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Polygenic variations and character association of morphological, biochemical and disease related traits in garlic (*Allium sativum* L.)

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Abstract
A field investigation was carried out at Bihar Agricultural University Sabour, Bhagalpur, Bihar, India during *Rabi* season 2016-17. The study comprised 38 garlic genotypes. These were evaluated to assess the mean performance and to find out inter relationship between field performance of genotype and storage loss of garlic. Results revealed that the mean squares due to genotypes were highly significant for all the traits. The maximum plant height (49.04 cm) was recorded in genotype BRG-13 and lowest was recorded (34.49 cm) in RG-463. The maximum number of leaves per plant was observed in WG-73 (9.22) and minimum in BRG-3 (6.57). The bulb yield per plant was maximum in line BRG-13(34.65 g) and minimum in G-1 (20.63g). Disease severity (%) was found least in the genotype IC-290440 (4.26%) and maximum (40.36%) in genotypes 507 (40.36%).The least percent disease index of stemphylium blight was recorded in genotype BRG-13(10.55%) while the highest percent disease index of stemphylium blight was found in BRG-3 (48.71%). least *Botrytis porri* infestation percentage was obtained in genotype WG-7(4.25%). However, the highest percentage was recorded in genotype RG-464 (22.19%). least black mould infestation percentage was recorded in 650 (2.56%). However, the maximum infestation percentage (9.25%) was obtained in genotype WG-48. Genotype BRG-13 exhibited maximum total phenol content (1.86 µg gallic acid/g) in leaves. However, the lowest amount of was noticed in BRG-3 (0.30 µg gallic acid/g) genotype. Maximum total phenol content in cloves was recorded in genotype BRG-13 (0.65 µg gallic acid/g) and the lowest amount of was observed in BRG-3(0.11 µg gallic acid/g).Maximum total soluble solid content was found in genotype 650 (39.37º Brix) followed by 4 (37.93º Brix) followed by IC-290440 (37.91ºBrix), whereas, minimum amount of total soluble solid was observed in WG-39 (26.49ºBrix).
Wide variability was present among morphological, biochemical and disease parameters under study suggesting ample scope of selection. The higher magnitude of phenotypic coefficient of variations (PCV) than genotypic coefficient of variations (GCV) for all the traits indicated environmental factor influencing their expression and high magnitude of PCV and GCV for all the characters under study pointed toward ample scope for improvement of these traits through selection. Genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV) was high in total soluble solid. High heritability was observed for total phenol content in leaves(98.31), total phenol content in cloves (99.64), total soluble solid (84.04), PDI % (84.59), D S % (97.77), *Botrytis porri* % (99.00), Black mould % (99.22), yield per plant (83.26), suggesting that selection for these traits would be effective.

Keywords: Phenotypic coefficient of variation, genotypic coefficient of variation, disease severity, percent disease index, heritability, genetic advance, garlic

Introduction
Garlic (*Allium sativum* L.) is a monocotyledonous underground vegetable, probably derived from *Allium longicuspis*, that has its origin in Central Asia (Kazakhstan). It belongs to the family Amaryllidaceae, having chromosome number 2n = 2*x* = 16. Garlic is a diploid species (2n = 2x = 16) of obligated apomixes therefore its reproduction is vegetative (McCollum, 1987; Figliuolo *et al.***,** 2001; Ipek *et al.*, 2003 and 2005) [15, 5, 11]. Although some garlic plants found in the Campania region of Italy were shown to be tetraploid (4n = 32), although some cultivars might be triploid.
It is grown throughout the world and used as spices and flavouring agent for many foods (Velisek *et al.*, 1997) [34]. The area under garlic cultivation in India is 280.95 thousands hectares producing 1617.34 thousands metric tons with an average national productivity of 5.76 tonnes/ha. In Bihar the area, production and productivity are 4.25 thousands ha, 4.00 thousands metric tonnes and 0.94 t/ha respectively (DOGR, 2015-16). It can be grown in almost all parts of India except higher altitudes. The major garlic producing states are Madhya Pradesh, Gujarat, Maharashtra, Karnataka, Rajasthan and Uttar Pradesh. More than 50%

production, however, comes from Madhya Pradesh and Gujarat only. Garlic enjoys almost universal cultivation for its valuable bulb.

Garlic is grown a under wide range of climatic condition. It, however cannot with stand too hot or too cold temperature. It requires cool and moist period during growth and relatively dry period during maturity of bulb. Bulb development takes place during longer days and at higher temperature. In general, cool growing period gives more yield than warm.

According to the traditional Indian medication - Ayurveda, garlic is used in treatment for diseases like running cold, saliva formation, asthma, influenza, diarrhoea, etc. More recently, it has been found from a clinical trial that a mouthwash containing 2.5% fresh garlic shows good antimicrobial activity, although the majority of the participants reported an unpleasant taste and halitosis (Groppo *et al.*2007) [8]. Garlic cloves are used as a remedy for infections (especially chest problems), digestive disorders, and fungal infections such as thrush. Garlic can be used as a disinfectant because of its bacteriostatic and bactericidal properties (Lemar *et al*. 2005) [13]. It is a rich source of protein, phosphorus, calcium, magnesium, potash and ascorbic acid. In one fresh peeled garlic cloves having 62.8% moisture, 6.3% protein, 0.1% fat, 0.8% fibre, 29.0% carbohydrates, 0.03% calcium, 0.31% phosphorus etc. (Srivastava and Singh 1977) [29].

Garlic is affected by many diseases caused by fungi, bacteria, nematode and viruses but Purple blotch and Stemphylium blight are two major serious diseases affecting the productivity adversely. Stemphylium blight has been reported to be caused by fungus *Stemphylium vesicarium* (Wall). It is a foliar disease of garlic and it was reported in Kullu, Himanchal Pradesh during 1973. The pathogen survives in infected plant debris. A foliar infection up to 90% has been reported in susceptible cultivar of garlic (Bisht and Agrwal, 1993) [3]. Leaves being the only photosynthetic organ directly affect the bulb yield. Significant reduction in bulb yield (25-60%) has been observed. Severe outbreak of leaf blight of garlic was reported from Bihar during 1995 on varieties Vanarshi and P-49 (Patna selection), ranging the disease severity from 25.6 to 76% and 20.16 to 75% respectively (Anon. 2013a) [2]. This disease adversely affects the garlic production in other states too particularly Bihar.

Thus in spite of being a disease of significant importance, no detailed study on stemphylium blight has been conducted so far. Since it is an important limiting factor for garlic production, comprehensive studies on disease development, its severity and management are essential. Screening is the first step towards resistance breeding. Selection of resistant / tolerant variety is a viable option for managing these diseases.

Garlic is consumed gradually hence it requires long term storage. But storability is a major constraint in garlic. The storage loss of 12.5% is recorded in garlic stored at 1-5ºC and 75% RH compared to over 25% losses in ambient temperature. Management of disease through chemicals is not always effective and desirable. Hence study on disease incidence and disease severity is indispensable. The basic pre-requisite for yield improvement is the presence of genetic variability in genetic stock and knowledge of inheritance and interrelationship of the yield components, along with their relative influence on each other. Information on the variability and correlation between morphological, biochemical and disease parameter with yield are important for supporting breeding program of the plant. In addition, knowledge of the nature of association of bulb yield with yield contributing characters is necessary for yield improvement through selection of better varieties (Haydar *et al*., 2007) [9]. Hence, to boost the economy of garlic growing farmers in Bihar, the present investigation was carried out with the objectives to assess the mean performance and to determine variability and correlation among growth, yield and yield attributing traits.

Method and Material

Field evaluation of thirty eight genotypes was carried out. Genotypes were selected out of the collections maintained at the Department of Horticulture (Vegetable and Floriculture) BAU, Sabour during the *rabi* season of 2016-17 (Table 1).The experiment was laid out in randomized block design (RBD) with 38 treatments, replicated three times. The climate of the experimental site is tropical to sub-tropical with slight semi-arid nature and is characterized by very dry summer, moderate rainfall and very cold winter. Metrological data was procured from the Agro- observatory meteorological department of the university.

The crop was planted in the third week of October at a spacing of 15 cm × 10 cm. The recommended dose of fertilizers N, P_2O_5 and K_2O was applied in the form of urea, di-ammonium phosphate and muriate of potash, respectively was applied. All the agricultural practices were performed as recommended. A random sample of five plants of each cultivar was collected from each plot to measure the plant height (cm),number of leaves per plant, Disease severity percentage (DS), Percent disease incidence (PDI), Black mould infestation percentage (BlM), *Botrytis porri* infestation percentage (BP), Total soluble solid in degree Brix (TSS), Total phenol content in leaves in µg gallic acid/g (TPL),Total phenol content in cloves in µg gallic acid/g (TCC) and yield per plant (g) were recorded at the time of harvesting and after harvesting as the case was. The data were analyzed statistically by applying ANOVA technique of randomized block design (RBD) as suggested by Panse and Sukhatme (1967) [22].

Screening was done on 0-9 point rating scale based on leaf area covered by the pustules (Mayee and Datar, 1986) [14]. Five plants at bulb developmental stage were randomly selected for scoring the disease at fortnightly intervals. Percent disease index (PDI) was calculated on the basis of rating scale and the total number of plants observed as given below.

$$\text{P.D.I. (\%)} = \frac{\text{Sum of rating (0-9 scale) x 100}}{\text{Maximum possible score x No. of leaves examined}}$$

Grade	Per cent area covered (leaf)
0	Absolutely free from infection
1	Small sized lesions on the leaf covering <1% Area
2	Small sized lesions on the leaf covering <2-5% % Area
3	Small sized lesions on the leaf covering <6-10% % Area
4	Small sized lesions on the leaf covering <11-15% 1% Area
5	Small sized lesions on the leaf covering < 16-25% Area
6	26-40% area covering
7	41-60% area covering
8	61-75 % area covering
9	>75% area covered with spot, most of the leaves dried

The study for the diseases under storage condition was also carried out. For this purpose 100 bulb were selected for each genotype and were stored separately in three replications each. The bulbs were noted for the symptoms of *botrytis porri* and black mould and their respective disease infestation percentage was calculated as per the formula given below

$$\text{Disease incidence} = \frac{\text{No. of infected bulb} \times 100}{\text{Total no. of bulb assessed}}$$

Result and Discussion

The ANOVA for the characters under study revealed that the mean square estimates due to genotypes were highly significant for all the characters studied (Table 2). In other words, the performance of the genotypes with respect of these characters was statistically different; suggesting that, there exists ample scope for selection in different traits for garlic improvement. On the basis of performance, the mean data (Table 3) indicated that the ANOVA for all the traits under study revealed that the mean square estimates due to genotypes were highly significant for all the characters studied (Table 2). In other words, the performance of the genotypes with respect of these characters was said to be statistically different; suggesting that, there exists abundant scope for selection in different traits for garlic genotypes improvement. In the present study, the selection of thirty 38 desirable genotype is primarily based on mean performance.

On the basis of the performance mean data (Table 3), the maximum plant height was observed in genotype BRG-13(49.04 cm) followed by genotype 644 (45.11 cm) and the minimum was recorded in RG-463 (34.49 cm). Similar variability trend for plant height was also observed by Mathur *et al*. (1985); Nurzynska-Wierdak (1997) [20]; Kohli and Prabal (2000) [12], and Sengupta *et al*. (2007) [25] in garlic. The highest number of leaves was exhibited in line WG-73(9.22) which was statically at par with genotypes 650 (9.00) while, it was the lowest in BRG-3 (65.7) followed by WG-38 (6.97) WG-376 (7.25). These results are in agreement with the works of Mehta and Patel (1985) [16], Nurzynska-Wierdak (1997) [20] and Sengupta *et al*. (2007) [25].

The highest bulb yield per plant was obtained in line BRG-13(34.65g) which had statistical parity with BRG-14 (32.68 g), 644 (34.18 g) and BRG-10 (32.11 g) while, the lowest yield per plant was obtained in genotype G-1 (20.63g) followed by 507 (21.89 g), RG-464 (24.19 g) and IC-375107 (24.65 g). Higher bulb yield may be attributed to cumulative effects of number of leaves per plant, length and diameter of bulb, number of cloves per bulb and average weight of cloves. Variation in yield amongst the lines was also reported by Pandey *et al*. (1996) [21], Nurzynska Wierdak (1997) [20], and Shrivastava *et al.* (2004) in garlic. The least disease severity percentage of Stemphylium blight was recorded in genotype IC-290440 (4.24%) while the highest was found in genotype 507 (40.37%). These findings are in consonance with the research deliberations of Mishra *et al*. (2013) [17], Suheri and Price (2000) [30] in garlic. The least percent disease index of Stemphylium blight was recorded in genotype BRG-13(10.55%) while the highest percent disease index of Stemphylium blight was found in BRG-3 (48.71%). These findings are similar to the study of Mishra *et al*. (2009) [18] and Veeraghanti (2017) [33] in onion. The least black mould severity percentage was recorded in genotype 256 (6.50%), however, the maximum black mould severity percentage was recorded in WG-48 (9.45%). The results of present study are quite similar with research of Prajapati and Patil (2015) [23] in onion. The minimum *Botrytis porri* infection percentage was recorded in genotype 256 (6.50%). However, the maximum infection percentage (9.45%) was recorded in WG-48. The results of present study are fairly similar with findings of Schwartz (2006) [24] in garlic.

As for the biochemical performances, maximum content of total soluble solid was recorded in 650 (39.37°Brix), however, the lowest amount of total soluble solid was noticed in RG-463(25.58°Brix). This finding is similar research findings of Geleta *et al*. (2013) [7] in garlic. The maximum amount of total phenol content in leaves was recorded in BRG-13 (1.86 µg gallic acid/g), however, the lowest amount of was noticed in BRG- 3 (0.30µg gallic acid/g).The results of present study are quite similar with research of Geleta *et al*. (2013) [7] in garlic. The maximum amount of total phenol content in clove was recorded in BRG-13 (0.65 µg gallic acid/g), however, the lowest amount of was noticed in BRG- 3 (0.11µg gallic acid/g). These findings are similar of Geleta *et al*. (2013) [7] in garlic. All the traits indicated environmental factor influenced their expression and their susceptibility to environmental fluctuations (Table 4). The traits exhibiting higher PCV and GCV are of economic importance and there is scope for improvement of these traits through selection. High PCV and GCV were recorded for total phenol content in leaves, total phenol content in cloves, disease severity of Stemphylium blight, black mould severity percentage and moderate PCV and GCV recorded for total soluble solid, percent disease index of Stemphylium blight and *botrytis porri* infestation percentage. It showed that genotypic variance for these characters are probably due to additive gene effect. Therefore selection based on phenotypic performance of these characters would be useful for achieving desire result. Hence characters like total phenol content in leaves, total phenol content in cloves having high GCV and PCV may be suggested for selection on the basis of phenotypic performance. These findings were in conformity with the results of Frasca *et al.* (1997) [6] for bulb weight; Narayan and Khan (2002) [19] for bulb yield per plot and bulb weight; Shri (2002) [26] for bulb yield and weight of 50 clove; Agrawal and Tiwari (2004) [1] for clove weight and bulb yield, bulb weight and bulb yield per hectare, and Haydar *et al.* (2007) [9] for total soluble solid; Geleta *et al.* (2013) [7] for total phenol content and Chen *et al.* (2013) [4] for disease severity of Stemphylium blight; Mishra *et al.* (2013) [17], Suheri and Price (2000) [30], Tripathi *et al*. (1998) and Huq and Khan (2007) [10] for black mould infestation percentage; Prajapati and Patil (2015) [23] for bulb in garlic. The heritability values of different traits ranged from (36.71 to 99.74%). High value of heritability was recorded for Total phenol content in cloves (99.64 %) followed by Black mould % (99.22%) and *Botrytis porri* % (99.00%). High heritability for above traits clarified that, they were least effected by environmental modifications and selection based on phenotypic performance would be reliable. The findings are in consonance with observations of Tsega *et al*. (2010). The heritability estimates along with genetic advance are more useful than the heritability values alone for selecting the best individual. From the present investigation, highest genetic advance as percentage of mean (87.21%) was obtained for total phenol content in cloves followed by TPC in leaves (67.81 µg gallic acid/g), disease severity Stemphylium blight (60.63%), black mould infestation percentage (44.48%), percent disease incidence of Stemphylium blight (32.13%), *botrytis porri* infestation percentage (33.60%), Yield per plant (20.21). However, TSS (19.58 ºBrix) showed moderate amount of genetic advance as percentage of mean. High heritability and high genetic advance were recorded for total phenol content in cloves, total phenol content in leaves, disease severity with respect to

Stemphylium blight, black mould infestation percentage, TSS, percent disease incidence of Stemphylium blight, *botrytis porri* infestation percentage and yield per plant. Mehta and Patel also recorded highest heritability along with genetic advance as percent of mean for average yield per plant. Selection will be effective for these characters due to additive gene effect. This result was in agreement to the findings of Haydar *et al*. (2007) [9] in onion and Tsega *et al* (2011) [32] in garlic. Heritability in conjunction with genetic advance (GA) was found to be more effective and reliable in predicting the result and effect of selection. Heritability and genetic advance when estimated together are more useful for predicting the genetic progress in selection as high heritability coupled with high genetic advance reflect preponderance of additive gene action.

High estimates of heritability, genetic advance as percent of mean and moderate estimates of GCV were observed for cloves/bulbs, bulb diameter, whereas moderate heritability coupled with low genetic advance and low GCV and PCV were observed for TSS and dry matter and moderate heritability coupled with high genetic advance was observed for average bulb weight and bulb yield. However, plant height, leaves/plant and maturity duration showed low heritability and low genetic advance, as also reported by Agarwal and Tiwari (2004) [1].

The phenotypic correlation coefficient of genotypes for all the characters under study has been presented in Table-5. Correlation studies revealed that the plant height showed highly significant and positive correlation with number of leaves per plant (rp=0.294), total phenol content in leaves (rp = 0.375), TSS (rp = 0.48) and yield per plant (rp = 0.610). The negative and significant correlation coefficient of yield was noted with percent disease incidence % (rp = -0.349), disease severity % (rp = - 0.210). Number of leave showed highly significant and positive correlation with yield per plant (rp = 0304) and significant and positive correlation with black mould infestation percentage (rp = 0.197).Total phenol content in leaves showed highly significant and positive correlation with total phenol content in cloves (rp= 0.886), yield per plant(rp = 0.375) but it had highly significant and negative correlation with percent disease incidence (rp = -0.908), *Botrytis porri* infestation percentage (rp = -0.205) and disease severity (rp = -0.427).Total phenol content in cloves had significant and positive correlation with yield per plant (rp =0.211) but it had highly significant and negative correlation with percent disease index (rp =-0.971) and disease severity of Stemphylium blight (rp =-0.489). Total soluble solid had highly significant and positive correlation with yield per plant (rp =0.494). Percent disease index of Stemphylium blight showed highly significant and positive correlation with *Botrytis porri* infestation percentage (rp = 0.491), disease severity of Stemphylium blight (rp = 0.254) also showed significant but positive correlation with Black mould (rp = 0.195) and it had highly significantly negative and correlation with yield per plant (rp = -0.269). Disease severity of Stemphylium blight had showed highly significant and positive correlation with black mould infestation percentage (rp = 0.285) and had highly significantly but negative correlation with yield per plant (rp = -0.314). *Botrytis porri* infestation percentage showed highly significant and positive correlation with black mould infestation percentage (rp = 0.298).

Thus the present findings highlighted the existence of adequate genetic variability for various traits in the accessions and they can be used for economic traits improvement. The traits that showed positive correlation with yield could be exploited to bring improvement in yield and yield components.

Table 1: Genotypes of Garlic used under investigation

S. No.	Garlic genotype	Source
1	BRG-10	Local collection maintained at BAU, Sabour
2	BRG-3	Local collection maintained at BAU, Sabour
3	569	Line from DOGR maintained at BAU
4	644	Collection from DOGR maintained at BAU
5	650	Collection from DOGR maintained at BAU
6	BRG-1	Collection from DOGR maintained at BAU
7	IC-290440	Collection from DOGR maintained at BAU
8	BRG-8	Local collection maintained at BAU, Sabour
9	BRG-13	Local collection maintained at BAU, Sabour
10	4	Collection from DOGR maintained at BAU
11	WG-471	Collection from DOGR maintained at BAU
12	WG-7	Collection from DOGR maintained at BAU
13	G-323	Collection from DOGR maintained at BAU
14	BRG-9	Local collection maintained at BAU, Sabour
15	BRG-14	Local collection maintained at BAU, Sabour
16	WG-73	Collection from DOGR maintained at BAU
17	M-175	Collection from DOGR maintained at BAU
18	553	Collection from DOGR maintained at BAU
19	WG-2	Collection from DOGR maintained at BAU
20	RG-464	Collection from DOGR maintained at BAU
21	WG-7	Local collection maintained at BAU, Sabour
22	507	Collection from DOGR maintained at BAU
23	G1	Collection from DOGR maintained at BAU
24	IC-375107	Collection from DOGR maintained at BAU
25	IC-345585	Collection from DOGR maintained at BAU
26	BRG-7	Collection from DOGR maintained at BAU
27	G- 282	Collection from DOGR maintained at BAU
28	G-50	Collection from DOGR maintained at BAU
29	WG-48	Collection from DOGR maintained at BAU
30	RG-463	Collection from DOGR maintained at BAU
31	IC-141151	Collection from DOGR maintained at BAU
32	WG-376	Collection from DOGR maintained at BAU
33	IC-375005	Collection from DOGR maintained at BAU
34	WG-38	Collection from DOGR maintained at BAU
35	WG-35	Collection from DOGR maintained at BAU
36	Godavari	Collection from DOGR maintained at BAU
37	WG-39	Collection from DOGR maintained at BAU
38	Otur 555	Collection from DOGR maintained at BAU

Table 2: Analysis of variance for 19 morphological, biochemical and disease parameter under study

	Mean sum of square		
Characters	Replication	Genotypes	Error
	df=2	df=74	df=37
Plant height (cm)	19.630	24.941**	9.102
Number of leaves per plant	0.011	0.996**	0.251
Yield per plant (g)	2.956	33.302**	4.001
TSS (^{0}Brix)	3.270	37.066**	2.206
Total phenol content in leaves	0.015	0.349**	0.002
Total phenol content in cloves	0.000	0.083**	0.000
PDI% of Stemphylium blight	14.458	103.520**	5.926
DS % of Stemphylium blight	0.227	19.187**	0.002
Botrytis porri infestation percentage	0.091	27.270**	0.091
Black mould infestation percentage	0.268	43.447**	0.113

Table 3: Mean performance of 38 genotypes of garlic for morphological, biochemical and disease parameter

No	Character/genotype	PH	NLe	Y/P	DS %	PDI%	BIM%	BP %	TSS	TCL	TCC
1	BRG-10	38.61	8.61	32.12	5.95	31.28	4.64	11.80	32.55	0.90	0.37
2	BRG-3	41.73	6.57	28.73	12.88	48.71	3.46	12.22	33.03	0.30	0.11
3	569	42.36	7.72	31.65	7.96	24.78	3.07	10.60	37.18	1.41	0.58
4	644	45.11	8.76	34.18	6.54	21.60	5.07	8.65	29.64	1.50	0.63
5	650	42.06	9.00	31.73	25.22	46.15	2.56	9.81	39.37	0.59	0.12
6	BRG-1	37.55	8.02	27.88	38.71	42.59	4.81	14.13	31.08	0.70	0.20
7	IC-290440	40.65	8.33	29.54	4.24	20.21	6.58	11.79	37.91	1.58	0.62
8	BRG-8	40.52	8.61	27.81	12.61	41.45	8.43	14.47	35.47	0.70	0.22
9	BRG-13	49.04	8.64	34.65	5.91	10.55	3.18	10.62	37.21	1.86	0.65
10	4	38.01	8.33	25.78	10.96	25.60	4.38	12.03	37.93	1.17	0.55
11	WG-471	35.04	8.39	26.77	7.83	25.73	6.02	8.96	34.99	1.11	0.57
12	WG-7	38.11	8.26	25.06	21.82	43.92	7.25	11.06	33.37	0.66	0.19
13	G-323	38.52	8.72	26.93	7.23	39.63	8.33	10.99	36.69	0.72	0.28
14	BRG-9	38.20	7.96	29.31	5.74	24.53	14.72	6.35	36.48	1.39	0.58
15	BRG-14	42.25	8.74	32.68	7.11	12.32	8.39	4.41	36.56	1.46	0.60
16	WG-73	39.84	9.22	27.76	16.76	38.31	8.46	9.78	31.90	1.46	0.25
17	M-175	37.19	8.24	23.86	12.51	28.82	3.57	10.86	34.70	0.98	0.41
18	553	39.17	8.29	27.03	6.82	40.11	3.07	9.63	33.93	0.70	0.23
19	WG-2	36.97	8.35	25.67	9.75	28.75	3.05	13.90	32.24	0.96	0.41
20	RG-464	37.14	8.71	24.20	10.37	40.51	3.16	22.19	32.53	0.71	0.24
21	WG-7	39.48	8.34	29.28	9.51	26.75	7.01	4.29	30.46	1.10	0.42
22	507	37.39	8.50	21.89	40.36	28.92	10.44	7.05	29.99	0.93	0.42
23	G1	35.78	8.48	26.07	11.45	31.31	3.27	8.92	29.59	0.89	0.38
24	IC-375107	37.57	8.08	24.65	16.27	41.40	3.88	7.97	32.35	0.69	0.17
25	IC-345585	38.81	7.66	24.70	18.05	43.95	5.12	5.99	33.19	0.68	0.16
26	BRG-7	37.15	7.42	22.73	9.56	26.80	5.81	10.28	32.43	1.00	0.43
27	G- 282	37.10	8.66	24.04	13.66	30.00	4.40	8.72	33.83	0.90	0.35
28	G-50	37.27	7.55	28.21	11.25	46.50	6.05	7.57	37.55	0.63	0.12
29	WG-48	38.43	7.49	24.02	11.04	28.23	9.45	13.11	29.45	0.99	0.39
30	RG-463	34.49	7.54	24.67	8.94	27.40	9.23	11.50	25.58	0.96	0.47
31	IC-141151	34.63	7.76	26.23	11.53	23.80	7.60	8.92	34.49	1.43	0.62
32	WG-376	37.67	7.25	26.17	9.76	24.20	6.54	8.40	32.77	1.40	0.54
33	IC-375005	38.12	8.63	25.76	7.03	34.60	9.57	10.16	28.59	0.83	0.30
34	WG-38	37.01	6.97	24.01	11.37	25.51	8.50	13.50	29.17	1.19	0.50
34	WG-35	36.01	8.37	25.31	9.96	25.00	8.48	7.33	34.25	1.22	0.48
36	GODAVARI	35.42	7.92	23.81	9.44	24.85	9.09	11.83	27.25	1.38	0.59
37	WG-39	38.54	8.67	24.98	9.16	26.91	8.61	8.37	26.49	0.98	0.45
38	0TUR 555	36.27	7.97	25.18	9.82	33.20	9.14	6.90	27.21	0.86	0.32
	Mean	38.49	8.17	26.97	12.23	31.18	6.43	10.13	32.88	1.02	0.39
T	SE	1.78	0.28	0.84	0.38	0.85	0.37	0.18	0.86	0.28	1.78
a	C.D. 1%	5.04	0.81	2.39	1.08	2.41	1.06	0.35	2.43	0.81	5.04
b	C.V.	8.03	6.12	5.44	13.48	4.19	2.58	4.92	4.54	6.12	8.03

Characters and their abbreviation in parenthesis: Plant height in cm (PH), Number of leaves per plant (NLe), Yield per plant in gram (YP), Disease severity percentage (DS), Percent disease incidence (PDI), Black mould infestation percentage (BlM), *Botrytis porri*in festation percentage (BP), Total soluble soli (TSS),Total phenol content in leaves in µg gallic acid/g (TPL) and Total phenol content in cloves in µg gallic acid/g (TCC).

Table 4: GCV, PCV, Heritability, Genetic Advance and Genetic Advancement as percentage of mean for morphological, biochemical character and disease parameter under study.

Characters	GCV	PCV	h^2	Genetic Advance	GA% means
plant height	5.959	9.835	36.710	2.868	7.438
No of leaves	6.094	8.638	49.767	0.724	8.856
Total phenol content in leaves	33.198	33.482	98.316	0.695	67.810
Total phenol content in cloves	42.414	42.490	99.647	0.342	87.219
Total soluble solid	10.368	11.309	84.048	84.590	19.580
PDI %	16.961	18.441	84.590	10.806	32.134
D S %	29.766	30.102	97.778	12.032	60.632
Botrytis porri %	16.397	16.479	99.007	6.170	33.609
Black mould %	21.678	21.763	99.225	7.799	44.484
Yield per plant	11.648	13.829	83.260	5.423	20.210

Table 5: Phenotypic correlation coefficient among different morphological, biochemical &disease parameter

	PH	NLe	TPL	TPC	TSS	PDI	D S	BP	BlM	Y/P
PH	1.000	0.294**	0.375**	0.127	0.485**	-0.349**	-0.210*	-0.065	0.149	0.610**
NLe		1.000	0.171	0.011	0.167	-0.108	0.023	-0.063	0.197*	0.304**
TPL			1.000	0.886**	0.108	-0.908**	-0.427**	-0.205*	-0.159	0.375**
TPC				1.000	-0.001	-0.971**	-0.489**	-0.164	-0.134	0.211*
TSS					1.000	-0.009	-0.096	-0.034	-0.062	0.494**
PDI						1.000	0.491**	0.254**	0.195*	-0.269**
D S							1.000	0.030	0.285**	-0.314**
BP								1.000	0.298**	-0.148
BM									1.000	-0.004
Y/P										1.000

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