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Introgression of productivity and other desirable traits from ricebean (*Vigna umbellata*) into black gram (*Vigna mungo*)

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With 6 tables

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Abstract

Crosses were performed to introgress genes for productivity and other desirable traits from ricebean (*Vigna umbellata*) into black gram (*Vigna mungo*). Crossability was very poor in black gram × ricebean crosses, and only two to nine true hybrid plants were obtained. Plant fertility was very poor in initial generations, but was improved gradually from F_2 onwards. Twenty-four uniform progenies, bulked in F_7, were evaluated for yield potential. The percentage increase/decrease in yield ranged from −35.48 to 50.31 over the check cultivar ('Mash338', female parent). All the progenies were found resistant to Mungbean yellow mosaic virus, *Cercospora* leaf spot and Bacterial leaf spot diseases. Overall, it was found that desirable traits such as high pod number, seed weight, productivity and resistance to diseases have been introgressed successfully into black gram from ricebean. A derivative line, KUG114, recorded yield superiority of 39.45% over the check cultivar 'Mash338' on the average of 14 multilocation research trials. It was released under the name 'Mash114' for cultivation in the Punjab state.

Key words: *Vigna* — interspecific hybridization — introgression — productivity — disease resistance

Grain legumes play an important role in human food and health and in sustenance of several eco-systems. They offer cheap source of protein thereby helping in combating malnutrition and also enrich soil by fixing atmospheric nitrogen. At present, the *per capita* human consumption of legumes is below the standards fixed by FAO and WHO, primarily due to less production and productivity of legumes (Vepa 2003). Black gram (*Vigna mungo* L. Hepper), also known as urdbean, is the third most important crop of India among the various grain legumes. It is being cultivated during summer, rainy (*kharif*) and winter (*rabi*) seasons in different parts of India. On account of its short duration, photo-insensitivity and dense crop canopy, it assumes special significance in crop intensification and diversification, conservation of natural resources and sustainability of production systems (Katiyar et al. 2010). It has a special nutrition status and is an important source of protein in the diet of vegetarian masses. It has various desirable characters like short maturity duration, amenability for crop rotation and tolerance to shattering. But it is susceptible to various diseases such as mungbean yellow mosaic virus (MYMV), *Cercospora* leaf spot (CLS) and bacterial leaf spot (BLS). Among the diseases, MYMV is the most important and can cause 100% yield losses (Nene 1972, Basak et al. 2004). Resistance to MYMV is available within *Vigna mungo,* but it breaks down easily and frequently due to rapid formation of new pathotypes (Kartikeyan et al. 2011). Further, the productivity level of black gram is also low due to narrow genetic base (Kumar et al. 2011) and is stagnant around 1.2 t/ha. If the productivity level is raised up to 2.0 t/ha, only then it can compete with other rainy season crops whose net profits are comparatively higher.

Wide hybridization is an important tool to transfer desirable traits from wild or cultivated related species into cultivated ones. However, the transfer of specific genes is frequently associated with transfer of large alien chromosome segments having undesirable traits (Tanksley and Nelson 1996). Owing to linkage drag, the genes for primitive or wild traits are often introduced along with desirable traits. Breaking linkages with unwanted type and restoring the genotype associated with accepted agronomic background may take a long time. Therefore, improvement through interspecific hybridization often takes longer time than intraspecific breeding programme. Over the last decade, convincing evidence at both morphological and molecular levels has come forth for utility of wild progenitors and related species as donors of productivity alleles in some crops (Tanksley et al. 1996, Xiao et al. 1996, Singh and Ocampo 1997, Singh et al. 2005). The productivity-enhancing genes/QTL have been introgressed in oats from *Avena sterilis* (Frey et al. 1983); in tomato from *Lycopersicon pimpinellifolium* and *L. parviflorum* (Tanksley et al. 1996, Fulton et al. 2000); and in rice from *Oryza rufipogon* (Xiao et al. 1996, Ji et al. 2012). In chickpea, genes for productivity have been transferred from *Cicer echinospermum, C. reticulatum* (Singh and Ocampo 1997) and *C. reticulatum* (Singh et al. 2005).

Introgression of unexplored genes from the wild relatives could be rewarding for broadening the genetic base of various grain legumes including black gram especially for improving yield-enhancing traits and resistance to diseases. However, the distantly related wild species possess several undesirable traits, and success of desirable introgression is diluted significantly as a result of linkage drag and partial sterility. In this situation, extensive back cross-breeding is warranted that takes a heavy toll in terms of resources and time; hence, breeders are reluctant to use distantly related wild species and rather look for closely related species that possess minimum undesirable traits. Fortunately, ricebean (*Vigna umbellata*), a cultivated *Vigna* species, is a closely related species to black gram. Both the species, black gram and ricebean, are diploid and having same number of somatic chromosomes (i.e. 2n = 22). Ricebean is not a major cultivated legume; however, it is locally important in parts for South and South-East Asia. It has high test weight and high number of pods that leads to high productivity. Besides, it possesses high level of resistance to MYMV (Monika et al. 2001), CLS and BLS. It is also a source of bruchid resistance (Tomooka et al. 2000). So far, limited efforts have been made to introgress desirable traits from *V. umbellata* into *Vigna mungo*. However, ricebean (*V. umbellata*) was crossed with green gram (*V. radiata*) to incorporate resistance to MYMV and other desirable traits into latter with varying success (Dar et al. 1991, Verma et al. 1991, Verma and Brar 1996). The interspecific crosses did not show any MYMV symptom like the ricebean parents, were closer to ricebean parents for days to flower initiation and were nearly intermediate for leaflet length/breadth ratio but possessed more nodes as compared to both the parents. These studies and some other studies (Singh and Bains 2006) indicated that stable and high degree of resistance to MYMV and some other desirable traits could also be successfully incorporated into black gram from ricebean. A partially fertile rare interspecific hybrid between a black gram x green gram derivative and adzuki bean (*Vigna angularis*) was developed with the aim to combine desirable traits of three *Vigna* species (Gupta et al. 2002).

Although successful transfer of many desirable traits have been achieved in different crops, but the actual release of new cultivars and its use by farmers is rather scanty. A wide gap exists between making initial interspecific hybrids and releasing cultivars with good agronomic performance. Low fertility levels in early generations usually results in small population sizes, thus limiting gene recombination among species. Therefore, the present study aims at developing black gram cultivars with improved productivity and high degree of resistance to various diseases for practical utility.

Materials and Methods

The experimental material for the present investigation comprised three black gram (*V. mungo*) genotypes, namely 'Mash338', UG562 and UG844 and one ricebean (*V. umbellata*) genotype RBL1. The black gram genotypes were used as female and ricebean as male parent. The black gram genotypes have determinate growth habit, erect and compact plant type, bear pods on the lower side under the canopy, while ricebean genotype has indeterminate growth habit, high yield, vigorous growth, profuse podding distributed equally on entire plant and resistance to MYMV, CLS and BLS (Verma and Brar 1996, Sandhu et al. 2007). In each cross-combination, 240–300 pollinations were made during 1996. The flowers of female parents were emasculated in the evening and pollinated in next morning with fresh pollen from male parent using camel hair brush. A combination of growth regulators, for example GA_3 (120 ppm) + indole acetic acid (30 ppm) + kinetin (15 ppm), was applied for two consecutive days at the base of pedicel to enhance flower retention (Verma et al. 1990). Crossed pods were harvested at maturity and the crossed F_1 seeds were grown in the field during summer season 1997 (March to June). The hybridity of the F_1s was confirmed based on prominent morphological traits of male parent such as orientation of top leaf and tendrils. The F_2 seeds harvested from true F_1 plants of the cross 'Mash338' × RBL1 were grown during rainy season 1997. From F_2 onwards, pedigree method of selection was followed for advancing the segregating generations. In F_3, 400 plants from 36 progenies, in F_4 150 plants from 60 progenies, in F_5 70 plants from 25 progenies and in F_6 60 plants from 18 progenies were selected for advancing the generations. Finally, 24 homozygous progenies were bulked in F_7 for evaluation for yield potential during rainy seasons 2002 and 2003.

Keeping in the mind the improvement in black gram, the directional selections were made in segregating generations to select plants morphologically more similar to black gram. While making selections, pollen fertility at flowering stage and pod filling and seed colour (black gram type) at maturity were taken as selection criteria. All the segregating generations starting from F_2 onwards were sown during rainy (*kharif*) season at Regional Research Station, Gurdaspur, India, except F_3 generation which was grown during summer season. The Gurdaspur location is a hot spot for MYMV, CLS and BLS diseases. After each 10 progenies, one infector row (mixture of susceptible lines) was also planted to increase the incidence of natural disease epiphytotics. For screening against MYMV, CLS and BLS, the standard scale of 1–9, that is, 1 = highly resistant; 9 = highly susceptible (Singh and Kaur 1998), was used. In early segregating generations, single plants having more number of filled pods, vigorous growth and moderate-to-high degree of resistance to MYMV were selected. However, in latter generations, the vigorous plants having more pods and high degree of resistance to MYMV were selected. The non-segregating morphologically uniform black gram type 24 progenies were bulked in F_7 for preliminary yield evaluation against the standard check cultivar 'Mash338', in a station trial at Gurdaspur location having two replications. Each progeny was accommodated in a plot of four rows of 4 m length keeping row to row spacing of 30 cm. Based on yield evaluation in this trial, 15 progenies that recorded at least 10% superiority over the check cultivar were promoted to multilocation Final Yield Trial for yield evaluation which was conducted at three locations, that is, Gurdaspur, Ludhiana and Faridkot in the Punjab state for 3 years (2004 to 2006). The plot size for multilocation trials was eight rows of 4 m length keeping row to row spacing of 30 cm. In these trials, data on various morphological traits namely days to flowering, days to maturity, number of fruiting branches, number of pods, seeds per pod, plant height, 100-seed weight and seed yield per plot were recorded. In addition, data on reaction to various diseases were also recorded. Based on average yield performance in nine multilocation trials over 3 years, finally one line KUG114 was selected for yield evaluation along with check variety 'Mash338' at farmers' field in 11 districts of Punjab state. In each district, four to six un-replicated Adaptive Research Trials of 500 m^2 area and 20 Front-Line Demonstrations of 0.40 ha area were conducted following standard package of practices to evaluate the adaptability and stability performance of new genotype in diverse agro-climatic conditions of the state. Data on cooking quality parameters such as water absorption capacity (%) and volume expansion (%) after soaking in normal water and after cooking were generated as described by Shivashankar et al. (1974).

Results

The perusal of Table 1 revealed that the success percentage of true hybrid seeds was very low, only two to nine true hybrid plants were obtained from different crosses, and the highest crossability (3.0%) was observed in the cross 'Mash338' × RBL1. The phenotype of F_1 hybrids was more similar to the female parents, but the traits of the male parent such as orientation of top leaves and tendrils were very prominent in the hybrids. Further, the shape of the lower leaves and colour of the leaves were intermediate between the parents. Based on leaf orientation, presence of tendrils and intermediate shape and colour of leaves, the hybridity of F_1s was confirmed. Some other traits such as flower colour (dark yellow) and pod position (distributed all over the plant) of male parent also expressed in the hybrids. The F_1 plants were partially fertile or sterile (Table 2) and were very vigorous with medium green

Table 1: Crossability of black gram (Mash338, UG562 and UG844) with ricebean (RBL1)

Sr. No.	Cross	Flowers pollinated	True hybrid plants obtained	Crossability (%)
1	Mash338 × RBL1	300	9	3.00
2	UG562 × RBL1	250	2	0.80
3	UG844 × RBL1	240	3	1.25

Table 2: Characters of female (black gram, Mash338) and male (rice-bean, RBL1) parents and their F_1 hybrids

Sr. No.	Character	Female parent Mash338	Male parent RBL1	Hybrids
1	Growth habit	Determinate	Indeterminate	Semi-determinate
2	Plant type	Erect and compact	Semi-erect and non-compact	Semi-erect and compact
3	Tendrils	Absent	Long tendrils	Short tendrils
4	Pod position	Lower side under the canopy	Distributed all over the plant	Distributed all over the plant
5	50% flowering	~37 days	~60 days	~48 days
6	Maturity duration	~77 days	~125 days	~90 days
7	Leaf colour	Dark green	Light green	Medium green
8	Leaf shape	Broad, round ovate	Narrow, long,	Medium, ovate
9	Flower colour	Light yellow	Dark yellow	Dark yellow
10	Pod hairiness	Hairy	Non-hairy	Hairy
11	Plant height	Dwarf	Tall	Medium tall
12	Pollen fertility	>95%	>95%	55–60%
13	Seeds per pod	5–6	10–11	3–4

leaves and bear few partially filled pods. The seeds per pod were less (three to four seeds) in F_1 hybrid plants as compared to female (five to six seeds) and male (10–11 seeds) parents. Pollen fertility was examined using acetocarmine under microscope revealed that only 55–60% pollens were fertile.

The MYMV disease appeared in epidemic form in infector rows and later spread to the F_2 populations. The F_2 plants segregated for number of traits including reaction to MYMV and fertility. Of 245 F_2 plants, only 55 plants showing good fertility and moderate-to-high degree of resistance were advanced (Table 3). In F_3 generation, the selection was primarily based on plant vigour, number of pods and fertility of plants. The disease pressure was low during summer season; hence, selection was not based on disease reaction. In F_4, only highly fertile plants having high levels of MYMV resistance were selected and advanced for further evaluation. In F_5 generation, the progenies were more uniform but still segregating for fertility and levels of MYMV resistance. In F_6 generation, the progenies were almost uniform for most of the traits including MYMV resistance but still segregating for fertility. Hence, stringent selection was made for pollen fertility and pod filling.

The fertility was improved gradually in segregating generations from F_2 onwards, and the plants were nearly 100% fertile in F_7 generation (Table 3). As the selection was inclined towards black gram phenotype, most of the progenies were very near to female parent 'Mash338' in general appearance. Similarly the average level of resistance to MYMV was also improved gradually from F_2 onwards and most of the progenies in F_6/F_7 were found to be resistant with score of ≤ 3 (Table 4).

Table 3: Fertility status in segregating generations of an interspecific cross (Mash338 × RBL1)

Generation	Total plants	No. of plants having good fertility	Percentage of plants having good fertility	Pollen fertility (%)
F_2	245	55	22.5	55–60
F_3	400	150	37.5	60–70
F_4	150	70	47.7	70–80
F_5	70	60	85.7	80–85
F_6	60	55	91.7	85–90
F_7	24 uniform lines bulked having plant fertility > 95%			

In F_7 generation, 24 uniform interspecific derivatives (progenies) were bulked and evaluated in station yield trials at Gurdaspur location for two years, and the results are given in Table 4. Among the progenies, KUG172 and KUG202 recorded highest yield (1410 kg/ha), followed by KUG175 (1363 kg/ha). The percentage increase/decrease in yield ranged from −35.48 to 50.31 over the check cultivar/female parent 'Mash338' (938 kg/ha). Some of the progenies were very late (105 days) as genotype KUG208 and some were very early (84 days) as genotype KUG137, followed by genotype KUG114 (87 days). Transgressive segregants were recovered for pods per plant, and it ranged from 12 to 42 in comparison with 18 and 32 in female ('Mash338') and male (RBL1) parents, respectively. The 100-seed weight ranged from 3.6 to 5.2 g of the progenies and three progenies, namely KUG137, KUG172 and KUG175, had more than 5.0 g 100-seed weight compared with 4.5 g of female parent, 'Mash338'. All the progenies were found resistant to MYMV, CLS and BLS and gave a score of 1.0 to 2.0. The male parent RBL1 recorded 1.0 score to all the three diseases, and female parent 'Mash338' recorded 5.0 score to MYMV and 3.0 score to CLS and BLS (Table 4).

Of 24 progenies, 15 were found promising and promoted to multilocation trials in the Punjab state. On the basis of nine multilocation trials (2004–2006), KUG114 was the highest yielder among 15 progenies and recorded 1138 kg/ha, followed by KUG172 (1062 kg/ha), KUG202 (1045 kg/ha), KUG218 (1041 kg/ha) and KUG222 (1015 kg/ha) as compared to 835 kg/ha of check cultivar 'Mash338' (data not shown). The yield of rest of the progenies ranges between 850 and 975 kg/ha. Thus, based on average yield of nine multilocation trials, KUG114 was approved by Research Evaluation Committee, Punjab Agricultural University, Ludhiana, India, for its evaluation at farmers' fields. In research trials, the grain yield of KUG114 ranged between 638 and 1389 kg/ha, and on the average of 14 trials including station and state multilocation trials conducted during 2002–2007, KUG114 recorded the highest grain yield of 1117 kg/ha against 801 kg/ha of check cultivar 'Mash338', with yield superiority of 39.40% (Table 5). It was also tested in 77 Adaptive Research Trials and 36 Front-Line Demonstrations over two years in different climatic conditions of the state. In these trials, the grain yield levels of KUG114 ranged between 530 and 1380 kg/ha, and it recorded 9.27–35.50% increase in grain yield over the check cultivar 'Mash338'. The line KUG114 was found to be superior to the check cultivar for grain yield in almost all the Adaptive Research Trials and Front -Line Demonstrations.

The line KUG114 was found resistant (score 2.0) to MYMV and highly resistant (score 1.0) to CLS and BLS, while the female parent 'Mash338' showed moderately resistant (score 5.0) reaction to MYMV and resistant (score 3.0) reaction to CLS and BLS (Table 6). The susceptible check showed susceptible to highly susceptible reaction to these diseases indicated high pressure of disease inoculums.

The cooking quality traits such as water absorption capacity and volume expansion after soaking in normal water and after cooking were found to be quite similar in both KUG114 and 'Mash338' (data not shown). Keeping in view the yield advan-

Table 4: Mean performance of derivatives of cross Mash338 × RBL1 in station preliminary yield trials for yield, maturity, pods, seed weight and foliar diseases (2002–2003)

Sr. No.	Line/genotype	Yield (kg/ha)	Increase/decrease in grain yield over Mash338 (%)	Maturity (days)	Pods per plant	100-seed weight (g)	MYMV score (1–9 scale)	CLS score (1–9 scale)	BLS score (1–9 scale)
1	KUG109	608	−35.48	90[1]	12	4.3	1.0	1.0	1.0
2	KUG114	1302[2]	38.81	87	35[3]	4.6	1.0	1.0	1.0
3	KUG116	747	−20.36	90[1]	16	4.3	1.0	1.0	1.0
4	KUG117	677	−27.82	87	12	4.4	1.0	1.0	1.0
5	KUG129	798	−14.92	88[1]	13	4.5	1.0	1.0	1.0
6	KUG133	868	−7.46	88[1]	13	4.7	1.0	1.0	1.0
7	KUG137	833	−11.19	84	15	5.2[4]	1.0	1.0	1.0
8	KUG145	1042	11.09	90[1]	25	4.8	1.0	1.0	1.0
9	KUG172	1410[2]	50.32	96[1]	40[5]	5.1[4]	2.0	2.0	1.0
10	KUG175	1363[2]	45.31	90[1]	40[5]	5.1[4]	2.0	2.0	1.0
11	KUG181	938	00.00	88[1]	25	4.9	1.0	1.0	1.0
12	KUG195	1250[2]	33.26	98[1]	30[3]	3.9	1.0	1.0	1.0
13	KUG198	1250[2]	33.26	96[1]	28[3]	4.8	2.0	1.0	1.0
14	KUG202	1410[2]	50.32	101[1]	42[5]	3.6	2.0	1.0	2.0
15	KUG204	1258[2]	34.12	95[1]	36[3]	4.3	1.5	1.0	1.0
16	KUG206	1302[2]	38.81	99[1]	30[3]	3.9	1.0	1.0	2.0
17	KUG208	1324[2]	41.15	105[1]	33[3]	3.8	1.0	1.0	1.0
18	KUG211	1324[2]	41.15	97[1]	30[3]	4.2	1.0	1.0	1.0
19	KUG213	1250[2]	33.26	96[1]	27[3]	4.4	1.0	1.0	1.0
20	KUG215	1354[2]	44.35	97[1]	31[3]	4.3	1.0	1.0	1.0
21	KUG218	1406[2]	49.89	98[1]	35[3]	3.8	1.0	1.0	1.0
22	KUG222	1348[2]	43.71	96[1]	40[5]	3.6	1.0	1.0	1.0
23	KUG223	1042	11.09	98[1]	33[3]	3.9	1.0	1.0	1.0
24	KUG225	1250[2]	33.26	101[1]	29[3]	4.2	1.0	1.0	1.0
	Mean of progenies	1139.7	–	93.9	27.9	4.3	–	–	–
25	Mash338 (Female)	938	–	80	18	4.5	5.0	3.0	3.0
26	RBL1 (Male)	1575	–	125	32	6.8	1.0	1.0	1.0
	LSD (0.05)	145.5	–	8.2	7.3	0.5	–	–	–

[1] Significantly later than Mash338.
[2] Significantly higher than Mash338.
[3] Significantly higher pods than Mash338.
[4] Significantly higher seed weight than Mash338.
[5] Significantly higher pods than Mash338 and RBL1.

Table 5: Grain yield performance of black gram line KUG114 and check cultivar Mash338 in various trials (2002–2007)

Type of trial	No. of trials	Grain yield (kg/ha)				Increase over check cultivar Mash338 (%)
		KUG114		Mash338		
		Average	Range	Average	Range	Average
Research trials	14	1117	638–1389	801	495–1120	39.45
Adaptive Research trials	77	825	530–1380	755	480–1240	9.27
Front-Line Demonstrations	36	985	775–1050	860	675–925	14.53

tage and resistance to different diseases, the line KUG114 was released for cultivation in the state of Punjab.

Discussion

Wide hybridization has been proved to be quite useful for the introgression of desirable traits from related species into cultivated species in many crops such as rice (Xiao et al. 1996, Lee et al. 2005, Ji et al. 2012), barley (Naz et al. 2012), tomato (Tanksley et al. 1996), pea (Clement et al. 2009), *Vigna* species (Verma et al. 1991, Verma and Brar 1996) and chickpea (Singh and Ocampo 1997, Singh et al. 2005). Results of the present study showed that crossability in interspecific crosses in *Vigna* is genotype dependent and suggest that more number of genotypes of both species should be involved to get more interspecific hybrids. Application of growth hormones to the base of pedicel of flowers helps prevent flower drop (Verma et al. 1990, Singh et al. 2005, Wang et al. 2011). The hybridity of F_1s can be confirmed from the expression of dominant traits of ricebean such as leaf orientation and presence of tendrils and from the intermediate shape and colour of leaves (Pal et al. 1991). The low pollen fertility (55–60%) and low seed set (three to four seeds per pod) in F_1 hybrid plants as compared to female and male parents indicated the extent of partial sterility/fertility of F_1 hybrid plants. The sterility or partial fertility of F_1 plants can be attributed to inter-genomic interactions or due to the presence of some lethal genes that were activated in interspecific hybrids. Poor crossability and partial fertility was also observed earlier by various workers in interspecific crosses involving *Vigna* species (Dar et al. 1991, Verma et al. 1991, Verma and Brar 1996, Gupta et al. 2002). Pandiyan et al. (2008) recovered interspecific hybrids of green gram var. VRM (Gg) 1 with two accessions

Table 6: Reaction of KUG114 and check cultivar Mash338 to different foliar diseases (Maximum score recorded during 2002–2007)

Disease	KUG114	Mash338	RBL1	Susceptible check
Mungbean yellow mosaic virus (1–9 scale)	2.0	5.0	1.0	9.0
Cercospora leaf spot (1–9 scale)	1.0	3.0	1.0	7.0
Bacterial leaf spot (1–9 scale)	1.0	3.0	1.0	7.0

(yellow and red) of *Vigna umbellata* and observed that the F_1 hybrid plants were intermediate in phenotype with light green colour of leaves.

The improvement in fertility of plants in segregating generations from F_2 onwards indicated gradual elimination of undesirable genes or unstable gametes with abnormal chromosome numbers that form univalents or multivalents instead of normal bivalents. Recovery of plants or progenies morphologically similar to female parent, 'Mash338', in general appearance can be attributed to inclined selection towards black gram phenotype. This indicated that directional selection resulted in the selective elimination of ricebean genome during segregating generations. The selective genomic elimination had also been reported earlier by Gill et al. (1983) and Pal et al. (1991) in black gram x green gram crosses. In present study, we have crossed cultivated species, *Vigna mungo,* with another cultivated *Vigna* species, *Vigna umbellata,* having least undesirable traits. Therefore, the simple phenotypic selection in segregating generations resulted in the isolation of desirable progenies. This indicated that if cultivated species are involved in hybridization, there would be minimum linkage drag and desirable traits can be introgressed successfully without using backcross that takes heavy toll of resources and time as also advocated by Gill et al. (1983) and Pal et al. (1991). However, previous studies in other crops have advocated at least two cycles of backcross to eliminate the linkage drag effect (Tanksley and Nelson 1996, Tanksley et al. 1996, Xiao et al. 1996, Fulton et al. 2000, Singh et al. 2005, Ji et al. 2012).

Gradual improvement in average level of resistance to MYMV from F_2 onwards and recovery of progenies with higher degree of resistance to CLS and BLS suggested that desirable traits such as resistance to diseases can be successfully introgressed from related species through stringent selection in target environment. Resistance to biotic stresses has also been introgressed successfully earlier in different legume crops from related species (Dar et al. 1991, Verma et al. 1991, Verma and Brar 1996, Singh et al. 2005). Further, recovery of transgressive segregants for pods per plant and productivity and progenies with higher seed weight compared with female parent indicated that desirable traits such as high pod number, seed weight, productivity and resistance to diseases have been incorporated successfully into black gram from ricebean. Useful traits were also introgressed earlier from related cultivated or wild species in the genus *Vigna*, for example MYMV resistance and other desirable traits into green gram from ricebean (Verma and Brar 1996); higher number of pods and MYMV resistance from wild progenitor species *V. radiata* var. *sublovata* into green gram (Reddy and Singh 1989); and MYMV resistance into green gram from black gram (Gill et al. 1983, Pal et al. 1991). Superiority of the interspecific derivative line KUG114 over the check cultivar for grain yield in almost all the Adaptive Research Trials and Front-Line Demonstrations indicated the stability and adaptability over a range of climatic conditions.

There is a risk of deterioration of nutritional and cooking quality traits while transferring desirable traits from related species. A study conducted on 32 black gram genotypes including KUG114 and 'Mash338' revealed that most of the nutritional quality traits such as total sugars, starch, total soluble proteins and total lipids in KUG114 were comparable with 'Mash338' (Suneja et al. 2011). It also reported that among the anti-nutritional factors, total phenols, *o*-dihydroxyphenols and flavonols were only slightly higher, whereas saponins and phytic acid were slightly lower in KUG114 compared with 'Mash338' (Suneja et al. 2011). The cooking quality traits remained intact in the interspecific derivative KUG114. Overall, the results indicated that productivity, disease resistance and other desirable traits can be successfully incorporated into black gram from ricebean without any adverse effect on nutritional and cooking quality traits.

The other interspecific derivatives, namely KUG215, KUG218 and KUG222 possessing high degree of resistance to MYMV, CLS and BLS, respectively, were found superior to the check cultivar 'Mash338' in the preliminary yield trials, but could not surpass KUG114 for yield potential in multilocation trials and therefore could not be considered for release as cultivars. However, these derivatives are being used in breeding programme to broaden the genetic base and for improving disease resistance level of elite lines of black gram. These derivatives can also be used to study genetics and mapping of resistance gene(s) by developing mapping populations. Further, these derivatives can also be used to transfer high degree of resistance to MYMV into green gram as these two *Vigna* species are easily crossable (Gill et al. 1983, Dar et al. 1991, Pal et al. 1991). These novel gene(s) introgressed from ricebean for resistance to MYMV, CLS and BLS may provide durable resistance in both black gram and green gram. The process of introgression of desirable traits from related species to cultivated ones can further be accelerated using molecular marker–assisted breeding procedures (Kumar et al. 2011, Dhole and Reddy 2012). The advanced interspecific derivatives possessing high degree of resistance to MYMV, CLS and BLS can be screened extensively using molecular markers to identify derivatives having minimum ricebean segments for use in breeding programmes to minimize the noise of undesirable traits.

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