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Influence of date of planting and spacing on growth, yield and quality of garlic (*Allium sativum* L.)

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Abstract
The present investigation was conducted during year 2018-19 and 2019-20 at experimental field of Division of Vegetable Sciences, SKUAST-Kashmir to assess the sole as well as interaction effect of date of sowing and spacing on growth, yield, and quality of garlic (*Allium stadium* L) under temperate conditions of Kashmir valley. Pooled result of two years (2018-19 and 2019-20) revealed that sole effect of date of sowings showed treatment T_3 (15th Nov) recorded maximum values of plant height (87.60 cm),no. of cloves per bulb (9.78),average clove weight (9.77gms),average bulb weight (38.83 gms),Equatorial diameter (4.94cm,), polar dia (3.76 cm),neck thickness (0.67 cm),bulb yield (226.56 q ha^{-1}), T.S.S $Brix^0$ (36.25),vitamin C content (12.89 $mg100^{-1}g$) and protein content (6.41%) which was significantly superior to all treatments but at par with treatment D_2 (30th Oct) while as sole effect of spacing revealed that maximum values of plant height (79.60 cm),no. of cloves per bulb (7.32 cm),average clove weight (8.55 gms),average bulb weight (37.51 gms),equatorial dia (4.73 cm,),polar dia (3.61 cm),neck thickness (0.64 cm),bulb yield (223.45 q ha^{-1}), T.S.S $Brix^0$ (36.42),Vitamin C content (12.28 $mg100^{-1}g$) and protein content (6.32%) but were at par with S_2 (15×7.5 cm) treatment in respect of all parameters except bulb yield which was significantly maximum. Further it was also observed that interaction effect showed significant difference among treatments in respect of various growth, yield and quality parameters.

Keywords: Garlic, dates, spacings, yield, and quality, factors

Introduction
Garlic (*Allium sativum* L.) is the second most important bulb vegetable crop in India. Garlic belongs to family Alliaceae and has originated from Central Asia (Vavilov, 1926) [14]. Garlic is a frost hardy, bulbous, herbaceous annual for bulb production. Garlic is used as a spice or condiment throughout India and has higher nutritive value than other bulb vegetable crops. The area and production of garlic in India is 354 000 hectares and 2836.000 metric tonnes respectively and productivity of 8.1 MT per hectare (Anonymous, 2018-19). In Jammu and Kashmir garlic is grown on an area of 0.70 thousand hectares with a production of 0.56 thousand metric tonnes and productivity of 0.81 T per hectare, respectively (Anonymous, 2018-19)

The edible portion of garlic is a composite bulb and contains 62.8 per cent moisture, 6.3 per cent proteins, 29 per cent carbohydrates, 13 mg 100^{-1} g vitamin C, 0.03 per cent calcium, 0.31 per cent phosphorous, 0.0031 per cent iron and pyruvic acid content of 35-60 µmol g^{-1}. Garlic is considered as "Nectar of Life" in Ayurveda. A colourless, odourless and water soluble amino acid "allin" present in garlic breaks down in to a sulphur containing product allium on injury or crushing. Allium is the anti-bacterial substance of garlic and has typical odour of fresh garlic. In allium principal ingredient is odoriferous "diallyl disulphide" (Rai and Yadav, 2005) [11].

Garlic oil is used in paralytic and rheumatic infections and also in several food preparations such as chutney's, pickles, curries, vegetables and tomato ketchup. Garlic has many medicinal uses also. Antibiotics have been prepared from garlic extracts. It is used in stomach troubles, headache, toothache, ear ache, sore eyes and numerous other diseases. Pungency is developed in garlic when allianase enzyme interacts with precursors collectively known as S allyl cysteine sulfoxide, after cutting or crushing cloves. Pungency is estimated in terms of enzymatically formed pyruvic acid.

With the arrival of new and frightening viral diseases like AIDS and flesh eating bacteria, boosting immunity is receiving new attention. Because these types of diseases have no effective cures or treatments, strengthening the body's ability to fight off infection has become even more important. Garlic has an abundance of sulphur containing amino acids and other compounds that seem to initiate increased activity in the *Garlic* immune system (Walker, 1988) [15].

We are constantly assaulted by inadequate nutrition, cigarette smoke, physical injury, mental tension, and chemical pollution. Recently, the notion that vaccinations may also tax the immune system has emerged. In light of the enormous pressure which our immune systems sustain, supplemental nutrients like garlic are clearly needed.

The anticarcinogenic action of garlic can also be attributed to its role in preventing DNA-carcinogen adduct formation and activation of carcinogen (Liu *et al.,* 1992) [9]. It was revealed that water extract of raw garlic, DAS (Diallyle sulphides) and SAC (organo-sulphur compounds) could reduce BP-DNA adduct formation in stimulated human peripheral blood lymphocytes *in vitro* (Hageman *et al.,* 1997) [7]. Garlic powder and allyl sulfur compounds were shown to modify selenite protection against DMBA induced mammary cancer by inhibition of DNA-adduct formation (Schaffer *et al.* 1997) [12].

However, regarding production status, the productivity of garlic in India is very low. The productivity and quality of garlic can be enhanced by proper nutrient management. Besides proper nutrition optimum date of sowing and plant spacing are also important to improve garlic production as well as productivity. Garlic has lot of demand and is highly valued in the national and international markets due to its health benefits and nutritional importance. It is known that among yield influencing factors under normal conditions, date of planting and plant spacing are the main factors which greatly influence the growth, yield and quality of garlic crop (Kilgori *et al*., 2007) [8]. The present study was an attempt to identify suitable planting time and plant spacing for successful production of garlic under temperate conditions of Kashmir region

Materials and Methods

A field experiment was carried out at experimental field Division of Vegetable Sciences, SKUAST-Kashmir during rabi 2018-19 and rabi 2019-20 in factorial experiment with two factors *viz*.,1. Factor =date of sowing consisting of four levels as D_1(15th Oct),D_2(30th Oct),D_3(15thNov),D_4(30th Nov) and 2. Factor= spacing with two levels as S_1 (15×10cm) and S_2 (15×7.5 cm) laid out in Randomized Block Design with three replications. The experiment was laid out in split plot design with 8 treatments replicated thrice. The garlic cloves were sown at 4 dates of planting (15th Oct, 30th Oct, 15 Nov, and 30th Nov) in open conditions at a spacing of (15×10 cms and 15×7.50) used as treatments. Recommended dose of fertilizers were applied at the rates of 100: 60 and 60 kg per hectare in the form of urea, diammonium phosphate and muriate of potash, respectively along with 20 tonnes of FYM. Before final land preparation, 50% of nitrogen and entire quantity of phosphorus and potash were applied as basal dos Recommended package of practices were followed as per schedule of Skuast-Kashmir, Sgr.

The plant protection measures were taken up to control pest and diseases as and when required along with intercultural operations. In each plot 10 plants were tagged for taking all observations. plant height, was recorded at final pickings in cms. Harvesting of garlic cloves was done at 50-70% neck fall stage. Plant height was taken with the help of measuring scale during full vegetative stage. Clove parameters were taken after harvesting of cloves. Number of cloves per bulb, average clove weight, average bulb weight were taken in grams on average basis. polar dia, equatorial dia and neck thickness were taken with the help of vernier caliper in centimetres. Bulb yield was taken on plot basis and then converted into quintals per hectare.

Chemical analysis was done using the standard procedures. T.S.S^0 Brix was recorded with Digital Refractometers, Ascorbic acid (mg100g^{-1}) content of clove from each treatment was determined by 2,6 dichlorophenol indophenols visual titration method suggested by A.O.A.C (1975) and expressed in milligram per 100 g of fresh weight for all the treatment combinations in all replications. The protein content was calculated by multiplying a factor 6.25 (protein factor) with total nitrogen content in cloves. Total nitrogen content in bulbs was determined by Kjeldahls method as outlined by Tandon (1993) [13]. Data recorded were tabulated pooled and statistically analysed as per Gomez and Gomez, 1984 Significant difference between treatment means was tested through 'F' test and critical difference (CD) was worked out wherever 'F' value was found to be significant for treatment effect.

Research findings and Discussion

Sole effect of date of sowing on growth, yield, Yield related attributes and quality of garlic

As per tables –(1, 2 and 3) pooled data revealed that sole effect of date of sowing showed that treatment D_3 (15th Nov) maximum values of plant height, (87.60 cm),no. of cloves bulb^{-1}(9.78), average clove weight (9.77gms),average bulb weight (38.83gms),equatorial diameter (4.94 cm), polar diameter (3.76 cm) but recording minimum values of neck thickness (0.67 cm) which was significantly superior to rest of other treatment but at par with treatment D_2 in case of plant height, average bulb weight, equatorial diameter polar diameter and neck thickness where as, average clove no, average clove weight, bulb yield (226.56 qha^{-1}) was found significantly superior with respect to all treatments. From table (3) it was found that maximum values of T.S.S Brix^0 (36.25), Vitamin C content (12.89 mg 100 g^{-1}) and protein content (6.41%) were and was significantly maximum to all other treatments in case of protein content only but at par with D_1(15th oct) and D_2 in case of T.S.S (Brix)^0 and with D_2 in case of Vitamin C content (mg 100^{-1}g).

Sole effect of spacing revealed that maximum values of plant height (79.60 cm),no. of cloves per bulb (7.32 cm),average clove weight (8.55 gms),average bulb weight (37.51 gms),Equatorial dia (4.73 cm,),polar dia (3.61 cm),neck thickness (0.64 cm),bulb yield (223.45 q ha^{-1}), T.S.S Brix^0 (36.42),Vitamin C content (12.28 mg100^{-1}g) and protein content (6.32%) but were at par with S_2 (15×7.5 cm) treatment in respect of all parameters except bulb yield which was significantly maximum (table 4, 5 and 6).

The higher values of growth, yield and quality parameters could be due to higher assimilatory rates and enhanced source sink relationship at optimum time of sowing due to suitable climatic conditions for growth and development at D_3 (15th Nov) followed by D_2 (30th Oct) and lesser values at other time of sowings. Our results are in line with M.A. Islam *et al*., 2008 in garlic G. Vidya *et al.*,2013 [5] in garlic and Adekpe, D.I., *et al.* 2008 [2] in garlic. The highest value of all parameters at spacing S_1 (15× 10 cm) can be attributed to compensatory effect of number of plants per unit area as

compared to 15×7.5 cm. The difference between the highest and the lowest population could be due to higher net assimilate obtained at optimum population density per unit area. Increased spacing could have lead to more competition for nutrients, water and light and therefore leading to slight reduction of growth, yield and quality parameters . 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 These results are in accordance with the findings of Nagina Muneer *et al.*, 2017 [10] and Asaduzzaman *et al.*, (2012) [4] in garlic.

Interaction effect of date of sowing and spacing on growth, yield, yield related attributes and quality of garlic

From tables 7 to 8 pooled analysis of two years (rabi-2018 and rabi-2019) interaction effect of sowing and spacing has revealed that maximum values of plant height, (91.68 cm),no. of cloves bulb^{-1}(9.61),average clove weight (9.77gms), average bulb weight (38.16 gms), equatorial diameter (5.04 cm), polar diameter(4.10 cm),bulb yield (230.05 q ha^{-1}) but minimum values of neck thickness (0.56 cm), were recorded with treatment T_3 (D_3 S_1) followed T_2(D_2S_1) treatment and the values were significantly superior with respect to all treatments for plant height but at par to treatments T_1& T_2 for clove no., clove weight (gms), T_2 for Bulb yield (qha^{-1}),T_2,T_4 and T_5 for bulb weight (gms), T_1, T_2 and T_5 for Equatorial diameter (cm), T_2, T_4 and T_7 for polar diameter (cm) and lower but at par with T_2, T_4, T_6, T_7 and T_8 for neck thickness (cm).

Further from (table 9) pooled data of two years revealed that that maximum values of T.S.S Brix^0 (37.72), Vitamin C content (12.85 mg 100 g^{-1}) and protein content (6.44%) were recorded with treatment T_3 (D_3S_1) followed T_2(D_2S_1) treatment and the values were significantly higher as compared to all treatment for protein content (%) but at par to T_1 T_2 and T_4 for T.S.S. (Brix)^0 and T_2, T_4, T_5 T_6, T_7 and T_8 for Vitamin C content 100 mg 100g^{-1}) (table 9).The interaction effect of date of planting was also showing positive interaction in case of various plant growth, yield and quality parameters. The interaction between dates of planting and plant spacing significantly influenced the growth. Yield and quality parameters of garlic. The results are in accordance with Kilgori *et al*., 2007 [8], Adekpe, *et al*., 2008 [2], and G. Vidya *et al.*, 2013 [5] in garlic.

Table 1: Sole effect of date of sowing on growth and yield attributes of garlic

Treatment details	Plant Height (cm)	No. of cloves/bulb	Avg. Clove Wt.(gms)	Avg. Bulb wt.(gms)
D_1 (15th oct)	70.34	7.12	7.37	35.42
D_2 (30th oct)	86.63	7.23	8.21	37.18
D_3 (15th Nov)	87.60	9.78	9.77	38.83
D_4 (30th Nov)	71.86	7.15	8.08	36.22
C.D≤5%	4.11	1.56	0.94	2.04

Table 2: Sole effect of date of sowing on yield and yield related attributes of garlic

Treatment details	Equatorial dia (cm)	Polar dia (cm)	Neck thick ness (cm)	Bulb yield (qha^{-1})
D_1 (15th oct)	4.43	3.31	0.75	216.39
D_2 (30th oct)	4.73	3.45	0.71	222.27
D_3 (15th Nov)	4.94	3.76	0.67	226.56
D_4 (30th Nov)	4.04	3.10	0.77	215.80
C.D≤5%	0.39	0.37	0.07	3.71

Table 3: Sole effect of date of sowing on quality attributes of garlic

Treatment details	T.S.S (Brix^0)	Protein content %	Vitamin C mg/100 g
D_1 (15th oct)	35.51	6.27	11.64
D_2 (30th oct)	35.41	6.29	12.36
D_3 (15th Nov)	36.75	6.41	12.89
D_4 (30th Nov)	33.30	6.28	11.42
C.D≤5%	1.70	0.04	0.87

Table 4: Sole effect of spacing on growth and yield attributes of garlic

Treatment details	Plant Height (cm)	No. of cloves/bulb	Avg. Clove Wt.(gms)	Avg. Bulb wt.(gms)
S_1 (15×10 cm)	**79.60**	**7.32**	**8.55**	**37.51**
S_2 (15× 7.5 cm)	78.62	7.15	8.16	36.51
C.D≤5%	2.91	1.52	0.66	1.44

Table 5: Sole effect of spacing on yield and yield related attributes of garlic

Treatment details	Equatorial dia (cm)	Polar dia (cm)	Neck thick ness (cm)	Bulb yield (qha^{-1})
S_1 (15×10 cm)	4.73	3.61	0.64	223.45
S_2 (15× 7.5 cm)	4.60	3.54	0.66	217.05
C.D≤5%	0.27	0.26	0.06	3.71

Table 6: Sole effect of spacing on quality attributes of garlic

Treatment details	T.S.S (Brix^0)	Protein content	Vitamin C mg/100 g
S_1 (15×10 cm)	**36.42**	**6.32**	**12.28**
S_2 (15× 7.5 cm)	35.52	6.30	11.89
C.D≤5%	1.20	0.03	0.93

Table 7: Interaction effect of date of sowing and spacing on growth and yield attributes of garlic

Treatment details	Plant Height cms	No. of cloves/bulb	Average clove weight (gms)	Average bulb Weight (gms)
$T_1 = D_1S_1$	68.48	8.84	8.84	32.10
$T_2 = D_2S_1$	85.97	9.40	8.91	36.40
$T_3 = D_3S_1$	91.68	9.61	9.77	38.16
$T_4 = D_4S_1$	75.27	7.01	6.68	34.45
$T_5 = D_1S_2$	68.97	7.14	7.65	35.73
$T_6 = D_2S_2$	72.65	6.89	6.97	34.38
$T_7 = D_3S_2$	87.15	7.34	7.57	32.11
$T_8 = D_4S_2$	90.06	6.64	7.83	33.65
C.D≤0.5	5.65	1.73	1.55	3.76

Table 9: Interaction effect of date of sowing and spacing on yield & yield related parameters of garlic

	Equatorial Diameter (cm)	Polar Diameter (cm)	Neck thickness (cms)	Bulb Yield (qtls ha^{-1})
$T_1 = D_1S_1$	4.67	3.27	0.70	214.83
$T_2 = D_2S_1$	4.81	4.02	0.60	226.12
$T_3 = D_3S_1$	5.04	4.10	0.56	230.05
$T_4 = D_4S_1$	4.08	3.71	0.63	217.95
$T_5 = D_1S_2$	4.57	3.23	0.73	211.89
$T_6 = D_2S_2$	4.29	3.24	0.57	219.71
$T_7 = D_3S_2$	4.30	3.80	0.65	218.42
$T_8 = D_4S_2$	4.37	3.53	0.65	223.07
C.D≤0.5	0.55	0.46	0.13	5.24

Table 8: Interaction effect of dates of sowing and spacing on quality parameters of garlic

Treatment details	T.S.S (Brix^0)	Vitamin C (mg/100 g)	Protein content (%)
$T_1 = D_1S_1$	36.84	11.34	6.28
$T_2 = D_2S_1$	37.56	12.22	6.37
$T_3 = D_3S_1$	37.72	12.85	6.44
$T_4 = D_4S_1$	34.79	12.15	6.30
$T_5 = D_1S_2$	33.07	12.07	6.29
$T_6 = D_2S_2$	32.42	11.55	6.29
$T_7 = D_3S_2$	33.79	12.09	6.27
$T_8 = D_4S_2$	32.78	11.83	6.28
C.D≤0.5	3.17	1.32	0.06

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