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DEVELOPMENT OF A NEW HIGH YIELDING CANOLA QUALITY RAPESEED VARIETY *DURR-E-NIFA* FOR GENERAL CULTIVATION IN NWFP

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Abstract

An Australian canola genotype 'Dunkeld' and a local rapeseed mutant variety 'Abasin-95' were hybridized at Nuclear Institute for Food and Agriculture (NIFA), Peshawar during Rabi, 1995-96. Selection of the high yielding recombinant line 'NH 97-1/5-1' was made in F_2 segregating populations during 1997. The hybrid was thoroughly evaluated in various replicated yield trials for yield potential and stability test at NIFA and other stations from 1999 to 2004. The proposal of the recombinant 'NH 97-1/5-1' was submitted for approval as commercial variety to NWFP Provincial Seed Council. The Seed Council approved the hybrid line 'NH 97-1/5-1' as a new improved variety under the name "DURR-E-NIFA" for general cultivation in NWFP in its meeting held on 19th September 2005 (Anon., 2005). The major improvement in 'DURR-E-NIFA' is manifested in the form of increase in seed size, decrease in plant height, stiff stem, broader adaptability as compared to check variety 'Shiralee'. The large seed size of 'DURR-E-NIFA' is the main contributing factor towards the increase in seed yield compared to Shiralee. Short stature and stiff stem of 'DURR-E-NIFA' helps in showing resistance to lodging. DURR-E-NIFA has 12.5% high seed yield potential, up to 9.7% higher oil content of canola quality compared to the commercial variety. The release of this new improved rapeseed variety for commercial cultivation in rainfed and irrigated areas will increase the domestic edible oil production.

Introduction

Pakistan is deficient in edible oil and continues to meet the domestic requirements through import at the cost of precious foreign exchange. A huge amount of 59.506 billion rupees were spent on the import of 1.787 million tons of edible oil during 2006-07. An additional amount of Rs. 24.368 billion was spent on the import of seed by solvent industry for crushing during the said period, thus the total import bill rose to staggering figure of 83.874 billion Rupees. In terms of foreign exchange, the import bill cost the National exchequer US $ 1.366 million (Anon., 2007, Pers. Comm. 2008). This huge edible oil import bill can only be reduced by increasing the domestic oilseed production. Rapeseed and mustard are traditionally important oilseed crops of Pakistan and currently contribute about 16% to the domestic oilseed production, however, the per acre yield is very low due to many reasons but the lack of high yielding varieties is the most important one. The national average yield of rapeseed and mustard is quite low (837kg ha-1), and the average yield in NWFP is the lowest (447 kg ha-1) of the four provinces (Anon., 2004). Moreover, the traditional varieties of rapeseed and mustard contain high levels of erucic acid in oil and glucosinolates in meal, thus making them unfit for humans and animals consumption respectively. Cultivar (cv) of canola quality (which contain less than 3% erucic acid in oil and 30 micromole total glucosinoates in one gram oil free meal) is available and being grown on an area of about 268,000 acres in the country (Anon., 2004). However, most of the canola varieties have been brought from West and

are not well adapted to the agro climatic conditions of Pakistan. The increase in canola acreage is mainly hampered with long maturity duration, seed shattering and poor plant stand due to excessive heat during entire growth period especially at maturity of the crop.

Hybridization research (Recombination breeding) was, therefore, initiated at NIFA to develop canola quality rapeseed varieties adaptable to the local environmental conditions of Pakistan. The Classical breeding research resulted in the development of a hybrid line, NH 97-1/5-1, which is high yielding, early flowering, with high oil content of Canola quality and broader adaptability to the diversified environments of the country. This paper reports the development history of the new improved rapeseed variety 'DURR-E-NIFA' for commercial cultivation in rainfed and irrigated areas of NWFP.

Material and Methods

An Australian canola genotype 'Dunkeld' characterized by high yield potential, canola quality, short stature and resistance to black leg disease but poorly adapted to the agro climatic conditions of Pakistan, was hybridized with Abasin-95, a local rapeseed mutant variety with early maturity, high yield potential and broader adaptability at NIFA during Rabi 1995-96. F1 generation of the cross was planted the same year during summer (May-Sep.) 1996 at Kaghan and the hybrid plants were harvested individually. F2 populations were raised in rabi 1996-97 at Peshawar for selecting high yielding, early maturing recombinants with canola quality and recombinant 97-1/5-1 along with some other desirable F2 hybrids were selected. Generation of the selected recombinants was advanced to F3 to confirm its breeding behavior/genetic stability for desired traits at Kaghan during summer 1997. The high yielding line 97-1/5-1 was evaluated in replicated Preliminary Yield Trial (PYT, 1999-2000), Advanced Lines Yield Trials (ALYT, 2000-01), Multi locations Adaptation Zonal Yield Trials (ZYT, 2001-02), and National Uniform Rapeseed Yield Trials (NURYT) during 2002-2003 and 2003-04. All replicated yield trials were conducted using Randomized Complete Block Design (RCBD) with plant-to-plant and row-to-row spacing of 5 and 30 cm, respectively. The rows were 5m long and numbers of rows were four in PYT and six in all others trials, per plot per replication. The yield trials data were analyzed on computer using Michigan State University's software, (MSTAT-C, 1983-93).

The seed quality of different genotypes for total oil content, fatty acid profile and total seed glucosinolates were analyzed by Near Infrared Reflectance Spectroscopy (NIRS) system at NIFA Oilseed Analytical Lab.

Results and Discussion

Yield performance of NH 97-1/5-1 in preliminary and advanced yield trials: Results of PYT conducted during 1999-00 and Advanced Lines Yield Trial conducted during 2000-01 at NIFA are presented in Table 1 and Table 2, respectively. NH 97-1/5-1 out yielded the check variety and ranked first by producing 2161 kg/ha in PYT. In ALYT, the line exhibited top yield performance (2630 kg ha^{-1}) and out yielded all the entries.

Yield performance of NH 97-1/5-1 in multi locations adaptation yield trial: Based on excellent performance of NH 97-1/5-1 in PYT and ALYT under irrigated conditions, it was tested in a 16-entry multi location adaptation yield test in NWFP during 2001-02. The combined analysis over locations (Table 3) showed that 97-1/5-1 significantly out yielded the check and other entries.

Table 1. Performance of rapeseed genotypes[1] in preliminary yield trial (PYT) conducted at NIFA during 1999-00.

Entry	50% Flowering (days)	Plant height (cm)	Yield/ha (kg)	Aphid attack[2]	*Alternaria* blight
97 1/5-1	116.5 ABCD	190.7 CDE	2161 A	2.50	MR
97 1/5-4	105.0 BCD	190.6 CDE	1962 A	2.89	MR
97 1/5-5	115.3 A-D	184.8 E	2025 A	3.10	R
97 1/5-7	95.3 D	188.0 CDE	2088 A	2.98	MS
97 1/5-23	126.3 AB	195.0 ABCD	1795 A	3.00	MR
97 3/13-1	131.3 A	195.9 ABC	1816 A	3.02	MR
97 3/13-2	114.8 A-D	195.4 ABCD	1962 A	2.96	R
97 3/13-7	120.8 ABC	194.6 ABCD	2025 A	2.99	T
97 3/13-18	101.8 CD	189.6 CDE	2140 A	3.20	MR
97 3/13-19	114.8 A-D	193.9 ABCD	2056 A	2.56	MR
97 4/5-1	115.5 A-D	199.9 A	2014 A	2.78	MS
97 4/5-2	125.8 AB	187.6 DE	2035 A	2.99	S
97 4/5-3	120.5 ABC	190.9 BCDE	1921 A	2.56	S
Abasin-95 (control)	109.5 A-D	198.9 AB	2067 A	3.40	MR

1= Means sharing a common letter are not significantly different at $p<0.05$, using Duncan New Multiple Range Test (DNMRT).
2= Aphid attack was recorded on the basis of aphid colony size (cm) on the main shoot.
R= Resistant, MR= Moderately Resistant, T= Tolerant, S= Susceptible, MS= Moderately Susceptible

Table 2. Agronomic performance[*] of rapeseed genotypes in advanced lines yield trial conducted at NIFA during 2000-01.

S. No.	Entries	50% flowering (days)	Plant height (cm)	Yield/ha (kg)
1.	1266	74.3 G	222.8 BCD	2440 A
2.	1284-1	97.8 D	232.0 AB	1440 EF
3.	1293	80.3 F	220.8 BCD	1480 DEF
4.	1265	96.0 D	230.5 ABC	1420 EFG
5.	NH 97 1/5-1	99.0 CD	182.5 G	2630 A
6.	97 1/5-7	98.8 CD	177.0 G	1620 CDE
7.	97 1/5-18	97.5 D	186.8 FG	2200 ABC
8.	1268-1	90.0 E	228.3 ABC	1280 EFG
9.	1290	81.5 F	230.3 ABC	1300 EFG
10.	97 3/13-19	97.5 D	197.3 EF	1680 CDE
11.	97 1/5-5	98.3 CD	180.3 G	1700 CDE
12.	1311	110.0 B	215.8 CD	780 G
13.	1255	96.8 D	235.5 AB	1180 EFG
14.	DLJ-3 (P)	121.3 A	242.5 A	840 FG
15.	Abasin (C)	101.3 C	201.0 EF	2100 BCD
16.	BM-1 (C)	80.8 F	210.0 DE	2020 BCD

*Means sharing a common letter are not significantly different at $p<0.05$, using DNMRT.

Table 3. Yield performance of adaptation yield trial of rapeseed genotypes* conducted at multi locations in NWFP during 2001-02.

S. No.	Entries	Yield/ha (kg)			Mean over locations
		NIFA	Kohat[1]	S. Naurang	
1.	1266	2440 A	1520 A	1557 B	1839.0
2.	1284-1	1440 EF	729 B	779.8 E	982.9
3.	1293	1480 DEF	807 B	1288.0 C	1191.1
4.	1265	1420 EFG	796 B	687.2 FG	967.7
5.	NH 97 1/5-1	2780 A	1486 A	1984.0 A	2083.3
6.	97 1/5-7	1620 CDE	874 B	727.0 EF	1073.7
7.	97 1/5-18	2200 ABC	612 B	957.4 D	1256.5
8.	1268-1	1280 EFG	562 B	438.5 H	760.2
9.	1290	1300 EFG	411.9 B	1068 D	926.6
10.	97 3/13-19	1680 CDE	701.4 B	962.9 D	1114.8
11.	97 1/5-5	1700 CDE	790.5 B	600.8 G	1030.4
12.	1311	780 G	400.8 B	380.7 H	520.3
13.	1255	1180 EFG	801.6 B	324.7 H	768.8
14.	DLJ-3	840 FG	439.8 B	199.8 I	493.2
15.	Abasin (C)	2100 BCD	1587 A	1238 C	1641.7
16.	BM-1 (C)	2020 BCD	314.5 B	708.5 EFG	1147.7

* Means sharing a common letter are not significantly different at p<0.05, using DNMRT.
1= Total rainfall received during the entire experiment was 89.4 mm at Kohat.

Table 4. Combined seed yield (kg/ha) of rapeseed entries in NURYT conducted by oilseed coordinator, PARC at different locations in Pakistan during RABI 2002-03.

Entry	NARC	CHK	FSD	K-Pur	B-Pur	Pesh	NIFA	DIK	Kohat	T-jam	Quetta	Mean
19-H	2078	2007	877	1621	1104	3617	1708	2417	1317	1179	762	1699
Shiralee (C)	1907	2104	793	1516	1071	3600	1667	2375	889	1139	1077	1649
Norseman	1683	1722	757	1366	1042	3967	1750	2167	1011	1420	912	1618
Dunkeld	1838	1938	548	1197	1092	2925	1792	2458	1189	966	850	1527
RBN-96040	1457	1764	1040	1586	1763	3308	1667	3042	878	1386	1229	1738
DN-2	1595	1882	1127	1389	1700	3567	2375	2542	1500	1231	896	1800
97- 1/5-1	1528	2139	1110	1401	1333	4250	1625	3042	1600	1235	1137	1855
99CBN-6	1292	1847	875	1482	1550	3800	1250	2500	967	1077	1262	1627
99CBN-8	1608	2285	843	1435	1323	3058	1667	2500	867	1093	971	1605
KN-120	1850	2125	881	1262	1229	3358	1708	2333	1111	1074	1114	1640
Average	1684	1981	885	1426	1321	3545	1721	2538	1133	1180	1021	
LSD	187	152	217	198	131	NS	319	519	497	NS	144	
(0.05)	7.7	5.3	16.9	9.6	6.9	31.9	12.8	14.1	25.6	18.0	9.8	

NARC= National Agricultural Research Centre, CHK= Chakwal, FSD= Faisalabad, K-Pur= Khanpur, B-Pur= Bahawalpur, Pesh= Peshawar, T-Jam= Tandojam, NIFA= Nuclear Institute for Food and Agriculture, DIK= Dera Ismail Khan

Yield performance of NH 97-1/5-1 in national uniform yield trials conducted by oilseed coordinator, PARC, Islamabad: Based on consistent performance of 97-1/5-1 in various yield trials at different locations, it was assessed for adaptability in diversified environments through out Pakistan in National Uniform Rapeseed Yield Trial (NURYT), 2002-03 and 2003-2004. The combined results over locations (Table 4) revealed that NH 97-1/5-1 produced 1.86 tons per hectare seed yield and out yielded all the entries. It out yielded the check in 8 out of 11 sites in NURYT 2002-03 i.e. at Chakwal, Faisalabad, Bahawalpur, Peshawar, Kohat, D. I. Khan, Tandojam and Quetta and produced 12.5% higher yield than the check cv (Shiralee). In NURYT 2003-04, NH 97-1/5-1 repeated its excellent performance and produced 1.623 t ha-1 yield (Table 5), thus yielded 101% of the check (Shiralee). It out yielded the check in 5 of 10 sites i.e., at Chakwal, Faisalabad, Bahawalpur, Kohat and Quetta, indicating broader adaptability and genetic stability over years and locations (Tables 4 and 5).

Resistance against insects and diseases: The major insects of rapeseed in Pakistan are aphids. The results (Table-1) revealed that NH 97-1/5-1 was fairly tolerant to aphid infestation. The main diseases of rapeseed/mustard in Pakistan are *Alternaria* blight, caused by *Alternaria brassicae*, NH 97-1/5-1 was found to be moderately resistant to the disease (Table 1).

Oil content, erucic acid and glucosinolates: Initially seed of NH 97-1/5-1 contained oil content, ranging from 39.7- 42.9% with 2.4% erucic acid and 19 micro moles of total glucosinolates per gram oil free air dried meal (Tables 6 and 7). The Canola quality standards for Pakistan require a maximum of 5% erucic acid in oil and 40 micro moles total glucosinolates in oil free solid. Thus NH 97-1/5-1 is well within the Canola standards and possesses 2.6 to 9.7% higher oil content compared to the check.

Discussion

Scientists of NIFA, Peshawar have evolved earlier two high yielding varieties, one each of rapeseed and mustard through induced mutation for general cultivation in NWFP (Shah *et al*., 1999, 2001 & 2005). The currently evolved variety DURR-E-NIFA manifested improvement in the form of increase in seed size, decrease in plant height, stiff stem, high oil content of canola quality, earliness in maturity and broader adaptability to diversified climatic conditions as compared to check variety Shiralee. The large seed size in rapeseed is the main contributing factor toward seed yield (Salisbury, 1988). The short stature and stiff stem of rapeseed helps in showing resistance to lodging. These two traits of this variety will encourage the sugar cane farmers for its intercropping in September sown sugar cane, which will not only increase their income per unit area but also protect the sugarcane from winter frost. Similar results about genetic changes in the above mentioned traits through traditional breeding techniques and induced mutations have also been reported by Hovinen & Laakso (1987), Laakso *et al*., 1986, Salisbury (1988), Shah *et al*., (1995, 1999 & 2005), Oram & Kirk (1992). NH 97-1/5-1 is well adapted to both irrigated and rainfed areas of NWFP and other provinces as is clear from the results (Tables 1 to 5). The release of this new improved rapeseed variety for commercial cultivation in rainfed and irrigated areas will increase the domestic edible oil production.

Table 5. Combined seed yield (kg/ha) of rapeseed entries in NURYT conducted by oilseed coordinator, PARC at different locations in Pakistan during RABI 2003-04.

Entry	NARC	CHK	FSD	K.Pur	B.Pur	NIFA	DIK	Kohat	Quetta	Mean
20-E	2016	2264	873	1690	1380	2438	1021	2405	658	1638
97-1/5-1	2055	2167	1076	1597	1517	2376	958	2038	825	1623
Shiralee (C)	2191	1875	810	1678	1471	2625	1229	1749	742	1597
Rapeseed-A	1809	2181	961	1656	1442	2417	1000	2075	719	1584
99CBN008	1995	2139	995	1592	1385	2479	979	1577	792	1548
99CDN006	1953	2125	845	1516	1400	2417	1063	1617	742	1520
DN.6	1837	1945	752	1632	1261	2146	1271	1642	727	1468
Average	1979	2099	902	1623	1408	2414	1074	1872	743	1568
LSD (0.05)	194	115	NS	NS		354	NS	473	42	
CV (%)	6.6	3.7	19.6	10.7		9.9	12.8	17	3.8	

NARC= National Agricultural Research Centre, CHK= Chakwal, FSD= Faisalabad, K-Pur= Khanpur, B-Pur= Bahawarpur, DIK= Dera Ismail Khan, T-Jam= Tandojam, NIFA= Nuclear Institute for Food and Agriculture

Table 6. Combined oil contents (%) of rapeseed entries in NURYT 2002-03.

Entry	NARC	Faisalabad	Kohat	Peshawar	Mean
19-H	41.8	36.8	37.1	41.9	39.4
Shiralee (C)	41.0	36.1	37.5	40.9	38.9
Norseman	41.2	36.8	37.0	39.2	38.6
Dunkeld	41.2	32.9	38.3	41.6	38.5
RBN-96040	40.7	37.4	39.4	40.3	39.4
DN-2	39.7	36.7	37.7	41.0	38.8
97 1/5-1	42.9	36.0	37.9	41.5	39.6
99CBN-6	39.5	35.7	37.2	39.5	38.0
99CBN-8	39.8	34.6	37.8	40.8	38.3
KN-120	39.9	35.0	38.5	80.6	38.5
Average	40.0	35.7	37.7	40.7	
LSD (0.05)	1.4	0.6	1.4	NS	
C.V. (%)	2.4	1.2	2.6	5.0	

Table 7. Oil content, erucic acid and total glucosinolate contents of NH 97-1/5-1 (DURR-E-NIFA) and Shiralee (control).

Entry name	Oil content (%)	Erucic acid (%)	Glucosinolates (μ mole/g)
NH 97-1/5-1 (DURR-E-NIFA)	39.6-42.9	2.4	19.0
Shiralee (Control)	36.1-41.8	4.0	60

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