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Original Research

Response of Tomato (*Solanum lycopersicum* L.) and Onion (*Allium cepa* L.) to Different Intercrops in Sudan Savanna Ecological Zone of Nigeria

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ABSTRACT: A field experiment was conducted at the Teaching and Research Farm of Faculty of Agriculture, Bayero University, Kano (BUK) and National Horticultural Research Institute, Bagauda Sub- station, Kano during the 2015 wet season. The objectives were to investigate the growth and yields of tomato and onion to different intercrops, as three intercropping of the two crops and their sole crops [three rows of tomato and three rows of onion (3:3), four rows of tomato and two rows of onion (4:2), two rows of tomato and four rows of onion (2:4), sole tomato and sole onion]. The treatments were arranged in a Randomized Complete Block Design with three replications. Vegetative growth characters and yield were measured and data were subjected to analysis of variance. Intercropping significantly affected some of the growth characters, plant height, chlorophyll content, tomato fruit and onion bulb diameter, tomato mean fruit and onion bulb weight and yield of both crops. Land equivalent ratio indicated yield disadvantage of tomato and onion intercrop (LER <1) at both BUK and Bagauda.

Keywords: Yield, chlorophyll content, land equivalent ratio

INTRODUCTION

Intercropping can be explained as a system where two or more crop species are grown in the same field at the same time during a growing season. It is a simple and inexpensive strategy and has been recognized as a potentially befitted technology to increase crop production due to its substantial yield advantage than sole cropping (Awal *et al*., 2006). The purpose of intercropping is to generate beneficial biological interactions between the crops. Intercropping can increase yields, more efficiently use available resources, reduce weed, insect and disease pressures and provide greater biological and economic stability. Intercropping has been an essential production method in tropical regions for hundreds of years (Maw Ni *et al*., 2017) and to a lesser extent in temperate regions (Li *et al*., 2001). Intercropping has a long history, and is employed in many regions. In tropical agriculture, for example, tall and short crops are grown together to maximize production. In arid regions, intercropping improves the conservation of water. The most common goal of intercropping is to produce a greater yield on a given piece of land by making use of resources that would not be utilized by a single crop. Better intercrop production could be achieved with the choice of appropriate crops (Santalla *et al*., 2001), population density and planting geometry of component species/crops (Kakon *et al*., 2007). Greater productivity in intercropping system is commonly achieved by minimizing inter-specific competition and maximizing

complementary use of growth resources (Islam, 2002).

The predominant practice of mixed intercropping in the developing countries including Nigeria indicated that farmers have refused to adopt the sole cropping technology packages. Best utilization of growth resources and modified microclimate by component crops of intercropping for their better yield performance are practical only when the right planting pattern of component crops is followed. Planting pattern defines the pattern of distribution of plants over the ground, which determines the shape of the area available to the individual plants (Willey, 1990). Increased productivity of intercropping over sole cropping has been attributed to better use of solar radiation, nutrients and water and fewer incidences of insect pests and diseases (Willey, 1990). Planting pattern of intercrops is an important management practice that can improve better use of these resources and opportunities (Willey, 1990).

Management of soil fertility in an intercropping system has a major influence on crop production. Several studies have revealed that intercropped mixtures extracted more nutrients from the soil than did single stands per unit area (Adeola, 2011). High cost of nitrogen fertilizer has led to several research studies on the benefit of intercropping with legumes. Intercropping has been identified as a promising system that results in an effective use of land and other resources, efficient utilization of water and soil nutrients and reduction of the cost of production (Moses *et al*., 2011). The main aim of this research work is to assess the effect of different row arrangement on growth and yield of tomato and onion intercrop.

MATERIALS AND METHODS

The research was conducted at the Teaching and Research Farm of Faculty of Agriculture Bayero University, Kano (11^0 58' N, 8^0 25' E and 475m above sea level) and National Horticultural Research Institute, Bagauda sub-station (12^0 08' N, 8^0 32'E, and 500m above sea level). Both locations are situated in Sudan Savannah ecological zone of Nigeria. The experiment was carried out during the 2015 wet season. The treatments consist of three different row arrangement of tomato and onion mixture and their sole crops as follows: Three rows of tomato and three rows of onion plant (3:3), Four rows of tomato and two rows of onion plant (4:2), Two rows of tomato and four rows of onion (2:4), Tomato sole and Onion sole. These were laid out in Randomized Complete Block Design (RCBD) with three replications. The seeds of tomato and onion were raised in a nursery where the soil was thoroughly mixed with farm yard manure at the rate of 5.5 t ha^{-1}(Mbah *et al.,* 2010). Two nursery seedbeds of $4m^2$ were prepared with one for tomato and the other for onion. The beds were irrigated using watering can. The seeds of both crops were broadcasted into the beds and mulch with millet stalks, which were removed one week after germination. The seedlings were allowed to grow for four weeks before transplanting. The land was cleared, harrowed and divided into plots using a tractor. The field consisted of 45 plots. Each replication consisted of 15 plots divided three blocks. The replications were separated by 1 m space while the plots were separated by 0.5 m space each.

Seedlings raised in nurseries were transplanted to the field at a spacing of 20 x 10cm for onion and 60 x 40cm for tomato, when the rainfall was fully established on 5th August, 2015 and 8th August, 2015 at BUK and Bagauda, respectively at 6 weeks after sowing. Hoe weeding was done at 4, 6 and 8 weeks after transplanting (WAT) to keep plants free from weeds. The plots were sprayed with dimethioate (organophosphate) at the rate of 30 g per 15 litre of water in a knapsack sprayer to control insect pest 4 times at interval of 2 WAT. Spraying started at 2 WAT.

Data collection and analysis

Plant height was measured at 3, 6 and 9 weeks after transplanting (WAT) of both tomato and onion, using meter rule. Similarly, number of leaves, leaf chlorophyll content were determined using leaf chlorophyll meter (Minolta SPAD 502), leaf area using digital leaf area meter (YMJ-A Model), while leaf area index was computed using the relation LAI=LA/GA, Where LA = leaf area and GA=ground area. The diameter of tomato and onion were measured (cm) using veneer caliper at harvest. Total yield of both crops were obtained by taking the weight of freshly harvested onion bulbs and tomato fruits from the net plot using a weighing balance. Using a simple proportionate equation, the total weight (in kg/m^2) per plot was extrapolated to tonnes per hectare. All data obtained were subjected to analysis of variance (ANOVA) using SAS statistical software (SAS, 2001). Student Newman Keuls (SNK) was used to compare the treatment means.

RESULTS AND DISCUSSION

The effect of intercropping in row arrangement on plant height is presented in (Table 1), tomato plant height was not significantly affected but highest plant was recorded in sole tomato plots at BUK while there was significant effect recorded on tomato plant height at 3WAT at Bagauda with highest plant in 3:3 arrangement of tomato and onion intercrop. Row arrangement of tomato and onion intercrops significantly affected the plant height of onion throughout the sampling period at BUK.

Table 1. Plant height of tomato and onion as affected by intercropping in 2015 wet season.

Treatments	BUK						Bagauda					
	Tomato (WAT)			Onion (WAT)			Tomato (WAT)			Onion (WAT)		
	3	6	9	3	6	9	3	6	9	3	6	9
Intercropping												
3:3	22.16	45.93	61.31	14.17^{bc}	30.24^{b}	36.98^{a}	41.34^{a}	56.20	67.52	21.54	44.68	36.98
4:2	24.27	48.24	63.54	13.58^{c}	31.30^{ab}	30.62^{b}	34.68^{a}	50.62	66.00	24.63	39.29	30.62
2:4	25.69	49.18	71.15	15.37^{ab}	34.20^{ab}	38.06^{a}	22.46^{b}	46.61	64.04	22.33	38.57	38.06
Sole tomato	25.54	53.14	68.95	-	-	-	39.26^{a}	62.49	67.75	-	-	-
Sole onion	-	-	-	15.93^{a}	36.84$_{a}$	39.33^{a}	-	-	-	26.70	45.90	39.33
SE±	1.93	3.44	3.39	0.56	2.00	1.93	3.17	5.28	4.48	2.16	3.80	1.93

Means followed by different letter(s) are significantly different at P≤0.05 using DMRT. WAT= weeks after transplant, 3:3= 3 rows of tomato and 3 rows of onion, 4:2= 4 rows of tomato and 2 rows of onion, 2:4= 2 rows of tomato and 4 rows of onion.

Table 2. Chlorophyll content of tomato and onion as affected by intercropping in 2015 wet season.

Treatments	BUK						Bagauda					
	Tomato (WAT)			Onion (WAT)			Tomato (WAT)			Onion (WAT)		
	3	6	9	3	6	9	3	6	9	3	6	9
Intercropping												
3:3	20.43	28.01^{b}	42.36^{ab}	1.74^{b}	8.82^{b}	21.76^{b}	21.73	32.32	40.10	6.69	13.30^{ab}	23.25^{b}
4:2	24.04	34.11^{a}	49.89^{a}	1.96^{ab}	7.91^{b}	17.43^{b}	21.87	32.22	40.01	4.89	11.33^{b}	24.00^{b}
2:4	21.19	28.30^{b}	38.91^{b}	1.76^{b}	9.41^{b}	22.79^{b}	21.50	29.65	35.65	4.24	9.83^{b}	20.75^{b}
Sole tomato	22.19	29.68^{ab}	42.21^{ab}	-	-	-	24.22	33.67	44.88	-	-	-
Sole onion	-	-	-	2.68^{a}	19.92^{a}	47.03^{a}	-	-	-	7.23	16.11^{a}	34.40^{a}
SE±	1.39	1.63	3.01	0.30	2.30	6.42	3.31	2.74	3.84	1.89	1.39	2.10

Means followed by different letter(s) are significantly different at P≤0.05 using DMRT. WAT= weeks after transplant, 3:3= 3 rows of tomato and 3 rows of onion, 4:2= 4 rows of tomato and 2 rows of onion, 2:4= 2 rows of tomato and 4 rows of onion.

Table 3. Tomato Fruit and Onion Bulb Diameters (mm) as affected by Intercropping in 2015 Wet Season.

Treatments	BUK		Bagauda	
	Tomato	Onion	Tomato	Onion
Intercropping				
3:3	27.43^{b}	46.44^{b}	37.49	40.14
4:2	27.90^{b}	44.10^{b}	35.97	38.80
2:4	30.53^{ab}	50.01^{ab}	35.23	39.10
Sole tomato	31.70^{a}	-	37.89	-
Sole onion	-	65.06^{a}	-	36.11
SE±	1.27	5.49	2.42	2.06

Means followed by different letter(s) are significantly different at P≤0.05 using DMRT. 3:3= 3 rows of tomato and 3 rows of onion, 4:2= 4 rows of tomato and 2 rows of onion, 2:4= 2 rows of tomato and 4 rows of onion.

Tallest plant height was recorded in sole onion cropping throughout the sampling periods. There was no significant effect recorded at Bagauda throughout the sampling periods.

Table 2 shows the effect of row arrangements in tomato and onion intercrop on chlorophyll content of tomato and onion leaves. Significant effect were recorded in chlorophyll content of tomato at 6 and 9WAT. At 6WAT tomato and onion intercrop of 4:2 rows arrangement and sole tomato were statistically similar but 4:2 was higher than 3:3 and 2:4 rows arrangement of tomato and onion intercrops at BUK. No significant differences were observed throughout the sampling period at Bagauda. Sole onion had significantly higher chlorophyll content than other intercrops at 6 and 9WAT at BUK and at 9 WAT at Bagauda. Row arrangement of tomato and onion intercrops on tomato fruit and onion bulb diameter is presented in (Table 3), significant effect on the tomato fruit diameter in which sole tomato cropping produced significantly wider tomato diameter than 3:3 and 4:2 of tomato and onion intercrops at BUK. No significant effect was recorded at Bagauda trial location. There was a highly significant effect of intercropping on tomato fruit yield at both BUK and Bagauda. The highest tomato yield was recorded when tomato was sole cropped at both locations (Table 4). Similarly highest yield were produced

Table 4. Tomato fruit and onion bulb yield (kgha^{-1}) as affected by Intercropping patterns in 2015 Wet Season.

Treatments	BUK		Bagauda	
	Tomato	Onion	Tomato	Onion
Intercropping				
3:3	8988^{b}	1944.4^{c}	5456.8^{c}	2245.6^{c}
4:2	10978^{b}	918.2d^{c}	12092.0^{b}	840.3^{d}
2:4	5718^{c}	3588.0^{b}	3062.7^{d}	4034.7^{b}
Sole tomato	16062^{a}	-	16909.1^{a}	-
Sole onion	-	15810.2^{a}	-	23368.1^{a}
SE±	910.67	390.02	204.77	236.65

Means followed by different letter(s) are significantly different at P≤0.05 using DMRT. 3:3= 3 rows of tomato and 3 rows of onion, 4:2= 4 rows of tomato and 2 rows of onion, 2:4= 2 rows of tomato and 4 rows of onion.

Table 5: Land equivalent ratio of tomato and onion intercrops at BUK and Bagauda in 2015 Wet Season.

	BUK			BAGAUDA		
Intercropping	Tomato	Onion	Total	Tomato	Onion	Total
3:3	0.56	0.12	0.68	0.32	0.10	0.42
4:2	0.68	0.06	0.74	0.72	0.04	0.76
2:4	0.36	0.23	0.59	0.18	0.17	0.35

3:3= 3 rows of tomato and 3 rows of onion, 4:2= 4 rows of tomato and 2 rows of onion, 2:4= 2 rows of tomato and 4 rows of onion

by sole onion cropping pattern at both locations. Land equivalent ratio (LER) values in the intercrops ranged from 0.59 to 0.74 at BUK and 0.35 to 0.76 at Bagauda (Table 5). In both locations, tomato had higher partial LER than onion in all cropping systems used. Tomato and onion growth and yield were reduced by intercropping probably because of competition of the two crops in mixture for growth resources, the higher tomato population the lesser the positive response of onion. Growth and yield reduction in onion were higher than those of tomato by considering at the partial Land Equivalent Ratio (Table 5) of both crops. This may be due to differences in competiveness of certain resources between two different crops. Muoneke and Ndukwe (2008) and Manga *et al.* (2003) had reported reduction in growth and yield of some component crops in mixtures. The result also agreed with the finding of Muoneke and Nduwe (2008) who reported that it is better to grow okro and vegetable amaranth separately especially at higher amaranth planting density because there was yield disadvantage when they were grown in mixtures. Tomato depressed the growth and yield of onion while planting in mixture. However, the finding is in contrast with result revealed by Xia *et al*. (2016) who reported that intercropping potato onion and tomato promoted the growth, yield and phosphorus uptake of tomato in P rich soil.

Conclusion

Results of this study showed that there was competition of nutrient, water, solar radiation and other essential resources in tomato and onion intercrops as such they are not compactable to each other. This indicated that is more advantageous to grow tomato and onion as sole crops especially at higher population density of tomato because of depressive effect of tomato on onion, there was yield disadvantage when they are grown in mixture.

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