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EFFECT OF PLANT POPULATION DENSITY OF GUNA MELON (*CITRULLUS COLOCYNTHIS* (L.) SCHRAD) ON YIELD PERFORMANCE OF GUNA MELON – PEAR MILLET (*PENNISETUM GLAUCUM* (L.) R. BR.) INTERCROP IN SEMI-ARID ZONE OF NIGERIA.

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ABSTRACT

Plant population density is one of the most important yield contributory factors that can be manipulated to attain maximum production per unit area. Two experiments were conducted on farmer's farm in Gashua, Yobe state in semi-arid environment of Nigeria to assess the effect of plant population density of guna melon on yield performance of guna melon – pear millet intercrop in 2017 and 2018 cropping seasons. A randomized complete block design (RCBD) with three treatments made up of three population densities of guna melon (6,000; 11,000 and 15,700 plants/hectare) in a fixed population density of 133,000 plants/hectare of pearl millet. The inter-row and intra-row spacing for pearl millet was 75cm x 30cm while the spacing for guna melon were 180cm x 180cm, 100cm x 180cm and 85cm x 150cm at 2:1 cropping ratio of pearl millet to guna melon. Results revealed that in 2017 the vegetative parameters were significantly ($p < 0.05$) higher in sole pearl millet at 133,000 plants/ha (SM_1) but were inconsistent for the different population densities of guna melon in 2018. Grain yield was superior for sole pearl millet at 133,000 plants/ha (SM_1) with values of 2230 kg/ha and 2839.0 kg/ha in 2017 and 2018, respectively. Highest seed yield of 3937.0 kg/ha and 3783.0 kg/ha for sole guna melon (SG_1) and superior seed yield of 1410.0 kg/ha and 1617. 0 kg/ha for intercropped guna melon (M_1G_1) were recorded at a low population density of 6,000 plants/ha in 2017 and 2018 seasons when compared to other treatments.

Keywords: Guna melon, pearl millet, intercrop, plant population density, semi-arid environment

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1. INTRODUCTION

The intercropping system in semi-arid environment such as Gashua in Yobe state, Nigeria (latitude 12^0.874' N and longitude 11^0.04'E at an altitude of 299 meters above sea level) is generally characterized by uncertain rainfall distribution of 300-500 mm, a hot dry spell which extends from March to May (Alhassan *et. al.*, 2012) and limited diversity in the choice of the associated crops or varieties. Desert gourd or bitter gourd (*Citrullus colocynthis* (l.) Schrad) popularly known as guna melon in Nigeria belongs to the family *Cucurbitaceae* is widely grown in Yobe state, north-east, Nigeria. Guna melon, a drought-tolerant; trailing crop that requires little water continues to grow and fruit virtually up to the on-set of the next rainy season. It provides effective soil cover in the season when most other vegetation cover had dried-up, also protect the soil from adverse wind erosion and increase the soil organic matter when the dead guna plant decomposes (NEAZDP, 1992; Gwandzang, 1995, Amshi and Odo (2001). The economic importance of guna melon lies in their seeds, which are processed to produce edible oil, cosmetics, pharmaceuticals and other industrial purposes (Penuel *et. al.*, 1998, Menon *et. al.*, 2014 and Amshi, 2015). Amaza *et. al.*, (2006) further reported that guna melon production in semi-arid environment ensures suitable subsistence returns from low inputs. The choice of pearl millet intercropped with guna melon was made to determine whether guna melon component could form the basis for an alternative to pearl millet-cowpea intercropping system which had been very popular in the state, but recently suffering persistent yield reduction due to environmental hazards. In pearl millet – guna melon intercropping, the combined yields of the crops could be greater than either of the sole crops due to increased plant population. Consequently, the need to increase and sustain the growing interest towards cultivation of guna melon (oil seeds) as pearl millet (food grains) intercrop cannot be over emphasized. Unfortunately, little is currently known about the extent some improved cultural practices could play in the productivity in the semi-arid zone of Nigeria. An understanding of the effect of plant population density on the various components may therefore help in evolving an efficient crop yield. In view of the above, a two-year study (2017 and 2018 cropping seasons) was conducted to identify the attributes that could be considered agronomically desirable to suit the farmers' needs and objectives.

2. MATERIALS AND METHODS

2.1 Total monthly rainfall (mm), relative humidity (%) and soil physical and chemical properties of the experimental site during the 2017 and 2018 rainy seasons at Gashua, Yobe state, Nigeria

The total monthly rainfall data and relative humidity were collected from meteorological station located at Yobe State Agricultural Development Programme (YOSADP) Gashua, Yobe state,

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Nigeria. Soil samples were collected from different parts of the experimental field. The composite sample was used to determine the physical and chemical properties of the soil before planting. The soil physical and chemical properties were conducted in Department of soil science Laboratory, University of Maiduguri, Borno state, Nigeria.

2.2 Crop varieties

Pearl millet (*Pennisetum glaucum* (L.) R. Br.), variety Gwagwa, a local landrace and guna melon (*Citrullus colocynthis* Schrad), also a local variety were used for the trials. The varieties of both crops show a good adaptation to Gashua environment.

2.3 Treatment and experimental design

There were three treatments made up of different population densities of guna melon. The population densities of guna melon were 6,000; 11,000 and 15,700 plants per hectare in a fix population of pearl millet (133,000 plants/ha). The planting pattern adopted for the trail was 2 rows of pearl millet and 1 row of guna melon (2:1 cropping ratio). Inter-row and intra-row spacing of 75cm x 30cm for pearl millet was maintained while for guna melon, the spacing were 180cm x 180cm, 180cm x 100cm and 150cm x 85cm which varied with the different population densities. Monocrop of each crop entry was sown as control for the intercrops (Table 1). The field trails were Randomized Complete Block Design (RCBD) and treatments were replicated three times. The total experiment was 868.6m^2 with a total of 21 plots. Each plot was 27m^2 with an inter-plot and border space of 1m.

Table 1: Plant population densities of guna melon and pearl millet intercrop and monocrops

Pearl millet			Guna melon	
Cropping ratios	Planting Spacing (cm)	Population density (plant/ha)	Plant Spacing (cm)	Population density (plant/ha)
SM_1 (0:1)	75x30	133,000	-	-
SG_1 (1:0)	-	-	180x180	6,000
M_1G_1 (2:1)	75x30	133,000	180x180	6,000
SG_2 (0:1)	-	-	180x100	11,000
M_1G_2 (2:1)	75x30	133,000	180x100	11,000
SG_2 (2:1)	-	-	150x85	15,700
M_1G_2 (2:1)	75x30	133,000	150x85	15,700

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SM_1 = Sole pearl millet in a fixed population density of 133,000; SG_1, SG_2, SG_3 = Sole guna melon at 6,000; 11,000 and 15,700 population density; M_1G_1, M_1G_2, M_1G_3 = Pearl millet at a fixed population density intercropped with 6,000; 11,000 and 15,700 population density of guna melon.

2.4 Cultural practices and harvesting

All crops were planted on a flat land after manual clearing was carried out with minimum tillage. Both sole and intercropped pearl millet were sown on the 18th July, 2017 and 5th July, 2018, respectively. While guna melon component were sown six weeks after the pearl millet (28th August, 2017 and 16th august, 2018); when the associate pearl millet was on verge of maturity (Amshi, 2017). Weeding was done twice, at two weeks after sowing and 6 weeks after sowing using a hand-hoe. Fertilizers were applied in split doses; firstly at sowing (N.P.K 15-15-15) and at six weeks after sowing urea (46% N) was applied. Pearl millet was harvested when the leaves turned yellow and the grain at the base of the spikelet could not be crushed between two fingers. Guna melon was harvested when the fruit pedicle changed from green to brown and the fruit turned creamy in colour which were sign of maturity.

2.5 Data collected and analysis

Data collected on pearl millet included number of leaves per stand that was determined by physical counting the leaves arising from the main shoot of five randomly tagged plants within the net plot and the mean were recorded. Number of tillers per stand was determined by physical counting the tillers from the base of five randomly tagged plants within the net plot and the mean were recorded. For guna melon component, the number of vines per stand was determined by physical counting from the base of five randomly tagged plants within the net plot and the mean were recorded. Length of vines per stand (cm) of guna melon was determined by measuring five tagged branches within the net plot with a graduated meter rule from the point of attachment of the main stem to the end of the branch and mean were recorded. 1000 - grain weight (g) of pearl millet and 100 - seed weight (g) of guna melon were obtained at physiological maturity by counting 1000 – grains and 100 – seeds from the net plot and weighed. Grain yield per hectare (kg) for pearl millet and seed yield per hectare (kg) for guna melon were determined by weighing grains and seeds from the net plot and extrapolated to kilograms per hectare. Data collected from the field trails were subjected to two-way analysis of variance (ANOVA). Differences between means were compared using the Least Significant Difference (LSD) at 5% (Gomez and Gomez, 1984).

3. RESULTS AND DISCUSSION

Total monthly rainfall (mm), relative humidity (%) and soil physical and chemical properties of the experimental site during the 2017 and 2018 rainy seasons at Gashua, Yobe state, Nigeria.

Data in table 2 shows the trend of total monthly rainfall (mm) and relative humidity (%) at Gashua during the 2017 and 2018 cropping seasons. Results indicated that, the highest amounts of rainfall (216.9mm and 221.3mm) were recorded in month of August in 2017 and 2018, respectively. The highest relative humidity of 64.07% in 2017 and 72.82% in 2018 coincided with the month (August) when the greatest amount of rainfall occurred in both years. Table 3 indicates that the soil was sandy loam with pH values of 5.31 and 5.29 for 2017 and 2018 seasons, indicating that the soil was slightly acidic. Available calcium was higher than magnesium while available potassium and phosphorus were quite low. Organic matter content was low.

Table 2: Total monthly rainfall (mm) and relative humidity (%) of the experimental site during the 2017 and 2018 rainy seasons at Gashua, Yobe state, Nigeria

Month	2017		2018	
	Total monthly rainfall (mm)	Relative humidity (%)	Total monthly rainfall (mm)	Relative humidity (%)
May	38.3	7.39	31.4	7.24
June	67.9	9.21	53.0	7.13
July	139.3	33.02	123.4	43.20
August	216.9	64.07	221.3	72.82
September	17.4	52.14	12.0	50.23
October	0.0	48.30	0.0	40.13
November	-	19.15	-	17.19
December	-	26.68	-	23.26
Total	479.80		441.1	
Mean	95.96		88.22	

Table 3: Soil physical and chemical properties of the experimental site during the 2017 and 2018 rainy seasons at Gashua, Yobe state, Nigeria

Parameters	2017	2018
Chemical properties		
Organic matter (%)	0.163	0.192
Organic carbon (%)	0.08	0.10
Total nitrogen (%)	0.15	0.14
Available calcium (me/100g)	2.65	2.53
Available magnesium (me/100g)	1.28	1.16

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Available phosphorus (me/100g)	0.25	0.29
Available potassium (me/100g)	0.20	0.98
Soil pH (1:1 H_2O)	5.13	5.29
Soil pH (1:1 KCl_2)	3.09	3.62
Particle-size distribution (%)		
% Sand	80.21	81.33
% Silt	13.80	15.65
% Clay	6.03	5.09
Textural class	Sandy Loam	Sandy Loam
Bulk density (mg/m^3)	1.59	1.69

Effect of different population densities of guna melon on number of leaves per stand and number of tillers per stand of pearl millet in pearl millet – guna melon intercrop in 2017 and 2018 seasons at Gashua, Yobe State, Nigeria

In this study, results indicate that pearl millet number of leaves/stand and number of tillers/stand increased in sole pearl millet at a population density of 133,000 plants/ha (SM_1) in 2017 (Table 3). While in 2018, the number of leaves/stand and number of tillers/ stand were inconsistent for the different population densities of guna melon. These results suggest that different population densities of guna melon had no effect on vegetative parameters of pearl millet 2017 and 2018 seasons.

Table 3: Effect of different population densities of guna melon on number of leaves/stand and number of tillers/stand of pearl millet in pearl millet – guna melon intercrop in 2017 and 2018 at Gashua, Yobe State, Nigeria

Plant population	Number of leaves /stand			Number of tillers /stand		
density	4WAS	6WAS	8WAS	4WAS	6WAS	8WAS
2017						
SM_1	4.20	6.50	9.17	4.63	8.70	8.63
M_1G_1	3.07	6.73	10.00	4.10	5.60	5.43
M_1G_2	3.80	7.80	8.87	3.40	6.77	5.60
M_1G_3	3.77	6.11	9.60	3.80	5.60	5.40
S.E	0.36	0.59	3.31	0.42	1.86	0.96
$LSD_{0.05}$	1.71	NS	NS	NS	NS	4.67
2018						
SM_1	5.20	6.07	9.10	4.63	8.87	5.60
M_1G_1	4.23	6.87	8.80	4.87	4.77	4.97

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M_1G_2	3.57	5.97	9.60	3.97	6.07	9.97
M_1G_3	4.30	5.80	11.23	2.93	4.53	4.83
S.E	0.80	1.06	2.07	0.63	2.34	1.91
$LSD_{0.05}$	NS	NS	9.87	3.04	NS	9,08

WAS = Weeks After Sowing; SM_1 = Sole pearl millet in a fixed population density of 133,000; SG_1, SG_2, SG_3 = Sole guna melon at 6,000; 11,000 and 15,700 population density; M_1G_1, M_1G_2, M_1G_3 = Pearl millet at a fixed population density intercropped with 6,000; 11,000 and 15,700 population density of guna melon; Subscripts indicates population density; NS = Not significant.

Effect of different population densities of guna melon on 1000-grain weight/plot (g) and grain yield (kg/ha) of pearl millet in pearl millet – guna melon intercrop in 2017 and 2018 at Gashua, Yobe State, Nigeria

Results in table 4 indicate that 1000-grain weight/plot (g) of pearl millet were significantly ($p < 0.05$) higher where guna melon was sown at medium population density of 11,000 plants/ha (M_1G_2) in 2017. While in 2018, 1000-grain weight (g) of pearl millet increased at a low population density of 6,000 plants/ha of guna melon (M_1G_1). Table 4 further showed that highest yield of 2230.0 kg/ha and 2839.0 kg/ha for sole pearl millet (SM_1) were recorded in 2017 and 2018, respectively. In intercropped pearl millet at lowest population of guna melon (6,000 plants/ha - M_1G_1), superior grain yield of 983.3 kg/ha and 1059.0kg/ha were recorded compared to other treatment in 2017 and 2018 season. On the other hand lowest yield of 661.0kg/ha were recorded for pearl millet at a medium population density of guna melon (11,000 plants/ha - M_1G_2) in 2017. While in 2018, pearl millet recorded the least grain yield of 714.2 kg/ha at a higher population density of guna melon (15,700 plants/ha – M_1G_3). Thus, guna melon crop appears to fit well into the millet based cropping system because it does not detract the yield of the millet component.

Table 4: Effect of different population densities of guna melon on 1000-grain weight/plot (g) and grain yield (kg/ha) of pearl millet in pearl millet – guna melon intercrop in 2017 and 2018 at Gashua, Yobe State, Nigeria

Plant population density	1000 – grain/plot weight (g)		Grain yield (Kg/ha)	
	2017	2018	2017	2018
SM_1	24.57	26.20	2230.0	2839.0
M_1G_1	26.87	28.23	983.3	1059.0
M_1G_2	27.42	24.73	773.3	714.3

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M_1G_3	21.57	21.20	661.1	864.9
S.E	2.06	1.50	177.3	261.1
$LSD_{0.05}$	9.80	7.13	843.9	1242.8

WAS = Weeks After Sowing; SM_1 = Sole pearl millet in a fixed population density of 133,000; SG_1, SG_2, SG_3 = Sole guna melon at 6,000; 11,000 and 15,700 population density; M_1G_1, M_1G_2, M_1G_3 = Pearl millet at a fixed population density intercropped with 6,000; 11,000 and 15,700 population density of guna melon; Subscripts indicates population density; NS = Not significant.

Effect of different population densities of guna melon on number of vines per stand and length of vines per stand (cm) of guna melon in pearl millet – guna melon intercrop in 2017 and 2018 seasons at Gashua, Yobe State, Nigeria

Results in Table 5 indicate that the guna melon number of vines/stand and length of vines/stand (cm) were inconsistent for all treatments in 2017 and 2018. However, the length of vines/stand (cm) spreads more than 40cm to up to 100cm across the rows and formed complete ground cover at all populations. This could be a strategy to replace one hand - weeding thereby the farmer could benefit from a cost effective weed control method (a biological weed control). Similar result was earlier reported by Unumma *et. al.*, (1990) were intercropping egusi melon (*Citrullus lanatus* Thumb) at a population density of 20,000 plants/hectare resulted in a good and better control of mixture of weeds and higher crop yield was obtained from the usual practice of hand-hoeing by farmers.

Table 5: Effect of different population densities of guna melon on number of vines per stand and length of vines per stand (cm) of guna melon in pearl millet – guna melon intercrop in 2017 and 2018 seasons at Gashua, Yobe State, Nigeria

Plant population	Number of vines /stand			Length of vines/stand (cm)		
density	4WAS	6WAS	8WAS	4WAS	6WAS	8WAS
2017						
SG_1	7.27	4.87	5.56	19.40	57.17	69.17
M_1G_1	8.87	5.60	10.68	21.53	129.79	216.67
SG_2	8.43	8.52	9.13	22.30	107.07	223.90
M_1G_2	7.37	7.31	6.67	20.27	60.07	96.80
SG_3	6.87	6.07	5.70	19.13	55.67	71.27
M_1G_3	7.30	8.20	9.00	23.53	120.93	147.37
S.E	0.90	1.09	2.73	2.99	23.63	53.12
$LSD_{0.05}$	NS	3.64	NS	NS	78.70	176.88
2018						

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SG_1	4.67	5.37	5.80	17.03	49.83	74.47
M_1G_1	5.73	8.10	8.33	21.23	60.10	78.00
SG_2	8.40	7.30	7.97	19.40	63.43	106.73
M_1G_2	5.43	9.33	8.32	20.87	59.83	73.33
SG_3	6.50	8.63	7.35	16.77	85.77	91.93
M_1G_3	7.67	10.80	9.50	14.67	108.52	113,60
S.E	2.95	14.23	21.80	2.07	1.13	1.99
$LSD_{0.05}$	NS	48.38	NS	NS	3.76	NS

WAS = Weeks After Sowing; SG_1, SG_2, SG_3 = Sole guna melon at 6,000; 11,000 and 15,700 plants per hectare (low, medium and high population density); M_1G_1, M_1G_2, M_1G_3 = Pearl millet at a fixed population density of 133,000 plants/hectare intercropped with 6,000; 11,000 and 15,700 population density of guna melon; Subscripts indicates population density; NS = Not significant.

Effect of different population densities of guna melon on 100-seed weight/plot (g) and seed yield (kg/ha) of guna melon in pearl millet – guna melon intercrop in 2017 and 2018 at Gashua, Yobe State, Nigeria

From the present investigation (table 6), results indicate that in 2017, 100 – seed weight/plot (g) of guna melon was not affected by population density. In 2018, intercropped guna melon at medium population density of 11,000 plants/hectare (M_1G_2) recorded significantly ($p < 0.05$) higher 100-seed weight/plot (g) compared to other treatments. Results also showed that seed yield (kg/ha) of guna melon was highest for sole guna melon and intercropped guna melon at a low population density of 6,000 plants/ha (SG_1; M_1G_1) recording 3937.0 kg/ha and 3783.0 kg/ha when compared to other treatments in 2017 and 2018 seasons, respectively. However, in semi-arid environment, farmers have adopted only 1,500 plants/hectare of guna melon in pearl millet-guna melon intercrop (Amshi and Odo, 2001). This practice used by farmers does not necessarily give the best result in terms of enhancing the overall yield. Increase in the density of guna melon from 1,500 plants/hectare to 6,000 plants/hectare sown at a spacing of 180cm x 180cm could therefore be an improvement to the farmers practice. Furthermore, combined yields of pearl millet and guna melon were higher than that of either sole crop. These yield advantage recorded could be due to increase in population density with marked differences in maturity periods of component crops in an intercrop as earlier reported by Andrews (1972). Grema (1994) reported similar result where increased yield per unit area was recorded in pearl millet – cowpea intercrop as a result of increased population density of the component crops involved.

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Table 6: Effect of different population densities of guna melon on 100-seed weight/plot (g) and seed yield (kg/ha) of guna melon in pearl millet – guna melon intercrop in 2017 and 2018 at Gashua, Yobe State, Nigeria

Plant population density	100 – seed weight/plot (g)		Seed yield (kg/ha)	
	2017	2018	2017	2018
SG_1	61.43	51.90	3937.0	3783.0
M_1G_1	66.90	78.53	1410.0	1617.0
SG_2	72.50	79.50	1325,0	1283.0
M_1G_2	71.67	82.60	1263.0	1363.0
SG_3	61.07	44.17	1234.0	1432.0
M_1G_3	75.33	56.63	1257.0	1609.0
S.E	13.64	12.67	255.8	360.7
$LSD_{0.05}$	NS	40.51	851.8	1201.1

WAS = Weeks After Sowing; SG_1, SG_2, SG_3 = Sole guna melon at 6,000; 11,000 and 15,700 plants per hectare (low, medium and high population density); M_1G_1, M_1G_2, M_1G_3 = Pearl millet at a fixed population density of 133,000 plants/hectare intercropped with 6,000; 11,000 and 15,700 population density of guna melon; Subscripts indicates population density; NS = Not significant.

4. SUMMARY AND CONCLUSION

In the present study, the different population densities of guna melon had no effect on vegetative parameters and it does not detract the yield of the millet component of pearl millet. Guna melon number of vines/stand and length of vines/stand (cm) were inconsistent for all treatments. However, seed yield (kg/ha) of guna melon was highest for sole guna melon and intercropped guna melon at a low population density of 6,000 plants/ha when compared to other treatments. Based on these findings, low population density 6,000 plants/hectare at a spacing of 180cm x 180cm could be most suitable population density to be adopted by the farmers to produce the maximum grain and seed yield from pearl millet - guna melon intercrop. It could also be another strategy to fully utilize land, use the residual soil moisture remaining after pearl millet harvest and guna melon as a cover crop could provide efficient soil conservation and wind erosion control measure in semi-arid environment of Yobe state, Nigeria.

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