



# Super Canola: Newly Developed High Yielding, Lodging and Drought Tolerant Double Zero Cultivar of Rapeseed (*Brassica napus* L.)

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## ABSTRACT.

The aim of present research was to develop a high yielding rapeseed cultivar having good quantitative and qualitative characteristics under the scenario of climate change. The research was initiated during 2005 and successfully completed during 2018 by Oilseeds Research Institute, Faisalabad Pakistan. Super Canola (RBN-13018) is an outcome of hybridization (Rainbow × RBN-03052) in 2005-06 and subsequently following by the pedigree method of selection. Homozygous progenies from F7 were bulked in 2013-14 for yield evaluation in replicated trials. Its performance was evaluated in the station and outstation yield trials at different agro-climatic conditions. RBN-13018 performed well in all yield trials by giving 44% better yield in Station Yield Trials, 9% better yield in Micro Yield Trials and 23% to 29% better yield in National Uniform Rapeseed Yield Trials conducted during 2015 to 2017 than the check Canola varieties. It also gave 6% higher yield than the widespread rapeseed hybrid Hyola 401 in National Uniform Rapeseed Yield Trials. RBN-13018 showed good tolerance against Alternaria blight and White rust and also exhibited better lodging tolerance. It also performed well in

Polyethylene Glycol (PEG 6000) induced drought and showed good genetic potential against drought stress. Oil quality analysis through Near Infrared (NIR) Spectroscopy showed that it has a best ratio of saturated and unsaturated fatty acids for human consumption and its meal is also fit for animals. Agronomic studies revealed that this variety thrives well with the prevailing rate of inputs and agronomic practices. Considering the qualitative and quantitative performance of RBN-13018 Punjab Seed Council (Pakistan) approved this strain as commercial variety for general cultivation with the name of Super Canola.

**Keywords:** Drought tolerance; Pedigree method; Seed yield; Erucic acid; Glucosinolates.

## INTRODUCTION

Pakistan is facing severe scarcity of edible oil due to increase in per capita consumption and small local production of edible oil. So, edible oil has a big share in Pakistan's import bill (Mustafa et al. 2017). Total availability of edible oils during 2016-17 remained at 3.623 million tonnes of which local production contributed 0.431 million tonnes (12 percent) and the import share of edible oil/oilseeds was 3.191 million tonnes (88 percent). The import bill of edible oil during 2016-17 was Rs 320.893 billion (US\$ 3.063 billion) (Economic Survey of Pakistan 2017-18). The major oilseed crops grown in the country include Sunflower, Canola, Rapeseed/Mustard and Cotton. Rapeseed and mustard are the second most important source of vegetable oil in Pakistan (Syed and Rahman, 2009).

Rapeseed (*Brassica napus* L.) is an amphidiploid (AACC genome,  $2n=38$ ) and developed through inter-specific hybridization between diploid *Brassica rapa* L. (AA genome,  $2n=20$ ) and *Brassica oleracea* L. (CC genome,  $2n=18$ ) (Mustafa, Bibi, Mahmood 2014; Yadava et al. 2012). *Brassica napus* L. belongs to (Brassicaceae) family which becomes one of the most important sources of the vegetable oil in the world (Nath et al., 2016). Rapeseed contains high oil content (40-42%) and protein (43.6%) in its seed. The protein present in seed meal has a complete component of amino acids including lysine, methionine cystine. However, canola has less than 2% Erucic acid in oil and less than 30  $\mu\text{mol/g}$  Glucosinolates in the oil-free meal. Erucic acid is a long chain monounsaturated fatty acid that causes heart triglyceride accumulation in experimental animals resulting in heart damage. Tradition rapeseed oil contains 20-55% erucic acid which is injurious for human consumption (Iqbal, Akhtar, Zafar, Ali, 2008).

Canola (*Brassica napus* L.) is one of the most important oilseed crops, and its area has increased rapidly over the last decade. Canola oil has high oleic acid ( $\omega$ -9) which is commonly used for food and industrial purposes. Canola oil is considered good edible oil for health (Onemli, 2014). Canola oil contains a desirable profile of saturated fatty acids (7%) and high level of monounsaturated fatty acid oleic acid (61%) and medium level of polyunsaturated fatty acids linoleic acid (21%) and (11%) linolenic acid therefore considers a healthy edible oil (Joughi, Hervan, Rad, Noormohamadi, 2018; Toosi 2015). Increasing seed oil quality and oil quantity is one of the most important breeding criteria. However, oil content in rapeseed is a complex quantitative trait, which is correlated with other storage and structural compounds present in seed and also influenced by environmental conditions. The value and suitability of rapeseed oil for nutritional aspect is determined by its fatty acid profile. The demand for Canola oil is increasing due to its good quality edible oil. Canola oil comprises high-quality fatty acids and anti-oxidants which is agreed by many nutritionists (Abbadi and Leckband, 2011).

Rapeseed Canola is sensitive to heat and drought stress which are correlated with the flowering period. Early flowering genotypes escape terminal drought and perform well in the low rainfall areas, while late flowering genotypes produce more biomass and yield in the high rainfall areas (Zhang and Flottmann 2016; Zhang et al. 2013; Cullis et al. 2010). Evaluation of drought tolerance at seedling stage is now an available method for screening of germplasm in a laboratory which reduces the time and labour for field testing (X. Zhang et al., 2014). Polyethylene

glycol (PEG-6000) is a chemical used to induce artificial drought in laboratory conditions for screening drought tolerant genotypes at seedlings stage (Ahmad et al. 2015). The challenge for breeders is to utilize the genetic variation within the rapeseed gene pool on the basis of adaptability. Breeders should be select the best combinations for hybridization for the development of high yielding rapeseed varieties/hybrids which are stable in different environments (Abbadi and Leckband, 2011). The Oilseeds Research Institute, Faisalabad (Pakistan) is working on the development of high yielding canola varieties in rapeseed and mustard. The breeding program is aiming to develop canola quality (double low) Rapeseed & Mustard cultivars having high seed yield, lodging tolerance, early maturing and disease tolerance suitable under the current scenario of climate change.

## MATERIAL AND METHODS

The present research was initiated during 2005-06 at research area of Oilseeds Research Institute (ORI), Faisalabad (31.4040°N, 73.0512°E, Altitude 184 m above sea level) Pakistan. The experimental material consists of high yielding with double zero quality lines of *Brassica napus* L and Pedigree method of plant breeding was used for the development of high yielding and canola quality varieties of *Brassica napus* L. All recommended agronomic and cultural practices were carried out during the whole tenure of the experiment.

### Crossing and filial generation development

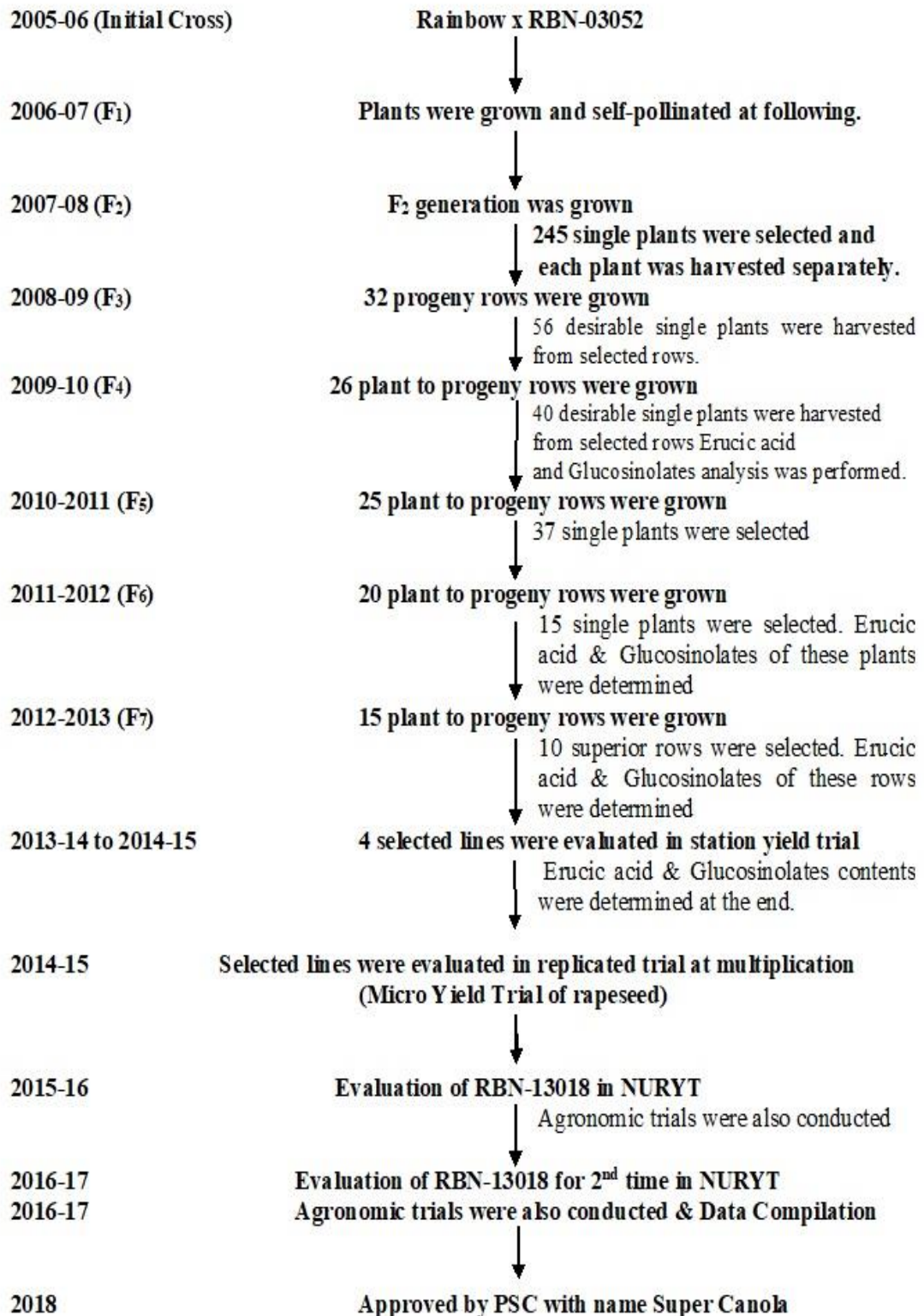
RBN-03052 was a locally developed high yielding canola line of rapeseed and Rainbow was an Australian rapeseed variety having low Erucic acid (1.5 %) and Glucosinolates (< 30  $\mu$  moles/g of the oil-free meal) were grown at research area of Oilseeds Research Institute, Faisalabad, Pakistan during 2005-2006.

At flowering stage, Rainbow was emasculated (female parent) and crossed with RBN-03052 (male parent). The F1 plants were grown and self-pollinated at flowering during 2006-07. From F2 generation, 245 single plants having early maturity, lodging tolerance and good plant vigour were selected and harvested separately during 2006-07. 32 plants were selected from 245 single plants of F2 generation on basis of high seed yield and canola quality characteristics to grow F3 progeny rows during 2007-08. 56 plants were harvested separately from the selected rows on the basis of plant health and yield. Out of these selected plants, 26 single plants were further grown to have plant to progeny rows of F4 during 2008-09. 40 desirable single plants were harvested from the selected rows.

The F5 was raised from 25 plants to row progenies having low Erucic acid and Glucosinolates during 2009-10. The 20 progeny rows were further selected to grow F6. The 15 single plants were further selected to grow F7. Ten superior rows of F7 were selected for Canola quality analysis during 2010-11. The oil contents of elite strains were determined by Nuclear Magnetic Resonance (Model MQA 7005). Erucic acid and Glucosinolates of elite strains were determined by Gas Chromatograph (Model Varian-3900 GC) and UV/Visible Spectrophotometer (PD-303 UV) respectively.

On the basis of quality analysis, 4 lines were selected for evaluation in Station yield trials. The segregating material F2 to F7 was maintained in isolation tunnels to avoid any foreign pollen contamination. The best performing lines were evaluated in Micro Yield Trials. After evaluation in Micro Yield Trials, RBN-13018 was evaluated in National Uniform Rapeseed Yield Trials for consecutive two years 2015-16 & 2016-17. The detail breeding history is shown in Figure 1.

## Breeding History of Super Canola



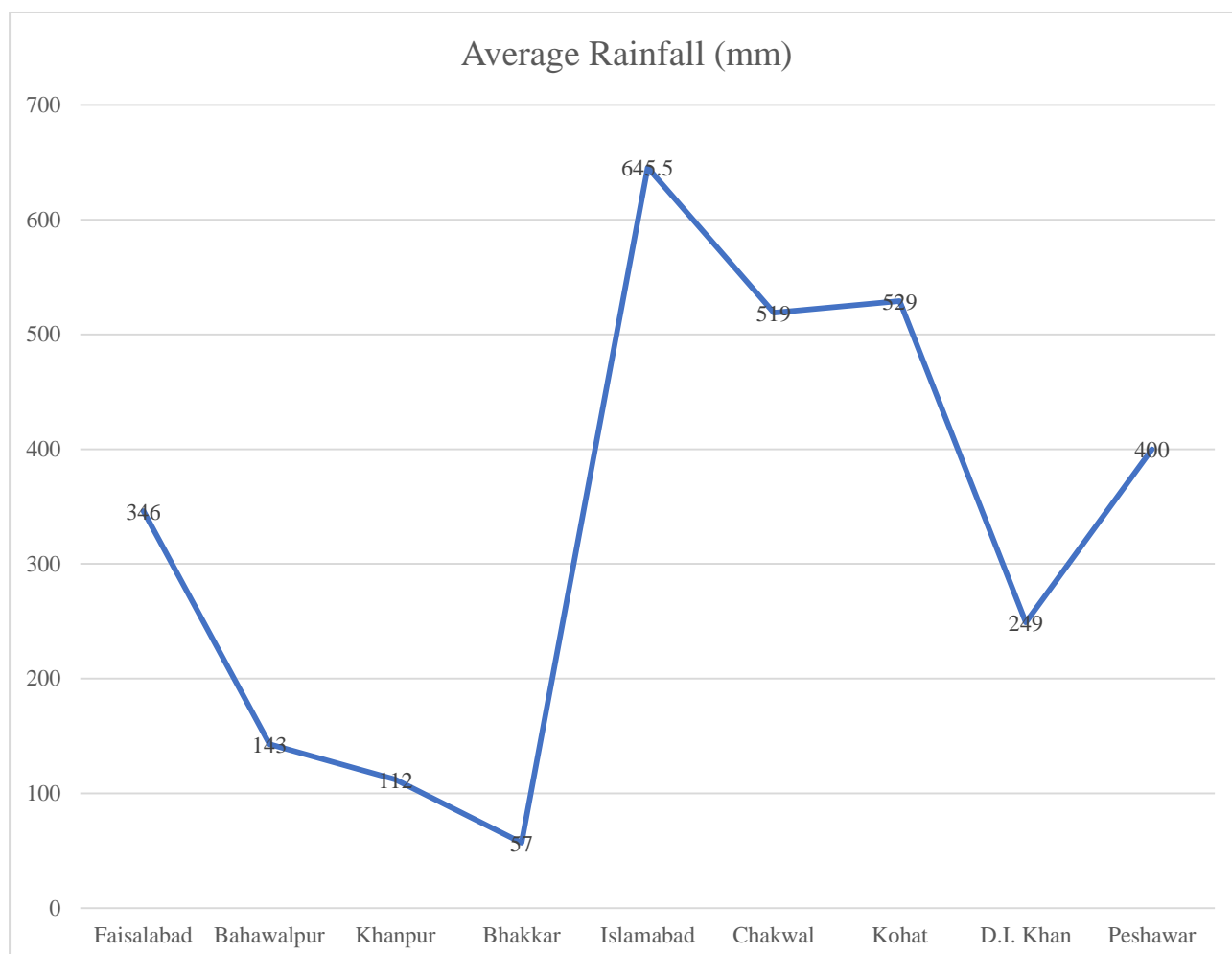
**Figure 1:** Detailed breeding history of Super Canola (RBN-13018)

### Station yield trials

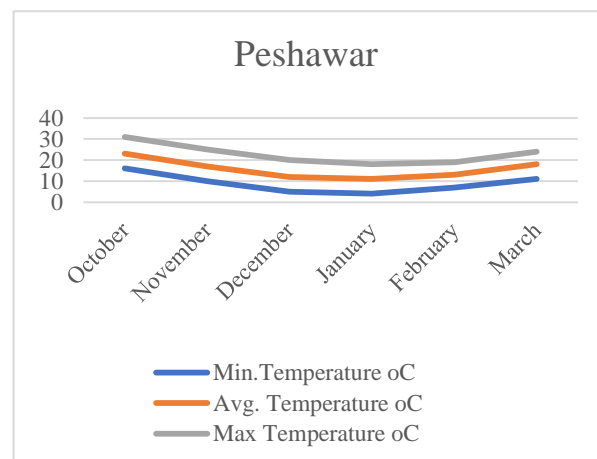
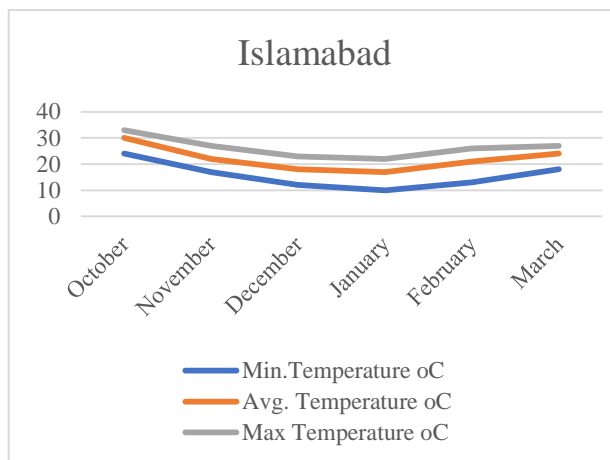
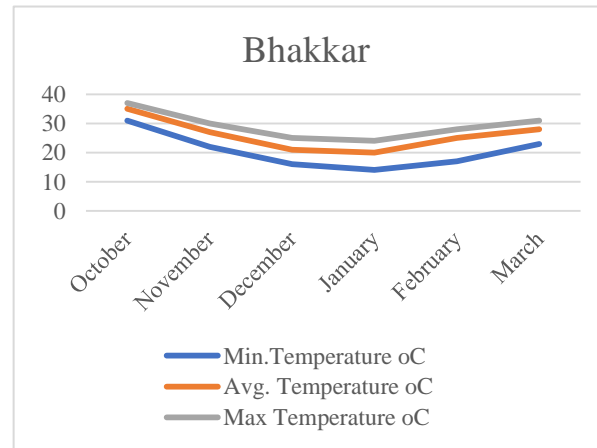
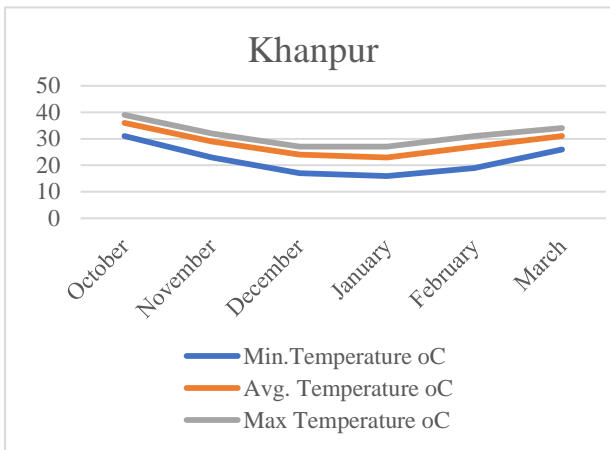
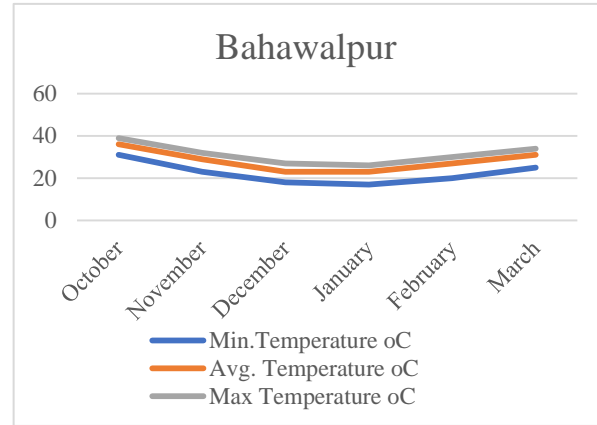
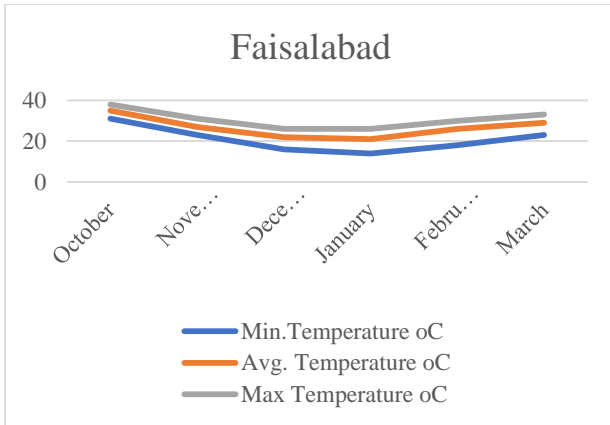
The newly developed strain RBN-13018 was tested in Preliminary Yield Trial (PYT) during 2013-14 and in Advance Yield Trial (AYT) during 2014-15 at research area of Oilseeds Research Institute, Faisalabad, Pakistan. Existing cultivar Faisal Canola was used as check variety. The experiments were sown in randomized complete block design (RCBD) having three replications. Manual seed drill was used for the sowing of seeds keeping a 45cm distance between rows. The plot consists of three rows of each entry with five meters length. All recommended agronomic and cultural practices were practiced during the whole tenure of the experiment. The recommended dose of NPK (90:85:60 kg/ha) were applied. The data for seed yield was recorded at harvesting.

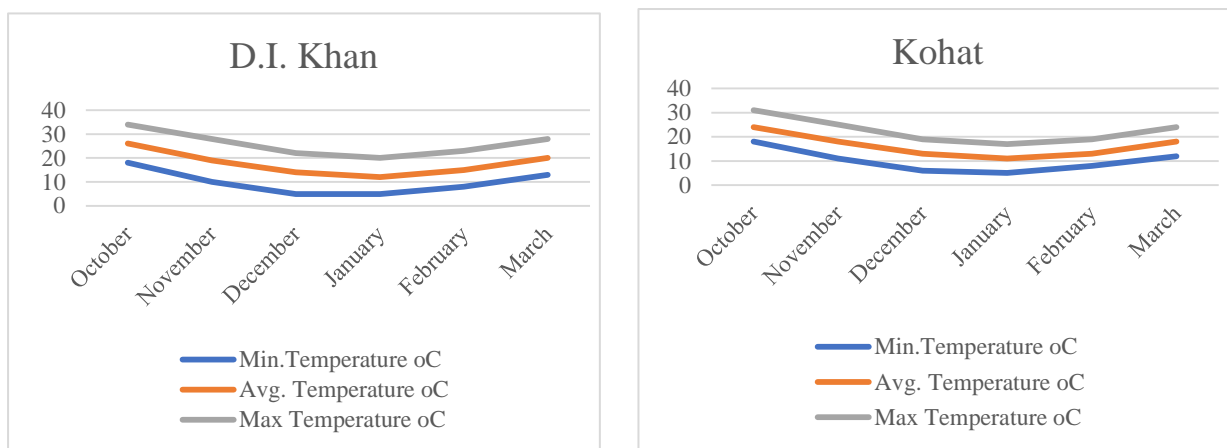
### Outstation trials

The adaptability and yield performance of newly developed strain RBN-13018 were evaluated in high, low and medium rainfall as well as in warm and mild temperature regions of Pakistan through Micro Yield trials (MYT) and National Uniform Rapeseed Yield Trials (NURYT). The climatic data of these areas are given in Figure 2 (Annual rainfall) and Figure 3 (Temperature).



**Figure 2:** Average rainfall at all locations of experiments.





**Figure 3:** Monthly average, maximum and minimum temperatures during rapeseed growing period at all locations of experiment

### Micro Yield Trials (MYT)

The stability and yield performance of strain RBN-13018 was evaluated against varied climatic conditions throughout the province by Micro Yield Trials during 2014-15. The research trials were sown at four locations of Punjab province having different agro-climatic conditions. The names of stations are Oilseeds Research Institute, Faisalabad (31.4040°N, 73.0512°E, Altitude 184 m above sea level), Regional Agricultural Research Institute, Bahawalpur (29.3544°N, 71.6911°E, Altitude 214 m above sea level), Oilseeds Research Station Khanpur (28.6332°N, 70.6574°E, Altitude 97 m above sea level) and Arid Zone Agricultural Research Institute, Bhakkar (31.8621°N, 71.3824°E, Altitude 171 m above sea level). Existing cultivar Faisal Canola was used as check variety. The experiment was sown in randomized complete block design (RCBD) having three replications at all locations. Manual seed drill was used for the sowing of seeds keeping 45cm distance between rows. The plot consists of four rows of each entry with five meters length. Same agronomic and cultural practices were carried out during the whole tenure of the experiment at all locations. The recommended dose of NPK (90:85:60 kg/ha) were applied. The data for seed yield was recorded at harvesting.

### National Uniform Rapeseed Yield Trials (NUYRYT)

The stability and yield performance in broader aspect to combat the changing climatic conditions was also checked throughout the country by National Uniform Rapeseed Yield Trials (NURYT) for two years during 2015 - 16 and 2016-17. Existing variety Faisal Canola and International hybrid Hyola 401 were used as check cultivar. Randomized complete block design (RCBD) with four replications was followed at all locations. Each plot consisted of 4 rows with 6 meters in length. Seeds were planted with the help of a Manual Seed Drill and a 45cm distance between the rows was maintained. The recommended dose of NPK (90:85:60 kg/ha) were applied. The complete plot was harvested at maturity and data for seed yield was recorded. During 2015 -16 NURYT was sown at eight locations i.e., National Agricultural Research Centre Islamabad (33.6701°N, 73.1261°E, Altitude 540 m above sea level), Barani Agricultural Research Institute Chakwal (32.9309°N, 72.7211°E, Altitude 498 m above sea level), Oilseeds Research Institute Faisalabad (31.4040°N, 73.0512°E, Altitude 184 m above sea level), Regional Agricultural Research Institute Bahawalpur (29.3544°N, 71.6911°E, Altitude 214 m above sea level), Oilseeds Research Station Khanpur (28.6332°N, 70.6574°E, Altitude 97 m above sea level), Barani Agricultural Research Station Kohat (33.50°N, 71.50°E, Altitude 489 m above sea level), Arid Zone Research Institute D.I. Khan (31.8626°N, 70.9019°E, Altitude 165 m above sea level) and Nuclear Institute for Food and Agriculture Peshawar (34.0151°N, 71.5249°E, Altitude 331 m above sea level). During 2016 -17 NURYT was sown at six locations i.e. National Agricultural Research Centre Islamabad, Barani Agricultural Research Institute Chakwal, Oilseeds Research Institute Faisalabad, Oilseeds Research Station Khanpur, Arid Zone Research Institute D.I. Khan and Nuclear Institute for Food and Agriculture Peshawar.

## **Agronomic studies**

**Fertilizer experiments:** The fertilizer response was tested with different doses of Nitrogen and Phosphorus at Oilseeds Research Institute Faisalabad during 2015-16 and at Agronomic Research Institute, Faisalabad during 2016-17.

**Sowing date experiments:** RBN-13018 was evaluated for defining best a package of production technology with different sowing dates starting from 15th September to 15th November with fifteen days of an interval in each sowing date. The experiments were sown during 2015-16 and 2016-17 at Oilseeds Research Institute Faisalabad.

## **Pathology and Entomology Studies**

**Disease incidence:** The data on the infestation of diseases (Alternaria blight and White rust) was also recorded from NURYT 2015-16 and 2016-17. RBN-13018 was compared with check variety Faisal Canola.

## **Aphid attack**

The crop was sown in the first week of October to escape from aphid attack.

## **Screening against drought stress**

An experiment was conducted in laboratory conditions during 2017 to evaluate the genetic potential of advance lines of *Brassica napus* against drought stress at seedling stage. Thirty genotypes of rapeseed were sown in 0%, 5%, 10% and 15% solution of Polyethylene Glycol 6000 (PEG 6000) in completely randomized design following methods as described by Shanahan et al. 1990.

## **Oil quality analysis**

The fatty acid profile analysis was carried out at Pakistan Council of Scientific and Industrial Research (PCSIR) Laboratories Complex, Lahore (Pakistan) during 2017. The oil contents of elite strains were determined by Nuclear Magnetic Resonance (Model MQA 7005). Erucic acid and Glucosinolates of elite strains were determined by Gas Chromatograph (Model Varian-3900 GC) and UV/Visible Spectrophotometer (PD-303 UV) respectively. The complete fatty acid profile was also estimated through Near Infrared (NIR) Spectroscopy (Model Perten DA 7250 Oilseeds calibrations) at Hi-technology laboratory of Oilseeds Research Institute, Faisalabad (Pakistan).

## **Spot examination**

During winter season 2017-18, two demonstration plots of RBN-13018 were sown on an area of half an acre at research area of Oilseeds Research Institute, Faisalabad and Post Graduate Agricultural Research Station, University of Agriculture Faisalabad along with check variety Faisal Canola for the Spot examination. A small seeded drill was used for the sowing of seeds keeping 45cm distance between rows. Same agronomic and cultural practices were carried out during the whole tenure of the experiment at all locations. The recommended dose of NPK (90:85:60 kg/ha) were applied.

## **RESULTS AND DISCUSSION**

The new strain RBN-13018 was tested in the irrigated and rainfed areas of Pakistan under different agro-climatic zones. The performance of RBN-13018 was consistently better in Station Yield Trial, Micro Yield Trials and National Uniform Rapeseed Yield Trials. The yield data recorded in series of the experiment is given accordingly. Same procedure was adopted by (Mustafa et al. 2017) (Nadeem et al., 2017) (Mahmood, Ali, &



Hussain, 2012) (Mahmood, Hussain, Tahir, Sharif, et al. 2011) (Shah, Zamir, Shah, 2007) for the evaluation of their varieties AARI Canola, Rohi Sarson, Faisal Canola, Punjab Sarson and DURR-E-NIFA respectively.

### Station Yield Trials

The new strain RBN-13018 was performed well in Preliminary Yield Trial (PYT) and Advanced Yield Trial (AYT) and gave significantly higher yield than the check variety Faisal Canola. The seed yield data of these trials are presented in Table 1. The data of station yield trials indicated that RBN-13018 yielded 44% more seed yield than check variety Faisal Canola.

**Table 1:** Yield performance of RBN-13018 in station yield trials at ORI, Faisalabad.

Variety/Line	Seed Yield in kg/ha			Avg.	% increase
	PYT (2013-14)	AYT (2014-15)			
RBN-13018	3681	1743		2712	44
Faisal Canola (C)	2259	1506		1883	

### Out Station Yield Trials

RBN-13018 performed well in multiple environments during Micro Yield Trials (MYT) and National Uniform rapeseed yield Trials (NURYT). On the basis of the mean seed yield of four locations during MYT, the seed yield of RBN-13018 was 9% higher than the check variety Faisal Canola as showed by Table 2 which is quite good as compared to check variety. During NURYT 2015-16, RBN-13018 surpasses all other varieties/hybrids and got the first position in seed yield. On the basis of the mean seed yield of eight locations, the seed yield of RBN-13018 was 6% higher than the international hybrid Hyola-410 and 29% higher than the check variety Faisal Canola as shown in Table 3. During NURYT 2016-17, RBN-13018 also performed well and gave higher seed yield than the check variety/hybrid. On the basis of the mean seed yield of six locations, the seed yield of RBN-13018 was 6% higher than the international hybrid Hyola-410 and 26% higher than the check variety Faisal Canola as shown in Table 4. Development of high yielding genotypes with stable performance is the breeders' priority but genotype x environment ( $G \times E$ ) interaction is a major constraint. Early flowering hybrids with long flowering phases were consistently productive in both low and high rainfall areas, showing broad adaptability. Breeding for broadly adapted and high yielding canola is possible by testing high yielding genotypes through multiple environment trials (H. Zhang, Berger, Herrmann, 2017).

**Table 2:** Yield performance of RBN-13018 in Micro Yield Trial, 2014-15

Variety/Line	Seed Yield in kg/ha				Avg.	% increase
	Faisalabad	Bahawalpur	Khanpur	Bhakkar		
RBN-13018	2504	2363	2145	1265	2069	09
Faisal Canola (C)	1941	2322	2037	1241	1885	

**Table 3:** Yield performance of RBN-13018 in National Uniform Rapeseed Yield Trial, 2015-16

Entry Name	Seed Yield in kg/ha									Mean	% Increase
	NARC ISD	BARI CHK	ORI FSD	RARI B. Pur	ORS K. Pur	BARS Kohat	AZRC D.I.Khan	NIFA Peshawar			
<b>RBN-13018</b>	2713	2281	1515	1444	1729	2008	2770	2206		2083	
<b>Hyola 401 (C)</b>	2168	1761	1363	1575	1625	2083	2817	2400		1974	6
<b>Faisal Canola (C)</b>	1469	1777	1254	1131	1750	1492	2509	1556		1617	29

**Table 4:** Yield performance of RBN-13018 in National Uniform Rapeseed Yield Trial, 2016-17

Entry Name	Seed Yield in kg/ha						Mean	% Increase		
	NARC, ISD		BARI, CHK		ORI, FSD	ORS, K.Pur			AZRC, DI.Khan	NIFA, Peshawar
<b>RBN-13018</b>	2765		573		2006	1145	3288	2417	2032	
<b>Hyola-401 (C)</b>	2312		588		1964	937	2973	2767	1924	6
<b>Faisal Canola (C)</b>	2155		568		2044	833	2718	1633	1659	23

### Agronomic performance of RBN-13018

#### (i) Response of RBN-13018 to different levels of NPK

The data for seed yield was statistically significant and ranged from 15015 to 2879 kg/ha among treatments (Table 5). The maximum seed yield of 2879 kg/ha was produced by treatment 4 in which N: P: K was applied @ 75:75:60 kg/ha followed by treatment 3 with seed yield of 2805 kg/ha. The 3rd treatment gave at par seed yield to treatment 4 but less fertilizer cost. (Nour, Lazim, Fattah, 2000; Prakash, Ramakrishnan, Koushik, 2011) also studied the impact of different level of NPK on Brassica and found similar results.

**Table 5:** Response of RBN-13018 to different levels of NPK fertilizers.

Treatment	Nitrogen (kg/ha)	Phosphorus P <sub>2</sub> O <sub>5</sub> (kg/ha)	Potash K <sub>2</sub> O (kg/ha)	Seed Yield 2015-16 (kg/ha)	Seed Yield 2016-17 (kg/ha)	Average Seed Yield (kg/ha)
1	00	00	00	1494	1535	1515
2	75	75	00	2268	2223	2246
3	75	75	30	2795	2814	2805
4	75	75	60	2840	2918	2879
5	75	75	90	2560	2493	2527
6	100	90	00	2380	2405	2393
7	100	90	30	2437	2518	2478
8	100	90	60	2370	2345	2358
	LSD 5%			148	165	

**(ii) Response of RBN-13018 to different sowing dates**

Sowing time is an important factor and affect crop yield. The average yield performance of RBN-13018 in sowing date trial was assessed from September 15<sup>th</sup> to November 15<sup>th</sup> at fifteen days intervals. The yield data is presented in the Table 6. The table showed that the highest mean yield 2882 kg/ha was recorded in treatment-2 (October 1st). Turhan et al. (2011) investigated the effects of sowing time on the growth, yield, and quality of rapeseed genotypes and found significant interactions with seed yield. He explained that sowing time is an important factor for seed yield and quality in rapeseed.

**Table 6:** Response of RBN-13018 to different sowing dates

Sowing Date	Yield (kg/ha)		Average (kg/ha)
	2015-16	2016-17	
15 <sup>th</sup> September	2351	2285	2318
<b>Ist October</b>	<b>2816</b>	<b>2948</b>	<b>2882</b>
15 <sup>th</sup> October	2414	2500	2457
Ist November	1841	1778	1810
15 <sup>th</sup> November	1571	1375	1473
<b>LSD 5%</b>	129	105	

**Disease and insect pest reaction**

**(i) Disease reaction of RBN-13018**

White rust caused by *Albugo candida* Kuntze and Alternaria blight caused by *Alternaria brassicae* (Berk.) Sacc. have been reported to be most widespread and destructive fungal diseases of rapeseed and mustard throughout the world (Prasad, Kumar, Kumar, 2017). Weather conditions, especially air temperature and precipitation, have a great effect on Alternaria blight severity in different years (Awasthi and Kolte, 1989). The average of two years (2015-16 & 2016-17) data presented in Table 7 showed that the infestation of Alternaria blight on RBN-13018 was less than check variety Faisal Canola while Table 8 revealed that no symptoms of white rust were observed on RBN-13018.

**Table 7:** Reaction of RBN-13018 against Alternaria Blight Disease

Variety/Line	NURYT-2015-16			NURYT-2016-17		
	Disease incidence (%)	Intensity (0-9)	Remarks	Disease Incidence (%)	Intensity (0-9)	Remarks
<b>RBN-13018</b>	20	2	T	22	2	T
<b>Faisal canola (C)</b>	35	4	MT	36	4	MT

**Scale:** 0 = Resistant (R), 1-2 = Tolerant (T), 3-4 = Moderately tolerant (MT), 5-6 = Moderately susceptible (MS), 7-8 = Susceptible (S), 9-10 = Highly Susceptible (HS)

**Table 8:** Reaction of RBN-13018 against White Rust Disease

Variety/Line	NURYT-2015-16		NURYT-2016-17	
	Disease (%)	Remarks	Disease (%)	Remarks
RBN-13018	0	R	0	R
Faisal canola (C)	0	R	4	R

**(ii) Aphid attack on RBN-13018**

There are various insect pests which may attack on Brassica like aphids, whitefly, painted bug, pea leaf miner and sawfly but aphid (*Lipaphis erysimi*) is a serious insect of rapeseed (Agarwal and Datta, 1999). Aphids rapidly multiply under favourable climatic conditions mainly on inflorescence and suck the sap. The yield loss ranges 30-35% due to the attack of aphids on Brassica spp. The yield loss may increase up to 70% by the attack of aphids on Brassica (Farooq and Tasawar, 2007). Hervé, (2017) stated that insect pests are one of the biggest challenges of *Brassica napus* which are usually controlled by using insecticides, but the sole use of these substances are not good to control insects. The climatic conditions in the month of February are favourable for aphid attack in Pakistan as the weather becomes warmer gradually. 1st week of October is the best sowing time for Canola crop in Punjab province (Pakistan) to escape from aphid attack. Being early maturing variety, Super Canola completes its silique formation in the month of February and crop switch over towards maturity. Therefore this variety escapes aphid attack.

**Drought tolerance**

Many studies revealed that polyethylene glycol can change the osmotic potential of nutrient solution and as a result create water scarcity in a controlled way. Drought tolerant cultivars maintained their cell membrane stability and integrity against water stress. Electrolyte leakage extent increases steadily with the increase in drought stress (Ahmad et al. 2015). RBN-13018 performed well at all level of PEG 6000 induced stress environment and maintain their cell membrane stability. The response of RBN-13018 against PEG induced drought showed its good genetic potential against drought stress. The same method was used by (Ahmad et al. 2015) (Tsago, Andargie, & Takele, 2013) (Dutta, Bera, Chandra, Viswavidyalaya, 2008) in their screening experiments against drought stress.

**Quality characteristics**

A bold seeded new variety “Super Canola” has good quality characteristics suitable for edible oil production. Super Canola has 41-43% oil content having Erucic acid 0.1-0.2% and Glucosinolates 24  $\mu$  mole/g oil-free meal. Newly developed variety Super Canola has good and balanced fatty acid profile for human health shown in Table 9. Canola oil contains lowest saturated fats as compared to other vegetable oils so, diet-conscious consumers are preferring canola oil. Erucic acid and Glucosinolates are considered toxic for both human as well as animals' health and are also a cause of bitter taste. Safe limits for these compounds have been described as less than 2% of erucic acid in oil and less than 30  $\mu$ mol g<sup>-1</sup> of Glucosinolates in oil-free meals (Moghadam, Zahedi, Ghooshchi, 2011).

**Table 9:** Fatty acid profile of Super Canola (RBN-13018) & Faisal Canola (C)

Sr. #	Tests		RBN-13018	Faisal Canola (C)
1	FFA (% as Oleic acid)		0.04	0.06
2	Peroxide value (meq/kg)		0.50	0.43
3	Fatty Acids (%)	Lipid No.		
i	Myristic acid	C <sub>14:0</sub>	0.5	0.4
ii	Palmitic acid	C <sub>16:0</sub>	8.5	11.9
iii	Palmitoleic acid	C <sub>16:1</sub>	1.4	0.7
iv	Stearic acid	C <sub>18:0</sub>	1.3	1.4
v	Oleic acid	C <sub>18:1</sub>	54.2	49.2
vi	Linoleic acid	C <sub>18:2</sub>	23.0	25.4
vii	alpha-Linolenic acid	C <sub>18:3</sub>	8.0	6.7
viii	Arachidic acid	C <sub>20:0</sub>	0.8	2.9
ix	Gondoic acid	C <sub>20:1</sub>	1.2	0.7
X	Behenic acid	C <sub>22:0</sub>	0.4	0.5
xi	Erucic Acid	C <sub>22:1</sub>	0.1	0.2
xii	Lignoceric acid	C <sub>24:0</sub>	0.2	-
xiii	Nervonic acid	C <sub>24:1</sub>	0.2	-



**Figure 4:** Super Canola (RBN-13018) Spot Examination

## Variety approval

Spot Examination Committee evaluated the strain on March 09, 2018 at research area of Oilseeds Research Institute, Faisalabad and Post Graduate Agricultural Research Station, University of Agriculture Faisalabad. The committee recommended RBN-13018 to Experts Sub-committee for its approval. The Strain RBN-13018 showed in Figure 4 was recommended by Expert Sub-Committee in its 77th meeting held on March 15, 2018, to Punjab Seed Council for its approval on the basis of high seed yield, good quality oil, lodging tolerant and earliness.

50th meeting of Punjab Seed Council (PSC) Pakistan was held on May 9, 2018, at Agriculture House, Lahore (Pakistan). The Minister Agriculture, Govt. of the Punjab (Pakistan) chaired the meeting. The case of RBN-13018 for variety approval was presented before Punjab Seed Council. The chair and the member of PSC were convinced with the performance of RBN-13018 and PSC approved this strain as a variety with name Super Canola for general cultivation. The BNS and Pre-basic seed have been produced from a uniform and stable lot at Oilseeds Research Institute, Faisalabad (Pakistan).

## CONCLUSION

It is concluded that new variety Super Canola (RBN-13018) is a high yielding cultivar having good quality oil and disease tolerance. In the present scenario of climate change, abrupt high-temperature fluctuations and water scarcity during grain filling stage hamper grain yield. Super canola exhibited better tolerance for changing climatic conditions owing to its early flowering initiation and better plant structure and stature. Super Canola showed broader adaptability and expressed better yield performance in different agro-climatic conditions proving suitable for food security. It is fit to grow in all irrigated as well as in rain-fed areas. Due to versatile characteristics, Super Canola is quite suitable for regions/countries having similar climatic conditions prevailing in Pakistan.

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## AUTHORS CONTRIBUTIONS

- TM is the team leader of Rapeseed & Mustard research team at Directorate of Oilseeds, Ayub Agricultural Research Institute Faisalabad (Pakistan) and supervises research activities. He designed the methodology of experiments and reviewed this manuscript.
- HS is the team member of Rapeseed & Mustard research team at Directorate of Oilseeds, Ayub Agricultural Research Institute Faisalabad (Pakistan). He is involved in all research activities (hybridization, Maintenance of filial generation, station and outstation yield trials, quality analysis, data recording and variety approval). He wrote the manuscript. He is involved in hybridization, Maintenance of filial generation, station yield trials and data recording. He provided the yield data of station yield trials.
- MA is the Director of the institute and supervises all research activities of the institute. He wrote the conclusion of this manuscript.
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- AM is Professor Institute of Molecular Biology and Biotechnology, University of Lahore, Lahore Pakistan served as corresponding author of manuscript.

## CONFLICT OF INTEREST

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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