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DEVELOPMENT OF THAL GUARA: A HIGH-YIELDING, EARLY MATURING AND DROUGHT TOLERANT GUAR (*CYAMOPSIS TETRAGONOLOBA*) VARIETY FOR SUSTAINABLE AGRICULTURE

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Abstract

Guar (Cyamopsis tetragonoloba (L.) Taub.) is an important leguminous crop with significant agricultural and industrial value due to its ability to improve soil fertility and serve as a major source of guar gum. The present study focused on the breeding, selection, and multi-environment evaluation of a newly developed guar variety, Thal Guara. Multi-location yield trials conducted from 2014 to 2020 indicated that Thal Guara exhibited superior performance compared with the standard check varieties BR-99 and BR-2017, with yield increases of up to 25.4% under optimal agronomic conditions. The variety was evaluated at different agro-ecological zones and performed best when sown in early June with a fertilization regime of 30-60-60 kg NPK ha $^{-1}$. Thal Guara also demonstrated enhanced drought resilience, lower pest infestation, and moderate resistance against bacterial blight and Alternaria blight. Biochemical analysis of Thal guara exhibited high guar gum contents, protein, and carbohydrates which are suitability for diverse industrial uses. The stable yield performance and desirable agronomic traits indicate its potential for large-scale adoption of Thal Guara to enhance guar production and promote sustainable agriculture.

INTRODUCTION

Guar (Cyamopsis tetragonoloba) is a plant that has multiple applications in agriculture and industry due to its many benefits and uses, as well as due to its leguminous nature. Guar, which is a native crop of arid and semi-arid regions of India and Pakistan, is essential to rural livelihood, sustainable agriculture and economic growth (Zubair et al., 2022).Guar serves as a high-protein fodder crop to the food security program and enhances soil health and fertility due to its capacity to fix nitrogen, and sustainability in farming due to its drought resistance and the ability to use water efficiently (Nayyar et al., 2023; Ravelombola et al., 2021; Gautam et al., 2024). Moreover, growing guar offers employment opportunities to the smallholder farmers and rural people. Its seeds provide guar gum, a hydrocolloid that is composed of guar gum, containing excellent gelling, stabilizing and thickening qualities. Guar gum can be employed in various industries like food processing, pharmaceutical, cosmetic, and oil drilling, and also in innovative biomedical

applications (Dallabrida et al., 2024), where it acts as a thickener, stabilizer, texture modifier, binder, disintegrant, emulsifier and a fracturing agent (Minhas et al., 2025; Barber et al., 2023).

Guar gum is also associated with health benefits, including improved gut health, sleep quality, and motivation (Abe et al., 2023), and has potential therapeutic applications (Awan et al., 2024; Kumbhar et al., 2025).Guar demand is increasing day by day in the world due to its multiple uses.Modified guar biopolymers are being explored for tissue engineering and other advanced applications (Sharahi, 2025). The major producers of guar are India, Pakistan and the United States, with India contributing about 80 percent of the worldwide production (Sharma et al., 2023). Guar is mainly grown in Sindh and Punjab provinces of Pakistan, and the Bahawalpur district of Punjab has become one of the well-known regions in the production of this guar. Bahawalpur has a climatic environment which is suitable; the area is hot and dry, which complements the growth specifications of the guar plant. The high economic potential of guar has led to its recognition as one of the major crops by farmers in this region. Nevertheless, its significance does not exclude the existence of difficulties, including the lack of research on developing varieties, pests, and diseases control, and access to the market, which hinders production at the highest level (Khan et al., 2023).

It is highly important to develop new varieties of guar to overcome the existing challenges and to ensure that the crop is more resistant to pests, diseases, and adverse weather conditions. Most varieties available lack the characteristics of high productivity, good disease resistance, and adaptation to various weather conditions (Nayyar et al., 2023; Ravelombola et al., 2021; Gautam et al., 2024). Guar production can be increased by breeding better varieties developed during breeding programs to provide the farmers with an alternative in the face of changing farming conditions (Gupta et al., 2023). Recent advances in guar genomic resources further provide molecular insights into gum biosynthesis pathways (Gaikwad et al., 2023).

The Agricultural (Guar) Research Station (ARS) in Bahawalpur initiated a breeding program to come up with a new variety of guar to help the local farmers. This paper provides a detailed summary of the development process, including the selection of the germplasm to the eventual release of the Thal Guara variety. This paper seeks to offer an insight into the breeding process and the major challenges, opportunities, and lessons learnt in the development of Thal Guara. Through this experience, we would like to help in the progress of guar research and development, which will ultimately benefit farmers, rural communities, and the agriculture sector in general.

MATERIAL AND METHODS

1. Experimental site

This experiment was conducted was in the Agricultural (Guar) Research Station, Bahawalpur, Pakistan. Bahawalpur district is in the Southern part of Punjab Province with a climate that is harsh climate and temperatures that reach up to 48 °C in summer and cold and dry winters below 7 °C. It is located in one of Pakistan's most arid regions. The district is physically separated into three physiographic units: the plain area, the desert area, and the riverine area. The soil under study had a sandy loam texture and had pH, EC, and Zn levels of 8.2, 2.8 dS m^{-1}, and 1.43 ppm, respectively.

2. Germplasm selection

The Thal guar variety coded as "S-6384" is developed by single plant selection from the gene pool Line No. "ARS-G-6054" at Agricultural Research Station, Bahawalpur, based on plant type, number of pods $plant^{-1}$, days to 90% pods maturity, drought tolerance and resistance to insect pests and diseases. Table 1 shows the salient traits of the Thal Guara variety.

Table 1. Salient Traits of Thal Guara variety compared to BR-17 (check).

Traits	Thal Guara	BR-2017 (Check)
Plant surface	hairy (pubescent)	hairy (pubescent)
Plant height (cm)	110-120	150-160

No. of branches plant^{-1}	8-12	0-1
Days to flowering (50%)	45-50	50-55
Days to maturity	100-110	110-120
Pods plant^{-1}	260-280	200-230
Seed size	Bold	Medium bold
Seed pod^{-1}	7-8	7-8
1000 seed weight (g)	35	30
Seed Yield Potential (Kg ha^{-1})	2900	2400
Guar Gum (%age)	33.52	33.71
Crude Protein (%age)	31.00	30.75

Thal-Guara

BR-17 (Check)

The variety was subjected to different selection cycles in several repeated trials from 2012-13 to 2021-22, i.e., Single Plant Selections, Identification of promising progeny lines of guar, preliminary yield trials, regular yield trials, Zonal yield trials and National uniform yield trials.

The selection of a superior single plant was carried out during 2012-13 to develop this variety. This single planting was continued with the rejection of unwanted/diseased plants in natural conditions. The seed harvested from desirable plants was bulked.Guar germplasm has been reported to exhibit broad genetic diversity and population structure, providing strong potential for varietal improvement (Malani et al., 2024).The breeding

approach adapted for the development of said variety had already been used by many breeders (Minhas et al., 2021). The breeding history of the new guar strain is given in Table 2.

Table: 2 Breeding history of "Thal Guara" variety from 2012-13 to 2021-22

S. No.	Year	Generation / Trial	V. Code
1	2012-13	Single Plant Selections	S-6384
2	2013-14	Identification of promising progeny lines of guar	-do-
3	2014-15	Preliminary Guar Yield Trials (A-Trial)	-do-
4	2016-17	Regular Guar Yield Trials (B-Trial)	-do-
5	2017-18	Advance Guar Yield Trials (C-Trial)	-do-
6	2018-19	Zonal Trial, NUGYT, DUS	-do-
7	2019-20	Zonal Trial, NUGYT, DUS	-do-
8	2021-22	Spot Examination	-do-

3. Station Yield Trials

The variety was initially evaluated in Station yield trials at Agricultural (Guar) Research Station, Bahawalpur, from 2014-15 to 2017-18 that included Preliminary guar yield trials (A-Trial), Regular guar yield trials (B-Trial), and Advance guar yield trials (C-Trial) in comparison with the Check variety BR-17 before its testing in Multi-locational yield trials. All guar trials were sown in Randomized Complete Block Design (RCBD) with 3 replications. The distance between two rows was kept at 45 cm. The Planting was completed with the use of a single row drill, and each genotype was contained in 4 rows of 5 m length. One to two (1-2) approved varieties used as checks were used in each trial for the comparison.

4. Multi-locational Yield Trials

4.1 Zonal yield trial

The trial was conducted at 3 locations, i.e. ARS, Khanewal, ARS, Bahawalpur and ARS, Karore for two years, 2018-19 & 2019-20.

4.2. National Uniform Wheat Yield Trial (NUWYT)

Thal variety codded as "S-6384" was tested at (05) different locations of Pakistan for two years consecutively in Kharif 2018 and Kharif 2019 by the National Coordinator (Fodder), NARC, Islamabad to assess the yield potential at different locations.

5. Agronomic performance evaluation

5.1. Drought Tolerance Evaluation

The yield potential of Thal guara variety was also assessed under drought stress conditions for areas experiencing water shortage. No irrigation was applied from sowing till harvesting except soaking dose (rowni). The experiment was conducted for two years, 2018-19 & 2019-20. Total rainfall during the crop growth periods, i.e., emergence to physiological maturity, was recorded as 103mm in 2018-19 and 167mm in 2019-20.

5.2. Sowing dates Experiment

The sowing date trials were conducted for two years during 2019-20 to 2020-21 to find out the optimum sowing time of guar newly developed variety Thal guara at the Agricultural Research Station, Bahawalpur.

5.3. Fertilizers Doses Evaluation Trial

For evaluation of optimum fertilizer dose, 10 different combinations of Nitrogen, phosphorus, and Potash for two years during 2019-20 to 2020-

21 were applied at the time of sowing under irrigated conditions with a split-plot design comprising three replications. This trial was conducted to determine the optimum and economical fertilizer requirements of the variety. N, P, and K were applied in the form of urea, DAP & MOP, respectively.

5.4. Row Spacing

The variety was evaluated for the Row spacing trial that included 30cm, 45cm and 60cm distances. To find the best distance at which more fodder and seed yield can be obtained.

5.5. Water Requirements Under Irrigated Conditions

Five different irrigations were applied to Thal guara variety from sowing till harvesting at different growing stages of crop to find out optimum number of irrigations in order to get maximum grain yield,following approaches similar to Garcia et al. (2023), who studied guar performance under various irrigation regimes in the arid Southwest US.In irrigated areas the experiment was conducted for two years.

6. Entomological Studies

The response of Thal-guara to insect pest attacks was studied at the Entomological Section, RARI, Bahawalpur, during Kharif, 2017-18 and 2018-19.

7. Pathological studies

The disease reaction of Thal guara was evaluated at the Plant Pathological Section, RARI, Bahawalpur, during Kharif, 2018-19 and 2019-20.

8. Grain quality analysis

Testing of Guar Gum (%), Protein (%) and carbohydrates (%) of 'Thal guara'' variety coded as S-6384 in comparison with the check variety BR-17 was carried out by the Agricultural Chemist (Bio), Post-Harvest Research Centre, Ayub Agricultural Research Institute, Faisalabad.

RESULTS AND DISCUSSION

1.YIELD PERFORMANCE IN STATION YIELD TRIALS

Guar variety Thal Guara was compared to check varieties across different trials conducted in various years. The key findings are given in Table 3. In 2014-15 (A-Trial), Thal Guara produced 2745 kg/ha, whereas the check variety (BR-99) yielded 1745 kg/ha. This represents a 57.31% increase over the check variety. In 2016-17 (B-Trial), Thal Guara yielded 2685 kg/ha, while BR-99 had a yield of 1635 kg/ha, showing an even higher 64.22% increase over the check variety. In 2017-18 (C-Trial), Thal Guara yielded 2822 kg/ha, compared to 2250 kg/ha from a new check variety (BR-2017). The yield improvement over the check was 25.42%. The yield of Thal Guara remained consistently higher than the check varieties across all years, demonstrating its superior performance. The highest percentage change in the check variety was in the 2016-17 trial (64.22%), which showed substantial yield benefits in such conditions (Table 3, Figure 1).

TABLE 3. Results of Station Yield Trials (2013-14 to 2016-17)

Year	Trial	Grain Yield Kg/ha		% increase over check	LSD (0.05)
		Thal Guara	Check varieties		
2014-15	A-Trial	**2745**	1745 (BR-99)	57.31	115.0
2016-17	B-Trial	**2685**	1635 (BR-99)	64.22	165.5
2017-18	C-Trial	**2822**	2250 (BR-2017)	25.042	231.14

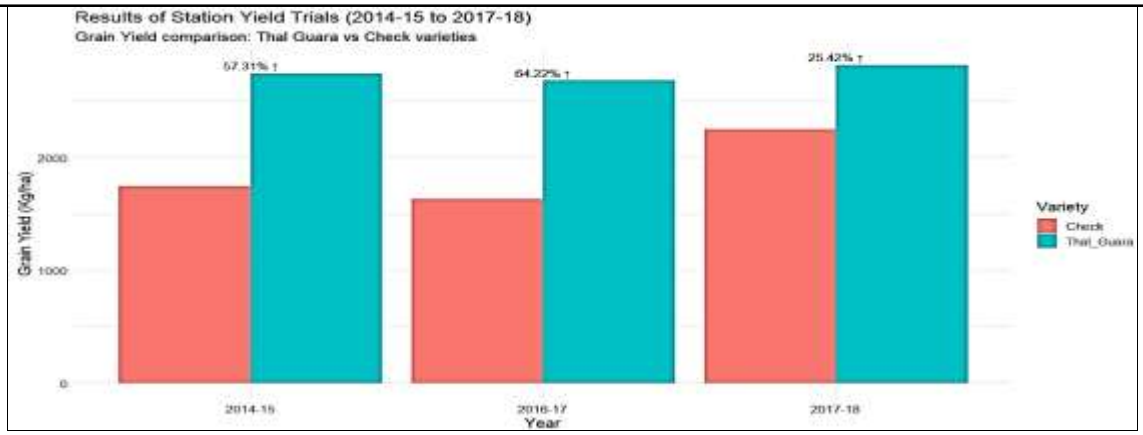

Figure 1 : Results of Station yield trials

2. YIELD PERFORMANCE IN ZONAL GUAR YIELD TRIAL

Yield performance of the Thal Guara variety was evaluated across various locations of Punjab to check its stability For this purpose, the variety was tested for two years, i.e., 2018-19 and 2019-20, at ARS Khanewal, ARS Karor, and ARS Bahawalpur, and it was proven that this newly emerging variety has stable yield across different locations.

In 2018-19, Thal Guara averaged yield 2098 kg/ha (28.79% higher than BR-2017), while in 2019-20 it improved to 2439 kg/ha (33.42% higher). ARS Bahawalpur consistently achieved maximum yields, and ARS Karor produced the least, probably because of difficult conditions. Thal Guara's yield remained stable, with a rising yield advantage in 2019–20, and it could be more widely used in the production of guar (Table 4 and Figure 2).

TABLE 4. Zonal Guar Yield Trial (2018-19 to 2019-20)

Years	Entry Name	Locations/Grain Yield (Kg ha^{-1})			Average Kg ha^{-1}	Percentage increase over check
		ARS, Khanewal	ARS, Karor	ARS, Bahawalpur		
2018-19	**Thal Guara**	**2257**	**1323**	**2713**	**2098**	**28.79**
	BR-2017 (Check)	1794	934	2160	1629	-
2019-20	**Thal Guara**	**2481**	**1897**	**2939**	**2439**	**33.42**
	BR-2017 (Check)	1704	1633	2148	1828	-

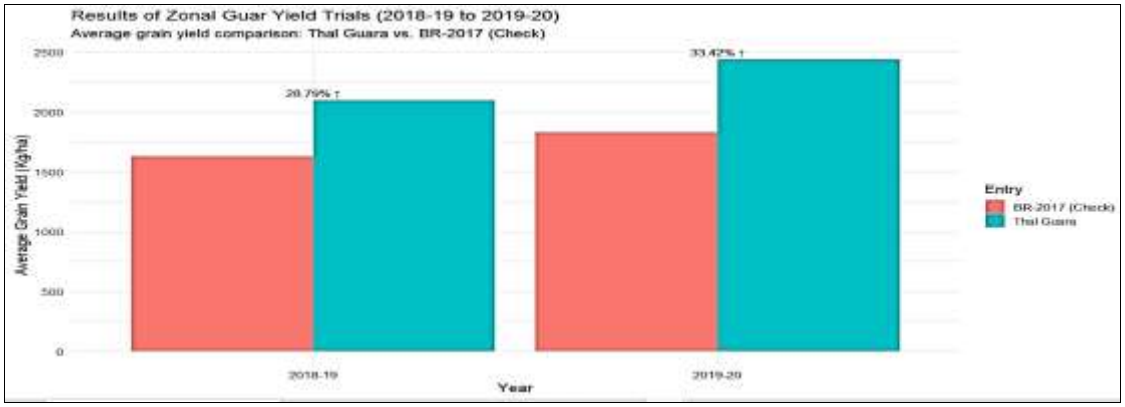

Figure 2: Results of Zonal guar yield trials

3 YIELD PERFORMANCE IN NATIONAL UNIFORM GUAR YIELD TRIAL

The table shows the multi-location performance of grain yield of Thal Guara as compared to the check variety BR-2017 in 5 research stations BARS, Fatehjang, AZRI, Bahawalpur, AZRI, Bhakkar, BARI, Chakwal, and CRI, Khanpur. At all sites, Thal Guara produced an average yield of 2,514 kg/ha that was 24.82 per cent greater than BR-2017 (2,014 kg/ha), and was better than BR-2017 at all sites. The best yield had been achieved at BARS Fatehjang (4,237 kg/ha), whereas the lowest had been found at AZRI Bhakkar (1,446 kg/ha). The statistical analysis (LSD, $p<0.05$) helped to prove that the difference in yield was significant, with the highest variability observed at AZRI Bhakkar (379.79) and the lowest at CRI Khanpur (151.45), as shown **in Table 5 and Figure 3.** These results highlight **Thal Guara strong adaptability, stability, and potential for higher grain production across different agro ecological zones.**

TABLE 5. Results of National Uniform Yield Trial of Guar (KHARIF, 2018)

Entry Name	Locations/ Grain Yield (Kg ha^{-1})						%age increase over check
	BARS, Fatejhang	AZRI Bahawalpur	AZRI Bhakkar	BARI, Chakwal	CRI, Khanpur	Avg	
Thal Guara	**4237**	**2319**	**1446**	**2140**	**2430**	**2514**	**24.82**
BR-2017 (Check)	3674	1909	881	1909	1698	2014	-
LSD(0.05)	229.42	216.29	379.79	351.42	151.45	-	-

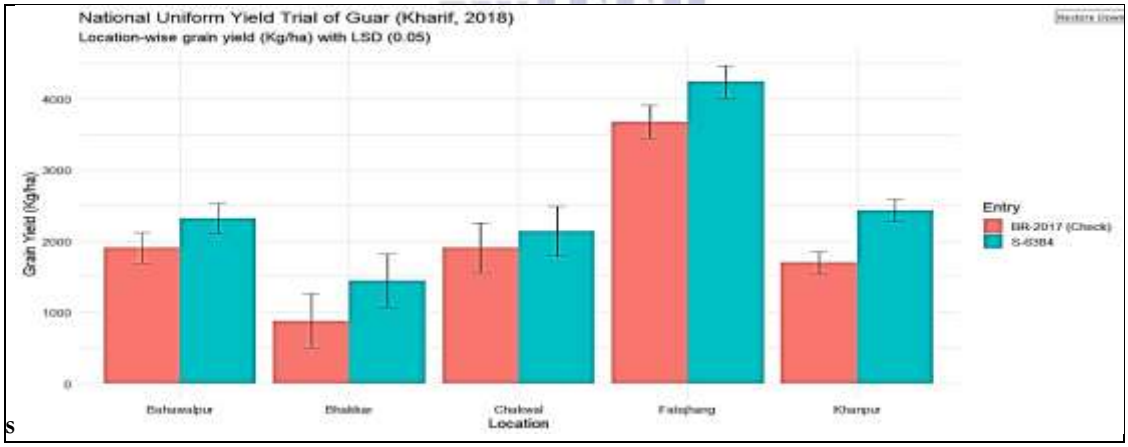

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Figure 3: Results of National Guar yield trial (Kharif, 2018)

The multi-location yield evaluation of Thal Guara and BR-2017 across four research stations confirmed Thal Guara's superior performance and adaptability. It achieved an average yield of 2679 kg/ha, 36.2% higher than BR-2017 (1967 kg/ha). Yield across locations ranged from 2509 to 2777 kg/ha for Thal Guara, consistently exceeding BR-2017. LSD (0.05) analysis indicated higher yield variability at BARS Fatehjang (330.6) and AZRI Bhakkar (282.77), while CRI Khanpur (109.57) showed more stability (Table 6 and Figure 4).

Overall, Thal Guara significantly outperformed BR-2017, demonstrating strong potential for enhanced Guar production in diverse agroecological zones.

TABLE 6. Results of National Uniform Yield Trial of Guar (KHARIF, 2019)

Entry Name	Locations/ Grain Yield (Kg ha^{-1})						%age increase over check
	BARS, Fatejhang	AZRI Bahawalpur	AZRI Bhakkar	BARI, Chakwal	CRI, Khanpur	Avg	
Thal Guara	**2675**	**2509**	**2754**	-	**2777**	**2679**	**36.20**
BR-2017 (Check)	2240	1625	2022	-	1980	1967	-
LSD(0.05)	330.6	234.36	282.77	-	109.57	-	-

The strain gave 24.82% & 36.20% higher yield than check

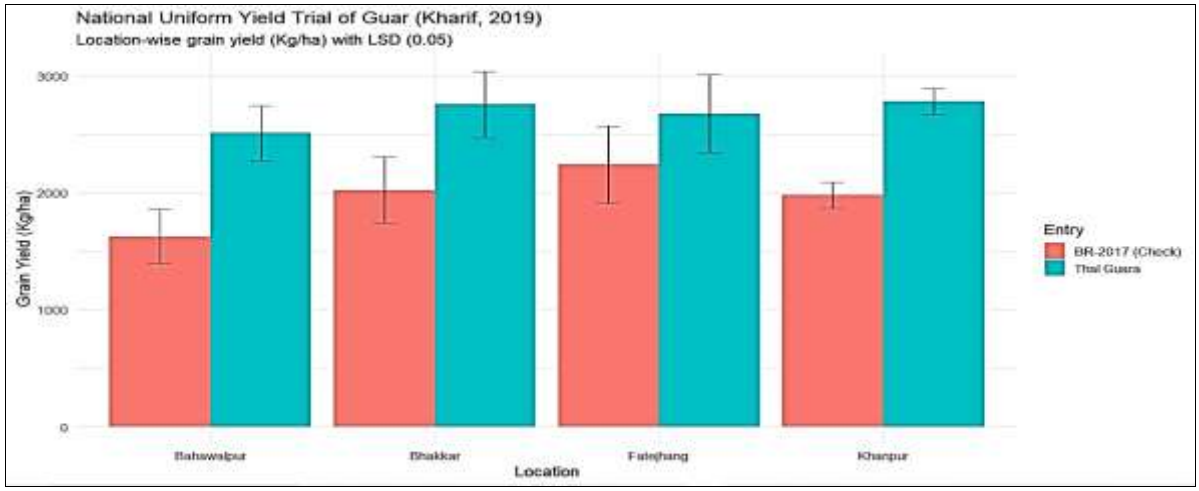

Figure 4: National Uniform Guar Yield Trial (KHARIF, 2019)

4.YIELD EVALUATION UNDER DROUGHT STRESS CONDITIONS

The yield performance of Thal Guara and BR-2017 was evaluated under no irrigation and three irrigations after sowing in 2018-19 and 2019-20. Results showed that Thal Guara consistently outperformed BR-2017 under both conditions, demonstrating better drought tolerance and higher yield potential with irrigation.

In 2018-19, under no irrigation, Thal Guara yielded 1689 kg/ha, which was slightly higher than BR-2017 (1569 kg/ha). With three irrigations, Thal Guara's yield increased significantly to 2801 kg/ha, outperforming BR-2017 (2246 kg/ha). A similar trend was observed in 2019-20, where Thal Guara produced 1910 kg/ha under no irrigation (compared to 1595 kg/ha for BR-2017) and 2922 kg/ha under three irrigations (compared to 2225 kg/ha for BR-2017).

The LSD (0.05) values indicate that yield differences under irrigation were more significant (356.61) compared to no irrigation (147.22) in Table 7 and Figure 5. These results confirm Thal Guara's superior performance under water-limited and irrigated conditions, making it a suitable variety for diverse moisture regimes. Deficit irrigation strategies have also been shown to sustain guar yield while conserving water resources (Singh et al., 2024).

Table 7: Results of Drought Stress Trials (2018-19 & 2019-20)

Year	Strains	Grain yield (Kg ha^{-1})	
		No irrigation after sowing	3 irrigations after sowing
2018-19	**Thal Guara**	**1689**	**2801**
	BR-2017 (Check)	1569	2246
	LSD (0.05)	147.22	356.61
2019-20	**Thal Guara**	**1910**	**2922**
	BR-2017 (Check)	1595	2225
	LSD (0.05)	147.22	356.61

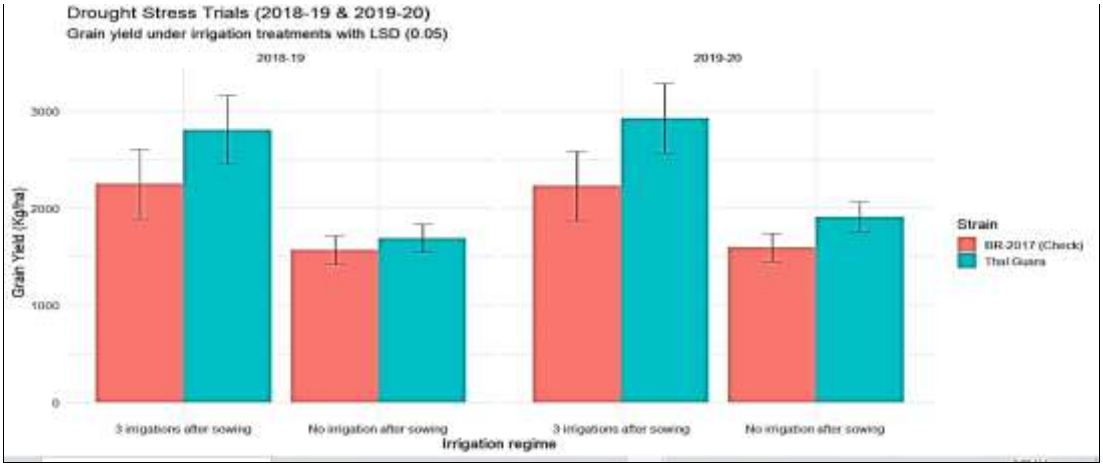

Figure 5: Results of Drought Stress Trials (2018-19 & 2019-20)

5. AGRONOMIC STUDIES

5.1. SOWING DATES TRIAL

The effect of sowing dates on grain yield was evaluated over two years (2019-20 and 2020-21). The results indicate that sowing time significantly influenced yield performance, with the highest yields observed in early June sowings.

In 2019-20, the highest yield (2850 kg/ha) was recorded for D3 (June 1st sowing), followed by D2 (May 15th, 2434 kg/ha) and D4 (June 15th, 2534 kg/ha). The lowest yield (1574 kg/ha) was recorded for D6 (July 15th sowing). A similar trend was observed in 2020-21, where D3 (June 1st) again had the highest yield (2725 kg/ha), while D6 (July 15th) had the lowest (1727 kg/ha).

On average, D3 (June 1st sowing) recorded the highest yield (2788 kg/ha), followed by D2 (May 15th, 2550 kg/ha) and D4 (June 15th, 2484 kg/ha). The lowest yield (1819 kg/ha) was observed for D5 (July 1st) and D6 (July 15th, 1651 kg/ha).

The LSD (0.05) values indicate that the yield differences across sowing dates were statistically significant (321.0 kg/ha in 2019-20 and 345.5 kg/ha in 2020-21) in Table 8, Figure 6(a) and Figure 6(b). These findings showed that the optimum sowing time to achieve maximum grain yield is during early June (D3), and any late sowing after mid-June results in a significant reduction in yield.

TABLE 8. Effect of Sowing Dates on Grain Yield of Thal Guara variety

Sr.No.	Treatments/Sowing dates	Grain Yield (Kg ha^{-1})		Average
		2019-20	2020-21	
1	D1 (01/05)	2349	2293	2321
2	D2 (15/05)	2434	2665	2550
3	**D3 (01/06)**	**2850**	**2725**	**2788**
4	D4 (15/06)	2534	2434	2484
5	D5 (01/07)	1835	1803	1819
6	D6 (15/07)	1574	1727	2321
LSD (0.05)		321.0	345.5	

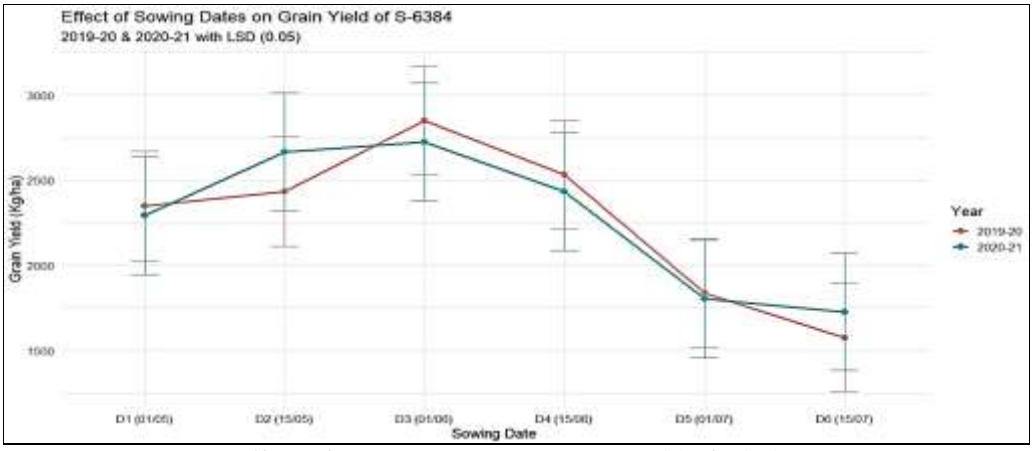

Figure 6(a): Effect of Sowing Dates on Grain Yield of Thal Guara variety

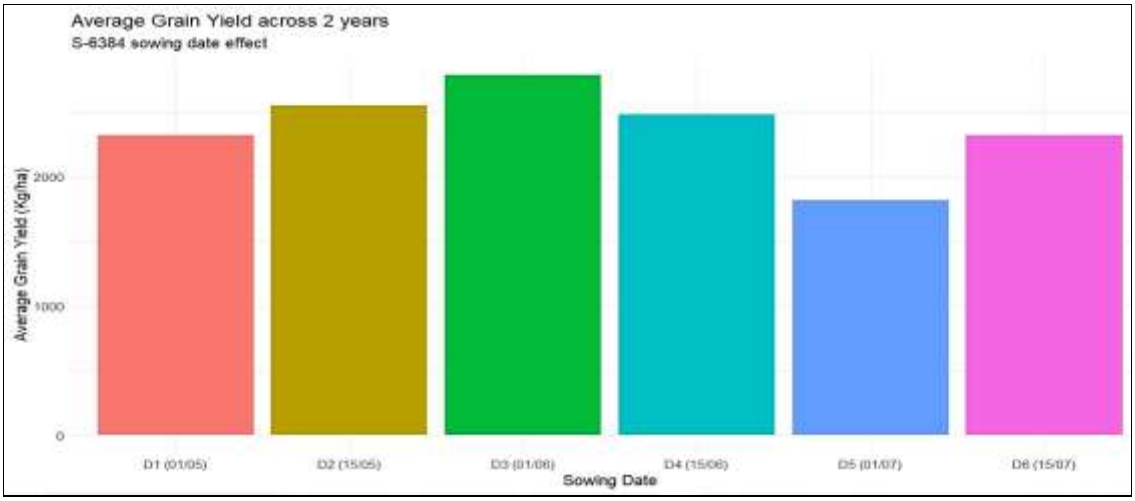

Figure 6(b): Effect of Sowing Dates on Grain Yield of Thal Guara variety

5.2. FERTILIZER REQUIREMENT

This experiment was to measure the effect of different applications of different NPK fertilizers on the grain yield after two years (2019-20 and 2020-21). The findings revealed that fertilizer application had a great impact on the yield, with the highest yield was experienced in T6 (30-60-60 kg NPK/ha), with an average of 2,808 kg/ha, and then T7 (30-90-60 kg NPK/ha) with an average of 2,688 kg/ha. Treatment T2: 0-1-0 kg NPK/ha, in turn, yielded the lowest (1,555 kg/ha). An increase of nitrogen to 30 kg/ha especially with 60 kg P and 60 kg K/ha gave a larger yield. But, it was found that further nitrogen application above 30 kg/ha (T8-T10) did not have significant impact on the yield, which demonstrated the significance of balanced fertilization. These LSD (0.05) values (389 in 2019-20 and 331 in 2020-21) were statistically significant yield differences among treatments. These findings emphasize the need for optimal nutrient management, with **T6 (30-60-60 kg NPK/ha)** emerging as the most effective combination for maximizing grain yield (Table 9, Figure 7a and Figure 7b).

Table 9: Results of NPK Fertilizer Trial of Thal Guara variety

Treatments	N (Kg ha^{-1})	P (Kg ha^{-1})	K (Kg ha^{-1})	Grain Yield (Kg ha^{-1}) 2019-20	2020-21	Average
T1	0	0	0	1620	1489	1555
T 2	15	30	30	1859	1835	1847
T 3	15	60	30	2067	2120	2094
T 4	15	90	30	2292	2079	2186
T 5	30	30	60	2511	2684	2598
T 6	**30**	**60**	**60**	**2790**	**2825**	**2808**
T 7	30	90	60	2631	2745	2688
T 8	45	30	90	2080	1866	1973
T9	45	60	90	2420	2301	2361
T10	45	90	90	1800	1995	1898
LSD (0.05)				389.0	331.0	

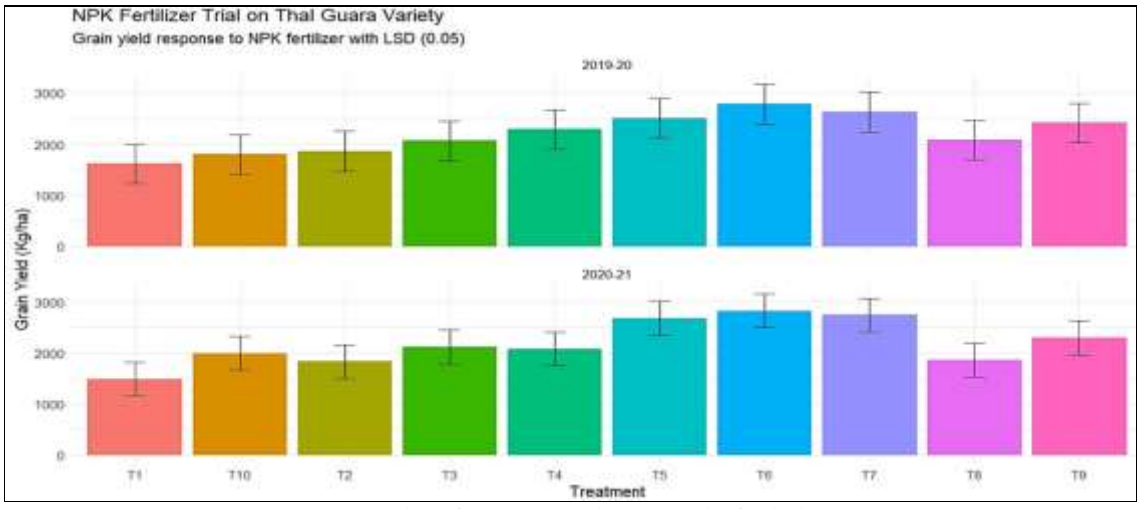

FIGURE 7(a): Results of NPK Fertilizer Trial of Thal Guara variety

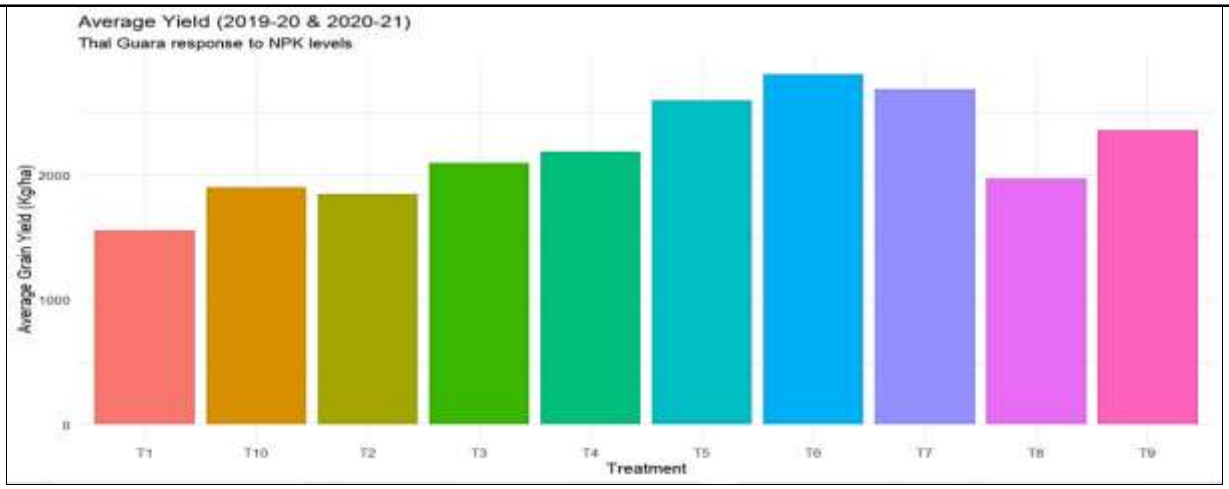

Figure 7(b): Results of NPK Fertilizer Trial of Thal Guara variety

5.3. ROW SPACING

The experiment compared the effect of various treatments of row width (30 cm, 45 cm, and 60 cm) on grain yield in two years (2019-20 and 2020-21). The findings revealed that the largest average grain yield was recorded using 45 cm row spacing (T2: 2,750 kg/ha), then 60 cm (T3: 2,371 kg/ha) and 30 cm (T1: 2,195 kg/ha). The 45 cm spacing was found to be the best in both years, proving that it was the most suitable when used in maximizing the grain yield. The values of LSD (0.05) were 335.20 kg/ha in 2019-20 and 191.15 kg/ha in 2020-21, which proved that the treatments differ significantly (Table 10, Figure 8(a), and Figure 8 (b).

Table: 10 Effect of Different Row Spacings on Grain Yield of Thal Guara

Sr. No.	Treatments/ Row Spacing		Grain Yield Kg ha^{-1}		Average./ bnuy76sa5665p
			2019-20	2020-21	
1	T1	30cm	2127	2262	2195
2	**T2**	**45cm**	**2810**	**2689**	**2750**
3	T3	60cm	2253	2488	2371
LSD (0.05)			335.20	191.15	

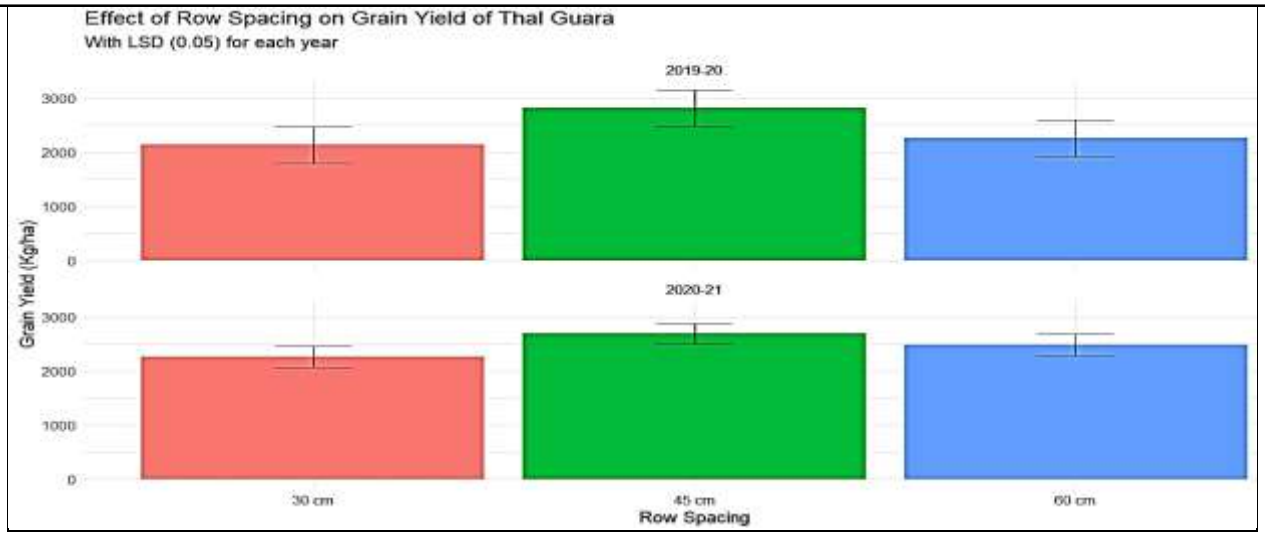

Figure 8(a): Effect of Different Row Spacings on Grain Yield of Thal Guara

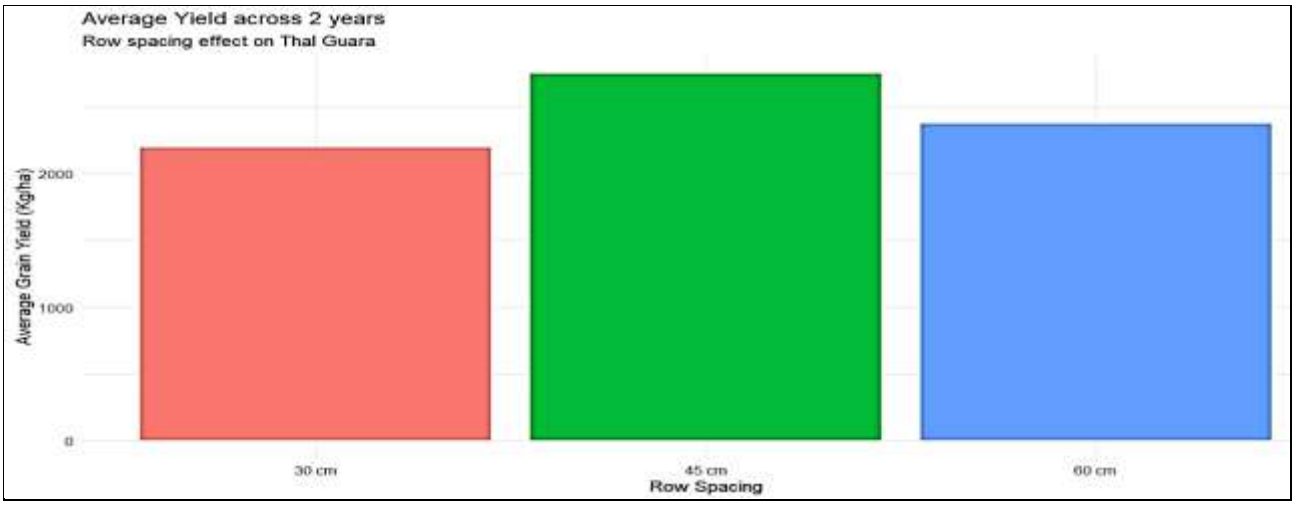

Figure 8(b): Effect of Different Row Spacing's on Grain Yield of Thal Guara (TWO years Average)

5.4. WATER REQUIREMENTS UNDER IRRIGATED CONDITIONS

The research evaluated the effect of the various irrigation regimes on the yield of grain within two years (2019-20 and 2020-21). As the results showed, three irrigations (T4: at 35 days after sowing, at flowering and at pod formation) resulted in the highest average grain yield (2,811 kg/ha), then two irrigations (T3: 2,341 kg/ha), and one irrigation (T1: 2,104 kg/ha). The least yield was observed in the control (T5: no irrigation) at 1,793 kg/ha. The LSD (0.05) of 2019-20 and 2020-21 were 387.0 kg/ha and 289.0 kg/ha respectively, which shows that there is a big difference in the yield between treatments. These results indicate that several irrigations are relevant in maximizing grain production (Table 11, Figure 9(a) and Figure 9(b).

Table: 11 Response of Thal Guara to different irrigation levels

Sr. No.	Treatments/ Irrigation levels		Grain Yield Kg ha^{-1}		Average
			2019-20	2020-21	
1	T1	One irrigation a/f 35 days of sowing	2110	2098	2104
2	T2	One irrigation at the flowering stage	2045	1850	1948
3	T3	(T1+T2)	2400	2281	2341
4	**T4**	**T3+ irrigation at pod formation stage**	**2845**	**2776**	**2811**
5	T5	No irrigation (Control)	1785	1801	1793
LSD (0.05)			387.0	289.0	

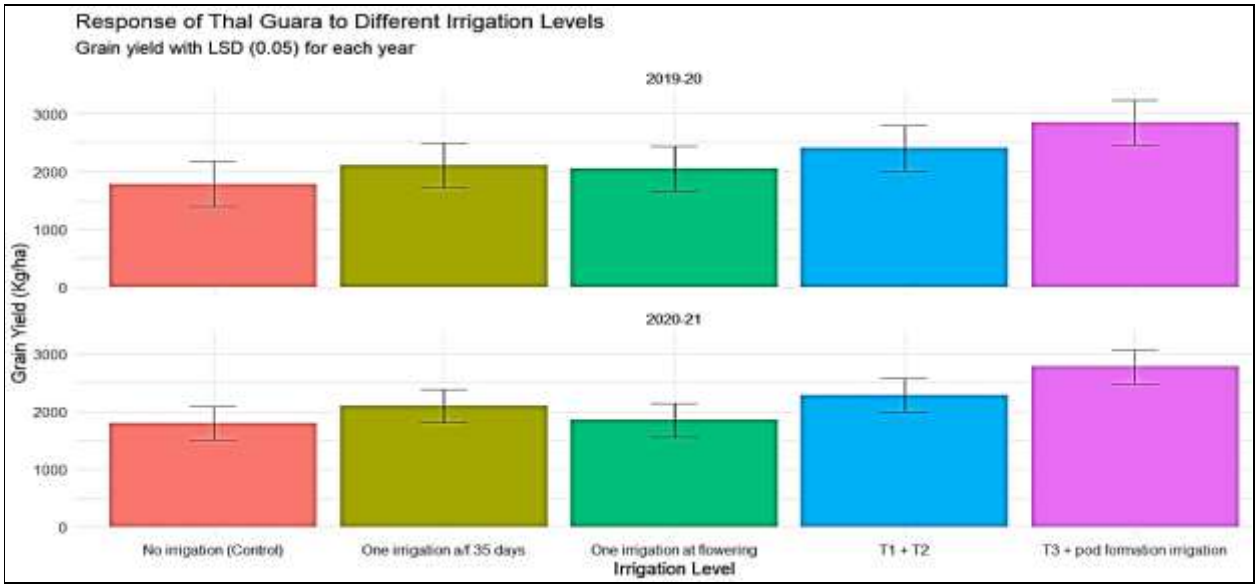

Figure 9(a): Response of Thal Guara to different irrigation levels

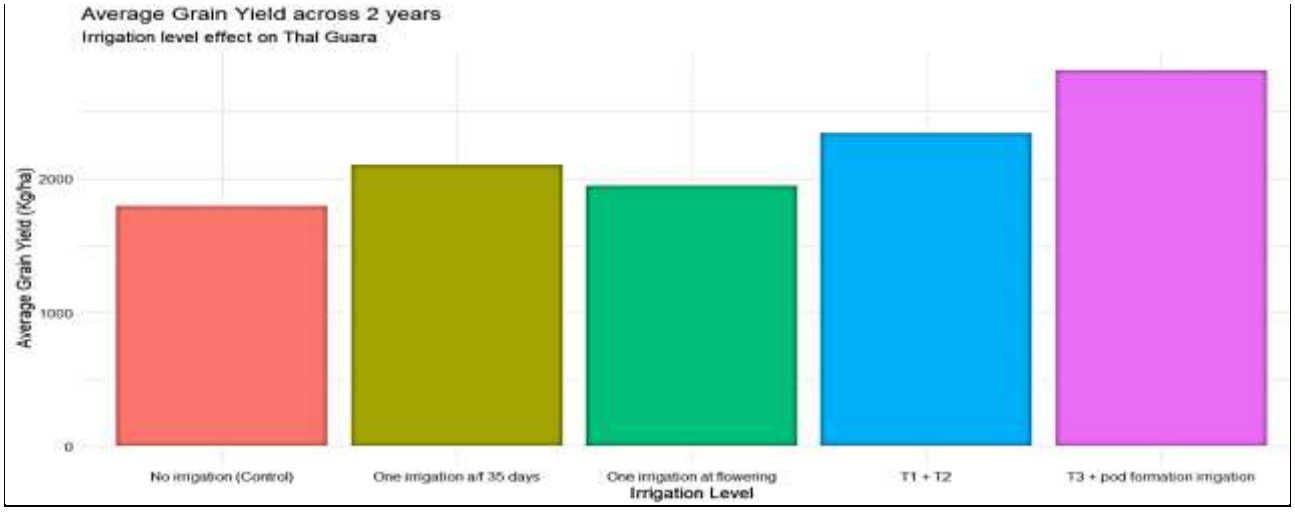

Figure 9(b): Response of Thal Guara to different irrigation levels (2 years average)

6. ENTOMOLOGICAL STUDIES

The study evaluated the resistance of **Thal Guara** and **BR-2017 (check)** against **jassid** and **whitefly** infestations during **2018-19 and 2019-20**. Results showed that **Thal Guara exhibited lower insect infestations** compared to BR-2017. In **2018-19,** jassid populations per leaf were **0.60** in Thal Guara and **1.40** in BR-2017, while whitefly populations were **2.00** and **5.50**, respectively. In **2019-20,** jassid infestations were further reduced **(0.24 in Thal Guara vs. 0.37 in BR-2017),** whereas whitefly counts remained lower in Thal Guara **(2.60 vs. 2.90** in BR-2017). The LSD (0.05) values indicated significant differences between varieties, confirming **Thal Guara's superior resistance** to both insect pests (Table 12 and Figure 10).

Table: 12 Response of Thal Guara against Insect Pest Attacks

Varieties	2018-19		2019-20	
	Jassid leaf^{-1}	Whitefly leaf^{-1}	Jassid leaf^{-1}	Whitefly leaf^{-1}
Thal Guara	**0.60**	**2.00**	**0.24**	**2.60**
BR-2017 (check)	1.40	5.50	0.37	2.90
LSD (0.05)	0.35	1.90	0.35	1.90

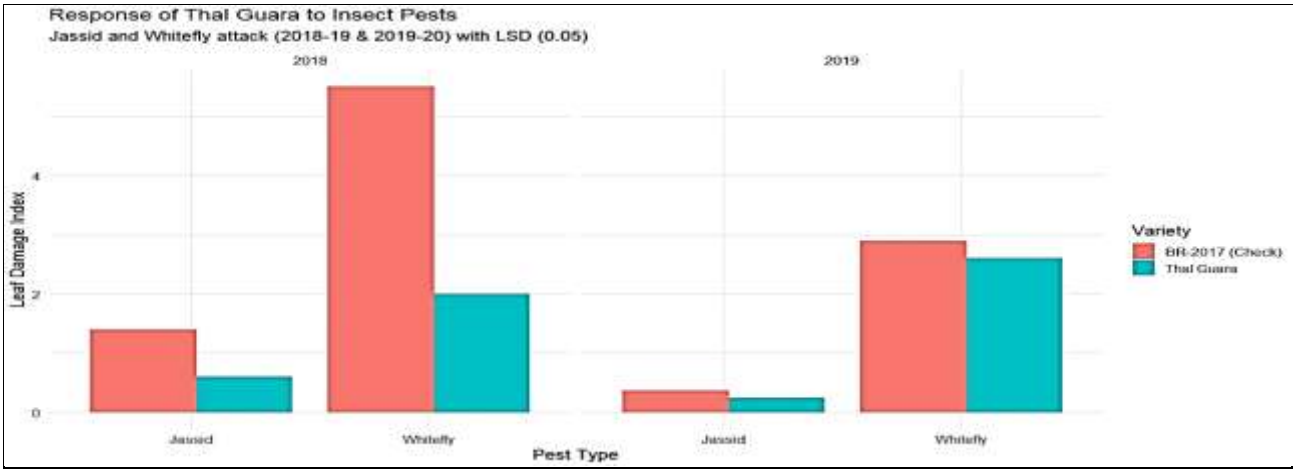

Figure 10: Response of Thal Guara against Insect Pest Attacks

7. PATHOLOGICAL STUDIES

The resistance of Thal Guara and the check variety BR-2017 to bacterial blight and Alternaria blight was evaluated during the 2018-19 and 2019-20 cropping seasons. Thal Guara exhibited moderate resistance to both bacterial blight and Alternaria blight across both years, demonstrating its stable disease tolerance. In contrast, BR-2017 showed moderate susceptibility to bacterial blight in 2018-19 but improved to moderate resistance in 2019-20, while maintaining moderate resistance to Alternaria blight in both years (Table 13). These findings highlight Thal Guara's consistent disease resistance, making it a promising variety for sustainable production in disease-prone regions.

TABLE 13. Response of Thal Guara against diseases

Varieties	2018-19		2019-20	
	Bacterial blight	Alternaria blight	Bacterial blight	Alternaria blight
Thal guara	Moderately	Moderately	Moderately	Moderately

BR-2017 (Check)	Resistant Moderately Susceptible	Resistant Moderately Resistant	Resistant Moderately Resistant	Resistant Moderately Resistant

8. QUALITY ANALYSIS

The gum, protein and carbohydrate levels were similar in the chemical composition analysis of Thal Guara and BR-2017 (check). Thal Guara had 33.47% gum, 31.00% protein and 38.51% carbohydrates, and BR-2017 had 33.71% gum, 30.75% protein and 38.90% carbohydrates (Table 14 and Figure 12). The findings show that there was a small percentage difference in protein content, with Thal Guara having slightly higher protein content and BR-2017 having slightly higher percentages of gum and carbohydrates. These results indicate that Thal Guara has a balanced chemical structure, which can be used in many industries as well as in food.

TABLE 14. Results of chemical analysis

Entry Name	Gum %age	Protein %	Carbohydrates %
Thal Guara	**33.47**	**31.00**	**38.51**
BR-2017(Check)	33.71	30.75	38.90

Source: Agricultural Chemist (Bio), Post-Harvest Research Centre, Ayub Agricultural Research Institute, Faisalabad

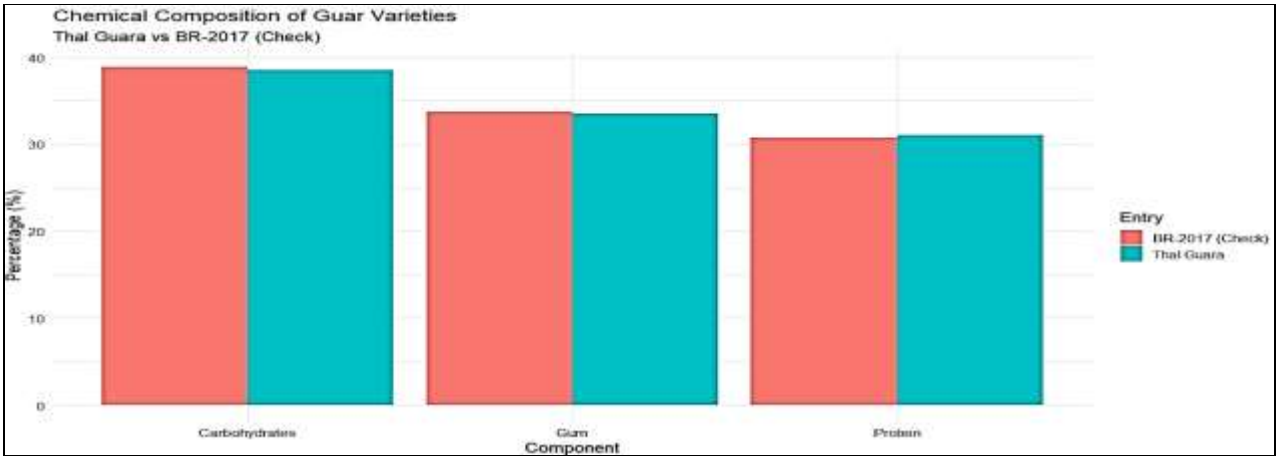

Figure 11: Chemical composition of Guar varieties

DISCUSSION

The results of this study clearly indicate that Thal Guara exhibits strong superiority over the check varieties BR-99 and BR-2017 across years, locations, and production systems (Zubair et al., 2017). Its consistently higher yields and stable performance reflect improved genetic potential and adaptability, traits that are essential for guar production in the variable agro-ecological zones of Punjab. Similar findings have been reported earlier, where genetically improved guar lines showed enhanced resilience and productivity under harsh climatic conditions (Minhas et al., 2025).

The multi-location trials further strengthened the evidence of Thal Guara's robustness, particularly with a 33.42% yield advantage over BR-2017 in 2019–20. The higher yields recorded at ARS Bahawalpur suggest that the hot, dry environment with sandy soils provides optimal conditions for this genotype. Previous studies also indicate that guar thrives in semi-arid regions with well-drained soils, and genotype × environment interaction plays

a significant role in maximizing yield (Sher et al., 2022; Zubair et al., 2022).

Thal Guara's strong performance under irrigated and non-irrigated conditions confirms its drought tolerance and efficient water-use capability. Guar is naturally recognized as a drought-hardy crop, but the significantly higher yield of Thal Guara under limited moisture suggests improved physiological resilience and enhanced water-use efficiency, in agreement with earlier research on guar adaptation to low-water environments (Gerdefaramarzi et al., 2024; Vishnyakova et al., 2023).

Agronomic trials highlighted the importance of timely sowing, balanced fertilization, optimal row spacing, and critical-stage irrigation. Early June sowing, balanced NPK at 30-60-60 kg/ha, and 45 cm row spacing produced the highest grain yields, reaffirming the crop's sensitivity to management practices. These findings are consistent with previous studies emphasizing that early planting and balanced nutrients significantly increase guar productivity (Zubair et al., 2022; Minhas et al., 2021). The statistically significant treatment differences underscore that appropriate input management is crucial for maximizing the genetic potential of improved guar varieties (Nayyar et al., 2023).

Thal Guara also exhibited lower infestation of jassid and whitefly and moderate resistance to bacterial blight and Alternaria blight. This resistance is agronomically advantageous, as guar is often subjected to pest pressure in arid and semi-arid regions. Earlier researchers have documented that varietal resistance is a key factor in reducing yield losses caused by sucking insects and foliar diseases in guar (Zubair et al., 2022).

The chemical composition analysis showed that Thal Guara and BR-2017 had comparable gum, protein, and carbohydrate contents, with Thal Guara showing a slight advantage in protein. Maintaining quality parameters alongside higher yield is essential for industrial use, as guar gum extraction relies heavily on seed composition. These findings agree with previous reports that modern guar cultivars can maintain chemical quality even when yield potential is enhanced (Sapkota et al., 2020).

Overall, the discussion reaffirms that Thal Guara is a genetically superior and agronomically efficient variety with broad adaptability. Its yield stability, drought tolerance, pest and disease resistance, and comparable chemical composition justify its recommendation for large-scale cultivation across Pakistan's guar-growing regions. These results align with global efforts to develop high-yielding, climate-resilient guar varieties suitable for sustainable production systems.

CONCLUSION

Thal Guara (S-6384) consistently outperformed the check varieties BR-17 & BR-99 in yield, drought tolerance, and agronomic traits across multi-environment trials (2012–2022). Its bold seed size, higher pod number, improved crude protein content, and resistance to major pests and diseases indicate strong adaptability to arid and semi-arid regions. The best key feature of this variety is its early maturing character. Thal Guara is a promising variety for enhancing guar productivity and farmer income in Pakistan. Future studies may explore its industrial use and gum extraction potential.

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