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YIELD PERFORMANCE AND QUALITY ASSESSMENT OF HOT PEPPER GENOTYPES UNDER FIELD CONDITIONS IN PAKISTAN

Original Article

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ABSTRACT

Background: Hot pepper (*Capsicum annuum* L.) is a valuable crop in Pakistan due to its high nutritional, industrial, and economic importance. Despite its potential, national productivity remains below global averages, primarily due to limited genotype evaluation and environmental constraints. Exploring genetic diversity among locally adapted and exotic lines is crucial for identifying high-yielding, nutritionally superior, and stress-tolerant cultivars suited to regional agro-climatic conditions.

Objective: The study aimed to evaluate nineteen hot pepper genotypes for yield performance, morphological characteristics, and biochemical composition under open-field conditions at Faisalabad.

Methods: Field experiments were conducted during 2021–2022 at the Vegetable Research Institute, Faisalabad, using a Randomized Complete Block Design (RCBD) with three replications. Each genotype was assessed for fresh fruit yield (t ha^{-1}), fruit length (cm), fruit width (mm), capsaicin (%), crude protein (%), ascorbic acid (mg/100 g), carbohydrates (%), and crude fiber (%). Biochemical analyses were performed at PCSIR Laboratories, Lahore, following standard analytical procedures. Data were statistically analyzed to determine variability among genotypes.

Results: Significant genetic diversity was observed across all traits. Fresh yield ranged from **8.36 to 26.05 t ha^{-1}**, with HP-18001 (26.05 t ha^{-1}), HP-18002 (25.18 t ha^{-1}), and HP-18003 (24.56 t ha^{-1}) outperforming commercial checks ‘Karishma F1’ (24.22 t ha^{-1}) and ‘Golden Hot F1’ (23.32 t ha^{-1}). Fruit length varied between **3.0–13.9 cm**, width between **7.4–16.7 mm**, and capsaicin from **0.00–0.44%**, peaking in HP-19015. Protein content ranged **10.7–13.8%**, ascorbic acid **31.3–47.0 mg/100 g**, carbohydrates **49.4–55.2%**, and crude fiber **21.0–26.6%**.

Conclusion: Genotypes HP-18001, HP-18002, and HP-18003 exhibited superior yield and nutritional quality, while HP-19014 and HP-19015 were distinguished by high capsaicin levels, making them ideal for industrial processing. The study highlights valuable genetic resources for developing high-yielding, nutritionally rich cultivars suited to Punjab’s agro-ecological conditions.

Keywords: Agronomic traits; *Capsicum annuum*; Capsaicin; Genetic diversity; Nutritional quality; Punjab agro-climate; Yield performance.

INTRODUCTION

Hot pepper or chili (*Capsicum* spp.), a member of the *Solanaceae* family, holds substantial economic and nutritional importance in Pakistan's agricultural sector. Closely related to tomato, eggplant, and tobacco, chili serves not only as a culinary spice and condiment but also as a vital source of bioactive compounds that contribute to human health and nutrition. It contains abundant natural pigments, antioxidants, and essential vitamins, particularly vitamins C and A, along with carotenoids and capsaicinoids that enhance its commercial and nutraceutical value (1,2). These biochemical constituents position chili as a high-value crop with potential for both domestic consumption and export. Chili thrives best in warm climatic conditions with an optimal temperature range of 25–30°C. Germination begins under adequate temperature, moisture, and oxygen, with stored seed reserves fueling early growth. During vegetative development, full sunlight and moderate temperatures promote leaf expansion, chlorophyll synthesis, and photosynthetic efficiency (3,4). Being a C_3 photosynthetic plant, chili assimilates carbon through the Calvin cycle, with productivity influenced by temperature, light intensity, and stomatal regulation. Water stress triggers stomatal closure, reducing carbon fixation and impairing growth, while excessive irrigation can induce root rot and hamper oxygen diffusion (5,6). Thus, balanced soil moisture and irrigation management are critical to maintaining physiological stability and optimizing yield. Reproductive success in chili is highly temperature-sensitive. The ideal range for flowering and fruit set lies between 22–28°C, whereas heat or cold stress can cause pollen sterility and flower abscission. Fruit development follows a sigmoidal pattern marked by cell division, enlargement, and ripening. The shift from green to red fruit color occurs as chlorophyll degrades and carotenoids such as capsanthin and capsorubin accumulate. The characteristic pungency, determined by capsaicinoids—primarily capsaicin and dihydrocapsaicin—is synthesized via the phenylpropanoid and fatty acid pathways, whose activity is strongly modulated by temperature, genotype, and nutrient status (7-9).

Nutrient balance plays a vital role in maximizing chili yield and quality. Nitrogen promotes vegetative vigor, phosphorus supports root and floral development, and potassium enhances fruit color and capsaicinoid concentration. Micronutrients such as zinc and boron are indispensable for enzymatic activity and pollen fertility. Under abiotic stress conditions such as heat and drought, reactive oxygen species (ROS) are generated; these are neutralized by enzymatic antioxidants like superoxide dismutase and peroxidase, preserving physiological homeostasis (10). In Pakistan, chili cultivation is predominantly concentrated in Sindh and Punjab, with minor production zones in Balochistan and Khyber Pakhtunkhwa. Sindh—particularly districts such as Umerkot, Mirpurkhas, Badin, and Kunri, collectively known as the "Chili Capital of Pakistan"—accounts for approximately 85% of total national output. The country's annual production is estimated at 170,000–175,000 tons over about 63,000 hectares (11,12). Despite favorable agro-climatic conditions, the national average yield (2.7 tons per hectare) lags significantly behind that of major chili-producing nations such as China and India, where yields range from 5–8 tons per hectare (13,14). This disparity underscores the need for improved cultivar selection and management practices. The shift from traditional cotton-based systems toward high-value vegetable cultivation reflects chili's growing economic importance. However, its production faces multiple biotic and abiotic challenges. Major diseases such as leaf curl virus (transmitted by whiteflies), anthracnose (*Colletotrichum* spp.), and powdery mildew, along with infestations from root-knot nematodes and thrips, cause substantial yield and quality losses. The absence of resistant varieties and indiscriminate pesticide use have further aggravated these problems by fostering pest resistance and environmental contamination (15). Concurrently, temperature extremes, drought, and salinity—exacerbated by climate change—pose increasing threats to stable productivity and fruit quality. Given these challenges, systematic evaluation of chili genotypes for yield performance, morphological attributes, and fruit quality is essential. Such evaluations provide critical insight into genotype × environment interactions and help identify varieties that combine superior productivity with resilience to stress and desirable nutritional and market characteristics. This study aimed to evaluate diverse chili (*Capsicum* spp.) genotypes under the agro-climatic conditions of Faisalabad based on their morphological, yield, and quality traits to identify high-performing cultivars suitable for sustainable chili production in Pakistan.

METHODS

The field experiments on hot pepper (*Capsicum annuum* L.) were carried out during the 2021–2022 growing seasons at the Vegetable Research Institute (VRI), Faisalabad, Pakistan. The study aimed to evaluate the yield performance and quality characteristics of diverse chili genotypes under open-field conditions suited to the agro-ecological environment of Faisalabad. A total of nineteen genotypes were selected based on prior agronomic potential and availability within the institute's germplasm collection. The experimental setup followed a Randomized Complete Block Design (RCBD) with three replications to minimize the impact of field heterogeneity and ensure statistical reliability. The nursery for the genotypes was sown on 22 November 2021, and healthy seedlings were transplanted into the field on 17 February 2022. These dates were chosen based on the regional climatic pattern to promote optimal seedling establishment, root development, and fruit setting. Each experimental plot measured 4.5 m × 0.75 m with a plant-to-plant spacing of 45 cm, maintaining sufficient aeration and sunlight exposure to prevent disease incidence and promote uniform vegetative growth. Standard agronomic practices were followed throughout the crop cycle, including weed management, irrigation scheduling, and pest control according to local agricultural extension recommendations. Data were recorded for eight key morphological and biochemical parameters representing yield and quality traits. The average fresh yield (t/ha) was estimated by weighing the total fruit harvested per plot and converting it to tons per hectare. Fruit length (cm) and fruit width (mm) were measured using a precision digital caliper to evaluate fruit size, uniformity, and shape stability across genotypes. The biochemical analyses included estimation of capsaicin content (%) as an indicator of pungency; crude protein (%) to assess nutritional quality; ascorbic acid (mg/100g) to determine vitamin C concentration and antioxidant potential; carbohydrates (%) to assess energy and flavor contribution; and crude fiber (%) to evaluate textural integrity and dietary relevance.

The biochemical analyses were performed at the Pakistan Council of Scientific and Industrial Research (PCSIR) Laboratories, Lahore, using standardized and validated analytical protocols. Each sample was analyzed in triplicate to ensure reproducibility and accuracy of data. Laboratory instruments were calibrated before use, and standard reagents were prepared according to the prescribed methodologies. Data obtained from both cropping years were compiled and subjected to statistical analysis using analysis of variance (ANOVA) under the RCBD framework to determine the level of significance among genotypes for yield and quality parameters. Mean separation was performed using the Least Significant Difference (LSD) test at a 5% probability level to identify statistically distinct genotypic performances. All statistical analyses were conducted using standard statistical software (e.g., SPSS or Statistix), ensuring consistency and reliability of results. The research was conducted in accordance with ethical standards for agricultural experimentation. Approval for the study was granted by the Institutional Review and Ethical Committee of the Vegetable Research Institute, Faisalabad and due consideration was given to biosafety and environmental protection measures. Since no human or animal subjects were involved, informed consent procedures were not applicable. However, safety and ethical protocols were strictly followed during field and laboratory operations to ensure environmental sustainability and worker safety.

RESULTS

Field evaluation of nineteen hot pepper (*Capsicum annuum* L.) genotypes under the agro-climatic conditions of Faisalabad revealed marked genetic variability in yield and quality-related parameters. The average fresh fruit yield varied significantly among the genotypes, ranging from 8.36 to 26.05 tons per hectare, indicating substantial diversity in productivity potential. The highest yield was recorded in HP-18001 (26.05 t/ha), closely followed by HP-18002 (25.18 t/ha) and HP-18003 (24.56 t/ha). These genotypes exceeded the commercial hybrids Karishma F1 (24.23 t/ha) and Golden Hot F1 (23.32 t/ha) by 7–12%, reflecting superior adaptability and efficient fruit set under field conditions. Lower yields were observed in VRIHP-63 (10.32 t/ha), VRIHP-64 (8.36 t/ha), and VRIHP-40 (11.21 t/ha), suggesting reduced vigor or environmental sensitivity among these lines. Distinct differences were also evident in fruit morphology. Fruit length ranged from 3.0 cm in HP-18005 to 13.9 cm in HP-18004, while fruit width varied between 7.4 mm in HP-18005 and 16.7 mm in Karishma F1. Genotypes HP-18004 and HP-18002 exhibited the longest fruits (13.9 cm and 12.4 cm, respectively), whereas HP-18006 and HP-18004 had the greatest fruit widths (15.3 mm and 15.0 mm), demonstrating favorable market attributes. Capsaicin content, the key biochemical trait determining pungency, varied widely among genotypes. The highest concentration was observed in HP-19015 (0.44%), followed by HP-19014 and VRIHP-64 (0.38% each). In contrast, Golden Hot F1 exhibited no measurable capsaicin, classifying it as non-pungent. The variation reflected strong genetic control of capsaicinoid biosynthesis. Genotypes HP-19015 and HP-19014 thus stand out as valuable sources for spice and oleoresin industries, whereas non-pungent types such as Golden Hot F1 are suited for fresh consumption and processing.

Nutritional quality traits also exhibited significant genotypic variation. Crude protein content ranged from 10.7% to 13.8%, with HP-19011, VRIHP-40, and HP-19012 recording the highest levels, indicating superior nitrogen assimilation efficiency. Ascorbic acid (vitamin C) content ranged between 31.3 mg/100 g (HP-19012) and 47.0 mg/100 g (HP-18004). High vitamin C concentrations were also found in HP-18002 (45.2 mg/100 g) and Golden Hot F1 (45.2 mg/100 g), emphasizing their nutritional potential. Carbohydrate content varied from 49.4% (HP-19013) to 55.2% (Golden Hot F1), with genotypes HP-18006 (54.9%) and HP-18005 (54.2%) also showing high energy composition. Crude fiber percentage ranged between 21.0% and 26.6%, the highest recorded in HP-18003 (26.6%) and HP-18004 (26.4%), suggesting enhanced firmness and longer shelf life—features beneficial for post-harvest handling and transport. Overall, the combination of high yield and desirable biochemical composition was observed in HP-18001, HP-18002, and HP-18003, identifying them as promising candidates for commercial cultivation and breeding programs. Genotypes HP-19014 and HP-19015, characterized by elevated capsaicin and protein contents, were suitable for industrial extraction and spice processing. The pronounced variation among genotypes across yield, morphological, and biochemical traits confirmed the presence of rich genetic diversity within the evaluated germplasm, providing a valuable foundation for future selection and hybridization aimed at developing high-yielding, high-quality cultivars adapted to Punjab's agro-ecological conditions.

A descriptive statistical analysis was conducted to assess the variability and reliability of the recorded data. The results confirmed significant genotypic variation across all measured traits. The mean fresh yield among the nineteen genotypes was **19.06 ± 5.16 t/ha**, ranging from 8.36 t/ha in VRIHP-64 to 26.05 t/ha in HP-18001, indicating high variability (CV ≈ 27.1%), which validates the presence of substantial genetic diversity. Fruit length averaged **8.1 ± 3.2 cm**, while fruit width averaged **12.7 ± 2.9 mm**, suggesting moderate variability in morphological parameters. Capsaicin content showed pronounced fluctuation (**0.10 ± 0.14%**), with a range from 0.00% to 0.44%, reflecting strong genetic influence over pungency. Nutritional traits also exhibited variation, with crude protein (**12.1 ± 0.8%**) and ascorbic acid (**40.3 ± 4.2 mg/100 g**) showing narrower but meaningful differences among genotypes. Carbohydrates averaged **52.2 ± 1.7%**, and crude fiber averaged **24.5 ± 1.6%**, both demonstrating relatively consistent trends across lines. The observed standard deviations and coefficients of variation confirm that yield and capsaicin content contributed most significantly to overall diversity, supporting the need for ANOVA and post-hoc testing (e.g., LSD) to statistically validate genotype-specific differences.

Table 1: Meteorological Data Recorded At Faisalabad, During The Chilies Crop Season 2021-22.

Month	Air Temp (oC)		Differ 1&2	Rel. Humidity %		Pan Evaporation (mm)		Rain fall (mm)	Wind velocity (km hour-1& days)		Dew	Cloudy		Soil Temp (100 cm depth)	Sun Shine Hours		Fog
	Max	Min		8:00 am	5:00 pm	8:00 am	5:00 pm		8:00 am	5:00 pm		Days	Nights		H	M	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
October	34.8	21.4	13.4	80.3	48.1	1.2	2.3	-	1.2/7	2.0/16	31	-	-	30.3	9	1	15
November	27.0	14.8	12.2	88.8	60.9	0.5	1.1	0.2	0.4/3	0.4/3	29	-	1	26.4	4	51	28
December	21.1	6.1	14.9	87.6	53.5	0.6	1.0	TR	1.0/6	1.6/12	31	-	-	20.9	5	56	6
January	21.5	5.5	16.0	88.0	51.5	0.6	1.2	TR	0.5/2	2.4/18	30	1	1	17.9	6	10	7
February	24.7	10.0	14.8	85.7	46.6	0.8	1.4	35.7	0.3/2	4.1/21	22	1	6	19.0	7	00	1
March	29.6	14.2	15.4	73.7	39.4	1.7	2.7	7.3	2.6/16	4.1/26	27	-	4	21.9	9	38	-
April	38.9	21.9	17.0	54.2	32.1	2.8	3.8	5.0	1.6/11	4.4/29	29	-	-	27.4	10	20	38.9

Table 2: Morphological, yield and quality traits of genotypes

Sr. No.	Genotypes	Av. Fresh Yield tons/ha	Fruit Length (cm)	Fruit Width (mm)	Capsaicin (%)	Crude Protein (%)	Ascorbic Acid (mg/100g)	Carbohydrates (%)	Crude Fiber (%)
1	HP-18001	26.050	10.1	14.4	0.03	11.6	36.5	52.6	24.7
2	HP-18002	25.180	12.4	14.2	0.014	12.1	45.2	52.5	24.0
3	HP-18003	24.560	10.7	13.7	0.012	12.3	40.0	49.6	26.6
4	HP-18004	22.415	13.9	15.0	0.010	11.7	47.0	50.6	26.4
5	HP-18005	21.840	3.0	7.4	0.05	12.3	38.3	54.2	22.3
6	HP-18006	21.425	6.0	15.3	0.024	10.7	43.5	54.9	23.1
7	HP-19011	20.920	9.0	14.4	0.013	13.8	33.1	50.1	25.3
8	HP-19012	19.770	7.4	16.5	0.007	13.3	31.3	50.4	24.7
9	HP-19013	18.770	10.8	13.7	0.01	13.1	38.3	49.4	25.8
10	HP-19014	18.240	7.7	15.6	0.38	11.7	43.5	53.5	24.5
11	HP-19015	17.800	11.5	10.8	0.44	11.9	41.8	53.6	22.8
12	VRIHP-37	17.775	3.1	10.7	0.03	11.9	36.5	52.1	24.5
13	VRIHP-38	15.090	6.4	8.6	0.13	11.6	43.5	51.0	25.4
14	VRIHP-39	14.880	6.0	9.1	0.19	12.3	41.8	50.8	25.7
15	VRIHP-40	11.21	6.1	13.2	0.14	13.7	40.0	49.5	25.7
16	VRIHP-63	10.32	6.0	9.1	0.11	12.3	34.8	54.3	22.4
17	VRIHP-64	8.36	3.1	10.7	0.38	11.7	43.5	53.5	24.5
18	Karishma F1(Check)	24.225	7.1	16.7	0.02	12.3	41.8	53.6	22.8
19	Golden Hot F1 Check)	23.32	7.0	15.2	00	11.7	45.2	55.2	21.0

Table 3: Descriptive Statistics of Morphological and Biochemical Traits in Hot Pepper Genotypes

Parameter	Mean	SD	Min	Max
Yield (t/ha)	19.06	5.16	8.36	26.05
Fruit Length (cm)	8.10	3.20	3.00	13.90
Fruit Width (mm)	12.70	2.90	7.40	16.70
Capsaicin (%)	0.10	0.14	0.00	0.44
Crude Protein (%)	12.10	0.80	10.70	13.80
Ascorbic Acid (mg/100g)	40.29	4.24	31.30	47.00
Carbohydrates (%)	52.20	1.70	49.40	55.20
Crude Fiber (%)	24.50	1.60	21.00	26.60

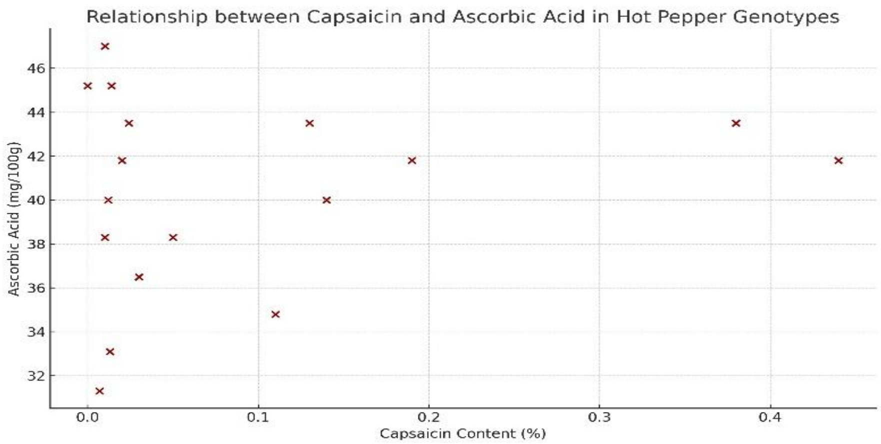

Figure 1 Relationship Between Capsaicin and Ascorbic Acid in Hot Pepper Genotypes

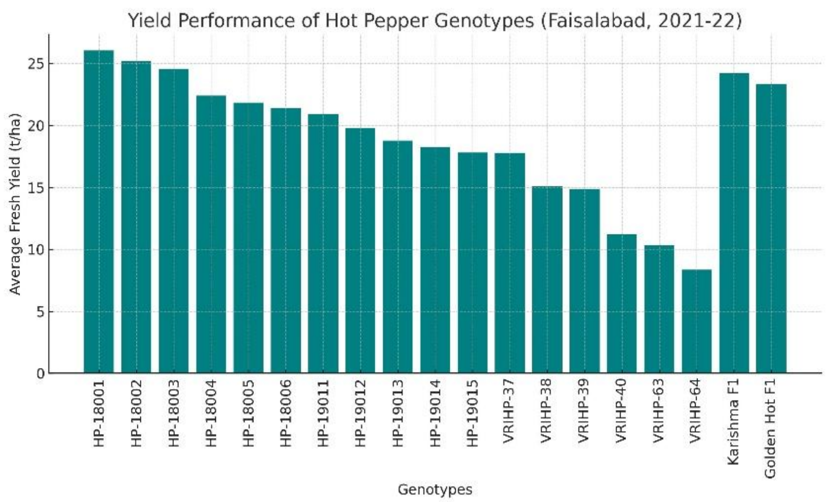

Figure 2 Yield Performance of Hot Pepper Genotypes (Faisalabad 2021-22)

DISCUSSION

The study demonstrated pronounced genotypic variability for yield and fruit-quality attributes in hot pepper under open-field conditions, a finding that aligned with the broad genetic base previously reported for *Capsicum* germplasm and its responsiveness to selection under sub-tropical environments. The top-yielding lines, HP-18001, HP-18002, and HP-18003, consistently outperformed the commercial checks, indicating superior adaptation and sink strength under the agro-climatic context of Faisalabad. The observed yield advantage of approximately 7–12% over hybrids suggested a tangible opportunity for advancing high-performing parental lines for hybrid development and for direct commercialization where uniformity thresholds are satisfied. This performance pattern was congruent with earlier observations that fruit size traits and canopy vigor co-vary with field productivity in pepper grown in comparable climates (13). Morphological differentiation reinforced the yield trends. Longer fruits in HP-18004 and HP-18002, and greater widths in HP-18006 and HP-18004, indicated a favorable blend of length-to-diameter attributes that support fruit mass and market appeal. Such size and shape contrasts mirrored the expected correlations between fruit morphometry and marketable yield reported across solanaceous vegetables and suggest utility for dual-purpose markets—fresh and processing—where length uniformity and pericarp robustness are commercial levers (14). The clear spectrum of fruit forms also pointed to the feasibility of ideotype-based selection, in which elongated, moderately broad fruits may optimize packing efficiency and downstream processing.

Biochemical diversity was equally salient. Capsaicin content ranged from non-detectable in Golden Hot F1 to 0.44% in HP-19015, consistent with the tight genetic control of capsaicinoid biosynthesis and its modulation by phenylpropanoid and branched-chain fatty-acid pathways. The role of key enzymatic steps—PAL, pAMT, KAS, and the terminal condensation by capsaicin synthase encoded by *Pun1*—provided the mechanistic backdrop to the observed range, which typically peaks during 20–40 days after flowering when placental tissues are most active (15-18). Environmental sensitivity of capsaicinoid accumulation to temperature and mild water limitation was in accord with earlier evidence, clarifying why high-pungency lines such as HP-19015 and HP-19014 would be reliable donors for spice and oleoresin value chains under warm, well-managed water regimes (19,20). Nutritional profiles further differentiated the genotypes. Elevated crude protein in HP-19011, VRIHP-40, and HP-19012, as well as higher ascorbic acid in HP-18004, HP-18002, and Golden Hot F1, offered distinct avenues for product positioning in functional foods and minimally processed pepper products. The carbohydrate range (49.4–55.2%) complemented these findings and reflected source–sink efficiency from photosynthetic fixation through phloem loading and sucrose partitioning in the fruit, processes governed by RuBisCO-driven carbon assimilation, sucrose transporter activity, and the invertase–SuSy axis that directs soluble versus structural carbohydrate pools (21-25). The higher carbohydrate percentages observed in HP-18006 and Golden Hot F1 suggested stronger sink activity and favorable sugar–acid balance, characteristics typically associated with improved consumer acceptability and processing yield. Implications for breeding and value-chain targeting were clear. HP-18001, HP-18002, and HP-18003 combined high yield with acceptable nutritional traits, meeting thresholds for broad-acre production in Punjab, while HP-19014 and HP-19015 offered specialized high-pungency profiles for spice extraction. The presence of non-pungent to low-pungent material within the same panel expanded the palette for breeding programs focused on fresh consumption, including segments that require mild flavor profiles and high vitamin C retention. The demonstrated diversity across agronomic, morphological, and biochemical traits supported a multi-trait selection strategy that balances productivity with nutritional and industrial endpoints.

Strengths of the study included field-based evaluation under locally relevant management, the use of a randomized complete block design, and a trait set spanning yield, morphology, and nutrition, which together offered a holistic assessment of commercial potential. The discussion nevertheless recognized several limitations. The single-location design restricted inference on genotype × environment interaction; stability across seasons and production zones remained to be tested. The absence of inferential statistics in the initial reporting—ANOVA F-tests, p-values, and post-hoc mean separation—limited the formal confirmation of between-genotype differences and the ranking confidence. Estimates of heritability, genetic advance, and trait correlations were not provided, constraining predictive selection for complex traits such as yield and capsaicinoid content. Disease and pest pressure were not quantified, despite their known influence on fruit set and biochemical profiles in pepper. Plot geometry and sampling intensity were not elaborated sufficiently to evaluate potential edge effects or within-plot variance. Future work would benefit from multi-environment trials across Sindh and Punjab with at least two to three seasons, coupled with ANOVA and mixed-model approaches to partition variance components and quantify stability. Path-coefficient and multivariate analyses could identify direct and indirect contributors to yield, while GGE biplots would clarify specific adaptation (26,27). Incorporation of capsaicinoid and carotenoid profiling by HPLC, alongside marker-assisted screening for *Pun1* and key pathway loci, would expedite selection for pungency classes and color attributes. Integration of standardized post-harvest evaluations—firmness loss, vitamin C retention, and shelf-life under ambient and cool-chain conditions—would bridge on-farm performance with market durability. The combination of agronomic validation and biochemical resolution would position the identified genotypes for targeted release and contracting within spice and fresh-produce pipelines, ensuring agronomic reliability while meeting nutritional and industrial benchmarks (25-27).

CONCLUSION

The findings of this study confirmed substantial genetic variability among the evaluated hot pepper genotypes, establishing a strong basis for breeding programs aimed at improving yield, fruit quality, and nutritional composition. The identification of genotypes with superior adaptability, high productivity, and desirable biochemical traits highlights their potential for commercial cultivation and hybrid development. These results emphasize the importance of genotype selection tailored to Punjab's agro-climatic conditions, where both environmental adaptability and market-oriented quality traits are crucial. Overall, the study contributes valuable insight toward developing resilient, high-yielding, and nutritionally enriched hot pepper cultivars that can enhance local production efficiency and strengthen Pakistan's competitive position in regional and international chili markets.

AUTHOR CONTRIBUTION

Author	Contribution
Muhammad Amin*	Substantial Contribution to study design, analysis, acquisition of Data Manuscript Writing Has given Final Approval of the version to be published
Atif Ali	Substantial Contribution to study design, acquisition and interpretation of Data Critical Review and Manuscript Writing Has given Final Approval of the version to be published
Muhammad Anser	Substantial Contribution to acquisition and interpretation of Data Has given Final Approval of the version to be published
Rafiq Shahid	Contributed to Data Collection and Analysis Has given Final Approval of the version to be published
Tariq Javed	Contributed to Data Collection and Analysis Has given Final Approval of the version to be published
Hafiz Wasif Javaad	Substantial Contribution to study design and Data Analysis Has given Final Approval of the version to be published
Maha Pervez	Contributed to study concept and Data collection Has given Final Approval of the version to be published

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