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## ASSESSMENT OF MORPHOLOGICAL TRAITS AND YIELD POTENTIAL IN WHITE ONION GENOTYPES GROWN DURING *KHARIF*

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### ABSTRACT

A field experiment was conducted during the *Kharif* season to evaluate the performance and genetic variability of 35 white onions (*Allium cepa* L.) genotypes under open field conditions. The study revealed substantial variation among genotypes for important growth, bulb and yield-related traits, indicating the presence of considerable genetic diversity within the experimental material. Plant height ranged from 39.02 to 64.30 cm, while the number of leaves per plant varied between 3.30 and 9.00, reflecting differential vegetative growth among genotypes. Significant variation was also observed in pseudo stem characteristics, with pseudo stem length ranging from 3.58 to 6.94 cm and width from 7.29 to 13.95 mm. Bulb-related traits exhibited wide variability, with equatorial diameter ranging from 2.51 to 4.90 cm and polar diameter from 2.41 to 5.18 cm, while neck thickness varied from 8.55 to 12.76 mm. Individual bulb weight showed marked differences among genotypes, ranging from 22.67 to 86.21 g, which directly influenced yield performance. Yield per plot varied from 6.33 to 25.56 kg, corresponding to a yield per hectare of 10.56 to 32.07 t ha<sup>-1</sup>. Among the evaluated genotypes, DOGR-2152 consistently outperformed others across several growths, bulb, and yield attributes, indicating its superior agronomic potential. Additionally, DOGR-2147 and DOGR-2144 recorded the highest yield per plot, highlighting their promise as high-yielding genotypes. The observed variability among the genotypes underscores the significant scope for selection and genetic improvement, and the identified superior genotypes may serve as valuable parental material in breeding programs aimed at developing high-yielding, *kharif* season-adapted white onion varieties.

**Keywords:** *kharif*, white onion, morphological traits, yield potential, bulb quality

### Introduction

Onion (*Allium cepa* L.) is among the most extensively cultivated and consumed vegetable crops worldwide, recognized for its culinary versatility, therapeutic potential and economic significance. In India, onions occupy a prominent position within the agricultural sector, functioning both as a dietary staple and a major export commodity. Nutritionally, onions are a rich source of carbohydrates, proteins, essential minerals, vitamins and dietary fiber. Moreover, they contain quercetin, a bioactive flavonoid and lachrymatory agent, which has been associated with various health-promoting properties, including anti-

cholesterol, anti-inflammatory, antioxidant and anticancer effects (Chalbi *et al.*, 2022).

India currently ranks as the world's second-largest onion producer, surpassed only by China. Recent data from the Ministry of Agriculture and Farmers Welfare (2023-24) estimates that onions are cultivated across 1.54 million hectares, yielding approximately 24.24 million metric tons. Despite these high numbers, the industry faces a persistent seasonal challenge. Production is heavily skewed toward the *rabi* (winter) season, which accounts for 60% of the annual output. In contrast, the *kharif* (monsoon) and late *kharif* (post-monsoon) seasons contribute only 20% each (Islam *et*

*al.*, 2017). This seasonal imbalance creates a volatile market with price peaking between September and November when supplies are low and declined during the January to April period during *rabi* harvest, while *kharif* cultivation offers farmers an opportunity to get profitable return as the environmental conditions during the monsoon are less favorable for onion cultivation. Unfavorable climatic factors during *kharif* season underscore the urgency of developing and standardizing onion varieties that strengthen producer profitability (Gupta *et al.*, 2020).

The development of such improved cultivars relies heavily on the effective utilization of plant genetic resources (PGR). To satisfy the demands of both producers (high yield and bulb size) and breeders (pest resistance and photoperiod stability), it is necessary to characterize germplasm and understand the correlations between key traits (Arya *et al.*, 2017). While genotype-environment interactions can make morphological assessment challenging, with many traits varying significantly across different locations, phenotypic characterization remains the foundational first step in any crop improvement program (Yuguda *et al.*, 2017; Gupta *et al.*, 2024).

Given the limited availability of adapted varieties for monsoon cultivation, there is an urgent need to identify genotypes that can thrive under stress without sacrificing yield. This study focuses on the comprehensive morphological characterization of *kharif* onion genotypes. By evaluating bulb characteristics, yield potential and environmental resilience, this research aims to identify superior genotypes that can stabilize production and support the agricultural economy during the challenging monsoon season

## Materials and Methods

The present field investigation was carried out during *kharif* season 2023 at ICAR-Directorate of Onion and Garlic Research, Rajgurunagar, Pune, Maharashtra, India. The experiment was laid out in Randomized Block Design with three replications having 28 genotypes and two commercially adopted varieties specifically *kharif* season. This farm is situated at 18.84° N latitude and 73.88° E longitudes. The geographical location falls under subtropical dry humid climate. Fungicide treated seeds were sown in the nursery block at ICAR –DOGR, Rajgurunagar, Pune during the second week of June 2023. All agronomical practices recommended by ICAR- DOGR for *kharif* onion production were followed.

The observations was recorded on different growth and yield parameters i.e., plant height (cm), number of leaves per plant, pseudo stem length (cm), pseudo stem width (mm), equatorial diameter (cm), polar diameter (cm), neck thickness (mm), average weight of bulb (g), yield per plot (kg) and yield per hectare (t/ha).

**Table 1:** The white onion genotypes used in this study

Sr. No.	Genotype	Sr. No.	Genotype
1.	DOGR-2121	18.	DOGR-2138
2.	DOGR-2122	19.	DOGR-2139
3.	DOGR-2123	20.	DOGR-2140
4.	DOGR-2124	21.	DOGR-2141
5.	DOGR-2125	22.	DOGR-2142
6.	DOGR-2126	23.	DOGR-2143
7.	DOGR-2127	24.	DOGR-2144
8.	DOGR-2128	25.	DOGR-2145
9.	DOGR-2129	26.	DOGR-2146
10.	DOGR-2130	27.	DOGR-2147
11.	DOGR-2131	28.	DOGR-2148
12.	DOGR-2132	29.	DOGR-2149
13.	DOGR-2133	30.	DOGR-2150
14.	DOGR-2134	31.	DOGR-2151
15.	DOGR-2135	32.	DOGR-2152
16.	DOGR-2136	33.	DOGR-2153
17.	DOGR-2137	34.	Bhima Safed
35.	Bhima Shweta		

## Growth parameters

### Plant height (cm)

Plant height (cm) was determined at the time of harvesting by measuring the distance from the soil surface to the plant apex using a steel scale. Data were expressed as the mean value per genotype/plot.

### Number of leaves per plant

Five plants were randomly selected at harvest to assess leaf productivity. The total count of green and functional leaves was recorded for each, and the resulting mean was computed for analysis.

### Pseudo stem length (cm)

Pseudo stem length (cm) was determined by measuring the distance between the bulb top and the leaf-base attachment. Data represent the mean of five plants sampled per treatment.

### Pseudo stem width (mm)

Pseudostem width (mm) was determined using a vernier caliper. Measurements were taken at the midpoint of the pseudostem, specifically at the position showing the maximum diameter.

## Yield parameters

### Equatorial diameter (cm)

The equatorial diameter of the bulb was measured at its widest point (mid-length) using digital vernier calipers in millimeters (mm). These values were subsequently converted to centimeters (cm) to calculate the mean for each treatment.

### Polar diameter (cm)

To determine the mean bulb length (cm), measurements were taken between the polar ends using digital vernier calipers. Data originally recorded in millimeters (mm) were standardized to centimeters (cm) prior to statistical analysis.

### Neck thickness (mm)

Neck thickness was measured in millimeters (mm) using digital vernier calipers at a point just below the leaf-stem junction. Measurements were taken from five randomly selected bulbs per treatment to calculate the mean neck thickness.

### Average bulb weight (g)

After harvesting, total weights of randomly selected five bulbs were recorded and then mean weight of bulb was worked out for each replication of all genotypes and expressed in gram (g).

## Yield per plot (kg)

Total bulb yield obtained from the plot was used to calculate the yield of the bulbs in kilograms (kg) per plot including marketable bulbs, unmarketable, splits and doubles, rotted, segregated and premature bolted bulbs after sun drying in field conditions (i.e. field curing). It is expressed in kilograms per plot.

## Yield per hectare (t ha<sup>-1</sup>)

The marketable yield obtained from plot and was used to calculate marketable bulb yield in term of quintal per hectare by sorting out splits, doubles, rotted, unmarketable and premature bolted bulbs after field curing.

## Statistical analysis

The experimental data were subjected to analysis of variance (ANOVA) based on the Randomized Block Design (RBD). All statistical computations were performed using the R-based web application GRAPES 1.1.0 (Gopinath *et al.*, 2020). To evaluate the performance of different genotypes, treatment means were compared using Tukey's Honest Significant Difference (HSD) test at a 5 % significance level ( $P \leq 0.05$ ).

**Table 2:** Morphological and yield performance of 35 white onion genotypes under *kharif* Season.

Sr. No.	Genotypes	Plant height (cm)	Number of leaves per plant	Pseudo stem length (cm)	Pseudo stem width (mm)	Equatorial diameter (cm)	Polar diameter (cm)	Neck thickness (mm)	Average bulb weight (g)	Yield per plot (kg/plot)	Yield per hectare (t/ha)
1	DOGR-2121	46.52 <sup>defghij</sup>	6.73 <sup>abcde</sup>	3.58 <sup>g</sup>	9.40 <sup>klm</sup>	3.51 <sup>cdefghij</sup>	3.51 <sup>efgh</sup>	9.51 <sup>abc</sup>	22.67 <sup>o</sup>	8.47 <sup>op</sup>	14.11 <sup>hij</sup>
2	DOGR-2122	52.55 <sup>bcd</sup>	6.87 <sup>abcde</sup>	5.40 <sup>bcde</sup>	10.80 <sup>defghijklm</sup>	4.53 <sup>abcd</sup>	4.26 <sup>bcde</sup>	11.01 <sup>abc</sup>	39.33 <sup>ghijkl</sup>	9.23 <sup>nop</sup>	16.12 <sup>ghij</sup>
3	DOGR-2123	49.96 <sup>cdefgh</sup>	6.33 <sup>bcde</sup>	4.66 <sup>bcdefg</sup>	11.37 <sup>cdefghijk</sup>	4.33 <sup>abcdef</sup>	3.81 <sup>cdefg</sup>	9.16 <sup>bc</sup>	23.56 <sup>no</sup>	9.75 <sup>mnop</sup>	16.81 <sup>fghij</sup>
4	DOGR-2124	49.60 <sup>cdefgh</sup>	6.87 <sup>abcde</sup>	4.83 <sup>bcdefg</sup>	12.83 <sup>abcd</sup>	4.62 <sup>abc</sup>	4.54 <sup>abcd</sup>	11.45 <sup>abc</sup>	46.00 <sup>cdefgh</sup>	20.40 <sup>abcdef</sup>	26.22 <sup>abcde</sup>
5	DOGR-2125	50.88 <sup>cdefgh</sup>	6.67 <sup>abcde</sup>	5.47 <sup>abcde</sup>	9.89 <sup>ijklm</sup>	3.88 <sup>abcdefghi</sup>	4.02 <sup>bcdef</sup>	8.55 <sup>c</sup>	47.33 <sup>cdefg</sup>	18.40 <sup>cdefghij</sup>	21.00 <sup>bcdefghi</sup>
6	DOGR-2126	47.63 <sup>defghij</sup>	7.47 <sup>abcde</sup>	5.33 <sup>bcde</sup>	10.99 <sup>defghijkl</sup>	4.63 <sup>abc</sup>	4.19 <sup>bcde</sup>	10.69 <sup>abc</sup>	46.33 <sup>cdefg</sup>	18.91 <sup>bcdefghi</sup>	24.85 <sup>abcdefg</sup>
7	DOGR-2127	50.41 <sup>cdefgh</sup>	7.33 <sup>abcde</sup>	5.13 <sup>bcdef</sup>	10.39 <sup>ghijklm</sup>	4.80 <sup>ab</sup>	4.02 <sup>bcdef</sup>	10.97 <sup>abc</sup>	52.83 <sup>bcdef</sup>	12.57 <sup>ijklmnop</sup>	20.96 <sup>bcdefghi</sup>
8	DOGR-2128	46.24 <sup>defghijk</sup>	6.33 <sup>bcde</sup>	5.83 <sup>abcd</sup>	12.18 <sup>abcdefgh</sup>	4.77 <sup>ab</sup>	5.18 <sup>a</sup>	10.35 <sup>abc</sup>	37.83 <sup>ghijklm</sup>	22.51 <sup>abcd</sup>	22.52 <sup>bcdefgh</sup>
9	DOGR-2129	52.80 <sup>bcd</sup>	6.10 <sup>cde</sup>	4.40 <sup>cdefg</sup>	9.66 <sup>ijklm</sup>	3.10 <sup>fghij</sup>	3.05 <sup>ghi</sup>	9.44 <sup>abc</sup>	24.80 <sup>mno</sup>	12.33 <sup>ijklmnop</sup>	20.56 <sup>bcdefghi</sup>
10	DOGR-2130	42.05 <sup>ijk</sup>	5.20 <sup>ef</sup>	4.82 <sup>bcdefg</sup>	7.29 <sup>n</sup>	3.21 <sup>efghij</sup>	4.35 <sup>abcde</sup>	9.75 <sup>abc</sup>	28.89 <sup>ijklmno</sup>	11.55 <sup>klmnop</sup>	19.26 <sup>bcdefghij</sup>
11	DOGR-2131	44.82 <sup>fghijk</sup>	6.40 <sup>bcde</sup>	4.63 <sup>bcdefg</sup>	8.84 <sup>mn</sup>	3.86 <sup>abcdefghi</sup>	4.04 <sup>bcde</sup>	9.93 <sup>abc</sup>	36.33 <sup>ghijklmn</sup>	12.97 <sup>hijklmno</sup>	21.62 <sup>bcdefghi</sup>
12	DOGR-2132	44.71 <sup>ghijk</sup>	3.30 <sup>f</sup>	4.60 <sup>bcdefg</sup>	11.56 <sup>cdefghij</sup>	2.79 <sup>ij</sup>	2.81 <sup>hi</sup>	8.63 <sup>c</sup>	29.33 <sup>ijklmno</sup>	12.53 <sup>ijklmnop</sup>	20.89 <sup>bcdefghi</sup>
13	DOGR-	40.73 <sup>jk</sup>	5.87 <sup>cdef</sup>	5.07 <sup>bcdefg</sup>	9.27 <sup>lmn</sup>	3.36 <sup>defghij</sup>	4.12 <sup>bcde</sup>	9.66 <sup>abc</sup>	28.50 <sup>klmno</sup>	11.10 <sup>klmnop</sup>	18.49 <sup>defghij</sup>

	2133										
14	DOGR-2134	51.71 <sup>cdefg</sup>	8.13 <sup>abcd</sup>	4.47 <sup>cdefg</sup>	11.83 <sup>bcdefghi</sup>	4.88 <sup>a</sup>	4.60 <sup>abcd</sup>	11.65 <sup>abc</sup>	59.00 <sup>bc</sup>	24.40 <sup>abc</sup>	22.78 <sup>bcdefgh</sup>
15	DOGR-2135	47.97 <sup>defghij</sup>	7.40 <sup>abcde</sup>	4.53 <sup>bcdefg</sup>	10.73 <sup>efghijklm</sup>	4.17 <sup>abcdefg</sup>	4.27 <sup>bcde</sup>	10.68 <sup>abc</sup>	43.33 <sup>defghi</sup>	17.45 <sup>defghijk</sup>	25.75 <sup>abcdef</sup>
16	DOGR-2136	46.73 <sup>defghij</sup>	6.47 <sup>abcde</sup>	4.17 <sup>efg</sup>	10.63 <sup>efghijklm</sup>	3.72 <sup>abcdefghij</sup>	3.50 <sup>efgh</sup>	10.42 <sup>abc</sup>	39.00 <sup>ghijkl</sup>	13.75 <sup>ghijklmno</sup>	22.92 <sup>abcdefgh</sup>
17	DOGR-2137	43.88 <sup>hijk</sup>	6.40 <sup>bcde</sup>	5.20 <sup>bcdef</sup>	9.34 <sup>klm</sup>	3.68 <sup>abcdefghij</sup>	3.50 <sup>efgh</sup>	10.06 <sup>abc</sup>	37.96 <sup>ghijklm</sup>	16.03 <sup>defghijklm</sup>	23.39 <sup>abcdefg</sup>
18	DOGR-2138	47.88 <sup>defghij</sup>	7.47 <sup>abcde</sup>	5.00 <sup>bcdefg</sup>	11.69 <sup>cdefghij</sup>	4.84 <sup>a</sup>	4.18 <sup>bcde</sup>	10.99 <sup>abc</sup>	41.33 <sup>efghijkl</sup>	19.58 <sup>abcdefg</sup>	22.64 <sup>bcdefgh</sup>
19	DOGR-2139	46.41 <sup>defghij</sup>	6.92 <sup>abcde</sup>	5.30 <sup>bcdef</sup>	9.28 <sup>lmn</sup>	3.37 <sup>cdefghij</sup>	2.72 <sup>hi</sup>	10.89 <sup>abc</sup>	41.67 <sup>efghijk</sup>	15.47 <sup>efghijklmn</sup>	22.44 <sup>bcdefghi</sup>
20	DOGR-2140	49.47 <sup>cdefgh</sup>	6.80 <sup>abcde</sup>	6.00 <sup>ab</sup>	10.44 <sup>efghijklm</sup>	3.43 <sup>cdefghij</sup>	4.38 <sup>abcde</sup>	9.87 <sup>abc</sup>	34.11 <sup>ghijklmno</sup>	10.40 <sup>lmnop</sup>	17.33 <sup>efghij</sup>
21	DOGR-2141	47.90 <sup>defghij</sup>	5.87 <sup>cdef</sup>	6.94 <sup>a</sup>	10.72 <sup>efghijklm</sup>	2.91 <sup>hij</sup>	2.64 <sup>hi</sup>	10.40 <sup>abc</sup>	25.67 <sup>mno</sup>	6.33 <sup>p</sup>	10.56 <sup>j</sup>
22	DOGR-2142	47.50 <sup>defghij</sup>	6.40 <sup>bcde</sup>	4.97 <sup>bcdefg</sup>	12.73 <sup>abcde</sup>	3.37 <sup>cdefghij</sup>	4.28 <sup>bcde</sup>	12.09 <sup>ab</sup>	54.41 <sup>bcde</sup>	21.85 <sup>abcde</sup>	26.41 <sup>abcde</sup>
23	DOGR-2143	52.25 <sup>bcde</sup>	5.87 <sup>cdef</sup>	5.67 <sup>abcde</sup>	11.93 <sup>abcdefgh</sup>	2.51 <sup>j</sup>	2.41 <sup>i</sup>	9.75 <sup>abc</sup>	41.83 <sup>efghij</sup>	16.68 <sup>defghijkl</sup>	27.79 <sup>abc</sup>
24	DOGR-2144	51.82 <sup>bcdefg</sup>	7.07 <sup>abcde</sup>	4.73 <sup>bcdefg</sup>	10.34 <sup>ghijklm</sup>	3.47 <sup>cdefghij</sup>	4.88 <sup>ab</sup>	11.05 <sup>abc</sup>	28.28 <sup>lmno</sup>	25.28 <sup>ab</sup>	25.47 <sup>abcdef</sup>
25	DOGR-2145	39.02 <sup>k</sup>	5.65 <sup>def</sup>	3.80 <sup>fg</sup>	9.13 <sup>lmn</sup>	3.85 <sup>abcdefghi</sup>	3.75 <sup>defg</sup>	12.72 <sup>a</sup>	40.01 <sup>ghijkl</sup>	14.47 <sup>efghijklmno</sup>	24.12 <sup>abcdefg</sup>
26	DOGR-2146	55.45 <sup>bc</sup>	8.33 <sup>abc</sup>	5.80 <sup>abcd</sup>	12.45 <sup>abcdef</sup>	2.88 <sup>hij</sup>	2.82 <sup>hi</sup>	11.83 <sup>abc</sup>	44.33 <sup>defghi</sup>	15.24 <sup>efghijklmn</sup>	28.07 <sup>ab</sup>
27	DOGR-2147	51.92 <sup>bcdefg</sup>	5.53 <sup>ef</sup>	4.60 <sup>bcdefg</sup>	10.32 <sup>hijklm</sup>	3.57 <sup>bcdefghij</sup>	4.01 <sup>bcdef</sup>	11.44 <sup>abc</sup>	46.67 <sup>cdefg</sup>	25.56 <sup>a</sup>	25.94 <sup>abcdef</sup>
28	DOGR-2148	50.47 <sup>cdefgh</sup>	7.20 <sup>abcde</sup>	5.77 <sup>abcd</sup>	10.24 <sup>hijklm</sup>	3.75 <sup>abcdefghij</sup>	3.15 <sup>efghi</sup>	11.02 <sup>abc</sup>	32.60 <sup>ijklmno</sup>	13.39 <sup>ghijklmno</sup>	22.32 <sup>bcdefghi</sup>
29	DOGR-2149	45.29 <sup>efghijk</sup>	7.33 <sup>abcde</sup>	4.73 <sup>bcdefg</sup>	13.39 <sup>abc</sup>	3.21 <sup>efghij</sup>	3.07 <sup>ghi</sup>	11.10 <sup>abc</sup>	32.90 <sup>hijklmno</sup>	10.27 <sup>lmnop</sup>	13.27 <sup>ij</sup>
30	DOGR-2150	48.29 <sup>cdefghi</sup>	6.33 <sup>bcde</sup>	5.33 <sup>bcde</sup>	11.81 <sup>bcdefghi</sup>	4.07 <sup>abcdefgh</sup>	4.16 <sup>bcde</sup>	9.69 <sup>abc</sup>	41.00 <sup>efghijkl</sup>	14.14 <sup>efghijklmno</sup>	18.56 <sup>defghij</sup>
31	DOGR-2151	45.67 <sup>defghijk</sup>	6.93 <sup>abcde</sup>	5.90 <sup>abc</sup>	10.30 <sup>hijklm</sup>	3.04 <sup>ghij</sup>	3.81 <sup>cdefg</sup>	11.17 <sup>abc</sup>	29.87 <sup>ijklmno</sup>	13.40 <sup>ghijklmno</sup>	18.77 <sup>cdefghij</sup>
32	DOGR-2152	64.30 <sup>a</sup>	9.00 <sup>a</sup>	4.63 <sup>bcdefg</sup>	13.78 <sup>ab</sup>	4.42 <sup>abcde</sup>	4.86 <sup>ab</sup>	12.76 <sup>a</sup>	86.21 <sup>a</sup>	19.24 <sup>abcdefgh</sup>	32.07 <sup>a</sup>
33	DOGR-2153	59.17 <sup>ab</sup>	8.80 <sup>ab</sup>	4.37 <sup>defg</sup>	13.95 <sup>a</sup>	3.90 <sup>abcdefghi</sup>	4.64 <sup>abc</sup>	12.44 <sup>ab</sup>	65.05 <sup>b</sup>	15.00 <sup>efghijklmn</sup>	25.00 <sup>abcdefg</sup>
34	Bhima Safed	52.19 <sup>bcdef</sup>	6.67 <sup>abcde</sup>	4.80 <sup>bcdefg</sup>	11.94 <sup>abcdefgh</sup>	4.23 <sup>abcdefg</sup>	4.22 <sup>bcde</sup>	12.40 <sup>ab</sup>	52.87 <sup>bcdef</sup>	20.46 <sup>abcdef</sup>	24.10 <sup>abcdefg</sup>
35	Bhima Shweta	49.26 <sup>cdefghi</sup>	6.60 <sup>abcde</sup>	4.77 <sup>bcdefg</sup>	12.37 <sup>abcdefg</sup>	4.90 <sup>a</sup>	4.52 <sup>abcd</sup>	10.93 <sup>abc</sup>	55.59 <sup>bcd</sup>	13.23 <sup>ghijklmno</sup>	26.59 <sup>abcd</sup>
	Mean	48.95	6.70	5.01	10.97	3.82	3.89	10.70	41.07	15.50	21.99
	Range	39.02 – 64.30	3.30 – 9.00	3.58 – 6.94	7.29 – 13.95	2.51 – 4.90	2.41 – 5.18	8.55 – 12.76	22.67 – 86.21	6.33 – 25.56	10.56 – 32.07
	SE (m)	1.31	0.46	0.27	0.36	0.22	0.16	0.60	2.36	1.15	1.63
	MSD	7.39	2.58	1.50	2.05	1.25	0.88	3.41	13.33	6.51	9.20

## Result and Discussion

Significant variation was observed among the thirty-five diverse onion genotypes for morphological parameters (Table 2). Plant height recorded at 75 days after planting (DAP) ranged from 39.02 to 64.30 cm, with DOGR-2152 exhibiting the maximum plant height, while the minimum was observed in DOGR-2145. The differences in plant height among the

genotypes can be primarily attributed to genetic variability influencing vegetative growth and adaptation to *kharif* season conditions. Additionally, *kharif*-specific environmental factors, such as temperature fluctuations, rainfall patterns, and soil nutrient availability, along with variations in agronomic management practices, may have contributed to the observed variability. Similar findings highlighting significant genotypic differences

in plant height among onion genotypes were also reported by Ganie *et al.* (2019) and Aswani *et al.* (2023).

Similarly, a wide range was observed for the number of leaves per plant, which varied from 3.30 to 9.00. DOGR-2152 recorded the highest number of leaves per plant (9.00), which was statistically at par with DOGR-2153 (8.80), DOGR-2146 (8.33), and DOGR-2134 (8.13), while the lowest number of leaves per plant was observed in DOGR-2132 (3.30). The variation in leaf number among onion genotypes can be largely attributed to genetic differences influencing leaf production capacity and overall vegetative vigor. During the *kharif* season, environmental factors such as consistent rainfall, high soil moisture, elevated humidity and fluctuating temperatures generally promote vegetative growth; however, challenges like waterlogging, disease incidence and reduced solar radiation due to cloudy conditions may adversely affect photosynthesis and leaf initiation. Consequently, the observed differences reflect the variable stress tolerance and adaptive ability of individual genotypes. Similar observations were reported by Jana *et al.*, (2023).

The pseudo stem length exhibited considerable variation, ranging from 3.58 to 6.94 cm, with DOGR-2141 (6.94 cm) recording the maximum pseudo stem length, while the minimum was observed in DOGR-2121 (3.58 cm). Pseudo stem width varied from 7.29 to 13.95 mm, with DOGR-2153 (13.95 mm) showing the highest value and DOGR-2130 (7.29 mm) the lowest. These results are in agreement with earlier findings reported by Dwivedi *et al.* (2019) and Ganiger *et al.* (2018). The equatorial diameter of bulbs varied from 2.51 to 4.90 cm, with Bhima Shweta (4.90 cm), DOGR-2134 (4.88 cm), and DOGR-2138 (4.84 cm) recording the maximum equatorial diameter, whereas DOGR-2143 (2.51 cm) exhibited the minimum value. The polar diameter ranged from 2.41 to 5.18 cm, with the highest polar diameter observed in DOGR-2128 (5.18 cm), which was statistically at par with DOGR-2144 (4.88 cm), DOGR-2152 (4.86 cm) and DOGR-2153 (4.64 cm). The minimum polar diameter was again recorded in DOGR-2143 (2.41 cm).

During *kharif* conditions, heavy rainfall and intermittent waterlogging adversely affect both equatorial and polar bulb diameters by disrupting root activity, photosynthesis and nutrient translocation, which are essential for bulb enlargement. Prolonged flooding intensifies root decay, accumulation of toxic metabolites and chlorophyll degradation, thereby restricting bulb development (Gedam *et al.*, 2022). The bulb initiation stage (20–30 days after transplanting) is

particularly sensitive to excess moisture, often resulting in smaller bulbs with restricted equatorial growth under flood stress (Ghodke *et al.*, 2018). Furthermore, stagnant water conditions favor the incidence of anthracnose and bulb rot diseases, which impair leaf function and reduce carbohydrate translocation to bulbs, leading to comparatively smaller bulb size than that obtained in other seasons (Gadge and Lawande, 2012). Similar trends were reported by Umamaheshwarappa and Chandrappa (2014).

Neck thickness exhibited notable variation, ranging from 8.55 to 12.76 mm. The minimum neck thickness was recorded in DOGR-2125 (8.55 mm) and DOGR-2132 (8.63 mm), which were at par with DOGR-2123 (9.16 mm), while the maximum neck thickness was observed in DOGR-2152 (12.76 mm) and DOGR-2145 (12.72 mm). Variability in neck thickness may be attributed to genotypic differences and variation in maturity duration, further influenced by excess nitrogen availability, which is known to promote thicker neck formation. Similar observations were reported by Ganie *et al.* (2019) and Gupta *et al.* (2020). The average bulb weight ranged from 22.67 to 86.21 g. The highest average bulb weight was recorded in DOGR-2152 (86.21 g), which was at par with DOGR-2153 (65.05 g) and DOGR-2134 (59.00 g), while the lowest bulb weight was observed in DOGR-2121 (22.67 g). These findings are in close agreement with the results reported by Jana *et al.* (2023).

The yield per plot varied significantly among the genotypes, ranging from 6.33 to 25.56 kg. The highest yield per plot was recorded in DOGR-2147 (25.56 kg), which was statistically at par with DOGR-2144 (25.28 kg) and DOGR-2134 (24.40 kg), while the lowest yield per plot was observed in DOGR-2141 (6.33 kg). The yield per hectare ranged from 10.56 to 32.07 t ha<sup>-1</sup>, with DOGR-2152 (32.07 t ha<sup>-1</sup>) producing the highest yield, followed by DOGR-2146 (28.07 t ha<sup>-1</sup>) and DOGR-2143 (27.79 t ha<sup>-1</sup>), which were at par.

During the *kharif* season, heavy rainfall during the bulb development stage imposes excess moisture stress on onion plants. Although partial physiological recovery may occur once stress conditions subside, yield recovery is often limited, as yield is a complex quantitative trait governed by the interaction of genetic potential, plant architecture and prevailing environmental conditions. The source–sink relationship of individual genotypes plays a decisive role in determining yield performance under moisture stress conditions (Dubey *et al.*, 2021). Furthermore, inter-annual yield variability is strongly influenced by fluctuations in temperature, rainfall distribution, planting time, and pest and disease incidence

(Choudhary *et al.*, 2021). Severe and erratic weather conditions restrict vegetative growth, reduce bulb size, and ultimately result in lower total yield. Comparable yield trends have also been reported by Santra *et al.* (2017), who recorded a yield of 306.42 q ha<sup>-1</sup>, and Sharma *et al.* (2015), who reported yields of 39.64 t ha<sup>-1</sup> in onion under similar agro-climatic conditions.

### Conclusion

The present study revealed substantial genetic variability among the thirty-five onion genotypes evaluated under *kharif* conditions, indicating considerable scope for selection and genetic improvement. The wide variation observed in key morphological traits highlights the importance of vegetative vigor in determining bulb development and overall yield performance. Among the evaluated genotypes, DOGR-2147 and DOGR-2144 were identified as superior for yield per plot, while DOGR-2152 exhibited consistent and superior performance across growth, bulb and yield-related traits, reflecting strong genetic resilience and adaptability to adverse *kharif* environmental conditions. Overall, onion yield was governed by the interactive effects of vegetative growth and bulb attributes and the elite genotypes identified in this study hold significant promise as potential parental lines and candidate varieties for future onion breeding and varietal improvement programs targeting *kharif* season adaptation.

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