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HIGH YIELDING DESI CHICKPEA (*CICER ARIETINUM* L.) VARIETY "NIFA-2005"

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Abstract

The seeds of a local chickpea variety Pb-91 were irradiated at 0.30 KGy doses of gamma rays using ^{60}Co gamma cell and raised M_1 generation at Nuclear Institute for Food and Agriculture (NIFA) during 1994-95. M_2 to M_6 generations were raised along with parents and standard varieties from 1996 to 2000 and made selections on the basis of more pods and branches per plant, large seed size and good plant type. Performance of the line CMN-257 along with standard varieties was evaluated in various replicated yield trials and screened for diseases from 2000-2004. The proposal of the mutant CMN-257 was submitted for approval as commercial variety for NWFP to the Provincial Seed Council meeting held on 19th September 2005 at NWFP Agricultural University, Peshawar. The Provincial Seed Council approved the mutant CMN-257 as a commercial variety under the name **"NIFA-2005"** for general cultivation in NWFP.

The major improvements in CMN-257 are manifested in the form of increase in seed size and erect plant type with stiff stem as compared to standards NIFA-88 and NIFA-95. The large seed size of CMN-257 is the main contributing factor towards increase in seed yield compared to NIFA-88 and NIFA-95. Erect plant type and stiff stem of CMN-257 helps in showing resistance to lodging, which reduces seed yield losses. Pods per plant, branches per plant, seeds per pod and protein contents of CMN-257 compare favorably with standards NIFA-88 and NIFA-95. CMN-257 has 16 % and 48 % high seed yield potential compared to the standard varieties NIFA-88 and NIFA-95. Its experimental seed yield was 1994 kg ha^{-1}. CMN-257 also showed tolerance to wilt/root rot and chickpea blight.

Introduction

Chickpea is one of the major rabi pulse crops, which is the only source of income for the poor farmers living in most dry and low fertile lands of Pakistan. In rabi season, the chickpea growing areas can not be utilized for any other crops due to their low fertility and scarcity of water. Rains are the only source of moisture in major chickpea growing areas in NWFP. In D. I. Khan some farmers have started chickpea cultivation on irrigated areas in rice belt and on the fields where the available irrigation facility is insufficient for cultivation of wheat crop. A new and profitable utilization of chickpea crop as goat and sheep grazing at seedling stage in irrigated areas of D. I. Khan is in practice. The chickpea crop utilization as grazing fields returns at least Rs. 1 per goat or sheep per day to the farmers. Chickpea green fleshy leaves and stem at pre-flowering stage is one of the most popular winter vegetables amongst people living in southern districts of NWFP, which also returns reasonable amount and provide employment opportunities to the growers.

The research work for the improvement of chickpea is being carried out at Agricultural Research Station (ARS), Karak, Agricultural Research Institute (ARI), D. I. Khan and Nuclear Institute for Food and Agriculture (NIFA), Peshawar in NWFP. ARS, Karak has evolved a number of chickpea varieties, which are being successfully cultivated in major chickpea growing areas in the province. Two desi mutant varieties, NIFA-88 approved in 1990, NIFA-95 approved in 1996 and one kabuli mutant variety, Hassan-2k approved in 2000 have been evolved by NIFA, Peshawar. NIFA's breeders have an advantage to select and evaluate chickpea breeding material on clay soil with high water table. Thus the breeding material developed at NIFA has the capability to resist iron deficiency and responsive to high inputs, which cannot be achieved by developing chickpea breeding material on sandy soil.

The new chickpea variety "NIFA-2005" has large seed size and stiff stem along with high yield potential compared to the earlier varieties developed/evolved by NIFA i.e. NIFA-88 and NIFA-95. NIFA-2005 will replace NIFA-88 and NIFA-95. The proposed chickpea variety will also be the inclusion of new genetic makeup in the existing gene pool available in the form of desi chickpea varieties in the province. This variety is very suitable for D. I. Khan environmental conditions particularly irrigated areas. Development and evolution of the new desi chickpea variety "NIFA-2005" is described herein.

Materials and Methods

The seeds of a local chickpea variety Pb-91 were irradiated at 0.30 KGy doses of gamma rays using ^{60}Co gamma cell and raised M_1 generation at Nuclear Institute for Food and Agriculture (NIFA) during 1994-95. All M_1 plants were harvested individually and planted as plant progeny rows in M_2 population along with parent and standard varieties during 1995-1996. Selections as single plant progeny rows were made in M_2 populations on the basis of more pods and branches per plant, large seed size and good plant type. M_3, M_4, M_5 and M_6 generations of high yielding mutants were raised as line progeny rows along with parent and standard varieties to confirm the desired breeding behaviour of the selected mutants from 1996-2000. Performance of "NIFA-2005" along with standard varieties was evaluated in various replicated yield trials and screened for diseases during 2000-2004. Breeding history of chickpea variety "NIFA-2005" is presented in chronological order in Table 1. All replicated yield trials were conducted using Randomized Complete Block Design (RCBD) with plant-to-plant and row-to-row spacing of 10 and 30 cm, respectively. The row was 4m long and numbers of rows in PYT were 4, and in all other trials, 6 rows per plot per replication. The yield trials data were analyzed according to Steel & Torrie (1980).

Results

Results of the preliminary yield trial conducted at NIFA during 2000-01 and advanced lines yield trial conducted during 2001-02 are presented in Table 2 and 3. CMN-257 produced the highest yield of 3250 kg ha^{-1} as compared to NIFA-88 (Standard check) with a yield of 2604 kg ha^{-1} in preliminary yield trial. In advanced lines yield trial, CMN-257 produced seed yield of 1253 kg ha^{-1} as compared to the two standards check varieties i.e., NIFA-88 and NIFA-95 with yields of 490 kg ha^{-1} and 431 kg ha^{-1}, respectively.

Table 1. Breeding history of the proposed chickpea variety "NIFA-2005" is described in chronological order.

S. No.	Year	F. Gen./ Trial	Remarks
1.	1994-95	M_1	Planted M_1 and harvested all plants individually
2.	1995-96	M_2	Selected single plants for high yield
3.	1996-97	M_3	Confirmation of breeding behavior and single lines selection
4.	1997-2000	M_4-M_6	Generation advancement and confirmation of breeding behavior as line progeny rows
5.	2000-2001	Evaluation in trials	Evaluated CMN-257 in PYT at NIFA and screened for diseases
6.	2001-2002	Evaluation in trials	Evaluated CMN-257 in ALYT and AYT
7.	2002-2003	Evaluation in trials	Evaluated CMN-257 in AYT and NUYT
8.	2003-2004	Evaluation in trials	Evaluated CMN-257 in AYT and NUYT, and screened for diseases

Table 2. Yield performance of CMN-257 in Preliminary yield trial (PYT) conducted during 2000-01 at NIFA, Peshawar.

Entry	Parentage	Yield kg ha^{-1}
CMN-218-2	Mutant derived from K850	2083
CMN-224-4-2	-do-	1854
CMN-227-1	-do-	2896
CMN-220-1	-do-	2021
CMN-213-3	-do-	3011
CMN-204-1	-do-	2604
CMN-228-1	-do-	2573
CMN-239-2	Mutant derived from NEC138-2	2896
CMN-257	**Mutant derived from Pb-91**	**3250**
CMN-251	-do-	2511
NIFA-88	Mutant derived from 6153	2604
SE	-	31.5
LSD 5%	-	210

Table 3. Yield performance of CMN-257 in advanced lines yield trial (ALYT) conducted during 2001-02 at NIFA, Peshawar.

Entry	Parentage	Yield kg ha^{-1}
CMN-210-3	Mutant derived from K850	328
CMN-227-1	-do-	592
CMN-227-2	-do-	414
CMN-213-3	-do-	499
CMN-231-1	Mutant derived from NEC138-2	528
CPSI-19/99	ICARDA-Selection	832
CPSI-21/99	-do-	606
CPSI-22/99	-do-	707
CMN-257	**Mutant derived from Pb-91**	**1253**
NIFA-88	Mutant derived from 6153	490
NIFA-95	-do-	431
SE	-	25.6
LSD 5%	-	145

Table 4. Yield performance and % increase in seed yield of CMN-257 in adaptation yield trial conducted at various locations in NWFP during 2002-03.

Entry	Parentage	Yield Kg ha^{-1}			% Increase
		NIFA	Karak	Ave.	
CMN-727	Mutant derived from C-44	1413	850	1132	4.6
CMN-782-5	-do-	983	783	883	25.6
CMN-730-2	-do-	1480	650	1065	10.0
CMN-561-7	-do-	833	750	792	33.3
CMN-257	**Mutant derived from Pb-91**	**1607**	**767**	**1187**	**-**
Sheenghar-2000	Standard check variety	743	750	747	37.1
NIFA-95	Standard check variety	990	667	829	30.2
SE	-	28.4	38.4	-	-
LSD (5%)	-	130	185	-	-

Table 5. Yield performance and % increase in seed yield of CMN-257 in adaptation yield trial conducted at various locations in NWFP during 2003-04.

Entry	Parentage	Yield Kg ha^{-1}				% Increase
		NIFA	D.I.Khan	Karak	Ave.	
CMN-727	Mutant derived from C-44	2167	2431	868	1822	6.5
CMN-782-5	-do-	2234	1910	683	1609	17.4
CMN-730-2	-do-	2083	2517	880	1827	6.3
CMN-561-7	-do-	2094	1646	1238	1659	14.9
CMN-257	**Mutant derived from Pb-91**	**2380**	**2299**	**1169**	**1949**	-
NIFA-88	Standard check variety	1883	1865	1111	1620	16.9
NIFA-95	Standard check variety	1686	1517	1042	1415	27.4
SE	-	25	38.5	-	-	-
LSD (5%)	-	84	288	-	-	-

CMN-257 produced higher average seed yield of 1187 kg ha^{-1} compared to Sheengahar-2000 (747 kg ha^{-1}) and NIFA-95 (829 kg ha^{-1}) in adaptation yield trial conducted at NIFA, Peshawar and ARS, Karak during 2002-03 (Table 4). The % increase shown by CMN-257 over Sheenghar-2000 and NIFA-95 was 37% and 30%, respectively. Similarly in adaptation yield trial conducted during 2003-04, CMN-257 was the highest yielding genotype with an average yield of 1949 kg ha^{-1} compared to NIFA-88 (1620 kg ha^{-1}) and NIFA-95 (1415 kg ha^{-1}). The % increase in seed yield of CMN-257 over NIFA-88 and NIFA-95 was 16% and 27%, respectively (Table 5).

The results of NUYTs conducted by Pulses Coordinator, Islamabad across different locations throughout the country during 2002-2003 and 2003-04 are presented in Table 6 and 7. Seed yield of CMN-257 was among the high yielding group of entries in both years. CMN-257 produced 1285 kg ha^{-1} and 1482 kg ha^{-1} in NUYTs conducted during 2002-03 and 2003-04, respectively.

Important agronomic, morphological and qualitative characteristics of CMN-257 along with parent and standards are presented in Table 8. CMN-257 showed large seed size, erect, tall and stiff stem plant type, and high harvest index compared to the check varieties NIFA-88 and NIFA–95. CMN-257 showed tolerance to wilt/root rot and chickpea blight (Table 9 and 10).

Table 6. Chickpea National Uniform Yield Trial conducted by Pulses coordinator, Islamabad during 2002-03 showing yield Kg ha^{-1}.

Entry	L1	L2	L3	L4	L5	L6	L7	L8	L9	L10	L11	L12	L13	L14	Av.
99cc-005	2601	2950	2500	1276	1577	286	1467	614	791	731	1161	1076	938	1342	1379
99cc-015	1662	2144	3229	828	1279	452	1555	606	630	1084	1038	1402	913	1431	1304
Aug786	2102	1911	2291	1219	750	432	1848	1030	839	801	1265	2012	787	1489	1341
BRC-4	2695	2050	2265	1078	993	520	1420	1075	768	731	1521	1210	905	1366	1328
CMN-257	**1196**	**2332**	**1926**	**937**	**1080**	**562**	**1405**	**629**	**604**	**2149**	**1321**	**1573**	**905**	**1374**	**1285**
CM-738/93	2235	2333	1614	0	730	104	498	782	596	538	907	768	749	1406	1020
PB2000	2630	2367	2499	1333	1192	312	1817	821	937	1986	1038	1146	799	1797	1477
CM2385	2410	2206	2629	0	590	218	1669	750	1101	411	1038	1030	14	1768	1218
CM1852/96	2185	2550	1250	0	727	88	1260	817	901	634	999	1617	822	1308	1166
KC2135	2386	2683	1302	672	513	304	1091	1069	804	801	1169	1086	1126	1722	1195
NCS9903	2629	2250	1927	1422	1920	395	1053	959	1190	1542	1576	1133	970	1273	1446
NCS9911	2788	2450	2552	1390	1493	666	1525	843	1051	1290	1815	1712	833	1365	1555
NCS9905	2514	2250	2814	1437	1440	419	1309	1048	627	1201	1628	1298	1031	1481	1464
NCS9904	1982	2283	1380	1307	808	434	1567	905	1077	1420	1010	1371	1049	1467	1290
90280	1786	2178	2239	901	1083	333	623	1148	660	1141	918	1113	1031	1652	1200
92280	2495	2067	1640	1375	583	302	1159	869	1150	611	1295	1190	928	1258	1209
96051	2902	2472	2343	1042	1580	330	1270	1297	622	1448	1735	1350	853	1280	1466
96052	2594	2333	3410	1130	1176	463	1735	917	678	2041	1628	1454	950	1408	1566
BC6-5	2035	2133	1953	1250	965	393	1322	867	596	814	888	1120	881	1459	1191
DC1	2329	2067	2265	708	857	421	1672	579	696	598	853	1050	979	1324	1171
BITTAL98	2104	2111	2083	1224	1087	404	1342	1057	830	1045	1254	973	970	1555	1289
CM72 X ILC3279	2638	1917	2604	1318	1208	572	1669	1002	793	1638	2069	1298	963	1602	1521

L1= NARC,Islamabad, L2= AARI, Faisalabad, L3=RARI, Bahawalpur, L4= AZRI, Quetta, L5= NIFA, Peshawar, L6= BARS, Kohat, L7= AZRI, Bahawalpur, L8= AZRI, Bahakar, L9= RRI, Dhokri, Sindh, L10= NIAB, Faisalabad, L11= BARI, Chakwal, L12= UAF, Faisalabad, L13= Kotli, Muzafarabad, L14= GRS, Karak,

Table 7. Chickpea National Uniform Yield Trial conducted by Pulses coordinator during 2003-04 showing yield Kg ha^{-1}.

Entry	L1	L2	L3	L4	L5	L6	L7	L8	L9	L10	L11	L12	L13	L14	Av.
NCS9904	2767	1388	1601	1767	767	1979	1231	1319	972	1396	1283	214	2084	1163	1424
CM72XILC3279	2730	1133	1566	1685	577	2322	884	1923	937	1233	1085	165	2295	851	1385
NCS9911	3048	1055	1545	2074	776	2479	629	1510	798	1159	588	153	2246	1096	1368
C44XE100YM	2718	1416	1472	1792	459	3354	638	1666	833	1179	395	227	2320	1110	1399
CM3821/97	2731	2200	689	2003	294	0	1898	1770	0833	1114	186	0494	1880	0794	1299
CMN257	**2493**	**1575**	**3160**	**1283**	**664**	**2619**	**1731**	**1562**	**937**	**1044**	**475**	**323**	**2286**	**596**	**1482**
CMN2358/96	2278	1996	1361	2100	187	0	1356	1545	1024	1189	493	215	1657	684	1237
96A3148	3227	2308	1013	1614	641	2526	1495	2131	1163	1294	805	381	2263	686	1539
99CC-005	3057	1863	1678	1688	687	1661	1500	1472	885	1243	569	384	2292	995	1427
KC-2140	2041	2221	909	2148	275	0	2166	1631	1128	1312	632	317	1652	779	1324
99CC015	2997	1855	1919	1803	542	1786	1995	1354	1024	1207	1181	233	2321	787	1500
99CC011	2713	1688	1639	1803	589	2197	1162	1690	989	1325	786	437	2335	900	1447
CM1852/96	2645	2146	0687	1807	226	0	1754	1833	1232	1169	122	355	1837	834	1281
90261	2591	1621	3170	1174	1034	2239	1962	1854	833	1424	772	429	2283	783	1584
PB2000	2746	2580	1300	2044	881	2395	1444	1225	1111	1566	1167	205	2341	855	1561
98154	3512	1430	955	1574	324	2890	1458	2006	833	1128	810	181	2306	921	1452
97086	3644	2180	1997	1562	1027	2593	1689	1937	972	1237	1027	398	2305	1044	1687
98004	2880	2191	1428	2161	798	2208	2736	1368	1163	1240	605	174	2237	1045	1588
BITTLE98	3164	1980	1538	1818	666	2526	1990	1319	1145	1184	456	218	2189	945	1510
NCS9903	2760	1050	1666	1814	629	2552	587	1166	642	1207	809	180	2187	1072	1309
NCS9905	2909	858	2328	1681	833	2270	449	1138	763	1172	369	108	2310	1405	1328
Bahawalpur	3009	1933	2287	2137	665	2562	1763	1381	989	1218	210	272	2256	360	1503

L1= NARC,Islamabad, L2= NIAB, Faisalabad, L3= ARI, D.I.Khan, L4= BARI, Chakwal, L5= RRI, Dhokri, Sindh, L6= BARS, Jarma, Kohat, L7= AARI, Faisalabad, L8= RARI, Bahawalpur, L9= Res. Station Kalorkote, L10= AZRI, Bhakkar, L11= ARI, Sariab, Quetta, L12= AZRI, Bahawalpur, L13= NIFA, Peshawar, L14= RSK, Kotli, AJ&K

Table 8. Important agronomic/morphological/qualitative characteristics of CMN-257 as compared to parent (Pb-91) and standards NIFA-88 and NIFA-95. (Average of four years 2000-2004).

Characters	CMN-257	Pb-91	NIFA-88	NIFA-95
Days to flower	117 ± 6	117 ± 7	119 ± 5	117 ± 3
Days to maturity	177 ± 7	175 ± 5	180 ± 8	184 ± 8
Plant height (cm)	81 ± 5	72 ± 6	73 ± 5	71 ± 7
Pods per plant	40 ± 4	37 ± 3	33 ± 3	36 ± 4
Seed per pod	2	2	2	2
Primary branches per plant	5 ± 1	4 ± 1	4 ± 1	4 ± 1
Harvest Index (%)	35.5 ± 3	30.2 ± 4	29.7 ± 4	28.6 ± 3
100 seed weight (g)	24 ± 1	25 ± 1	17 ± 1	17 ± 1
Seed protein (%)	23.8	23.6	23.5	23.7
Seed coat color	Reddish brown	Dark brown	Light brown	Light brown
Anthocyanin pigmentation	Present	Present	Present	Present
Reaction to gram blight	Tolerant	Tolerant	Tolerant	Tolerant
Reaction to wilt	Tolerant	Tolerant	Tolerant	Tolerant

Discussion

The recently evolved desi chickpea variety "NIFA-2005" has been developed through induced mutations (gamma rays). Mutation breeding particularly induced mutation has played an important role in developing many crop varieties in various parts of the world apart from enhancing the desired genetic variability in different traits of plants (Micke, 1988; Haq *et al*., 2003). Two desi chickpea varieties i.e. NIFA-88, NIFA-95, a kabuli chickpea variety Hassan-2k have been developed through induced mutation and evolved for general cultivation in NWFP on the basis of high yield potential (Hassan & Khan, 1991; Hassan *et al*., 1997 and 2001). A chickpea variety CM-98 developed through induced mutation and a mungbean variety NM 98 developed through cross breeding have been evolved on the basis of high yielding for general cultivation in Punjab province (Haq *et al*., 1999; Siddique *et al*., 1999).

NIFA-2005 manifested improvement in the form of increase in seed size, high harvest index along with more vegetative growth and stiff stem as compared to standard varieties NIFA-88 and NIFA-95. Because of the quick and more vegetative growth, NIFA-2005 crop can be utilized for goat and sheep grazing at seedling stage in irrigated areas of D. I. Khan. The more vegetative growth of "NIFA-2005" will ensure more production of green fleshy leaves and stem at pre-flowering stage, which is one of the most popular winter vegetable amongst people living in southern districts of NWFP. The high yielding, large seed size with desired ideotype chickpea mutants suitable for NWFP chickpea growing areas developed through induced mutation have been reported by many researchers (Hassan & Khan, 1991; Javed & Hassan 1995; Khattak *et al*., 2003, 2004). The large seed size and high harvest index in chickpea has also been reported by many researchers as an important seed yield component (Waldia *et al*., 1991, 1996; Mehla *et al*., 2000, Khattak *et al*., 2003, 2004).

Table 9. Reaction of chickpea cultivars to wilt/root rot and blight diseases evaluated at various locations in NUYT during 2003-04.

Cultivars	NARC Islamabad	NIAB FSD	ARI D.I. Khan	BARI Chak.	RRI Sind	BARS Kohat.	AARI FSD	RARI Baha	AZRI Bhak.	NIFA Pesh.	AZRI Baha.	ARI Quetta
NCS9904	R	R	R	R	T	R	S	S	T	R	S	T
CM72XILC3279	R	R	T	R	T	R	S	T	R	R	T	R
NCS9911	R	S	S	R	T	R	S	S	R	R	S	T
C44XE100YM	R	R	T	R	S	R	S	R	R	R	R	R
CM3821/97	R	R	S	R	S	R	S	R	R	R	R	R
CMN-257	**R**	**R**	**R**	**R**	**R**	**R**	**S**	**R**	**R**	**R**	**R**	**T**
CMN2385/96	R	R	S	R	S	R	S	R	R	R	S	T
96A3148	R	R	S	R	S	R	S	R	T	R	S	R
99CC-005	R	S	T	R	R	R	S	R	R	R	R	S
KC2140	R	R	S	T	T	R	S	R	R	R	R	T
99CC-015	R	R	R	R	S	R	R	R	R	R	T	S
99CC-011	R	R	T	R	R	R	T	R	R	R	R	T
CM1852/96	R	R	S	R	T	R	T	R	R	R	T	R
90261	R	R	R	R	S	R	S	R	R	R	R	R
PB-2000	R	R	S	R	S	R	S	T	R	R	T	R
98154	R	R	T	R	T	R	T	R	R	R	R	R
97086	R	R	T	R	R	T	T	R	R	R	T	R
98004	T	R	T	T	R	S	R	R	R	R	S	R
Bittle98	R	R	S	R	S	S	R	R	R	R	S	R
NCS9903	R	R	T	R	T	S	S	T	S	R	S	R
NCS9905	R	R	R	R	S	S	S	S	T	R	S	R
Bahawalpur	R	R	S	R	T	R	R	T	R	R	R	T

Chickpea blight: Chickpea blight was not observed on any entry in desi chickpea NUYT at all locations

Table 10. Reaction of CMN-257 to chickpea wilt and blight as compared to the standards at NIAB, Faisalabad during 2001-02.

Line/Entry	Reaction to wilt	Reaction to blight
CMN-7	Tolerant	Tolerant
CMN-122	Highly susceptible	Tolerant
CMN-561-7	Susceptible	Tolerant
CMN-727	Highly susceptible	Tolerant
CMN-728-5	Highly susceptible	Tolerant
CMN-730-2	Susceptible	Tolerant
CMN-96-29	Resistant	Tolerant
CMN-96-59	Resistant	Tolerant
CMN-96-117	Tolerant	Tolerant
CMN-257	**Tolerant**	**Tolerant**
NIFA-88	Tolerant	Tolerant
NIFA-95	Tolerant	Tolerant

Chickpea wilt/root rot rating score.

Disease severity	Score	Disease reaction
0 % plants infested	1	Highly resistant (HR)
6-10 % plants infested	3	Resistant (R)
21-40 % plants infested	5	Moderately resistant (MR)
61-80 % plants infested	7	Susceptible (S)
100 % plants infested	9	Highly susceptible (HS)

Chickpea blight rating score.

Disease severity	Score	Disease reaction
No lesions/disease visible on any plant	1	Highly resistant (HR)
Lesions visible on less than 10% of the plants, no stem girdling	3	Resistant (R)
Lesions visible on up to 25% of the plants, stem girdling on less than 10% of the plants but little damage	5	Tolerant (T)
Lesions present on most plants, stem girdling on less than 50% of the plants, resulting in the death of a few plants and causing considerable damage	7	Susceptible (S)
Lesions profuse on all plants, stem girdling present on more than 50% of the plants and death of most plants	9	Highly susceptible (HS)

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