Biological and Clinical Sciences Research Journal
eISSN: 2708-2261; pISSN: 2958-4728
www.bcsrj.com
DOI: https://doi.org/10.54112/bcsrj.v2024i1.986
Biol. Clin. Sci. Res. J., Volume, ***2024****: 998*
Original Research Article

EVALUATION OF CHICKPEA VARIETIES FOR CLIMATE RESILIENCE AND YIELD STABILITY AT DIFFERENT PLANTING DATES

RASOOL I[1], HUSSAIN K[1], AMEEN MA[1], BATOOL A[1], ANAM M[2], AZIZ A[1], HUSSAIN A[1], MAHMOOD MT[1], MAQSOOD Z[1], AHMAD RT[3], SAMAD RA[4]

[1]Pulses Research Institute, Faisalabad, Pakistan
[2]Department of Plant Breeding and Genetics, University of Agriculture, Faisalabad, Pakistan
[3]Regional Agricultural Research Institute, Bahawalpur, Pakistan
[4]Pulses Research Program, National Agricultural Research Centre, PARC, Islamabad, Pakistan
Corresponding author: irfanrasooldeo@gmail.com

(Received, 15th March 2024, Revised 30th June 2024, Published 15th July 2024)

Abstract *The study was conducted to check the impact of variable date of sowing for climate resilience in two consecutive years 2021-2022 and 2022-2023 at Faisalabad. Three different dates of sowing 25th of October, 10th, and 20th of November were selected for screening of sixteen Desi chickpea, genotypes, and commercial variety Bittal-2016 as check. Data were recorded for days to 50% flowering, plant height, primary and secondary branches, pods per plant, 100-grain weight, and grain yield kg/ha. The highest grain yield per ha in both years was produced by D-20004 and D-20007. The comparison of sowing dates manifested that on 25th October the plant health remained good and was less affected by climate and produced enhanced grain yield. On the 10th of November and 20th of November, plant growth remained stunted and bear the low number of pods per plant ultimately producing a low yield. The selected lines can be used in breeding programs for the development of climate-resilient chickpea genotypes.*

Keywords *climate resilience; chickpea; grain yield; pods per plant; screening*

Introduction

Chickpea (Cicer et al.) is a self-pollinated legume from the Fabaceae family, divided into two types: Desi (brown gram) and Kabuli (white gram. (Rashid et al., 2021)). Chickpeas are a popular meat alternative with a protein content of 18-25% and have the highest protein bioavailability among pulse.(Erdemcı, 2018). They also contain about 5.0 mg of iron per 100 g and are rich in water-soluble vitamins. (Bicer, 2013). In Pakistan, chickpeas are crucial, covering 73% of the pulse area and contributing 76% of total pulse production. In the 2020-2021 crop year, Pakistan produced around 0.36 million tonnes of chickpeas, against a consumption of 0.40 to 0.70 million tonnes. The Thal region, known for its water scarcity, is a crucial area for chickpea cultivation, spanning one million hectares of irrigated and dry lands. (Maleki et al., 2016). However, biotic and abiotic stresses, particularly water scarcity, significantly impact crop development and profitability. With over 33% of the global population living in water-scarce areas, rising CO2 levels and climate change are expected to worsen drought stress. Changing climate conditions increasingly influence legume crop yields, with quicker adaptations needed in more severe climates. While chickpea grain yields remain high in irrigated areas, they are lower in desert regions where the Desi (Black) chickpea is traditionally grown for Daal and gram flour. Due to higher consumption than production, Pakistan imports chickpeas to meet demand. As one of the top ten countries most affected by climate change, Pakistan faces significant agricultural challenges. (Khan et al.). To mitigate these effects, developing climate-resilient chickpea genotypes is crucial. This involves identifying and screening existing genotypes for climate resilience and assessing suitable sowing times based on current climate conditions.

Materials and Methods

The experiment was conducted at Pulses Research Institute (PRI) Faisalabad in two consecutive cropping years, 2021-2022 and 2022-2023, to evaluate sixteen desi chickpea genotypes against changing climate. The experiment used three distinct sowing dates: the 25th of October and the 10th and 20th of November. The sowing dates were marked as D1, D2 and D3. Commercial variety Bittal-2016 used as check. The other genotypes were chickpea advance lines. With three replications, the treatment combinations were grouped in a two-factor factorial. A plot size of 4.8 m2 was divided into four rows of each genotype with a 30 cm between rows and 15 cm between plants spacing. Dibbler was used to help with the sowing. During the cropping season, proper plant protection measures were implemented. Weeds were kept under control by hand weeding as needed. Across all treatments, all agronomic procedures were kept consistent. The Faisalabad has a subtropical climate and is located between 31.4504° N and 73.1350° E, at an elevation of around 189 meters above sea level. Data recorded for days to 50% flowering, plant height, primary and secondary branches, number of pods per plant, 100-grain weight, and grain yield kg/ha.

[Citation: Rasool, I., Hussain, K., Ameen, M.A., Batool, A., Anam, M., Aziz, A., Hussain, A., Mahmood, M.T., Maqsood, Z., Ahmad, R.T., Samad, R.A. (2024). Evaluation of chickpea varieties for climate resilience and yield stability at different planting dates. *Biol. Clin. Sci. Res. J.,* **2024***:* 986. doi: https://doi.org/10.54112/bcsrj.v2024i1.986]

Results and Discussion

Table 2 shows that for days to 50 percent flowering secondary branches, days to maturity, and grain yield per plot, there was a significant difference in all varieties, treatments, and there for the year 2021-2022. Only the treatments for plant height showed significant differences. Primary branch analysis revealed substantial differences in all types and treatments and the number of pods per plant. For days to 50% maturity and grain yield kg/ha, the data for the years 2022- 2023 revealed significant variability in varieties and treatments. Plant height, secondary branches, days to maturity, and number of pods per plant were all shown to have significant values for both kinds and treatments in the study. Treatments of primary branches and their interactions yielded substantial outcomes. The data of the top eight best-performing chickpea genotypes are presented in Table 3, which shows the mean values of all evaluated factors for the year 2021-2022. Genotype D - 20004 produced the highest yield of kg/ha (2776 kg/ha) on the first date of sowing, 25th October, followed by D - 20007, which indicated the second highest yield (2514 kg/ha). Bittal-2016 required (112.5) maximum days to reach 50% flowering and days to maturity on the third date of sowing in the first year, while genotype D -20001 remained early in this criteria and reached 50% days to flowering (93.1). D-20004 grew to a maximum height of (69.5 cm), while genotype D-20015 grew to a minimum height of (25.3 cm) on the third date of sowing during 2021-22. Genotype D-20004 had the highest mean values for primary and secondary branches (1.9) and (4.9). Genotype D-20004 had the highest mean value (50.2) for the number of pods per plant and 100-grain weight (30.1 g) on the first date of sowing. During the 2nd year of 2022-23, chickpea genotype D-20007 had the highest grain yield (2966 kg/ha) in D1, followed by D-20004 indicated the second highest grain yield (2671 kg/ha). The commercial variety Bittal-2016 remained in 8th position and indicated grain yield (1763 kg/ha) on the first date of sowing and took the longest period in 50% date of flowering (112.1 days) and maturity (158.2 days) in D3. The tallest plants were observed in D-20004 (67.0 cm) in D1 and also indicated the highest number of primary branches (2), secondary branches (4.8), pods per plant (47.6), and 100-grain weight (23.1 g) in D1. The commercial variety Bittal-2016 indicated a grain yield of 1763 kg/ha in D1, primary and secondary branches (1.1) and (3.1), number of pods per plant (26.3), and 100-grain weight (23.5 g) in D1 in Table 4. Figure 1 compares grain yield (kg/ha) best-performing genotypes in 2021-22 and 2022-23. The advanced line of desi D-20004 had the strongest favorable reaction with the highest value of grain yield kg/ha on the first day of sowing (D1), while the third date of sowing date, had a low grain output and plants of all genotypes indicated stunted growth. Although chickpeas are legume plants that can fix nitrogen from the air, their production can be improved even more by applying nitrogen(Ismail et al., 2017). To promote root enlargement and seed development, it is essential to apply fertilizer effectively during the early growth stages (Janmohammadi et al., 2018). Potassium application has increased the number of pods, seeds, pod weight, and seed weight (Joshi et al., 2016). Proper fertilizer use also mitigates damage from changing climatic conditions and positively impacts chickpea seeds (Kaushal et al., 2013). Consequently, this study aimed to assess the effects of varying climatic conditions on chickpea growth and yield at different planting dates and to identify optimal sowing dates. The study revealed that advanced lines and commercial varieties responded differently to various sowing dates (Khamssi, 2011). The number of days to flowering and maturity was highest during 2022-2023 at the D3 sowing date and lowest during 2020-2021 at the D1 sowing date(Hussen et al., 2013). Weather conditions caused variations in days to maturity in 2021-2022 (Kishor et al., 2017). Desi chickpea genotypes delayed flowering at both years' second and third sowing dates (Krishnamurthy et al., 2011). The vegetative phase accelerates and enhances with rising temperatures(Kumar et al., 2013). Chickpeas exhibit a predictable growth pattern (Maleki et al., 2016). A longer vegetative development phase slows flowering and maturation (Maleki et al., 2016). Farmers prefer early maturing, short-duration chickpea genotypes due to cropping intensity (Pathak et al., 2012) and climate-resilient chickpea varieties. Compared to early varieties, the delayed flowering and late maturity of Desi advance lines made late seeding undesirable (Rani et al., 2020). Plant height is crucial for yield (Rashid et al., 2021). Chickpeas need a moderate height, but tall plants are better for mechanical harvesting. However, tall plants tend to lodge at maturity, causing significant yield losses (Rahman and Zhang, 2018). In the 2021-2022 growing season, sowing date had the most positive impact on plant height. In 2022-2023, the highest plant height was observed on the first sowing date, followed by the second and third treatments(Janmohammadi et al., 2018). Contradictory data indicated that climate had minimal effect on plant height (Saghfi and Eivazi, 2014). The number of primary and secondary branches was highest for the first sowing date in both years(Khan et al.), positively impacting total grain yield(Vimal and Kumar, 2018). The number of pods per plant was also highest on the first sowing date in both years (Shukla et al., 2010). The 100-grain weight and grain yield were highest on the first sowing date in both years. The average temperature and average precipitation during 2021-2022 and 2022- 2023 at two Faisalabad presented in Table 5 and Table 6. The fluctuation in temperature affected plant physiological functions. Low temperatures, particularly below 20°C, can significantly affect the physiological functions of plants. For instance, temperatures of 17.6/4.9°C (day/night) over 26 days during the reproductive phase can reduce relative leaf water content due to decreased root hydraulic conductivity, oxidative and membrane damage, and chlorophyll loss. Chilling stress at 13/10°C (day/night) for 18 hours during germination can inhibit α-amylase activity, disrupt sugar metabolism, reduce leaf water status, and hinder the uptake of essential minerals like nitrogen, phosphorus, and potassium, leading to delayed seedling emergence and poor growth in chickpeas. Temperature fluctuations can also impact root physiology, affecting ion absorption and causing visible deficiency symptoms. Exposure to 5°C for three days can inhibit root growth and the plant's ability to absorb water and minerals, impacting overall nutrition. Additionally, low temperatures (5/5°C for four days) can reduce leaf water content due to stomatal

[Citation: Rasool, I., Hussain, K., Ameen, M.A., Batool, A., Anam, M., Aziz, A., Hussain, A., Mahmood, M.T., Maqsood, Z., Ahmad, R.T., Samad, R.A. (2024). Evaluation of chickpea varieties for climate resilience and yield stability at different planting dates. *Biol. Clin. Sci. Res. J.,* **2024***:* 986. doi: https://doi.org/10.54112/bcsrj.v2024i1.986]

malfunction. Cold stress during the flowering stage (12–15/4–6°C day/night) can lead to flower abortion and poor pod set in chickpeas by reducing sucrose, glucose, and fructose levels in anthers and pollen of sensitive genotypes. Under cold stress conditions (3°C for 7 days), chickpea genotypes showed an increase in endogenous proline and carbohydrates (glucose, rhamnose, and mannose). These compounds may aid in osmoregulation and fulfill the heightened energy demands. Notably, the cold-tolerant genotypes exhibited superior performance in these aspects (Saghfi and Eivazi, 2014).

Excessive heat stress impacts every aspect of chickpea growth, phenology, and development, including biomass, flowering duration, pod number, days to maturity, seed weight, and grain yield. High temperatures affect seed germination in chickpeas, with genotypic variation observed for high-temperature tolerance (Shukla et al., 2010). No germination occurs above 45°C, and high temperatures can reduce seedling growth and even cause seedling death. Controlled environment studies show that biomass increases significantly in both tolerant and sensitive genotypes at 35/25°C, but exposure to 40/30°C decreases biomass at maturity in all genotypes, especially in sensitive ones (Rashid et al., 2021).

Heat stress affects chickpea growth and vigor at all stages, but the reproductive phase is particularly sensitive to temperature extremes. During reproduction, heat stress can reduce flower numbers, increase flower abortion, alter anther locule numbers, cause pollen sterility and poor pollen germination, reduce fertilization and stigma receptivity, cause ovary abnormalities, and reduce the remobilization of photosynthates to seeds(Rashid et al., 2021). This results in fewer seeds, lower seed weight, and reduced seed yield. Exposure to high temperatures (35/20°C) before anthesis can impair anther development, pollen production, and fertility by causing physiological abnormalities. High temperatures can also induce structural aberrations in anthers and pollen, such as changes in anther locule numbers, thickening of the anther epidermis wall, and pollen sterility, which are key factors in reducing chickpea yield. Pollen is more sensitive to heat stress than the female gametophyte. Post-anthesis heat stress is associated with poor pollen germination, pollen tube growth, fertilization, and loss of stigma receptivity, leading to reduced seed number, weight, and yield(Singh et al., 2018a). Temperatures Heat stress increased oxidative stress and decreased leaf photosynthesis, leading to a reduction in soluble carbohydrates and ATP in the pistil (Kumar et al., 2013). This disruption hindered nutrient transport from the style to the pollen tube, inhibiting pollen tube growth and ovary development (Kaushal et al., 2013). Screening chickpea genotypes for heat sensitivity showed significant genetic variation in high-temperature environments (Devasirvatham et al., 2013). Heat-tolerant chickpea genotypes were able to produce pods at temperatures above 35/20°C, while sensitive genotypes aborted most of their flowers (Singh et al., 2018b). It was found that heat-tolerant genotypes had a higher pod set compared to heat-sensitive genotypes above 45°C are particularly harmful to pollen fertility and stigma function (Sohu et al., 2015).

Table 1. Advance lines and check varieties of Desi chickpea

	Var.	Sr.NO	Var.	Sr.NO	Var.	Sr.NO	Var.
1	D -20012	5	D -20001	9	D -20004	13	D -20009
2	Bittle-2016	6	D -20010	10	D -20007	14	D -20013
3	D -20015	7	D -20011	11	D -20005	15	D -20003
4	D -20014	8	D -20002	12	D -20006	16	D -20008

Table 2. ANOVA for 2021-2022 and 2022-2023

SOV	DF	DTF50%	P.H	P.BR	SEC.BR	DTM	Pods/P	100 G.W	GY/P
Replications	2	0.63	0.8	0.5	0.8	0.4	0.7	0.6	0.06
Varieties	15	62.5**	138.8**	2.3*	11.5**	0.3	996**	24.4*	205.6**
Error	30	0.8	6.7	3.1*	2.2	1.3	4.1	0.6	0.7
Treatment	2	121.5**	138.1**	3.4*	21.4**	4.1	65.7**	32.9*	231.7**
V*Trt	30	13.9**	26.4	4.1*	21.9**	1.5	175.1**	32.5*	270.1**
Error	64	0.7	2.7	0.12	0.7	0.6	1.9	5.1	6.9
SOV	**DF**	**DTF50%**	**P.H**	**P.BR**	**SEC.BR**	**DTM**	**Pods/P**	**100 G.W**	**GY/P**
Replications	2	1.1	0.06	0.03	0.1	0.04	0.04	0.4	0.7
Varieties	15	43.4**	144.2**	2.5*	21.6**	1.6	547.3**	55.9**	998.4**
Error	30	2.02	1.02	3.1*	2.1	0.6	1.5	0.08	2.8
Treatment	2	77.7**	201.2**	2.6*	41.2**	1.9	684.4**	159**	743.7**
V*Trt	30	2.6**	31.5**	3.1*	33.04**	1.4	229.1**	25.5**	269.2**
Error	64	0.68	6.5	0.08	1.9	0.9	1.9	0.6	4.1

DTF 50%: Days to 50% flowering. **P.H**: Plant height. **Pri.Br**: Primary branches. **Sec. br**: Secondary branches, **Pods/P**: Pods perplant. **DTM50%**: Days to 50% maturity.**100GW**: 100-grain weight.**GY/P**: Grain yield per plot.

[Citation: Rasool, I., Hussain, K., Ameen, M.A., Batool, A., Anam, M., Aziz, A., Hussain, A., Mahmood, M.T., Maqsood, Z., Ahmad, R.T., Samad, R.A. (2024). Evaluation of chickpea varieties for climate resilience and yield stability at different planting dates. *Biol. Clin. Sci. Res. J.*, **2024**: 986. doi: https://doi.org/10.54112/bcsrj.v2024i1.986]

Table 3. Mean Values of yield related traits in different sowing dates in year 2021-2022

	Genotypes		DTF50%	P.H	Pri.Br	Sec. br	Pods/p	DTM50%	100GW (g)	GY kg/ha
1	D -20004	D1	101.1	69.5	1.9	4.9	50.2	145.2	30.1	2776
		D2	101.3	58.2	1.5	3.5	45.7	148.2	23.1	2709
		D3	104.4	48.1	1.4	3.1	43.2	150.3	19.2	2576
2	D -20007	D1	102.1	63.8	1.4	5.0	50.1	147.1	28.3	2514
		D2	106.1	62.5	1.1	4.4	42.1	151.2	22.1	2381
		D3	109.1	50.7	1.2	3.7	40.7	155.5	19.1	2334
3	D -20005	D1	101.2	57.5	1.3	4.1	45.1	152.2	24.1	2289
		D2	104.1	56.6	1.2	4.0	40.5	154.1	20.2	2287
		D3	106.2	48.3	1.1	3.5	39.8	157.2	17.2	2232
4	D -20006	D1	101.1	47.9	1.0	4.1	43.3	148.1	23.5	2176
		D2	104.1	44.2	1.1	3.9	38.7	154.1	19.7	2167
		D3	110.1	41.1	1.1	3.6	35.8	158.2	15.3	2156
5	D -20001	D1	93.1	69.0	1.4	4.4	37.6	145.3	22.1	2134
		D2	96.1	44.8	1.1	4.6	34.9	150.2	18.7	2056
		D3	103.2	40.3	1.4	4.8	32.7	145.1	15.7	2051
6	D -20010	D1	100.1	64.2	1.0	4.1	35.1	152.1	22.8	1703
		D2	104.1	43.7	1.4	4.1	32.9	155.2	18.1	1505
		D3	107.2	40.4	1.1	4.6	30.2	157.1	16.1	1450
7	D -20011	D1	97.3	57.1	1.1	4.2	32.1	150.1	21.5	1650
		D2	100.2	40.5	1.2	4.1	28.3	152.2	17.4	1450
		D3	109.1	37.3	1.0	4.2	20.8	155.3	16.5	1350
8	Bittle-2016	D1	101.1	59.4	1.4	4.8	28.6	148.4	18.1	1501
		D2	104.2	38.7	1.1	4.7	18.9	153.1	14.4	1305
		D3	112.5	34.7	1.0	3.9	15.8	158.1	11.1	1102

DTF50%: Days to 50% flowering. **P.H**: Plant height. **Pri.Br**: Primary branches. **Sec.br**: Secondary branches, **Pods/P**: Pods per plant. **DTM50%**: Days to 50% maturity.**100GW**: 100 grain weight.**GY/P**: Grain yield per plot

Table 4. Mean Values of yield related traits in different sowing dates in year 2022-2023

Sr. No	Genotypes		DTF50 %	P.H	Pri.Br	Sec.br	Pods/p	DTM50%	100GW (g)	GY kg/ha
1	D -20007	D1	95.1	67.0	2	4.8	47.6	145.3	23.1	2966
		D2	95.1	61.8	2	3.6	39.9	150.2	21.7	2755
		D3	105.2	53.3	1	3.8	37.7	145.1	17.7	2700
2	D -20004	D1	98.1	61.2	1.2	4.5	45.1	152.1	22.3	2671
		D2	101.1	60.7	1.8	3.1	36.9	155.2	20.1	2609
		D3	106.2	51.4	1.5	2.6	32.2	157.1	16.1	2549
3	D -20005	D1	98.1	58.1	1.8	4.3	45.1	150.1	21	2509
		D2	98.2	55.5	1.4	3.1	34.3	152.2	19.4	2493

[Citation: Rasool, I., Hussain, K., Ameen, M.A., Batool, A., Anam, M., Aziz, A., Hussain, A., Mahmood, M.T., Maqsood, Z., Ahmad, R.T., Samad, R.A. (2024). Evaluation of chickpea varieties for climate resilience and yield stability at different planting dates. *Biol. Clin. Sci. Res. J.*, **2024**: 986. doi: https://doi.org/10.54112/bcsrj.v2024i1.986]

		D3	108.3	50.3	1.1	2.2	30.8	155.3	17.5	2489
4	D -20006	D1	98.1	47.4	1.8	4.1	41.6	148.4	17.1	2415
		D2	100.5	43.7	1.5	3.7	35.9	153.1	16.4	2302
		D3	110.5	42.7	1.1	2.9	32.8	158.1	12.1	2296
5	D -20001	D1	99.1	66.5	1.1	3.9	39.8	145.2	28.2	2252
		D2	102.3	54.2	1.2	3.1	34.7	148.2	22.1	2249
		D3	108.4	46.1	1.8	2.2	28.2	150.3	20.2	2229
6	D -20010	D1	101.1	61.8	1.8	3.4	34.1	147.1	25.3	2194
		D2	105.1	61.5	1.2	3.1	28.1	151.2	21.1	1809
		D3	109.1	50.7	1.1	2.8	20.7	155.5	19.1	1703
7	D -20011	D1	100.2	59.5	1.2	3.1	25.1	152.2	24.1	2001
		D2	105.1	59.6	1.4	2.3	23.5	154.1	19.2	1850
		D3	108.2	49.3	1.4	2.1	17.8	157.2	16.2	1650
8	Bittle-2016	D1	102.1	48.9	1.1	3.1	26.3	148.1	23.5	1763
		D2	103.1	45.2	1.2	2.9	19.7	154.1	20.7	1550
		D3	112.1	44.1	1.6	2.6	12.8	158.2	19.3	1320

TF50%: Days to 50% flowering. **P.H**: Plant height. **Pri.Br**: Primary branches. **Sec.br**: Secondary branches, **Pods/p**ods per plant. **DTM50%**: Days to 50% maturity.**100GW**: 100grain weight.**GY/P**: Grain yield per plot.

Table 5. Meteorological conditions for Faisalabad, Pakistan during 2021-22

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Record high °C	26.6	30.8	37	44	47.8	48	46.1	42	41.1	40	36.1	29.2
Average high °C	19.4	22.2	27.4	34.2	39.7	41	37.7	36.5	36.6	33.9	28.2	22.1
Average low °C	4.8	7.6	12.6	18.3	24.1	27.6	27.9	27.2	24.5	17.7	10.4	6.1
Record low °C	−4	−2	1	7	13	17	19	18.6	15.6	9	2	−1.3
Average precipitation mm	16	18	23	14	9	29	96	97	20	5	2	8

Table 6. Meteorological conditions for Faisalabad, Pakistan during 2022-23

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Record high °C	22.4	26.8	31.2	37.2	44.8	48.1	47.1	43	42.1	38.2	32.1	27.2
Average high °C	18.2	20.2	25.4	30.2	34.7	43.4	43.1	35.5	37.6	32.9	26.2	21.1
Average low °C	4.8	7.6	12.6	18.3	24.1	27.6	27.9	27.2	24.5	17.7	10.4	6.1
Record low °C	−3	−3	2	8	14	18	20	17.6	16.8	10.1	3	−1.1
Average precipitation mm	17	15	18	10	12	32	100	102	10	8	6	1

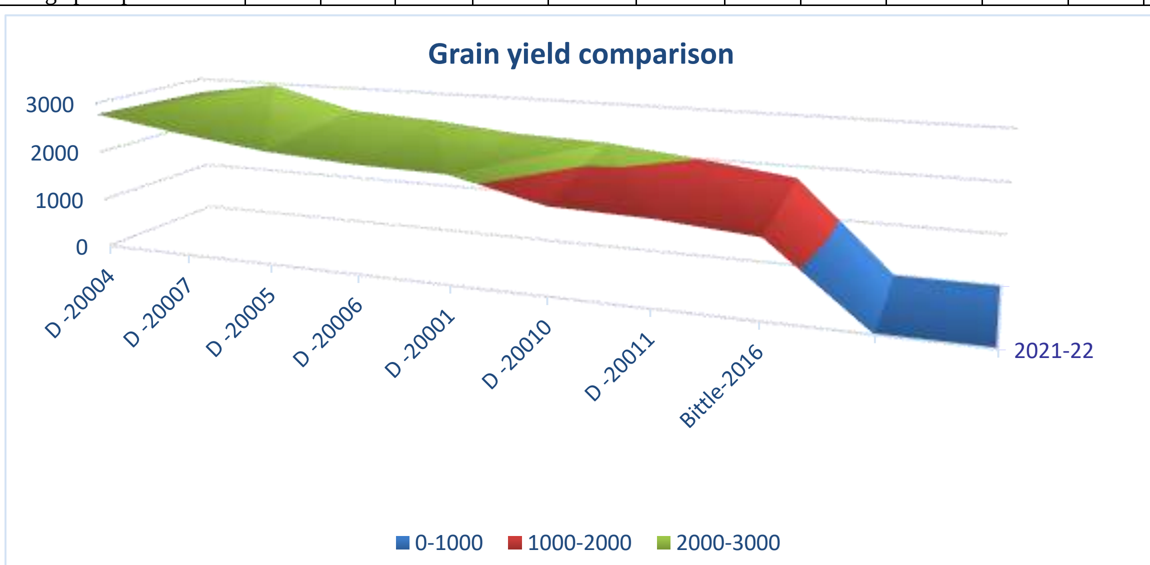

Figure 1. Grain yield comparison of Chickpea Genotypes during 2021-2022 and 2022-23

[Citation: Rasool, I., Hussain, K., Ameen, M.A., Batool, A., Anam, M., Aziz, A., Hussain, A., Mahmood, M.T., Maqsood, Z., Ahmad, R.T., Samad, R.A. (2024). Evaluation of chickpea varieties for climate resilience and yield stability at different planting dates. *Biol. Clin. Sci. Res. J.*, **2024***:* 986. doi: https://doi.org/10.54112/bcsrj.v2024i1.986]

References

Bicer, B. (2013). The effect of phosphorus doses on chickpea cultivars under rainfall conditions.

Devasirvatham, V., Gaur, P. M., Mallikarjuna, N., Raju, T. N., Trethowan, R. M., and Tan, D. K. (2013). Reproductive biology of chickpea response to heat stress in the field is associated with performance in controlled environments. *Field Crops Research* **142**, 9-19.

Erdemcı, İ. (2018). Investigating genotype× environment interaction in chickpea genotypes using AMMI and GGE biplot analysis. *Turkish Journal of Field Crops* **23**, 20-26.

Hussen, S., Yirga, F., and Tibebu, F. (2013). Effect of Phosphorus fertilizer on yield and yield components of chickpea (Cicer arietinum) at Kelemeda, South Wollo, Ethiopia. *Int. J. Soil Crop Sci* **1**, 1-4.

Ismail, M., Moursy, A. A., and Mousa, A. (2017). Effect of organic and inorganic N fertilizer on growth and yield of chickpea (Cicer arietinum L.) grown on sandy soil using 15N tracer.

Janmohammadi, M., Abdoli, H., Sabaghnia, N., Esmailpour, M., and Aghaei, A. (2018). The effect of iron, zinc and organic fertilizer on yield of chickpea (Cicer artietinum L.) in Mediterranean climate. *Acta Universitatis Agriculturae Et Silviculturae Mendelianae Brunensis* **66**.

Joshi, D., Gediya, K., Patel, J., Birari, M., and Gupta, S. (2016). Effect of organic manures on growth and yield of summer cowpea [Vigna unguiculata (L.) Walp] under middle Gujarat conditions. *Agricultural Science Digest-A Research Journal* **36**, 134-137.

Kaushal, N., Awasthi, R., Gupta, K., Gaur, P., Siddique, K. H., and Nayyar, H. (2013). Heat-stress-induced reproductive failures in chickpea (Cicer arietinum) are associated with impaired sucrose metabolism in leaves and anthers. *Functional Plant Biology* **40**, 1334-1349.

Khamssi, N. N. (2011). Grain yield and protein of chickpea (Cicer arietinum L.) cultivars under gradual water deficit conditions. *Research Journal of Environmental Sciences* **5**, 611.

Khan, I., Abdullah, M. I., and MI, K. S. Hashim, S. Afzal and K. Nawab. 2023. Management of wild onion (Asphodelus tenuifolius Cav.) in chickpea crop at district Karak. *Pakistan Journal of Weed Science Research* **29**, 164-178.

Kishor, K., David, J., Tiwari, S., Singh, A., and Rai, B. S. (2017). Nutritional composition of chickpea (Cicer arietinum) milk. *International journal of chemical studies* **5**, 1941-1944.

Krishnamurthy, L., Gaur, P., Basu, P., Chaturvedi, S., Tripathi, S., Vadez, V., Rathore, A., Varshney, R., and Gowda, C. (2011). Large genetic variation for heat tolerance in the reference collection of chickpea (Cicer arietinum L.) germplasm. *Plant Genetic Resources* **9**, 59-69.

Kumar, S., Thakur, P., Kaushal, N., Malik, J. A., Gaur, P., and Nayyar, H. (2013). Effect of varying high temperatures during reproductive growth on reproductive function, oxidative stress and seed yield in chickpea genotypes differing in heat sensitivity. *Archives of Agronomy and Soil Science* **59**, 823-843.

Maleki, S., Moghaddam, A. N., Sabbaghpour, H., Noorinia, A. A., and Sabouri, H. (2016). Effect of Zeolite and Potassium on Yield and Yield components of Chickpea (Cicer arietinum L.) in the different Irrigation Regimes. *Advances in Bioresearch* **7**.

Pathak, G. C., Gupta, B., and Pandey, N. (2012). Improving reproductive efficiency of chickpea by foliar application of zinc. *Brazilian Journal of Plant Physiology* **24**, 173-180.

Rahman, K. A., and Zhang, D. (2018). Effects of fertilizer broadcasting on the excessive use of inorganic fertilizers and environmental sustainability. *Sustainability* **10**, 759.

Rani, A., Devi, P., Jha, U. C., Sharma, K. D., Siddique, K. H., and Nayyar, H. (2020). Developing climate-resilient chickpea involving physiological and molecular approaches with a focus on temperature and drought stresses. *Frontiers in plant science* **10**, 1759.

Rashid, K., Akhtar, M., Cheema, K. L., Rasool, I., Zahid, M. A., Hussain, A., Qadeer, Z., and Khalid, M. J. (2021). Identification of operative dose of NPK on yield enhancement of desi and kabuli chickpea (Cicer arietinum L.) in diverse milieu. *Saudi Journal of Biological Sciences* **28**, 1063-1068.

Saghfi, S., and Eivazi, A. (2014). Effects of cold stress on proline and soluble carbohydrates in two chickpea cultivars.

Shukla, O., Singh, P., and Deshbhratar, P. (2010). Impact of phosphorous on biochemical changes in Hordeum vulgare L. in mixed cropping with Chickpea. *Journal of Environmental Biology* **31**, 575.

Singh, D., Singh, S., Kumar, V., and Kumar, A. (2018a). Impact of phosphorus and sulphur organo mineral fertilizers on growth and yield attributes of green gram (Vigna radiate (L.) Wilczek) on alluvial soil. *IJCS* **6**, 2983-2987.

Singh, I., Tomar, D., Mahajan, M., Nehte, D., Singh, L., and Singh, H. (2018b). Impact of front line demonstration on chickpea to meet the deficit pulse availability in Malwa Plateau and Central Plateau Region of India. *Int. J. Curr. Microbiol. App. Sci* **7**, 2305-2311.

Sohu, I., Gandahi, A. W., Bhutto, G. R., Sarki, M. S., and Gandahi, R. (2015). Growth and Yield Maximization of Chickpea (Cicer arietinum) Through Integrated Nutrient Management Applied to Rice-Chickpea Cropping System. *Sarhad Journal of Agriculture* **31**.

Vimal, S., and Kumar, A. (2018). Standardization of biofortification for enhance seed yield and its quality parameters in chickpea (Cicer arietinum L.). *Journal of Pharmacognosy and Phytochemistry* **7**, 1883-1887.

[Citation: Rasool, I., Hussain, K., Ameen, M.A., Batool, A., Anam, M., Aziz, A., Hussain, A., Mahmood, M.T., Maqsood, Z., Ahmad, R.T., Samad, R.A. (2024). Evaluation of chickpea varieties for climate resilience and yield stability at different planting dates. *Biol. Clin. Sci. Res. J.*, **2024**: 986. doi: https://doi.org/10.54112/bcsrj.v2024i1.986]

Declaration

Ethics Approval and Consent to Participate

Not applicable.

Consent for Publication

The study was approved by authors.

Funding Statement

Not applicable

Conflict of Interest

There is no conflict of interest among the authors regarding this case study.

Authors Contribution

All authors contributed equally.

[Citation: Rasool, I., Hussain, K., Ameen, M.A., Batool, A., Anam, M., Aziz, A., Hussain, A., Mahmood, M.T., Maqsood, Z., Ahmad, R.T., Samad, R.A. (2024). Evaluation of chickpea varieties for climate resilience and yield stability at different planting dates. *Biol. Clin. Sci. Res. J.*, **2024**: 986. doi: https://doi.org/10.54112/bcsrj.v2024i1.986]