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## HIGH YIELDING, STRESS TOLERANCE AND SHORT STATURE MUNG BEAN CULTIVAR (AZRI MUNG 2021): A NEW SUCCESS IN PUNJAB, PAKISTAN

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### ABSTRACT

High yield, disease tolerant and stress resistance are important cultivars traits, particularly for the crops sensitive to temperature and photoperiod. Mung bean (*Vigna radiata* L.) is the short day plant formerly cultivated in Asian countries and now consumed all around the world. However, there has been a relatively little research on its genetic improvement until the recent decades. AZRI-Mung 2021 is the mung bean cultivar which is developed via cross breeding between “Ramzan” and “NM-98” cultivars in Pakistan in the early part of this century. It is playing an important role in improving mung bean yield potential in Pakistan due to its higher yield, short stature, wider adoptability and high stress tolerance. Research article summarizes the development of AZRI-Mung 2021, describes its yield performance and adaptability in diverse eco-regions within the Punjab province and all over the country. It was concluded that being high yielding, disease tolerant and easily adjustable in cropping system AZRI-Mung 2021 might be used by farmers for higher production and by Breeders and Biotechnologists for further breeding programs and biotechnology. Due to its wider adaptability and higher yield characteristics it can be a game changer for food security challenges.

**Keywords:** Mung bean; cultivar; AZRI-Mung 2021; Short stature; Production and adaptability

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### INTRODUCTION

Mung bean (*Vigna radiata* L.) is a legume crop cultivated for its multiple uses (i.e., nutrient source for the humans, animal forage, soil fertilization, medicinal component, edible seeds and sprouts) across the Asia (Avav and Ugesse, 2009; Tomooka et al., 2012). It is the prime edible seed in Asia (Pakistan, India, East Asia and South East Asia) and also consumed in Southern USA and Southern Europe. Legumes like as beans, peas, groundnut and lentils belong to the family Leguminosae/Fabaceae and as an economically important legume crop, mung bean is commonly grown under irrigated and rain-fed conditions particularly for crop rotation or monoculture, moreover intercropping with diverse cereals is more frequent (Hondrade et al., 2017; Khalid et al., 2021), as it increases the level of N and C for the successive crops (Zang et al., 2015). Primarily, the pest infestation

considerably decreases during intercropping (Xie et al., 2012).

In the previous decades, extensive cultivation and delays in systemic breeding of mung bean has led to the misapprehension that mung bean have low yield potential however, the recently development of breeding lines with high yield potential and erect growth habit has increased the mung bean production (Khattak et al., 2006; Lee et al., 2004). Moreover, the mung bean production is adversely affected by the biotic (Diseases and pest infestation) and abiotic stresses (particularly drought). To address the stresses there are strict requirements for the attributes of mung bean cultivars (e.g., early flowering, consistent maturation and erect growth habit) (Wang et al., 2022).

To strengthen the mung bean traits numerous strategies have been used in mung bean breeding programs which leads to the development of new cultivars with desired traits (Tian et

al., 2021; Wang et al., 2009). Research activities on Mung bean breeding conducted in concerned project has resulted an important achievement regarding the release of variety “AZRI-Mung 2021” with desired traits (e.g., high yielding, disease and temperature tolerant). It is especially useful as a crop for post-disaster replanting owing to its relatively short stature and growth period.

## MATERIALS AND METHODS

Pre-breeding material for AZRI-Mung 2021 was originally derived from a cross between Ramzan and NM-98. The maternal line Ramzan is the commonly cultivated mung bean cultivar from Khyber Pakhtunkhwa, Pakistan and it has been widely used for mung bean production, breeding and as the plant material in various genetic studies. Maximum harvest index of the Ramzan influences physiological efficiency in photosynthates partitioning towards grain formation and it ultimately leads to the considerable increase in grain yield. The NM-98 is another paternal line developed by the Nuclear Institute of Food and Biology (NIAB), Punjab, Pakistan. Both the paternal and maternal cultivars were crossed during kharif (2005)

at research area of Arid Zone Research Institute, Bhakkar following the crossing technique of Khattak et al. (2006). After the hybridization, bulk selection was done from filial generations  $F_1$  to  $F_7$  at Arid Zone Research Institute (AZRI) Bhakkar Punjab, Pakistan. Generation of the selected recombinants was advanced for determining their genetic stability/breeding behavior of desired traits (Table 1). When the phenotypes of concerned line were distinct, uniform and stable than the planting tests were conducted. The high yielding line 13TM-04 later on named as AZRI Mung 2021 was assessed in replicated Preliminary Yield Trial (PYT), Regular Yield Trial (RYT), Micro Yield Trial (MYT), Mungbean National Uniform Yield Trial (MNUYT) in Punjab and then in all Pakistan during Autumn 2013-2017. All the trials were conducted by following Randomized Complete Block Design (RCBD) and replicated using 30 cm and 10 cm row to row and plant to plant spacing respectively. Length of the rows were kept 4 m whereas, the number of rows in all replicated trials were 4 which were constant in all the trails. All the yield trials data were recorded by following Steel and Torrie (1981).

Table 1. Chronological order/Breeding history of the new mung bean candidate variety AZRI Mung 2021.

Sr. No.	Year	Generation/ Trial	Variety Code
1	2005	Cross b/w Ramzan x NM98	$F_0$ seed was collected
2	2006	$F_1$	
3	2007	$F_2$	11
4	2008	$F_3$	34
5	2009	$F_4$	91
6	2010	$F_5$	124
7	2011	$F_6$	25
8	2012	$F_7$	15
9	2013	Preliminary yield trial	13TM-04
10	2014	Regular yield trial	-do-
11	2015	Micro yield trial	-do-
12	2016	MNUYT (Punjab)	-do-
13	2017	MNUYT (Pakistan)	-do-
14	2019 (05-08-2019)	Spot Examination and seed multiplication	-do-
15	2020 (27.07.2020)	80 <sup>th</sup> meeting of Experts Sub Committee	Recommended

## Agronomic Studies

Fertilizer trials and studies on planting dates were carried out at Arid Zone Research Institute, Bhakkar, Punjab, Pakistan to fix the agronomic requirements of AZRI- Mung 2021. The sowing date trials were conducted during 2016 & 2017 for candidate line 13TM-04 in comparison with

commercial variety NM-2011 in irrigated condition to identify optimum planting time. Varieties in trial were sown with 10 days interval from April 15<sup>th</sup> to June 25<sup>th</sup>. All other conditions were uniform for all sowing dates. The Seed rate trials were also conducted and five seed rates (20, 25, 30, 35 & 40 kg/ha) were used. All other inputs were uniform for all

treatments. Row spacing and fertilizer trial was also conducted under RCBD with factorial arrangement. The five fertilizer rates of N:P viz. 0:0, 22:23, 22:57, 22:46 & 22:69 kg/ha were tested along with three row spacings viz. 30, 45 & 60 cm. All other inputs were kept uniform for all treatments (Table 2).

Table 2. Important agronomic/morphological/qualitative characteristics of AZRI-Mung 2021.

Sr. No	Trait	Description
1	Growth behavior	Semi-erect
2	Plant color	Green
3	Pod color	Brownish/Black
4	Days to 50 % Flowering	36-40
5	Days to physical maturity	85-90
6	Plant height (cm)	40-50
7	Hairiness	Medium
8	Anthocyanin pigmentation	Weak
9	Disease reaction	Resistant/ tolerant
10	Yield potential	2500 kg/ha
11	Average yield	2200 kg/ha

**Diseases and Insect Pest Reaction**

**Pathological studies**

The screening against Bacterial leaf spot, Anthracnose, *Cercospora* leaf spot, Mung bean yellow mosaic virus and Urd bean leaf crinkle virus were carried out at Arid Zone Research Institute, Bhakkar Punjab Pakistan. AZRI-2021 was cultivated along with AZRI MUNG-2006 and NM-2011 to determine their reaction in pathological views.

**Entomological studies**

AZRI-Mung 2021 was cultivated along with AZRI MUNG-2006 and NM-2011 to determine their reaction in response to entomological studies. Insect pest infestation studies for pod borer, whitefly, Espanola bug and Jassid were conducted at Arid Zone Research Institute, Bhakkar Punjab

Pakistan.

**RESULTS**

**Yield Performance**

13TM-04 (AZRI Mung 2021) has been tested in different agro-climatic zones throughout the Pakistan.

**On-Station Yield Trials**

Yield performance in Preliminary yield trial (PYT) and Regular yield trial (RYT) during 2013 and 2014 respectively at Arid Zone Research Institute Bhakkar, Punjab Pakistan were determined. The recorded data shown that the candidate line 13TM-04 produced 24 & 27% higher yield than check varieties AZRI-MUNG-2006 and NM-2011 respectively (Table 3).

Table 3. Yield performance in Preliminary yield trial (PYT) and Regular yield trial (RYT) during 2013 and 2014 respectively at Arid Zone Research Institute Bhakkar, Punjab Pakistan.

Sr. No	Year	Name of Trial	Yield (Kg/ ha)			LSD <sub>(0.05)</sub>
			13TM-04 (AZRI Mung 2021)	AZRI MUNG 2006	NM-2011	
1	2013	Preliminary yield trial	801	724	697	93
2	2014	Regular yield trial	1349	1015	1000	242
		Mean	1075	869	849	
		% increase over check		24	27	

**Out-Station Yield Trials**

**Regional/Micro Yield Trials**

Trials to evaluate yield performance and adaptation of 13TM-04 line under mung bean Regional / Micro yield trials were

conducted at AZRI Bhakkar and GBRSS Kallur Kot during the year 2015. Candidate variety 13TM-04 produced 4% and 11% higher yield as compared with check varieties AZRI-Mung-2006 and NM-2011, respectively (Table 4).

Table 4. Yield performance and % increase in seed yield of 13TM-04 in mung bean Regional / Micro yield trials were conducted for adaptation at AZRI Bhakkar and GBRSS Kallur Kot during the year 2015.

Sr. No.	Location	Yield Kg/ha			LSD <sub>(0.05)</sub>
		13TM-04 (AZRI Mung 2021)	AZRI-M-2006	NM-2011	
1	AZRI Bhakkar	1260	1012	869	95
2	GBRSS Kallur kot	867	1033	1052	241
	Mean	1064	1023	961	
	% increase over check		4	11	

**Mung Bean National Uniform Yield Trials (2016-2017)**

These trials were conducted by the National Coordinator (Pulses), NARC Islamabad. Purpose of these trials was to find out adaptability and performance of the new strain at national level. Trials were conducted at different Research Institutes including Ayub Agricultural Research Institute Faisalabad, Arid Zone Research Institute Bhakkar, Barani Agriculture Research Station Chakwal, National Agriculture Research Council Islamabad, Nuclear Institute of

Agriculture and Biotechnology, Faisalabad, National Institute of Food and Agriculture Peshawar, and Quaid-e-Awam Agriculture Research Institute larkana in all over the Pakistan provinces.

Candidate variety 13TM-04 depicted very good performance on over all basis. Out yielded check varieties i.e. NM-2011 & AZRI-MUNG-2006 at all locations. Maximum grain yield 1780 kg/hectare was recorded at NIFA Peshawar in national uniform yield trial (Tables 5-8).

Table 5. Yield performance and % increase in seed yield of 13TM-04 (AZRI Mung 2021) in National Uniform Yield Trial (NUYT) during 2016 (All Punjab Locations).

Sr. No.	Site/ location	13TM-04 (AZRI Mung 2021)	NM-2011	AZRI MUNG-2006
1	RARI, Bahawalpur	1222	1185	1037
2	BARS, Fateh Jang	541	307	304
3	NIAB, Faisalabad	1400	986	1808
4	AZRI, Bhakkar	1136	1227	1171
5	AARI, Faisalabad	114	272	196
	Mean	883	795	903
	% increase over check		11	-2

Table. 6 Yield performance and % increase in seed yield of 13TM-04 (AZRI Mung 2021) in National Uniform Yield Trial (NUYT) during 2016 (All Pakistan locations).

Sr. No.	Site/ location	13TM-04 (AZRI Mung 2021)	NM-2011	AZRI MUNG-2006
1	NIAB, Faisalabad	1400	986	1808
2	AZRI Umer Kot	1338	998	829
3	BARS, Fateh Jang	541	307	304
4	AZRI, Bhakkar	1136	1227	1171
5	NARC, Islamabad	364	385	589
6	NIFA Peshawar	1780	1417	1377
7	AARI, Faisalabad	114	272	196
8	RARI, Bahawalpur	1222	1185	1037
	Mean	987	847	909
	% increase over check		17	9

Table 7. Yield performance and % increase in seed yield of 13TM-04 (AZRI Mung 2021) in National Uniform Yield Trial (NUYT) during 2017 (All Punjab locations).

Sr. No.	Site/ locations	13TM-04 (AZRI Mung 2021)	NM-2011	AZRI-MUNG-2006
1	AARI, Faisalabad	1284	1041	853
2	BARS, Fateh Jang	462	219	200
3	AZRI, Bahawalpur	1085	1112	1024
4	NIAB, Faisalabad	1252	1369	1172
5	AZRI, Bhakkar	937	982	869
Mean		1004	945	824
% increase over checks			6	22

Table 8. Yield performance and % increase in seed yield of 13TM-04 (AZRI Mung 2021) in National Uniform Yield Trial (NUYT) during 2017 (All Pakistan locations).

Sr. No.	Site/ locations	13TM-04 (AZRI Mung 2021)	NM-2011	AZRI-MUNG-2006
1	AARI, Faisalabad	1284	1041	853
2	ARI Mengora Sawat	785	783	742
3	ARI Tendo Jaam	1271	847	646
4	AZRI, Bahawalpur	1085	1112	1024
5	AZRI, Bhakkar	937	982	869
6	AZRI D. I. Khan	1094	976	978
7	AZRI, Umer Kot	1421	1136	1161
8	BARS, Fateh Jang	462	219	200
9	NARC, Islamabad	962	983	928
10	NIAB, Faisalabad	1252	1369	1172
11	NIFA Peshawar	1587	1413	1642
12	QAARI, Larkana	583	1069	1250
Mean		1060	994	955
% increase over checks			7	11

### Over All Performance

13TM-04 (AZRI-Mung 2021) showed significant results in terms of overall yield performance and % increase in seed yield at all yield trials during 2013 to 2017 (Table 9).

### Agronomic Studies

Agronomic studies regarding sowing date, seed rate, fertilizer and planting geometry were carried out at Arid Zone Research Institute, Bhakkar, Punjab, Pakistan.

### Sowing Date Trial

The sowing date trials were conducted during 2016 & 2017 for candidate line 13TM-04 in comparison with commercial variety NM-2011 in irrigated condition to identify optimum planting time. Verities in trial were sown with 10 days interval from April 15<sup>th</sup> to June 25<sup>th</sup>. All other conditions were uniform for all sowing dates. It was concluded that 25<sup>th</sup> May to 5<sup>th</sup> June is the best

sowing time (Table 10).

### Seed Rate Studies

Table 11 showed seed rate trial was conducted at Arid Zone Research Institute, Bhakkar during the year 2017 & 2018. The candidate variety 13TM-04 (AZRI-Mung 2021) gave higher yield at seed rate of 30kg/ha in both the years under study (Table 11).

### Fertilizer and Planting Geometry Studies

It is evident from the results that row spacing of 30 and 45cm proved best while fertilizer dose of 22: 57 NP kg/ha gave maximum yield (Table12).

### Plant Protection

### Pathological Studies

Disease resistance/tolerance traits are promoted for variety development. Disease data recorded at Arid Zone Research Institute, Bhakkar. The strain is resistant to yellow mosaic

virus and it fairly tolerance to other mung bean diseases like Bacterial leaf spot, *Cercospora* leaf spot and Anthracnose (Table 13).

**Hairiness as Repellent to Insect Pests**

Hairiness trait of the candidate variety 13TM-04 observed to be repellent to sucking insect pests.

Table 9. Over all yield performance and % increase in seed yield of 13TM-04 (AZRI Mung 2021) at all yield trials during 2013 to 2017.

S. No.	Name of Trial	Year	No. of trials	Average Yield kg/ha		
				13TM-04 (AZRI Mung 2021)	AZRI MUNG-06	NM-11
1	Station yield trials	2013-14	2	1075	870	760
2	Adaptation yield trial GBRSS K. Kot.	2015	1	867	1033	1052
3	Adaptation yield trial AZRI Bhakkar	2015	1	1260	1012	869
4	Mungbean national uniform yield trial	2016	8	987	909	847
5	Mungbean national uniform yield trial	2017	12	1060	955	994
Average		-		1049	955	904
% increase over check		-			10	16

Table 10. Mung bean Grain Yield (kg/ha) at Different Sowing Dates.

Variety	Year	D1 15 <sup>th</sup> Apr.	D2 25 <sup>th</sup> Apr.	D3 5 <sup>th</sup> May	D4 15 <sup>th</sup> May	D5 25 <sup>th</sup> May	D6 5 <sup>th</sup> June	D7 15 <sup>th</sup> June	D8 25 <sup>th</sup> June
13TM-04	2016	643	745	802	1400	1963	1723	783	375
NM-2011		611	702	732	1078	1700	1630	694	330
13TM-04	2017	782	763	815	1465	2235	1882	760	348
NM-2011		697	713	773	1221	1895	1672	571	311

Table 11. Seed rate trial was conducted at Arid Zone Research Institute, Bhakkar during the year 2017 & 2018.

Sr. No.	Seed rates (kg/ha)	2017	2018
1	40	763	637
2	35	1043	943
3	30	1501	1462
4	25	1265	1060
5	20	1140	982

Table 12. Fertilizer and planting geometry studies.

NP Levels (kg/ha)		Yield (kg/ha) at different row spacing		
N	P	S <sub>1</sub> = 30 cm	S <sub>2</sub> = 45 cm	S <sub>3</sub> = 60 cm
0	0	417	463	277
22	23	592	655	542
22	57	1183	1113	911
22	46	971	941	728
22	69	815	810	698
LSD <sub>(0.05)</sub> = 153		CV (%) = 14.2		

\*N; Nitrogen, P; Phosphorus, S; Spacing

Table 13. Disease resistance / tolerance traits are promoted for variety development. Disease data recorded at Arid Zone Research Institute, Bhakkar are given in the table to follow Scale (1-5).

Sr. No.	Disease	Genotype	2017
1	Bacterial leaf spot	13TM-04	2
		(AZRI Mung 2021)	
		NM-2011	3
2	Anthracnose	AZRI MUNG-2006	3
		13TM-04	1
		NM-2011	1
3	Cercospora leaf spot	AZRI MUNG-2006	1
		13TM-04	1
		NM-2011	2
4	Mungbean yellow mosaic virus	AZRI MUNG-2006	2
		13TM-04	1
		NM-2011	3
5	Urdbean leaf crinkle virus	AZRI MUNG-2006	1
		13TM-04	1
		NM-2011	2
		AZRI MUNG-2006	2

**DISCUSSION**

The 13TM-04 (AZRI Mung 2021) is higher yielder than existing commercial varieties AZRI-Mung-2006 and NM-2011. The strain is genetically different from all existing varieties and is heat tolerant. The proposed new variety is disease tolerant specially to yellow mosaic virus. Its inherent yield potential is up to 2500 kg/ha. It is short stature, early maturing and can easily be adjusted in any cropping system in Punjab and gives better and stable yield in local agro-climatic conditions.

It performed very good in terms of yield performance throughout the evaluation studies. It produced an excellent % increase in National Uniform Yield Trial (NUYT) on comparison to checks. On the basis of 13TM-04 (AZRI Mung 2021) Stable productivity and wide distribution. High grain yield potential is the only attribute that is highly valued by the growers (Hossain, 2012; Walker and Alwang, 2015), and high yielding kinds of crop plants helps in improving yield and production potential (Joshi et al., 2017; Zulfiqar and Hussain, 2014). Maximum yield potential of AZRI-2021 (code 13TM-04) will eliminate the alleviating constraints to mung bean production in particularly in Punjab and all over the country. One of the major pre-requisites for the newly developed crop variety is that the variety should surpass the existing varieties regarding seed yield and other agronomic traits as well as the wide adaptability across different locations. 10% and 16% increase in seed yield by AZRI Mung-2021 (Code 13TM-04) over check varieties AZRI Mung-2006 and NM-11

(Table 9) hints about its maximum yield potential and wider adoptability in Punjab and all over the country.

Mungbean cultivar AZRI Mung 2021 (13TM-04) is a high yielding, early maturing and resistant to *Cercospora* leaf spot, MYMD, ULCV, anthracnose. Natural disasters are more often as a result of climate change, and the intensity of disease outbreaks and insect infestations has increased (Zang et al., 2015; Zhu et al., 2022). These factors have a negative impact on the sustainable production of crops, including mung bean. We believe that 13TM-04 will be used to produce mung beans until better cultivars are created and made available for usage commercially for a number of reasons. The only mung bean cultivar that is still resistant to leaf spot is 13TM-04. Moreover, drought, one of the most significant effects of anthropogenic climate change, has hampered agricultural output all across the world. Breeders and farmers in many locations have confirmed that 13TM-04 has drought resistance capability.

This demonstrates that 13TM-04 (AZRI Mung 2021) had a greater number of advantageous modifying genes that conferred resistance to *Cercospora* leaf spot, MYMD, ULCV, anthracnose diseases, as it has been reported that MYMD resistance is the result of an accumulation of these types of genes in a genotype (Khattak et al., 2000). Additionally, crop varieties with recently discovered disease resistance manage output losses (Agrios, 2005; Savary et al., 2012) moreover, newly developed variety should surpass the susceptible cultivars regarding their agronomic performance. It is clear that the inherent potential of AZRI-

Mung 2021 against diseases will positively collaborate its due share for minimizing the threats for successful mung bean production in Punjab as well as Pakistan.

### CONCLUSION

AZRI-Mung 2021 out-yielded the local check varieties in all replicated trials conducted at Arid Zone Research Institute Bhakkar, Punjab as well as at different locations of Punjab and Pakistan. It produced maximum seed yield on comparison to the national varieties in NUYTs conducted across the country for two years. On the basis of maximum yield potential, diseases resistance and different genetic makeup, Punjab Provincial Seed Council approved AZRI-Mung 2021 as new mung bean commercial variety for Mung bean growing areas of Punjab. Being high yielding, disease resistant and suitable in cropping system this variety should be grown by farmers for better production and by breeders for further breeding programs.

### CONFLICT OF INTEREST

The authors declare that there is no conflict in the publication of this article.

### AUTHOR'S CONTRIBUTION

All the authors contributed equally in the manuscript.

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