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Effect of Plant Spacing and Date of Planting on Yield of Two Garlic (*Allium Sativum* L.) Cultivars in Sokoto, Nigeria

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Abstract: Two field experiments were carried out during the 1997 and 1998 dry seasons at the Usmanu Danfodiyo University Teaching and Research Fadama Farm Sokoto[13° 01'N Latitude and 5° 15'E Longitude], 350 meters above sea level, in order to study the response of two garlic (*Allium sativum* L.) cultivars to varying plant spacings and planting dates. A factorial combination of three planting dates (Nov. 29, Dec. 13 and Dec. 27), four plant spacings (5, 10, 15 and 20 cm) and two cultivars (ex-Lugu and ex-Kofa) were laid out in a Complete Randomized Block Design and replicated three times. Each gross plot was 1.5 m wide and 2.0 m long (3 m^2) consisting of ten rows, while the net plot was 0.9×1.4 m (1.26 m^2) consisting of six inner row. Data was collected on fresh and cured bulb yield and analysed. Results indicated that close spacing of 10 cm resulted in higher cured bulb yield, while early plantings Nov. 29 and Dec. 13 resulted in higher yield than late planting of Dec. 27. The local cultivar ex-Lugu out yielded the ex-Kofa. It is therefore suggested that garlic be planted early in the season (Nov. 29-Dec. 13) at 10 cm spacing using the local ex-lugu cultivar in Sokoto.

Key words: Plant spacing · date of planting · cultivar and garlic yield

INTRODUCTION

Garlic (*Allium sativum* L.) belongs to the family Alliaceae. Other crops in the family are onion (*A. cepa* L.), leek (*A. ameloprisum* L.), shallot (*A. asacloncum* L.) and chive (*A. schoenoprasum* L.). Garlic is the second most widely used of the cultivated bulb crops after onions. It is an erect annual herb that can reach a height of 75-90 cm and grows during dry and mild winter season [1].

Garlic is believed to have originated in Central Asia (India, Afghanistan, W. China, Russia etc.) and spread to other parts of the world through trade and colonization [2, 3]. According to FAO [4], production of garlic stood at about 10 million tonnes per annum which is only about 10% that of bulb onions. China is the world largest producer followed by South Korea. The world average yield of garlic is about 10 t ha^{-1}, but can go up to 19 t ha^{-1}.

Garlic is rich in sugar, protein, fat, calcium, potassium, phosphorus, sulfur, iodine, fibre and silicon, in addition to vitamins. Its pungent flavor makes it used mainly as a spice, seasoning and flavoring for foodstuff involving both green tops and bulbs. Its medicinal value is also well recognized in the control and treatment of hypertension, worms, germs, bacterial and fungal diseases, diabetes, cancer, ulcer, rheumatism etc. Dehydrated garlic and extracts are fast replacing fresh bulbs for industrial and home usage in the production of drugs, insecticides and explosives [2].

Sokoto is among the leading garlic producing states in Nigeria. Production of the crop dates back several decades in the state. Garlic cultivation covers an area of over 11,277 ha producing about 73,908 metric tonnes per annum [5]. The main producing Local Government areas are Goronyo, Wurno, Gada, Gwadabawa, Rabah and Kware, where the crop is grown under irrigation during the cool dry season (Hamattan) in Nov-March. The traditional husbandry practices have resulted in 3-4 t ha^{-1} yield as against the world average of 10-15 t ha^{-1}. At off-season same quantity of garlic is usually sold at twice or three times the value of onions. It is mostly exported to parts of Africa, Middle East, Asia and Europe through various trade routes. A number of studies in various parts of the world have shown that garlic production can be improved through appropriate cultural practices [6-8]. Unfortunately, there is dearth of information on garlic production in Nigeria, except for some recent work at Samaru on spacing, fertilizer and irrigation requirements [9-11].

It is in view of this background that this study was undertaken with the aim of exploring opportunities to improve the productivity of the crop through choice of

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appropriate plant spacing, planting date and cultivar that maximizes the yield factors.

MATERIALS AND METHODS

Two field experiments were carried out during the 1997 and 1998 dry seasons (November to March) at Usmanu Danfodiyo University, Teaching and Research Fadama Farm Sokoto [13° 01'N Lat. 5° 15'E Long; 350 meters above sea level] in order to study the response of two garlic (*Allium sativum* L.) cultivars to varying levels of plant intra-raw spacings and planting dates.

The treatments consisted of the two cultivars planted at three planting dates at two weeks interval (Nov. 29, Dec. 13, Dec. 29) and four inter-plant spacings (5, 10, 15 and 20 cm). The treatments were factorially laid out in Randomized Complete Block Design replicated three times.

Land preparation were carried out 14-18th November. Each gross plot was 1.5 m wide and 2.0 m long (3 m^2) consisting of ten rows, while the net plot was 0.9×1.4 m (1.26 m^2) consisting of six inner row. The experimental units used were ex-Lugu and ex-Kofa garlic cultivars. While the ex-Lugu is popularly grown in Lugu Village of Wurno Local Government area of Sokoto State whose mature cloves have light pinkish outer skin. The ex-Kofa is a local garlic cultivar popularly grown in Kofa Village in Bebeji Local Government area of Kano State. Its mature cloves have light pinkish covering scale.

Prior to planting, garlic bulbs were split into the individual cloves that were soaked in water over-night. The cloves were planted upright with epical tip exposed at 10 cm inter row spacing according to the treatment structure. The field was irrigated before sowing in order to provide good clove-soil-water contact. Subsequent irrigations were given at 7 days intervals.

Fertilizer was applied at 90 kg N, 22 kg P and 26.4 kg K per hectare in form of Urea (46% N), N.P.K (20-10-10) and single super phosphate (18% $P_2 0_5$ ha^{-1}). A basal dose of half the nitrogen rate and full doses of the phosphorus and potassium were applied at planting. The second half dose of the nitrogen was applied at four weeks after sowing.

There was no incidence of either pest or disease in the crop throughout the growth period of experimentation in both seasons except for the nut sedge (*Cyprus rotundus*) that was controlled manually hand picking and hand hoeing.

Bulbs were harvested when the leaves turned yellowish green and had started withering. The harvested bulbs were spread in single layers in an open space for two weeks for curing.

Table 1: Fresh bulb yield (kg ha^{-1}) as affected by plant spacing, planting date and cultivar during 1997 and 1998 dry seasons and combined analysis at Sokoto

	Fresh bulb yield		
Treatments	1997	1998	Combined
Nitrogen (kg ha^{-1})			
0	8131	4416b	6273b
60	7522	8047a	7785a
120	8140	8364a	8243a
180	7811	6658a	7234ab
240	7289	7271a	7280ab
Significance	ns	**	*
L.S.D.	1567	2162	1321
Phosphorus (kg ha^{-1})			
0	7698	6430	7064
22	7429	7376	7403
44	8208	7048	7628
Significance	ns	ns	ns
L.S.D.	1214	1675	1023
Cultivar			
Ex-Lugu	8121	6980	7550
Ex-Kofa	7436	6923	7180
Significance	ns	ns	ns
L.S.D.	991	1367	835
Interaction			
N*P	ns	ns	ns
N*C	ns	ns	ns
P*C	ns	ns	ns
N*P*C	ns	ns	ns

Means in a column followed by same letter(s) within a treatment group are not significantly different, *, ** = Significant at 5% and 1% levels of probability, respectively

Data collected on fresh and cured bulb yield from the net plot was subjected to analysis of variance as described by Snedecor and Cochran [12] using a Microcomputer Statistical Programme (MSTAT) [13]. Significant differences were further analysed using Least Significant Difference Test (L.S.D.).

RESULTS AND DISCUSSION

The mean monthly minimum and maximum temperatures recorded across the two seasons ranged from 10.02 to 27.81°C and 25.40 to 40.53°C, respectively, while the mean relative humidity ranged from 34.78 to 52.83 percent. Laboratory analysis of soil samples from experimental site indicated the soil to be sandy loam, low in nitrogen, phosphorus and cation exchange capacity, moderate in available cations and acidic in reaction.

Fresh bulb yield: Results on spacing, planting date and cultivar effects on fresh bulb yield in 1997 and 1998 seasons and combined are presented in Table 1. Results indicated that plant spacing had significant ($p<0.05$) effect on fresh bulb yield throughout the study. It was found that increasing plant spacing from 5 to 10 cm increased fresh bulb yield, further increase to 20 cm resulted in significant decline in the yield. The highest fresh yield of 10534 kg ha^{-1} was recorded at 10 cm spacing in 1998.

With regards to the effects of planting date on fresh bulb yield, it was found that the earliest planting date (Nov. 29) consistently resulted in significantly ($p<0.01$) higher fresh bulb yield than the later dates throughout the study. The highest fresh yield of 12810 kg ha^{-1} was recorded at the earliest planting date in 1997. This signified the advantage of early planting in favour of larger fresh bulb yield.

There was significant ($p<0.05$) difference in the fresh bulb yield of the two cultivars in 1998 and combined, with ex-Lugu out yielding ex-Kofa. No significant interactions were observed.

Cured bulb yield: Data on the effects of plant spacing, planting date and cultivar on cured bulb yield in 1997 and 1998 dry seasons and combined are presented in Table 2. Plant spacing had significant effect on cured bulb yield in both seasons and combined. It was observed that as plant spacing was reduced from 20 to 10 cm there was significant increase in cured bulb yield; further reduction to 5 cm reduced the yield. The highest yield of 8430 kg ha^{-1} was recorded from 10 cm spacing in 1998.

This indicated that close spacing of 10 cm had optimum effect on cured bulb yield. As spacing was increased, individual plant yield got better due to the declining level of interplant competition. But wider spacing meant less number of harvestable bulbs per unit area. Similar observations were reported by Duimovic and Bravo [14], Singh *et al.* [15], Lammerink [16], Aleksiev [8] and Babaji [9].

From the foregoing it is pertinent to observe that significant response was recorded on the effect of spacing on bulb yield. Widening the space between plant stands reduced interplant competition in favor of growth and yield factors, but reduced crop yield performance due to reduction in plant stand per unit area. This finding is in conformity with the work reported by Om and Srivastava [17], Noural [18], Lucero *et al.* [7], Rahim and Talukdar [19] and Lammerink [16]. Garlic crops planted at the widest spacing were found to give the maximum yield of bulbs per stand [19], but lower yield per unit area. This showed that an improvement in individual plants at wider spacing did not compensate for the reduction in yield due to a decrease in plant population. On the other hand, the closer spacing produced the highest yield but the quality (bulb size and weight) of produce may be adversely affected and may not attract good price in the market [15]. Kusumo and Widjajanto [6] in Indonesia obtained their best yields at spacing of 15×15 or 15×10 cm. In the Ukraine, Bogantirenko [20] obtained the highest yield at a spacing of 45×4 cm.

Planting date had highly significant effect on cured bulb yield throughout the study. A close observation of the data indicated significant decline in cured bulb yield with every two weeks delay in date of planting. The yields recorded in 1997 were 10675, 3070 and 2717 kg ha^{-1} for the Nov. 29, Dec. 13 and 27 planting dates, respectively. This indicated the positive effect of early planting in favour of higher cured bulb yield. In a similar

Table 2: Cured bulb yield (kg ha^{-1}) as affected by plant spacing, planting date and cultivar during 1997 and 1998 dry seasons and combined analysis at Sokoto

	Cured bulb yield		
Treatments	1997	1998	Combined
Nitrogen (kg ha^{-1})			
0	6102	3584b	4843b
60	5911	6439a	5913a
120	6422	6692a	6557a
180	5956	5326a	5641ab
240	5658	5817a	5688ab
Significance	ns	**	*
L.S.D.	1252	1729	1056
Phosphorus (kg ha^{-1})			
0	6028	5176	5602
22	5673	5901	5787
44	6328	5638	5983
Significance	ns	ns	ns
L.S.D.	970	1339	818
Cultivar			
Ex-Lugu	6324	5584	5954
Ex-Kofa	5695	5560	5627
Significance	ns	ns	ns
L.S.D.	792	1094	668
Interaction			
N*P	ns	ns	ns
N*C	ns	ns	ns
P*C	ns	ns	ns
N*P*C	ns	ns	ns

Means in a column followed by same letter(s) within a treatment group are not significantly different, *, ** = Significant at 5 and 1% levels of probability, respectively

report from Egypt, Maksoud *et al.* [21] and Shahien [22], observed that when cloves were planted on September 15th, October 1st or October 15th, planting on Sept. 15th produced higher yields than the planting on 1st and 15th October. In contrast to this however Nassar *et al.* [23] and Fouda *et al.* [24] working also in Egypt indicated that planting garlic on October 1st gave higher yield as compared with 1st September. Orlowski and Rekwska [25] while investigating the effect of planting date on two local garlic types in Sczecin (Poland) also observed that, early planting (20th Sept and 5th Oct) gave the highest marketable yield of 14 and 12 t ha^{-1}, respectively. Lipinski [26] also in Poland indicated that all the measured growth and yield indices studied were at their highest values with 25th Oct. planting. In Sudan Noural [18] found that garlic yields varied substantially from 1619 to 11123 kg ha^{-1} over a period of four seasons with three planting methods. He attributed the difference to temperature variations over time, higher planting rate resulted in higher yield but lower number of cloves per bulb. Also in Cordoba, Argentina Rendon *et al.* [27] obtained the highest yield (bulb with an average dry weight of 28.91 g) with white garlic planted early, Maksoud *et al.* [21] observed that under Egypian conditions suitable planting dates varies with location as follows Shakalan 1st to 15th September, Zagazig Sept. 15th to October 15th and Sids September 15th to 1st October. Under the conditions prevalent in different countries, the most suitable planting date for garlic was April 5th in Chile [28], Oct. 31st in Bangladesh [19], April 27th in New Zealand [29] and October 15th in India [15].

The effect of cultivar on yield performance was significant in 1998 and combined analysis. At these levels, the ex-Lugu significantly out yielded the ex-Kofa. The yields were 8024 and 5835 kg ha^{-1} for the two cultivars in 1998, respectively. Rendon *et al.* [27] in Cordoba, (Argentina) indicated that white garlic out yielded the red type. In Egypt Nassar *et al.* [23], Zaki [30] observed that the Chinese cultivar significantly out yielded the American and Egyptian cultivars. However Maksoud *et al.* [21] proved that the location where these cultivars were grown in Egypt, significantly affected their yield. They observed that Chinese cv. produced maximum yield at Shalkan and Zanazig, while the Egyptian cv. produced higher yield at Sids.

CONCLUSIONS

Based on the results obtained from this study it is suggested that garlic should be planted early in the dry season Nov. 29th to Dec. 13th and use inter plant spacing of 10 cm with ex-Lugu cultivar for maximum yield of garlic at Sokoto under similar soil and weather conditions as used in the trial.

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