Research Article

# Evaluation of Long Day Garlic (*Allium sativum* L.) Ecotypes For Growth, Yield and Quality Performance

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**Abstract**

Twenty four diverse genotypes of long day garlic were evaluated which exhibited significant differences for growth, yield and quality parameters viz., plant height, number of leaf, leaf length, polar and equatorial diameter of bulbs, average bulb weight, number of clove/bulb, total soluble solids and total bulb yield per plot. Among the lines, highest yielding genotype i.e. G-408 AP recorded maximum bulb yield (3.55 Kg/plot and 157.93 q/ha). The genotypes G-408 AP, CITH-G-10 and VLG-2 recorded bulb weight of 44.40 g, 42.60 g and 36.40 g, respectively. Maximum TSS of 42.50 $^0$brix was recorded in genotype UHF-G-12-2 followed by Selection 10-3 (41.50$^0$ brix) and G-417 (40.70 $^0$brix). Presence of wide range of variation of mean and coefficient of variations depicted the chance of improvement in the present genotypes through clonal selection and later on could be stabilized and utilized as new varieties for the region. The line G-408 A.P. has potential of highest bulb yield under long day condition of Kumaon hills of Uttarakhand. The genotypes under study showed sufficient genotypic variability, heritability and genetic advance for most of the traits especially economic trait i.e. bulb yield. Apart from it, the significant and positive correlation coefficients were also exists between the traits under study. Hence, there is chance of improvement in the genotypes through clonal selection and better variability in various traits could be developed through clonal selection for further improvement of the crop/genotype.

**Keywords:** Characters, Bulb yield, Garlic, Genotype, Quality

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## Introduction

Garlic (*Allium sativum* L.) is an important spice and condiment crop grown throughout the country as well as world. It is one of the most important bulb vegetable crop which have been used since ancient for its culinary, medicinal and health benefits [1]. It is the second most important cultivated bulb crop after onion grown in 0.30 million hectare area which produced 1.72 million tonne bulbs with the average productivity 5.73 tonne/ha [2]. In Asia, people use fresh leaves of garlic as salad, and pickle is also prepared from garlic cloves [3]. It has higher nutritive value than other bulb crops [4] and also good export potential as fresh bulb as well as in the dehydrated form [5]. Besides, garlic has several medicinal values such as antibacterial, antifungal, antiviral, antiprotozol, anti oxidant and anticancer properties [6]. Large quantities of this crop are exported to earn foreign exchange and it is also used in pharmaceuticals industries because of its great medicinal values. The lack of sexuality in garlic limits the increase of variability that is useful for breeding for economically important traits, such as tolerance to biotic and abiotic stress, earliness, yield and quality [7].

A large number of ecotypes have been established over time in various areas of cultivation. Considerable morphological and biochemical variations between and within ecotypes are been established [8]. To meet the domestic requirement and fulfill the export demand, selection of suitable variety for growing under different agronomic condition is necessary. Due to vegetative propagated crop, variation in garlic occurs only through random or induced mutation and/or somaclonal variation and new cultivars are bred by clonal selection, induced mutations, somaclonal variation or genetic engineering. In mid and high hills of Uttarakhand, Himachal Pradesh, Jammu and Kashmir etc., the long day type strains are to be developed/selected for getting high yield and quality.

Very scanty work has been done on the evaluation, selection and development of long day type garlic varieties/strains. Hence, with a view to develop/select good quality high yielding long day type garlic varieties/lines for growing under mid and high hills, different lines of various parts of the country received under All India Network Research Project (Onion and Garlic) were evaluated for their growth, yield and quality parameters at ICAR- Central Institute of temperate Horticulture Regional Station- Mukteshwar, Nainital (Uttarakhand) during rabi extended summer 2016-17.

## Materials and Methods

Twenty four diverse genotypes of long day garlic lines received under All India Network Research Project (Onion and Garlic) were planted in RBD with two replications at ICAR- Central Institute of Temperate Horticulture Regional Station Mukteshwar, Nainital (Uttarakhand) during last week of September 2016. Planting of cloves was done at a spacing of 20 cm x 10 cm. The recommended agro-practices were followed to ensure a healthy crop growth and development. The observations were recorded for growth and yield attributes on randomly selected 10 plants in each replication for all the characters viz., plant height (cm), leaf length (cm), number of leaves/plant, number of cloves/bulb, clove weight (g), bulb weight (g), total soluble solids ($^0$brix), and total yield per plot and per hectare. The data was statistically analyzed for variance and test the significance of variance using the standard procedure by [9].

## Results and Discussion

The analysis of variance showed significant differences among the genotypes for all traits under study in different trials, thereby indicating a large amount of genetic variability existing in the material and all the genotypes differ from one another with respect to these traits (**Tables 1-3**). The range of variation was enough for all the characters studied (Tables 1-3), indicating maximum variability present in these traits which showed a greater scope for selection among the existing genotypes.

**Table 1** Growth and yield performance of long day garlic genotypes

| No. | Geno types | PH (cm) | LL (cm) | LW (cm) | NOL | PL | PD (mm) | ED (mm) | CPD | CED | AWB (g m) | AWC (gm) | NOC/ Bulb | Day to 50 % neck fall | TY (kg /plot) | TY (q/ha) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | G-304 | 56.34 | 27.64 | 1.16 | 9.50 | 1.05 | 31.10 | 41.03 | 24.57 | 12.45 | 24.00 | 2.40 | 13.10 | 211.50 | 1.94 | 86.34 |
| 2 | G-384 (C) | 57.69 | 24.66 | 1.42 | 9.70 | 1.38 | 28.94 | 35.99 | 26.13 | 11.68 | 20.80 | 2.40 | 13.60 | 208.50 | 2.29 | 101.98 |
| 3 | JG-12-02 | 57.08 | 23.91 | 1.50 | 8.80 | 1.29 | 36.05 | 36.17 | 33.10 | 12.22 | 27.40 | 3.20 | 17.10 | 209.00 | 1.47 | 65.32 |
| 4 | DG-08-12 | 47.25 | 25.85 | 1.32 | 8.70 | 1.34 | 32.68 | 35.42 | 26.11 | 14.16 | 22.00 | 2.80 | 9.40 | 211.50 | 1.32 | 58.74 |
| 5 | Bhima Purple | 46.28 | 23.04 | 1.52 | 9.09 | 1.25 | 33.55 | 32.96 | 28.60 | 14.14 | 18.60 | 2.60 | 10.80 | 210.50 | 1.97 | 87.81 |
| 6 | Bhima Omkar | 37.45 | 22.46 | 1.15 | 9.30 | 1.20 | 32.11 | 31.38 | 30.02 | 14.57 | 15.40 | 2.60 | 10.50 | 212.00 | 1.63 | 72.79 |
| 7 | G-363 | 56.11 | 26.33 | 1.31 | 9.20 | 1.31 | 32.66 | 35.48 | 27.09 | 13.65 | 23.40 | 2.80 | 14.50 | 214.00 | 1.98 | 88.03 |
| 8 | G-408 A.P | 55.81 | 31.83 | 2.20 | 12.30 | 1.42 | 31.41 | 49.38 | 29.30 | 23.34 | 44.40 | 5.40 | 14.20 | 211.00 | 3.55 | 157.93 |
| 9 | CITH- G-10 | 52.17 | 31.66 | 2.64 | 12.00 | 1.42 | 34.86 | 55.70 | 28.85 | 16.33 | 42.60 | 4.00 | 14.10 | 213.00 | 3.42 | 152.34 |
| 10 | UHF G12-2 | 56.96 | 28.87 | 1.52 | 10.00 | 1.49 | 36.87 | 36.12 | 33.35 | 13.66 | 22.80 | 4.00 | 10.60 | 208.50 | 2.22 | 98.87 |
| 11 | VLG-2 | 51.41 | 28.65 | 2.05 | 11.60 | 1.42 | 30.54 | 45.57 | 27.05 | 17.46 | 36.40 | 4.80 | 13.60 | 214.50 | 2.35 | 104.65 |
| 12 | Local check | 45.55 | 32.17 | 2.00 | 12.50 | 1.15 | 29.85 | 42.38 | 25.19 | 15.09 | 30.00 | 4.60 | 13.10 | 213.50 | 2.36 | 105.23 |
| 13 | G-404 | 40.21 | 21.45 | 1.31 | 10.80 | 1.28 | 30.53 | 31.93 | 23.73 | 10.91 | 11.80 | 1.80 | 13.37 | 210.00 | 1.02 | 45.59 |
| 14 | G-417 | 40.72 | 24.67 | 1.22 | 11.00 | 1.19 | 32.18 | 31.78 | 27.89 | 12.62 | 17.72 | 2.40 | 10.80 | 210.50 | 1.56 | 69.72 |
| 15 | G-384 | 43.95 | 23.05 | 1.47 | 10.40 | 1.45 | 28.46 | 36.14 | 21.50 | 11.82 | 15.60 | 1.80 | 10.10 | 209.00 | 1.12 | 49.81 |
| 16 | G-408 A.P | 47.83 | 28.03 | 1.97 | 12.00 | 1.31 | 30.30 | 43.74 | 26.48 | 16.02 | 30.80 | 4.40 | 13.00 | 211.00 | 2.45 | 109.14 |
| 17 | JG-11-07 | 40.22 | 19.11 | 0.80 | 9.90 | 1.01 | 23.11 | 25.87 | 19.11 | 8.88 | 7.19 | 1.00 | 13.10 | 212.50 | 0.446 | 21.42 |
| 18 | DG-08-14 | 33.31 | 18.47 | 0.92 | 9.30 | 1.35 | 28.12 | 25.03 | 22.10 | 14.63 | 7.19 | 2.20 | 5.40 | 201.50 | 0.675 | 30.04 |
| 19 | PG-42 | 47.99 | 22.72 | 1.29 | 9.40 | 1.32 | 26.19 | 33.46 | 21.75 | 10.86 | 16.00 | 1.80 | 17.20 | 213.00 | 1.26 | 56.08 |
| 20 | CITH-G-13 | 52.50 | 35.18 | 2.61 | 12.10 | 1.68 | 32.44 | 37.31 | 26.50 | 16.24 | 22.80 | 3.80 | 10.80 | 213.00 | 2.16 | 96.07 |
| 21 | VLG-1 | 46.82 | 23.92 | 1.38 | 10.30 | 1.43 | 26.60 | 33.60 | 23.45 | 9.55 | 17.80 | 1.80 | 18.40 | 212.50 | 1.63 | 72.70 |
| 22 | Selection 10-3 | 43.47 | 23.29 | 1.00 | 11.00 | 113 | 28.19 | 28.16 | 22.08 | 12.14 | 12.00 | 1.60 | 10.60 | 212.50 | 1.04 | 46.30 |
| 23 | Bhima Purple | 38.32 | 24.07 | 1.38 | 10.00 | 1.21 | 30.23 | 30.88 | 23.70 | 11.57 | 14.40 | 2.20 | 11.30 | 214.00 | 1.31 | 58.30 |
| 24 | Local check | 39.22 | 28.20 | 2.39 | 11.50 | 1.10 | 28.28 | 40.40 | 29.40 | 14.08 | 24.20 | 4.40 | 13.80 | 213.00 | 2.10 | 93.72 |
| Mean | | 47.27 | 25.79 | 1.56 | 10.43 | 1.29 | 30.63 | 36.49 | 26.14 | 13.65 | 21.88 | 2.95 | 12.61 | 211.25 | 1.80 | 80.37 |
| CD 5% | | 6.48 | 3.61 | 0.263 | 0.78 | 0.256 | 2.68 | 4.43 | 3.17 | 2.51 | 2.21 | 0.853 | 2.95 | 2.86 | 0.70 | 6.62 |
| CV | | 8.34 | 8.53 | 10.23 | 4.58 | 12.01 | 5.34 | 7.39 | 7.39 | 11.20 | 6.16 | 17.59 | 14.27 | 0.826 | 23.71 | 5.01 |

PH-Plant height, LL-Leaf length, LW- Leaf width, NOL-No. of leaves, PL-First leave & clove distance, PD- Polar diameter, ED-Equatorial diameter, CPD-Central polar diameter, CED- Central equatorial diameter, AWB- Av. Weight of bulb, AWC-Av. Weight of clove, NOC/Bulb- No. of cloves/bulb,TY-Total yield

Most of lines exhibited significant differences for various growth, yield and quality parameters under study. Among the lines, G-408 AP was recorded maximum bulb yield of 3.55 Kg/plot and 157.93 q/ha. Maximum plant height of 57.69 cm was recorded in genotype GN-15-55 followed by 57.08 cm in JG-12-02 and 56.96 cm in UHF G 12-2. However, maximum number of leaves per plant was recorded in Local check (12.50) followed by in G-408 AP

(12.30) and in CITH-G-03 (10.00). Three top ranking genotypes for average bulb weight were G-408 AP, CITH-G-10 and VLG-2 with 44.40g, 42.60 g and 36.40 g, respectively. While in case of average clove weight, the genotype G-408 A.P. recorded maximum clove weight of 5.40g followed by 4.80g and 4.60g in VLG-2 and Local check, respectively. The genotype VLG-1 recorded maximum number of cloves per bulb (18.40) followed by PG-42 (17.20) and JG-12-02 (17.10).

**Table 2** Grading percentage, Storage loss after 2 month, days to 50 % neck fall and TSS of long day garlic genotypes

| S. No. | Genotypes | Bulb grading % | | | %TL2 MAS | TSS$^0$ brix |
|---|---|---|---|---|---|---|
| | | % A | % B | % C | | |
| 1. | G-304 | 46.29 | 42.36 | 11.34 | 16.00 | 35.95 |
| 2. | G-384 | 40.33 | 47.16 | 12.50 | 10.90 | 35.85 |
| 3. | JG-12-02 | 36.06 | 53.08 | 10.85 | 24.40 | 38.00 |
| 4. | DG-08-12 | 54.32 | 34.20 | 11.47 | 12.80 | 40.20 |
| 5. | Bhima Purple | 56.67 | 34.76 | 8.56 | 15.10 | 39.25 |
| 6. | Bhima Omkar | 52.24 | 39.33 | 8.22 | 16.50 | 39.70 |
| 7. | G-363 | 47.61 | 46.14 | 6.23 | 21.80 | 36.75 |
| 8. | G-408 A.P | 79.35 | 17.68 | 2.96 | 36.50 | 35.20 |
| 9. | CITH- G-10 | 76.72 | 14.84 | 8.43 | 34.40 | 38.20 |
| 10. | UHF G12-2 | 65.25 | 28.23 | 6.51 | 10.20 | 42.50 |
| 11. | VLG-2 | 66.67 | 26.84 | 6.48 | 17.40 | 35.65 |
| 12. | Local check | 61.10 | 26.28 | 12.61 | 22.60 | 34.25 |
| 13. | G-404 | 36.95 | 60.92 | 2.11 | 6.00 | 40.15 |
| 14. | G-417 | 51.52 | 47.32 | 1.15 | 16.30 | 40.70 |
| 15. | G-384 | 45.30 | 52.61 | 2.07 | 5.80 | 39.70 |
| 16. | G-408 A.P | 73.47 | 20.99 | 5.53 | 25.20 | 37.15 |
| 17. | JG-11-07 | 18.22 | 54.20 | 27.57 | 6.30 | 37.70 |
| 18. | DG-08-14 | 19.36 | 48.26 | 32.37 | 4.70 | 32.00 |
| 19. | PG-42 | 35.41 | 55.92 | 8.65 | 12.20 | 38.15 |
| 20. | CITH-G-13 | 62.50 | 29.43 | 8.06 | 7.60 | 39.20 |
| 21. | VLG-1 | 63.82 | 30.37 | 5.80 | 12.86 | 38.65 |
| 22. | Selection 10-3 | 36.91 | 40.79 | 22.28 | 3.60 | 41.50 |
| 23. | Bhima Purple | 54.30 | 41.92 | 3.76 | 10.80 | 39.60 |
| 24. | Local check | 71.76 | 24.79 | 3.44 | 27.50 | 34.55 |
| Mean | | 52.17 | 38.27 | 9.54 | 15.72 | 37.93 |
| CD 5% | | 13.19 | 13.19 | 1.98 | 4.66 | 4.28 |
| CV | | 15.38 | 20.96 | 12.65 | 18.04 | 6.87 |

%TL2MAS- % weight loss after 2 month of storage, TSS- Total soluble solids

The maximum A grade bulbs were recorded in G-408 AP (C) (79.35%). Likewise maximum B and C grade bulb were formed in PG-42 (55.92 %) and DG-08-14 (32.37 %), respectively. However, minimum B (14.84%) and C (1.15 %) grade bulbs were found in CITH-G-10 and G-417, respectively. Maximum TSS of 42.50 $^0$brix was recorded in genotype UHF-G-12-2 followed by Selection 10-3 (41.50$^0$ brix). After the harvesting of bulb, the weight loss during storage was recorded in all the genotypes. The weight loss percentage during two months of storage was recorded maximum (36.50 %) in G-408 AP, while minimum storage loss of 3.60 % was recorded in Selection-10-3

The estimates of phenotypic co-efficient of variation (PCV) were slightly higher than the genotypic co-efficient of variation (GCV) for all the characters, indicating that the influence of environment factors in expression of the traits values/performance is less and genetic constitution have major role in expression of the traits value/performance. The maximum GCV (373.62) and PCV value (374.52) were recorded in total bulb yield (q/ha) and minimum GCV (17.45) and PCV value (18.77) observed in days to 50% neck fall. High GCV and PCV were observed for Number of cloves per bulb, diameter of clove, weight of clove, neck thickness of bulb, width of leaf and length of clove [10]. Heritability, genetic advance and genotypic coefficient of variation together could provide the best image of the amount of advance to be expected from selection. It also described that genetic factors were predominantly responsible for expression of these attributes and selection could be made effectively on the basis of phenotypic performance. The findings of [11]. In the present study total bulb yield (q/ha), percent A and B grade bulbs exhibited high estimated for heritability, genetic advance and genotypic coefficient of variation as well, thus these traits could be improved through clonal selection it supposed that as these are governing by additive genes. The heritability (99

%) recorded for average weight of bulb, total yield q/ha and percentage C grade bulb. The highest genetic advance (69.00) recorded in total bulb yield (q/ha). Genetic advance as percentage of mean value (167.41) was observed highest for % C grade bulbs followed by (117.02) for % TL2MAS.

**Table 3** GCV, PCV, heritability, genetic advance and genetic advance as percentage of mean long day garlic genotypes

| Characters | GCV | PCV | $H^2$ | GA | GA as % of mean |
|---|---|---|---|---|---|
| Plant height | 100.13 | 105.47 | 0.90 | 14.18 | 30.00 |
| Leaf length | 78.49 | 82.38 | 0.90 | 8.21 | 31.84 |
| Leaf width | 33.58 | 40.92 | 0.67 | 0.86 | 55.39 |
| Number of leaves/plant | 36.29 | 37.28 | 0.94 | 2.41 | 23.15 |
| PL (First leave & clove distance) | 34.84 | 42.92 | 0.65 | 0.81 | 63.20 |
| Polar diameter | 54.58 | 57.18 | 0.91 | 6.22 | 20.31 |
| Equatorial diameter | 116.48 | 119.29 | 0.95 | 14.49 | 39.72 |
| Central polar diameter | 67.05 | 70.51 | 0.90 | 7.06 | 27.01 |
| Central equatorial diameter | 77.53 | 81.13 | 0.91 | 5.90 | 43.23 |
| AWB | 207.74 | 208.40 | 0.99 | 20.01 | 91.49 |
| AWC | 66.98 | 69.21 | 0.93 | 2.37 | 80.34 |
| NOL/bulb | 78.63 | 83.90 | 0.87 | 5.75 | 45.61 |
| Days to 50% neck fall | 17.45 | 18.77 | 0.86 | 5.22 | 2.44 |
| Total bulb Yield (Kg/plot) | 53.35 | 56.43 | 0.89 | 1.47 | 81.91 |
| Total bulb Yield (q/ha) | 373.62 | 374.52 | 0.99 | 69.00 | 85.85 |
| %A grade bulb | 221.63 | 230.74 | 0.92 | 32.97 | 63.21 |
| %B grade bulb | 195.62 | 209.47 | 0.87 | 24.92 | 65.14 |
| %C grade bulb | 251.02 | 252.02 | 0.99 | 15.97 | 167.41 |
| %Total weight loss 2 month after storage | 225.24 | 229.00 | 0.96 | 18.31 | 117.02 |
| TSS | 33.05 | 41.11 | 0.64 | 4.19 | 11.05 |

GCV- Genetic coefficient of variation, PCV- Phenotypic coefficient of variation, H2- Heritability, GA-Genetic advance, GA as % of mean- Genetic advance as % of mean

The correlation coefficient of different characters found significant to each other. The total yield (q/ha) had significantly and positively associated with plant height, polar diameter, equatorial diameter, average weight of bulb, average weight of clove, number of leaves per plant, days to 50% neck fall and total yield (Kg/plot). Such positive interrelationships between bulb yield and plant height, number of leaves per plant, bulb polar diameter and bulb weight was noted by [12]. Number of leaves per plant had positive association with bulb weight, number of cloves per bulb and clove length. It is similar to the results obtained by [13]. The traits under study exhibited positive and significant interrelationship with each other indicating that the improvement taken in one trait will take care of improvement in another trait (s) too.

## Conclusion

The present study shows that G-408 AP recorded maximum yield (3.55 Kg/plot and 157.93 q/ha) followed by CITH-G-10 (3.42 Kg/plot and 152.34 q/ha). Average bulb weight was recorded maximum (44.40 g) in genotype G-408 AP. Maximum Total Soluble Solids content (42.50 $^0$brix) was recorded in genotype UHF-G-12-2. The genotype G-408 AP has potential of highest bulb yield under long day garlic in Kumaon hills of Uttarakhand. Sufficient coefficient of variations as well as range of variations were found in the genotypes for various growth, yield and quality attributes which is indicative of chance of improvement in the genotypes for various trials under study applying clonal selection procedure. However, the top ranking genotypes could be stabilized and popularized after multi location testing for their growth, yield and quality parameters. Further, there is sufficient variability, heritability, genetic advance, correlation coefficients, etc. for stabilizing the genotypes, deciding and applying appropriate breeding/selection procedure for further improvement and development of new/ improved ecotype for the region.

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