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Evaluation of garlic (*Allium sativum* L.) genotypes in Rayalaseema region of Andhra Pradesh

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Abstract
An investigation was carried out at Dr. YSRHU- College of Horticulture, Anantharajupeta, Andhra Pradesh, during *rabi* season, 2022-2023 to evaluate twenty-eight garlic genotypes in Rayalaseema region of Andhra Pradesh. The genotypes were replicated in Randomized Block Design. On the basis of mean performance, Yamuna Safed 2 was found to be the best. Yamuna Safed-2 recorded significantly maximum bulb yield which was found to be statistically on par with Yamuna Purple-10 followed by Yamuna Safed, DOGR-681 and DOGR-253. High bulb weight, clove weight, bulb diameter, clove length, leaf length, plant height, and neck thickness were recorded in Yamuna Safed-2, Yamuna Purple-10, Yamuna Safed, DOGR-681 and DOGR-253 genotypes. Analysis of variance results revealed existence of high degree of variability among the germplasm.

Keywords: Garlic, *Allium sativum* L., genotypes, horticulture

Introduction
Garlic (*Allium sativum* L.) belonging to Amaryllidaceae family, is an important spice crop. After onion, it is the second most cultivated bulb crop and has the chromosome number 2n=16. Central Asia and Southern Europe especially Mediterranean region (Khadi *et al*., 2022) [6] is the native of garlic. China, India, Spain, Egypt, Korea and U.S.A are major garlic growing countries. India leads in garlic production next to China with the production of 31.89 lakh tonnes from 3.92 lakh hectare area and having an average productivity of 8.13 t ha^{-1}. Major garlic producing states in India are Madhya Pradesh, Gujarat, Karnataka, Maharashtra, Rajasthan and Uttar Pradesh.

Garlic is a frost hardy, erect annual herb and underground compound bulbs surrounded by exterior white thin scales. Leaves of garlic are simple, narrow, long and flat. It has long been thought to be a good source of carbohydrates, protein and phosphorus. A fresh peeled garlic bulb has moisture (62.8%), carbohydrate (29%), protein (6.3%), minerals (1.0%), fat (0.1%), fibre (0.8%), calcium (0.03%), iron (0.001%), phosphorus (0.31%), nicotinic acid (0.4 mg 100 g^{-1}) and vitamin C (13 mg 100 g^{-1}) (Mishra and Vikram 2017) [11]. Alliin present in garlic which is transformed into sulphur containing compound allicin with diallyl disulphide upon crushing. Garlic has antibacterial, antioxidant, antifungal, anti-atherosclerotic, detoxifying, hypo-glycemic and anti-carcinogenic properties (Nandini *et al*., 2018) [12]. Organo-sulphur substances such as allicin and quercetin have been linked to the prevention of viral infection (Kumar and Pandey 2013) [7].

Because of its nutritional benefits and increasing demand, there is a need to boost garlic output by expanding its cultivation to non-traditional areas with suitable varieties. As a result, identifying optimal genotypes is critical for increasing cultivation and yield. The present study was carried out to identify the genotypes that are suitable for Rayalaseema region of Andhra Pradesh.

Material and Methods
The present study was conducted in the Department of Plantation, Spices, Medicinal and Aromatic Crops at Dr. YSRHU- College of Horticulture, Anantharajupeta, Andhra Pradesh, during *rabi* season, 2022-2023. Twenty-eight genotypes were evaluated in randomized bock design with two replications. The healthy cloves were selected and dibbled in a plot size of 1.5 x 1 m^2. The package of practices for garlic were followed as per recommendations of Dr. Y.S.R. Horticultural University.

Five random plants in each genotype were selected and data was recorded for plant height (cm), leaf length (cm), leaf width (mm), number of leaves and pseudostem length (cm), neck thickness (mm), bulb weight (g), bulb diameter (cm), bulb yield (t $^{ha-}$1), number of cloves per bulb, clove weight (g), clove length (mm) and clove diameter (mm). The total variation was partitioned (ANOVA) and statistically analysed on the basis of the model described by Panse and Sukhatme (1961) [13].

Results and Discussion

The results of the present investigation revealed that significant differences existed among the garlic genotypes for all the traits studied. The growth parameters result was presented in the table 1. Plant height ranged from 36.04 to 52.09 cm with 8 genotypes having greater than mean value. The maximum plant height (52.09 cm) was recorded by the Yamuna Safed-2, which was statistically on par with DOGR-681 (49.48 cm), DOGR-253 (48.22cm), while the genotype DOGR-380 had recorded the shortest plant height (36.34 cm). Bamaniya *et al.* (2018) [2] and Kaur *et al*. (2020) [5] reported similar findings. Leaf length varied from 30.66 to 42.17 cm with 8 genotypes having greater than mean value (34.99 cm). Highest leaf length was recorded by Yamuna Safed-2 (42.17 cm) which was statistically on par with DOGR-681 (41.81 cm) and Yamuna Purple-10 (41.29 cm), while lowest leaf length was found in DOGR-380 (30.66 cm). The results are in line with Panse *et al*. (2013) [14] and Umamaheswarappa *et al*. (2014) [19]. Leaf width ranged from 5.94 to 11.74 mm. It was recorded maximum in the genotype Yamuna Safed-2 (11.74 mm) which was found to be statistically similar to Yamuna Purple-10 (10.86 mm) and Yamuna Safed (10.78 mm), whereas, DOGR-242 (5.94 mm) genotype recorded minimum leaf width. The results are in accordance with the findings of Rathva *et al.* (2018) [16] and Kumar *et al*. (2020) [8]. Range of number of leaves varied from 5.04 to 10.43. The genotype Yamuna Safed-2 (10.43) had maximum leaves, which was statistically equal to DOGR-253 (10.25) and Yamuna Safed (9.55), while the genotype DOGR-103 (5.04) had minimum leaves. Mishra *et al*. (2013) [10] and Alam *et al*. (2010) [1] found similar results. Range of pseudostem length varied from 5.69 to 8.23 cm. Highest pseudostem length was found in AAS-2 (8.23 cm) which was statistically equivalent to DOGR-681 (7.67 cm) and DOGR-144 (7.84 cm), followed by DOGR-517 (7.31 cm) and DOGR-253 (7.26 cm). However, Bhima Omkar (5.69 cm) recorded lowest pseudostem length. Siddappa *et al.* (2020) [18] and Rathva *et al.* (2018) [16] observed similar findings. Range of neck thickness was between 4.43 and 8.08 mm. Maximum neck thickness was measured in Yamuna Safed-2 (8.08 mm), which was statistically equal to DOGR-253 (7.69 mm) and DOGR-681 (7.69 mm) followed by Yamuna Safed (7.51 mm), while minimum neck thickness was measured in DOGR-598 (4.43 mm). The findings were consistent with those of Rajole *et al*. (2016) [15] and Bhatt *et al*. (2017) [3].

The data regarding bulb parameters was presented in table 2 and suggested that the diameter of the bulbs ranged from 1.09 cm to 4.08 cm, with an average of 2.14 cm. Yamuna Safed-2 (4.08 cm) recorded highest bulb diameter which was statistically equal to Yamuna Purple-10 (4.05 cm), followed by Yamuna Safed (3.54 cm). On the other hand, DOGR-95 (1.09 cm). Genotype was found to have minimum bulb diameter. Choudhary *et al*. (2017) [4] and Kumar *et al*. (2020) [8] reported similar findings. Bulb weight mean value ranged from 6.81 g to 25.61 g. Yamuna Safed-2 (25.61 g) had highest bulb weight which was statistically on par with Yamuna Purple-10 (25.43 g) followed by Yamuna Safed (22.34 g), while DOGR-114 (6.81 g) genotype had recorded lowest bulb weight. Similar findings were reported by Umamaheswarappa *et al*. (2014) [19] and Bhatt *et al.* (2017) [33]. Mean values of bulb yield (t ha^{-1}) varied from 2.04 to 7.68 t. Yamuna Safed-2 recorded highest bulb yield (7.68 t) which was statistically equivalent to Yamuna Purple-10 (7.63 t) followed by Yamuna Safed (6.75 t) and DOGR-681 (5.87 t) while DOGR-114 (2.04 t) genotype recorded lowest bulb yield per hectare. The results were in consonance with the findings of Umamaheswarappa *et al.* (2014) [19] and Kumar *et al.* (2020) [8]. Mean value for number of cloves per bulb ranged from 8.20 to 16.40. Maximum number of cloves per bulb were found in AAS-2 (16.40) which was statistically comparable to Bhima Purple (15.30) followed by DOGR-25 (14.50), whereas DOGR-380 (8.20) genotype was found to have minimum number of cloves per bulb. Shibana and Menon (2019) [17] and Kumari *et al.* (2021) [9] reported similar results. The weight of clove varied from 0.53 to 2.74 g. Yamuna Purple-10 (2.74 g) recorded maximum weight of clove followed by Yamuna Safed-2 (2.36 g), DOGR-681 (2.25 g), Yamuna Safed (1.61 g) and Agrifound White (1.37 g), while DOGR-114 (0.53 g) genotype recorded minimum clove weight. The results were in line with Vatsyayan *et al.* (2013) [20] and Siddappa *et al.* (2020) [18]. Length of clove ranged between 12.48 and 28.05 mm. Yamuna Safed-2 (28.05 mm) had highest clove length followed by Yamuna Safed (24.68 mm), Yamuna Purple-10 (24.14 mm) and Agrifound White (23.17 mm), while genotype DOGR-25 (12.48 mm) had lowest clove length. The results were consistent with the works of Rajole *et al.* (2016) [15] and Kumari *et al.* (2021) [9]. Clove diameter mean value ranged between 7.35 to 17.25 mm. Yamuna Purple-10 (17.25 mm) recorded maximum clove diameter followed by DOGR-103 (13.56 mm), Yamuna Safed-2 (12.64 mm) and Agrifound White (12.51 mm) However, DOGR-25 (7.32 mm) genotype had minimum clove diameter. Vatsyayan *et al.* (2013) [20] and Kumari *et al*. (2021) [9] recorded comparable results.

In quality parameters total soluble solids and pyruvic acid content estimation was carried out in 28 garlic genotypes and data was presented in table 2. The range of TSS was between 28.18 and 46.07 ^{o}Brix. High TSS was observed in genotype DOGR-598 (46.07 ^{o}Brix) which was statistically equivalent to Yamuna Safed-2 (44.37 ^{o}Brix) followed by DOGR-517 (43.78 ^{o}Brix) and DOGR-464 (42.65 ^{o}Brix), whereas genotype DOGR-380 (28.18 ^{o}Brix) recorded low TSS. The findings are in accordance with Vatsyayan *et al.* (2013) [20] and Rajole *et al.* (2016) [15]. Pyruvic acid content varied from 16.07 to 34.61 µ mol g^{-1}. High pyruvic acid content was recorded in DOGR-604 (34.61 µ mol g^{-1}) genotype statistically equivalent to DOGR-681 (33.04 µ mol g^{-1}) followed by AAS-2 (32.13 µ mol g^{-1}), DOGR-253 (31.65 µ mol g^{-1}) genotypes, while low pyruvic acid content was observed in DOGR-425 (16.07 µ mol g^{-1}) genotype. Similar findings were reported by Nandini *et al.* (2018) [12] and Kaur *et al.* (2020) [5].

Highly significant variation was observed in all the genotypes for all the traits studied. Variability observed among different genotypes might be due to genetic nature of the genotypes and the environment in which it was grown (Table 3).

Table 1: Mean performance for growth parameters in garlic genotypes

Genotypes	PH (cm)	LL (cm)	LW (mm)	NOL	PSL (mm)	NT (mm)
Bhima Purple	40.21	36.00	8.81	7.64	5.97	6.59
Bhima Omkar	39.52	33.75	7.86	7.48	5.69	5.78
DOGR-25	38.70	32.76	7.13	6.81	5.91	4.50
DOGR-51	39.23	34.90	6.51	6.29	6.26	4.55
DOGR-95	38.37	31.68	5.94	5.98	6.70	4.53
DOGR-103	39.14	32.96	6.80	5.04	6.21	4.77
DOGR-114	41.21	34.72	8.67	6.66	6.51	4.90
DOGR-144	42.24	34.37	7.55	6.06	7.84	4.67
DOGR-145	38.36	31.64	6.01	6.59	6.71	5.37
DOGR-230	39.99	33.61	5.97	6.04	6.39	5.10
DOGR-242	40.46	33.85	5.94	6.46	6.63	4.99
DOGR-253	48.22	40.98	9.62	10.25	7.26	7.69
DOGR-380	36.34	30.66	7.09	6.99	5.71	4.60
DOGR-425	41.88	35.18	8.64	7.56	6.72	4.78
DOGR-464	40.51	33.70	8.91	7.37	6.84	4.93
DOGR-510	39.79	32.90	8.75	7.33	6.87	5.38
DOGR-517	38.62	31.30	7.93	7.52	7.31	4.63
DOGR-568	41.08	34.47	7.74	7.16	7.10	6.35
DOGR-578	38.47	31.99	6.77	5.98	6.48	4.64
DOGR-598	39.42	33.50	7.63	5.86	5.96	4.43
DOGR-604	39.79	33.22	7.10	7.76	7.06	5.17
DOGR-681	49.48	41.81	8.82	8.58	7.67	7.69
AAS-2	40.91	32.73	8.68	6.67	8.23	5.50
Yamuna Safed	47.77	41.13	10.78	9.55	7.15	7.51
Agrifound White	41.20	34.47	8.43	7.72	6.74	5.64
Yamuna Safed-2	52.09	42.17	11.74	10.43	7.05	8.08
Yamuna Safed-9	45.09	37.89	8.56	6.93	7.16	6.37
Yamuna Purple-10	48.09	41.29	10.86	9.07	6.90	7.30
Mean	41.65	34.99	8.04	7.28	6.75	5.59
S.Em±	1.50	1.59	0.31	0.33	0.31	0.18
CD at 5%	4.35	4.60	0.90	0.97	0.91	0.52

PH – Plant Height LL- Leaf Length LW- Leaf Width NOL- Number of Leaves PSL – Pseudostem length NT- Neck Thickness

Table 2: Mean performance of bulb, clove and quality parameters in garlic genotypes

Genotypes	BD (cm)	BW (g)	BY (t ha^{-1})	CPB	CW (g)	CL(mm)	CD(mm)	TSS (^{O}Brix)	PA (µ mol g^{-1})
Bhima Purple	2.37	15.83	4.79	15.30	1.03	16.51	9.42	37.48	29.32
Bhima Omkar	2.13	12.36	3.71	14.40	0.86	13.55	7.70	35.68	21.51
DOGR-25	1.19	8.52	2.57	14.50	0.59	12.48	7.32	35.67	29.68
DOGR-51	1.09	7.21	2.16	12.60	0.57	14.06	7.41	32.38	24.42
DOGR-95	1.92	10.60	3.21	11.70	0.90	21.85	12.41	29.63	27.02
DOGR-103	1.31	7.01	2.13	8.90	0.79	16.28	13.56	29.79	19.24
DOGR-114	1.21	6.81	2.04	12.80	0.53	15.85	9.38	30.09	21.98
DOGR-144	1.90	9.30	2.79	14.30	0.65	13.96	8.70	38.97	19.05
DOGR-145	1.30	7.40	2.22	13.50	0.55	17.04	9.63	33.78	18.50
DOGR-230	1.26	7.28	2.18	9.20	0.79	15.49	9.79	31.28	25.22
DOGR-242	1.34	7.17	2.15	12.60	0.57	18.89	8.93	38.59	22.23
DOGR-253	3.40	18.82	5.67	14.40	1.28	22.55	9.70	31.88	31.65
DOGR-380	1.51	6.98	2.10	8.20	0.85	16.63	8.50	28.18	21.08
DOGR-425	2.06	8.36	2.51	13.30	0.63	17.46	11.37	34.59	16.07
DOGR-464	2.39	10.77	3.23	10.10	1.06	17.21	12.23	42.65	21.60
DOGR-510	2.90	13.66	4.14	10.60	1.28	21.07	11.15	35.85	31.61
DOGR-517	1.78	7.11	2.13	10.50	0.68	13.25	8.21	43.78	17.11
DOGR-568	2.01	10.27	3.08	8.90	1.15	16.94	9.00	39.72	17.48
DOGR-578	1.27	6.84	2.05	9.50	0.72	17.77	11.23	29.63	19.86
DOGR-598	1.17	6.85	2.06	10.70	0.62	16.47	12.22	46.07	25.05
DOGR-604	2.50	8.63	2.63	13.20	0.65	17.32	11.51	36.09	34.61
DOGR-681	3.17	19.21	5.87	8.50	2.25	23.13	11.57	33.54	33.04
AAS-2	2.59	12.59	3.78	16.40	0.77	17.31	8.21	42.07	32.13
Yamuna Safed	3.54	22.34	6.75	14.00	1.61	24.68	12.24	32.78	28.93
Agrifound White	2.20	12.20	3.74	8.90	1.37	23.17	12.51	33.24	27.22
Yamuna Safed-2	4.08	25.61	7.68	10.70	2.36	28.05	12.64	44.37	25.59
Yamuna Safed-9	2.38	11.33	3.40	8.60	1.31	19.49	11.10	28.81	24.76
Yamuna Purple-10	4.05	25.43	7.63	8.90	2.74	24.14	17.25	41.78	26.60
Mean	2.14	11.66	3.51	11.61	1.04	18.31	10.53	35.66	24.73
S.Em±	0.12	0.41	0.13	0.43	0.05	0.66	0.45	1.30	0.85
CD at 5%	0.33	1.42	0.38	1.24	0.13	1.9	1.3	3.58	2.47

BW – Bulb Weight BD – Bulb Diameter BY – Bulb Yield CPB – number of cloves per bulb CW – Clove Weight CL – Clove Length CD - Clove Diameter TSS- Total Soluble Solids PA – Pyruvic acid

Table 3: Analysis of variance for growth, yield and quality traits in garlic genotypes

	Source	Replication sum of squares	Treatment sum of squares	Error
	Degrees of freedom	**1**	**27**	**27**
1	Plant height	16.71	31.10**	4.48
2	Leaf length	8.81	23.37**	5.03
3	Leaf width	0.68	4.57**	0.19
4	Number of leaves	0.90	3.43**	0.22
5	Pseudostem length	0.15	0.77**	0.19
6	Neck thickness	0.19	2.62**	0.06
7	Bulb diameter	0.00	1.57**	0.03
8	Bulb weight	1.32	64.54**	0.34
9	Total bulb yield (t ha^{-1})	0.09	5.93**	0.03
10	Number of cloves per bulb	1.51	12.00**	0.36
11	Clove weight	0.00	0.67**	0.00
12	Length of clove	0.75	30.42**	0.86
13	Diameter of clove	1.70	9.96**	0.40
14	Total Soluble Solids	8.32	53.78**	3.40
15	Pungency	0.02	55.82**	1.45

**- significance at P=0.01

Conclusion

On the basis of mean performance, it was concluded that significant variations were observed for all the traits in all genotypes. Yamuna Safed-2, Yamuna Purple-10, Yamuna Safed, DOGR-681 and DOGR-253 genotypes have found superior performance under the Rayalaseema region of Andhra Pradesh.

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