant (P >0.05). Results indicated that the different soil amendments significantly (*P* < 0.001) affected stem girth only at 8 WAP (Figure 3), 10 WAP (figure 4) and 12 WAP (figure 5) although cowdung and control had better influence with NPK recording the least effect on stem girth. This observation could be due to the reason that stem girth (an indicator of plant growth) with time increases both in size and the number of cells increase [12, 13].

Cow-dung as an organic manure is a good source of the three main elements (nitrogen, phosphorus and potassium) which are needed by plants. It also improves the physical at 8 WAP.

texture of the soil by helping it to retain moisture in the case of sandy soils and by improving aeration in clay soils. The organic manure is an eco-friendly, economically viable and ecologically sound that also played a significant role in soil biology, chemistry and physics [14]. The augmentation of crude oil polluted soils with cow dung enhanced remediation and restoration of crude oil polluted soil [15]. Baobab seedlings without soil treatment also showed positive effect. This is because baobab plants have the ability to grow from clays [16], sands [17], alluvial silts [18] and loams of various kinds [19].

The experiment indicated that harvesting of leaves only at 4 WAP (figure 6) significantly (*P* <0.05) influenced stem girth with harvesting every three weeks and un-harvested plants recording the higher stem girth of 0.5cm. This may be an indication that less frequent harvesting of fresh leaves of baobab will enhance continuous cell division and enlargement of stem diameter [12].

Table 1. Effect of soil amendments on mean plant height at 14 days interval

	Mean Plant Height (cm)						
Soil Amendments	2 Weeks	4 Weeks	6 Weeks	8 Weeks	10 Weeks	12 Weeks	Means of treatments
Sheep manure	4.36	9.44	11.84	11.64	11.96	11.96	10.2
Cow dung	8.06	13.41	13.73	14.58	15.14	15.38	13.4
NPK	5.38	7.81	8.40	10.64	10.68	10.68	8.93
Poultry manure	6.99	13.26	14.90	15.00	15.06	14.07	13.2
Control	NPK	8.40	11.23	3.47	4.93	5.01	4.77
LSD (0.05)	2.657	4.084	4.708	4.347	4.796	4.616	

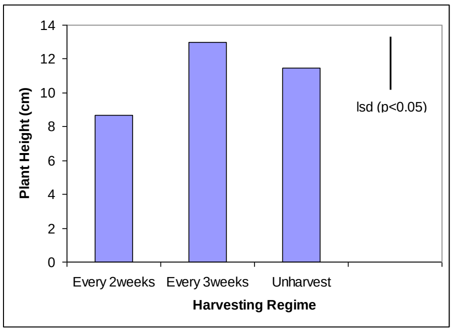

Fig.1. Effect of Harvesting Regimes on Plant Height at 4 WAP.

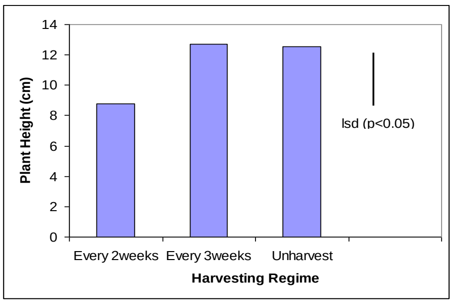

Fig. 2. Effect of Harvesting Regimes on Plant Height

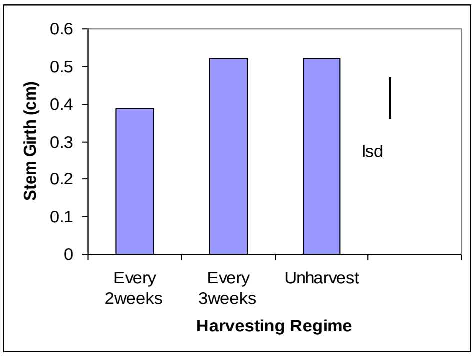

Fig. 3. Effect of Soil Amendments on Stem Girth at 8 WAP.

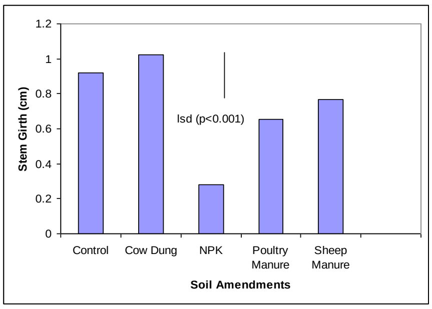

Fig. 4. Effect of Soil Amendments on Stem Girth at 10 WAP.

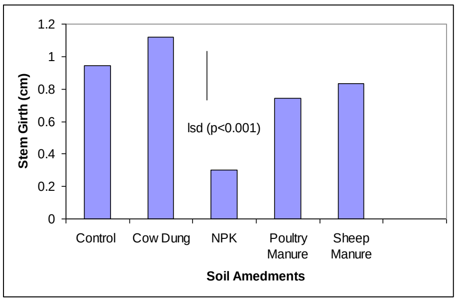

Figure 5. Effect of Soil Amendments on Stem Girth at 12 WAP.

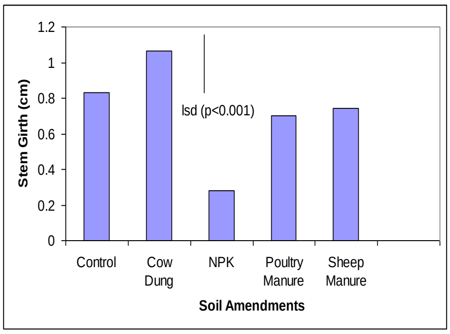

Figure 6. Effect of Harvesting Regimes on Stem Girth at 4 WAP.

Effect of soil amendments and harvesting on Mean Leaf Yield of baobab seedlings

The comparison between amendment type followed this gradient: Cow dung > Poultry manure > Sheep manure > NPK > Control. Even though, soil amendments and harvesting regimes did not have any interactive effect on leaf yield, but soil amendments alone significantly (*P* <0.05) affected first, second and fourth harvests. The first harvest showed much increase in leaf yield than the other harvests (Table 2). This was an indication that plants produced high number of leaves at the initial growth stages. From the results, NPK gave relatively low leaf yield over the period [20], while organic manure was able to provide enough nutrients that perhaps contributed to the high leaf yield [21]. Cow-dung, for instance has is not only popular among farmers in most parts of the savannah zone of Ghana, but has a lasting effect on the structure and water holding capacity. Similarly, the different harvesting regimes (2nd and 3rd harvests) had a significant (*P* <0.001) effect on mean leaf yield (Table 3). The less frequent leaf harvest (every 3 weeks) produced higher leaf yield than every 2 weeks was expected which perhaps enabled the seedlings to recover from defoliation.

Table 3. Effect of Harvesting Regimes on Mean Leaf Yield at Different Harvest.

	Mean Leaf Yield (g)				
Soil Amendments	1st Harvest	2nd Harvest	3rd Harvest	4th Harvest	Means of treatments
Sheep manure	1.278	0.289	0.366	0.461	0.60
Cow dung	1.188	0.376	0.393	0.788	0.69
NPK	1.117	0.202	0.480	0.441	0.56
Poultry manure	1.163	0.344	0.540	0.520	0.64
Control	0.259	0.149	0.164	0.147	0.18
l.s.d (0.05)	0.647	0.150	0.350	0.377	

Table 3. Effect of Harvesting Regimes on Mean Leaf Yield at Different Harvest.

				Mean Leaf Yield (g)	
Harvesting	1st Harvest	2nd Harvest	3rd Harvest	4th Harvest	Mean of treatments
2weeks	1.199	0.342	0.366	0.483	0.60
3weeks	1.703	0.374	0.700	0.831	0.90
Un harvest	-	-	-	0.100	0.1
l.s.d (0.05)	0.501	0.116	0.270	0.292	

Effect of Soil amendments and harvesting regimes on mean Leaf Count

According to the results soil amendments had a significant (*P* <0.05) effect on mean leaf count and the gradient is as follows: Cow dung > Poultry manure > Sheep manure > NPK > Control (table 4). Studies indicated that soil augmented with organic manure content to 4-5%, can maintain sufficient plant nutrition for a good crop to the end of the season or possibly over a period of years. This has been the practice, particularly in both rural and urban horticulture [22]. Organic soil amendment are very essential the sustainability of crop production systems since it forms important sources of nitrogen and carbon [23, 24] and it is also very critical in moderating pH and transportation of soil contaminants [22].

Table 4. Effect of Soil Amendments on Mean Leaf Count at Different Weeks

	Mean Leaf Count						
Soil Amendments	2 Weeks	4 Weeks	6 Weeks	8 Weeks	10 Weeks	12 Weeks	Means of treatments
Sheep manure	2.123	2.623	2.92	2.95	1.884	1.783	2.38
Cow dung	2.363	2.824	3.03	3.92	2.296	2.353	2.80
11.5g NPK	2.297	1.948	2.38	2.53	1.830	1.800	2.13
Poultry manure	2.379	2.767	3.02	2.99	2.228	2.351	2.62
Control	1.693	1.762	1.23	1.21	0.969	0.811	1.28
l.s.d (0.05)	0.470	0.578	0.725	0.726	0.615	0.559	

Generally, harvesting regimes significantly (*P* <0.05) affected mean leaf count positively except at 2 WAP where the harvesting did not significantly affect mean number of leaves (See table 5). Feeding at an early stage of plant growth makes a huge difference later [11], which probably might have accounted for the significant differences in mean leaf count subsequently. Organic manure, particularly animal manures have been used for plant production effectively for centuries and has been considered an integral part of sustainable agriculture [25].

Table 5. Effect of Harvesting Regimes on Mean Leaf Count at Different Weeks

	Mean Leaf Count						
Harvesting Regimes	2 Weeks	4 Weeks	6 Weeks	8 Weeks	10 Weeks	12 Weeks	Means of treatments
2weeks	1.937	1.924	2.08	2.05	1.312	1.336	1.77
3weeks	2.330	2.651	2.64	2.72	1.560	1.560	2.24
Unharvest	2.187	2.580	2.83	2.80	2.532	2..383	2.59
l.s.d (0.05)	0.364	0.449	0.561	0.563	0.476	0.433	

IV. RESEARCH IMPLICATIONS FOR NUTRITION AND INCOME SECURITY

Until recently, the baobab tree has never been planted deliberately but rather grows virtually wild. In the regions where the tree is found, it is cherished (even worshipped). However, land degradation, desertification and population pressure are now breaking down traditional farming systems, and the all-important trees particularly the baobab that sustain people are either disappearing or suffering from over exploitation. As a matter of fact, if people start to plant and cultivate their own trees, they will no longer have to strip so many leaves from adult trees around the village. According to Schreckenberg, et al. [26] leaf stripping prevents 90 percent of wild baobab from bearing fruit. However, if the findings of this study are adopted, that will mean relatively young seedlings can be used for intensive leaf production throughout the year for consumption. Baobab leaves have a high content of iron compared to numerous other wild-gathered foods, and are a rich source of calcium [27] which will go a long way to improve upon the diet of the people who utilize it most, particularly in northern Ghana Finally, the advantage of cultivating baobab seedlings include the use of limited production input. The seedlings have the potential to grow in soil with limited fertility although addition of organic manure will increase the soil nutrient level over long period of time and improve physical soil qualities. In order words, the physical and chemical qualities as well as soil microorganisms in soil will be improved.

V. CONCLUSION

Baobab seedlings can be grown in home gardens. Improving the soil nutrients will facilitate better plant growth under intensive garden cultivation. It was also evident that harvesting every three weeks will give high leaf yield. Cow-dung combined with harvesting of leaves every 3 weeks could support regular leaf yield and growth performance of baobab. The findings are in line with the purpose to domesticate baobab seedlings to market garden plants for commercial cultivation. Subsequent investigation should consider different aspect of Baobab cultivation practices such as the effect of intercropping, plant spacing and integrated pest control on leaf yield and retention.

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