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Influence of okra (*Abelmoschus esculentus*) genotypes on growth, yield and biochemical traits

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ABSTRACT

A field experiment was conducted at vegetable research farm of Sher-e-Kashmir University of Agricultural Sciences and Technology of Jammu, Jammu and Kashmir (J&K) during 2019–21 to evaluate the performance of 8 improved genotypes of okra (*Abelmoschus esculentus* L. Moench) and compare them with the popular check genotype in terms of yield attributes and yield, quality and biochemical traits. Among the okra genotype, DOV-44≥Punjab Padmani≥Kashi Kranti produced significantly ($P<0.05$) higher pod weight as compared to the remaining cultivars and recorded an improvement of 10.7–16.4% for pod weight over the local check (Parbhani Kranti). DOV-44 ≥Punjab Padmani ≥Kashi Kranti produced 110.7–120.1% higher okra pod yield over the check (Parbhani Kranti) averaged over the years. Significant positive correlation of yield attributes like days to 50% flowering ($r= 0.5294^*$, $P<0.05$) leaf length ($r= 0.8217^{**}$, $P<0.001$), pod length ($r= 0.6863^*$, $P<0.05$), pod diameter ($r= 0.7866^*$, $P<0.05$) and pod weight ($r= 0.8417^{**}$, $P<0.001$) with okra pod yield also affirmed it better performance as compared to local check. Among the cultivars, chlorophyll A among the cultivars also varied significantly ($P<0.05$) from 7.26 in DOV-88 to 5.13 in Pusa Bhindi-5. Calcium content was observed highest in Kashi Kranti (93.67) ≥ DOV-88 (92.00) and it was 21.5–23.8% higher than local check (Parbhani Kranti). The genetic make-up responsible for higher growth, better physiological and biochemical attributes may help in improving adaptive capacity for achieving optimal productivity. Thus, exploring improved genotypes suitable to J&K ecosystem promises improvement of okra productivity along with maintaining better biochemical traits in the J&K of India and other similar agro-ecological regions.

Keywords: Biochemical traits, Okra, Pigment, Yield attributes

Okra (*Abelmoschus esculentus* [L.] Moench) is an important multi-purpose vegetable crop cultivated and consumed across all tropical and temperate regions of the world. It is polyploid in nature with chromosome no. 2n=8x=72 or 144. Globally, okra is grown in an area of 1.12 million hectare (mha) with a production of 8.71 million tonnes (mt) and 7.8 tonnes/ha productivity. India ranks first in okra production of 6371 thousand tonnes (73.2%) of total world production (NHB 2019). Okra has useful industry and nutritional values. It has good nutritional value due to the presence of vitamins (A, B and C), minerals, calcium, carbohydrate, potassium, proteins and dietary fibre. Okra seeds have recently acquired popularity due to its anti-diabetic qualities by maintaining glucose (Zhang *et al.* 2018). The okra seed protein has balanced proportion of amino acids, like tryptophan and lysine which is quite comparable to that of proteins present in legumes and hence considered important constituent for balanced food. It has good industrial value as the mucilaginous substance extracted from its roots and stems are used to clarify the sugarcane juice in jaggery manufacturing (Pradeep *et al.* 2018). It is cultivated in tropical, subtropical, warm and temperate region as a sole crop or intercrop even in a vertical cropping system to increase production and productivity per unit area (Panwar *et al.* 2021). It is grown throughout the year in some parts of India and is considered as both garden and farm crop (Meena *et al.* 2019). Okra can be grown as early or off season crop (Singh *et al.* 2017) under a polyhouse structure. In spite of being a high-valued crop, little work has been carried out in the aspect of crop improvement which leads to poor yield as well as low productivity. The low productivity of okra might be due to adoption of traditional low yielding genotypes which are susceptibility to various stresses. Therefore, successful okra production depends on availability of suitable and location specific genotypes which can provide a major breakthrough in production and productivity. The foundation of effective crop production is high yield (Biswas *et al.* 2016). High yielding genotypes (HYGs) of okra are widely adopted in other parts of the country, but in the J&K, specific varieties are not available (Kajal *et al.* 2021). It is anticipated that HYGs selected

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from better parents have higher production potential and tolerance to pest and diseases. However, the suitability and performance of these genotypes and their contributing traits are important (Ranga *et al.* 2019). Most of the traits, such as fruit yield per hectare, pod length and pod weight which ultimately influence yield of the variety, differ greatly between genotypes. Okra pod yield is polygenic as it depends on yield associated traits (Vani *et al.* 2021). Keeping these aspects in view, the present investigation was conducted to evaluate high yielding genotypes (HYGs) for better yield and biochemical properties without any yield and quality penalty in the agro-ecological condition of J&K of India.

MATERIALS AND METHODS

The experiment was carried out at Experimental Research Farm I, Sher-e-Kashmir University of Agricultural Sciences and Technology of Jammu, Jammu and Kashmir (32.6^0 N, 74.65^0 E and 336 m amsl altitude) during the rainy (*kharif*) and the spring season of 2019–20 and 2020–21. The climate of vegetable experimental farm at Chatha is subtropical with hot dry summer, hot humid rainy season and cold winter months. The maximum temperature goes up to 45^0 C during summers (May–June) and minimum temperature falls to 1^0C during winter. The mean annual rainfall is about 1000–1200 mm. The experimental material for the present investigation comprised of 8 genotypes obtained from different agricultural institutes namely, PAU-Ludhiana, IARI-New Delhi, IIVR-Varanasi and CSKHPKV-Palampur. The experiment was laid out in Randomized Complete Block Design with three replications at a spacing of 60 cm × 45 cm in a plot size of 3.0 m × 2.0 m. All the recommended cultural practices to raise a healthy crop were followed as per package of practices. The collected data were statistically analyzed. The soluble protein content of the enzyme extract was estimated using the Bradford protein assay (Bradford 1976). Absorbance was read at 595 nm in UV Visible spectrophotometer. The protein content in the sample was expressed in protein/g fresh weight. The experimental site was well managed and free from weeds, diseases, and insect pests' incidences. Titrimetric estimation of ascorbic acid was estimated conventionally by using 2, 6-dichloro phenol indophenol dye solution. The ascorbic acid content was measured according to colorimetric technique using Folin-ciocalteu reagent as suggested by Jagota *et al.* (1982). The estimation of calcium (Ca) content was done according to the method suggested by Rangana (1986). The estimation of chlorophyll a, b and total caretonoids content was calculated as (Lichtenthaler *et al.* 2001):

$$\text{Chlorophyll a, Ca } (\mu g/ml) = 11.87\ A661.6 - 2.42\ A644.8$$

$$\text{Chloropyll b, Cb } (\mu g/ml) = 20.82\ A644.8 - 4.60\ A661.6$$

$$\text{Total Carotenoids, Cc } (\mu g/ml) = 1000\ A470 - 1.86\ Ca - 74.08\ Cb$$

The soil of the experimental site was sandy clay loam in texture, in reaction (*p*H 8.10), medium in organic carbon (4.9 g/kg) (Walkley and Black method), low in available nitrogen (alkaline permanganate N, 226.91 kg/ha), available phosphorus (0.5 m $NaHCO_3$ extractable P method, 15.23 kg/ha) and available potassium (141.12 kg/h, ammonium acetate extractable k using flame photometer method) contents.

Statistical analysis: The data for growth, yield attributes and quality traits were analyzed using analysis of variance (ANOVA) of Randomized Complete Block Design (RCBD) in SPSS v.16 software. Statistical significance was set at an alpha level of 0.05. Means were compared by the least significant difference (LSD) test if the f-value was significant.

RESULTS AND DISCUSSION

Genotypic variation on growth and yield attributes: The preliminary step is to study the variation present among the genotypes by the mean performance of all the characters. Genotypes showed significant difference in plant height at harvest which varied from 91.4–133.3 cm. Maximum plant height of 133.2 cm was recorded with Kashi Kranti followed by DOV-44 (97.8 cm) and minimum plant height of 91.4 cm was recorded with Pusa-A-4 (Table 1). Plant height might be due to the inherent potentiality of okra genotypes which may contribute towards higher yield (Singh *et al.* 2017). Among all the genotypes, DOV-88≥Kashi Kranti≥ Punjab Padmani≥DOV-44 took less days (37.7–41.6 days) to reach 50% flowering and indicated earliness of the genotypes which is a desirable trait, while other genotypes took more days (46.3–53.6) to reach 50% flowering, might be due to genetic architecture of genotypes. Okra leaf length (30.5 cm) and leaf width (30.9 cm) was significantly higher in Kashi Kranti followed by Punjab Padmani and DOV-88. Higher leaf size improves the photosynthesis and enhances the yield attributes and yield. Highest pod length was recorded in Punjab Padmini (19.5 cm) which was at par with DOV-88 (19.1 cm) and Kashi Kranti (18.7 cm) while, lowest was with local check, i.e. Parbhani Kranti (13.1 cm). Pod length varied from 19.5 cm (Punjab Padmini) to 11.5 cm (Pusa-A-4). Punjab Padmini, DOV-88 and Kashi Kranti registered a significant improvement of pod diameter which was 57.1% higher over the local check, i.e. Parbhani Kranti. These findings corroborate the results of Sujata *et al.* (2019) and Kundari *et al.* (2021). In this study, like the other yield attributes, pod weight in okra widely varied among the cultivars. The highest pod weight was recorded in Punjab Padmani and DOV-88 (16.3 g/pod) followed by Kashi Kranti (15.5 g/pod). These genotypes recorded 10.7–16.4% higher pod weight as compared to the local check (Parbhani Kranti, 14.0 g/pod). The variation in pod weight might be due to different growth traits which lead to variations in photosynthesis and finally pod weight. Similar trend in improvement in pod weight was also reported by Kundari *et al.* (2021).

The improvement in growth and yield attributes influenced okra yield. Significant variation in okra pod yield among the 8 cultivars was observed in this experiment. DOV-88 followed by Punjab Padmani and Kashi Kranti produced 110.7–120.1% higher okra pod yield over the local check (Parbhani Kranti). This might be due to more accumulation

Table 1 Genotypic variation on yield attributes and yields of okra (mean of 2 years)

Genotype	Plant height (cm)	Days to 50% flowering	Leaf length (cm)	Leaf width (cm)	Pod length (cm)	Pod diameter (cm)	Pod weight, (g)	Okra yield (q/ha)
DOV-88	131.2	37.7	28.0	31.0	19.1	2.2	16.3	152.3
Kashi Kranti	133.2	38.7	30.5	30.9	18.7	2.1	15.5	148.9
Punjab Padmani	129.4	40.9	30.1	29.1	19.5	2.2	16.3	145.6
VRO-3	101.3	47.7	22.0	22.0	12.1	1.9	14.8	114.7
Pusa Bhindi-5	113.1	53.6	25.0	26.5	15.3	2.0	14.4	87.5
DOV-44	97.8	41.6	21.8	28.6	15.2	1.4	14.9	84.1
Parbhani Kranti	99.7	49.1	18.9	26.4	13.1	1.4	14.0	69.1
Pusa-A-4	91.4	46.3	19.8	21.9	11.5	1.4	14.4	72.5
LSD (P<0.05)	6.5	3.5	4.6	3.4	1.7	0.3	1.3	7.4

of photosynthates in fruits responsible for higher pod weight and pod yield. However, the variation within the genotypes was associated with the genetic makeup and the environment effect (Faisal *et al.* 2021, Kundari *et al.* 2021). Selection of a character increases the chance of selecting the positively correlated traits and rejecting negatively correlated traits (Kundari *et al.* 2021). The formula provided by Al-Jibouri *et al.* (1958) was used to evaluate the correlation coefficient. Significant positive correlation of yield attributes like plant height (r= 0.0.826**, P<0.001), leaf length (r= 0.8217**, P<0.001), pod length (r= 0.6863*, P<0.05), pod diameter (r= 0.7866*, P<0.05) and pod weight (r= 0.8417**, P<0.001) with okra pod yield were estimated (Fig 1). Similar results were noted by Faisal *et al.* (2021) and Kundari *et al.* (2021). These results indicated that genotypic selection could be followed for these traits (Alam *et al.* 2021, Chavan *et al.* 2019). The days to 50% flowering (r= 0.5294*, P<0.05) was found to be negatively correlated with okra yield as increasing days to 50% flowering significantly reduced the okra pod yield. These results also affirmed to Kumari *et al.* (2017) who reported that delayed flowering reduced the yield traits in okra including canopy photosynthesis, conversion of assimilates to biomass and partitioning of assimilates to grain, and higher yield attributing traits (Noopur *et al.* 2021). DOV-88 and Kashi Kranti was found to be best for traits, namely plant height, leaf width, pod diameter, pod weight and okra yield. The results are in line with those of Kundari *et al.* (2021) which help in increasing source to sink ratio (Noopur *et al.* 2019).

Genotypic variation on pigments and biochemical changes: Chlorophyll A content in okra leaf was found to be varied significantly (P<0.05) from 7.26 (DOV-88) to 5.13 (Pusa Bhindi-5) (Table 2). DOV-88 had significantly higher Chlorophyll A content which was 30.9% higher than local check (Parbhani Kranti). These finding also affirmed with Alam *et al.* (2022) who reported that the chlorophyll content

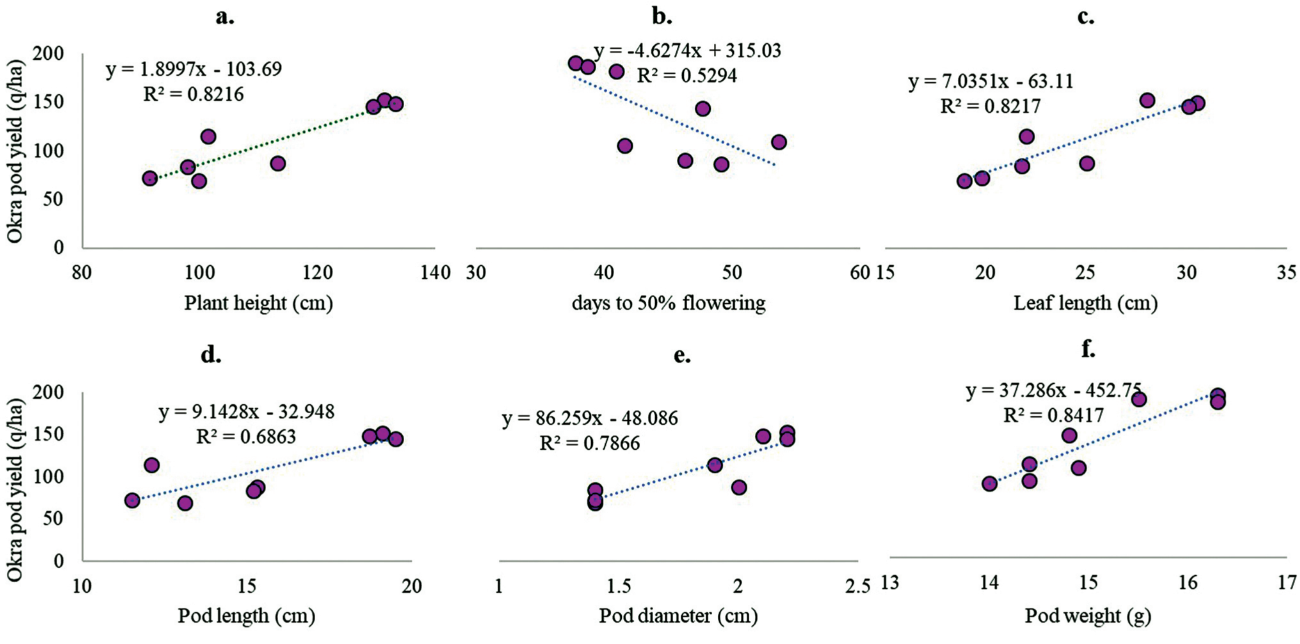

Fig 1 Correlation between yield attributes and yield of okra.

Table 2 Effect of genotype on plant pigments and biochemical changes in Okra (mean of 2 years)

Genotype	Chlorophyll A	Chlorophyll B	Total carotenoids (mg/100 g fresh wt.)	Ascorbic acid (mg/100 g)	Protein (%)	Calcium (mg/100 g)	Iodine (mg/100 g)
DOV-88	7.23	1.49	3.89	83.00	2.96	92.00	1.67
Kashi Kranti	6.06	1.17	3.64	53.44	1.10	93.67	1.45
Punjab Padmani	5.32	0.91	2.81	68.84	2.98	80.67	9.89
VRO-3	6.38	1.22	3.45	58.65	2.42	74.67	1.56
Pusa Bhindi-5	5.13	1.07	4.34	78.39	3.46	85.67	10.32
DOV-44	5.85	1.02	3.33	82.33	2.22	90.33	1.80
Parbhani Kranti	5.52	0.99	3.61	83.67	3.29	75.67	1.47
Pusa-A-4	5.80	1.39	2.05	68.06	2.47	82.00	1.91
LSD (P<0.05)	0.75	NS	NS	10.15	0.52	10.31	0.90

varied from 36.83–14.68 mmol m^2 under agroclimatic zones of Malaysia. However, no significant (P<0.05) differences in Chlorophyll B among the cultivars were recorded. Significant difference in total carotenoids contents was observed which varied from 2.05–4.35 mg/100 g. Highest amount of total carotenoid was recorded in Pusa Bhindi-5 followed by DOV-88 (3.89 mg/100 g). Biswas *et al.* (2016) reported similar trends in ascorbic acid content ranging from 3.35–1.99 mg/100 g. Ascorbic acid varied significantly across the genotypes ranging from 53.44–83.67 mg/100 g. The highest content of ascorbic acid was recorded in Parbhani Kranti (83.67 mg/100 g) followed by DOV-88 (83.00 mg/100 g). While lowest ascorbic acid was observed in Kashi Kranti (53.44 mg/100 g). Similarly, protein content also varied significantly ranging from Pusa Bhindi-5 (3.46%) to Kashi Kranti (1.10%). Highest protein content was recorded in Pusa bhindi-5 (3.46%) followed by Parbhani Kranti (3.29%) and DOV-88 (2.98%). While, calcium content was highest in Kashi Kranti (93.67) followed by DOV-88 (92.00) and it was 21.5–23.8% higher than local check (Parbhani Kranti). Pusa Bhindi-5 (10.32 mg/100 g)≥Punjab Padmani (9.89 mg/100 g) recorded higher iodine content as compared to local check Parbhani Kranti (1.47 mg/100 g). The results were in line with the findings of Habtamu *et al.* (2018). Significant genotypic variation responsible for the expression of biochemical traits in okra cultivars was reported by Adel *et al.* (2019). The genetic make-up responsible for higher growth and better physiological and biochemical attributes may help in improving adaptive capacity for achieving optimal productivity (Noopur *et al.* 2022).

Cultivation of low yielding genotypes of okra is one of the major reasons for low productivity in Jammu and Kashmir. However, replacement of popular local genotypes by high yielding genotypes will depend on pod yield. Present investigation showed that selection of HYGs with emphasis on better yield attributes and biochemical response can improve the productivity. In this study, okra yield was found to be positively correlated with yield attributing traits while Kashi Kranti and Pusa Bhind-5 was found to have maximum pod quality traits. DOV-88, Kashi Kranti and Punjab Padmani genotypes are suitable for the J&K agro-climatic condition. These findings recommend that the adoption of promising genotypes can increase the profitability and production efficiency of okra *vis-à-vis* food and livelihood security in the Eastern Himalaya of J&K.

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