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New high yielding mungbean [(*Vigna radiata* (L.) Wilczek] variety "AZRI. Mung-2018" for the Agro-climatic conditions of Thal, Region, Pakistan

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Abstract

AZRI Mung-2018 (12TM03) was developed through cross between Line No.1 (PRI line Vigna cross, small seeded, tall statured, heat tolerant and susceptible to Mungbean Yellow Mosac Virus (MYMV) and NM-96, bold seeded, high yielder and short statured line of NIAB Faisalabad. AZRI Mung-2018 was tested in a series of experiments for production technology and yield performance at Arid Zone Research Institute, Bhakkar and farmers' field in Thal area. Seed rate of30kg ha^{-1} coupled with $N:P_2O_5$ dose @ 22:57kg ha^{-1} gave maximum yield when planted in 30cm apart row. AZRI Mung-2018 out yielded among all candidate lines included in National Uniform Yield Trial (NUYT)-2015 and 2016 with an average yield of 1025kg ha^{-1} at 10 locations across the country, with highest grain yield of 2166kg ha^{-1} at NIFA Peshawar during 2015, AZRI Mung-2018 outclassed among 16 candidate lines across the country and stood on top on victory stand. Punjab Seed Council approved 12TM03 as "AZRI Mung-2018" for general cultivation in Punjab. AZRI Mung-2018 has 13 to 21% higher grain yield potential compared to the standard variety AZRI Mung-2006 and NIAB Mung-2011showed resistance to Bacterial leaf spot, Cercospora leaf spot, MYMV and heat stress tolerant with profused hairiness on plant parts.

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Introduction

Mungbean [*Vigna radiata* (L.) Wilczek], is an indigenous vegetable legume and one of the most important pulse crops in Pakistan. Being rich in digestible protein (24%), it is utilized in the cereal-based diets (Khattak *et al*., 2003). It contains vitamin A (94mg), iron (7.3mg), zinc (3mg), calcium (124mg) and folate (549mg) per 100g dry seed weight. Usually it is used in split form "Dhal" and in other different food products (Rasul *et al*., 2012). Mungbean, being leguminous crop fixes nitrogen thereby improving soil fertility and requires comparatively less irrigations than the other field crops (Khan *et al*., 2008).

Mungbean introduction in cereal cropping system can improve net returns, improving soil fertility, saving irrigations and can enhance sustainability of agriculture (Hussain *et al*., 2012). Mungbean cultivars being cultivated in Pakistan are vulnerable to high temperatures with indeterminate growth habit (Jahan and Golam, 2012), susceptible to YMV and insects (Khattak *et al*., 2006; Rehman *et al*., 2009). Moreover, Pakistan has been facing short fall of pulses by 12% and pulse import bill is about 10669 million rupees. It is therefore imperative to develop a high yielding, heat and disease tolerant Mungbean variety with inbuilt resistance against YMV and insects due to more hair density on plant parts. This new variety due to its higher yield potential (2500kg ha^{-1}), medium maturity and be adjusted in any cropping system with better adaptability to local environments and its medium shiny seeds enhanced its market value (Aslam *et al*., 2010). Arid Zone Research Institute, Bhakkar released 'AZRI Mung-2018' a variety developed from cross between Line No.1 x NM-96, that gives better yield (2.5t ha^{-1}). The variety has been recommended for cultivation in Punjab.

Materials and methods

Agro-Ecological Conditions

Arid Zone Research Institute, Bhakkar is situated in the Punjab Province, of Pakistan and lies in between 31° .37/ N latitude and 71°. 02/ East longitude. The sandy loam soils deficient in organic matter, nitrogen and phosphorus with marginal potassium. The summers are very harsh due to arid-semiarid climate pattern with scanty and uncertain rains during monsoon season. The experimental site is located 166m above sea level. The mean maximum and mean minimum temperatures during summer and winter are 45°C and 8°C, respectively. The precipitation ranges from 150-250mm annually and relative humidity of the area varies from 51% in June to 78% in October. The meteorological data depicts the detailed picture of the Thal region is given in Table 1.

Table 1. Meteorological Data.

Month	2015				2016			
	Temperature (°C)		Relative Humidity	Rainfall (mm)	Temperature (°C)		Relative Humidity	Rainfall (mm)
	Max	Min	0800 Hrs.		Max	Min	0800 Hrs.	
April	35.5	19.5	74.4	44	35.5	19.1	61.4	15
May	42.1	23.9	55.9	22	42.9	24.7	54.8	21
June	41.7	26.8	70.1	16	44.1	28.8	58.7	19
July	40.1	28.2	83.2	73	40.0	27.8	79.9	66
Aug.	38.9	27.4	86.9	95	38.1	26.9	84.7	101
Sept.	39.0	25.2	79.5	3	38.5	26.1	81.2	35
Oct.	35.0	19.6	81.4	61	36.6	19.5	77.9	0

Source: *Arid Zone Research Institute Bhakkar, Punjab, Pakistan*

Breeding Material and Process

PRI genotype Line No. 1 having high yield potential with small seed size, tolerant to heat stress was crossed with NM-96 (NIAB strain.) bold seeded susceptible to high temperature, during kharif2004. F_1 generation of the cross was planted during summer (May-July) 2005 and the recombinants were harvested individually. F_2-F_5 generations were raised as plant to row progenies for selecting high yielding recombinants having resistance to MYMV and heat tolerance during kharif 2005 to 2011. Kabuli Mung, a highly susceptible MYMV line was used as spreader and planted after each five rows to intensify MYMV disease. MYMV disease rating (0-9) was done as per method used by Sadiq *et al*., 2006. Candidate line was also tested against high temperature in comparison with AZRI Mung 2006 and NM-2011 and pod filling/grain formation was used as criteria to assess heat tolerance. After getting enough seed of line was tested in station trials (Preliminary Yield Trial-PYT, Regular Yield Trial-RYT and Micro Yield Trial-MYT at institute and out stations to check its performance in comparison with standard check varieties using Randomized Complete Block Design (RCBD) with plant - plant (10cm), row - row spacing (30cm), number of rows (4) and row length (5m) (Ahmad *et al*., 2004). The trials data were analyzed according to Steel *et al*., 1997.

Results and discussions

AZRI Mung-2018 (12TM03) was tested in Preliminary Yield Trial -PYT, Regular Yield Trial - RYT (Table 2), Micro Yield Trial –MYT (Table 3).

Among 15 lines evaluated in PYT during 2012, AZRI Mung-2018 (12TM03) yielded higher (993kg ha^{-1}) against standard AZRI Mung-2006 (814kg ha^{-1}). In RYT, AZRI Mung-2018 (12 TM 03) out yielded all other lines including check with grain yield of 735kg ha^{-1} as evident in Table 2. The candidate line 12TM03 (AZRI Mung-2018) gave a yield edge of 18, 23 and 26% over standard checks, NM-2006, AZRI Mung-2006 and NM-2011, respectively.

Table 2. Yield performance of AZRI MUNG 2018 in Preliminary and Regular yield trials.

SN	Year	Name of Trial	Yield (kg/ha)				
			AZRI MUNG 2018	AZRI MUNG 2006	NM-2006	NM-2011	LSD$_{(0.05)}$
1	2012	Preliminary yield trial	993	814	733	-	99
2	2013	Regular yield trial	735	592	-	682	132
Mean			864	703	733	682	
% increase over check				23	18	26	

AZRI Mung-2018 again gave the highest yield of 1173kg ha^{-1} against 922kg ha^{-1} in case of NM-2011 resultantly, 23% and 27% higher yield than standard check varieties AZRI-Mung-2006 and NM-2011, respectively (Table 3).

Table 3. Yield performance of AZRI MUNG 2018 in Micro Yield Trials.

SN	Location	Yield (kg/ha)			Tukey's value (0.05)
		AZRI MUNG 2018	AZRI-M-2006	NM-2011	
1	ARS Karor	1010	915	890	85
2	AZRI Bhakkar	1245	1027	960	183
3	GBRSS Kallurkot	1264	925	916	186
Mean		1173	956	922	
% increase over check			23	27	

In NUYT during 2015, candidate variety AZRI Mung-2018 was tested at eleven locations across the country and gave 8 and 10% higher yield as compared the standards NM-2006 and NM-92, respectively (Table 4). Similarly in NYUT-2016, candidate variety was tested at eight locations and gave 13 and 21%more yield over checks AZRI Mung-2006 and NM-2011, respectively (Table 5).

Table 4. Mung National Uniform Yield Trial 2015 across the country.

Entry No.	Entry Name	Locations*											
		1	2	3	4	5	6	7	8	9	10	11	Mean
1	07006	817	504	244	111	674	117	490	1615	1493	819	709	690
2	07008	740	479	135	73	465	113	420	1177	1436	646	819	591
3	NIFA Mung-4	463	551	106	52	874	114	451	1625	2158	764	715	716
4	NIFA Mung-5	1072	403	176	42	628	121	309	1792	2368	417	653	725
5	NM-14	729	775	106	63	425	135	351	1854	2166	694	590	717
6	NM-16	888	428	147	167	683	140	868	2146	1711	1076	875	830
7	NM-17	963	443	154	45	487	154	483	1500	1788	903	854	707
8	NM-18	1272	590	97	97	1090	125	344	1885	1566	882	431	762
9	NM-19	620	628	138	111	822	119	476	1771	2173	833	764	769
10	BRM-355	628	506	150	31	561	131	510	1240	1719	938	542	632
11	09-TM-11	1079	389	160	125	860	119	580	1854	1608	799	681	750
12	12-TM-03	644	292	197	87	697	121	573	1563	2166	674	667	698
13	AZ-MH-1	719	551	163	153	677	129	455	1594	1482	799	653	670
14	AZ-MH-4	597	418	114	69	578	114	601	2354	1310	708	834	700
15	AZ-MY-6	540	411	110	94	520	114	514	1646	1501	924	577	632
16	NCM-257-10	782	107	129	56	217	108	462	1031	1161	521	611	471
17	NCM-252-10	831	185	214	56	304	104	684	1031	1207	451	514	507
18	AZRI Mung-06	749	510	76	118	591	104	493	1771	1726	729	833	700
19	NM-2011	606	469	113	31	580	119	715	1479	1413	660	785	634
20	NM-06	655	440	231	90	795	150	476	1802	1482	382	632	649
Location Means		770	454	148	84	626	123	513	1636	1682	731	687	

Coefficient of variation=21.43% Location (L) and G x L interactions are highly significant (P<0.01)

***Locations:**

1= NARC, Islamabad 2= AARI, Faisalabad 3= ARI, Mingora, Swat 4= ARI, Karak 5= AZRC, D.I Khan 6= AZRI, Bhakkar 7= BARS, Fateh Jang

8= NIAB, Faisalabad 9= NIFA, Peshawar 10= RARI, Bahawalpur 11= BARI, Chakwal

Table 5. Mung National Uniform Yield Trial 2016 across the country.

Yield (kg/ha)

Entry No	Entry Name	Locations*								Mean
		1	2	3	4	5	6	7	8	
1	NIFA Mung-4	733	1037	604	691	336	1764	240	1518	865
2	NIFA Mung-4	921	963	574	888	316	1967	206	852	836
3	09-TM-11	1174	1082	563	1452	631	1795	182	1222	1013
4	12-TM-03	1711	921	556	1720	650	1768	131	741	1025
5	13-TM-04	1400	1338	541	1136	364	1780	114	1222	987
6	13-TM-14	1429	948	519	763	437	1734	244	1296	921
7	NM-16	1140	1084	511	941	721	1753	181	1481	977
8	NM-19	1476	1055	504	1227	396	1879	196	852	948
9	NM-18	792	898	504	1081	345	1161	147	1111	755
10	07008	351	790	500	532	582	951	163	889	595
11	BRM-353	948	976	489	624	447	1050	181	1037	719
12	BRM-357	372	1154	359	769	414	890	194	1407	695
13	NCM-257-10	541	938	344	688	433	1111	151	963	646
14	NCM-252-10	790	897	330	656	435	1131	164	1074	685
15	NM-2011	986	998	307	1227	385	1417	272	1185	847
16	AZRI Mung-06	1808	829	304	1171	589	1337	196	1037	909
Location means		1036	994	469	973	468	1468	185	1118	

Coefficient of variation=14.80% Location (L) and G x L interactions are highly significant (P<0.01)

***Locations:**

1= NIAB, Faisalabad 2= AZRI, Umer Kot 3= BARS, Fateh Jang 4= AZRI, Bhakkar

5= NARC, Islamabad 6= NIFA, Peshawar7= AARI, Faisalabad 8= RARI, Bahawalpur

Summarized results reflect that AZRI Mung-2018 surpassed by 16 and 29% when compared with checks AZRI Mung 2006 and NM-2011, respectively (Table 6). The candidate variety AZRI Mung-2018 was tested against major diseases like Bacterial leaf spot, Anthracnose, Cercospora leaf spot, Mungbean yellow mosaic virus and Urdbean leaf crinkle virus (Table 7), and it proved resistant to most prevalent pulses diseases in the country like Mungbean yellow mosaic virus, bacterial leaf spot, with fair tolerance against Urdbean leaf crinkle virus.

Table 6. Over all grain Yield performance of AZRI MUNG 2018.

SN	Name of Trial	Year	No. of trials	Average Yield (kg/ha)		
				AZRI MUNG 2018	AZRI MUNG - 06	NM-11
1	Station yield trials	2012-14	3	994	802	785
2	Adaptation yield trial ARS Karor	2013	1	1010	915	890
3	Adaptation yield trial GBRSS K.Kot.	2015	1	1264	925	916
4	Adaptation yield trial AZRI Bhakkar	2014	2	1245	1027	960
5	Mungbean national uniform yield trial	2015	11	698	649	634
6	Mungbean national uniform yield trial	2016	8	1025	909	247
Average		-		1039	871	739
% increase over check		-			16	29

Table 7. Disease rating of AZRI Mung-2018 in NUYT- 2015 and NUYT-2016.

SN	Disease	Genotype	Disease rating
1	Bacterial leaf spot	AZRI MUNG-2018	2
		NM-2011	3
		AZRI MUNG-2006	3
2	Anthracnose	AZRI MUNG-2018	1
		NM-2011	1
		AZRI MUNG-2006	1
3	Cercospora leaf spot	AZRI MUNG-2018	1
		NM-2011	2
		AZRI MUNG-2006	2
4	Mungbean yellow mosaic virus	AZRI MUNG-2018	1
		NM-2011	3
		AZRI MUNG-2006	1
5	Urdbean leaf crinkle virus	AZRI MUNG-2018	1
		NM-2011	2
		AZRI MUNG-2006	2

Four experiments designed to investigate the weed management practices to increase the productivity of AZRI Mung-2018 showed Stomp 330 EC as pre-emergence and Lactofen 24EC as post emergence weedicide can help eradicate weeds successfully when used in integration with hand weeding and ultimately the increased crop yield. Sowing dates results (Table 8) revealed that its sowing in first week of March during spring and third week of May during Kharif crop were the optimum period to get maximum yield. It may be due to the fact that it has increased net return compared to other planting dates, by boosting grain yield and its associated components (maximum number of pods plant^{-1}, 1000-grain weight and number of grain pod^{-1}).

Whereas according to Sadiq *et al.*, (2006) the best planting time for Mungbean was last week of May. Mungbean growers can get maximum return if cv. AZRI Mung-2018 is sown during spring and planting is completed in the 1st week of March for seed purposes. Moreover, the farmers may also be able to plant second crop on the same field in early June which may not only enhance their income but it will also improve soil fertility due to its N fixing ability. Rehman *et al.*, (2009) also concluded same results for M-1 (Mungbean cv.) for Peshawar valley but with different dates of planting, this variation may be due to varieties sown in diversified agro-ecological situations.

Table 8. Response of AZRI MUNG 2018 to different sowing dates.

Yield (kg/ha)

Variety	Year	D1 15th Apr.	D2 25th Apr.	D3 5th May	D4 15th May	D5 25th May	D6 5th June	D7 15th June	D8 25th June
AZRI Mung-18	2014	617	715	891	779	1021	1101	791	329
NM-2011		592	695	670	767	915	830	594	319
AZRI Mung-18	2015	720	750	785	750	1120	1090	760	345
NM-2011		670	713	745	719	1060	966	589	317

Seed Rate Studies

Seed rate trial was conducted at Arid Zone Research Institute, Bhakkar during the year 2015 & 2016. Grain yield data given in Table 9.

The candidate variety AZRI MUNG-2018 exhibited higher yield at seed rate of 30kg/ha in both the years study as depicted in table 10.

It is depicted from the study that row spacing of 30 and 45cm proved best while fertilizer dose of 22: 57 NPkg/ha gave maximum yield (Table 10).

Table 9. Response of AZRI MUNG 2018 to different seeding rates.

Yield (kg/ha)

SN	Seed rates (kg/ha)	2015	2016
1	40	725	537
2	35	1150	845
3	30	1435	979
4	25	1205	890
5	20	1165	715

Table 10. Fertilizer requirements and planting geometry studies.

NP Levels (kg/ha)		Yield (kg/ha)		
		Row spacing (cm)		
N	P	30	45	60
0	0	423	419	267
14	23	600	620	563
22	57	941	940	835
28	46	755	768	728
42	69	275	542	398
LSD $_{(0.05)}$= 162 CV= 15.9				

The research findings regarding Rhizobium strain for effective nodulation and phosphatic fertilizer doses revealed rhizobium strains, Vm M1 more effective by increasing number of effective nodules (Ahmed *et al.*, 2006). Vice versa results were observed in case of inoculated plots. Among nitrogen and phosphatic fertilizer doses 22:57 N:P_2O_5kg ha^{-1} proved economical than 20:70 N:P_2O_5kg ha^{-1} in terms of net return. Similar results were reported by Achakzai *et al.*, 2012. The investigations carried out for proper seed rate to achieve optimum plant population per unit area". It showed seed rate of 30kg ha^{-1} sown 30cm apart rows gave the maximum yield due to healthy plant density of Cv. AZRI Mung-2018 (Ahmad *et al.*, 2004). Production technology package evolved through conduct of different trials on planting time, planting density and inoculums + fertilizer is given in Table 11.

Table 11. Production technology for AZRI Mung-2018.

Soil	Sandy Loam
Sowing Time	Spring: 1st March to 7th March Kharif: 15st May to 5th June
Fertilizer	22:57 NPkg ha^{-1}
Row spacing	30cm
Inoculum	VmM1 @ 1.25kg^{-1}
Weed control	Manual or Pre-emergence or Post-emergence
Harvesting	Manual/Combine harvester after spray of defoliant
Threshing	Mechanical thresher

This newly evolved variety "AZRI Mung-2018" performed very well throughout Pakistan as depicted in National Uniform Yield Trials 2015 and 2016. Having medium seed size, less plant height, stiff stem, profuse hairiness on all plant parts and short duration as compared to standard varieties being grown in the country. Besides general preference of farmers, seed size is the main contributing factor towards grain yield (Khattak *et al.*, 2003) in mungbean because it fetches higher

price compared to small seeded varieties (Ali *et al*., 1997). High harvest index% of "AZRI Mung-2018" proves to its superior physiological efficiency in partitioning the photosynthesis for grain formation leading thereby to distinct increase in the grain yield. Being short statured and stiff stem of AZRI Mung-2018 is lodging resistant. Despite resistant to MYMV, these two distinct attributes of AZRI Mung-2018 are giving edge to the variety for preference over earlier released varieties.

Table 12. Physio-chemical analysis of AZRI-Mung-2018 in comparison with popular commercial varieties.

Client ID	Crude Protein (%)	100 Seed Weight (g)	Seeds Volume before soaking (mL/100 seeds)	Seeds Volume after soaking (mL/100 seeds)	Seed Density (g/mL)	Hydration Co-efficient%	Cooking Time (min)
AZRI-Mung-2006	19.09	5.69	3.00	8.67	1.90	176.71	28.50
NM-16	22.21	6.12	2.33	10.67	2.71	200.32	25.00
AZRI.Mung-2018	22.65	4.61	1.67	8.00	3.07	195.23	24.00

Source: Grain Quality Testing Laboratory, NARC, Islamabad.

Conclusion

AZRI Mung-2018 variety is suitable for edible purpose and contains 22.65% proteins, 306 Kcal energy, vitamin-A 5%, iron 6.6%, Zinc 3.4% and amino acids 11% with less cooking time (Table 12). AZRI Mung-2018 is a high yielding, bold seeded, disease resistant and dual nature variety fit for spring and Khrif seasons. The variety is erect with main stem length 45cm having indeterminate plant type with non-shattering habit. Seed is medium, oval shaped and dark green in color. AZRI Mung-2018 variety is resistant to common diseases found in Pakistan.

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