Research Article

New high yielding and disease resistant mungbean [*Vigna radiata* (L.) Wilczek] variety “NIFA Mung-19”

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Abstract

Mungbean is an important kharif crop of Pakistan as well as the Khyber Pakhtunkhwa (KP) province. The overall yield of this crop is low and one of the main reasons is the poor genetic background of the existing mungbean varieties in the country. Mungbean varieties adapted to the growing conditions have purple hypocotyls, whereas mungbean varieties with green hypocotyls have an additional potential for sprouts production. In order to replenish the existing pool of mungbean varieties with better ones, a locally adapted mungbean variety “NM 92” and an exotic Mungbean Yellow Mosaic Virus (MYMV) susceptible variety “VC 1560D” were crossed (NM 92 x VC 1560D) in kharif 2004 at Nuclear Institute for Food and Agriculture (NIFA), Peshawar. Single plants selections for more pods plant⁻¹, semi erect growth, purple/green hypocotyls color, resistance to MYMV disease, and confirmation of breeding behavior of these traits were carried-out in F₂ – F₅ generations during 2006-2010. One of the recombinants designated as NFM-5-36-27 was selected on the basis of overall better performance with green hypocotyls color, and further evaluated in disease screening nurseries and various replicated yield trials. NFM-5-36-27 produced seed yield of 530 to 2076 kg ha⁻¹ in replicated yield trials conducted during different years and locations compared with the check variety Ramzan (316 – 1417 kg ha⁻¹) with 38% to 68% increases in seed yield over Ramzan. In Mungbean National Uniform Yield Trial conducted in 2015 and 2017, NFM-5-36-27 produced higher seed yields of 725 and 996 kg ha⁻¹, respectively compared with national checks. NFM-5-36-27 has a future potential for mungbean sprouts production in the country due to its green hypocotyls color. NFM-5-36-27 was recommended as new mungbean commercial variety with the name “NIFA Mung – 19 by the KP Provincial Seed Council in its 38th meeting held on 3rd January, 2018 at Peshawar.

Keywords: disease; high yield; hypocotyls; recombinant; variety; *Vigna radiata*

Introduction

Among kharif season pulses, mungbean (*Vigna radiata* (L.) Wilczek) enjoys a unique position as it is grown on marginal lands of the country with negligible external inputs, therefore other major kharif crops e.g. maize, cotton, rice etc cannot find place in such cropping system because of requirements for

huge quantities of external inputs. Currently, mungbean is grown on an area of 178.7 thousand hectares in Pakistan and 7.5 thousand hectares in KP [1]. The average national yield of mungbean is far below as compared to other neighboring countries. This is mainly because of the limited availability of local mungbean varieties with

high yield potential as well as strong base for disease resistance, which in turn is the result of narrow genetic base of most of the local varieties. As pulses are grown by the farmers with small land-holdings, the only attractive trait of a new commercial variety is the higher grain yield [2, 3], and easy availability of such varieties to the farmers ensures harvesting of benefits from these varieties [4, 5]. New seed varieties ensure yield enhancement as well as higher per unit land production as compared to the traditional crop varieties [6]. It is therefore possible to increase both production and area under mungbean cultivation in the KP and the country as well through development of improved mungbean varieties. In order to fill the gap, agricultural research institutes in the country are taking efforts to develop new high yielding mungbean varieties with major share being contributed by the Punjab Province, and have released few commercial varieties with better yield potential and disease resistance [7]. These varieties perform well under local environmental conditions, whereas their yield performance does not remain stable under KP's growth conditions possibly due to differences in environmental conditions. Nuclear Institute for Food and Agriculture (NIFA), Peshawar realized this need and initiated an organized Research & Development (R&D) work on mungbean, and developed/evolved two high yielding and disease resistant varieties namely "Ramzan" [8] and NIFA Mung - 17 best suited to the environmental conditions of the KP.

Mungbean Yellow Mosaic Virus (MYMV) disease is devastating to overall mungbean production, and the only viable solution is the development of mungbean varieties with inherent potential to withstand this disease with little or no impact on seed yield. MYMV disease resistance is the effect of certain modifying genes [9], and gathering such favorable genes in a single high yielding

genotype guarantees protection of seed yield potential of that particular genotype/cultivar. It further improves overall acceptability and adoptability of such varieties among mungbean growers.

Apart from other uses, mungbean is also valued for sprouts production, and these are an important part of daily diets in many countries e.g. China, Malaysia, Korea etc [10]. Mungbean sprouts are only produced from mungbean plant types having green hypocotyls color. If proper markets for mungbean sprouts are explored in Pakistan, this will positively enhance revenue generated from mungbean crop, and will contribute towards uplifting living standards of farmers of marginal lands in the country. The current manuscript discusses development/evolution of new high yielding mungbean variety "NIFA Mung – 19.

Materials and Methods

An exotic mungbean accession "VC1560D" susceptible to MYMV disease from the Asian Regional Centre – Asian Vegetable Research and Development Centre (ARC – AVRDC), Thailand, and a local MYMV resistant cultivar "NM 92" were used in the current study. These were hybridized as single cross-combination (NM 92 x VC 1560D) following an efficient mungbean crossing technique [11] at the research farm of the Nuclear Institute for Food and Agriculture (NIFA), Peshawar during kharif, 2004. F₁ generation from this cross-combination was planted at NIFA, Peshawar during summer 2005. All recombinant plants were harvested individually and planted as F₂ population along with both parents for comparison during kharif 2006. The MYMV susceptible parent "VC 1560D" was planted as repeated rows through the entire segregating population. Single plants bearing more pods, more productive branches, MYMV resistance, semi-spreading growth habit, and green/purple hypocotyls color were selected. The selected recombinant single plants were

planted as plant-progeny-rows in kharif 2007 and further single plants selections based on the above-mentioned criteria was undertaken. The selected recombinants were further planted in F₄ – F₅ generations for generation advancement and confirmation of breeding behavior and genetic stability of the target traits during kharif 2008 and 2010, and better performing single lines were subsequently selected.

The selected single lines were evaluated for yield potential in various replicated yield trials i.e. Preliminary Yield Trails (PYTs), Advanced Lines Yield Trials (ALYTs) at NIFA, Peshawar and Adaptation Yield Trials (AYTs) at other locations outside NIFA during 2011 – 2017. Based on performance in these trials, the recombinant designated as NFM-5-36-27 was finally selected and tested

for wider adaptability and yield stability across country in Mungbean National Uniform Yield Trial (NUYT) during 2015 and 2017. The experimental material in all replicated trials was laid-out in Randomized Complete Block Design (RCBD) with each plot comprising of 04 rows of 04 meter length. Plant-to-plant and row-to-row distances were maintained at 10 cm and 30, respectively, and each plot was replicated three times. The crop was sown under irrigated conditions and irrigation was applied as and when required. All statistical analyses were performed according to Steel and Torrie, [12]. MYMV disease reaction data was recorded following standard procedure [13]. Breeding history of NIFA Mung – 19 (recombinant NFM-5-36-27) is presented in (Table 1).

Table 1. Breeding history of NIFA Mung-19 (recombinant NFM-5-36-27)

S. No.	Year	F. Generation/Trial	Remarks
1	Kharif 2004	F ₀	A single cross “VC 1560D x NM 92” was attempted between an exotic accession “VC1560D” and a local commercial variety “NM92” at Nuclear Institute for Food and Agriculture (NIFA), Peshawar. All crossed pods were picked.
2	Summer 2005	F ₁	F ₁ generation of the cross “VC 1560D x NM 92” was raised. All hybrid plants were harvested, threshed and bagged individually.
3	Kharif 2006	F ₂	F ₂ populations were raised as plant-progeny-rows from plants harvested from F ₁ generation along with parents. Populations were also screened for MYMV. Selections were made on the basis of both green/purple hypocotyls, more number of pods, resistance to MYMV and semi spreading plant type
4	Kharif 2007	F ₃	Plant populations along with parents were planted as F ₃ generation for confirmation of breeding behavior and generation advancement. Populations were also screened for MYMV. Single plants selections were made for green/purple hypocotyls color, more pods, resistance to MYMV and good plant type, based on visual observations.
5	Kharif 2008-10	F ₄ /F ₅ , and screening against MYMV	Selected plants were planted as plant-progeny-rows in F ₄ generation along with parents for generation advancement and to confirm breeding behavior of the traits. Screening was also carried-out for MYMV behavior. True breeding lines with desired hypocotyls color, more pods, good plant stand and resistance to MYMV were selected to confirm their breeding behavior. The selected lines were advanced

			as line-progeny-rows for seed increase, and confirmation of breeding behavior and MYMV resistance.
6	Kharif 2011-17	Yield Trials and screening against MYMV	<p>The recombinant lines selected for desired hypocotyls color, high yield and MYMV resistance were further evaluated for agronomic traits in replicated preliminary yield trials and also screened for MYMV in a separate nursery at NIFA, Peshawar.</p> <p>The advanced recombinant lines selected from preliminary yield trials on the basis of high yield potential, good plant type and resistance to MYMV were further evaluated in advanced lines and adaptation yield trials. The better performing recombinant line “NFM-5-36-27” with green hypocotyls color was evaluated for Distinctness, Uniformity and Stability (DUS) studies and National Uniform Yield trials.</p>

Results and discussion

Results of yield and yield components for NFM-5-36-27 (NIFA Mung – 19) are shown in (Table 2 to 8). In Preliminary Yield Trials (PYTs) conducted at NIFA, Peshawar during kharif 2011 and 2012, significant and higher seed yields of 1579 and 1892 kg ha⁻¹ were produced by NFM-5-36-27 compared with check variety Ramzan (1314 and 1417 kg ha⁻¹, respectively (Table 2 & 3). NFM-5-36-27 also produced significant and higher seed yields of 2076 and 1906 kg ha⁻¹ against seed yields of 1386 and 1189 kg ha⁻¹ produced by check variety Ramzan in Advanced Lines Yield Trials (ALYTs) conducted at NIFA, Peshawar during Kharif 2014 and 2015, respectively (Table 4 & 5). Similarly, in Adaptation Yield Trials (AYTs) conducted at Agricultural Research Station (ARS), Karak during 2016 and 2017, NFM-5-36-27 out yielded check variety Ramzan and produced significant and higher averaged seed yield of 530 kg ha⁻¹ as compared to averaged seed yield of 316 kg ha⁻¹ produced by the check variety with 68% increase in seed yield over check variety (Table 6). NFM-5-36-27 also produced significant and higher seed yield of 983 kg ha⁻¹ at Arid Zone Research Centre (AZRC), Dera Ismail Khan (D. I. Khan) during kharif 2017, whereas check variety Ramzan produced seed yield of 599 kg ha⁻¹ (Table 7). In Adaptation Yield Trial (AYT) conducted on farmer's field at Kuram during Kharif 2016 and 2017, NFM-5-36-27 produced

significant and higher averaged seed yield of 1855 kg ha⁻¹ compared with check variety Ramzan (averaged seed yield of 1347 kg ha⁻¹) with 38% increase in seed yield over check variety (Table 8). NIFA Mung-19 (code name NIFA MUNG-5) also performed well compared with the national check varieties in National Uniform Yield Trials (NUYT) conducted by the National Pulses Coordinator, National Agricultural Research Centre (NARC), Islamabad in 2015 and 2017. NIFA Mung-19 produced higher averaged seed yield of 725 kg ha⁻¹ compared with AZRI Mung-06 (700 kg ha⁻¹), NM-2011 (634 kg ha⁻¹) and NM-06 (649 kg ha⁻¹) in the NUYT conducted in 2015 (Table 9). Similarly, NIFA Mung-19 (code name NIFA MUNG-5) also produced high averaged seed yield of 996 kg ha⁻¹ compared with averaged seed yield of 975 kg ha⁻¹ and 919 kg ha⁻¹ produced by NM-2011 and AZRI Mung-06, respectively in the NUYT conducted in 2017 (Table 10). High yielding varieties of crop plants help in increasing yield as well as production [14-17] and high grain yield potential is the only trait that is highly regarded by the growers [2, 3]. The high yield potential of NIFA Mung-19 (Table 2 to 8) will help a great deal in alleviating constraints to improve mungbean production in the KP in particular and the country in general. One of the pre-requisite for new crop variety is the new variety must surpass the existing ones in terms of seed yield and other agronomic traits as well

as adaptability across locations. 65% and 38% increase in seed yield by NIFA Mung – 19 over check variety in Adaptation Yield Trials (Table

7 & 8) hints about its high yield potential and wider adaptability in the Province and in the country as well.

Table 2. Performance of NFM-5-36-27 (NIFA Mung-19) in preliminary yield trial conducted during kharif 2011 at NIFA, Peshawar

Entry	Parentage	Days to flowering	Days to maturity	Plant ht. (cm)	1000 seed weight (g)	Yield kg/ha
NFM-5-36-27	VC1560D x NM92	48	69	50	54	1579
NFM-5-36-29	-do-	46	67	46	58	1368
NFM-5-36-30	-do-	43	71	48	53	1212
NFM-5-36-33	-do-	41	71	43	51	710
NFM-5-36-41	-do-	42	71	53	55	1373
NFM-5-36-42	-do-	44	69	62	42	608
NFM-5-36-43	-do-	47	72	56	55	1368
NFM-5-36-45	-do-	44	70	44	53	1458
NFM-5-36-48	-do-	44	69	39	65	1056
NFM-5-36-49	-do-	44	71	39	53	912
NFM-5-36-50	-do-	43	69	46	65	1167
NFM-5-36-51	-do-	42	71	39	51	1370
NFM-5-36-52	-do-	44	74	40	56	1161
NFM-5-36-53	-do-	43	67	44	61	1247
NFM-5-36-55	-do-	45	69	51	64	1689
Ramzan (Check)	VC 1482C x NM 92	44	68	49	52	1314
CV		0.56	0.80	0.73	0.52	24.90
LSD 5%		1.15	1.64	1.49	1.06	50.84

Table 3. Performance of NFM-5-36-27 (NIFA Mung-19) in preliminary yield trial conducted during kharif 2012 at NIFA, Peshawar

Entry	Parentage	Days to flowering	Days to maturity	Plant ht. (cm)	1000 seed wt. (g)	Yield kg/ha
NFM-5-36-27	VC1560D x NM92	44	73	71	53	1892
NFM-5-36-29	-do-	41	74	78	50	1403
NFM-5-36-30	-do-	43	76	68	51	1597
NFM-5-36-33	-do-	41	74	68	47	1444
NFM-5-36-41	-do-	38	74	67	51	1448
NFM-5-36-42	-do-	43	74	63	46	1340
NFM-5-36-43	-do-	42	74	68	54	1472
NFM-5-36-45	-do-	40	74	75	48	1306
NFM-5-36-48	-do-	40	74	71	58	1747
NFM-5-36-49	-do-	40	74	78	50	1604
NFM-5-36-50	-do-	43	75	65	60	1896
NFM-5-36-51	-do-	40	75	71	50	1556
NFM-5-36-52	-do-	39	76	75	54	1663
NFM-5-36-53	-do-	42	74	74	56	1590
NFM-5-36-55	-do-	42	76	68	59	1684
Ramzan (Check)	VC 1482C x NM 92	39	74	69	50	1417
CV		1.33	0.88	3.02	0.22	69.91
LSD 5% level		3.85	2.55	8.73	0.32	201.90

Table 4. Performance of NFM-5-36-27 (NIFA Mung-19) in advanced lines yield trial conducted during kharif 2014 at NIFA, Peshawar

Entry	Parentage	Days to flowering	Days to maturity	Plant ht. (cm)	1000 seed wt. (g)	Yield kg/ha
NFM-5-36-27	VC1560D x NM92	33	94	90	51	2076
NFM-5-36-29	-do-	32	93	77	52	2069
NFM-5-36-30	-do-	32	92	87	45	2115
NFM-5-36-33	-do-	33	94	77	46	1795
NFM-5-36-41	-do-	35	94	84	48	1823
NFM-5-36-42	-do-	36	94	94	45	1215
NFM-5-36-43	-do-	36	93	88	44	997
NFM-5-36-45	-do-	36	92	97	54	2021
NFM-5-36-48	-do-	36	92	88	54	1976
NFM-5-36-49	-do-	37	92	88	50	2056
NFM-5-36-50	-do-	37	91	90	51	1750
NFM-5-36-51	-do-	37	91	90	44	1813
NFM-5-36-52	-do-	37	92	85	51	1403
NFM-5-36-53	-do-	37	92	66	53	2063
NFM-5-36-55	-do-	37	91	78	52	2236
Ramzan (Check)	VC 1482C x NM 92	37	90	66	48	1396
CV		2.3	2.7	2.1	1.4	13.2
LSD 5% level		3.5	3.5	5.3	2.1	187

Table 5. Performance of NFM-5-36-27 (NIFA Mung-19) in advanced lines yield trial conducted during kharif 2015 at NIFA, Peshawar

Entry	Parentage	Days to flowering	Days to maturity	Plant ht. (cm)	1000 seed wt. (g)	Yield kg/ha
NFM-5-36-1	VC 1560D x NM 92	46	84	89	46	1902
NFM-5-36-2	-do-	50	91	93	50	1523
NFM-5-36-4	-do-	47	87	91	51	1475
NFM-5-36-11	-do-	49	91	92	55	1549
NFM-5-36-24	-do-	46	82	92	53	1731
NFM-5-36-27	-do-	48	89	84	53	1906
NFM-5-63-8	VC1482C x NM92	52	90	89	48	1277
NFM-5-63-10	-do-	48	91	90	56	1115
NFM-5-63-14	-do-	50	90	90	49	1322
NFM-5-63-30	-do-	44	76	90	53	1718
NFM-5-63-35	-do-	47	91	92	53	1342
NFM-5-63-43	-do-	47	91	92	57	1316
NFM-5-63-48	-do-	44	78	90	55	1539
NFM-5-63-49	-do-	46	91	89	50	1536
NFM-5-63-51	-do-	45	81	90	46	1789
Ramzan (Check)	VC 1482C x NM 92	49	85	79	51	1189
CV		2.3	2.4	4.5	2.6	6.1
LSD 5% level		3.5	5.4	4.9	4.3	155

Table 6. Performance of NFM-5-36-27 (NIFA Mung-19) in mungbean adaptation yield trials planted at ARS, Karak during 2016 and 2017

Entry	Parentage	Days to flowering	Days to maturity	Plant ht. (cm)	Yield (kg ha ⁻¹)			% increase in seed yield over check
					2016	2017	Average	
NFM-8-22	NM93 x NM92	53	74	45	577	257	417	32
NFM-5-36-1	VC1560D x NM92	52	74	37	687	194	441	40
NFM-5-36-27	VC1560D x NM92	54	74	41	726	333	530	68
NFM-5-63-30	VC1482C x NM92	53	71	40	549	298	424	35
NFM-5-91-26	NM98 x VC3902A	54	71	39	543	201	372	18
Ramzan (Check)	VC 1482C x NM 92	54	70	37	445	187	316	-
CV		1.04	0.81	1.32	2.19	2.29		
LSD (5%)		0.94	1.0	1.23	20.1	15.35		

Table 7. Performance of NFM-5-36-27 (NIFA Mung-19) in mungbean adaptation yield trial planted at AZRC, D.I. Khan during 2017

Entry	Parentage	Days to flowering	Days to maturity	Plant ht. (cm)	Yield Kg ha ⁻¹	% increase in seed yield over check
NFM-8-22	NM93 x NM92	47	83	46	626	5
NFM-5-36-1	VC1560D x NM92	46	81	36	765	28
NFM-5-36-27	VC1560D x NM92	46	82	46	983	65
NFM-5-63-30	VC1482C x NM92	47	83	40	400	-
NFM-5-91-26	NM98 x VC3902A	46	83	40	460	-
Ramzan (Check)	VC 1482C x NM 92	49	83	45	599	-
CV		0.68	2.06	3.91	7.67	
LSD (5%)		0.57	4.53	2.81	90.12	

Table 8. Performance of NFM-5-36-27(NIFA Mung-19) in mungbean adaptation yield trials planted on farmer's field at Kuram Agency during 2016 & 2017

Entry	Parentage	Days to maturity	Plant ht. (cm)	Yield Kg ha ⁻¹			% increase in seed yield over check
				2016	2017	Ave.	
NFM-5-36-1	VC 1560D x NM 92	75	66	1070	2213	1642	22
NFM-5-36-27	VC 1560D x NM 92	78	78	1175	2534	1855	38
NFM-5-91-26	NM98 x VC 3902A	78	73	950	2171	1561	16
Ramzan (Check)	VC 1482C x NM 92	71	65	812	1882	1347	-

Table 9. Mungbean national uniform yield trial conducted by pulses coordinator during Kharif 2015

Entry Name	Locations (Yield Kg ha ⁻¹)											Average
	1	2	3	4	5	6	7	8	9	10	11	
07006	817	504	244	111	674	117	490	1615	1493	819	709	690
07008	740	479	135	73	465	113	420	1177	1436	646	819	591
NIFA MUNG-4	463	551	106	52	874	114	451	1625	2158	764	715	716
NIFA MUNG-5	1072	403	176	42	628	121	309	1792	2368	417	653	725
NM-14	729	775	106	63	425	135	351	1854	2166	694	590	717
NM-16	888	428	147	167	683	140	868	2146	1711	1076	875	830
NM-17	963	443	154	45	487	154	483	1500	1788	903	854	707
NM-18	1272	590	97	97	1090	125	344	1885	1566	882	431	762
NM-19	620	628	138	111	822	119	476	1771	2173	833	764	769
BRM-356	628	506	150	31	561	131	510	1240	1719	938	542	632
09-TM-11	1079	389	160	125	860	119	580	1854	1608	799	681	750
12-TM-03	644	292	197	87	697	121	573	1563	2166	674	667	698
AZ-MH-1	719	551	163	153	677	129	455	1594	1482	799	653	670
AZ-MH-4	597	418	114	69	578	114	601	2354	1310	708	834	700
AZ-MY-6	540	411	110	94	520	114	514	1646	1501	924	577	632
NCM-257-10	782	107	129	56	217	108	462	1031	1161	521	611	471
NCM-252-10	831	185	214	56	304	104	684	1031	1207	451	514	507
AZRI Mung-06	749	510	76	118	591	104	493	1771	1726	729	833	700
NM-2011	606	469	113	31	580	119	715	1479	1413	660	785	634
NM-06	655	440	231	90	795	150	476	1802	1482	382	632	649

Locations

Location code	Location	Location code	Location
1	NARC, Islamabad	7	BARS, Fateh Jang
2	AARI, Faisalabad	8	NIAB, Faisalabad
3	ARI, Mingora, Swat	9	NIFA, Peshawar
4	ARI, Karak	10	RARI, Bahawalpur
5	AZRC, D.I.Khan	11	BARI, Chakwal
6	AZRI, Bhakkar		

Table 10. Mungbean national uniform yield trial conducted by pulses coordinator during Kharif 2017

S.No	Entry Name	Locations (Yield Kg ha ⁻¹)										Average
		1	2	3	4	5	6	7	8	9	10	
1	NIFA Mung-4	1106	917	990	1314	1128	535	587	1265	1545	801	1019
2	NIFA MUNG-5	928	681	783	735	1510	490	845	1138	2038	809	996
3	TM-1418	1169	1104	783	832	1424	479	573	1508	1674	724	1027
4	TM-1426	1044	1083	897	1157	1078	465	741	1643	1667	749	1052
5	13-TM-04	1284	1271	937	1094	1421	462	962	1252	1587	785	1106
6	13-TM-14	1306	1021	1052	900	1213	431	826	1494	1833	850	1093
7	GV-1	1029	955	810	799	1778	420	843	1355	1531	808	1033
8	MH 3153	974	1049	1100	958	1108	406	886	1182	1670	742	1008
9	MMH 34143	854	1153	879	865	1178	403	513	1138	1170	791	894
10	120009	1032	1198	849	1158	2275	396	729	1168	1222	742	1077
11	14002	1060	708	828	906	1185	385	515	1106	1948	699	934
12	MSPS119	672	833	735	807	1581	361	1353	1348	973	701	936
13	NCM-11-2	709	1063	744	897	1303	351	1069	1037	1191	752	912
14	NCM-11-8	307	944	660	892	1006	337	602	471	774	772	677
15	NM-2011	1041	847	982	976	1136	219	983	1369	1413	783	975
16	AZRI Mung-06	853	646	869	978	1161	200	928	1172	1642	742	919

Locations

Location code	Location	Location code	Location
1	AARI, Faisalabad	6	BARS, Fateh Jang
2	ARI, Tando Jam	7	NARC, Islamabad
3	AZRI, Bhakkar	8	NIAB, Faisalabad
4	AZRI, D.I Khan	9	NIFA, Peshawar
5	AZRI, Umer Kot	10	ARI, Mingora, Swat

In (Table 11) shows Mungbean Yellow Mosaic Virus (MYMV) disease reaction analyses of NFM-5-36-27 (NIFA Mung – 19) along with both parents and standards conducted at NIFA, Peshawar during kharif 2008, 2009 and 2011. Results revealed that NFM-5-36-27 showed resistance to the MYMV disease as compared to one of the parents i.e. VC 1560D which was highly susceptible to MYMV disease with 97.2% infection. This shows that NIFA Mung – 19 possessed more number of favorable modifying genes conferring resistance against MYMV disease as it has been proved

that MYMV resistance is the accumulation of such type of genes in a genotype [9]. Furthermore, disease resistance in newly developed crop varieties controls yield losses [18-21], and a new crop variety should surpass the susceptible ones in terms of agronomic performance. The inherent potential of NIFA Mung – 19 for resistance against MYMV disease coupled with high seed yield potential will positively contribute its due share in alleviating mungbean production constraints in KP as well as the country.

Table 11. Reaction of NFM-5-36-27 (NIFA Mung-19) to MYMV as compared to parents and standards during Kharif 2008, 2009 and 2011

Entry	Mungbean Yellow Mosaic Virus Disease Rating								
	At NIFA, Peshawar-2008			At NIFA, Peshawar-2009			At NIFA, Peshawar-2011		
	% Infection	Score	Rating	% Infection	Score	Rating	% Infection	Score	Rating
NFM-8-22	7.4	2	R	7.1	2	R	7.6	2	R
NFM-5-36-1	6.9	2	R	7.9	2	R	7.4	2	R
NFM-5-36-27	7.1	2	R	7.5	2	R	7.7	2	R
NFM-5-63-30	4.1	1	HR	4.7	1	HR	4.1	1	HR
NFM-5-91-26	4.4	1	HR	4.4	1	HR	4.4	1	HR
NM 92 (Local parent)	4.2	1	HR	4.7	1	HR	3.9	1	HR
VC 1560D (Exotic parent)	95.8	8	HS	97.6	8	HS	97.2	8	HS
Ramzan (Check)	7.4	2	R	7.1	2	R	7.3	2	R

MYMV disease score

Plant parts infected/disease (%)	Score	Disease reaction
No infection	0	Immune (I)
1-5	1	Highly resistant (HR)
6-10	2	Resistant (R)
11-20	3	Moderately resistant (MR)
21-30	4	Tolerant (T)
31-40	5	Moderately tolerant (MT)
41-50	6	Moderately susceptible (MS)
51-80	7	Susceptible (S)
81-100	8	Highly susceptible (HS)

NIFA Mung – 19 has an additional future potential for mungbean sprouts production due to its green hypocotyls color which is a pre-requisite for mungbean sprouts

production, whereas mungbean varieties adapted to existing growing conditions in Pakistan have purple hypocotyls color. Mungbean sprouts are important part of daily

diets in many countries e.g. China, Vietnam, Malaysia, Korea, Indonesia etc. [10]. NIFA Mung – 19 has therefore future potential for additional income to the Pakistani growers if proper markets are explored for sprouts consumption in the country.

Conclusion

NIFA Mung – 19 out-yielded local check variety in all replicated yield trials conducted at NIFA, Peshawar as well as at other locations of the KP, while it produced higher seed yield as compared to the national check varieties in the NUYTs conducted across country for two years. Based on high yield potential, green hypocotyls, disease resistance and different genetic background, KP Provincial Seed Council approved NIFA Mung – 19 as a new mungbean commercial variety for mungbean growing areas of the KP in its 38th meeting held at Agricultural Research Institute (ARI), Peshawar – KP.

Authors' contributions

Conceived and designed the experiments: GSS Khattak & I Saeed, Performed the experiments: I Saeed & M Ibrar, Analyzed the data: I Saeed & M Ibrar, Contributed materials/ analysis/ tools: GSS Khattak & I Saeed, Wrote the paper: GSS Khattak & I Saeed.

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