Archives of Current Research International

Volume 24, Issue 11, Page 434-441, 2024; Article no.ACRI.126567
ISSN: 2454-7077

Evaluation of Chickpea (*Cicer arietinum* L.) Genotypes based on Morphological Traits in Vindhya Region of Uttar Pradesh, India

Baira Naresh [a++*], Bineeta Michael. Bara [a#*], Gaibriyal M. Lal [a†] and Vaidurya Pratap Sahi [a‡]

[a] Department of Genetics and Plant Breeding, Naini Agricultural Institute, SHUATS, Prayagraj, U.P, India.

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: https://doi.org/10.9734/acri/2024/v24i11983

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/126567

Original Research Article

Received: 08/09/2024
Accepted: 10/11/2024
Published: 21/11/2024

ABSTRACT

The study was conducted in the Field Experimentation Centre, Department of Genetics and Plant Breeding, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj (Uttar Pradesh) during *Rabi,* 2023-2024. The soil of experimental plot was sandy loam in texture, nearly neutral in soil reaction (pH 7.1), low in organic carbon (0.36 %), available N (171.48 kg/ha), available P (15.2 kg/ha) and available K (232.5 kg/ha). The experiment was laid out in Randomized Block Design with fifteen genotypes which were replicated thrice. The results revealed that plant height (55.69 cm), No. of primary branches (3.19), number of secondary

[++]M. Sc. Student;
[#]Assistant Professor;
[†]Professor;
[‡] Professor and Head;
**Corresponding author: Email: bineeta.bara@shiats.edu.in, bairanaresh11@gmail.com;*

Cite as: *Naresh, Baira, Bineeta Michael. Bara, Gaibriyal M. Lal, and Vaidurya Pratap Sahi. 2024. "Evaluation of Chickpea (Cicer Arietinum L.) Genotypes Based on Morphological Traits in Vindhya Region of Uttar Pradesh, India". Archives of Current Research International 24 (11):434-41. https://doi.org/10.9734/acri/2024/v24i11983.*

branches (10.34), no.of pods per plant (55.39), no. of seeds per plant (9.70), seed yield per plant (19.32 gm), seed yield per ha (3864.45 kg/ha), biological yield per plant (31.69 gm), harvest index (37.88%), seed index (19.38 gm), test weight (193.8gm), seed length (9.47 mm), seed width (8.23) were recorded highest in Phule Vikram genotype followed by PG-05 genotype and days to 50% flowering (56.79 DAS), days to 50% pod setting (81.09 DAS), days to maturity (117.43 DAS) were recorded the lowest in JG-16 genotype.

Keywords: Chickpea; genotypes; morphological characteristics.

1. INTRODUCTION

Pulses have been a key part of Indian agriculture for centuries, playing an essential role in the country's farming traditions. As the world's largest producer, consumer, and importer of pulses, India ranks first in area (73%) and production (75%) at Global level followed by Australia, Turkey and Ethiopia. In major producing countries the highest productivity of 2170 kg/ha is observed in Ethiopia followed by Australia (1725 kg/ha), Russian Fed. (1358 kg/ha) and Myanmar (1315 kg/ha). India's productivity is 1261 kg/ha (Directorate of pulses development, 2024). Chickpea solely contributes nearly 50% of the Indian pulse production. States like Maharashtra (25.97% contribution to national production), Madhya Pradesh (18.59%), Rajasthan (20.65%), Gujarat (10.10%) and Uttar Pradesh (5.64%) are major Chickpea producing states of India (ICAR-IIPR). Chickpea has been cultivated in semiarid regions for centuries, especially in countries like India, Pakistan, and across the Middle East (Kumar and Abbo, 2001). Chickpea is an important pulse crop grown and consumed all over the world, especially in the Afro-Asian countries. It is also one of the major pulse crops cultivated and consumed in India and also known as Bengal Gram. In India, chickpea accounts for about 45% of total pulses production. Chickpea, characterized by high dietary seed protein, abundant non-starch polysaccharides, low calorie content, low allergenicity, and high digestibility, offers a cost-effective protein source for low-income individuals and vegetarians. The crop is highly sensitive to high temperatures during its full bloom stage. Brief periods of elevated temperatures (30-35°C) during seed filling can lead to significant reductions in seed yield, negatively affecting seed set, seed weight, accelerating senescence, and ultimately lowering overall yield (Siddique et al*.,* 1999). Climatic conditions and genotypes are two important factors significantly affecting the yield of Chickpea. Chickpea production is heavily influenced by both abiotic and biotic stresses, with high temperatures being a leading factor in yield reduction (Gupta and Singh (2012)). Climate change, particularly rising temperatures, is expected to further impact grain yields in Chickpeas. Studies show that for every 1°C rise in mean seasonal temperature, Chickpea yields in India can decrease by up to 30.1 kg/ha. In India, Chickpeas often face high temperature stress during the growing season, particularly during the reproductive phase. The reproductive stage of Chickpea is more vulnerable to extreme temperatures than the vegetative stage. Both cold and high temperatures can harm pollen viability, fertilization, and seed development, ultimately lowering the harvest index. Thus, developing heat-tolerant cultivars that can withstand stress during the reproductive phase is essential for boosting and stabilizing Chickpea yields, as well as expanding its cultivation into new areas. This stress accelerates crop maturity under hot and dry conditions (above 30ºC), shortening the crop's growth period (Mola et al*.,* (2018)). Prayagraj agro-climatic conditions during the rabi season are characterized by mild winters with temperatures ranging between 10°C and 25°C. This period typically experiences low humidity and minimal rainfall, creating ideal conditions for the cultivation of Rabi crops. The cooler temperatures and clear skies during this season are conducive to crop growth, while the relatively dry conditions help in managing soil moisture and irrigation needs efficiently. So, in order to evaluate the effect of Prayagraj agro-climatic conditions on Chickpea genotypes the present experiment entitled "Screening of Chickpea (*Cicer arietinum.* L.) Genotypes based on Morphological Traits in Prayagraj Region" was held at the Field Experimentation Centre, Department of Genetics and Plant Breeding, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj, U.P.

2. MATERIALS AND METHODS

The present study was conducted during *Rabi* 2023-24 in Field Experimentation Centre, Department of Genetics and Plant Breeding, Sam Higginbottom University of Agriculture, Technology and Science, Prayagraj U. P. located 25.35^0 N and longitude 82.25^0 E at an altitude of 78m above mean sea level, with 15 genotypes replicated thrice and sown at 30*10 cm. Observations were recorded for every genotype on five randomly selected plants in each replications the field observations selected for investigation are plant height, days to 50% flowering, days to 50% pod setting, days to maturity, number of primary branches, number of secondary branches, number of pods per plant, number of seeds per pod, seed index, seed length, seed width, test weight, biological yield per plant, harvest index, seed yield per plant, seed yield per hectare. These observations gave a better understanding on effect of Prayagraj agro-climatic conditions on Chickpea genotypes.

3. RESULTS AND DISCUSSION

3.1 Pre-harvest

3.1.1 Field emergence

As per the data recorded highest field emergence (%) was recorded in genotype Phule Vikram with 94.28% with an rate of field emergence of 2108 and statistically at par values were recorded in PG-05 genotype with 93.62% with an rate of field emergence of 2088. The lowest field emergence was recorded in NBeG-49 genotype with 77.53% with an rate of field emergence of 1591.

3.1.2 Plant height

Significantly highest plant height was recorded in genotype Phule Vikram with 55.69cm and genotype PG-05 with 54.86 cm was statistically at par with Phule Vikram. The lowest plant height was observed in NBeG-49 genotype with 48.34 cm. The data on plant height was tabulated and depicted in Table 2. Semi-humid environments typically offer moderate rainfall, which can create favorable conditions for Chickpea growth. Adequate soil moisture supports root development, leading to improved nutrient absorption and consequently increased plant height. However, inconsistent rainfall patterns or periods of waterlogging can hinder growth, leading to stunted development in sensitive genotypes and the results are in acceptance with Tilahun et al*.,* (2015).

3.1.3 Days to 50% flowering

Significantly least number of days to 50% flowering were observed in JG-16 genotype with 56.79 DAS and genotype Phule Vikram with 57.31 DAS was statistically on par with JG-16 genotype. The highest number of days to 50% flowering were observed in FLIP-09-162 genotype with 62.18DAS. In semi-humid climates, where moderate but consistent rainfall occurs, adequate soil moisture generally promotes optimal vegetative growth and accelerates the transition to the reproductive phase. This can lead to a shorter time to 50% flowering in well-adapted Chickpea genotypes. However, inconsistent moisture, especially during dry spells or excessive rainfall, can delay flowering by stressing the plants, thus affecting their physiological processes. Similar results were shown by Mola et al*.,* (2018).

3.1.4 Days to 50% pod setting

From the data shown days to 50% pod setting varied significantly among all genotypes. JG-16 genotype with 81.09 DAS recorded least number of days to 50% pod setting over other genotypes and genotype Phule Vikram with 82.38 DAS was at par with JG-16 genotype. The highest days to 50% pod setting was observed in FLIP-09-162 genotype with 88.37 DAS.

3.1.5 Days to maturity

As per the data shown days to maturity varied significantly among all genotypes. JG-16 genotype with 117.43 DAS attained maturity earlier than other genotypes and genotype Phule Vikram with 117.68 DAS was statistically at par with JG-16 genotype. The highest days to maturity was observed in FLIP-09-162 genotype with 129.67 DAS. In semi-humid regions, moderate rainfall provides sufficient soil moisture, which typically supports steady plant development and can help ensure timely maturity. However, inconsistent rainfall, such as intermittent dry spells or excessive moisture, can affect plant physiology. Prolonged dry periods may stress the plants, leading to premature maturity, while too much moisture can delay maturity by promoting excessive vegetative growth. This variation in moisture availability can cause genotypes adapted to drier conditions to mature faster, whereas more moisture-dependent genotypes may take longer to reach maturity and the results are in acceptance with Sikdar et al*.,* (2015).

3.1.6 Number of Primary branches

Significantly higher number of primary branches were recorded in Phule Vikram genotype with

3.19 and statistically at par values were recorded in PG-05 genotype with 3.06 branches. The least number of primary branches were recorded in NBeG-49 genotype with 1.34 branches.

3.1.7 Number of Secondary branches

The data on number of secondary branches shows that significantly higher number of secondary branches were recorded in Phule Vikram genotype with 10.34 and statistically at par values were recorded in PG-05 genotype with 10.19 branches. The least number of secondary branches were recorded in NBeG-49 genotype with 7.56 branches. Adequate and well-distributed moisture in semi-humid climates generally promotes healthy vegetative growth in Chickpea plants, which includes an increase in the number of primary and secondary branches. Moisture stress, on the other hand, particularly during the vegetative phase, can limit the number of branches, as plants prioritize survival over lateral growth. Excessive moisture can lead to waterlogging, which negatively affects root function and stunts the development of branches. Therefore, a balance in moisture availability is crucial for promoting branching in Chickpea and the results are in acceptance with Shafi et al*.,* (2012).

3.2 Post-harvest

3.2.1 Number of pods per plant

From the data we can observe that the highest number of pods per plant was recorded in genotype Phule Vikram with 55.39 and genotype PG-05 with 55.17 was statically at par with genotype Phule Vikram. The lowest number of pods per plant was recorded in NBeG-49 genotype with 47.79. In semi-humid conditions, consistent rainfall or controlled irrigation ensures proper nutrient uptake, allowing the plant to invest more energy in reproductive structures like pods. However, excessive moisture during this period may lead to waterlogging, which can impair root function, reduce nutrient uptake, and lower pod production. Similar results were shown by Parwada et al*.,* (2022).

3.2.2 Number of seeds per plant

On perusal of data, it can be observed that the genotype Phule Vikram varied significantly and recorded highest number of seeds per plant with 99.70 and statistically at par values were recorded in genotype PG-05 with 97.10. The lowest number of seeds per plant was recorded in NBeG-49 genotype with 48.75. In semi-humid climates, moderate temperatures are generally conducive to pod and seed development. However, high temperatures (above 30-35°C) during the flowering and pod-filling stages can reduce pollen viability, impair fertilization, and lead to fewer seeds per pod or pod abortion. Conversely, low temperatures during early development can delay pod formation, potentially reducing the number of seeds per plant due to shortened reproductive periods. Similar results were shown by Haris and Chhabra., (2014).

3.2.3 Seed index

A perusal of data on seed index was recorded during the experimental crop growth period at the time of harvest, revealing a significant difference in seed index from genotype to genotype, which was recorded and tabulated in Table 2. The higher highest seed index was recorded in genotype Phule Vikram with 19.38 gm and genotype PG-05 with 19.11gm was statically at par with Phule Vikram. The lowest seed index was recorded in genotype NBeG-49 with 15.05 gm. In semi-humid climates, the moderate availability of moisture can positively influence the seed index by supporting optimal growth and development. Adequate moisture during the seed-filling stage is particularly important for maximizing seed size and weight, which directly impacts the seed index and the results are in acceptance with Zhelyazkova et al*.,* (2016).

3.2.4 Seed length

Significantly higher seed length was recorded in Phule Vikram genotype with 9.47 mm and statistically at par values were recorded in PG-05 genotype with 9.42 mm. The lowest seed length was recorded in NBeG-49 genotype with 8.09 mm. The data on seed length was tabulated and depicted in Table 2.

3.2.5 Seed width

Significantly higher seed width was recorded in Phule Vikram genotype with 8.23 mm and statistically at par values were recorded in PG-05 genotype with 8.16 mm. The lowest seed width was recorded in NBeG-49 genotype with 7.22 mm. Adequate moisture during the seed development and filling stages is crucial for increasing seed length and width in Chickpea. In semi-humid regions, moderate rainfall ensures a steady supply of water, which promotes cell expansion and the accumulation of nutrients in seeds, contributing to increased seed size. If moisture is limited during critical growth stages, such as flowering and pod filling, the seeds may not fully expand, leading to smaller seed dimensions. Similar results were shown by Sorecha et al*.,* (2017).

3.2.6 Test weight

Significantly highest test weight was observed in Phule Vikram genotype with 193.8gm and genotype PG-05 with 191.1 gm was statistically on par with Phule Vikram genotype. The lowest test weight was observed in NBeG-49 genotype with 150.5 gm. The data was depicted in Table 2. In semi-humid climates, moderate moisture levels during the growing season are essential for seed filling and directly contribute to increased test weight. Adequate moisture during the reproductive and seed-filling stages ensures proper nutrient translocation and promotes cell expansion within the seeds, leading to larger, heavier seeds. This increase in seed size translates to a higher test weight and the results are in acceptance with Suryakala et al*.,* (2019), Kashiwagi et al*.,* (2008).

3.2.7 Biological yield per plant

From the data shown in Table 2 biological yield per plant varied significantly among all genotypes. Phule Vikram genotype with 31.69 gm recorded highest biological yield per plant over other genotypes and genotype PG-05 with 30.84 gm was statistically at par with Phule Vikram genotype. The lowest biological yield per plant was observed in NBeG-49 genotype with 18.25 gm. Temperature fluctuations in semi-humid climates also influence the biological yield of Chickpea. Moderate temperatures during the vegetative and reproductive phases promote better growth and development. Chickpea plants perform optimally at temperatures between 15-30°C. In such conditions, the plant is able to allocate resources effectively for both vegetative and reproductive growth, leading to higher biomass production. Similar results were shown by Niveditha et al*.,* (2022).

3.2.8 Harvest index

As per the data shown in Table 2 harvest index varied significantly among all genotypes. Phule Vikram genotype with 37.88% attained highest harvest index over other genotypes and genotype PG-05 with 37.56% was statistically at par with Phule Vikram genotype. The lowest harvest index was observed in FLIP-09-162 genotype with 28.55%.

3.2.9 Seed yield per plant

Significantly higher seed yield per plant was recorded in Phule Vikram genotype with 19.32 gm and statistically at par values were recorded in PG-05 genotype with 18.56 gm. The lowest seed yield per plant was recorded in NBeG-49 genotype with 7.34 gm.

Table 1. Analysis of variance on screening of chickpea (*Cicer arietinum.* L) genotypes based on morphological traits in Prayagraj Region

S. No	Characters	Mean sum of squares		
		Genotype (d.f = 14)	Replication (d.f = 2)	Error (d.f = 28)
01.	Field emergence @ 10 DAS	75.29**	6.08	6.33
02.	Plant Height (cm)	14.34**	5.64	1.18
03.	Days to 50% Flowering	8.27**	9.01	2.08
04.	Days to 50% Pod setting	14.62**	7.50	3.68
05.	Days to maturity	54.74**	5.06	10.27
06.	No. of Primary branches	1.07**	0.01	0.01
07.	No. of Secondary branches	2.27**	0.02	0.04
08.	No. of Pods per plant	17.01**	2.97	1.72
09.	No. of Seeds per plant	857.59**	1.18	4.30
10.	Seed index (%)	6.27**	0.48	0.19
11.	Seed length(mm)	0.67**	0.14	0.03
12.	Seed width(mm)	0.29**	0.01	0.05
13.	Test weight(g)	626.58**	48.30	18.76
14.	Biological yield per plant	67.65**	1.27	0.55
15.	Harvest index (%)	27.80**	1.32	0.46
16.	Seed yield per plant(g)	47.56**	0.03	0.11
17.	Seed yield per ha.(quantal/ha)	1902267.30**	1064.81	4740.94

***Indicates significant at 5% level (P=0.05)*

Table 2. Mean performance on 17 morphological traits of 15 chickpea genotypes

Genotype	F.E @ 10 DAS	Rate of field emergence	PH	DFF	DFPS	DTM	NPB	NSB	NPP	NSPP	SI	SL	SW	TW	BYPH	HI	SYPP	SYPH
IPC 17-373	90.57	2012.00	54.32	58.24	83.22	119.28	2.76	9.89	54.48	89.89	18.84	9.26	8.06	188.4	29.43	36.54	16.94	3387.13
NBeG-3	83.29	1765.00	50.77	60.64	86.79	125.64	1.81	8.57	51.22	62.49	16.48	8.53	7.58	164.8	20.59	33.34	10.30	2059.62
FLIP-09-162	80.21	1635.00	49.61	**62.18**	**88.37**	**129.67**	1.45	7.89	48.36	51.26	15.15	8.13	7.32	151.5	19.45	28.55	7.77	1553.23
IPC-10-134	90.38	1973.00	53.64	58.45	83.68	119.63	2.52	9.73	53.24	86.25	18.56	9.22	7.94	185.6	29.17	35.45	16.01	3201.56
RVG-202	86.24	1851.00	51.67	59.91	86.17	124.28	2.07	8.89	51.69	72.88	17.38	8.81	7.67	173.8	22.68	35.83	12.67	2533.41
PG-05	**93.62**	**2088.00**	**54.86**	57.61	82.64	117.84	**3.06**	**10.19**	**55.17**	**97.10**	**19.11**	**9.42**	**8.16**	**191.1**	**30.84**	**37.56**	**18.56**	**3711.13**
NBeG-49	**77.53**	**1591.00**	**48.34**	61.73	87.56	128.75	**1.34**	**7.56**	**47.79**	**48.75**	**15.05**	**8.09**	**7.22**	**150.5**	**18.25**	**28.67**	**7.34**	**1467.25**
GC-38341	84.72	1783.00	51.49	60.24	86.34	124.83	1.89	8.74	51.59	68.61	17.14	8.64	7.64	171.4	21.44	35.44	11.76	2352.11
ICCV-16-317	82.14	1709.00	49.74	61.57	87.43	128.43	1.53	8.19	49.68	55.64	15.69	8.28	7.46	156.9	19.77	30.63	8.73	1746.03
Phule vikram	**94.28**	**2108.00**	**55.69**	**57.31**	**82.38**	**117.68**	**3.19**	**10.34**	**55.39**	**99.70**	**19.38**	**9.47**	**8.23**	**193.8**	**31.69**	**37.88**	**19.32**	**3864.45**
IPC-12-100	89.47	1943.00	53.26	59.14	84.36	120.73	2.47	9.55	52.77	82.85	18.17	9.15	7.89	181.7	27.43	35.43	15.05	3010.73
JG-36	88.63	1919.00	52.74	59.67	84.77	121.69	2.33	9.43	52.45	80.77	17.76	9.06	7.84	177.6	26.88	34.81	14.35	2869.06
JG-16	91.88	2052.00	54.71	**56.79**	**81.09**	**117.43**	2.95	10.08	54.73	93.59	18.91	9.34	8.11	189.1	30.27	36.90	17.70	3539.51
FLIP-97-53C	82.61	1736.00	50.51	60.81	87.28	127.29	1.74	8.43	49.84	58.31	16.16	8.47	7.53	161.6	20.36	31.64	9.42	1884.67
GG-2	86.72	1868.00	52.48	59.64	85.39	122.72	2.18	9.24	52.11	77.64	17.54	8.94	7.76	175.4	24.59	35.65	13.62	2723.75
Minimum	77.53	1591.00	48.34	56.79	81.09	117.43	1.34	7.56	47.79	48.75	15.05	8.09	7.22	150.5	18.25	28.67	7.34	1467.25
Maximum	94.28	2108.00	55.69	62.18	88.37	129.67	3.19	10.34	55.39	99.70	19.38	9.47	8.23	193.8	31.69	37.88	19.32	3864.45
S.Em	1.45		0.63	0.83	1.11	1.85	0.04	0.12	0.76	1.20	0.25	0.09	0.13	2.50	0.43	0.39	0.19	39.75
S.Ed	2.05		0.89	1.18	1.57	2.62	0.06	0.17	1.07	1.69	0.35	0.13	0.18	3.54	0.60	0.55	0.28	56.22
CV	2.90		2.08	2.42	2.25	2.60	3.29	2.23	2.52	2.76	2.49	1.81	2.83	2.49	2.98	1.97	2.54	2.59
CD	4.21		1.82	2.41	3.21	5.36	0.12	0.34	2.19	3.47	0.72	0.27	0.37	7.24	1.24	1.13	0.56	115.16

FE- Field emergence, PH-Plant Height(cm),DFF-Days to 50% Flowering, DFPS- Days to 50% pod setting, DTM-days to maturity, NPB- No.of primary branches, NSB- No.of secondary branches, NPP-No.of pods per plant, NSPP- No.of seeds per plant, SI- seed index, SL-seed length, SW-seed width, TW-Test weight, BYPP-Biological yield per plant, HI- Harvest index, SYPP-Seed yield per plant, SYPH-Seed yield per hectare

3.2.10 Seed yield per hectare

Significantly higher seed yield per hectare was recorded in Phule Vikram genotype with 3864.45 kg and statistically at par values were recorded in PG-05 genotype with 3711.13 kg. The lowest seed yield per hectare was recorded in NBeG-49 genotype with 1467.25 kg. Different Chickpea genotypes exhibit varying responses to semi-humid conditions, particularly concerning seed yield. Some genotypes are more resilient to moisture stress and high temperatures, allowing them to maintain better reproductive performance under adverse conditions. Breeding programs focused on developing Chickpea varieties that are better adapted to semi-humid climates can significantly enhance seed yield per plant and the results are in acceptance with Parwada et al*.,* (2022), Getachew et al*.,* (2021).

4. CONCLUSION

It can be concluded from the experiment conducted that highest growth and yield characteristics i.e., plant height, number of pods, seeds per plant, seed yield per plant, seed yield per hectare and harvest index were recorded by Phule Vikram genotype followed by PG-05 genotype over other genotypes. Findings are based on research done in one season in Prayagraj (Allahabad) U.P. further trails may be required for considering it for the recommendation.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

ACKNOWLEDGEMENT

I express my gratitude to the Department of Genetics and Plant Breeding & all higher authorities of university for providing us with all facilities for the study. The Authors are thankful to the staff of Seed Science and Technology department laboratory for their cooperation during the study.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

Crop-wise pulses global scenario, Directorate of pulses development, 2024.

Getachew, A. and Abraham, T. (2021). Effect of Sowing Dates on Yield and Yield Components of Some Selected Chickpea (*Cicer arietinum* L.) Varieties. Asian Journal of Advances in Agricultural Research, 15(3): 9-15.

Gupta, V. and Singh, M. (2012). Effect of seed priming and fungicide treatment on Chickpea (*Cicer arietinum*) sown at different sowing depths in Kandi belt of low altitude sub-tropical zone of Jammu. Applied Biological Research, 14(2): 187-192.

Haris, A.A. and Chhabra, V. (2014). Climate change impact on Chickpea yield over a sub humid climatic environment. International Journal of Research in Agricultural Sciences, 1(4): 258-261.

Kashiwagi, J., Krishnamurthy, L., Gaur, P.M., Umezaki, T., Zheng, S.H., Hiraoka, Y., Terauchi, T. And Iwama, K. (2008). Genotype-environment interaction in Chickpea (*C. arietinum* L.) for adaptation to humid temperate and semi-arid tropical environments. Tropical Agriculture and Development, 52(4): 89-96.

Kumar, J. and Abbo, S. (2001). Genetics of flowering time in Chickpea and its bearing on productivity in semiarid environments. Advances in Agronomy, 72: 107-138.

Mola, T., Alemayehu, S., Fikre, A., Ojiewo, C.O., Alemu, K. and Degefu, T. (2018). Heat tolerance responses of Chickpea (*Cicer arietinum* L.) genotypes in the thermal zone of Ethiopia, a case of Werer station. Ethiopian Journal of Crop Science, 6(2): 95-118.

Niveditha, M.P., Patil, S.B., Kalaghatagi, S.B. and Ashvathama, V.H. (2022). Growth and yield of Chickpea genotypes under changing weather scenario in the Northern Dry Zone of Karnataka. Journal of Farm Sciences, 35(02): 192-198.

Parwada, C., Parwada, T.F., Chipomho, J., Mapope, N., Chikwari, E. and Mvumi, C. (2022). Evaluation of Cicer arietinum (Chickpea) growth performance and yield in different soil types in Zimbabwe. Journal of Current Opinion in Crop Science, 3(1): 16-27.

Shafi, A., Shabbir, G., Akram, Z., Mahmood, T., Bakhsh, A. and Noorka, I.R. (2012).

Stability analysis of yield and yield components in Chickpea (*Cicer arietinum* L.) genotypes across three rainfed locations of Pakistan. Pak. J. Bot, 44(5): 1705-1709.

Siddique, K.H.M., Loss, S.P., Regan, K.L. and Jettner, R.L. (1999). Adaptation and seed yield of cool season grain legumes in Mediterranean environments of south-western Australia. Australian Journal of Agricultural Research, 50(3): 375-388.

Sikdar, S., Abuyusuf, M., Ahmed, S., Tazmin, M.F. (2015). Variety and Sowing Time on the Growth and yield of Chickpea (*Cicer arietinum* L.) in Southern Region of Bangladesh. European Academic Research, 3(6): 6922-6945.

Sorecha, E.M., Kibret, K., Hadgu, G. and Lupi, A. (2017). Exploring the impacts of climate change on Chickpea (*Cicer arietinum* L.) production in central highlands of Ethiopia. Academic Research Journal of Agricultural Science and Research, 5(2): 140-150.

Suryakala, A., Murthy, V.R.K., Rekha, M.S. and Jayalalitha, K. (2019). Growth and yield of Chickpea in Vertisols of Krishna Zone of Andhra Pradesh. The Andhra Agricultural Journal, 66(4): 603-605.

Tilahun, G., Mekbib, F., Fikre, A. and Eshete, M. (2015). Genotype x environment interaction and stability analysis for yield and yield related traits of Kabuli-type Chickpea (*Cicer arietinum* L.) in Ethiopia. African journal of Biotechnology, 14(18): 1564-1575.

Peer-review history:
The peer review history for this paper can be accessed here:
https://www.sdiarticle5.com/review-history/126567