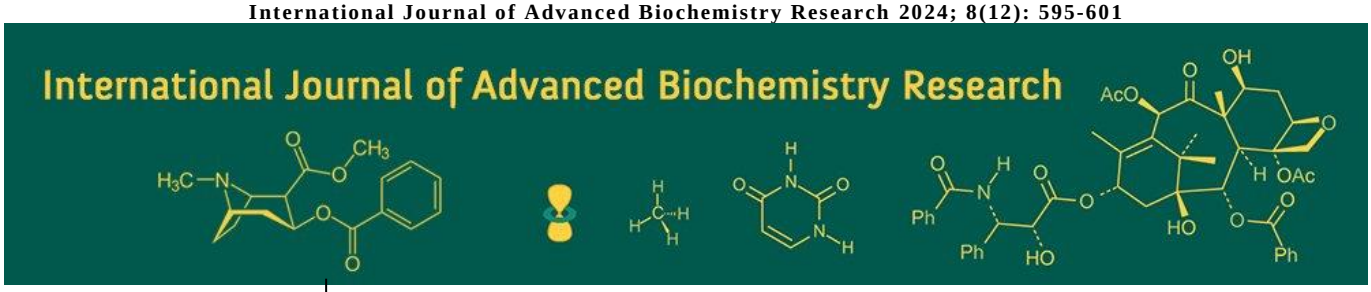


ISSN Print: 2617-4693
ISSN Online: 2617-4707
IJABR 2024; 8(12): 595-601
www.biochemjournal.com
Received: 24-09-2024
Accepted: 30-10-2024

Amol P Solanke
(1) ICAR-National Institute of Abiotic Stress Management, Pune, Maharashtra, India
(2) Mahatma Phule Krishi Vidyapeeth, Rahuri, Maharashtra, India

RR Lipane
Mahatma Phule Krishi Vidyapeeth, Rahuri, Maharashtra, India

AV Gavale
Dr. Babasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli, Maharashtra, India

SR Gadakh
(1) Mahatma Phule Krishi Vidyapeeth, Rahuri, Maharashtra, India
(2) Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra, India

NS Kute
Mahatma Phule Krishi Vidyapeeth, Rahuri, Maharashtra, India

AA Kale
Mahatma Phule Krishi Vidyapeeth, Rahuri, Maharashtra, India

VR Awari
Mahatma Phule Krishi Vidyapeeth, Rahuri, Maharashtra, India

VS Wani
Mahatma Phule Krishi Vidyapeeth, Rahuri, Maharashtra, India

VL Amolic
Mahatma Phule Krishi Vidyapeeth, Rahuri, Maharashtra, India

Gurumurthy S
ICAR-National Institute of Abiotic Stress Management, Pune, Maharashtra, India

Corresponding Author:
Amol P Solanke
(1) ICAR-National Institute of Abiotic Stress Management, Pune, Maharashtra, India
(2) Mahatma Phule Krishi Vidyapeeth, Rahuri, Maharashtra, India

Characterization of morpho-physiological, and yield parameters of chickpea genotypes under shallow basaltic soils

Amol P Solanke, RR Lipane, AV Gavale, SR Gadakh, NS Kute, AA Kale, VR Awari, VS Wani, VL Amolic and Gurumurthy S

DOI: https://doi.org/10.33545/26174693.2024.v8.i12h.3221

Abstract
Eight chickpea genotypes were evaluated in RBD with two replications to explore the phenological, growth, physiological, and yield-contributing traits to identify high-performing cultivars suitable for shallow basaltic soils. Notable variation was observed in phenological traits, with Phule-G-0616-20-3 exhibiting late flowering and maturity, while JG-14 demonstrated early flowering and maturity. Growth parameters revealed Phule-G-1415-15-15 as the tallest plant, and JG-14 exhibited the highest branching. Physiologically, JG-14 showed superior NDVI, relative water content, and moderate canopy temperature, indicating excellent water-use efficiency, while Phule-G-1424-4-2 demonstrated lower physiological indices. In terms of productivity, IPC-06-11 excelled with the highest pod count, seed yield, and harvest index, while JG-14 achieved the highest yield per plant and per hectare. This study underscores the potential of selecting resilient, high-yielding genotypes to enhance sustainable chickpea production, contribute to SDG-2 (zero hunger), and promote climate-smart agriculture in shallow basaltic soils.

Keywords: Chickpea, morpho-physiological, phenological parameter, yield and its contributing traits, shallow basaltic soils

1. Introduction
India is a global leader in the cultivation and production of pulses, with a notable increase in the area dedicated to pulse farming, growing from 19 Mha in 1950-51 to 28.8 Mha in 2021-22. Among pulses, chickpea (*Cicer arietinum* L.) is a vital crop, playing a significant role in the country's agricultural productivity and nutritional security. In 2020-21, chickpea was cultivated on 10.0 Mha across India, yielding 11.9 MT with an average productivity of 1192 kg ha^{-1} (Anonymous, 2022) [2]. Maharashtra, the second-largest producer of chickpea after Madhya Pradesh, contributed substantially with 2.23 Mha under cultivation, producing 2.40 MT, with an average yield of 1074 kg ha^{-1} (Anonymous, 2022) [2]. Despite its significant share in national acreage and production, the yield in Maharashtra remains below the national average, presenting an opportunity for improvement.
The global demand for food is expected to double by 2050, necessitating a substantial increase in crop productivity. Concurrently, agriculture faces mounting challenges from climate change, including temperature extremes, irregular rainfall, and reduced water availability. These challenges emphasize the need to develop high-yielding, climate-resilient chickpea varieties that can perform well under harsh environmental conditions. The shallow basaltic soils, typical of many chickpea-growing regions, are particularly susceptible to these challenges, highlighting the need for region-specific strategies to enhance productivity and ensure long-term agricultural sustainability.
Chickpea productivity depends on various factors, including phenological traits, growth patterns, physiological efficiency, and yield-related characteristics (Fikre *et al*., 2020) [5]. Genotypes with early flowering and maturity, improved water-use efficiency, and higher yield potential are crucial for addressing the challenges of semi-arid and rainfed environments. However, there is a lack of comprehensive research on evaluating chickpea genotypes under diverse environmental conditions specific to shallow basaltic soils. Identifying genotypes with superior agronomic traits is essential for guiding breeding

programs and promoting sustainable farming practices in these areas.

This study hypothesizes that evaluating diverse chickpea genotypes under contrasting environmental conditions will reveal cultivars with superior phenological, physiological, and yield traits. The findings aim to identify climate-resilient genotypes that can thrive in challenging conditions while ensuring enhanced productivity. Additionally, the research contributes to achieving the global Sustainable Development Goals (SDGs), particularly SDG-2 (Zero Hunger), by improving food security and promoting climate-smart agricultural practices. These insights are expected to provide valuable information for breeding strategies and sustainable agricultural interventions tailored to the unique conditions of shallow basaltic soils.

2. Materials and Methods

2.1 Location and climate of experimental site

The field experiment was conducted at the South Research Farm of ICAR-NIASM, Baramati, Pune, India, situated at 18°09' N latitude, 74°30' E longitude, and an elevation of 550 m above mean sea level. The region experiences a semi-arid tropical climate characterized by hot summers, moderate rainfall, and mild winters. Agro-meteorological data, including maximum and minimum temperatures, relative humidity, wind speed, bright sunshine hours, rainfall, and evaporation, were recorded daily at the ICAR-NIASM observatory. The experimental soil was black with a pH of 8.30, an electrical conductivity of 0.27 dS m^{-1}, and low organic carbon content (0.65%). The available nutrient content in the soil was as follows: nitrogen (161.08 kg ha^{-1}), phosphorus (8.15 kg ha^{-1}), potassium (156.50 kg ha^{-1}), sulfur (10.41 mg kg^{-1}), iron (1.17 mg kg^{-1}), manganese (1.42 mg kg^{-1}), zinc (0.14 mg kg^{-1}), copper (0.46 mg kg^{-1}), and boron (0.13 mg kg^{-1}) in the top 15 cm layer of the soil. The field capacity and permanent wilting point were recorded as 28.7% and 14.3% (w/w), respectively.

2.2 Experimental setup, treatment details and crop management

The field study followed a randomized block design with eight contrasting chickpea genotypes: ICE-15654-A, JG-14, ICCV-92944, IPC-06-11, Phule-G-1424-4-2, Phule-G-08108, Phule-G-1415-15-15, and Phule-G-0616-20-3, replicated three times. The site was prepared through ploughing, harrowing, and grass removal before layout preparation. Seeds sourced from the Pulse Improvement Project, MPKV, Rahuri, and ICAR-NIASM, Baramati, were sown during the *rabi* season on 28th November 2023 using the dibbling method at a spacing of 30 × 10 cm. Two seeds per hill were initially sown, followed by gap filling at 6 DAS and thinning at 15 DAS to retain one healthy plant per hill. Fertilizers were applied as a basal dose with an RDF of 30:60:30 kg ha^{-1} for nitrogen, phosphorus, and potassium. Regular weeding and hoeing ensured weed-free plots. Chlorantraniliprole (18.5% w/w) was applied at 0.5 ml L^{-1} for plant protection.

2.3 Growth, physiological and yield attributes analyses

Morphological traits, including phenological parameters such as days to initiation of flowering, days to 50% flowering, days to first pod formation, days to 50% podding, and days to physiological maturity, were recorded through visual observations. Plant height (cm) and the number of branches per plant were measured on five randomly selected plants per plot. Physiological parameters, including normalized difference vegetation index (NDVI), canopy temperature (°C), and relative water content (RWC, %), were assessed at the 50% flowering stage using standard operating procedures. Yield-contributing traits, such as pods per plant, seeds per plant, 100-seed weight (g), yield per plant (g), yield per hectare (kg ha^{-1}), and harvest index, were also recorded from the same randomly selected plants.

2.4 Statistical analysis

Genotypes effects were assessed using statistical analysis based on the means of three independent replicates, following a Randomized Block Design as outlined by Panse and Sukhatme (1985) [15].

3. Results and Discussion

3.1 Morphological parameters

The morphological parameters are detailed in Table 1 and illustrated in Figure 1. The days to initiation of flowering (DIF) ranged from 47.98 days in IPC-06-11 to 53.08 days in Phule-G-0616-20-3. The highest DIF was observed in Phule-G-0616-20-3, while the lowest was recorded in IPC-06-11. Genotypes ICE-15654-A, JG-14, and ICCV-92944 were on par with each other, showing intermediate DIF values around 49 days. The days to 50% flowering (D50%F) ranged from 55.01 days in JG-14 to 59.98 days in Phule-G-0616-20-3. The earliest flowering was observed in JG-14, followed by ICCV-92944 and IPC-06-11. Phule-G-0616-20-3 exhibited the latest flowering, significantly differing from other genotypes. Regarding days to physiological maturity (DPM), Phule-G-0616-20-3 recorded the highest value at 91.97 days, followed by Phule-G-1424-4-2 (86.27 days) and Phule-G-08108 (87.02 days), all significantly differing from the other genotypes. On the other hand, JG-14 exhibited the earliest maturity at 77.77 days, with IPC-06-11 and ICCV-92944 showing intermediate values around 77-80 days. These results align with those of Gurumurthy *et al*. (2024b) [8], who observed a positive relationship in the phenological parameters of the IPC 06-11 chickpea genotype, leading to earlier maturity compared to others, and with Gaur (2008), who highlighted early phenology in chickpea.

The plant height (PH) varied between 35.89 cm in IPC-06-11 and 48.23 cm in Phule-G-1415-15-15. Phule-G-1415-15-15 showed the tallest plants, significantly outperforming the other genotypes, while IPC-06-11 exhibited the shortest plants. Genotypes ICE-15654-A and Phule-G-0616-20-3 were comparable in plant height, with values around 42-44 cm, while JG-14 and ICCV-92944 displayed intermediate values. The number of branches per plant ranged from 5.67 in Phule-G-1415-15-15 to 9.03 in JG-14. JG-14 exhibited the highest branch count, significantly differing from other genotypes, whereas Phule-G-1415-15-15 had the lowest number of branches. ICE-15654-A, Phule-G-1424-4-2, and Phule-G-0616-20-3 showed intermediate values, with Phule-G-08108 having slightly fewer branches. The results are consistent with those reported by Basha *et al*., 2018 [3].

3.2 Physiological parameters

The physiological parameters are detailed in Table 2 and illustrated in Figure 2. The Normalized Difference Vegetation Index (NDVI) ranged from 0.65 in Phule-G-1424-4-2 to 0.75 in JG-14. The genotype JG-14 exhibited the highest NDVI, significantly differing from the others,

while Phule-G-1424-4-2 showed the lowest NDVI. Genotypes ICE-15654-A and ICCV-92944 exhibited similar NDVI values, around 0.72, and were statistically comparable to each other. The results align with Hazratkulova *et al*. (2012) [9], who identified genotypes with lower NDVI values from booting to the dough stage in the same environment as stress-tolerant.

Canopy temperature (CT) ranged from 28.12 °C in Phule-G-1424-4-2 to 29.71 °C in Phule-G-0616-20-3. The lowest canopy temperature was recorded in Phule-G-1424-4-2, while Phule-G-0616-20-3 had the highest. Other genotypes showed intermediate values, with IPC-06-11 and Phule-G-08108 recording temperatures above 29 °C, while ICE-15654-A and JG-14 displayed slightly lower values, indicating a moderate thermal response. The findings are consistent with those reported by Jadhav *et al*., 2021.

The relative water content (RWC) ranged from 67.19% in Phule-G-08108 to 84.93% in JG-14. JG-14 had the highest RWC, significantly higher than the other genotypes, while Phule-G-08108 exhibited the lowest RWC. Intermediate RWC values were observed in genotypes such as ICE-15654-A, IPC-06-11, and Phule-G-0616-20-3. These findings suggest that JG-14 has a better water retention capacity compared to other genotypes. The result alien with the Bindra *et al*., 2021 [4].

3.3 Yield and its parameters

The yield and its parameters are detailed in Table 3 and illustrated in Figure 3. The number of pods plant^{-1} ranged from 42 in Phule-G-08108 to 55.23 in IPC-06-11. IPC-06-11 exhibited the highest number of pods per plant, significantly higher than other genotypes, while Phule-G-08108 had the lowest. Genotypes like JG-14 and ICE-15654-A had comparable pod numbers (around 52-53 pods), showing no significant difference among them. Neenu *et al*. (2014) [12] similarly reported significantly higher pods per plant and seed index in the JG 11 variety.

For seeds plant^{-1}, the highest value was observed in JG-14 (68.23 seeds), followed closely by IPC-06-11 (70.34 seeds). Phule-G-0616-20-3 had the lowest seed count plant^{-1} (39.12 seeds), with Phule-G-08108 and Phule-G-1415-15-15 showing intermediate values.

The 100-seed weight ranged from 19.03 g in ICE-15654-A to 25.03 g in Phule-G-1415-15-15. Phule-G-1415-15-15 exhibited the highest 100-seed weight, significantly greater than the other genotypes, while ICE-15654-A had the lowest seed weight. Similar results were reported by Karasu *et al*. (2009) [11], who found that cultivars significantly influenced 1000-seed weight at the 1% probability level.

Yield plant^{-1} was highest in JG-14 (22.56 g), followed by IPC-06-11 (19.34 g). The lowest yield was recorded in Phule-G-0616-20-3 (10.12 g). Other genotypes like ICE-15654-A and ICCV-92944 exhibited moderate yields ranging from 15.78 g to 17.89 g.

In terms of yield hectare^{-1}, JG-14 achieved the highest yield (2238.29 kg ha^{-1}), significantly outperforming other genotypes, while Phule-G-1415-15-15 showed the lowest yield (1748.52 kg ha^{-1}). IPC-06-11 also demonstrated high yield (2250.83 kg ha^{-1}), comparable to JG-14. This result aligns with the earlier findings reported by Gurumurthy *et al*. (2024a) [7], where the IPC 06-11 genotype exhibited a higher yield compared to others, as well as with the observations of Akbar and Kamran (2006) [1].

The harvest index (HI) was highest in IPC-06-11 (0.57), indicating better partitioning of biomass towards reproductive parts. Genotypes JG-14 (0.51) and ICCV-92944 (0.51) showed similar harvest indices, while Phule-G-1424-4-2 (0.42) and Phule-G-08108 (0.39) recorded the lowest values. Shah *et al*. (2007) [14] reported that improved chickpea cultivation practices enhanced soil moisture availability, enabling the JG11 variety to produce higher grain and stover yields.

Table 1: Impact of chickpea genotypes on morphological traits under shallow basaltic soils

Genotype		DIF (days)	D50%F (days)	DPM (days)	PH (cm)	Branches (No.)
G1	ICE-15654-A	49.98±0.613	56.86±0.005	84.56±2.727	42.89±0.112	7.53±0.484
G2	JG-14	49±1.16	55.01±1.498	77.77±1.247	37.89±0.868	9.03±0.711
G3	ICCV - 92944	48.91±1.128	55.04±1.69	80.35±5.736	38.04±0.647	6.23±0.485
G4	IPC-06-11	47.98±0.878	55.16±3.114	77.99±1.562	35.89±2.129	7.45±0.588
G5	Phule-G-1424-4-2	51.02±1.181	57.27±1.292	86.27±1.968	42.34±0.385	8.34±0.334
G6	Phule-G-08108	51.7±1.486	58.03±1.949	87.02±2.319	43.64±1.469	6.34±0.51
G7	Phule-G-1415-15-15	51.29±2.691	58.46±2.649	88.44±3.238	48.23±3.87	5.67±0.578
G8	Phule-G-0616-20-3	53.08±2.315	59.98±0.908	91.97±0.981	44.67±1.171	6.34±1.018
CD @ 5%		4.65	5.68	9.07	4.84	1.74

Note: Growth parameter observed at the stage of physiological maturity; DIF- Days to initiation of flowering (days); D50% F- Days to 50% flowering (days); DPM- days to physiological maturity (days); PH- Plant height; CD- Critical difference.

Table 2: Impact of chickpea genotypes on physiological traits under shallow basaltic soils

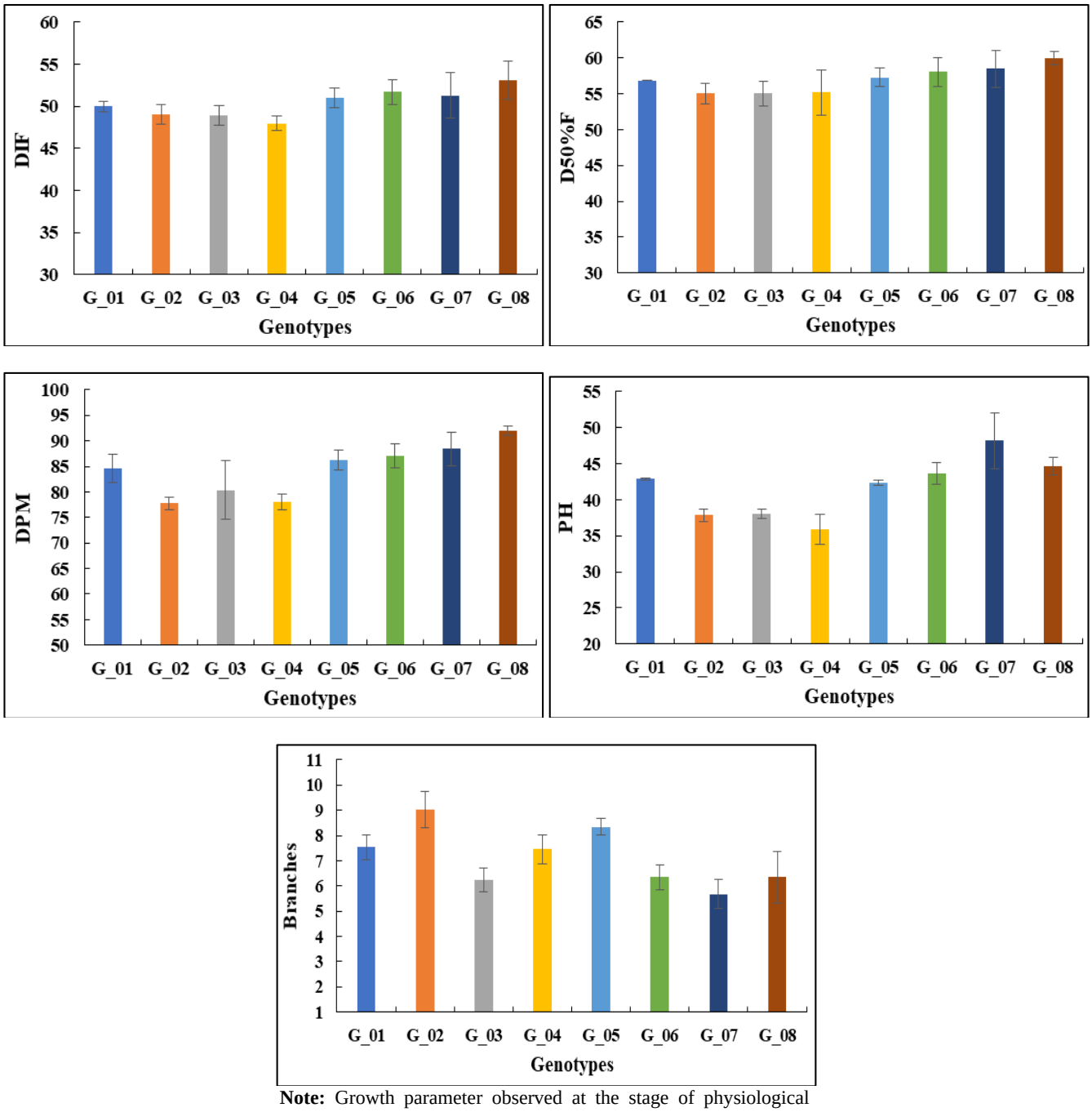
Genotype		NDVI	CT (°C)	RWC (%)
G1	ICE-15654-A	0.72±0.054	28.66±0.76	79.71±3.68
G2	JG-14	0.75±0.02	28.42±1.043	84.93±2.94
G3	ICCV - 92944	0.73±0.017	28.56±1.182	76.67±1.066
G4	IPC-06-11	0.73±0.041	29.12±0.703	82.29±5.464
G5	Phule-G-1424-4-2	0.65±0.023	28.12±0.907	70.86±1.142
G6	Phule-G-08108	0.68±0.011	29.26±1.292	67.19±4.344
G7	Phule-G-1415-15-15	0.7±0.048	28.96±0.622	70.66±3.056
G8	Phule-G-0616-20-3	0.66±0.03	29.71±0.78	73.45±2.415
CD @ 5%		0.089	2.92	8.83

Note: Physiological parameter observed at the stage of 50% flowering stage; NDVI: Normalized Difference Vegetation Index; CT- Canopy temperature (°C); RWC- Relative water content; CD - Critical difference.

Table 3: Impact of chickpea genotypes on yield and its contributing traits under shallow basaltic soils

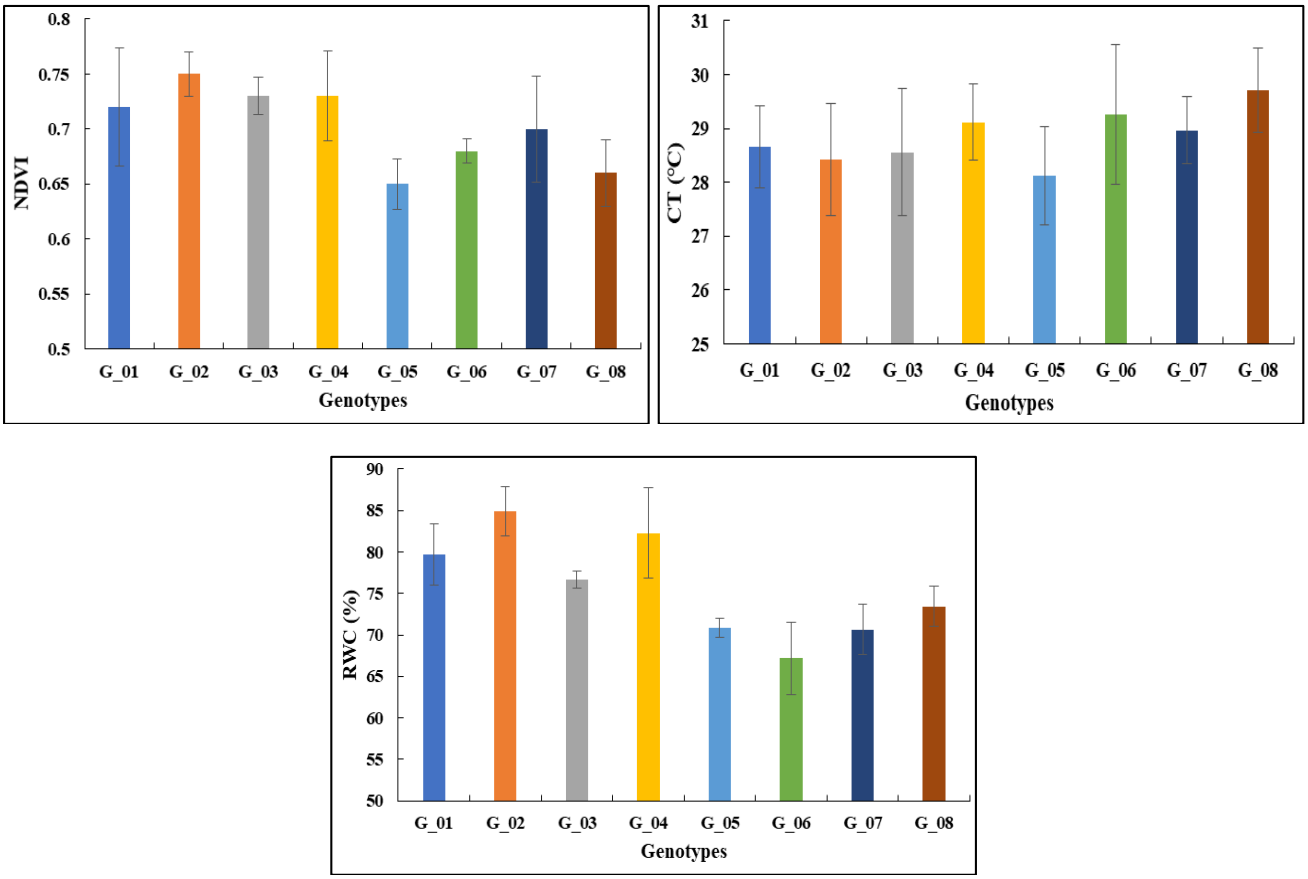
Genotype		Pods plant^{-1}	Seeds plant^{-1}	100 Seed weight	Yield plant^{-1}	Yield ha^{-1}	HI
G1	ICE-15654-A	52.67±0.667	67.89±3.445	19.03±0.464	17.89±1.095	2056.19±36.153	0.53±0.015
G2	JG-14	53.45±3.246	68.23±3.551	22.87±0.79	22.56±1.926	2238.29±19.197	0.51±0.01
G3	ICCV - 92944	52±2.517	67.23±1.128	21.41±0.26	15.78±1.544	1908.71±40.329	0.51±0.019
G4	IPC-06-11	55.23±2.04	70.34±4.372	23.71±1.331	19.34±0.963	2250.83±139.102	0.57±0.044
G5	Phule-G-1424-4-2	44.78±3.659	55.56±8.736	21.84±0.241	11.45±1.253	1822.6±40.105	0.42±0.008
G6	Phule-G-08108	42±2.082	50.34±4.221	20.56±0.48	13.67±1.576	1836.95±85.621	0.39±0.022
G7	Phule-G-1415-15-15	47.45±4.58	49.39±4.806	25.03±0.214	14±1.711	1748.52±120.712	0.46±0.02
G8	Phule-G-0616-20-3	43±2.082	39.12±2.959	21.42±1.365	10.12±1.83	1804.08±114.591	0.46±0.019
CD @ 5%		8.29	11.11	1.99	2.28	249.50	0.06

Note: CD- Critical difference.



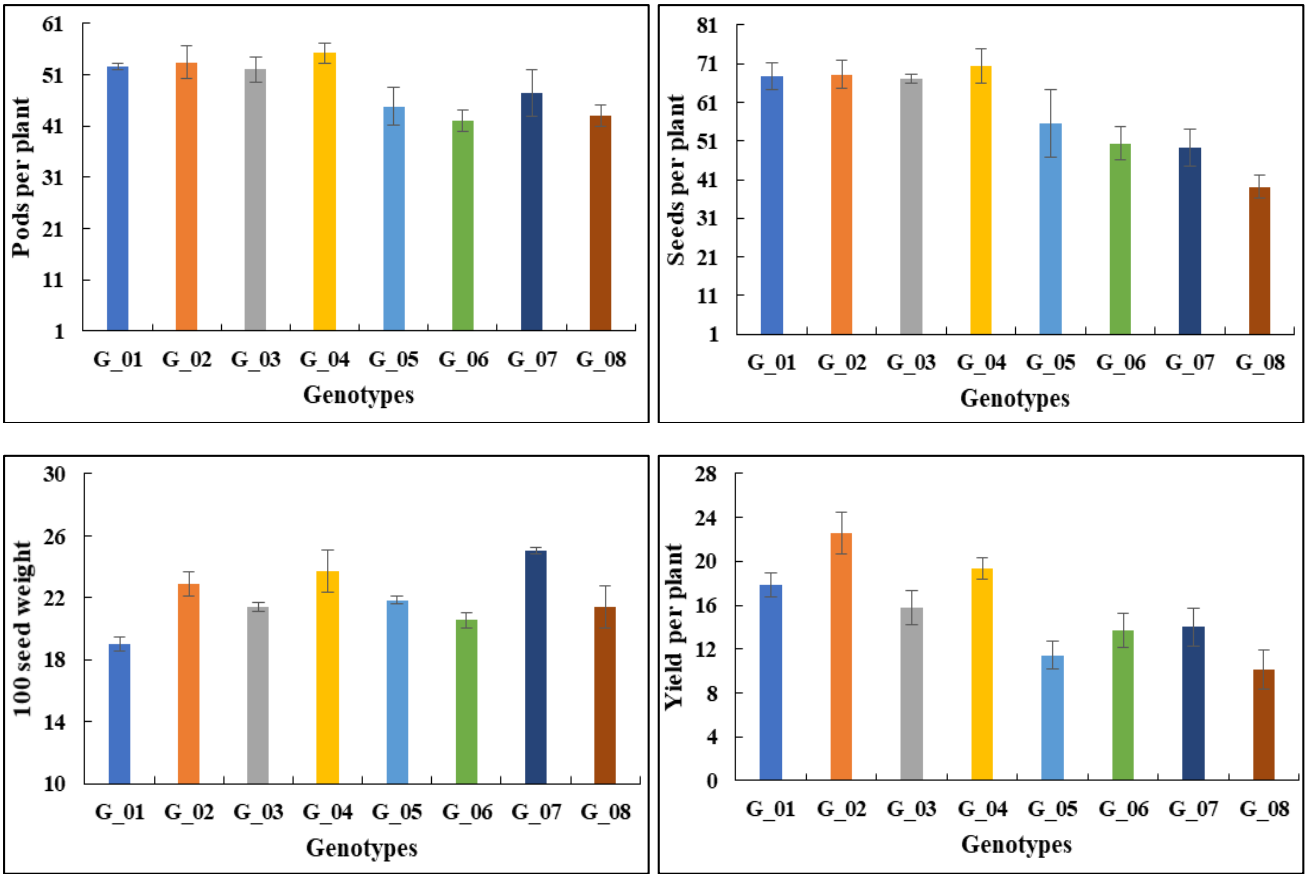
Note: Growth parameter observed at the stage of physiological maturity; DIF- Days to initiation of flowering (days); D50%F- Days to 50% flowering (days); DPM- days to physiological maturity (days); PH- Plant height; CD- Critical difference.

Fig 1: Impact of chickpea genotypes on morphological traits under shallow basaltic soils



Note: Physiological parameter observed at the stage of 50% flowering stage; NDVI: Normalized Difference Vegetation Index; CT- Canopy temperature (°C); RWC- Relative water content; CD - Critical difference.

Fig 2: Impact of chickpea genotypes on physiological traits under shallow basaltic soils



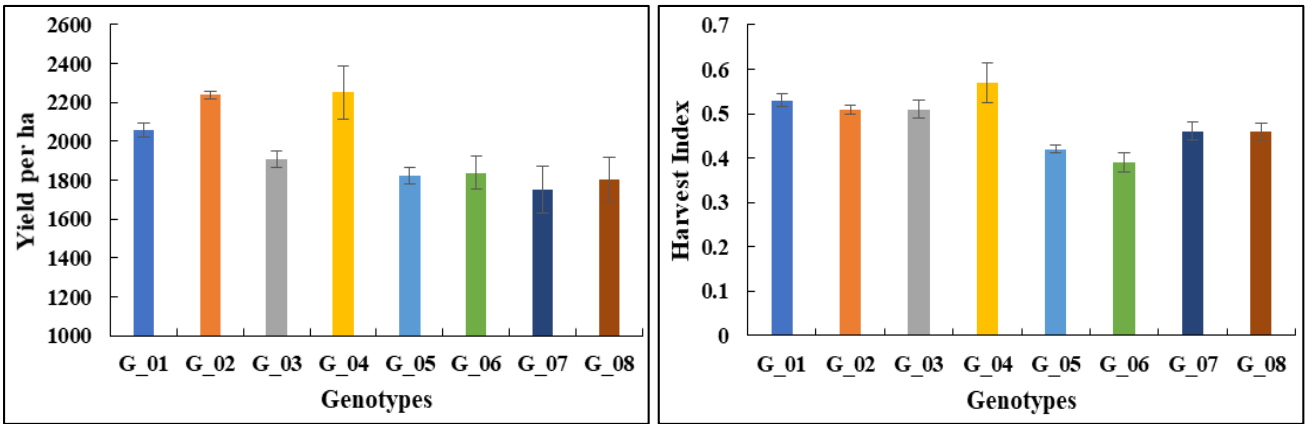


Fig 3: Impact of chickpea genotypes on yield and its contributing traits under shallow basaltic soils

4. Conclusion

The study revealed significant variation in phenological, growth, and physiological traits among chickpea genotypes in shallow basaltic soil conditions. Genotypes like Phule-G-0616-20-3 and JG-14 exhibited distinct developmental patterns, with Phule-G-0616-20-3 showing delayed flowering and JG-14 exhibiting early flowering. Phule-G-1415-15-15 demonstrated superior plant height, while JG-14 showed higher branching. JG-14 also exhibited better NDVI, relative water content (RWC), and moderate canopy temperature, indicating better physiological performance. In terms of yield, IPC-06-11 was the most productive, while JG-14 showed higher yield per plant and hectare. This research offers valuable insights for selecting resilient genotypes adapted to shallow basaltic soil, promoting sustainable farming practices. It supports SDG-2 by enhancing chickpea yields and contributes to climate-smart agriculture by identifying genotypes with better water-use efficiency and resilience to climate change, specifically in regions with shallow basaltic soil.

5. Acknowledgments

The authors gratefully acknowledge the ICAR-National Institute of Abiotic Stress Management, Baramati, Pune and the Mahatma Phule Krishi Vidyapeeth, Rahuri, Maharashtra, India

6. Funding

The authors have no relevant financial or nonfinancial interests to disclose.

7. Data availability statement

Datasets generated and/or analyzed during the current study are available from the corresponding author upon reasonable request.

8. Declarations

8.1 Conflict of interest

We declare that we have no conflicts of interest.

9. Reference

1. Akbar AA, Kamran M. Relationship among yield components and selection criteria for yield improvement of safflower (*Carthamus tinctorius* L.). Journal of Applied Sciences. 2006;6:2853-2855.
2. Anonymous. Agricultural Statistics at a Glance, 2022. Economics & Statistics Division, Department of Agriculture and Farmers Welfare; 2022. Available from: www.agricoop.nic.in and http://desagri.gov.in.
3. Basha JF, Jaya Lakshmi V, Trivikram Reddy A, Kamakshi N, Khayum Ahammed S. Estimate of growth and yield parameters of chickpea (*Cicer arietinum* L.) cultivars amenable to mechanical harvesting. Journal of Pharmacognosy and Phytochemistry. 2018;7(5):2089-2091.
4. Bindra S, Singh I, Singh S, Kushwah A, Gill BS, Salaria S, *et al*. Use of morpho-physiological and biochemical traits to identify sources of drought and heat tolerance in chickpea (*Cicer arietinum*). Crop and Pasture Science. 2021. https://doi.org/10.1071/cp21189
5. Fikre A, Desmae H, Ahmed S. Tapping the economic potential of chickpea in sub-Saharan Africa. Agronomy (Basel). 2020;10(11):1707. https://doi.org/10.3390/agronomy10111707
6. Gaur PM, Kumar J, Gowda C, Pande S, Ketema D. Breeding chickpea for early phenology: perspectives, progress and prospects. Indian Society of Genetics and Plant Breeding. 2008;2:39-48.
7. Gurumurthy S, Mamatha B, Rudresh, Basavaraja, Bheemanahalli R, Pal M, *et al*. Identification of photothermo-insensitive with climate-smart early-maturing chickpea genotypes. Plant Genetic Resources: Characterization and Utilization. 2024a;22(3):149-157. https://doi.org/10.1017/s1479262124000108
8. Gurumurthy S, Ashu A, Kruthika S, Solanke AP, Basavaraja T, Soren KR, *et al*. An innovative natural speed breeding technique for accelerated chickpea (*Cicer arietinum* L.) generation turnover. Plant Methods. 2024b;20(1):177. https://doi.org/10.1186/s13007-024-01299-9
9. Hazratkulova S, Sharma RC, Alikulov S, Islomov S, Yuldashev T, Ziyaev Z, *et al*. Analysis of genotypic variation for normalized difference vegetation index and its relationship with grain yield in winter wheat under terminal heat stress. Plant Breeding. 2012;131(6):716-721. https://doi.org/10.1111/pbr.12003
10. Jadhav ND, Gadakh SR, Korade SB, Kute NS. Morpho-physiological responses of chickpea genotypes under different temperature regimes. The Pharma Innovation Journal. 2021;10(11):343-348.
11. Karasu A, Oz M, Dogan R. The effect of bacterial inoculation and different nitrogen doses on yield and yield components of some chickpea genotypes (*Cicer*

arietinum L.). African Journal of Biotechnology. 2009;8(1):59-64.
12. Neenu S, Ramesh K, Ramana S, Biswas AK, Rao AS. Growth and yield of different varieties of chickpea (*Cicer arietinum* L.) as influenced by the phosphorus nutrition under rainfed conditions on Vertisols. International Journal of Bio-Resource and Stress Management. 2014;5(1):53-57.
13. Rajagopal V, Choudhary RL, Kumar N, Krishnani KK, Singh Y, Bal SK, *et al*. Soil health status of NIASM Southern farm land. NIASM Technical. 2018;15:115:54.
14. Shah NA, Aujla KM, Abbas M, Mahmood K. Economics of chickpea production in the Thal desert of Pakistan. Pakistan Journal of Life and Social Sciences. 2007;5:6-10.
15. Panse VG, Sukhatme PV. Statistical Methods for Agricultural Workers. Indian Council of Agricultural Research, New Delhi; 1985.