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Full Length Research Paper

Influence of intra-row spacing and mulching on weed growth and bulb yield of garlic (*Allium sativum* l.) in Sokoto, Nigeria

A.K. Karaye and A.I. Yakubu*

Department of Crop Science, Usmanu Danfodiyo University, Sokoto, Nigeria.

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Two field experiments were conducted during 2000/2001 and 2001/2002 dry seasons under irrigation at Kwalkwalawa Research *Fadama* Farm of Usmanu Danfodiyo University, Sokoto to investigate the response of weed growth and bulb yield of garlic to intra-row spacing and mulching. The treatments consisted of three intra-row spacings (10, 15, and 20 cm) and four mulching rate (0, 5, 7 and 9 t/ha). These were laid out in split plot design and replicated three times. Intra-row spacing was assigned to main plots and mulching was allotted to sub plots. Gross and net plot sizes were 3 x 1.5 m and 2.5 x 1 m, respectively. Results indicated that the number of leaves/plant, weed growth and cured bulb yield responded significantly to intra-row spacing and mulching, except in 2000/2001 trial, when the effect of mulching on cured bulb yield was not significant. Based on the results obtained, it could be concluded that for optimum bulb yield in garlic, the intra-row spacing of 10 cm and 9 t/ha mulching rate should be adopted.

Key words: Intra-row spacing, mulching, weed, garlic.

INTRODUCTION

Garlic (*Allium sativum L.)* belongs to the family *Alliaceae* and genus *Allium*, and is a shallow rooted vegetable crop (Purseglove, 1992; Hanelt, 1990). In terms of production, garlic is ranked second after onion and it is grown for its pungent flavoured bulbs and used world-wide to season foods (Brewster, 1990; Valadez, 1992). Garlic is usually grown under irrigation by farmers as a cash crop in the Savanna zone of Nigeria, between the months of November and March, during which there is cool, dry weather condition that favours its growth and yield. In Nigeria, however, reliable production figures are not readily available due to paucity of published information on the production of this crop.

Low planting density due to wide spacing has been identified as one of the reasons responsible for low yield of garlic (Brewster, 1994; Abubakar, 2001). The need therefore arises to investigate the optimum plant density for garlic production with an aim of increasing the returns on investment. Bulb yield losses of about 79 - 89% due to weed infestation have been reported (Ahmed, 1991). For this reason, therefore, investigation into alternative cultural weed control strategies that are ecologically friendly, devoid of resistance by weeds and yet compatible with the meager resources of farmers, will yield handsome dividends in this direction. Mulching using rice straw was observed to suppress weed growth effectively in garlic and onion (Ibrahim, 1994; Umar et al., 2000). Garlic is sensitive to moisture stress and high temperature and about 60% reduction in yield has been associated with water stress (Miko et al., 2000; Bello, 2001). For this, it was envisaged that mulching, which offers a practical and reliable means of conserving soil water and regulating soil temperature, is likely to have advantageous effects on the growth and yield of this crop. Such effects might also be reflected in reducing cost of irrigation and ensuring efficient management of the little water resources. In fact, there has been very

*Corresponding author E-mail: aiyakubu2003@yahoo.co.uk.

Table 1. Weed species present at the experimental site and their level of infestation during 2000/2001 and 2001/2002 cropping season.

Weed species	2000/2001	2001/2002
Grasses	**Level of infestation**	
*Cynodon dactylon*_(L) *Pers*	x	x x
Chloris pilosa Schum	x	x
Dactyloctum aegyptium	x	x x
Eleusine indica (L) *Gaert*	x	x
Echinochloa colona (*Linn*) Link	x	x x
Oryza longistaminata A. Chev & Roehr	x x	x x x
Broad leaved weeds		
Amaranthus spinosus L.	x	x
Amaranthus viridis L.	xx	xxx
Ageratum conyzoides L.	x	xx
Azolla africana L.	xx	xx
Acalypha ciliata Forsh	x	x
Crotalaria retusa L.	-	x
Cleome rutidosperma DC	x	x
Dissotis rotundifolia SM	x	xx
Eclipta prostrata L.	-	x
Hibiscus asper (Hoon) F.	x	x
Ipomea aquatica	xx	xx
Ludwigia absyssinica (A) Rich	x	x
Portulaca oleracea L	x	xx
Phyllantus amarus Schum	x	xx
Pentadum pentandra Schum	x	x
Sedges		
Cyperus rotundus L	x	x
Cyperus difformis L.	-	x

- = Nil (absent).
x = Low infestation (1-39% occurrence).
xx = Moderate infestation (40-59% occurrence).
xxx = High infestation (60-100% occurrence).

little research efforts to exploit fully the yield potential of garlic in Nigeria. This has therefore created an information dearth that needs. This trial was therefore undertaken to determine the response of weed growth and bulb yield to intra-row spacing and mulching under Nigeria conditions.

MATERIALS AND METHODS

Two field experiments were conducted during 2000/2001 and 2001/2002 dry seasons under irrigation at Kwalkwalawa Research *Fadama* Farm of Usmanu Danfodiyo University, Sokoto (13°01' N, 5°15' E and 300 m above sea level) to ascertain the effect of intra-row spacing and mulching on weed growth and yield of garlic. The treatments consisted of three intra-row spacings (10, 15 and 20 cm), and four mulching rates (0, 5, 7 and 9 t/ha) using rice straw. These were laid out in split plot design with three replications. Intra-row spacing was assigned to main plots while mulching was allotted to sub-plots. The intra-row spacing used was 20 cm. Gross and net plot sizes were 3 x 1.5 m and 2.5 x 1 m, respectively. In each trial, a local garlic variety named "Dagin-Kura" was used. Planting was done manually, using one clove per hole. In 2000/2001 season, planting was done on 2nd December, 2000 while in 2001/2002 season cloves were sown on 16th December, 2001. Immediately after planting, irrigation followed. For the first four weeks after planting, irrigation was carried out at three days interval. Thereafter, the irrigation frequency was extended to weekly basis throughout the remaining period of the plants' growth. Irrigation was stopped two weeks before harvest. In both trials, farm yard manure at the rate of 20 t/ha was incorporated into the soil during land preparation and at four weeks after crop emergence, NPK 20:10:10 at the rate of 20 kg/ha was applied in a single dose. At two weeks after planting, all the experimental plots were hand weeded and then rice straw mulch at the rate of 5, 7 and 9 t/ha were applied to the appropriate plots. While control plots were further hand weeded at 4, 6 and 8 weeks after crop emergence, the mulched plots were left un-weeded. Bulbs were harvested at maturity, as indicated by slight yellowing and partial drying of the leaves and plant falling over. In both trials, observations were taken on stand count, number of leaves/plant, plant height, days to 50% bulb maturity, fresh bulb yield, cured bulb yield, bulb size, number of cloves/bulb, weed frequency, weed cover score and weed dry weight. The data obtained were subjected to analysis of variance and treatment effects were compared using least significant difference as described by Gomez and Gomez (1984).

RESULTS

Analysis of soil from the experimental field revealed the soil to be sandy loam, slightly acidic (pH ranging from 5.61 – 5.80) and generally low in organic carbon (0.40 - 1.45%), phosphorus (0.021-0.026 ppm) and residual nitrogen (0.014-0.021%). Atmospheric temperature during the periods of the experiments ranged from 18 - 38°C in 2000/2001 season and 16 - 38°C in 2001/2002 season.

The 15 and 20 cm intra-row spacings produced significantly higher number of leaves/plant than 10 cm intra-row spacing in 2000/2001 trial, except at 60 days after planting (DAP) when both 10 and 15 cm spacings were statistically similar in leaf number/plant. In 2001/2002 trial, more leaves/plant was observed at 10 cm intra-row spacing compared to control as well as 5 t/ha-mulching rate at 60 DAP (Table 1). In 2001/2002 season, no significant difference in the number of leaves/plant was registered between the three mulching rates (0, 5 and 7 t/ha) at 30, 50 and 60 DAP. However, a significant reduction in the number of leaves/plant was observed as the mulching density was increased to 9 t/ha. Table 2 shows that 10 cm intra-row spacing produced significantly higher weed dry weight compared to 15 and 20 cm intra-row spacings which were statistically similar at 40 and 50 DAP in 2001/2002 season. The control plots produced statistically higher weed dry weight than all the mulched plots, and among the mulched plots, 9 t/ha mulching rate gave the lowest weed dry weight (Table 2).

Cured bulb yield decreased statistically with increase in intra-row spacing in both trials, except that the observed

Table 2. Number of leaves per garlic plant as influenced by intra-row spacing and mulching during 2000/2001 and 2001/2002 cropping seasons.

	2000/2001				2001/2002			
Treatments	**30DAP**	**40DAP**	**50DAP**	**60DAP**	**30DAP**	**40DAP**	**50DAP**	**60DAP**
Spacing (cm)								
20 x 10	2.60b	4.69	6.34[b]	12.54b	2.68	3.90	5.76a	10.75
20 x 15	2.72a	4.78	6.88[a]	13,35ab	2.60	3.76	5.38b	10.04
20 x 20	2.78a	4.92	7.06[a]	13.53a	2.59	3.93	5.57ab	10.20
LSD	0.1124	0.2376	0.2892	0.9635	0.1029	0.2469	0.3447	0.9823
Significance	*	**NS**	*	*	**NS**	**NS**	*	**NS**
Mulching (t/ha)								
0	2.64b	4.81	6.62	12.54[bc]	2.62ab	3.91	5.67a	9.93[ab]
5	2.70ab	4.74	6.70	12.34[c]	2.61ab	3.91	5.63ab	11.05[a]
7	2.69ab	4.75	6.86	13.48ab	2.71a	3.92	5.70a	10.76[a]
9	2.77a	4.88	6.87	14.20a	2.55b	3.72	5.27b	9.59[b]
LSO	0.1298	0.2743	0.3339	1.1126	0.1188	0.2851	0.3981	1.1342
Significance	*	**NS**	**NS**	*	*	**NS**	*	*
Interactions								
SXM		NS	NS	NS	NS	NS	NS	NS

Means followed by the same letter(s) within the same treatment column are statistically the same at 5% level of significance using least significant difference (LSD).
NS = Not significant.
* = Significant at 5% level probability .
DAP = Days after planting.

difference in yield between 10 and 15 cm spacings was not significant (Table 3).

DISCUSSION

The higher number of leaves/plant recorded at 15 and 20 cm intra-row spacings might be attributed to the fact that, plants widely spaced experienced little or no competition for limited environmental resources compared to closely spaced plants (Table 1). This observation is in conformity with the work of Ibrahim (1994) and Bodnar et al. (1998) who reported that widely spaced garlic plants tend to grow more vegetatively and bear more leaves/plant. It was possible that the plants did not experience serious competition for growth factors to the extent that can depress growth or alternatively the plants were opportuned to form a micro-environment that is more fertile than the rest portions of the land on which other plants grew. Leaf production/plant was observed to reach maximum at 9 t/ha mulched plots in 2000/2001 trial. This indicated the positive effect of high-density mulch on moisture conversation and weed suppression, which resulted in higher number of leaves/plant. While in 2001/2002 trial, leaf number/plant reached maximum at 7 t/ha mulching rate. This indicated the 7 t/ha-mulching rate to be adequate for better leaf production in garlic as per that season. Hence, mulch application beyond 7t/ha resulted in significant reduction in number of leaves/plant. The positive effect of mulching on number of leaves/plant observed in this trial agreed with the findings of John (1999) and Umar et al. (2000) who reported significant effect of mulching on leaf number/plant in onions, but disagreed with that of Ibrahim (1994) who reported insignificant effect of mulching on leaf number/plant in garlic.

Lower weed dry weight was recorded at 15 and 20 cm intra-row spacings. The tendency of wider spacing to enhance vegetative growth of the plants, leading to the development of adequate leaf area index, might have been responsible for the advantage conferred to 15 and 20 cm intra-row spacings in reducing weed infestation through shading. This observation buttressed those of Ahmed (1991) and Suchumacher (1997) who reported significant response of weed growth to intra-row spacing in onions, but deviated from that of Umar (2000) who recorded insignificant response of weed growth to intra-row spacing in onion plants. Higher weed dry weight was recorded at the control plots compared to mulched plots. Among the mulching treatments, 9 t/ha produced the least weed dry weights, substantiating the finding of John (2000) who reported that the smothering effect of mulching on weed depends on solid volume fraction (thickness) and mulch area index (the projected area of mulch elements per unit soil).

Highest bulb yield (9176.7 kg/ha) was obtained from 10 cm intra-row spacing while 20 cm intra-row spacing gave the lowest bulb yield of 5263.3 kg/ha (Table 3). The

Table 3. Weed dry weight (kg/ha) as influenced by intra-row spacing and mulching during 2000/2001 and 2001/2002 cropping seasons.

	2000/2001			2001/2002		
Treatments	**40DAP**	**50DAP**	**60DAP**	**40DAP**	**50DAP**	**60DAP**
Spacing (cm)						
20 x 10	242.42a	313.92a	201.75ab	319.50a	443.67[a]	218.75
20 x 15	136.25b	164.25b	172.25b	256.42ab	189.42[b]	240.83
20 x 20	158.17b	138.33b	226.50a	164.50b	171.17[b]	246.92
LSD	48.949	47.714	32.541	96.229	101.51	79.174
Significant	*	*	*	*	*	**NS**
Mulching (t/ha)						
0	333.44[a]	350.33[a]	319.44[a]	509.11[a]	469.67[a]	407.11[a]
5	202.89[b]	178.78[b]	190.89[b]	264.11[b]	269.67[b]	225.78[b]
7	115.67[c]	187.67[b]	166.22[b]	130.11[c]	216.22[bc]	186.22[bc]
9	63.78[c]	105.22[c]	124.11[c]	83.89[c]	116.78[c]	122.89[c]
LSO	56.521	55.095	37.575	111.12	117.21	91.422
Significance	**	**	**	**	**	**
Interactions						
SXM	NS	NS	NS	NS	NS	NS

Means followed by the same letter(s) within the same treatment column are statistically the same at 5% level of significance using least significant difference (LSD).
NS = Not significant.
* = Significant at 5% level probability.
** = Significant at 1% level probability.
DAP = Days after planting.

positive increase in bulb yield at closer spacing might be ascribed to increase plant population per unit land area while the decrease in bulb yield at wider intra-raw spacing could be associated with decreased plant population per unit land area. It can thus be seen that, the total yield per unit area depends not only on the performance of individual plants but also on the number of plants per unit area as confirmed in this study. Similar observations were reported by Babaji (1996) and Abubakar (2001). The lack of response of bulb yield to mulching observed in 2000/2001 season, might be related to the existence of conducive climatic conditions resulting from early planting of cloves, which favoured plant growth and yield (Table 3). The highest mulching rate (9 t/ha) recorded the highest bulb yield (7344.4 kg/ha) in 2001/2002 season while the control gave the lowest bulb yield (6026.7). This indicated the positive effect of high density mulch on moisture retention, temperature regulation and weed suppression, which invariably become manifested in higher bulb yield. Higher bulb yield in garlic and onion in response to mulching have been reported by Ibrahim (1994), John (2000) and Umar et al. (2000).

Comparing the two growing reasons, yield in 2000/2001 is higher than 2001/2002 trial. Late planting witnessed in 2001/2002 (16 December) as opposed to (2 December) in 2000/2001 season could be responsible for the variation in yield between the two seasons. Brewster (1994) also reported that late sown garlic plants switched from leaf blade to bulb formation. Consequently, the leaf index and the interception of light by crop canopy becomes much lower than that of early sown plants, which subsequently become reflected in low yield as confirmed in this study. High weed infestation observed in 2001/2002 seasons might also play a role in this direction. Hence, there is a positive correlation between weed density and weed competition as reported by Brewster (1994). It was possibly the competition generated by high weed infestation that was reflected in reduced growth and yield.

Based on the results obtained, it could be concluded that for optimum bulb yield in garlic, 10 cm intra-row spacing and 9 t/ha mulching rate appeared to be adequate. And for better weed control in garlic, the intra-row spacings of 15 and 20 cm and 9 t/ha mulching treatment should be adopted under similar climatic conditions.

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