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PJBS

ISSN 1028-8880

Pakistan Journal of Biological Sciences

ANSInet
Asian Network for Scientific Information
308 Lasani Town, Sargodha Road, Faisalabad - Pakistan

Pakistan Journal of Biological Sciences 5 (10): 1028-1031, 2002

Dry Matter Accumulation and Partitioning and Growth of Garlic as Influenced by Land Configuration and Cultivars

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Abstract: Study was conducted to determine the effects of various land configurations on dry matter production, distribution and growth of garlic. Ridge planting method significantly influenced total dry matter (TDM) production and its distribution into root, stem and leaf. It had higher total, stem, root and leaf dry matter, leaf area index (LAI) and crop growth rate (CGR) over furrow and flat methods of planting. Varietal difference in dry matter partitioning and growth of garlic was revealed in this study. The cv. Faridpur that had highest clove weight produced higher total, stem, root and leaf dry matter, LAI and CGR over the other two cultivars.

Key words: *Allium sativum* L., CGR, dry matter, growth, LAI, garlic, ridge planting

Introduction

Garlic (*Allium sativum* L.) has been used as a food, condiment and for medicinal purposes for over 5,000 years. It is thought to have originated in central Asia and then later brought to the Mediterranean area. Garlic bulbs are composed of a number of thick, modified storage leaves called cloves, which are used as planting stock. Garlic is grown during the short winter in Bangladesh. The bulbing response is stimulated by the long days and warm temperatures of late spring. Bulbs of Bangladeshi garlic cultivars are very small which resulted in the lowest yield among the Asian countries. The probable causes might be the lack of improved varieties, virus infection and inadequate information on the planting method and subsequent cultural practices.

It is known that bulb growth and development in garlic largely depend on the photoperiod and temperature prevailing during growth period (Aoba and Takagi, 1975; Pyo *et al*., 1979). Castillo *et al*. (1996) reported that planting geometry has influence on dry matter production, LAI, LAD, CGR and yield of garlic. Planting method might modify the growth and dry matter production of garlic. We have reported earlier that yield traits and yield were influenced by different land configurations (Haque *et al*., 2002). In present study, the effects of different planting methods on the dry matter partitioning and growth were investigated in three local garlic cultivars of Bangladesh.

Materials and Methods

The experiment was carried out at the Field Laboratory of the Department of Crop Botany, Bangladesh Agricultural University, Mymensingh, during November, 2000 to March 2001. The soils of the experimental site were sandy loam in texture and belong to the Brahmaputra alluvial tract. The climate of the locality was humid tropical, characterized by a heavy down pour of rainfall during the months from June to September and scanty rainfall during rabi season (November to March).

Locally available cultivars of garlic (Faridpur, Meherpur and Kishoregonj) were collected from the market and were used as planting materials for the experiment. The main land was ploughed and cross-ploughed several times followed by laddering using bullock drawn country plough. The land was finally prepared by spading and crop residues, etc. were removed. Cow dung (10 tons ha^{-1}), urea (173 kg ha^{-1}), triple superphosphate (TSP, 148 kg ha^{-1}) and muriate of potash (MP, 148 kg ha^{-1}) were applied to the land. The entire amounts of cow dung and TSP were applied at the time to final land preparation. Half of the dose of urea and MP was applied 15 days after planting (DAP) and the rest was applied at 26 DAP. The experiment was laid out in a randomized complete block design with three replications. The blocks were separated from each other by 0.75 m and plots within a block were separated from each other by 0.5 m. The total number of unit pots was 27. The three planting methods were: ridge method (M_1), furrow method (M_2) and flat method (M_3). Garlic cloves were planted in rows on 14th November, 2000. The distance between two adjacent ridges or furrows bottom was 20 cm. The clove to clove distance was 20 cm. Weeding was done as and when required. The crop was irrigated twice a month.

Crop sampling, beginning from 30 DAP was carried out at 12 days interval until 130 DAP. The plants from each harvest-area were uprooted carefully by a "khurpi" ensuring their maximum root retention and were carried to the laboratory encasing in polythene bags to prevent transpiration losses. Then the harvested plants were cleaned in running tap water and blotted with blotting paper to remove the adhering water, if any. The component parts representing leaf, stem, roots etc. were separated. Then each component was oven dried 89°C for 48 hrs and weighed to measure dry matter partitioning. Leaf area of the individual plant was measured (Rahim and Fordham, 1989). Standard growth analyses were undertaken for leaf area index (LAI) and crop growth rate (CGR) by using the leaf area and dry weight according to the formulae given by Hunt (1978).

Analysis of variance was performed for LAI, CGR, root dry matter (RDM), leaf dry matter (LDM), stem dry matter (SDM) and total dry matter (TDM) and their treatment means were compared by LSD.

Results and Discussion

Leaf area index (LAI): A higher LAI was observed with ridge method followed by the furrow and flat methods throughout the entire growth period (Fig. 1). Development of LAI among three cultivars was not much pronounced, although the cultivar Faridpur showed superiority over the other two cultivars. LAI development in Faridpur tended to be higher than the other cultivars throughout the growth period (Fig. 2). Maximum leaf area index was recorded for the cultivar Faridpur with ridge method (data not shown). The leaf area, a measure of leafiness and photosynthetic surface area of crops depends on the leaf growth, number of leaves, plant density and leaf senescence (Khan, 1981). Higher number of leaves were found in the plants grown in ridges. Crops grown in ridges had the higher LAI, which corresponded to the higher number of leaves.

Total dry matter: The cumulative dry matter accumulation of garlic due to the influence of the planting methods has been presented (Fig. 3). An initial slow growth rate was followed by a high rate of accumulation until the attainment of maximum at 90 DAP and thereby ended with a sharp decrease at the approach of maturity in all the treatments (planting methods). However, a significantly higher rate of DM accumulation was recorded for ridge method followed by the furrow and flat methods, respectively. The cumulative dry matter accumulation of the cultivars, as recorded from 30 DAP until maturity at 114 DAP, is presented (Fig. 4). The rate of dry matter accumulation was slow and gradual until about 54 DAP in all the cultivars. After 54 days

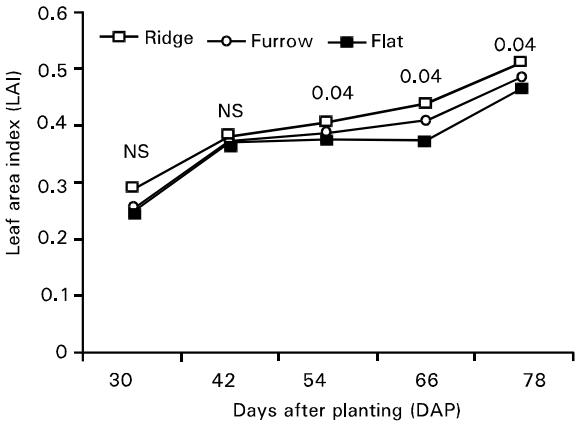

Fig. 1: Effect of methods of planting on leaf area index at different growth stages of garlic.

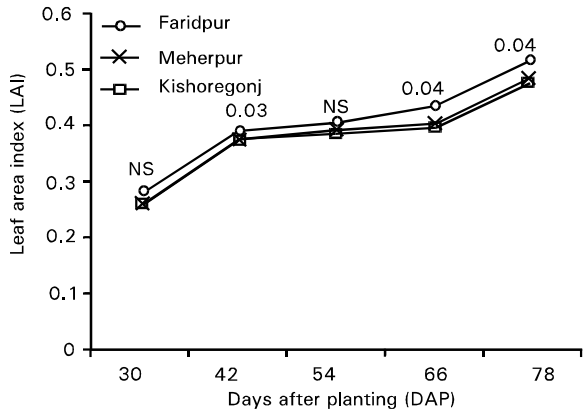

Fig. 2: Varietal difference in leaf area index at different growth stages of garlic.

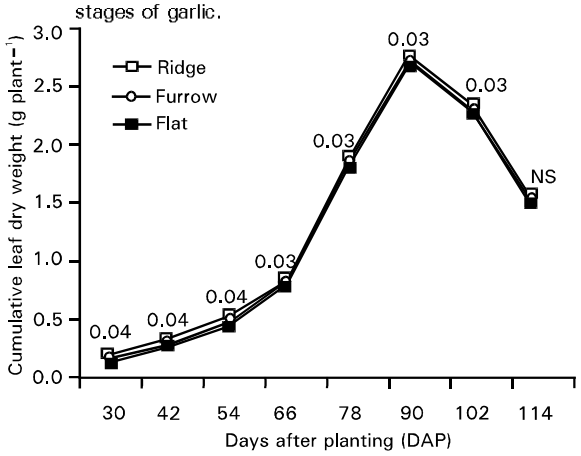

Fig. 3: Cumulative total dry matter accumulation among the three planting methods of garlic at different days after planting (DAP). The figures indicate LSD value.

of growth an accelerated rate of DM accumulation was marked up to 90 DAP. Thereafter, the dry matter accumulation slightly declined until maturity at 114 DAP. The overall performance of cv. Faridpur was better than cv. Meherpur. Highest dry matter production was found in ridge method. Bhinder and Sawhney

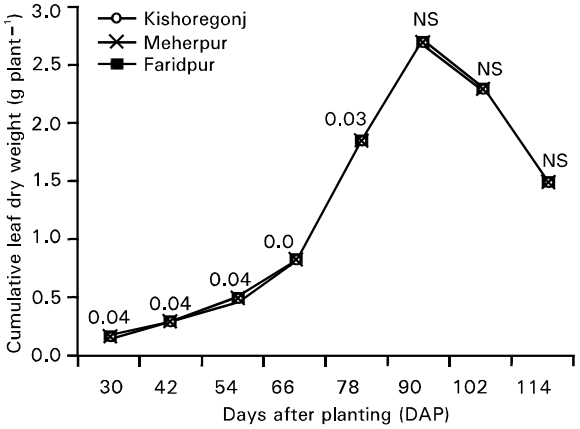

Fig. 4: Cumulative total dry matter accumulation among the three cultivars of garlic. The figures indicate LSD value.

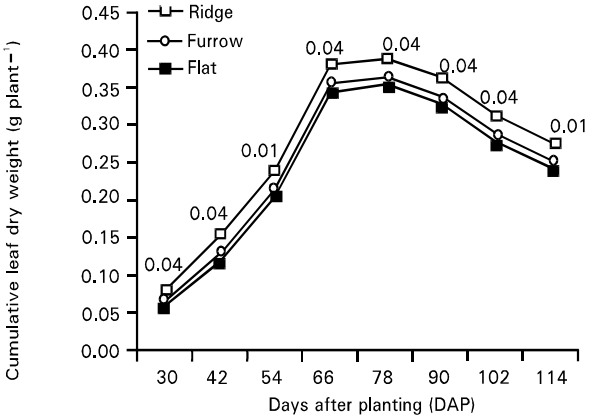

Fig. 5: Cumulative dry weight accumulation in garlic leaves as affected by planting methods. The figures indicate LSD value.

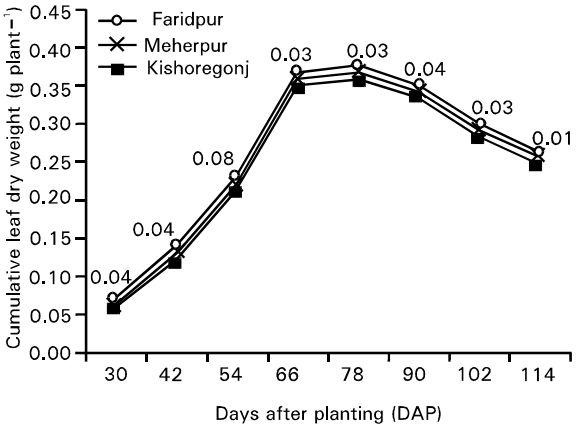

Fig. 6: Comparative leaf dry weight accumulation in garlic cultivars. The figures indicates LSD value.

(1985) reported similar results in maize cultivated in rabi season. Ridge sowing showed higher dry matter production in comparison with flat sowing.

Leaf dry matter accumulation: Leaf dry matter accumulation increased steadily with the advancement of plant growth in all

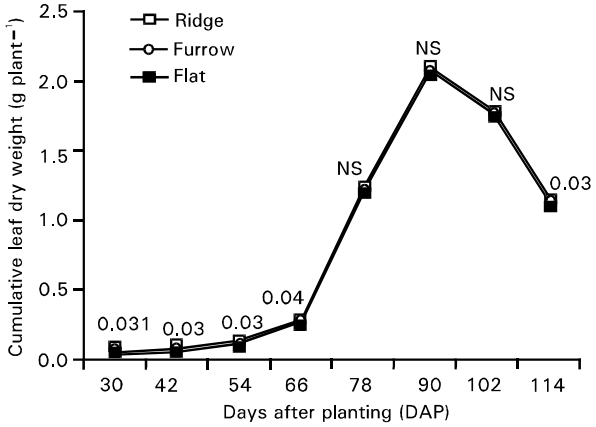

Fig. 7: Influence of planting methods on stem dry matter accumulation garlic with time. The figures indicate LSD value.

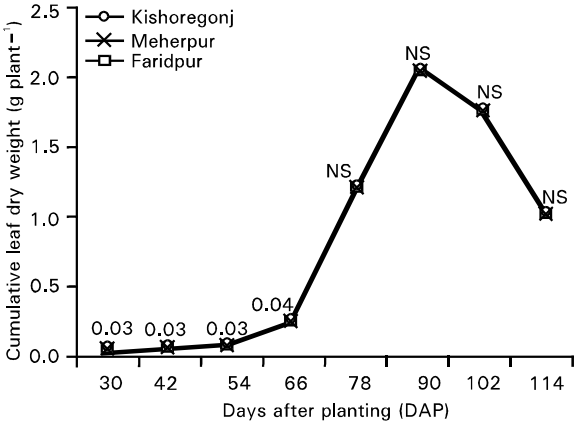

Fig. 8: Variety difference in cumulative stem dry matter accumulation of garlic with time. The figures indicate LSD value.

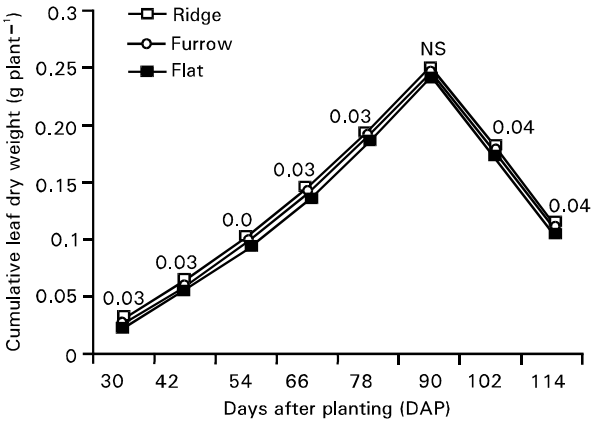

Fig. 9: Influence of planting methods on cumulative root dry matter accumulation of garlic with time. The figures indicates LSD value.

planting methods till the attainment of maximum at about 66 to 78 DAP (Fig. 5). After the attainment of maximum, the leaf dry matter had a lag phase with the approach of maturity.

Ridge method was observed to attain the highest leaf dry matter

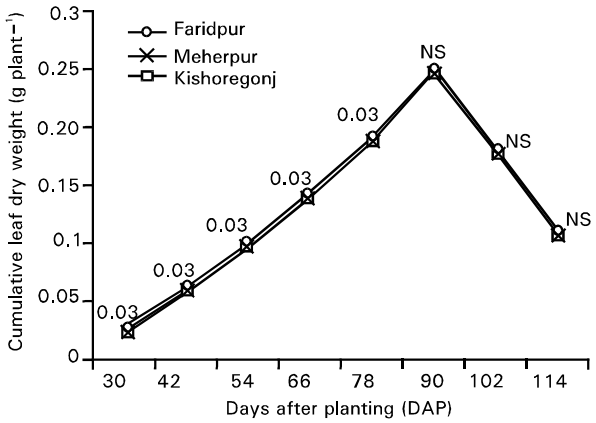

Fig. 10: Cultivar difference in root dry matter accumulation at various dates after planting of garlic. The figures indicate LSD value 5% level.

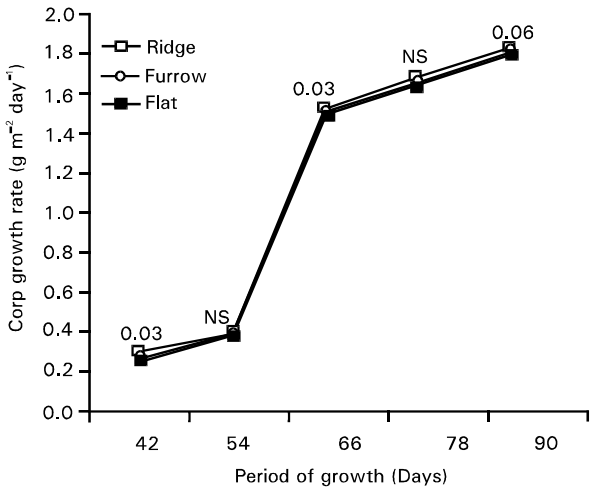

Fig. 11: Crop growth rate in garlic with time as influenced by planting methods. The figures indicate LSD value.

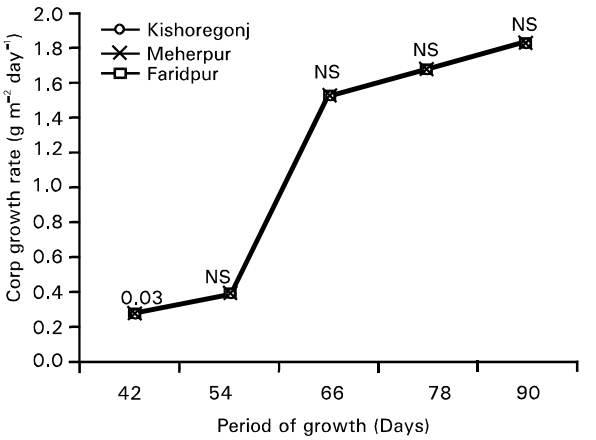

Fig. 12: Varietal differences of crop growth rate in garlic with time. The figures indicate LSD value 1% level.

accumulation (Fig. 5). The superiority of ridge method was maintained at all growth stages. The flat method was the least efficient in leaf DM accumulation. The performance of three cultivars in their ability to accumulate leaf dry matter has been presented (Fig. 6). All the cultivars had more or less similar pattern with planting methods (Fig. 5). All cultivars showed a sharp increase of leaf dry matter until 66 DAP followed by a gradual decrease at the approach of maturity. Cultivar Faridpur had a marked superiority over the other two cultivars. Leaves are the main centers for photosynthetic DM production. Therefore, with the increase in leaf area (Fig. 2) there was an increase in leaf dry matter accumulation. The subsequent reduction was related to the leaf senescence and an age dependent reduction in photosynthetic capacity (Brouwer, 1962). Faridpur cultivar had higher leaf DM over the other two cultivars. The higher leaf DM of cv. Faridpur might be due to its larger clove size (Baten *et al.*, 1994).

Stem dry matter accumulation: Variation in stem dry matter accumulation due to the effect of planting methods of garlic showed a significantly higher stem DM accumulation and was accounted for ridge method compared with flat and furrow methods. The flat methods however, was least efficient in stem dry matter accumulation. Initially the stem DM was increasing at a slower rate, but increased sharply after 66 days when the crop was in a state of bulbing (Fig. 7). The pattern of DM distribution was more or less similar in the three cultivars (Fig. 8). There was an initial lag period of DM accumulation extending up to 66 DAP, thereafter stem DM accumulation increased slowly and continuously until 90 DAP. The trend of dry matter accumulation was same in three cultivars. Cultivar Faridpur was superior to cv. Meherpur and cv. Kishoregonj in terms of its ability to accumulate the stem DM. Overall pattern of stem DM accumulation was similar to that of total DM accumulation (Fig. 3 and 4). A higher stem DM accumulation during the latter stage of growth after bulb initiation was probably due to the high rate of photosynthesis required to meet the demand of greater sinks (growing cloves). Production of higher stem DM by the cv. Faridpur is in agreement with the findings of Baten *et al.* (1994), who reported that large sized clove produced higher dry matter in garlic bulb (stem).

Root dry matter accumulation: Significantly higher root DM accumulation was accounted for ridge method compared to flat and furrow methods. The root DM increased sharply up to 90 DAP and thereafter declined sharply till maturity (Fig. 9). The final decrease in root dry matter might be due to more diversion of DM towards the bulb. The root DM decreased so sharply from 90 DAP because of root senescence and diversion of photosynthates from roots to the developing bulb. Variation in the root dry matter accumulation in the three cultivars of garlic, as recorded from 30 DAP till final harvest presents that the highest root dry matter accumulation among the three cultivars was recorded in Faridpur at all stages (Fig. 10). The trend of root dry matter accumulation in all cultivars was identical to the trend for planting methods (Fig. 9). The ridges might provide favourable environment for root growth. The higher root DM of cv. Faridpur may be related to its relatively higher clove size. Similar results were also reported by Baten *et al.* (1994).

Crop growth rate (CGR): The crop growth rate is the rate of dry matter production per unit area of land per unit time. Crop growth rate (CGR) increased steadily until the attainment of a maximum at 90 DAP (Fig. 11). After this period the CGR was not measured. Performance of ridge method was higher during the entire growth period. Cultivar difference of CGR in garlic with time was calculated from 30 DAP to 90 DAP and the pattern of CGR among cultivars was quiet similar. There was non significant difference in CGR among the cultivars except for 42 DAP (Fig. 12). It was positively correlated with LAI (Watson, 1947). CGR increased along with the increase in LAI and declined after reaching the maxima (Katiyar, 1980). The lower value of CGR at the initial stages of growth was the result of lower LAIs. Similar results were also reported in chickpea (Prasad *et al.*, 1978).

In conclusion dry matter production and partitioning, growth and development of garlic was greatly influenced by planting methods and cultivars. Garlic bulbs were developed under soil and the soil temperature, moisture conditions and physical condition might have profound effect on developmental process. However, the underlying causes for the better growth and dry matter production of the plants grown in ridges in this study in relation to soil environment are remained for future study.

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