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Effect of planting density on growth, yield and quality of Garlic at Rawalakot, Azad Kashmir

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Abstract

The studies on effect of planting density on growth, yield and quality of garlic was conducted at the Farm, Faculty of Agriculture, University of Poonch Rawalakot, during the year 2014-15. Bulbs of Desi garlic (Baghi) was collected locally from the grower of Rawalakot. There were fifteen treatments with three replications. The treatments were based on plant to plant distance of 3, 5, 7, 9 and11cm with row to row distance of 12, 14 and 16cm. The experiment was laid out according to randomized complete block design (RCBD) with two factor factorial. Data statistically analyzed and mean significant difference compared through LSD test. Plant spacing 5cm and 11 cm show significant result for leaf area, leaf length, plant height, bulb size, bulb fresh weight, bulb dry weight, number of cloves bulb^{-1} and yield ha^{-1}. As compare to other treatment row spacing of 14 cm gave more leaf area, leaf length, bulb size, bulb fresh weight, bulb dry weight, number of cloves bulb^{-1}and yield ha^{-1}. Growth, yield and quality of garlic affected by planting density, plant spacing of 5 cm and 11 cm and row spacing of 14 cm proved optimum.

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Introduction

Garlic (*Allium sativum* L.) is a bulb and it belonging to the family Alliaceous. It is the second most widely cultivated crop after onion (Hamma *et al.,* 2013).Garlic crop originated from Central Asia and it spread to the other parts of the world through trade and colonization (Purseglove, 1972).

Garlic has been used both as food and for medicine in many cultures for thousands of years. Garlic is claimed to prevent heart diseases, cholesterol, blood pressure, cancer, common cold and plaque. It has been successfully used in AIDs patients to treat cryptosporidium in China (Sovovo and Sova, 2004). Garlic also used as an insecticide and reduce cholesterol level in human blood and as a repulsive to snakes (Platan and Jennes, 1982).

Due to inadequate and improper adoption of agronomic practices garlic has lower productivity. Planting density has an important part in deciding the yield of any crop (Nonnecke, 1989). Economic importance of the garlic crop has increased considerably in the entire world in recent years. The most suitable sowing date and planting density are very important management practices in garlic production (Khodadadi and Nosrati, 2012). Garlic production and bulb yield could be improved through manure application and proper spacing (Kusumo and Widjajan to, 1973; Alecksiev, 1989).

Valley of Rawalakot, lies at an altitude of 1800-2000 m, at East longitude 73°-75° and 33°-36° North latitude under the foothills of Himalaya with temperate, sub-humid climate and annual rainfall of 500-2000 mm that is irregular with stroms during monsoon and winter. Temperature of this area ranges from 20-30°C with severe cold and snowfall in winter (Abbasi and Khan, 2004). Garlic grower of this area used traditional way of cultivation followed by weeding, hoeing and irrigation. Grower used planting without taking care of plant to plant and row to row distance (planting density).

Another reason for low yield of garlic is low planting density which is due to wider spacing (Abubakar, 2001). For increasing garlic production there is a need to check the optimum density of garlic.

Planting density decrease competition for light, water and nutrient in plants. Without wastage optimum plant population ensures effective use of available cropland (Geremew *et al.,* 2010).

Yield of garlic is dependent on the number of plants per unit area of land. Planting of garlic at proper spacing increases the yield and also improves the grade of bulbs. Several authors (Purewal and Daragan, 1961; Om and Srivastava, 1977) has been reported that wider spacing increased number of leaves. A non-chemical way of minimizing effect of weeds on yield is manipulation of agronomic factors like plant and row spacing (Cushman *et al.,* 2004).

To meet the requirements of the market it is necessary to adjust size of the harvested crop by maintaining planting density (Buhler, 2002). For producing quality garlic seeds bulb size and plant spacing are important factors (Mirshekari *et al.,* 2006).

Commercially garlic is very important; its cultivation is handicapped by several factors which greatly influenced its yield. Among the cultural practices, nutrient supply and row spacing are of greater significance in garlic productivity. Spacing between rows of plants is another factor that affects the growth and yield of the crop. Evapotranspiration and weed infestation were found high in the crop grown with wider spacing and hence it is necessary to grow the crop at optimum spacing (Rahman & Talukdar, 2003).

Rawalakot is hilly and people has small holding with minimum cultivated land compared to plain areas. To utilize the land properly, with maximum production. Optimum plant spacing keeping in view the crops, variety, environment and other factor relevant to its growth such as fertilizer, cultural practices, method of sowing, time of sowing up to harvesting and proper handling to maintain its quality according to market value.

Keeping in view the importance of crop and market demand in Rawalakot area,

present studies were conducted with following objectives to increase its production by using minimum inputs over a limited space, to find out most suitable spacing (plant to plant and row to row) under Rawalakot conditions and to utilize the land properly for better growth and yield.

Material and methods

The present research work was conducted during 2014-15 at the Experimental Farm Faculty of Agriculture, The University of Poonch Rawalakot, Azad Jammu and Kashmir, to evaluate the effect of planting density on growth, yield and quality of garlic, grown under condition of Rawalakot Azad Kashmir.

Experimental Description

Bulbs of Desigarlic (Baghi) were collected from local grower of Rawalakot, Azad Kashmir. Experiment was laid out under randomized complete block design (RCBD) with two factors. Plant to plant and row to row distances were considered as factors. Bed size was 3 meter square and total numbers of beds were 45. The treatments were based on plant to plant distance of 3, 5, 7, 9 and 11 cm with row to row distance of 12, 14 and 16 cm. There were fifteen treatments with three replications. Following treatment combinations were used in experiment:

Treatment combinations i.e. plant to plant distance and row to row distance

T_1= 3 x 12	T_6= 3 x 14	T_{11}= 3 x 16
T_2= 5 x 12	T_7= 5 x 14	T_{12}= 5 x 16
T_3= 7 x 12	T_8= 7 x 14	T_{13}= 7 x 16
T_4= 9 x 12	T_9= 9 x 14	T_{14}= 9 x 16
T_5= 11 x 12	T_{10}= 11 x 14	T_{15}= 11 x 16

Cultural practices

Ploughing was done to prepare beds for sowing. Weeding and irrigation were done regularly.

Data collection

Data was collected on following parameters:

Leaf area (cm²)

Three leaves from individual plant were collected and area was measured with the help of measuring tape.

Leaf area= Length x width x C. F

Leaf length (cm)

Leaf length from ten selected plants was measured with the help of measuring tape.

Plant height (cm)

Data on plant height (cm) were calculated with the help of measuring tape and plant height was measured from the soil surface to the top of the plant and average was worked out.

Bulb size (cm²)

Bulb size was measured with the help of Verniercalliper.

Bulb fresh weight (g)

Bulb fresh weight was measured after harvesting with the help of electric balance.

Bulb dry weight (g)

Bulb dry weight was measured after drying with the help of electric balance.

Number of cloves per bulb

Number of cloves were determined by counting the cloves per bulb, in selected samples.

Average yield (Kg)

Average yield was determined by weighing the collected bulbs from each plot and yield per hectare were calculated.

Statistical analysis

Analysis of variance ANOVA was used to analyse the data and means exhibiting significant differences were compared by using (LSD) Least Significant Difference test (Steel *et al*., 1997).

Results

Leaf area (cm²)

The mean values for plant spacing, row spacing and their interaction (A×B) shows highly significant difference for leaf area (Table 1, 2, 3). Results presented in Table 1.1. revealed that leaf area of garlic was significantly influenced by increasing plant spacing. Maximum leaf area (101.59 cm²) was achieved with plant spacing of 11cm while the minimum leaf area (91.46 cm²) was achieved from plant spacing of 3cm. Means for leaf area for row spacing exhibiting significant difference (Table 1.2).

Maximum leaf area (103.59 cm²) was observed with row spacing of 14cm while the minimum leaf area (92.53) was observed with row spacing of 12cm.

The interactive effect of plant and row spacing had significant effect on the leaf area as shown in Table 1.3. Maximum leaf area (104.80 cm²) was recorded for T_9 (plant spacing of 9cm with row spacing of 14cm) while minimum leaf area (71.30 cm²) was recorded for T_1 (plant spacing 3 cm with row spacing of 12cm).

The other treatments showed values in between for leaf area.

Table 1. Means for effect of plant spacing on area (cm²).

Sr. No.	Plant spacing (cm)	Means
1	3 cm	91.46 b
2	5 cm	99.52 a
3	7 cm	100.50 a
4	9 cm	100.84 a
5	11 cm	101.59 a

Means sharing same letter do no differ significantly.

Table 2. Means for effect of row spacing on area (cm²).

Sr. No.	Row spacing (cm)	Means
1	12 cm	92.53 b
2	14 cm	103.23 a
3	16 cm	100.59 a

Means sharing same letter do no differ significantly.

Table 3. Means of interaction for leaf area (cm²).

Plant ×Row spacing (cm)	Means	Plant ×Row spacing (cm)	Means	Plant ×Row spacing (cm)	Means
T_1	71.3 c	T_6	100.8ab	T_{11}	102.0 ab
T_2	91.4 b	T_7	103.7ab	T_{12}	103.4 ab
T_3	99.9 ab	T_8	102.0ab	T_{13}	99.5ab
T_4	98.5 ab	T_9	104.8a	T_{14}	99.1ab
T_5	101.4ab	T_{10}	104.7 a	T_{15}	98.5ab

Means sharing same letter do no differ significantly.

Leaf length (cm)

Data regarding to leaf length in Table 4 showed that leaf length of garlic increase by increasing plant spacing. Maximum (58.701cm) leaf length was observed for plant spacing 11cm while minimum (51.001cm) leaf length was noted for plant spacing 3cm. The examination of leaf length in Table 2.2 showed that maximum (59.716cm) leaf length was observed for row spacing 14 cm while minimum leaf length (49.945cm) was observed for row spacing 12cm. The combine effect of plant spacing and row spacing significantly increase the leaf length as shown in Table 2.3. Maximum leaf length (64.9cm) was observed for T_{10} (plant spacing 11 cm with row spacing 14 cm) while minimum leaf length (35.5cm) was found for T_1 (plant spacing 3 cm with row spacing of 12cm).

Table 4. Means for effect of plant spacing on leaf length (cm).

Sr. No.	Plant spacing (cm)	Means
1	3cm	51.001 b
2	5cm	56.391 a
3	7cm	55.800 a
4	9cm	57.498 a
5	11cm	58.701 a

Means sharing same letter do no differ significantly.

Table 5. Means for effect of row spacing on leaf length (cm).

Sr. No.	Row spacing (cm)	Means
1	12 cm	49.945 b
2	14 cm	59.716 a
3	16 cm	57.973 a

Means sharing same letter do no differ significantly.

Table 6. Means of interaction for leaf length (cm).

Plant ×Row spacing (cm)	Means	Plant ×Row spacing (cm)	Means	Plant ×Row spacing (cm)	Means
T_1	35.5 d	T_6	56.3abc	T_{11}	61.1ab
T_2	48.7 c	T_7	58.1abc	T_{12}	62.2 ab
T_3	54.0bc	T_8	56.2abc	T_{13}	57.1abc
T_4	55.3abc	T_9	62.9ab	T_{14}	54.2bc
T_5	56.1abc	T_{10}	64.9 a	T_{15}	55.0bc

Means sharing same letter do no differ significantly.

Plant height (cm)

The Table 7 showed that plant height significantly increase by increasing plant spacing. Maximum (66.157cm) plant height was observed for plant spacing 11cm while the minimum (58.519cm) plant height was observed for plant spacing 3cm. Table 3.2 showed that maximum (66.709 cm) plant height was noted for row spacing 14cm while minimum (56.647cm) plant height was noted for row spacing 12 cm. Plant spacing and row spacing significantly increase plant height as depicted by the Table 3.3.

Maximum plant height (72.04cm) was found for T_{10} (plant spacing 11cm with the row spacing of 14cm) while minimum plant height (41.60 cm) was found for T_1 (plant spacing 3 cm with the row spacing 12cm).

Table 7. Means for effect of plant spacing for plant height (cm).

Sr. No.	Plant spacing (cm)	Means
1	3cm	58.519 b
2	5cm	63.119 a
3	7cm	63.067 a
4	9cm	64.094 a
5	11 cm	66.157 a

Means sharing same letter do no differ significantly.

Table 8. Means for effect of row spacing on plant height (cm).

Sr. No.	Row spacing (cm)	Means
1	12 cm	56.647 b
2	14 cm	66.709 a
3	16 cm	65.618 a

Means sharing same letter do no differ significantly.

Table 9. Means of interaction for plant height (cm).

Plant ×Row spacing (cm)	Means	Plant ×Row spacing (cm)	Means	Plant ×Row spacing (cm)	Means
T_1	41.60 d	T_6	64.09ab	T_{11}	69.85ab
T_2	54.60 c	T_7	65.36ab	T_{12}	69.96ab
T_3	61.80bc	T_8	63.04abc	T_{13}	64.36ab
T_4	61.52bc	T_9	69.00 ab	T_{14}	61.75bc
T_5	64.26ab	T_{10}	72.04 a	T_{15}	62.16bc

Means sharing same letter do no differ significantly.

Bulb size (cm²)

Table 10showed that maximum bulb size (4.15cm²) was obtained from plant spacing 11cm while minimum (3.61cm²) bulb size was obtained from plant spacing 9cm. Result showed that bulb size increase by increasing plant spacing. Interactive effect of plant and row spacing in Table 4.2 showed significant difference. Maximum bulb size (4.33cm²) was found for T_5 (plant spacing 11cm with row spacing of 12cm) while minimum (3.32cm²) bulb size was found for plant spacing T_{14} (9cm with row spacing of 16cm).

Table 10. Means for effect of plant spacing on bulb size (cm²).

Sr. No.	Plant spacing (cm)	Means
1	3 cm	3.797ab
2	5 cm	3.91ab
3	7 cm	3.79ab
4	9 cm	3.61 b
5	11 cm	4.15 a

Means sharing same letter do no differ significantly.

Table 11. Means of interaction for bulb size (cm²).

Plant ×Row spacing (cm)	Means	Plant ×Row spacing (cm)	Means	Plant ×Row spacing (cm)	Means
T_1	3.60ab	T_6	3.59ab	T_{11}	4.20ab
T_2	3.62ab	T_7	4.22ab	T_{12}	3.88ab
T_3	4.33 a	T_8	3.52ab	T_{13}	3.54ab
T_4	3.80ab	T_9	3.71ab	T_{14}	3.32 b
T_5	4.30 a	T_{10}	4.27ab	T_{15}	3.88ab

Means sharing same letter do no differ significantly.

Bulb fresh weight (g)

Above results showed that maximum bulb fresh weight (34.633g) were recorded for plant spacing 5cm while minimum bulb fresh weight (27.400g) were recorded for plant spacing 7cm. Above results revealed that highest bulb fresh weight (36.293g) were obtained from row spacing 14cm and the minimum bulb fresh weight (26.929g) were obtained from row spacing 12cm. Table 14 showed that interaction of plant and row spacing had significant effect on bulb fresh weight.

The highest bulb fresh weight (44.0g) were obtained for T_{11} (plant spacing 3cm with row spacing of 16cm) whereas minimum bulb fresh weight (18.83g) obtained was for T_{13} (plant spacing 7cm with row spacing 16cm).

Table 12. Means for effect of plant spacing on bulb fresh weight (g).

Sr. No.	Plant spacing (cm)	Means
1	3 cm	33.433 a
2	5 cm	34.633 a
3	7 cm	27.400 b
4	9 cm	31.289 a
5	11 cm	33.537 a

Means sharing same letter do no differ significantly.

Table 13. Means for effect of row spacing on bulb fresh weight (g).

Sr. No.	Row spacing (cm)	Means
1	12 cm	26.929 c
2	14 cm	36.293 a
3	16 cm	32.953 b

Means sharing same letter do no differ significantly.

Table 14. Means of interaction for bulb fresh weight (g).

Plant ×Row spacing (cm)	Means	Plant ×Row spacing (cm)	Means	Plant ×Row spacing (cm)	Means
T_1	24.66 fg	T_6	31.63cdef	T_{11}	44.00 a
T_2	24.90fg	T_7	38.90abc	T_{12}	40.10ab
T_3	28.00ef	T_8	35.36bcde	T_{13}	18.83 g
T_4	27.53ef	T_9	36.80abcd	T_{14}	29.53def
T_5	29.54def	T_{10}	38.76abc	T_{15}	32.3bcdef

Means sharing same letter do no differ significantly.

Bulb dry weight (g)

Observation of Table 15 showed that maximum bulb dry (33.467g) weight was recorded for plant spacing 5cm while the minimum bulb dry weight (26.111g) was recorded for plant spacing 7cm. Above results revealed that maximum bulb dry weight was obtained for row spacing 14 cm while minimum bulb dry weight was obtained for row spacing 12cm. Close observation of Table 6.3 showed that maximum (42.600g) bulb dry weight was obtained for T_{11} (plant to plant distance 3cm with row spacing 16 cm) while minimum (17.300g) bulb dry weight was obtained for T_{13} (plant spacing 7cm with row spacing 16cm). The other treatments showed in between values for bulb dry weight.

Table 15. Means for effect of plant spacing on bulb dry weight (g).

Sr. No.	Plant spacing (cm)	Means
1	3 cm	31.956 a
2	5 cm	33.467 a
3	7 cm	26.111 b
4	9 cm	29.844 a
5	11 cm	32.000 a

Means sharing same letter do no differ significantly.

Table 16. Means for effect of row spacing on bulb dry weight (g).

Sr. No.	Row spacing (cm)	Means
1	12 cm	25.533 c
2	14 cm	34.940 a
3	16 cm	31.553 b

Means sharing same letter do no differ significantly.

Table 17. Means of interaction for bulb dry weight (g).

Plant ×Row spacing (cm)	Means	Plant ×Row spacing (cm)	Means	Plant ×Row spacing (cm)	Means
T_1	23.16fg	T_6	30.10cdef	T_{11}	42.60 a
T_2	23.60fg	T_7	37.90abc	T_{12}	38.90ab
T_3	26.83 ef	T_8	34.20 bcde	T_{13}	17.30 g
T_4	25.96 f	T_9	35.40abcd	T_{14}	28.16def
T_5	28.10def	T_{10}	37.10abc	T_{15}	30.8cdef

Means sharing same letter do no differ significantly

Number of cloves bulb^{-1}

Table 18 showed that maximum number of cloves bulb^{-1} (7.9333) were obtained for plant spacing 5cm while minimum number of cloves bulb^{-1} (7.4444) were obtained for plant spacing 11cm. Observation of Table 7.2 showed that maximum number of cloves bulb^{-1} (7.9200) were recorded for row spacing 14cm while minimum number of cloves bulb^{-1} (7.4800) were recorded for row spacing 12cm. The results depicted that maximum number of cloves bulb^{-1} (8.50) were recorded for T_{11} (plant spacing 3cm with row spacing 16cm) while minimum number of cloves bulb^{-1} (6.80) were recorded for T_5 (plant spacing 11cm with row spacing 12cm).

Table 18. Means for effect of plant spacing on number of cloves bulb^{-1}.

Sr. No.	Plant spacing (cm)	Means
1	3cm	7.7000 a
2	5 cm	7.9333 a
3	7 cm	7.7333 a
4	9 cm	7.7111 a
5	11 cm	7.4444 b

Means sharing same letter do no differ significantly.

Table 19. Means for effect of row spacing on number of cloves bulb^{-1}.

Sr. No.	Row spacing (cm)	Means
1	12 cm	7.4800 c
2	14 cm	7.9200 a
3	16 cm	7.7133 b

Means sharing same letter do no differ significantly.

Table 20. Means of interaction for number of cloves bulb^{-1}.

Plant ×Row spacing (cm)	Means	Plant ×Row spacing (cm)	Means	Plant ×Row spacing (cm)	Means
T_1	7.20ef	T_6	7.40 de	T_{11}	8.50 a
T_2	7.30def	T_7	8.20abc	T_{12}	8.30 ab
T_3	8.30ab	T_8	7.70cde	T_{13}	7.20 ef
T_4	7.80 bcd	T_9	8.10 abc	T_{14}	7.23ef
T_5	6.80 f	T_{10}	8.20 abc	T_{15}	7.33 def

Means sharing same letter do no differ significantly.

Average Yield (Kg)

Plant spacing showed significant difference for yield hectare^{-1} of garlic. Maximum yield hectare^{-1} (3494.2kg) was recorded from plant spacing 11cm while minimum yield hectare^{-1} (3048.2kg) was observed in plant spacing of 3cm.

Row spacing showed significant difference for yield hectare^{-1} of garlic. Maximum yield hectare^{-1} (3406.5 kg) was shown for row spacing 14cm while minimum yield hectare^{-1} (3160.5kg) was recorded for row spacing 12cm. Interaction of plant and row spacing also had a significant effect on yield of garlic. Maximum (4094.5 g) yield hectare^{-1} was obtained for T_{10} (plant to plant distance 11 cm with row to row distance of 14cm) while minimum (2246.1g) yield hectare^{-1} was obtained for T_1 (plant spacing 3cm with row spacing 12cm).

Table 21. Means for effect of plant spacing on yield hectare^{-1} (kg).

Sr. No.	Plant spacing (cm)	Means
1	3 cm	3048.2 b
2	5 cm	3298.9 a
3	7 cm	3320.0 a
4	9 cm	3347.0 a
5	11 cm	3494.2 a

Means sharing same letter do no differ significantly.

Table 22. Means for effect of row spacing on yield hectare^{-1} (kg).

Sr. No.	Row spacing (cm)	Means
1	12 cm	3160.5 b
2	14 cm	3406.5 a
3	16 cm	3306.5ab

Means sharing same letter do no differ significantly.

Table 23. Means of interaction for yield hectare^{-1} (kg).

Plant ×Row spacing (cm)	Means	Plant ×Row spacing (cm)	Means	Plant ×Row spacing (cm)	Means
T_1	2246.1 f	T_6	3129.8 cde	T_{11}	3768.8 ab
T_2	3056.6 de	T_7	3183.8 cde	T_{12}	3656.1 abc
T_3	3518.3 bcd	T_8	3253.9 bcde	T_{13}	3187.7 cde
T_4	3363.5 bcd	T_9	3528.0 bcd	T_{14}	3149.4 cde
T_5	3617.9bc	T_{10}	4094.5 a	T_{15}	2770.4 ef

Means sharing same letter do no differ significantly

Discussions

Light is important source of photosynthesis for plant growth, wider spaced plant get proper light intensity and nutrient as compare to the closely spaced plant that's why leaf area of wider spaced plant is more. Similar results have been reported by Kahsay *et al.,* (2014) who found that wider spaced plant get more leaf area.

Leaf length increase as we increase plant spacing, plants spread more and leaf area increases due to moisture availability, nutrients and additional light intensity. Supplement of nutrient is important factor during leaf formation widely space plant get enough nutrients due to less competition with plants. Leaf is an important part of plant and is responsible for food synthesis and supply of carbohydrates to plant for better growth and development. Monald *et al.,* (1993) reported that in closer row spacing vegetative growth was less which obviously affects the reproductive growth of plant.

More vegetative growth noted under wider spacing might be due to the fact that wider planting distance provided more space for growth and better light intensity which might have led to increased photosynthesis resulting in higher plant height. These observations are in agreement with the findings of Ara *et al.,* (2007). The results showed that plant height increases by increasing plant spacing with the increase of row spacing.

Closer spacing resulted in competition for nutrient and light thus resulting in plants that were short while the wider spaced plants had adequate space for their growth and development (Biru, 2015). Wider spaced increase plant height and number of leaves has been reported by several authors (Purewal and Daragan, 1961).

Interaction was found to be significant for bulb size which showed that plant spacing and row spacing were dependent for each other. Closer spacing resulted in competition for nutrient and light thus resulting in plants that were thin while the wider spaced plants had adequate space for bulb growth and development (Biru, 2015). Bulb size is an important quality character and different markets require different bulb size. Plant population also influences the shape of bulb. An increase in population leads to elongated bulbs (Kanton *et al*., 2002).

Observation of results for various plant spacing showed that almost all plant spacing under study responded positively for bulb fresh weight. These results are also similar with the results of Bosekeng and Gesin, (2015). More bulb size obtained from wider spacing may be due to vigorous plant. Bulb fresh weight increase by increasing row spacing due to adequate nutrients availability. Bulb store more food for vegetative as well as reproductive growth. These results are in agreement with the results of Rahman and Talukdar, (2003).

The results for bulb dry weight showed that optimum spacing is better than maximum and minimum plant spacing. Ademe *et al.,* (2012) reported that wider spaced plant showed high bulb dry weight due to more space availability to plant to spread more. Bulbs planted at 20cm intra-row spacing produced greater bulb dry weight per plant than those planted at 15 and 10cm intra-row spacing.

Observation of result for various plant spacing showed that almost all plant spacing under study responded positively for number of cloves bulb^{-1}. In wider row plant have more space to grow vigorously and produce more number of cloves bulb^{-1}.

The results for interaction showed that almost all interaction under study responded positively for number of cloves bulb^{-1}.

Leaf area, plant height and bulb size of plant spacing 11cm are more so yield of widely space plant is more than closely spaced plant. The wider spacing facilitated the plant to develop properly for less inter and intra plant competition for utilizing the available resources resulting higher yield.

These results are also comparable with the results of Asaduzzaman *et al.,* (2012). Result showed that optimum row spacing show better performance than maximum and minimum row spacing. Spacing between rows of plants is another factor that affects the growth and yield of the crop. Evapotranspiration and weed infestation were found high in the crop grown with wider spacing and hence it is necessary to grow the crop at optimum spacing (Rahman and Talukdar, 2003). The wider spaced crop got abundant area around each plant which did not cause them to compete with each other for food and nutrients and as results of which each plant showed better performance in respect of individual character (Alam *et al.,* 2010). These results are also similar with the results of Rahim *et al.,* (1984).

Conclusions

Plant spacing 5cm and 11cm gave best result for leaf area, leaf length, plant height, bulb size, bulb fresh weight, bulb dry weight, number of cloves bulb-1 and yield ha^{-1}. While Row spacing 14 cm gave more leaf area, leaf length, bulb size, bulb fresh weight, bulb dry weight, number of cloves bulb^{-1} pHand yield ha^{-1}. Therefore, plant spacing from 5 to 11cm and row spacing 14cm is suitable for garlic production under Rawalakot Azad Jammu and Kashmir conditions.

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