DOI: https://doi.org/10.71317/kjard.2.9.2026.523

The Kashmir Journal of Academic Research and Development

Journal homepage: https://rjsaonline.org/index.php/KJARD

Development and Release of Anmol Til: A High-Yielding, Disease-Resistant Sesame (*Sesamum indicum* L.) Cultivar Characterized by Single-Stem Growth Pattern and Multi-Locular Pods

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ARTICLE INFO

Received:
July 29, 2026
Revised:
August 11, 2026
Accepted:
August 22, 2026
Available Online:
September 03, 2026

Keywords:
Sesamum indicum L., Anmol Til, Single stem, Multi-locule, High-yielding variety, disease resistance

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ABSTRACT

Sesame (*Sesamum indicum* L.) is a vital export-oriented oilseed crop for Pakistan, yet its productivity is often limited by biotic, abiotic stresses, and a lack of high-yielding, climate-resilient cultivars. This study details the development and multi-year evaluation of "Anmol Til," a new sesame variety developed at the Oilseeds Research Institute, Faisalabad. Developed through the hybridization of TH-6 × 92001 and advanced via the pedigree selection method from 2010 to 2016, the variety was rigorously tested in station, multi-location, and National Uniform Yield Trials (NUYT) from 2017 to 2021. In station yield trials (2017–2018), Anmol Til achieved a mean yield of 1,567 kg ha^{-1}, representing a 74% increase over the commercial check TH-6. Multi-location Micro Yield Trials (2019) across five locations demonstrated its wide adaptability with a 19% average yield advantage. Notably, in the 2021 NUYT, it exhibited a 91% yield increase over the check variety TS-5 and an 11% increase over TH-6. Beyond yield, Anmol Til demonstrated a resistant (R) reaction to charcoal rot (*Macrophomina phaseolina*) and displayed lower susceptibility to major insect pests, including whitefly, mirid bug, and pod borer, compared to existing cultivars. Quality analysis revealed superior seed attributes, with oil content ranging from 50–52% and 18% protein. The variety was also registered under the Plant Breeders' Rights Act, 2016, with Registration No. SS/109/2024 on 30 January 2024. Characterized by a single stem growth habit and multi-locule pods, Anmol Til has been recommended for commercial cultivation in both irrigated and rainfed regions of Pakistan. This variety offers a promising solution to boost national sesame productivity, enhance export earnings, and improve oilseed sustainability.

Introduction

Sesame (*Sesamum indicum* L.) is one of the oldest cultivated oilseed crops and is popularly known as the "Queen of Oilseeds" because of its excellent nutritional quality, high oil content and remarkable oxidative stability (Li et al., 2024; Mostashari & Mousavi Khaneghah, 2024). The crop belongs to the family Pedaliaceae (2n = 2x = 26) and is cultivated predominantly in tropical and subtropical regions of Asia and Africa (Angamuthu et al., 2025). Sesame seeds contain approximately 45–60% high-quality oil, 18–25% protein, and are rich sources of unsaturated fatty acids, lignans (sesamin and sesamolin), vitamin E, calcium, phosphorus, iron and zinc (Sharma et al., 2020). Owing to these nutritional and functional attributes, sesame is widely utilized in edible oil production, bakery and confectionery products, tahini, pharmaceuticals, cosmetics and nutraceutical industries (Pathak et al., 2017).

Worldwide, sesame has become an increasingly important cash crop because of the growing demand for healthy vegetable oils and functional foods (Mahajan & Sadana, 2025). According to the Food and Agriculture Organization (FAO), global sesame production has increased substantially during the last five decades, reaching more than 7 million tonnes annually, cultivated on approximately 14–15 million hectares worldwide (Haque et al., 2025). Sudan, India, Myanmar, China, Tanzania, Nigeria, Ethiopia and South Sudan are among the major sesame-producing countries, while China remains the world's largest importer because of its expanding food processing industry (Haque et al., 2025; Langham et al., 2021). Continuous growth in international demand has made sesame one of the most valuable export-oriented oilseed crops, particularly for developing countries (Hussain et al., 2023; Langham et al., 2021; Myint et al., 2020).

Pakistan has emerged as one of the fastest-growing sesame-producing countries during the past few years. According to the Economic Survey of Pakistan 2024–25, the area under sesame cultivation increased from 259.9 thousand hectares in 2022–23 to 399.8 thousand hectares in 2023–24, while production nearly doubled from 152.2 thousand tonnes to 301.2 thousand tonnes, representing an increase of approximately 98% in production within one year (Economic Survey of Pakistan 2024-25). This remarkable expansion was primarily driven by increased cultivated area, favorable market prices and strong export demand (Rauf, 2025).

The rapid growth of Pakistan's sesame sector has also translated into significant export earnings. The Ministry of National Food Security and Research reported that sesame exports increased from US$89.3 million in 2020 to US$407 million in 2023, making Pakistan the fifth-largest sesame exporter in the world, with more than 80% of exports destined for China. This unprecedented expansion highlights the strategic importance of sesame as a high-value export commodity capable of contributing substantially to agricultural income and foreign exchange earnings (Hussain et al., 2023; Khan et al., 2024).

Punjab is the major sesame-producing province of Pakistan, contributing approximately 95% of the national production. According to the Pakistan Oilseed Department (2024), sesame occupied 1.76 million acres in Punjab during Kharif 2024, producing approximately 419,343 tonnes. However, despite the substantial increase in cultivated area, productivity remains vulnerable to climatic fluctuations, particularly high temperatures and erratic monsoon rainfall, which adversely affect seed set, yield and quality (Hussain et al., 2025).

Despite recent progress, sesame productivity in Pakistan remains considerably below its genetic potential because of several biotic and abiotic constraints (Rauf, 2025; Rizwan et al., 2025). Major production challenges include susceptibility to diseases such as charcoal rot (*Macrophomina phaseolina*) and phyllody phytoplasma, capsule shattering, lodging, asynchronous maturity, limited tolerance to drought and waterlogging, and the availability of relatively few improved, climate-resilient cultivars (Weldemichael et al., 2025; Yadav et al., 2022). The increasing frequency of extreme weather events associated with climate change further emphasizes the necessity for developing varieties possessing higher yield potential, wider adaptability, resistance to major diseases and superior seed quality (Weldemichael & Gebremedhn, 2023).

Genetic improvement through plant breeding remains the most economical and environmentally sustainable strategy for increasing sesame productivity (Sravanthi et al., 2022; Wacal et al., 2024). The development of improved varieties with enhanced yield stability, disease resistance, stress tolerance and desirable oil quality is essential for ensuring sustainable production, strengthening Pakistan's export competitiveness and reducing dependence on imported edible oils. Therefore, the present study was undertaken to document the development, evaluation and release of the newly developed sesame variety.

Materials and methods

Crossing and early-stage selection

The new strain Anmol Til is an outcome of hybridization (TH-6× 92001) during 2010 and selected through pedigree method from F1 to F6 (Figure 1). During 2011, the F_1 generation was grown to confirm successful hybridization, and the resulting plants were self-pollinated to produce the F_2 generation. From 2012 onward, the breeding population was advanced through the

pedigree selection method, with selection being practiced in each segregating generation. Individual superior plants possessing desirable agronomic characteristics were selected and assigned unique pedigree numbers. The selected progenies were designated as 1005 (F_1), 2005 (F_2), 3008 (F_3), 4018 (F_4), 5012 (F_5), and 17003 (F_6), reflecting the progressive advancement and purification of the breeding material. By the F_6 generation (2016), the breeding line had attained a high level of genetic uniformity and stability. The superior line, designated 17003, consistently exhibited desirable agronomic performance and was subsequently advanced to preliminary and multi-location yield evaluations.

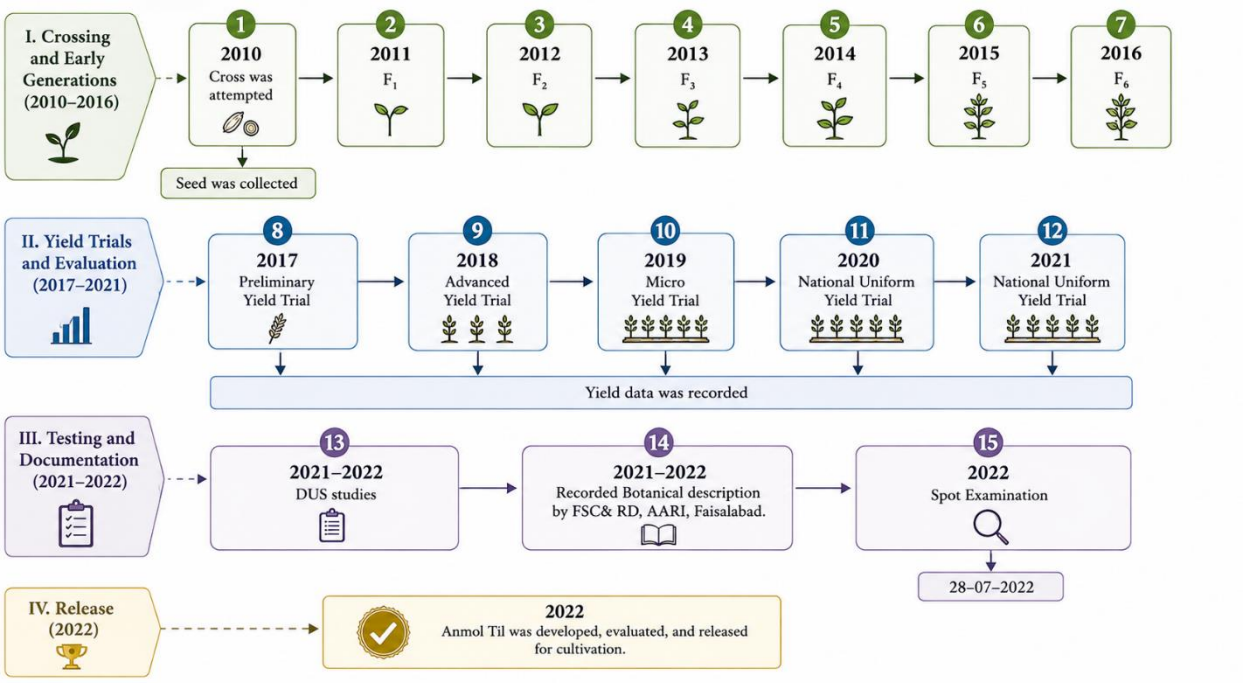

Figure 1: Flowchart depicting the breeding history and sequential development, evaluation, testing, and release of 'Anmol Til'

Yield trials

The selected line was subsequently subjected to a series of replicated yield trials to evaluate its productivity, adaptability, and stability. The line was first tested in the Preliminary Yield Trial (2017), followed by the Advanced Yield Trial (2018). These trials compared the candidate line with standard commercial check varieties under field conditions, and data were collected on seed yield and other important agronomic traits to assess its performance. In 2019, multi-location evaluation was conducted under diverse agro-climatic conditions (Faisalabad, Karor, Piplan, Bahawalpur and Khanpur) to determine adaptability and yield stability. To verify its wide adaptability and yield stability, the candidate line was evaluated in the National Uniform Yield Trials (NUYT) during 2020 and 2021 across different agro-climatic regions of Pakistan. The consistent superior performance of the line over multiple locations and years demonstrated its broad adaptation and stable yield performance, supporting its advancement for varietal release.

All yield trails were sown in Randomized Complete Block Design with three replications and each plot consisted of 4 rows with each row being 5 meters long. The 1.5-2 ft distance between beds was maintained and seeds were sown using Hand Seed Drill. All recommended agronomic and cultural practices were carried out during the whole tenure of the experiments. The recommended dose of NPK was applied during different growth stages and seed yield of a plot was recorded for yield evaluation at maturity.

DUS studies

The DUS studies of candidate sesame Variety "Anmol Til" was conducted by FSC & RD during 2021-22 at research area of Oilseeds Research Institute, Faisalabad.

Disease and insect incidence

Screening studies of disease (Charcoal Rot) in sick fields were carried out at Plant Protection Research Institute Faisalabad, Punjab, Pakistan during 2020. Disease effected plants were counted during growth period till maturity. Percentage of the disease was calculated according to Bedawy and Mohamed 2018 as follow:

Disease incidence (DI)% = (Number of diseased plants/ Total number of plants) × 100

Scoring of different levels of resistance was done by following the disease rating scale explained by Bedawy and Mohamed 2018 (Table 1).

Table 1: The disease scale used for evaluation of disease resistance in sesame lines.

1. Score	2. Remarks
0	Immune
1	Highly Resistant (HR)
2	Resistant (R)
3	Moderately Resistant (MR)
5	Susceptible (S)
6	Highly Susceptible (HS)

Insect incidence

The experimental material was evaluated for its reaction against the major insect pests of sesame under natural field infestation at the Oilseed Research Institute, Faisalabad, in collaboration with the Oilseed Entomology Division. Observations were recorded at regular intervals from vegetative growth until physiological maturity on five randomly selected plants from each experimental plot. Data were collected for the following insect pests.

Whitefly (*Bemisia tabaci* Genn.)

Whitefly population was recorded during the vegetative and early flowering stages when infestation was at its peak. Adult whiteflies were counted early in the morning from the upper, middle and lower leaves of each selected plant. Three fully expanded leaves per plant (one from each canopy level) were examined, and the number of adults per leaf was recorded. The average number of whiteflies per leaf was calculated for each genotype.

$$\text{Average whiteflies per leaf} = \frac{\text{Total number of whiteflies counted}}{\text{Total number of leaves observed}}$$

Mirid Bug (*Nesidiocoris tenuis Reuter*)

Mirid bug infestation was assessed during the flowering and capsule formation stages. Adults and nymphs present on the terminal shoots, flower buds and young capsules of the selected plants were counted by visual inspection during morning hours. The average number of mirid bugs per plant was calculated for each genotype.

Formula

$$\text{Average mirid bugs per plant} = \frac{\text{Total number of mirid bugs}}{\text{Total number of plants observed}}$$

Pod Borer (*Antigastra catalaunalis Duponchel*)

Pod borer damage was recorded during capsule development until maturity. The total number of capsules and the number of damaged capsules showing feeding holes or larval injury were counted on each selected plant.

Pod damage (%) was calculated as:

$$\text{Pod damage (\%)} = \frac{\text{Number of damaged capsules}}{\text{Total number of capsules}} \times 100$$

Statistical Analysis

Statistx 8.1, a computer statistical software package, was used to calculate and analyze variance for different measured traits and differences among means were tested at 5% probability level.

Varietal Approval

The new strain Anmol Til was evaluated by spot examination committee on 28-07-2022 and all the experts/members of Spot Examination Committee unanimously recommended the case of this new candidate variety of Sesame Anmol Til developed by Oilseeds Research Institute, AARI, Faisalabad for consideration in Experts Sub-committee of Punjab Seed Council**.**

Results

Station Yield trials

The yield performance of Anmol Til was evaluated in station yield trials at the Oilseeds Research Institute (ORI), Faisalabad, during 2017–2018, using TH-6 as the check variety (Table 2). In the Preliminary Yield Trial (2017), Anmol Til produced a seed yield of 1,884 kg ha^{-1}, compared with 1,001 kg ha^{-1} for TH-6, representing an 88% increase over the check. In the Advanced Yield Trial (2018), Anmol Til yielded 1,250 kg ha^{-1}, whereas TH-6 produced 804 kg ha^{-1}, showing a 55% yield advantage.

Across both years, Anmol Til recorded a mean seed yield of 1,567 kg ha^{-1}, while the check variety TH-6 produced an average yield of 903 kg ha^{-1}. Overall, Anmol Til exhibited a 74% higher yield than TH-6 under station conditions, demonstrating its superior yield potential and consistent performance across different stages of yield evaluation. These results indicate that Anmol Til is a promising high-yielding sesame variety suitable for further multilocation testing and commercial cultivation.

Table 2: Yield Performance of Anmol Til in Station Yield Trial 2017-2018at ORI. Faisalabad.

Year	Trial	Yield kg/ha		Increase (%)
		TH-6 (C)	Anmol Til	
2017	**Preliminary Yield Trial**	1001	1884	88
2018	**Advanced Yield Trial**	804	1250	55
Average		903	1567	74

Micro Yield Trial

The yield performance of Anmol Til was further evaluated in the Micro Yield Trial (2019) across five locations, namely Faisalabad (FSD), Karor, Piplan, Bahawalpur, and Khanpur, and compared with the check variety TH-6 (Table 3). Anmol Til outperformed the check at four of the five testing locations. The highest seed yield of 1,148 kg ha^{-1} was recorded at Khanpur, followed by 1,124 kg ha^{-1} at Faisalabad, 930 kg ha^{-1} at Bahawalpur, 900 kg ha^{-1} at Karor, and 578 kg ha^{-1} at Piplan. In comparison, the check variety TH-6 produced yields of 902, 937, 444, 596, and 1,056 kg ha^{-1} at Faisalabad, Karor, Piplan, Bahawalpur, and Khanpur, respectively.

Across all locations, Anmol Til recorded an average seed yield of 936 kg ha^{-1}, whereas the check variety TH-6 averaged 787 kg ha^{-1}, resulting in an overall 19% increase in seed yield. The consistent superiority of Anmol Til under diverse agro-climatic conditions demonstrates its wider adaptability and stable yield performance, supporting its suitability for cultivation across sesame-growing regions of Punjab.

Table 3: Yield Performance of Anmol Til in Micro Yield Trial, 2019

Variety/Line	Seed Yield in kg/ha						
	FSD	Karor	Piplan	Bahawal Pur	Khanpur	Average	% Increase
Anmol Til	1124	900	578	930	1148	936	19
TH-6(Check)	902	937	444	596	1056	787	

National Uniform Sesame Yield Trials

The performance of Anmol Til was evaluated in the National Uniform Sesame Yield Trial (NUSYT) 2020 across three testing locations: ORI Faisalabad, NIAB Faisalabad, and AZRI Bahawalpur (Table 4). The candidate variety produced seed yields of 613, 594, and 344 kg ha^{-1} at ORI Faisalabad, NIAB Faisalabad, and AZRI Bahawalpur, respectively, with an overall average yield of

517 kg ha^{-1}. In comparison, the check variety TS-5 recorded yields of 424, 488, and 312 kg ha^{-1}, with a mean yield of 408 kg ha^{-1}.

During NUSYT 2021, the yield performance of Anmol Til was assessed across the available testing locations and compared with the check varieties TS-5 and TH-6 (Table 5). Due to heavy rainfall, trials at NIAB Faisalabad and AZRI Bahawalpur were severely affected; therefore, data from these locations were excluded from the final analysis.

Based on the remaining valid locations, Anmol Til recorded seed yields of 359, 895, and 627 kg ha^{-1}, with an average yield of 627 kg ha^{-1}. The variety showed a substantial yield advantage over TS-5, which produced an average yield of 329 kg ha^{-1}, resulting in an overall 91% increase in seed yield. Compared with TH-6, which recorded an average yield of 563 kg ha^{-1}, Anmol Til exhibited an 11% yield advantage.

Table-4 Yield Performance of Anmol Til in NUSYT, 2020

Variety/Line	Seed Yield in kg/ha				% Increase
	ORI-FSD	NIAB FSD	AZRI BWP	Average	
Anmol Til	613	594	344	517	27
TS-5(check)	424	488	312	408	

Table 5: Yield Performance of Anmol Til in NUSYT, 2021

Variety/Line	Seed Yield in kg/ha			
	Variety/Line	Variety/Line	Variety/Line	Variety/Line
Anmol Til	359	895	627	
TS-5 (Check)	216	441	329	91
TH-6 (Check)	363	763	563	11

Note: *Two locations (NIAB Fsd & AZRI Bwp) were severely affected due to heavy rainfall and not included.*

In National Uniform Sesame Yield Trial during 2020 and 2021 the performance of Anmol Til is better than TS-5 (check) by giving 27%, 91%increases respectively and from check TH-6 11% more yield in 2021.

Disease reaction

Anmol Til exhibited a resistant (R) reaction against charcoal rot under natural field conditions at Faisalabad during 2020 (Table 6). It received a disease rating of 3, indicating a high level of resistance according to the disease rating scale. The resistant response of Anmol Til was comparable to the resistant check variety TS-5, which also recorded a disease score of 3. In contrast, the susceptible check TH-6 showed a disease rating of 5, corresponding to a moderately resistant (MR) reaction, indicating greater disease incidence than both Anmol Til and TS-5.

Table 6: **Disease Reaction against charcoal Rot of Anmol Til at Faisalabad during 2020**

Variety/Line	Disease attack under Natural condition. Reaction against charcoal Disease 2020	Immunity level
Anmol Til	03	Resistant
TS-5 (Check)	03	Resistant
TH-6 (Check)	05	Moderately resistant

0=Immune, 1=Highly Resistance, 3=Resistance, 5=Moderately Resistance, 7=Moderately Susceptible, 9=Susceptible.

Insect pest reaction

The insect pest reaction of Anmol Til was evaluated under natural infestation at Faisalabad during the 2020 and 2021 growing seasons for three major sesame insect pests, namely whitefly, mirid bug, and pod borer. Across both years, Anmol Til consistently recorded lower pest populations and infestation levels than the check variety TH-6 (Table 7).

In 2020, Anmol Til recorded 0.80 whiteflies per leaf and 3.5 mirid bugs per plant, both of which were well below the respective economic threshold levels (ETL) of 5 whiteflies per leaf and 6 mirid bugs per plant. Similarly, pod borer infestation was limited to 7.33%, compared with 9.57% in TH-6. The check variety showed relatively higher populations of whitefly (1.20 per leaf) and mirid bug (5.1 per plant), although these values also remained below the ETL.

A similar trend was observed in 2021, where Anmol Til recorded 0.98 whiteflies per leaf, 3.10 mirid bugs per plant, and 6.9% pod borer infestation, all lower than the corresponding values for TH-6 (1.57 whiteflies per leaf, 5.40 mirid bugs per plant, and 9.03% pod borer infestation).

Table 7: Insect Pest Reaction of Anmol Til at Faisalabad during 2020-2021

Variety/line	Insect attack under Natural condition.					
	2020			2021		
	White fly/leaf (ETL= 5)	Mirid Bug/Plant (ETL= 6)	Pod Borer (% infestation)	White fly/leaf (ETL= 5)	Mirid Bug/Plant (ETL= 6)	Pod Borer (% infestation)
Anmol Til	0.8	3.5	7.33	0.98	3.10	6.9
TH-6 (check)	1.2	5.1	9.57	1.57	5.40	9.03

Quality analysis

The seed quality analysis revealed that Anmol Til possesses desirable oil and protein contents, making it suitable for both edible oil production and nutritional use. The oil content of Anmol Til ranged from 50–52%, which was slightly higher than the check variety TH-6 (50–51%). Likewise, Anmol Til exhibited a protein content of 18%, compared with 17% in TH-6 (Table 8). The comparatively higher oil and protein contents indicate the superior seed quality of Anmol Til. These characteristics enhance its commercial value and make it a promising variety for increasing edible oil production while providing improved nutritional quality.

Table 8: Quality parameters

Quality Parameter	Percentage (%)	
	Anmol Til	TH-6 (Check)
Oil content	50-52	50-51
Protein content	18	17

Variety Registration and Plant Breeders' Rights

Anmol Til was registered as a new sesame (*Sesamum indicum* L.) variety under the Plant Breeders' Rights Act, 2016. The variety was granted Plant Variety Protection by the Government of Pakistan through the Plant Breeders' Rights Registry (figure 2). It was registered under Registration No. SS/109/2024 on 30 January 2024. The certificate recognizes the variety as a new plant variety and grants the respective rights to the registered breeder(s)/owner(s) for the specified period in accordance with the Plant Breeders' Rights Act, 2016.

Seed availability

Breeder/pre-basic seed of Anmol Til has been produced and maintained at the Oilseeds Research Institute, Faisalabad, to ensure the availability of quality seed for future multiplication and dissemination.

Form PB-10
[See Rule 13(1)]

Serial No. 000039

Government of Pakistan
Plant Breeders' Rights Registry

CERTIFICATE OF PLANT VARIETY PROTECTION

Registration No.	39-SS/109-2024	Dated:	30-01-2024
Crop:	Sesame	Denomination of Variety:	Anmol Til
Type:	New	Conventional/GMC:	Conventional
OP/Hybrid:	OP	Local/Exotic:	Local

As declared

- That Muhammad Anwar, Maria Ghias, Salsabeel Rauf, Hafiz Saad Bin Mustafa, Dr. Ejaz-ul-Hasan & Muhammad Altaf

  has/have developed new plant variety and also that they are the true breeder(s).

- By virtue of an application that has been made to grant plant variety protection rights and that plant variety has particularly been described with respect to its distinctive features and a suitable denomination.

- There is no objection to grant plant variety protection rights of the said variety under the Plant Breeders' Rights Act, 2016 in favour of:

OILSEEDS RESEARCH INSTITUTE, FAISALABAD

آئل سیڈز ریسرچ انسٹی ٹیوٹ، فیصل آباد

By virtue of this certificate, the above mentioned owner(s) of the rights have under the Plant Breeders' Rights Act, 2016, the exclusive right to produce, sell, market, distribute, import or export the variety (seed) or propagating material for a term of Twenty years starting from the 30th day of January 2024 and expiring on the 29th day of January 2044

Registrar

Date of Grant 30-09-2024

Figure 2. Certificate of Plant Variety Protection of Anmol Til issued under the Plant Breeders' Rights Act, 2016.

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