# Journal of
# Plant Sciences

ISSN 1816-4951

Academic
Journals Inc.

www.academicjournals.com

Journal of Plant Sciences 2 (2): 202-208, 2007
ISSN 1816-4951


# Response of Garlic (*Allium sativum* L.) to Irrigation Interval and Clove Size in Semi-Arid, Nigeria

[1]H.G. Ahmed, [1]M.D. Magaji, [1]A.I. Yakutu, [2]L. Aliyu and [1]A. Singh
[1]Department of Crop Science, Usmanu Danfodiyo University, Sokoto, Nigeria
[2]Department of Agronomy, Ahmadu Bello University, Zaria, Nigeria

**Abstract:** Field trials were carried out during 2002/03 and 2003/04 dry seasons (Nov. to March) at Sokoto to investigate the performance of garlic (*Allium sativum* L.) to varying levels of irrigation interval and clove size. Treatments consisted of factorial combinations of four irrigation intervals in days (3, 5, 7 and 9 days) and two clove sizes (small, <2 cm and large, 2-3 cm). Treatments were laid out in a randomized complete block design with three replications. The results obtained revealed that 3-day irrigation interval significantly affected number of leaves per plant, plant height at maturity, bulb yield, bulb weight, number of cloves per bulb and clove weight throughout the period of investigation, while increase in the number of days between irrigation interval negatively affected the growth and yield and performance of the garlic. Generally, 3-day irrigation interval out-yielded the rest of the irrigation intervals in all the parameters assessed in both seasons. Clove size had significant effect on the number of leaves per plant, plant height, bulb yield, bulb weight, number of cloves per bulb and clove weight and they increased as the clove size increased. Large sized cloves had significantly and consistently out yielded small sized cloves in both seasons. It was concluded from this study that large clove size and applying irrigation at 3-day interval may be recommended for good performance of garlic under semi-arid condition of Sokoto, Nigeria.

**Key words:** Garlic (*Allium sativum*), irrigation, clove size, semi-arid, Nigeria

## INTRODUCTION

Garlic *(Allium sativum* L.) belongs to the family Alliaceae (Hanelt, 1990). Garlic originated in central Asia and later spread to Mediterranean region (Simon, 2001, Kilgori *et al*., 2005). It is grown in both temperate and tropical climates (FAO, 2001). Because of its commercial value, garlic is one of the most promising vegetable cultivated in the northern part of Nigeria during the dry season, under irrigation. At this particular time, most vegetable crops can not be grown through to maturity successfully without adequate watering. According to Chuman and Maurya, (1986) efficient utilization of water is vital for economic production and both water deficiency and over irrigation reduces garlic growth and yield performance.

Water as a solvent is a pre-requisite to successful garlic production (Michael, 1999). However, as a result of it fibrous and shallow rooting system, garlic requires adequate attention with regards to its water need. According to Buwalda (1987) and Choi *et al.* (1980), garlic requires adequate moisture from establishment through to maturity for better growth and yield performance and quality. They further reported that the crop did not withstand application of excess water and that water deficiency may cause substantial yield reduction.

Garlic is propagated from the cloves. The production of higher quality cloves is therefore prerequisite to a successful garlic production. In an investigation on a single garlic cultivar, Agustin and

**Corresponding Author:** H.G. Ahmed, Department of Crop Science, Usmanu Danfodiyo University, Sokoto, Nigeria

Longden (1967) found higher emergence, heavier clovelings and higher early bulb yield with larger clove and that graded clove generally produced more uniform bulbs. Apart from being the principal method of reproduction, the clove is largely responsible for the pungent quality having the highest amount of sulfur compound compared with other crop parts (Kochar, 1986). By and large, since the planting materials are cloves, there is therefore the need for grading of the cloves to be planted and also to determined the most appropriate irrigation scheduling for garlic so that both its growth and yield potentials would be properly exploited. Garlic is one of the most promising vegetable crops cultivated in Nigeria during dry season under irrigation in the northern part of the country because of its commercial values. Unfortunately, in Nigeria, there is very little information generated by research on garlic. As a result of being neglected as regards to research, only few findings on the crop were published in Nigerian Journals. Therefore, this research was carried out with a view to determining both the most optimum irrigation scheduling and clove size for garlic production in garlic producing areas of Nigeria.

## MATERIALS AND METHODS

Field trials were carried out during 2002/03 and 2003/04 dry seasons at Usmanu Danfodiyo University, Fadama Teaching and Research Farm, Sokoto (latitude 13°01'N; longitude 5°15'E, 300 m above sea level) to investigate the response of garlic to varying levels of irrigation and clove size. The site is a low lying Sokoto and Rima river flood plain (*Fadama*). The land is submerged by flood water from August/September to October/November. The area is characterized by a long dry season with cool air during harmattan (November-February), hot dry air during hot season from March to May. The meteorological data for the period of the experiment are minimum temperature of about 20.0 and 23.0°C and maximum temperatures of 30.0 and 34.5°C. Relative humidity ranged from 27 to 30% in the mornings and 38 to 40% in the evenings. Soil of the experimental site was sandy loam with a pH of 5.70 (in $H_2O$), 7.7 to 8.8% organic carbon; 0.85 to 0.88% N and available phosphorus of 0.54 to 1.93 ppm.

The treatments consisted of four irrigation intervals (3, 5, 7 and 9 days) and two clove sizes small (<2 cm) and large (2≥3 cm) in diameter, arranged in all possible factorial combinations and laid out in a randomized complete block design with three replications. Individual plot size was 1.5×3 m with 2.7 $m^2$ as net plot size. The spacing used was 15×10 cm with a single clove per hill. Five pre-treatment irrigations were given initially to enable the stands to be well established. Irrigation scheduling was altered to correspond to irrigation treatments. To obtain uniform maturity, irrigation was stopped two weeks before harvesting. Fertilizers NPK (15: 15: 15) was applied at the rates of 80, 50 and 50 kg $ha^{-1}$, respectively. Nitrogen was split applied at sowing (45-46% N) and at 4 weeks after sowing. All of the P and K were applied at bed preparation. All the fertilizers were incorporated into the soil in order to minimize losses. Bulbs were harvested when the leaves had turned pale green and started falling. Data were collected on number of leaves per plant, plant height at maturity, bulb yield, bulb weight, number of cloves per bulb and clove weight. Data were analyzed statistically and multiple comparison of treatment means were carried out using Duncan's Multiple Range Test (Little and Hills, 1978).

## RESULTS

Number of leaves per plant and plant height at maturity were significantly affected by irrigation interval and clove size in both seasons (Table 1). Three-day irrigation interval produced significantly higher number of leaves per plant and taller plants than the rest of the irrigation intervals in 2003/2004 season. It produced statistically similar leaf number with 5 and 7 days intervals in 2002/03 seasons (Table 1). In the same season however, the height of 7 and 9 day irrigation interval was statistically at par. In the second season each delay in irrigation interval significantly reduced the plant height.

Table 1: Mean number of leaves per plant and plant height (cm) as affected by irrigation interval and clove size during 2002/2003 and 2003/2004 dry seasons

| | No. of leaves/plant | | Plant height (cm) | |
|---|---|---|---|---|
| Treatments | 2002/03 | 2003/04 | 2002/03 | 2003/04 |
| **Irrigation interval (I) (days)** | | | | |
| 3 | 21.8a | 19.2a | 61.0a | 41.2a |
| 5 | 20.7ab | 15.7b | 59.3a | 38.5b |
| 7 | 18.2ab | 15.5b | 56.6ab | 32.7c |
| 9 | 17.1b | 11.0c | 54.0b | 29.0d |
| SE | 0.80 | 0.56 | 1.2 | 0.53 |
| Significance | ** | ** | ** | ** |
| **Clove size (C)** | | | | |
| Small | 18.6b | 15.2 | 56.2b | 33.1b |
| Large | 20.3a | 15.5 | 59.2a | 37.5a |
| SE | 0.52 | 0.17 | 0.6 | 0.5 |
| Significance | ** | NS | ** | ** |
| **Interaction** | | | | |
| I×S | ** | NS | NS | NS |

Means in a column followed by same letter (s) within a treatment group are not significant at 5% level of significance using Duncan Multiple Range Test (DMRT). NS = Not Significant; * and ** Significant at 1% and 5% levels, respectively

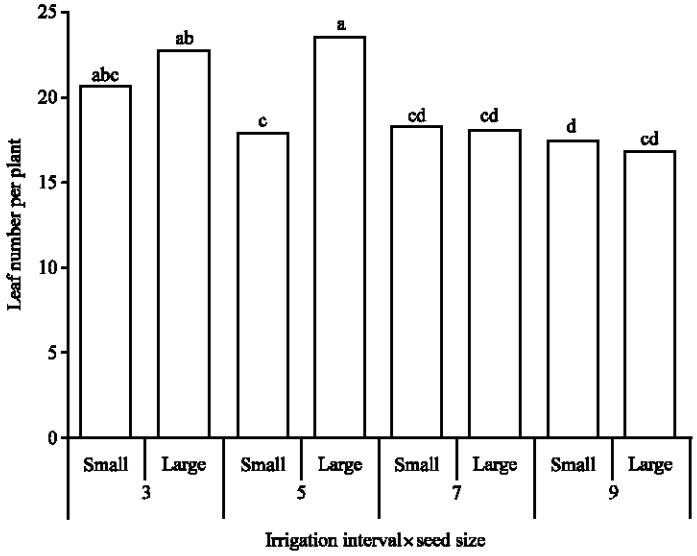


Fig. 1: Number of leaves per plant at maturity as affected by irrigation interval and clove size interaction during 2002/03 dry seasons. Bars with same letter(s) are not significantly different at 5% level of significance, using Duncan Multiple Range Test (DMRT)

Clove size had significant effect on the number of leaves per plant at maturity only in 2002/03 season (Table 1). Large sized cloves had higher average leaf number than the small sized cloves in both seasons. As regards to plant height, the differences due to clove size were highly significant in both seasons. Large cloves resulted in taller plants in the two season's.

In 2002/03 when the same level of irrigation was examined for the mean of clove size, it was found that large sized cloves produced higher number of leaves than small sized clove at 5 day irrigation interval (Fig. 1). There was no significant difference in the number of leaves produced by large or small cloves in other irrigation interval. If the same size of clove is examined against different irrigation

intervals in both small and large sized cloves the difference 3 and 3 day irrigation interval was not significant. Likewise the difference between 5 and 7 day irrigation intervals was not significant. However, 3 and 5 day irrigation intervals produced higher number of leaves than 7 and 9 day irrigation intervals.

Irrigation interval had significant effect on cured bulb yield in both seasons. Three-day irrigation interval produced significantly higher cured bulb yield than the remaining irrigation intervals (Table 2). Nine day irrigation interval produced lower cured bulb yield in 2003/2004 though was statistically at par with 7 day irrigation interval. In 2002/2003, 7 day irrigation interval had lower cured bulb yield but was not statistically different from 5 and 9 day irrigation intervals.

Bulb weight decreased as the irrigation interval increased in both seasons (Table 2). In 2003/2004, 3 day irrigation interval had statistically similar bulb weight with 5 day irrigation interval while in 2002/2003 the difference in bulb weight was significant. There was significant difference between 7 day and 9 day irrigation interval in 2003/2004 while the two irrigation intervals were at par in 2002/2003. Each increase in an irrigation interval from 3 to 7 days significantly reduced the bulb weight (Table 2). Similar significant of bulb weight was observed in 2003/2004.

Clove size affected bulb weight significantly in both seasons. Higher bulb weight was recorded in large sized cloves than in small sized cloves which had the least bulb weight in both seasons (Table 2).

From the (Table 3) the two individual seasons revealed similar significant interaction. When the irrigation interval was held constant and each interval was examined across the clove size, it was

Table 2: Mean bulb yield and weight as affected by irrigation interval and clove size during 2002/03 and 2003/04 dry seasons

| | Bulb yield (kg ha$^{-1}$) | | Bulb weight (g) | |
|---|---|---|---|---|
| Treatments | 2002/03 | 2003/04 | 2002/03 | 2003/04 |
| **Irrigation Interval (I) (days)** | | | | |
| 3 | 3322.4a | 3859.4a | 12.8a | 16.4a |
| 5 | 2464.8b | 2780.5b | 10.5b | 14.6a |
| 7 | 2051.3b | 2095.6c | 8.4c | 11.4b |
| 9 | 2206.8b | 1804.0c | 8.4c | 8.7c |
| SE | 211.3 | 188.9 | 0.05 | 0.81 |
| Significance | ** | ** | ** | ** |
| **Clove size (C)** | | | | |
| Small | 1909.1b | 2081.7b | 9.0b | 11.2b |
| Large | 3113.6a | 3188.0a | 11.1a | 14.3a |
| SE | 125.3 | 95.8 | 0.03 | 0.30 |
| Significance | ** | ** | ** | ** |
| **Interaction** | | | | |
| I×S | ** | ** | NS | NS |

Means in a column followed by same letter within a treatment group are not significant at 5% level of significance using Duncan Multiple Range Test (DMRT). NS = Not Significant; * and ** Significant at 1 and 5% levels, respectively

Table 3: Cured bulb yield as affected by irrigation interval and clove size interaction during 2002/2003, 2003/2004 seasons

| | Cured bulb yield (kg ha$^{-1}$) | | | |
|---|---|---|---|---|
| | 2002/03 | | 2003/04 | |
| Irrigation Interval (days) | Small | Large | Small | Large |
| 3 | 2354.6cd | 4290.3a | 3120.1b | 4598.8a |
| 5 | 2018.4cd | 3258.2b | 1984.6cde | 3576.4b |
| 7 | 1591.9c | 2510.8c | 1713.0de | 2478.4c |
| 9 | 1671.5d | 2395.1c | 1509.3e | 2098.8cd |
| SE | 250.65 | | 191.5 | |

Means followed by same letter(s) within a set of interaction are not significantly different at 5% level of significance, using Duncan Multiple Range Test (DMRT). * and ** Significant at 1 and 5% levels, respectively

Table 4: Number of clove per bulb and clove weight as affected by irrigation interval and weeding regime during 2002/03, 2003/04 dry seasons

| | Number of cloves bulb$^{-1}$ | | Clove weight (g) | |
|---|---|---|---|---|
| Treatments | 2002/03 | 2003/04 | 2002/03 | 2003/04 |
| **Irrigation Interval (days) (I)** | | | | |
| 3 | 10.5a | 17.3a | 0.70a | 0.81a |
| 5 | 9.5b | 16.0ab | 0.58ab | 0.69a |
| 7 | 8.7c | 15.1b | 0.58ab | 0.68a |
| 9 | 7.5d | 10.3c | 0.55b | 0.44b |
| SE | 0.19 | 0.61 | 0.045 | 0.046 |
| Significance | ** | ** | ** | ** |
| **Clove size (C)** | | | | |
| Small | 8.2b | 13.7b | 0.54b | 0.58b |
| Large | 9.8a | 15.7a | 0.66a | 0.74a |
| SE | 0.21 | 0.12 | 0.027 | 0.015 |
| Significant | ** | ** | ** | ** |
| **Interaction** | | | | |
| I×S | NS | NS | NS | NS |

Means followed by same letter within a treatment group are not significant at 5% level of significance using Duncan Multiple Range Test (DMRT). * and ** Significant at 5 and 1% levels of probability, NS = Not Significant

revealed that large sized cloves yield higher bulb yield at all irrigation intervals in both seasons. When each clove size was examined across irrigation interval mean in the large sized cloves, each increase in irrigation interval significantly decreased bulb yield from 3 to 7 day interval and increasing the irrigation interval from 7 to 9, however, did not decrease the yield in both seasons.

Clover weight decreased as the irrigation interval increased in both seasons (Table 4). In 2003/04, 3 day irrigation interval had statistically similar clover weight with 5 day irrigation interval while in 2002/03, the difference in clover weight was significant. There was significant difference between 7 day and 9 day irrigation interval in 2003/04 while the two irrigation intervals were at par in 2002/03. Each increase in an irrigation interval from 3 to 7 days significantly reduced the clover weight (Table 4). Clove size affected clover weight significantly in both seasons. Higher bulb weight was recorded in large sized cloves than in small sized cloves which had the least bulb weight in both seasons. The interaction was not significant (Table 4).

From Table 4, the results indicated that irrigation interval affected number of cloves per bulb significantly in both seasons. The trend in the number of cloves per bulb showed a decrease with increase in irrigation interval in both seasons. Three-day irrigation interval resulted in similar number of cloves per bulb with 5 day irrigation interval in 2003/2004. Non-significant difference was observed between 5 and 7 day irrigation interval in 2003/2004 season. In 2002/2003 season, all the irrigation intervals differed significantly from one another. Nine-day irrigation interval had significantly the least number of cloves per bulb in both seasons.

Clove size was observed to affect number of cloves per bulb significantly ($p<0.05$). Large sized cloves had significantly higher average number of cloves per bulb than the small sized cloves in both seasons (Table 4). Generally, for all the treatments, there were higher clove numbers in 2003/04 than in 2002/03 season. Clove size had also significant effects on clove weight in both seasons (Table 4). Large sized cloves had higher average clove weight and highly significantly differed from small sized cloves. The interaction among treatments was not significant.

## DISCUSSION

Adequate irrigation has been known to stimulate crop growth, development and yield of most vegetable crops. In this study significant increase in number of leaves per plant, plant height at maturity, bulb yield, bulb weight, number of cloves per bulb and clove weight as a result of irrigating

the crop after every 3 days could be attributed to availability of water at the root zone and this increased photosynthetic ability of the crop and also very vital for both transpiration and tissue formation and this resulted in increased bulb size and quality. Similar result was reported by Lazzari *et al*. (1978), Scalopi *et al*. (1971), Choi *et al*. (1980) and Carrijo *et al*. (1982) independently noted significant increased in number of leaves per plant, plant height and bulb yield, size and quality with frequent but light irrigation. In garlic the number of leaves per plant has been reported to have direct bearing on the number of cloves per bulb, which in turn affects both size and weight of the bulb. These parameters found to be highly likely optimum with 3 day irrigation interval suggesting given water at every three days to be adequate. This result confirmed the findings of Mikko *et al*. (2000) who reported positive effects of frequent irrigation on yield attributes of garlic. He reported 5 day irrigation interval as being optimum, probably as a result of differences in soil type and climate. Also Buwalda (1987) reported that garlic crop did not withstand application of excess water and that water stress could decrease both growth and yield attributes by up to 60%.

Cloves are the reproductive structure in garlic. Number of leaves per garlic plant, plant height, bulb yield, and bulb weight, number of cloves per bulb and clove weight were highest with large-sized cloves. This could be as a result of positive effects of available food reserves in the large size clove, which makes the crop to be established better, increased crop vigor which could have direct bearing with increase leaf number and consequently dry matter yield. Availability of food reserves for the young clovelings allowed them to be more vigorous in their growth and development. This was in conformity with what was reported by Olupinyo (1995, 1994) and Anna *et al*. (2000) that large-sized cloves produced plants which were taller with heavier bulbs, more number of leaves per plant and more clove number per bulb and finally with higher yield than small-sized cloves. They further attributed these growth and yield components to be as a result of more food reserves available in the large-sized cloves. Similarly, Kusomo and Widja janto (1973) and Bogatirenko (1977) reported that planting of large cloves resulted in higher growth and yield attributes.

## CONCLUSIONS

Based on the two season's experiments, it is deduced that the application of water at 3-days interval and the use of large sized cloves appeared optimum for maximum performance of garlic.

## REFERENCES

Agustin, R.B. and P.C. Longden, 1967. Some effects of clove size and maturity on the yield of carrot crops. J. Hortic. Sci., 42: 339-353.

Anna, D., F.G. Lapichino and A. Miceli, 2000. Effect of clove weight on yield and bulb quality of garlic grown for storage. A Paper Presented at the 18th International Symposium on Timing Field Production in Vegetables, Held at Bari, Italy. ISHS Acta Hortic., pp: 533.

Bogatirenko, A.K., 1977. The effect of clove size and spacing on garlic yield. Referatirynyi Zhumal No. 21: 10-14. Hortic. Abst., 47: 3535.

Buwalda, J.G., 1987. Nitrogen nutrition of garlic (*Allium satium* L.) Under irrigation: Crop Growth Dev. Sci. Hortic., 29: 55-68.

Carrijo, O.A., A.F.L Olitta, K. Minami and J.A. Menezes, 1982. Effects of Different Water Qualities on the Productivity of Two Garlic Cultivars Under Drip Irrigation. Assint. J. Agric. Sci., 9: 15-23

Choi, J.K., C.D. Ban and Y.S. Kwon, 1980. Effects of the amount and times of irrigation on bulbing and growth in garlic research reports on the effect of rural development. Hortic. Sericul. Swun, 22: 20-33.

Chuman, B.S. and P.R. Maurya, 1986. Response of onion to irrigation in a tropical soil. Agron. J., 78: 747-757.

FAO, 2001. Food and Agricultural Organization Rome: The Origin and Distribution of Garlic, USDA Agric. Res. Unit, USA., pp: 98-108.

Hanelt, P., 1990. Taxanomy, Evolution and History of Alliums: In: Brewster, J.L. (Ed.), Onions and other Vegetables, pp: 11.

Kilgori, J.M., M.D. Magaji and A.I. Yakudu, 2005. Productivity of two garlic (*Allium Sativum* L.) Cultivars as affected by different levels of nitgenous and phosphorous fertilizers in Sokoto, Nigeria. Bulletin of the Science Association of Nigeria, Proceedings of 41st Annual Conference, Vol. 26, Usmanu Danfodiyo University, Sokoto.

Kochar, S.L., 1986. Tropical Crops, A Textbook of Economic Botany. Macmillan Publishers' Ltd., pp: 237.

Kusomo, S. and D.D. Widjajanto, 1973. The effect of large bulbs used as clove on the yield and quality of garlic. Hortic. Abst., 46: 1063.

Lazzari, M.A., R.A. Resell and M. Landriscini, 1978. Garlic production. Nitrogen fertilizers and irrigation. Turrialba, 28: 245-251.

Little, J.M. and F.J. Hill, 1978. Agricultural Experimentation, Design and Analysis. John Wiley and Son Inc. New York, pp: 350

Michael, A.M., 1999. Irrigation theory and practice. Vikas Publishing House PTV Ltd. (NewDelhi). pp: 261-465.

Mikko, S., 2000. Effect of nitrogen, phosphorus and irrigation interval on the growth and yield of garlic (*Allium sativum* L.), Ph.D. Thesis submitted to the Postgraduate School, Ahmadu Bello University, Zaria, Nigeria.

Olupinyo, F.K., 1995. Effect of clove size and n-fertilization on the performance of garlic. B.Sc. Project, ABU. Zaria, Nigeria.

Scalopi, E.J., A.E. Klar and E.F.C. Vesconcellos, 1971. Irrigation and nitrogen fertilization in garlic. Agric. Res. Rev., 57: 233-242.

Simon, W., 2001. The origin and distribution of garlic. USDA, Vegetable Crops Res. Unit, pp: 1-3.