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RESEARCH ARTICLE

Evaluation of chili genotypes for yield and yield attributing traits in two contrasting Indian environments

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Abstract

Capsicum annuum L., commonly known as chili, holds global significance as a widely cultivated species for both culinary and spice purposes. This study sought to identify high-yielding chili and bell pepper varieties adaptable to diverse environments. Twelve genotypes were assessed for seven qualitative and six key quantitative yield-related traits under contrasting conditions: ICAR-IARI, New Delhi, and ICAR-RCER Research Center, Ranchi, Jharkhand utilizing a Randomized Block Design (RBD) with three replications. Pooled Analysis of Variance revealed significant variations among genotypes and between locations for all quantitative traits. Notably, plant height, fruit width, fruit length, days to 50% flowering, days to maturity, and yield exhibited high Genotypic Coefficient of Variation (GCV) and Phenotypic Coefficient of Variation (PCV), coupled with significant heritability and genetic advance. Arka Meghana emerged as the superior genotype under both environmental conditions, displaying the highest fruit length (10.9 cm at Ranchi and 10.6 cm at New Delhi), maximum yield per plant (0.650 kg/plant at Ranchi and 0.57 kg/plant at New Delhi), and the shortest days to 50% flowering (40.6 days at Ranchi and 47 days at New Delhi). These findings contribute valuable insights for optimizing Chili and Bell pepper cultivation practices to enhance yield and quality traits under diverse environmental contexts.

Keywords: *Capsicum annuum* L, Genetic advance, Heritability, Genotypic coefficient of variation, Phenotypic coefficient of variation, yield.

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Introduction

Capsicum annuum L. species, encompassing Chili and Bell peppers, enjoys widespread cultivation globally due to its versatile applications as a vegetable, salad ingredient, pickling item, sauce base, spice, and condiment. Its multifaceted utility establishes it as a commercially significant vegetable. India, being a key player, dominates the global chili market as the primary producer, consumer, and exporter. The vast cultivation area of 7.33 lakh hectares in India represents a substantial 42.81% of the world's chili production, yielding approximately 17.64 lakh tonnes (NHB, 2018-19). Despite its widespread cultivation, chili exhibits pronounced sensitivity to environmental fluctuations, resulting in substantial yield variations across diverse agro-climatic conditions. This inherent trait necessitates the identification or development of phenotypically stable chili genotypes, posing a crucial challenge in breeding programs. Compounded by its tendency for frequent cross-pollination, a wide spectrum of variability exists among chili genotypes. Consequently, subjecting these genotypes to multi-environmental or multi-location trials emerges as a promising avenue for identifying potential genotypes

adaptable to diverse agro-climatic conditions, enabling year-round cultivation.

The present study addresses this need by evaluating twelve chili genotypes in two distinct locations, utilizing various biometrical tools. This approach provides a unique opportunity to assess genotypic and phenotypic performances under different agro-climatic conditions. The outcomes of this research contribute to the identification of potential genotypes adaptable to varied environments, facilitating year-round cultivation practices. Such insights are essential for the sustainable cultivation of *Capsicum annuum* L. and hold promise for advancing chili breeding programs worldwide.

Materials and Methods

Experimental Locations

The research investigation was conducted at two distinct agro-climatic conditions. The first location was the research farm of the Division of Vegetable Science, IARI, New Delhi (28.080N latitude, 77.120E longitude, 228.61 m above MSL, average annual rainfall of 760 mm). This location experiences a sub-temperate and semi-arid climate. The second location was the research plot of ICAR-Regional Complex for Eastern Region (RCER), Regional Research Centre, Ranchi, Jharkhand (23°25′ N latitude, 85°20′ E longitude, 620 m above MSL, average annual rainfall of 1100-1400 mm). Ranchi has a sub-humid and subtropical climate.

Genotypes used

Twelve genotypes were used in the experiment: Arka Meghana (AM), Aparna (AP), Black bullet (BB), Haldi Pada (HP), Kullu Local (KL), Pusa Jwala (PJ), Phule Mukta (PM), PusaSadabahar (PS), Utkal Yellow (UY), WBC Sel-5 (WBC), Bomby (BO), and Orobelle (OBL).

Cropping and Experimental Layout

Sowing was done in June, 2019 at ICAR-IARI, New Delhi, and at ICAR-RCER research centre, Ranchi. Seedlings were transplanted directly onto ridges with a spacing of 60 cm x 45 cm following a Randomized Block Design (RBD) after 30 days of sowing. The Standard Package of practices was adhered to in both the nursery and the main field.

Observations and Recorded Traits

Qualitative and quantitative traits were recorded from five representative plants of each variety. Qualitative traits included fruit color at unripe and ripe stages, fruit-bearing habit, fruit orientation, longitudinal section fruit shape, fruit shape at base and apex, and cross-sectional corrugation of the fruits. Quantitative characters comprised average plant height (cm), fruit length (cm), fruit width (cm), days to 50% flowering, days to fruit maturity and yield plant^{-1}.

Plant height was recorded at the final picking of five randomly chosen competitive plants, while fruit length and fruit width were measured on five randomly selected fruits from the fourth picking.

Data Analysis

The obtained data were subjected to a pooled analysis of variance and estimated important genetic parameters like genetic variability, genetic advance (GA), genotypic coefficient of variation (GCV), phenotypic coefficient of variation (PCV), and heritability (h2) using R software (version 4.3.2). The above biometrical tools were determined to assess the performance and stability of the genotypes under different agro-climatic conditions.

Results and Discussion

A combined analysis of variance is employed to assess interactions and characterize the main effects within and among the various sources of variation. The pooled analysis of variance for yield and yield traits from two environments are presented in Table 1. The mean square of the location, genotype, and genotype by location (G x E interaction) showed significant differences ($p \leq 0.01, 0.05$) for plant height, fruit length, fruit weight, days to 50% flowering, days to maturity and yield, revealing the wide range of variability among the genotypes performance and important role played by the environment in the expression of most traits. G x E interaction was significant for all the traits except yield, which meant that the performance of the genotypes for all of these traits was significantly different under the two environments. Diversity and genetic parameters study of chili in three different locations of Indonesia by Sayekti et al. (2021) also stated that the yield component traits like

Table 1: Analysis of variance for yield and yield component of the chili and bell pepper genotypes tested in 2 locations

Source	*df*	*Mean Square*					
		Plant height	*Fruit length*	*Fruit width*	*Days to 50% flowering*	*Days to maturity*	*Yield plant^{-1}*
Location	1	276.44**	0.037**	0.109**	112.50**	6.13**	0.050**
Rep (Env)	4	25.33**	0.423**	0.006^{ns}	4.736**	6.49**	0.009^{ns}
Genotype	11	829.46**	26.682**	23.309**	210.419**	475.83**	0.050**
G x E	11	111.35**	0.844**	0.035**	20.682**	10.58**	0.006^{ns}
Error	44	24.91**	0.270**	0.019^{ns}	20.691**	5.91**	0.005^{ns}
CV (%)		9.09	8.12	7.85	8.84	2.73	20.83

fruit length, fruit diameter, fruit weight, number of fruits per plant, fruit yield per plant, days to flowering and days to harvest had the significant effect of genotypes, location and G x E.

Mean square values for all the quantitative traits at Ranchi varied widely among the genotypes, such as plant height (37.13 cm in BO to 56.91 cm in KL), fruit length (3.27 cm in BB to 10.9 cm AM), fruit width (0.72 cm in UY to 6.28 cm in OBL), days to 50% flowering (40.6 days in AM to 58.6 days in UY), days to fruit maturity (76.6 days in BO to 102.3 days in WBC),and yield per plant (0.313 kg in WBC to 0.650 kg in AM). Similar variations were observed at New Delhi, with plant height (34 cm in OBL to 68.2 cm in KL), fruit length (3.17 cm in BB to 10.6cm in AM), fruit width (0.67 cm in PJ to 6.07cm in OBL), days to 50% flowering (44.6 days in BO & OBL to 62.6 days in PS), days to fruit maturity (79.3 days in OBL to 105 days in PS) and yield per plant (0.20 kg in WBC to 0.57 kg in AM) (Tables 2 and 3). High variability for quantitative traits like plant height, plant spread, fruit girth, fruit length, average fruit weight, days to initial flowering, days to 50% flowering, No. of fruits/plant, a number of seeds fruits^{-1}, fruit yield plant^{-1} and dry fruit yield plant^{-1}in chili have also been reported by Janaki et al. (2015); Nahak et al. (2018) and Tirupathamma et al. (2021). From all the mean values of yield parameters, it is evident that the quantitative parameters studied were slightly affected by the environment. At Ranchi, the mean maximum temperature in the growing period was 29.5ºC and the minimum temperature was 22 ºC with an average annual rainfall of 168.3 mm. Whereas in New Delhi, the mean maximum temperature in the growing period is varied from 32.2 to 40ºC and minimum temperature from 12.2 ºC to 27.5 ºC with an average rainfall of 152 mm. However, all the factors responsible for the mean value difference cannot be determined. However, this is believed to be connected to the local conditions of temperature, rainfall, and humidity. Flowering and fruit sets are negatively affected by high temperature and humidity accompanied by low rainfall (Wubs et al., 2011). Therefore, the environmental conditions of Ranchi were highly favorable for the growth of chili. Lohiti-iaswa et al., (2000) reported highly significant variations in yield traits like days to initiation of flowering, plant height, number of secondary branches, average fruit weight and number of fruits per plant is due to genotype and environments.

The height of the plant is a key growth parameter relevant to crop management. In the current study, distinct variations in plant height were noted among the different genotypes under each of the environmental conditions studied (Table 2). The genotype Kullu local had the tallest plants in both environments. The pooled analysis showed that the average plant height of Kullu local (71.933 cm) was significantly higher than that of the average plant height of Aparna (66.216 cm) and Black Bullet (65.466 cm). On the other hand, the genotypes Bomby and Orobelle had the lowest plant height with a mean value of 36.183 and 35.7 cm, respectively. The genotypes with the tallest and shortest plant heights did not necessarily have the highest or lowest yields, respectively. This indicates a lack of correlation between plant height and fruit yield. Tembhurne et al. (2008) and Dhaliwal et al. (2015) in their study have also reported a negative correlation between plant height and fruit yield in chili which was further substantiated by the study of Gupta et al. (2009). Nevertheless, some studies have also reported a noteworthy positive correlation between plant height and fruit yield (Kumari et al., 2011) and such variability might be attributed to the diversity in genotypes used in the respective studies.

Fruit length and fruit width are crucial attributes influencing yield and determining consumer acceptance. The genotype Arka Meghana had the longest fruits at both locations. The mean value of the pooled fruit length of Arka Meghana (10.813 cm) was on par with Pusa Jwala (8.426 cm) and Aparna (8.343 cm) and the lowest mean value for fruit length was recorded in Black bullet (3.223 cm). The pooled analysis showed that the maximum fruit width was exhibited by Orobelle (6.176 cm), which is at par with Bomby (5.746 cm) whereas the minimum fruit width was recorded by Utkal Yellow (0.726 cm). Fruit length and fruit width were positively correlated to fruit yield (Table 2). Positive association of fruit length with fruit yield in chili has earlier been reported in a number of studies such as those by Tembhurne et al. (2008), Gupta et al. (2009) and Kumari et al. (2011).

The days required for 50% flowering and maturity after transplantation serve as significant indicators of the crop's earliness, exhibiting significant differences (Table 3). Dahal et al. (2006) found that fruit-bearing habits and fruit orientation indirectly linked to the earliness of the crop. According to the findings, they suggested that the genotypes having erect fruits or those having fruits in clusters required more days to 50% flowering. In the present study, we observed that three varieties i.e., Utkal Yellow with erect/single fruit, Pusa Sadabahar and WBC-Sel-5, both having Erect fruits in clusters, took more days to 50% flowering and days to maturity compared with other varieties with either the pendant fruit orientation or single bearing habit. The pooled analysis showed that the mean value of days to 50% flowering for Utkal yellow, Pusa Sadabahar and WBC sel-5 were 59.166, 58.833 and 56.833 days, respectively, whereas the mean values of days to maturity for WBC Sel-5, Pusa Sadabahar and Utkal Yellow were 102.333 days, 100.833 days and 100.166 days respectively. As per the pooled analysis, minimum days to 50% flowering and days to maturity were recorded in Orobelle (43.16 and 78.16 days), Bomby (47.33 and 78.33 days) and Arka Meghana (43.83 days and 79.33 days).Distinct variations in the mean values of these traits were observed among the same genotypes at two

locations. For example, Arka Meghana exhibited an average of 40.66 days to reach 50% flowering in Ranchi, whereas the corresponding duration was 47 days in New Delhi. The observed values in each of the locations studied as well as the pooled analysis, reveal that not only the genotypic differences but also the G x E interaction accounted for significant variability for these traits. This suggests that the assessed genotypes displayed unique reactions to each specific local environment. Significant G x E interaction for days to 50% flowering in chili genotypes has been reported by Tembhurne and Rao (2013) and Singh et al. (2024).

Achieving a high crop yield is a primary goal in any program focused on enhancing crop quality and productivity. The maximum pooled fruit yield plant^{-1} was exhibited by Arka Meghana (0.604 kg/plant) and was significantly higher than Pusa Sadabahar (0.422 kg/plant) and Utkal Yellow (0.385 kg/plant) (Table 3). While notable variations existed among genotypes within each location and across different locations, the interaction between genotype and environment (G x E) did not demonstrate statistical significance. The superior performance of the genotype Arka Meghana in both environmental conditions stands out. Despite the negative correlation between days to 50% flowering and yield reported in numerous studies (Ajith et al., 2015), the efficient early-stage utilization of photosynthates in Arka Meghana aligns with the findings by Kumar et al. (2018).

Having a greater range of variability in the initial breeding material increases the likelihood of generating desired traits in a crop plant. The results of the genotypic coefficient of variance (GCV), phenotypic coefficient of variation (PCV), broad sense heritability (h^2) and genetic advance for all six characters in two locations are furnished in Tables 4 and 5 and Fig 1. The values of PCV in general, were higher than those of GCV. However, the difference was very narrow, indicating the negligible influence of the environment on the expression of the yield components under study and traits may be governed by non-additive genes. Similarly, chili genotypes exhibiting high PCV and GCV for yield per plant and fruit length (Jyothi et al., 2011), Fruit diameter (Tirupathamma et al., 2021), fruit length, fruit diameter and yield plant^{-1} (Bijalwan and Madhvi, 2016) have also been reported. Days to 50% flowering exhibited substantial environmental influence, as indicated by higher PCV (15.41) than GCV (9.58) at Ranchi environmental conditions, though the values indicated the higher magnitude of variability and scope of their improvement through selection, similar observation for the trait was not reported in New Delhi environmental conditions as the values were in the range of 12.01 for GCV and 12.684 for PCV. Therefore, improvement through selection for such types of traits may sometimes be misleading. These findings were similar to the findings reported by Dhaliwal et al. (2015), where GCV and PCV values for yield-related traits like red fruit yield, fruit length, number of seeds fruits^{-1} and dried seed weight varied across the environment. The remaining yield components like Plant height, fruit length, days to maturity, yield plant^{-1}, and fruit width showed a decreasing level of environmental influence. In the current study, fruit width exhibited the highest GCV and PCV values, indicating the greater diversity for the trait. At the same time, days to 50% flowering and days to maturity displayed the least variation under both environmental conditions, suggesting lesser variability for the traits compared to other traits.

The product of the genetic coefficient of variation (GCV) and the selection differential provides an estimate of the utmost effectiveness achievable through selection, while heritability signifies the degree of proximity to the desired goal (Singh et al., 1968). High heritability estimates (Tables 4 and5) were observed for all quantitative traits at Ranchi except for days to 50% flowering (38.65%), with fruit width exhibiting the highest heritability (99.10%). In contrast, at New Delhi, days to 50% flowering showed high heritability (89.63%), along with fruit width (99.9%). Yield plant^{-1} heritability was 80.5% at Ranchi and 82.23% at New Delhi. In Previous studies by Shirshat et al. (2007), Ajith et al. (2015), Nahak et al. (2018) and Tirupathamma et al. (2021) also reported high heritability for quantitative traits like plant height, fruit length, fruit width, days to 50% flowering, days to maturity and yield plant^{-1}in chili genotypes. Less heritability for days to 50% flowering in Ranchi indicates that the variation observed was mainly due to the environment and selection based on this trait might be misleading.

The combination of heritability estimates and genetic advance is more valuable than relying solely on heritability values when predicting the selection of superior individuals (Johnson et al. 1955) because of the presence of both additive and epistatic effects in broad sense heritability. A favorable condition for establishing selection criteria involves the presence of both high heritability and high genetic advance (Allard, 1960). Genetic advance, indicative of genetic gain through selection, varied across traits (Tables 4 and 5). Plant height displayed the highest genetic advance with the values 21.28 and 25.37 at Ranchi and New Delhi, respectively, followed by days to maturity (18.88 at Ranchi and 16.37 at New Delhi). In contrast, yield plant^{-1} exhibited the lowest genetic advance with the value 0.17 at Ranchi and 0.16 at New Delhi. Low genetic advance was reported for fruit length, fruit width, and days to 50% flowering at Ranchi. In New Delhi, the value for days to 50% flowering was low (12.34). Heritability for this trait was moderate to high in the New Delhi location, suggesting the non-additive gene action is responsible for the expression of the trait. However, days to maturity were one such trait in the current study where high heritability, as well as high genetic advance, is reported. So, direct selection through these characters will

Table 2: Average performances of chili and bell pepper genotypes for plant height, fruit length and fruit width component traits across two environments.

Genotypes	*Plant Height*			*Fruit Length*			*Fruit Width*		
	Ranchi	*New Delhi*	*Mean*	*Ranchi*	*New Delhi*	*Mean*	*Ranchi*	*New Delhi*	*Mean*
Arka Meghana	65.133^{bc}	58.400^{bc}	61.766^{bc}	11.393^{a}	10.633^{a}	10.813^{a}	1.193^{c}	1.107^{d}	1.150^{d}
Aparna	70.200^{ab}	62.233^{b}	66.216^{ab}	8.287^{b}	8.400^{b}	8.343^{b}	0.987^{cd}	1.073^{d}	1.0300^{de}
Black Bullet	62.800^{bc}	68.133^{a}	65.466^{b}	3.273^{g}	3.173^{h}	3.223^{g}	1.780^{b}	1.793^{c}	1.786^{c}
Haldi Pada	59.467^{cd}	57.167^{bc}	58.316^{cd}	5.567^{cde}	6.807^{d}	6.186$_{d}$	0.760^{d}	0.780^{fg}	0.770^{f}
Kullu Local	75.667^{a}	68.200^{a}	71.933^{a}	7.713^{b}	7.247^{c}	7.480^{c}	1.000^{cd}	0.780^{fg}	0.890^{ef}
Pusa Jwala	50.133^{de}	49.367^{d}	49.750^{e}	8.280^{b}	8.573^{b}	8.426^{b}	0.813^{d}	0.673^{h}	0.743^{f}
Phule Mukta	64.867^{bc}	40.800^{e}	52.833^{de}	6.473^{c}	5.793^{ef}	6.133^{d}	0.847^{d}	0.773^{g}	0.810^{f}
Pusa Sadabahar	56.867^{cde}	53.907^{cd}	55.386^{de}	6.467^{c}	5.507^{f}	5.986^{de}	0.820^{d}	0.867^{e}	0.843^{f}
Utkal Yellow	55.800^{cde}	68.000^{a}	61.90^{bc}	4.473^{ef}	5.913^{e}	5.193^{f}	0.720^{d}	0.733^{gh}	0.726^{f}
WBC Sel 5	46.933^{ef}	39.800^{e}	43.366^{f}	3.840^{fg}	3.493^{g}	3.666^{g}	0.807^{d}	0.860^{ef}	0.833^{f}
Bomby	37.133^{f}	35.233^{ef}	36.183^{g}	5.273^{de}	5.873^{e}	5.511^{ef}	5.967^{a}	5.527^{b}	5.746^{b}
Orobelle	37.333^{f}	34.067^{f}	35.700^{g}	6.033^{cd}	5.680^{ef}	5.856^{de}	6.280^{a}	6.073^{a}	6.176^{a}
Mean	56.86^{a}	52.95^{b}	54.901	6.422	6.424	6.401	1.83	1.753	1.792

Table 3: Average performances of Chili and bell pepper genotypes for days to 50% flowering, days to maturity and yield plant-1, component traits across two environments.

Genotypes	Days to 50% flowering			Days to Maturity			Yield		
	Ranchi	New Delhi	Mean	Ranchi	New Delhi	Mean	Ranchi	New Delhi	Mean
Arka Meghana	40.66^{d}	47.000^{ef}	43.833^{cd}	78.000^{d}	80.667^{efg}	79.333^{f}	0.638^{a}	0.570^{a}	0.604^{a}
Aparna	46.333^{cd}	51.000^{c}	48.666^{bc}	88.333^{b}	88.000^{d}	88.166^{cd}	0.380^{bcd}	0.290^{cd}	0.335^{bc}
Black Bullet	56.000^{abc}	58.333^{b}	57.166^{a}	91.000^{b}	88.667^{d}	89.833^{c}	0.296^{cd}	0.323^{cd}	0.309^{cd}
Haldi Pada	50.000^{abcd}	49.667^{cde}	49.833^{b}	87.000^{bc}	87.333^{d}	87.166^{cd}	0.357^{bcd}	0.320^{cd}	0.338^{bc}
Kullu Local	47.667^{bcd}	47.333^{def}	47.500^{bcd}	88.667^{b}	83.000^{ef}	85.833^{de}	0.329^{cd}	0.313^{cd}	0.321^{c}
Pusa Jwala	46.000^{cd}	50.667^{cd}	48.333^{bcd}	83.333^{c}	83.333^{e}	83.333^{e}	0.317^{cd}	0.283^{d}	0.300^{cd}
Phule Mukta	57.000^{ab}	57.000^{b}	57.000^{a}	97.667^{a}	95.667^{c}	96.666^{b}	0.421^{bc}	0.283^{d}	0.352^{bc}
Pusa Sadabahar	55.000^{abc}	62.667^{a}	58.833^{a}	101.667^{a}	100.000^{ab}	100.833^{a}	0.499^{ab}	0.347^{cd}	0.422^{b}
Utkal Yellow	58.667^{a}	59.667^{ab}	59.166^{a}	102.000^{a}	98.333^{bc}	100.166^{a}	0.441^{bc}	0.330^{cd}	0.385^{bc}
WBC Sel 5	53.667^{abc}	60.000^{ab}	56.833^{a}	102.333^{a}	102.333^{a}	102.333^{a}	0.248^{d}	0.200^{e}	0.224^{d}
Bomby	50.000^{abcd}	44.667^{f}	47.333^{bcd}	76.667^{d}	80.000^{fg}	78.333^{f}	0.407^{bcd}	0.353^{c}	0.380^{bc}
Orobelle	41.667^{d}	44.667^{f}	43.166^{d}	77.000^{d}	79.333^{g}	78.166^{f}	0.337^{bcd}	0.423^{b}	0.380^{bc}
Mean	50.22^{b}	52.72^{a}	51.472	89.4^{a}	88.88^{b}	89.180	0.389^{a}	0.336^{b}	0.362

Table 4: Genotypic coefficient of variation (GCV), Phenotypic coefficient of variation (PCV), heritability (H2) and Genetic advance (GA) in 12 genotypes of chili evaluated at Ranchi.

Trait	*GCV (%)*	*PCV (%)*	*H^2*	*GA*
Plant height	20.404	23.134	0.778	21.080
Fruit Length	33.589	35.388	0.900	4.189
Fruit Width	110.496	110.996	0.991	4.149
Days to 50% flowering	9.580	15.410	0.386	6.162
Days to maturity	10.695	11.164	0.917	18.886
Yield	22.401	33.895	0.436	0.118

Table 5: Genotypic coefficient of variation (GCV), Phenotypic coefficient of variation (PCV), heritability (H2) and Genetic advance (GA) in 12 genotypes of chili evaluated at New Delhi.

Trait	*GCV (%)*	*PCV (%)*	*H^2*	*GA*
Plant height	24.069	24.900	0.934	25.375
Fruit Length	32.666	32.798	0.992	4.305
Fruit Width	109.328	109.366	0.999	3.947
Days to 50% flowering	12.009	12.684	0.896	12.348
Days to maturity	9.182	9.428	0.948	16.373
Yield	25.915	28.513	0.826	0.163

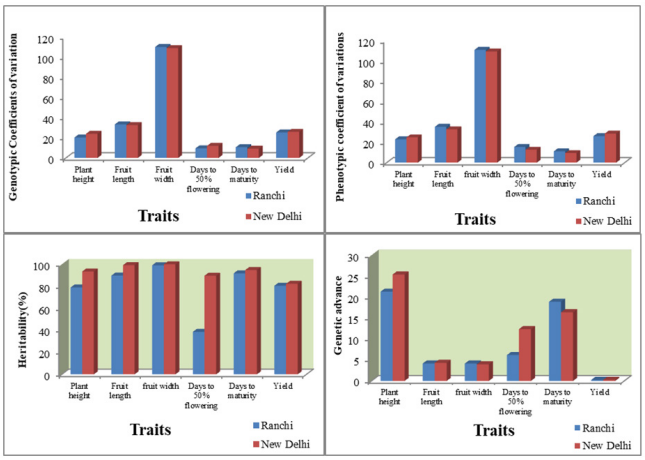

Figure 1: Comparison of GCV, PCV, genetic advance and heritability between genotypes under study at ICAR-RCER Research Centre, Ranchi and IARI, New Delhi

be effective in the improvement of chili. However, yield plant^{-1} showed high heritability and low genetic advance at both locations. Similar findings were reported in chili by Pandiyaraj et al. (2017) for days to first flowering, Shirshat et al. (2007) for fruit length and yield per plant and Pujar et al. (2017) for plant height, fruit length and fruit girth. When there is a high heritability accompanied by low genetic advance, it suggests that non-additive gene effects play a significant role. This situation implies that rather than opting for direct selection, it may be more effective to consider heterosis breeding (Nahak et al., 2018).

Qualitative traits and environmental influence

Qualitative traits demonstrated minimal environmental influence but exhibited variation among genotypes within each environment. Traits such as solitary fruit-bearing habit (83%), pendent fruit orientation (75%), medium red ripened fruit color (42%), narrowly triangular longitudinal fruit shape (58%), acute fruit shape at apex (75%), round fruit shape at cross-sectional corrugation (83%), acute fruit shape at base (58%) and narrowly triangular longitudinal fruit shape (58%) were frequently observed across genotypes within the same environment. Similar results on qualitative traits of chili were also stated by Sran et al. (2021), wherein fruit-bearing habit, fruit shape at apex and base and fruit curvature were found to be important for varietal identification. These results underscore the significant variations in quantitative traits among genotypes under different environmental conditions, highlighting the importance of selecting adaptable genotypes for diverse agro-climatic regions.

Conclusion

In conclusion, this study underscores the pivotal role that environmental conditions play in shaping the quantitative traits of chili genotypes. Arka Meghana's consistently superior performance, possibly attributed to its efficient utilization of photosynthates during the early growth stage, positions it as a promising candidate for future breeding programs. The study accentuates the imperative consideration of environmental factors in the design and execution of chili breeding initiatives. Furthermore, the heritability estimates and genetic advance values provided valuable insights into the underlying genetic mechanisms governing the studied traits. Most of the traits studied were governed by non-additive gene action. This information contributes to a nuanced understanding of the genetic basis of key traits in chili plants. The study's findings not only offer practical implications for ongoing chili breeding efforts but also lay the foundation for future research endeavors.

Conflict of interest

The authors have no conflict of interest to declare.

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सारांश

कैप्सिकम एन्यूअम एल., जिसे चिल्ली के रूप में सामान्य रूप से जाना जाता है, पाकऔरमसालादोनोंउद्देश्यों के लिए व्यापक रूप से उत्पादित की जाने वाले प्रजातियों के रूप में वैश्विक महत्व रखती है। इस अध्ययन का उद्देश्य विभिन्न परिस्थितियों के लिए अनुकूलनीय उच्च उत्पादक चिल्ली और बेल पेपर जातियों की पहचान करना था। बारह जेनोटाइप्स का, तीन पुनरावृत्तियों के साथ एक यादृच्छिक ब्लॉक डिज़ाइन (आरबीडी) का उपयोग करके, सात गुणात्मक और छह मुख्य मात्रात्मक उत्पादन संबंधी विशेषताओं के लिए विपरीत परिस्थितियों के अंतर्गत, आईसीएआर-आईएआरआई, नई दिल्ली, और आईसीएआर-आरसीईआर अनुसंधान केंद्र, रांची, झारखंड में मूल्यांकन किया गया । विभाजन के समरूप विश्लेषण ने सभी मात्रात्मक गुणों के लिए जेनोटाइप्स और स्थानों के बीच महत्वपूर्ण अंतर दिखाया। विशेष रूप से, पौधे की ऊचाई, फल की चौड़ाई, फल की लंबाई, 50% फूल आने के दिन, परिपक्वता के दिन, और उत्पादन ने उच्च जीनोटाइपिक भिन्नता गुणांक (जीसीवी) और फेनोटाइपिक भिन्नता गुणांक (पीसीवी) को प्रदर्शित किया, जो महत्वपूर्ण विरासती और आनुवंशिक प्रगति के साथ संबंधित था। अर्का मेघना दोनों पर्यावरणीय स्थितियों के तहत उत्कृष्ट जेनोटाइप के रूप में प्रकट हुआ, जिसने सबसे अधिक फल की लंबाई (रांची में 10.9 सेमी और नई दिल्ली में 10.6 सेमी), प्रति पौधे में अधिकतम उत्पादन (रांची में 0.650 किलोग्राम प्रति पौधा और नई दिल्ली में 0.57 किलोग्राम प्रति पौधा), और 50% फूल आने के लिए सबसे कम दिन (रांची में 40.6 दिन और नई दिल्ली में 47 दिन) प्रदर्शित किए। यह खोज विभिन्न पर्यावरणीय संदर्भों के तहत चिल्ली और बेल पेपर उत्पादन के गुणवत्ता और गुणों को बढ़ाने के लिए महत्वपूर्ण दर्शन प्रदान करती हैं।