Official publication of Pakistan Phytopathological Society
Pakistan Journal of Phytopathology
ISSN: 1019-763X (Print), 2305-0284 (Online)
http://www.pakps.com

A LANDMARK IN CHICKPEA PRODUCTION FOR FOOD SECURITY: BITTAL-2022, A NEW HIGH YIELDING AND DISEASE RESISTANT CULTIVAR

[a]Irfan Rasool, [a]Muhammad Akhter, [b]Muhammad Aqeel, [a]Muhammad A. Amin, [a]Amer Hussain, [c]Muhammed T. Mahmood, [a]Asia Batool, [a]Muhammad E. Khan [a]Ali Aziz

[a] *Pulses Research Institute, Ayub Agricultural Research Institute, Faisalabad, Pakistan.*
[b] *Maize and Millet Research Institute, Yousaf Wala, Pakistan.*
[c] *Gram Breeding Research Sub Station, Kallurkot, Pakistan.*

ABSTRACT

The current study was designed to introduce the new Chickpea cultivar Bittal-2022, an outcome of hybridization (90156 X 05014) followed by pedigree method of selection. This variety was tested in a series of trials on Research Stations throughout the chickpea growing areas of Pakistan. It out-yielded check variety Bittal-2016 in Station and Adaptation yield trials. In National Uniform Yield Trials (NUYT), it surpassed check variety Bittal-2016 and stood 3rd during 2019-20 whereas in 2020-21, it surpassed check variety by 7%. Its maximum yield potential of 3958 kg/ha was achieved in CYT (Co-operative Yield Trials) during 2018-19 at RARI, Bahawalpur. The cultivar Bittal-2022 produced an overall 10% higher yield than check varieties in different yield trials conducted from 2016-17 to 2020-21. This variety is suitable for mechanical harvesting and exhibited resistance to shattering at maturity. It is moderately resistant against Ascochyta blight & Fusarium wilt and exhibited tolerance against insect pests. In addition, this approved variety needs no special production technology and fit in a better way with the existing agronomic practices. So approved cultivar Bittal-2022 is suitable for both irrigated and rain-fed chickpea cultivated areas of the Punjab province.

Keywords: Chickpea cultivar**,** High yielding, Food security, Punjab.

INTRODUCTION

Chickpea, scientifically called *Cicer arietinum* is a legume crop belonging to family *Leguminaceae,* indigenous to southeastern Turkey. Chickpea is diploid (2n=2x=16), self-pollinated, annual crop with genome size of 738MB (Yadav *et al*., 2023). Chickpea played a significant role on ecosystem by fixing nitrogen in the soil from environment through nitrogen fixing bacteria present in their root nodules. It can fix 41% atmospheric nitrogen. It is a rich source of protein, dietary fiber and minerals such as iron and zinc.

Globally chickpea is cultivated on around 15 million hectares, producing 15 million tones at a yield of 10578 kg/ha, however in Pakistan chickpea is cultivated on 0.8 million hectares producing 0.2 million tones at a yield of 2650 kg/ha. (FAO, 2021). Pakistan ranked 7th in terms of chickpea production and produce 2.5% of the world production (Maitlo *et al*., 2014). Punjab province of Pakistan shares around 90% of chickpea production and meets 80% of the country's chickpea demand (Naveed *et al*., 2020). Despite having the second-largest chickpea land area in the world, Pakistan's total output is poor, variable, and much below local requirements therefore in ordered to fulfil local chickpea demands Pakistan needs to import chickpea from different countries (Australia, Canada and Middle East).

The reasons for Pakistan's low chickpea yield include a lack of effective crop development projects, dissemination of seeds infrastructure, poor quality marginal land, alkaline soils with low nutrients, erosion, changing climates, lack of crop-specific machines, losses after the harvest, and marketing challenges, as well as abiotic stresses such as high

Submitted: March 28, 2023
Revised: May 17, 2023
Accepted for Publication: June 05, 2023
* Corresponding Author:
Email: ehsankhanuaf@gmail.com

temperatures, drought, salinity, and biotic stresses such as diseases, insect-pests, weeds (Ullah *et al*.,2020).

Various challenges, such as biotic and abiotic stresses including disease, drought, and salinity, pose obstacles to chickpea production, resulting in reduced yields (Haware and Pande, 2020). Chickpea blight and wilt, among the biotic stresses, are particularly severe and exhibit non-linear characteristics. These diseases are frequently reported in chickpea-growing regions such as Pakistan, India, Spain, Iran, Bangladesh, and the USA. The global annual crop losses caused by diseases are estimated to reach approximately $60 billion (Reddy *et al*., 2009). Wilt can lead to yield losses ranging from 10% to 90%. In Pakistan, wilt has caused a decline in the cultivation of chickpeas on irrigated lands from 50% to 10% (Johansen *et al*., 2000). Santos *et al*. (2019) demonstrated the potential of specific rhizobacterial strains to effectively suppress Fusarium wilt in chickpea plants, thereby providing opportunities for sustainable disease management strategies. Another significant disease, blight, caused by *Ascochyta rabiei*, can result in yield losses of 50% to 70%. (Patel *et al*., 2019) identified genetic markers associated with resistance to Ascochyta blight, offering valuable insights for breeding programs aimed at developing disease-resistant chickpea cultivars. Although blight can be controlled through the use of foliar and seed dressing fungicides, disease-free seeds, and the removal of diseased plant debris, certain conditions may limit the feasibility of these approaches.

To overcome these challenges, numerous studies have indicated that increasing chickpea production can be achieved by developing high-yielding and disease-resistant varieties (Abbo *et al*., 2020).

Plant breeders have developed various techniques to improve chickpea production, including conventional breeding and genetic engineering. Molecular breeding, a relatively new breeding technique, has shown promise in developing high-yielding and disease-resistant chickpea varieties (Jaba *et al*., 2020). It involves using molecular markers and genomic tools to select plants with desirable traits, including resistance to biotic and abiotic stresses. This technique has facilitated the development of new chickpea varieties with enhanced resistance to diseases such as Fusarium wilt, Ascochyta blight, and Botrytis gray mold (Haware and Pande, 2020).

In this study, we aim to evaluate the performance of newly developed chickpea varieties that combine high yield potential with disease resistance in field trials under biotic and abiotic stress conditions. Our results will provide valuable insights into the potential of these varieties for improving chickpea production and contributing to food security in regions where chickpea is a staple crop. We hypothesize that the newly developed varieties will exhibit higher yield potential and disease resistance compared to existing varieties, which could significantly contribute to increased chickpea production and enhanced food security.

The breeding program at Pulses Research Institute, Faisalabad is aimed to develop high yielding, blight and wilt tolerant varieties of chickpea suitable for both rain-fed and irrigated areas as well. The cultivar Bittal-2022 is hoped will be a popular variety because of its yield potential and resistance against major chickpea diseases.

MATERIALS AND METHODS

Site of the experiment: All the experiments are carried out in Pulses Research Institute, Faisalabad and at out-stations including chickpea growing areas of Pakistan. Geographical co- ordinates of Faisalabad are the rolling flat plains of north-east Punjab. Its latitude is 31°25′00′′ towards North and longitude is 73°04′59′′ towards East, with an elevation of 186 meter above sea level. High evapotranspiration is reported in Faisalabad due to which its climate is arid or semiarid. The recorded average yearly rainfall is almost 13.417mm, while average temperature during winter range from 21°C -28°C and in summer, average temperature rises between 30°C-45°C. The humidity (average) is 35.17g.m-3 (https://www.weather-atlas.com/en/pakistan/faisalabad-climate#temperature) recorded on average yearly basis.

Hybridization / Pedigree method of selection: Parental lines 90156 (A cross of ICC 196 & CM 72-160, high yielding and bold seeded parent) and 05014 (Erect, Suitable for mechanical harvesting and resistant to wilt and blight) (male & female), source population having pedigree 21- 21- 108 - 108 - 157- 059 - D-16029 was sown in the month of November 2009-10 Rabi season. Crossing was attempted early in the morning at Pulses Research Institute, Faisalabad. F_0 population was successfully harvested at the end of season and advanced to F1 population for sowing during 2010-11.

Generation advancement (F_1 to F_6): Single row having 4m length was sown along with parental lines. By using Dibbler seed was sown having row to row 30cm and plant to plant 10cm distance. Produce of F_1 seed was harvested successfully to advance generation F_2. From F_2 selection was made on the basis of plant vigor and disease free plants that continued to F_5 generation. Pure lines were selected in F_6 generation; its yield was tested in Preliminary Yield Trial during 2016-17.

Table 1. Stages of hybridization and selection of Bittal-2022

Year	Filial generation/trial	Operation
2009-10	Cross was attempted	F_0 seed was harvested
2010-11	F_1	Seed of F_1 cross harvested
2011-12	F_2	Single plant selection
2012-13	F_3	Single plant selection
2013-14	F_4	Plant to row progenies
2014-15	F_5	Pure Line Selection
2015-16	F_6	Pure line selection and seed multiplication.
2016-17	Preliminary Yield Trial	Yield data were recorded
2017-18	Advanced Yield Trial	- do-
2018-19	Co-operative Yield Trial	- do-
2019-20	National Uniform Yield Trial	- do-
2020-21	National Uniform Yield Trial, DUS, Entomological and Pathological Studies	- do-
2021-22	DUS, Entomological and Pathological Studies	- do-
2021-22	Spot Examination	24-03-2022

Evaluation in different yield trials: Bittal-2022 was tested in Preliminary Yield Trial (PYT) for yield evaluation during 2016-17, then it was tested in Advanced and Co-operative yield trials. After two years of National Uniform Yield Trial (NUYT) and Entomological and Pathological Studies, it was studied in Distinguished Uniformity Stability (DUS) during 2020-21 & 2021-22. Fertilizer trial was conducted during Rabi 2021-22, three different treatments were applied with one control. Highest yield was obtained with one bag of DAP and one bag of Potash i.e treatment T_2.

Table 2. Different doses of Fertilizer in Bittal-2022

	Treatments	Yield Kg/ha
T0	No fertilizer	1409
T1	1 Bag Dap + 1 Bag Potash	1893
T2	1.5 Bag Dap + 1 Bag Potash	1569
T3	2 Bag Dap + 1 Bag Potash	1413

STATISTICAL ANALYSIS

Throughout the study period, the recorded traits were subjected to analysis of variance (Steel *et al*., 1997) and mean comparison tests (Tukey, 1949) to determine the genetic variations among the parameters. Significant variations were observed in nearly all the morphological parameters related to yield and yield-related parameters.

RESULTS AND DISCUSSION

The newly developed Bittal-2022 variety exhibits high-yielding characteristics, maintaining excellent yield performance throughout the evaluation studies. In the Preliminary and Advanced yield trials, it demonstrated an impressive overall grain yield that was 10.6% and 9.7% higher, respectively, than the check variety Bittal-2016. During the Cooperative Yield Trials conducted in seven different environments, Bittal-2022 achieved a 3.3% higher grain yield as compared to the check variety. Notably, in the National uniform yield trials of 2019-20, it outperformed the check varieties by 27.8% in Punjab locations and 13.3% in country-wide locations, securing the top rank in Punjab locations. Similarly, in

the National uniform yield trials of 2020-21, it showcased an increase of 4.11% in Punjab locations and 6.86% in country locations. Bittal-2022 achieved its potential yield of 3958 kg/ha in the CYT Trial at RARI, Bahawalpur. Overall, across all the trials, it consistently produced a higher yield of 10.0% compared to the check varieties. A detailed overview of the yield performance can be found in Table-3.

Table 3. Yield performance of Bittal-2022 in different yield trials

Year	Name of Trial	Locations	Yield (Kg/ha)		% +/- increase
			Bittal-2016	D-16029 Check (s)	
2016-17	Preliminary Yield Trials	PRI, Faisalabad	2594	2665	
		GBRSS, Kallurkot	2361	2813	
		Average	2477	2739	10.6%
2017-18	Advanced Yield Trials	GBRSS, Kallurkot	1215	1333	9.7%
		Average			
2018-19	Co-operative Yield Trials	PRI, Faisalabad	1035	1174	
		NIAB, Faisalabad	713	674	
		GBRSS, Kallurkot	1354	1646	
		AZRI, Bhakkar	1792	2260	
		ARF, Karor	2532	2785	
		RARI, Bahawalpur	4027	3958	
		GBRSS, Kallurkot (Barani)	1479	1372	
		AZRI, Bhakkar (Barani)	1049	910	
		K.Kot (Farmers Field)	889	632	
		GBRF, Rakhutra	309	139	
		Mankera (Farmers Field)	697	853	
		Average	1443	1491	3.3%
2019-20	National Uniform Yield Trials (Punjab Locations)	PRI, Faisalabad	918	319	
		AZRI	1885	1077	
		AZRI	1632	1875	
		BARI	673	535	
		GBRSS	2243	1681	
		NIAB, Faisalabad	979	1029	
		Average	1086	1388	27.8%
2020-21	National Uniform Yield Trials (Punjab Locations)	PRI, Faisalabad	2171	2749	
		AZRI, Bhakkar	1176	1723	
		BARI, Chakwal	1132	1104	
		GBRSS, Kallurkot	2875	3139	
		BARS, Fateh Jang	1611	1823	
		NIAB, Faisalabad	2399	2450	
		RARI, Bahawalpur	2535	2257	
		ARF, Karor	1904	1208	
		Mean	1975	2057	4.1%
2016-21	Overall Average Increase				10.0 %

Agronomic Studies: Sowing date, plant spacing and fertilizer trials studies were conducted at Pulses Research Institute, Faisalabad during 2021-22 to fix specific agronomic requirements of the candidate variety Bittal-2022. It was observed that this variety adhered to the existing production technology and needed no special treatments.

Different sowing dates trials were conducted during 2021-22 to get appropriate sowing time for the chickpea varieties. 29th October is the best sowing time for chickpea genotypes. Bittal-2022 performed better as compared to check variety Bittal-2021.

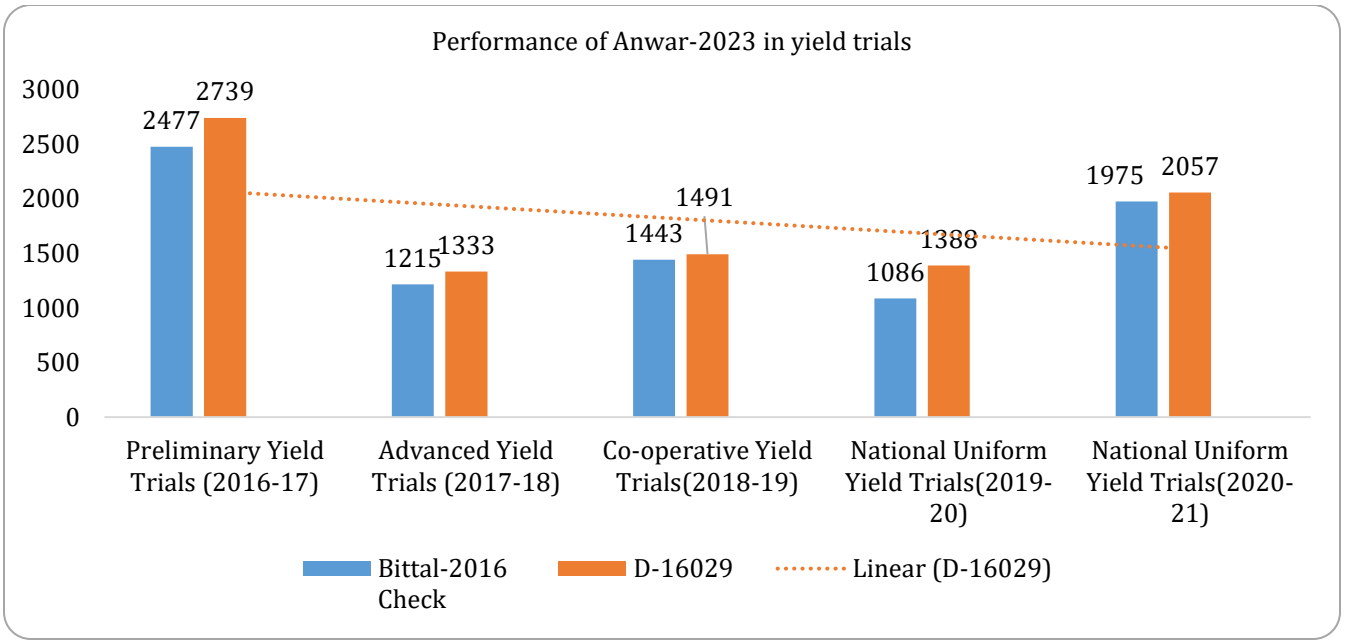

Figure 1. Graphical Presentation of Different Yield Trials for Evaluation of Anwar-23

Table 4. Different sowing dates trial for evaluation of Bittal-2022

Sowing date	Yield Kg/ha		
	Bittal-2021	D-16029	D-17006
14th October 2021	841	932	1148
29th October 2021	1092	1186	1430
14th November 2021	1291	1458	1387

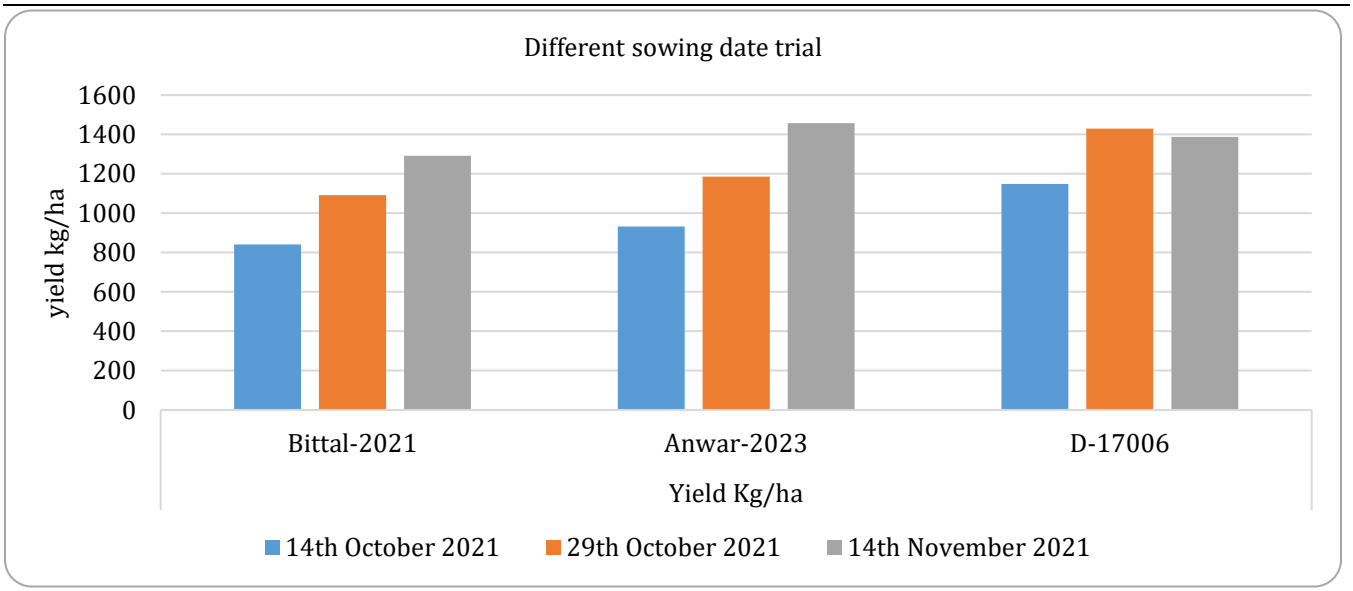

Figure 2. Graphical Presentation of Different Sowing Dates Trials for Evaluation of Anwar-23

Spacing Trial

Table 5. Spacing trial for evaluation of Bittal-2022

Treatments	Row to row spacing	Plant to plant spacing	Yield Kg/ha
S1	30 cm	15 cm	1803
S2	45 cm	10 cm	1915
S3	60cm	7.5 cm	1672

Diseases Reaction: Chickpea Fusarium wilt and Ascochyta blight: At the Pulses Research Institute, Faisalabad, screening studies were conducted to assess the resistance of the variety Bittal-2022 and the check variety against Fusarium wilt and Ascochyta blight. Both varieties were categorized as moderately resistant (MR). The Scale for Fusarium wilt included the following categories: Highly Resistant (HR) with 0% plants infested, Resistant (R) with 0% 6-10 plants infested, Moderately Resistant (MR) with 21-40% plants infested, Susceptible (S) with 61-80% plants infested, and Highly Susceptible (HS) with 100% plants infested. The Scale for Ascochyta blight consisted of the following categories: Immune (no infection), Highly Resistant (HR) with 1-5% plants infested, Resistant (R) with 6-10% plants infested, Moderately Resistant (MR) with 11-15% plants infested, Tolerant with 16-40% plants infested, Moderately Susceptible (MS) with 41-50% plants infested, Moderately Susceptible to Susceptible (S) with 51-75% plants infested, Susceptible (S) with 76-100% and HS=Highly Susceptible (100% plants infested) breakage of branches and pod infection.
(ICARDA-2013).

Insect Pest: Insect pest's infestation studies for gram pod borer were carried out during 2019-20 at ERI, Faisalabad and during 2020-21 at Pulses Research Institute, Faisalabad. The Data revealed low prefer ability of pod borer towards D-16029

Table 6. Entomological studies for evaluation of Bittal-2022

Line / Variety	Cutworm infection % at early stage	Aphid /twig seasonal average	Gram Pod borer seasonal average	Bio control population/ plant	Pod wall thickness (mm)	Pod Hair density (per cm^2)
Anwar - 2023	5.8	7.6	9.8	1.7	0.28	152.3
Bittal 2016	5.7	7.9	7.3	1.9	0.32	169.0

Quality of Bittal-2022: This new candidate line is bold seeded, attractive in shape & color and suitable for table purpose both as whole as well as split (Dall). It has high protein % age (22.6)

Table 7. Different sowing dates trial for evaluation of Bittal-2022

Line / Variety	Moisture (%)	Ash (%)	Crude fat (%)	Crude Protein (%)
Anwar -2023	6.98	3.05	3.02	22.6
Bittal-2016	6.67	3.49	3.28	23.2

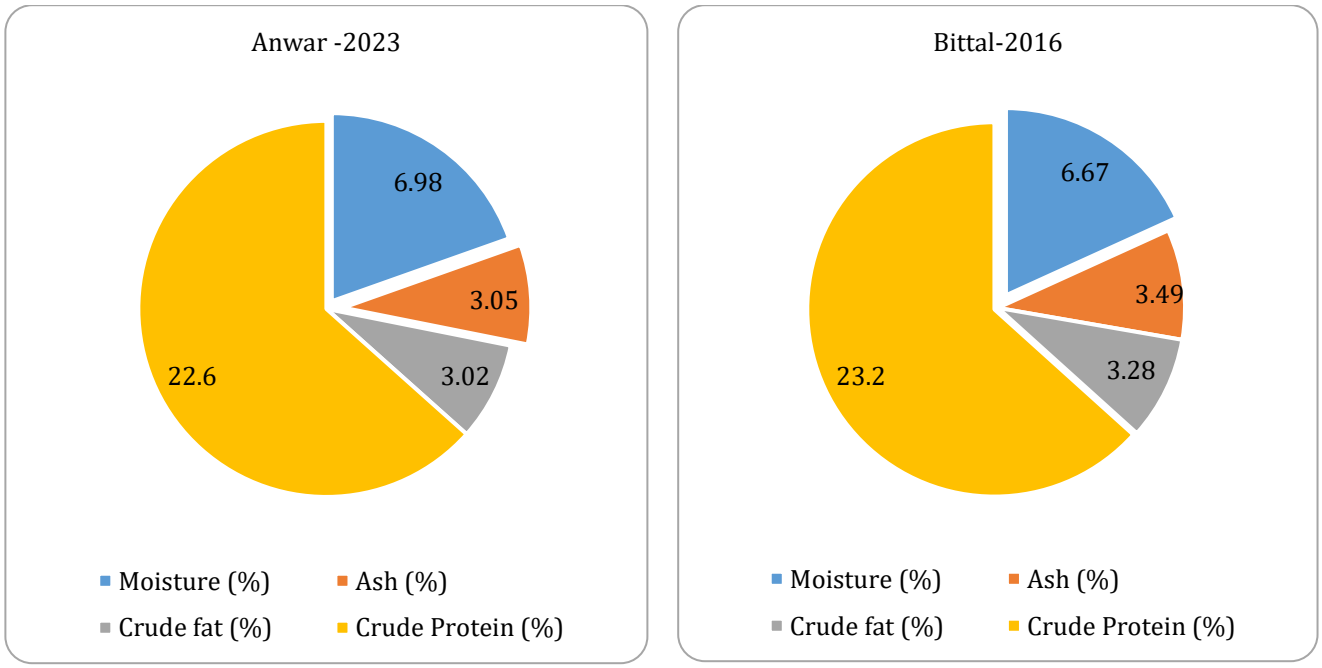

Figure 3. Comparison of Quality Analysis of Bittal-2022 and Bittal-2016

Table 8. characterization studies of Bittal-2022 and Bittal-2016

Characteristics		Bittal-2016
Plant traits		
Growth habit	Semi erect to erect	Semi erect
Plant height (cm)	58-65	60-65
Stem anthocyanin	Medium	Medium
Canopy spread	Medium	Medium
Stem color	Green	Green
Primary branches	3-5	4 - 5
Secondary branches	8-14	8-12
Maturity duration	Medium	Long
Leaf characteristics		
Leaf color	Dark green	Waxy dark green
No. of leaflets	14-18	14 – 17
Leaf let size	Medium	Large
Leaf hairiness	Medium	Medium
Flower characteristics		
Days to flowering (50%)	95-100	103-105
Flower color	Pink	Pink with purple veins
Flower size	Medium	Medium
Days to maturity	150 – 160	150-165
Pod characteristics		
Pod size	Large	Large
Pods shattering	Absent	Low
Pods / plant	55 – 82	65-75
Seeds / pod	1 – 3	1 – 3
Seed characteristics		
Seed color	Light brown to brown	Light brown
Seed shape	Ram head	Ram head
Seed size	Bold	Bold
100-seed weight (g)	27.4 – 29	27 – 29
Distinguishing Characteristics	High yielding, bold seeded, resistant to pod shattering and suitable for mechanical harvesting	High yielding with pods on tertiary branches

Botanical Description: Bittal-2022 is a medium seeded, ram headed variety as it is preferred type in Pakistan. It has semi erect to erect growth habit while Bittal-2016 has semi erect growth habit and equally suitable for both irrigated and rainfed chickpea growing areas of Punjab Province. Depending upon biotic and abiotic factors primary branches of Bittal-2022 varies from 3-5 and secondary branches from 8-14 as compared to check variety

Flower characteristics: It has medium sized pink colored flower. Its days to 50% flowering varies from 95-100 while check variety take 103-105 days to complete its 50% flowering.

Pod characteristics: Pod is large having 55-82pods/plant as compared to check, having 65-75 pods/plant. Number of seeds per pod varies from 1-3. Pod shattering is one of a major problem in chickpea i.e absent in Bittal-2022.

Seed characteristics: Seed color varies from light brown to brown, has ram headed seed shape. Its 100grain weight varies from 27.4-29g.

CONCLUSION

BITTAL-2022 was tested at Pulses Research Institute, AARI, Faisalabad as well as at different chickpea sowing areas of Pakistan. It is concluded that this latest variety with a yield potential of 3958 kg ha^{-1} is better as compared to check variety Bittal-2016. It produced an overall 10 % higher yield than check variety Bittal-2016 in different yield trials. It is recommended for both Rain-fed and irrigated areas of Punjab. A new chickpea cultivar

have distinguished characteristics, high yielding, bold seeded, resistant to pod shattering at the time of harvesting and suitable for mechanical harvesting as it is a one of the major issue at harvesting. It is Moderately resistant to Ascochyta blight and pod Borer attack and have high protein % age (22.6).

ACKNOWLEDGEMENT

Bittal-2022 is a result of continuous, hectic and concerted efforts of a team of scientists of Pulses Research Institute, Faisalabad who worked whole heartedly for its planning, hybridization, selection, screening, evaluation and approval

REFERENCES

Abbo, S., J. Berger, N.C. Turner, D. Bajaj and V. Vadez. 2020. Evolution of chickpea: pattern of changes associated with modern breeding. Theoretical and Applied Genetics, 133: 1461-1480.

FAO. 2021. Food and Agriculture Organization of the United Nations. FAOSTAT statistical database, Rome, Italy.

Johansen, C., J.M. Duxbury, S.M. Virmani, C.L.L. Gowda, S. Pande and P.K. Joshi. 2000. Legumes in rice and wheat cropping systems of the Indo-Gangetic plain-constraints and opportunities, International Crops Research Institute for the Semi-Arid Tropics Patancheru 502 324, Andhra Pradesh, India and Cornell University Ithaca, New York USA. pp. 230.

Haware, M. P and Pande, S. 2020. Chickpea diseases and their management. In Chickpea Breeding and Management. Springer, Singapore. pp. 179-222.

Jaba, J., D. Singh, S. Kumar and K.D. Sharma. 2020. Molecular breeding for chickpea improvement: progress, prospects, and challenges. Frontiers in Plant Science, 11: 1-16.

Maitlo, S.A., R.N. Syed, M.A. Rustamani, R.D. Khuhro and A.M. Lodhi. 2014. Comparative efficacy of different fungicides against fusarium wilt of chickpea (*Cicer arietinum* L.), Pakistan Journal of Botany, 46: 2305-2312.

Naveed, M., M. Shafiq, M. Nadeem, A.U. Haq and M. A. Zahid. 2020. "Noor-2013" a bold seeded and high yielding chickpea kabuli variety developed indigenously, The Journal of Animal and Plant Sciences, 30: 885-894.

Patel, M., R. Kumar and L. Verma. 2019. Identification of genetic markers associated with Ascochyta blight resistance in chickpea. Plant Breeding, 136: 587-595.

Reddy, D.V.R., M.R. Sudarshana, M. Fuchs, N.C. Rao and G. Thottappilly. 2009. Genetically engineered virus-resistant plants in developing countries: Current status and future prospects. Advances in Virus Research, 75: 185-220.

Santos, J. A., K. Kuki and P. Altas. 2019. Rhizobacteria-mediated suppression of Fusarium wilt in chickpea: Mechanisms and prospects. Plant Pathology, 68: 231-243.

Steel, R.G., J.H Torrie and D.A Dickey. 1997. Principles and Procedures of Statistics: A Biological Approach; McGraw-Hill: New York, USA.

Ullah, A., T.M. Shah and M. Farooq. 2020. Pulses production in Pakistan: Status, constraints and opportunities. International Journal of Plant Production, 14: 549-569.

Tukey, J.W. 1949. Comparing individual means in the analysis of variance. International Biometric Society, 5: 99-114.

Yadav, R.K., M.J. Tripathi, S. Tiwari, N. Tripathi, R. Asati, V. Patel, R.S. Sikarwar and D.K. Payasi. 2023. Breeding and genomic approaches towards development of fusarium wilt resistance in chickpea. Life, 13: 988-995.

Contribution of Authors:

Irfan Rasool	:	Write up research article
Muhammad Akhter	:	Reviewed the article
Muhammad Aqeel	:	Represent graphic presentation of paper
Muhammad A. Amin	:	Helped in statistical analysis
Amer Hussain	:	Planned all yield trials and data collection
Muhammad T. Mahmood	:	Technically evaluate data and research article
Asia Batool	:	Conduct Pathology experiments and Write up pathological part of research article
Muhammad E.Khan	:	Reviewed the article
Ali Aziz	:	Conduct Entomological experiments and collect data of insect pests