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ASSESSMENT OF SOWING DATE OF GUNA MELON (*Citrullus colocynthis* (L) Schrad) IN PEARL MILLET (*Pennisetum glucum* (L) R. Br) BASED INTERCROP FOR DESERTIFICATION CONTROL IN SAHELIAN AGRO-ECOLOGY OF YOBE STATE – NIGERIA

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ABSTRACT

Desertification is a major environmental concern in Yobe state and demand for sustainable crop management is imperative. Thus, field trials were conducted to determine the appropriate sowing dates of guna melon in pearl millet based intercrop as it relate to edaphic and environmental characteristics for adaptation, reduced desertification, sustainable food, nutritional, income and energy security. Treatments consisted of four different sowing dates of guna melon (18th July, 1st August, 15th August and 28th August) laid out in Randomized Complete Block Design (RCBD) with three replicates. Result showed that early sowing of guna melon significantly affected both number of vines/stand and length of vines/stand (cm) when compared to late sowing of guna melon both as sole and as intercrop. Results also revealed that yield components and seed yield of guna melon differed with different planting dates where highest number of fruits/stand, seeds/fruit and seed yield (kg/ha) were produced at the fourth sowing dates for both sole and intercropped guna melon (SG_4; M_1G_4) in 2015 and 2016 seasons. Total LER values greater than unity (1.00) were recorded for pearl millet–guna melon intercrop in both years. Based on these findings, the fourth sowing date of guna melon is highly recommended for improved agricultural productivity, sustainable nutritional security, enhanced income, source of alternative energy and desertification control in the sahelian agro-ecology zone. Future research efforts should be focused on genetic improvement of guna melon.

Keywords: Guna melon, pearl millet, intercrop, sowing date, sahelian agro-ecology.

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1. INTRODUCTION

Intercropping is one of the important cropping systems recommended to mitigate the aberrant climatic conditions of the sahalian agro-ecology of Yobe state, Nigeria. It has been reported that at least 50,000 farmers in about 100 villages in Yobe state were at risk of abandoning farming due to reduced agricultural output caused by dunes covering a large expanse of their farmlands (Olagunju, 2015). As a result, Yobe state government has been making efforts aimed to combating environmental problems of desertification through afforestation programmes. However, prominence has been given in planting of trees and relegating to the background the use of locally adapted and economically important crop species such as guna melon (*Citrullus colocynthis* (L.) Schrad). Guna melon, also known as desert gourd or bitter gourd, is a member of the *Cucurbitaceae* family and is widely grown in Yobe state, north-east Nigeria. It is a perennial drought-cool-tolerant-trailing crop with an extensive root system, a feature which makes it obtains water even at peak of dry season and to utilize very little residual soil moisture for its growth and flourish to maturity under the cool weather of the harmattan. Odo *et. al.*, (1994) reported that, in the more drought prone areas, north of Yobe state, 90% of farmers grow guna melon because of the increased awareness of its high seed protein of about 20% to 27% and 60% of edible oil (Penuel *et. al.*, 1998). In addition of being a source of edible oil, it has potential to be used as bio-diesel feedback, cosmetics and for medicinal purpose (Menon *et. al*, 2014; Gurudeeban *et. al*., 2010). The residue after oil extraction from the seeds (press-cake) is high in protein and is usually useful as livestock feed. Extracts of guna melon fruits, leaves, roots and stem could be a source of natural insecticide and can be a better substitute for synthetic insecticide that may leave hazardous residues in the agro-ecosystem (Torkey *et. al.*, 2009). Both living and dead plant material helps to minimize direct impact of high temperature, retain moisture and increase the soil organic matter when it decomposes (Amshi and Odo, 2001). As reported by Amshi (2017), guna melon is grown as a component of intercrop that involves pearl millet (*Pennisetum glucum* (L) R. Br), a cropping combination that provides a balanced and nutritional diet to both urban and rural settings. Therefore, guna melon-pearl millet intercropping is found to be an environmentally compatible cropping system that matches with the priorities of local subsistence farmers who mainly focus on the use of land, labour and other resources for improved agricultural productivity. In recognition of the potentials of guna melon (*Citrullus colocynthis* (L.) Schrad), trials were conducted to assess the appropriate sowing date of guna melon in pearl millet based intercrop as it relate to edaphic and environmental characteristics for adaptation, food/nutritional and energy security, economic returns and desertification control in the sahelian agro-ecology of Yobe state, Nigeria.

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2. MATERIALS AND METHOD

2.1 Description of the study area

Two-year field trials were conducted during 2015 and 2016 rainy seasons on a farmer's farm at Gashua, Yobe state, Nigeria (latitude 12^0.874' N and longitude 11^0.04'E at an altitude of 299 meters above sea level). The cropping history of the farm over a period of five years showed that pearl millet (*Pennisetum glucum* (L) R. Br) and/or sorghum (*Sorghum bicolor* L.) had been intercropped with cowpea (*Vigna unguiculata* (L.) Walp), rosette (*Hibiscus sabdariffa*) and/or guna melon continuously in the area.

2.2 Weather record and physio-chemical properties of soil

Data on weather elements were obtained for Gashua from June to December, in years 2015 and 2016 as presented in Table 1. Total rainfall for 2015 was 463.3mm while that of 2016 was 452.7mm. The mean monthly temperature were highest in June while the relative humidity were highest in August (77% and 76%), which coincided with the month when the greatest amount of rainfall (226.6mm and 216.9mm) occurred for both years. Soil samples were collected from different part of the experimental field. The composite sample was used to determine the physical and chemical properties of the soil before planting. Table 2 indicates that the soil was sandy loam with pH values of 5.27 and 5.11 for 2015 and 2016 seasons, indicating that the soil was slightly acidic. The organic matter content was low. Available calcium was higher than magnesium while available potassium and phosphorus were quite low. Bulk density of 1.60mg/m^3 and 1.58 mg/m^3 were recorded for 2015 and 2016, respectively (Table 2).

2.3 Planting materials

Pearl millet (variety gwagwa) and guna melon, local landraces were obtained from Yobe State Agricultural Development Programme. These varieties were selected because they are mostly grown by farmers for their high yields and resistance to drought.

2.4 Treatments and experimental design

The treatments consisted of four sowing dates of guna melon (18^{th} July (G_1), 1^{st} August (G_2), 15^{th} August (G_3) and 28^{th} August (G_4). Both sole and intercropped pearl millet were sown on the 18^{th} July (M_1), the first sowing date of guna melon component (G_1). Double-rows of pearl millet alternating with single-row of guna melon (2:1) cropping pattern were employed in the trials. On each sowing date, sole guna melon was sown as control for the intercrops. Plant population density of 6,000 plants per hectare for guna melon and 133,000 plants per hectare for pearl millet were employed. Inter-row and intra-row spacing adopted for guna melon was 180cm x 180cm

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while for pearl millet, the spacing was 75cm x 30cm. The experiments were laid out in Randomized Complete Block Design (RCBD) with three replications into which the treatments were assigned. The total experimental area was 1111m^2 with a total of 27 plots each measuring 5.4m x 5.0m. Each plot was bonded at the edge to minimize run-on and run-off flood from torrential rainfall. 1.0 meter pathway separated adjacent plots. Similarly, each block was separated from the other by1.0 meter pathway.

2.5 Cultural practices and harvesting

All the crops were planted on a flat land after manual land clearing was carried out with minimum tillage. The row orientation for all treatments for both years was north-south direction in order to reduce wind erosion. Weeding was done manually two times; firstly 2 weeks after sowing and 6 weeks after sowing with a simple African hoe. Fertilizers were applied in two split doses; at time of sowing (N.P.K 15:15:15) and urea (46% N) at six weeks after sowing Pearl millet was harvested when the leaves turned yellow and the grain at the base of the spikelet could no longer be crushed between two fingers. While guna melon was manually hand-picked when the fruit pedicle changed from green to brown and the fruit became creamy in colour, then seeds were extracted.

2.6 Data collection and analysis

Data was collected on guna melon included number of vines/stand at harvest, determined by counting from the base of five randomly tagged plants within the net plot and the mean recorded. Length of vines/stand (cm) at harvest was determined by measuring five tagged main vine within the net plot with a graduated meter rule from the point of attachment of main stem to the end of the vine and the mean recorded. The number of fruits/stand was determined by counting the fruits on the five tagged plants within the net plot and averaged. Number of seeds/fruit was obtained at harvest by counting the seeds from individual fruit on the five tagged plants from the net plot and averaged. Seed yield/hectare (kg) for guna melon and grain yield/hectare (kg) for pearl millet were determined by weighing seeds and grains from the net plot and extrapolated to kilogramme per hectare. Intercropping advantages were evaluated using land equivalent ratio (LER) as given by Mead and Willey (1980). Data collected from the field trials were subjected to two-way analysis of variance (ANOVA). Differences between treatment means were compared using the least significant difference (LSD) at 5% level of significant (Gomez and Gomez, 1984).

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3. RESULTS AND DISCUSSION

Table 1:Total monthly rainfall (mm), relative humidity (%) at 0900 hours and monthly air temperature (^{o}C) from June to December, 2015 and 2016 for Gashua, Yobe state, Nigeria.

Month	2015	2016	2015	2016		
	Total monthly rainfall (mm)		Relative Humidity (%)			
June	36.3	68.9	51	57		
July	120.8	139.2	64	73		
August	226.6	216.9	77	76		
September	66.4	17.4	76	73		
October	13.2	10.3	55	52		
November	-	-	20	18		
December	-	-	26	19		
Total	463.3	452.7				
Mean	92.7	90.5				
Monthly air temperature (^{0}C)						
	Maximum	Minimum	Mean	Maximum	Minimum	Mean
		2015			**2016**	
June	38.3	25.9	32.1	36.8	25.7	31.3
July	35.1	24.9	30.0	33.2	23.2	28.2
August	31.3	22.4	26.9	32.1	21.5	26.8
September	32.4	23.1	27.8	34.7	22.6	28.7
October	35.8	22.6	29.2	36.6	22.5	29.6
November	30.1	16.7	23.4	31.5	17.0	24.3
December	28.2	14.3	21.3	25.2	15.8	20.5

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Table 2: Soil physio-chemical properties of the experimental site during 2015 and 2016 seasons at Gashua, Yobe state, Nigeria

Parameter	2015	2016
Chemical properties		
Soil pH (1:1 H_2O)	5.27	5.11
Soil pH(1.1KC1)	3.89	3.06
Organic carbon (%)	0.09	0.07
Organic matter (%)	0.171	0.163
Total nitrogen (%)	0.14	0.15
EC (me/100g)	0.48	0.47
CEC (me/100g)	0.84	0.82
Available calcium (me/100g)	2.80	2.65
Available magnesium (me/100g)	1.30	1.18
Available potassium (me/100g)	0.20	0.20
Available phosphorus (me/100g)	0.26	0.25
Particle-size distribution (%)		
Sand	79.52	80.21
Clay	6.06	6.03
Silt	14.36	13.80
Textural class	SL	S L
Bulk density (mg/m^3)	1.60	1.58

SL = Sandy loam

Source: Analysis conducted in the Department of Soil Science Laboratory, University of Maiduguri, Maiduguri, Borno State, Nigeria.

Effect of sowing dates of guna melon in pearl millet based intercrop on number of vines/stand and lengths of vines/stand (cm) of guna melon in 2015 and 2016 seasons at Gashua, Yobe state, Nigeria.

Data presented in Table 3 indicated that different sowing dates significantly influenced growth and yield attributes of guna melon. Guna melon produced the highest number of vines/stand at the third sowing date for sole and intercropped guna melon (SG_3;M_1G_3) in both years. Superior length of vines/stand (cm) were produced at the fourth sowing date of sole guna melon (SG_4) in 2015 and sole and intercropped guna melon (SG_4;M_1G_4) in 2016. Similar results were reported by NEAZDP (1992) where late sowing allowed guna melon to spread profusely and cover large ground area thereby reducing or controlling wind erosion when the land is devoid of any

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vegetation cover. Gwangzang (1995) also reported that guna melon could be used for sand dune stabilization.

Table 3: Effect of sowing date of guna melon in pearl millet based intercrop on number of vines/stand and length of vines/stand (cm) of guna melon in 2015 and 2016 seasons at Gashua, Yobe state, Nigeria

Treatment	Vines/stand		Length of vines/stand (cm)	
	2015	2016	2015	2016
SG_1	9.20	5.57	72.77	69.77
M_1G_1	6.80	4.63	71.27	68.47
SG_2	16.27	5.73	74.00	72.97
M_1G_2	17.27	6.63	69.93	69.07
SG_3	32.60	11.13	185.67	196.47
M_1G_3	32.13	9.80	143.40	154.17
SG_4	29.93	9.27	207.67	223.87
M_1G_4	28.93	9.13	143.40	212.63
SE	2.53	1.06	32.60	26.73
$LSD_{0.05}$	7.00	2.93	90.30	74.05

SG_1, SG_2, SG_3, SG_4 = 1st, 2nd, 3rd, 4th sowing dates of sole guna melon;
M_1 = Sowing date of pearl millet, M_1G_1, M_1G_2, M_1G_3, M_1G_4 = 1st, 2nd, 3rd, 4th sowing dates of intercropped guna melon.

Effect of sowing dates of guna melon in pearl millet based intercrop on number of fruits/stand and seeds/fruit of guna melon in 2015 and 2016 seasons at Gashua, Yobe state, Nigeria.

Results indicate that early sowing of guna melon affected both fruits production and number of seeds/fruit when compared to late sowing of guna melon. Highest number of fruits/stand were produced at the fourth sowing date for sole guna melon (SG_4) in 2015 and in both sole and intercropped guna melon (M_1S_4; SG_4) in 2016. Similarly, the fourth sowing date of guna melon recorded highest number of seeds/fruit for both sole and intercropped guna melon (M_1S_4; SG_4) in both years (Table 4) when lowest rainfall of 13.2mm and 11.2mm were experienced in October for the two seasons (Table 1). These results, therefore, indicates that moisture stress had no effect on the production of fruits and seeds.

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Table 4: Effect of sowing date of guna melon in pearl millet based intercrop on number of fruits/stand and seeds/fruit of guna melon in 2015 and seasons at Gashua, Yobe state, Nigeria

Treatment	Fruits/stand		Seeds/fruit	
	2015	2016	2015	2016
SG_1	12.40	19.34	687.05	452.40
M_1G_1	12.33	18.60	493.48	638.30
SG2	18.33	29.77	747.49	755.80
M_1G_2	24.00	22.36	655.27	704.60
SG_3	49.67	53.08	880.50	802.10
M_1G_3	48.33	43.70	801.69	710.30
SG_4	53.00	57.36	955.72	1042.90
M_1G_4	49.00	56.67	899.74	946.80
SE	6.34	7.89	122.72	142.54
$LSD_{0.05}$	17.68	21.86	339.95	374.77

SG_1, SG_2, SG_3, SG_4 = 1st, 2nd, 3rd, 4th sowing dates of sole guna melon;
M_1 = Sowing date of pearl millet, M_1G_1, M_1G_2, M_1G_3, M_1G_4 = 1st, 2nd, 3rd, 4th sowing dates of intercropped guna melon.

Effect of sowing dates of guna melon in pearl millet based intercrop on yield and land equivalent ratio (LER) of pearl millet-guna melon intercrop and their monoculture in 2015 and 2016 seasons at Gashua, Yobe state.

Data presented in table 5 indicated that lowest seed yield of 530.0kg/ha and 393.4kg/ha were recorded from the first and second sowing dates (M_1G_1; SG_2,) at a period when rainfall was high for both years and the crop was exposed to field insect pest problems. Similar findings were earlier reported by Buahin (1991) that insect pests such as (Corridus vidugutus - pentomic bug) and Aphis craccivora Koch (aphids) attacked guna melon and caused decrease in yield in the northeastern zone of Yobe state. While guna melon sown on the fourth sowing (SG_4 and M_1G_4) when rainy season was about to terminate and the associate pearl millet component was on verge of maturity recorded highest seed yield of 3508.0kg/ha and 2668.0kh/ha from sole guna melon (SG_4) and 1168.0kg/ha and 991.2kg/ha from intercropped guna melon (M_1G_4) for both years. Results also showed that low soil moisture content recorded at 50% fruiting of guna melon (Figures 1 and 2) did not affect yields of guna melon in both years. This might explain the

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xeromorphic attributes that made guna melon survived the harsh weather condition of the sahelian ecology as earlier reported by Amans et, al., (1992). Results on pearl millet indicated that grain yields on the fourth sowing date of intercropping guna melon were significantly higher, recording 1194.08kg/ha and 1104.0kg/ha for sole pearl millet (SM_1) and 1080.0kg/ha and 721.7kg/ha for pearl millet intercropped with guna melon (M_1G_4) in 2015 and 2016 seasons, respectively. When the yields of the component crops of pearl millet-guna melon intercropping were considered in combined form using land equivalent ratio (LER) as proposed by Mead and Willey (1980), all treatments obtained LER greater than unity thereby indicating more efficient land use advantage resulting in greater output per unit area (table 5). Therefore, sowing pearl millet with the on-set of rains and deliberately delaying sowing guna melon as an intercrop could be a major step taken to avoid undue competition among the crop components and to reach their yield potential.

Table 5: Yields (kg/ha) and land equivalent ratio (LER) of pearl millet- guna melon intercrop and their monoculture in 2015 and 2016 seasons at Gashua, Yobe state.

Treatment	Pearl Millet	Guna melon	Partial LER of pearl millet	Partial LER of guna melon	Total LER
			2015		
SM_1	1194.0		1.00	-	1.00
SG_1	-	724.7	-	1.00	1.00
M_1G_1	614.3	530.3	0.51	0.73	1.24
SG2	-	647.7	-	1.00	1.00
M_1G_2	525.0	549.7	0.44	0.85	1.29
SG_3	-	849.9	-	1.00	1.00
M_1G_3	505.4	826.6	0.42	0.97	1.39
SG_4	-	3508.0	-	1.00	1.00
M_1G_4	1080.0	1168.0	0.91	0.33	1.24
			2016		
SM_1	1104,0		1.00		1.00
SG_1	-	680.2	-	1.00	1.00
M_1G_1	509.1	632.7	0.46	0.93	1.39
SG_2	-	393.4	-	1.00	1.00
M_1G_2	478.6	472.1	0.43	1.20	1.63
SG_3	-	715.2	-	1.00	1.00
M_1G_3	577.6	689.2	0.52	0.96	1.48
SG_4	-	2668.0	-	1.00	1.00
M_1G_4	721.7	991.2	0.65	0.37	1.02

SG_1, SG_2, SG_3, SG_4 = 1st, 2nd, 3rd, 4th sowing dates of sole guna melon;

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M_1 = Sowing date of pearl millet, M_1G_1, M_1G_2, M_1G_3, M_1G_4 = 1st, 2nd, 3rd, 4th sowing dates of intercropped guna melon.

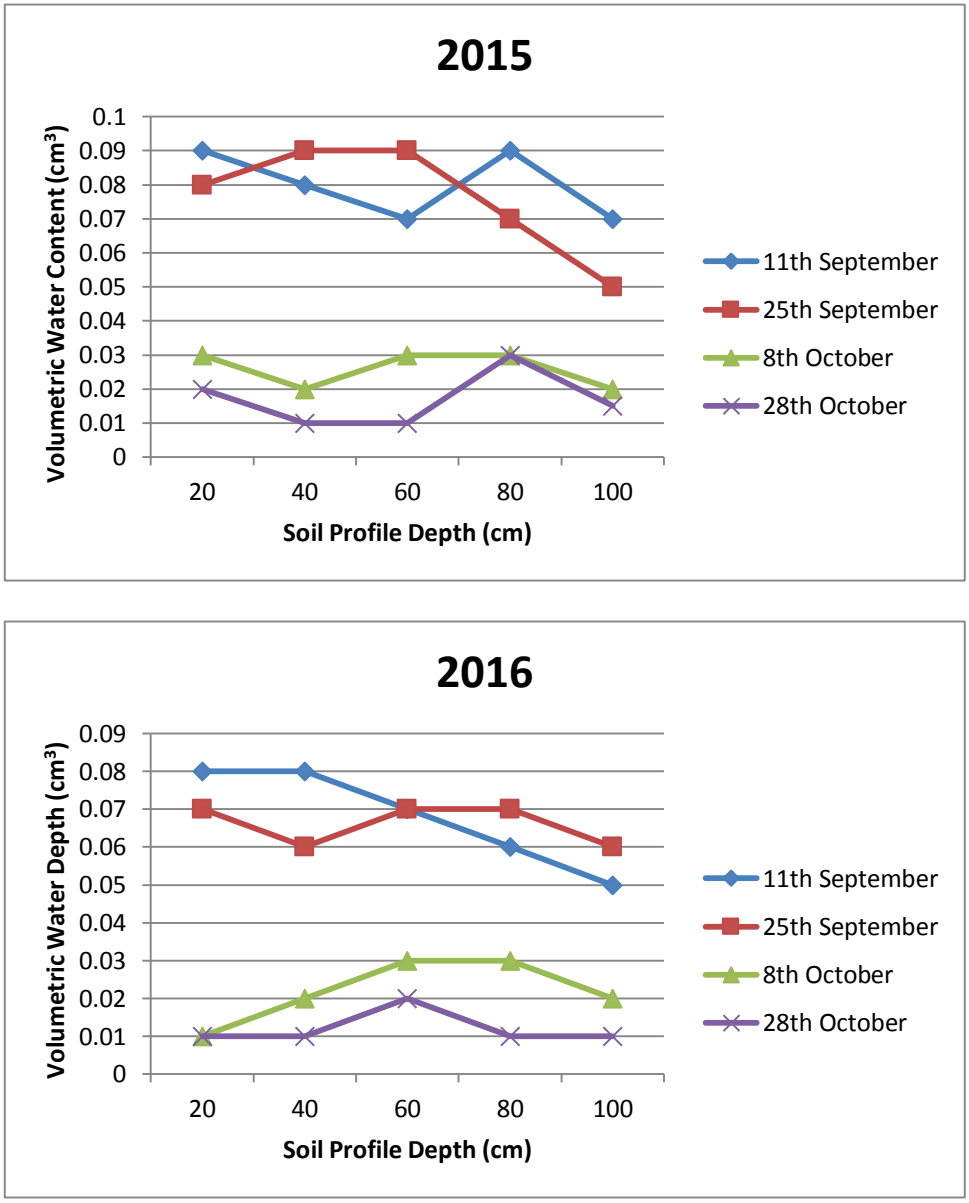

Fig. 1a and 1b: Soil moisture content (cm^3) at 50% fruiting of guna melon in pearl millet Based intercrop for 2015 and 2016 cropping seasons.

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4. SUMMARY AND CONCLUSION

From the trials conducted in 2015 and 2016 seasons, growth performance, number of fruits/stand, number of seeds/fruit and the overall yields of guna melon sown at the fourth sowing date for both sole and intercropped were significantly higher when compared to other treatments. Based on these findings, the fourth sowing date of guna melon (towards the end of the rainy season), as sole and as intercrop is recommended with a view of achieving a sustainable agricultural productivity, enhanced economic returns and effective desertification control in the sahelian agro-ecology. Undoubtedly, it is another avenue to satisfy farmer's needs. Future research efforts should, therefore, give more attention to genetic improvement in order to take full advantage of the economic and ecological benefits of guna melon in Yobe state, Nigeria.

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