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Research Article

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Effect of Plant Spacing and Harvest Interval on the Growth Parameters of Moringa oleifera Lam (Periyakulam-1) in Sokoto (Semi-Arid Environment)

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Abstract

Moringa is a typical representative of multi-purpose tropical tree crop due to the high nutritional value, it is an important source for food to many communities and provides raw materials for animal feed industries. This study investigates the influence of plant densities (15 x 15 cm, 15 x 20 cm, 20 x 20 cm, and 20 x 30 cm) and four (4) harvesting intervals (HI) of 2, 4, 6 and 8 weeks was laid out using Randomized Complete Block Design (RCBD) replicated three times. Data on silvicultural practices were collected and six (6) plants were randomly selected for harvest from each plot which were subsequently separated into leaves, stems and twigs. Fresh and air-dried weights were recorded for analysis. Analysis of Variance (ANOVA) was used for data analysis Duncan's Multiple Range Test was used to separate the means. Results of the present study show non-significant effects of plant density ($p>0.05$) between treatments. However, greater number of branches, leaves, height and biomass accumulation was recorded at 8 weeks harvesting interval. A significant interaction effects were recorded between spacing and HI.

Keywords: Space Interval, PKM-1, Growth Parameters, Biomass, Semi-Arid Environment.

Introduction

Agricultural sector contribution in developing economies to achieve sustainable and inclusive growth can however never be over-emphasis. Agricultural sector played an important role in Nigeria dated back to 1960 relative to other sectors in terms of contribution to foreign exchange earnings, employment generation and domestic production [1]. Nevertheless, after oil booming in the early 1970s agricultural sector was neglected posing threats to food security and livestock production. Furthermore, climate changes due to changes in temperature and rainfall could result in spatial shifts of agricultural production output which may have considerable socio-economic impacts. Other impacts such as unavailability of water to the animals which could likely lead to malnutrition, frequent disease and increase poverty particularly among the poor/underdeveloped countries [2]. Some of these challenges can be tackle by the quality and nutritional composition of the food consumed. Thus, all parts of Moringa tree can be used for nutritional and other purposes as a multi-use crop.

Every part of Moringa is a storehouse of important nutrients and the leaves are rich in essentials minerals and vitamins [3]. Other phytochemicals which can be found in Moringa includes; reducing sugar, anti-cancerous agents, alkaloids, saponins, flavonoids, sterols and tannins [4]. Moringa leaves can be used in the diet of the obese individuals having low calorific value. Also, due to fibrous nature of Moringa pods, it is reported to thwart colon cancer and treat digestive problems [5].

Furthermore, Moringa play a significant role against desert encroachment because of its adaptation to dry areas. Moringa crop being adaptive to a wide range of soil and climatic conditions can be easily propagated in semi-arid and arid regions. According to Stevens et al. (2015) Moringa crop also played vital role in the enhancement of family incomes and even national economies [6]. Not least, another relevant aspect is the provision of shade to protect humans and animals from severe solar radiation.

There is paucity in information on the growth parameters and quality of Moringa (PKM-1) under the Sokoto semi-arid environment. Thus, this study was conducted to evaluate the plant spacing and harvest interval effect on growth performance and nutritional quality of PKM-1 in the Northwestern region of Nigeria.

Materials and Methods

Study Area

The study was conducted at Research farm of the faculty of Agriculture, Usmanu Danfodiyo University, Sokoto, Nigeria, located between latitudes 1106`N and 1309`N and longitudes 307`E and 609`E, the location has an altitude of 281 (meters) above sea level with average daily maximum temperature ranges between 35 and 37°C. Rainy and dry seasons are the two predominant seasons in the study location [7]. The rainy season is short and erratic, usually falling between the months of June and September (500-700mm/annum) and the dry season that starts from October and ends in May. The vegetation of the area is characterized by sparse, widely spaced trees (5-9m height) and dominated by shrubs and grasses. The combination of natural and human activities, including droughts, persistent deforestation and continuous encroachment of the natural vegetation are some of the basic features of the area [8].

Experimental Design and Treatment

This study is a factorial experiment which consists 2 factors (plant spacing and harvesting interval). The treatment consisted of factorial combination laid out in Randomized Complete Block Design (RCBD). The combinations comprises of Four (4) plant spacing (15 x 15 cm, 15 x 20 cm, 20 x 20 cm, and 20 x 30 cm) and four (4) harvesting intervals of 2, 4, 6 and 8 weeks,.

Land Preparation and Silvicultural Practices

The land was prepared manually at 20 cm depth, harrowed and levelled. Three blocks of 8.7 m x 8.7 m were established and within each block sixteen main plots were also established. Each main plot has dimension of 1.8 m x 1.8 m with 0.5 m space between treatments. Plant spacing and harvesting interval as two sub-plot factors were randomly assigned in each main plot factor. Seeds of *Periyakulam*-1 (PKM-1 which is a superior Indian Variety) were obtained from International Crop Research Institute for Semi-Arid Tropics (ICRISAT, Niger Republic). Planting stations were marked in each plot and planted with the following plant spacing of 15 cm x 15 cm, 15 cm x 20 cm, 20 cm x 20 cm and 20 cm x 30 cm respectively.

The experimental units were irrigated once daily during the trial period. Recommended fertilizer rate of NPK 45:15:30 kg per hectare was also applied at planting [9]. Two weeks after plant emergence, seedlings were thinned to one healthy plant per station to reduce competition. Weeding was done manually as at when due using hand hoe to reduce competition as weeds compete with plants for growth factors. Harvesting was started at four (4) weeks after complete germination, seedlings were uniformly pinched back and all the foliage were removed. Ten (10) plants were randomly selected from the net plot of 0.8 m x 0.8 m for harvesting of the regrowth fortnightly (2, 4, 6 and 8 weeks harvesting intervals).

Field Data Collection

Data collection commenced two weeks after seedlings were uniformly pinched back. Parameters studied (Plant height, Number of branches, Number of leaves and Collar diameter per seedlings) were measured fortnightly for eight (8). Number of leaves and branches were counted manually, a meter rule and Vernier caliper were used to measure Plant height and Collar diameter, respectively. The fresh weight of shoots were harvested per plot whereas Leaf Area Index (LAI), root-shoot ratio and Biomass (Seedlings fresh and dry weight) were assessed at 8wks through destructive sampling (Aderounmu, 2010). Seedlings were sampled and separated into leaves, stem and roots. Fresh weight of leaves and stem were measured using electronic weighing balance (S Metter 500) thereafter they were oven dried at 60^0C for 72 hours to a constant weight for dry matter measurements [9]. LAI and root-shoot ratio were determined using the formula described by Remison (1997).

Data Analysis

Data collected during the field and laboratory analysis was analyzed using Analysis of Variance (ANOVA) and where significant differences exist among the means, Duncan's Multiple Range Test was used to separate the mean values using SPSS package (Version 20).

Results and Discussion

Effect of Spacing and Harvesting Interval (HI) on Growth

The effects of spacing on number of leaves (NL), number of branches (NB), plant height (PH) and collar diameter (CD) were shown in [Table 1]. The study revealed no significant difference on all the spacing interval investigated. [Table 2] revealed significant influence of HI on seedlings growth parameters of the study specie. There was increase in NB, PH and CD as the harvesting interval increases except NL that recorded inconsistent pattern of growth.

Greater number of leaves is vital for a species when direct seeding is done at early establishment owing to the fact that number of leaves ensure proper light interception due to sufficient leaf area, improved photosynthesis which can results to increased crop yields and growth [10].

The planting density, inherent capacity of species to coppice following defoliation and harvesting intervals are the most important factors influencing plant performance under continuous harvest when defoliation is taking place. Generally, higher growth performance is correlated with longer harvesting intervals. Therefore, in order to obtain maximum quality and quantity of foliage, it is imperative to find an optimum planting density and time of harvest [11]. There was a general increase in the average NL for PKM 1 with time (Harvesting interval). This is probably due to competition for essential growth factors such as nutrients, sunlight, space and water, thus the continuous nutrients intake by plants results in depletion of soil nutrients with a corresponding decline in leaf yields [9]. This also agrees with the findings of Sadeghi et al. (2009); [12-17].

Table 1: Effect of Spacing on Growth Performance of PKM-1

Treatments	Growth Parameter			
	NL	NB	PH(cm)	CD(mm)
Spacing (cm)				
15x15	193.00	8.00	28.10	0.55
15x20	161.00	6.00	24.02	0.49
20x20	151.46	7.00	24.75	0.49
20x30	199.00	6.00	23.50	0.43
SEM	35.769	0.657	3.944	0.050
Sig.	Ns	Ns	Ns	Ns
NL- Number of leaves NB- Number of branches PH- Plant Height CD- Collar diameter				

The 15x15 cm spacing according to the findings of the present study is most ideal density for improved initial seedling establishment which encourages leaf production and development.

The study showed continuous increase in NB, PH and CD with time (HI), several works have supported this phenomenon that plant growth is an irreversible increase in size occurring through increase in the number of cells and cell size [9, 18]. Plant spacing of 15x15 cm also showed higher (P<0.05) NB and PH compared to 20x30 cm spacing, while CD was higher (P<0.05) with 20x30 cm spacing compared to 15x15 cm spacing. PH differences with successive HI are not unusual, and have been reported by [12, 19]. Again, 15x15 cm spacing generally resulted in taller PH compared with 20x30 cm spacing, this could be due to competition for growth factors such as light and space. This is in agreement with the findings of Akinbamijo et al. (2003) who reported pronounced effect on overall shoot yield, stem size and leaf production with increase in spacing over time [12]. Also, 20x30 cm spacing produces plants with bigger CD which could be attributed to reduction in competition for growth factors, consequently leads to accumulation of nutrient reserve (particularly carbohydrate) in the stems. This was supported by several studies conducted on the effects of spacing and harvesting interval of Moringa crop [12, 14]. Findings from our study have indicated that 20x30 cm spacing produced the highest CD, therefore if the aim is for seed and firewood production purposes, then 20x30 cm spacing is suitable being faster and greater in respect to individual plant growth with wider CD.

Table 2: Effect of Harvesting Interval (Hi) on Growth Parameters of PKM-1

Growth Parameters	HI (weeks)				Sig	SEM
	2	4	6	8		
NL	185.00^{b}	69.00^{c}	168.00^{b}	282.00^{a}	*	28.260
NB	4.00^{c}	6.00^{b}	7.00^{b}	9.00^{a}	*	0.441
PH(cm)	13.61^{c}	21.64^{b}	26.97^{b}	38.13^{a}	*	2.301
CD(mm)	0.31^{b}	0.53^{a}	0.56^{a}	0.57^{a}	*	0.041
Means followed by the same superscript (s) within a row are not significantly different (p<0.05) HI- Harvesting Interval NL- Number of leaves NB- Number of branches PH- Plant Height CD- Collar diameter						

Effect of Spacing on Leaf Area Index (LAI), Root-Shoot Ratio and Biomass Accumulation

The study revealed that low and moderate spacing (15x15cm-205x20cm) showed higher (P<0.05) LAI [Table 3]. The present study is in agreement with the report of Damtew et al. (2011) where an increase in LAI with increase in plant population density was recorded, this could be ascribed to the greater number of plants/unit area [20]. Increased LAI might be due to increased rate in capture of photosynthetically active radiation (PAR). This is because exposure of more leaves to sunlight radiation, leads increase in the rate of photosynthesis. In their conclusion, highlighted that spacing of plants greatly influences growth of plants and their yield [21].

Our results indicated that 15x20 cm spacing gave higher (P<0.05) root-shoot ratio [Table 3]. Thus, the plants in medium densities had adequate moisture and nutrients. Therefore, roots did not have to expand in search of growth resources. Plants that can withstanding adverse environmental conditions such as fluctuating water availability and dry spells have extensively developed rooting system capable of anchoring firmly into the soil. Somewhere (Squire, 1990) in their study on other multi-purpose trees reported increase in plant population density leads to an increase in plant growth when each plant competes with its neighbor and with resources being utilized when roots and stems entangle [22]. According to Sadeghi *et al*. (2009), plants efficiently utilize environmental and

soil conditions whereby inter-or-intra-specific competition is reduced in production systems where suitable plant densities are needed [17]. Also it has been reported that the number of plants in a given unit area influence yield of a crop in which narrow (15 cm) row spacing increased yields compared to the middle (30 cm) and wider (45 cm) spacing [23].

Table 3: Effect of Spacing on Leaf Area Index, Root-Shoot Ratio and Biomass Accumulation

Plant Spacing (cm)	Leaf Area Index (cm)	Root-shoot (cm)	Biomass	
			Fresh (g)	Dry (g)
15x15	0.63^{ab}	5.77^{cd}	80.48^{ab}	13.50^{abc}
15x20	0.67^{a}	8.37^{a}	91.30^{a}	15.37^{ab}
20x20	0.60^{b}	7.20^{b}	79.63^{ab}	13.26^{abc}
20x30	0.53^{c}	7.60+	93.67^{a}	15.93^{a}
SEM	0.082	0.279	10.652	2.879
Means followed by the same superscript (s) within a column are not significantly different (p<0.05)				

Assessment of biomass was conducted at 8 wks and it was observed that higher fresh and dry matter were recorded with increase in age. Previous works have established that, longer HI increases biomass production (Latt *et al*., 2000; Tuwei *et al*., 2003). More foliage in plants could be attributed to high plant biomass production might resulted in improving radiation capture, thus increased in plant yields. Our results is consistence with the earlier findings of that indicated increased biomass trend patterns as the plant density increases [16, 17].

Interaction Effect of Spacing and Harvesting Interval on Growth Parameters

Spacing of 15x15 cm and 15x20cm for *PKM* 1showed higher (P<0.05) NL (395 and 359) respectively compared to 20x20 cm and 20x30 cm obtained at 8wks HI, while 2wks HI gave least NL in all the spacing. It was also observed that in all the spacing obtained at 8wks HI gave similar (P>0.05) NB, while 15x20 cm spacing obtained at 2wks HI recorded the least NB (3.00). It was also revealed that at 15x15 cm and 15x20 cm spacing had similar PH with 48.67 cm and 41.33 cm, but higher (P<0.05) than 20x20 cm and 20x30 cm spacing obtained at 8wks HI, while all the four spacing recorded the least PH at 2wks HI. CD were higher (P<0.05) in all the spacing with statistically similar values except for 15x15 cm that gave 0.60 mm obtained at 8wks HI, while 2wks HI gave the least CD in all the spacing [Table 4].

Table 4: Interaction Effect of Spacing and Harvesting Interval on Growth Parameters

Spacing (cm)	HI (weeks)	NL	NB	PH(cm)	CD (mm)
15x15	2	65.00^{f}	5.00^{e}	11.33^{f}	0.30^{e}
	4	70.00^{f}	7.00^{b}	21.73^{d}	0.50^{cd}
	6	242.00^{bc}	9.00^{a}	30.67^{bc}	0.57^{c}
	8	395.00^{a}	10.00^{a}	48.67^{a}	0.60^{b}
15x20	2	58.00^{f}	3.00^{g}	11.43^{f}	0.30^{e}
	4	151.00^{d}	5.00e	20.13^{de}	0.37^{de}
	6	162.00^{cd}	6.00^{cd}	23.17^{cd}	0.40^{d}
	8	359.00^{a}	9.00^{a}	41.33^{ab}	0.67^{ab}
20x20	2	86.00^{f}	4.00^{fg}	16.83^{e}	0.37^{de}
	4	103.00^{e}	6.00^{cd}	19.77^{ef}	0.50^{cd}
	6	190.00^{c}	7.00^{b}	29.73^{bc}	0.50^{cd}
	8	226.00^{bc}	8.00^{ab}	29.83^{bc}	0.67^{ab}
20x30	2	62.00^{f}	4.00^{fg}	14.83^{e}	0.28^{e}
	4	88.00^{f}	5.00^{e}	16.00^{e}	0.50^{cd}
	6	288.00^{b}	6.00^{cd}	29.83^{bc}	0.67^{ab}
	8	271.00^{b}	9.00^{a}	33.33^{b}	0.77^{a}
SEM		39.310	0.833	3.876	0.068
Means followed by the same superscript (s) within a column are not significantly different (p<0.05)					

Conclusion and Recommendation

Our results showed that spacing and harvesting interval had a significant influence on Moringa growth parameters investigated in the present study. Therefore, plant density and age at which plant is harvested need to be taking into consideration for the production of Moringa. Based on the condition in which the present work was conducted, plant spacing does not have any significant effect on the number of leaves, branches and height. However, for increased number of leaves, branches, height and biomass production, it is recommended to harvest Moringa interval at 8 wks of age [23-27].

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