Successful Interspecific hybridization between mungbean [Vigna radiata (L.) Wilczek] and ricebean [V. umbellata (Thunb.) Ohwi & Ohashi]

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Successful Interspecific hybridization between mungbean [*Vigna radiata* (L.) Wilczek] and ricebean [*V. umbellata* (Thunb.) Ohwi & Ohashi]

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ABSTRACT

Successful interspecific hybridization between several cultivars of mungbean (*Vigna radiata*) and ricebean (*V. umbellata*) was achieved using mungbean as the female parent. Hybridization was not achieved if ricebean was used as the female parent. Seeds of hybrids were viable and grew and developed normally, producing viable seeds. The gene action of all observed quantitative characters was partially dominant, implying that it should be possible to produce stable hybrids. The progeny had desirable characteristics of both parents suggesting that interspecific hybridization of the two species could be used to produce a new, superior cultivar.

Key words: Gene action, Hybrids, Interspecific hybridization, Mungbean, Ricebean.

INTRODUCTION

Mungbean (*Vigna radiata*) is one of the main crops in Indonesia. It is an excellent protein source and easily digestible. It is an important short-duration legume crop with wide adaptability, requires low fertilizer inputs and has the ability to improve soil fertility by fixing nitrogen from the air (Arshad *et al*., 2009, Fery, 2002, Turkova and Klozova, 1985). The main problems of mungbean cropping systems are low yields and susceptibility to many pests. The yield and resistance to pests and diseases can be improved through plant breeding programs, but mungbean has a low genetic background (Choudhary *et al*., 2017, Das *et al*., 2015, Somta *et al*., 2007). According to Kumar *et al*. (20s15), Fasoula and Fasoula (2002), genetic variability is essential in plant breeding programs to achieve crop improvement. Ricebean (*V. umbellata*) has superior characters with respect to pod number per plant and resistance to some pests that are not found in mungbean.

This paper reports the interspecific hybridization between mungbean and ricebean and we report the production of hybrids with superior characters. This was achieved by enhancing the number of pods per plant using this genetic trait from ricebean (Ghafoor *et al*., 2002, Gopinathan and Babu, 1985).

MATERIALS AND METHODS

The hybridization work was conducted from May 2010 to August 2011 in pots set up in a shade house at the Agricultural Faculty, Mataram University. Field evaluation was conducted in irrigated lowland. Planting was conducted for 3 weeks at weekly intervals for both the mungbean and ricebean cultivars to maximize the possibility of both species attaining flowering at the same time. The plants were prepared for hybridization by removing one third of the flowers and all of the anthers in the afternoon of the day before the flower was anticipated to flower. Pollination was conducted in the morning by placing pollen from the donor on the pistil of emasculated flowers. The interspecific hybridization between mungbean and ricebean to form the F1 and BC1.1 populations was conducted according to the IITA Research Guide 42 Hand Crossing of cowpea (Myers, 1996) except that pollination is done by hooking the stamen of ricebean to the stigma of the mungbean. Hybrids were evaluated using a randomized completely block design with four replications. The data were analyzed using analysis of variance, Duncan's Multiple Range Test, cross ability degree and estimation of gene action.

RESULTS AND DISCUSSION

Interspecific hybridization between mungbean as female parent and ricebean as male parent was successfully carried out as assessed by the degree of cross ability (%) and change of the offspring characters. Eight F1 populations were obtained using four mungbean genotypes which have different characteristics and two genotypes of ricebean (Table 1). The highest cross ability degree was achieved between the Manyar variety of mungbean with the yellow seed ricebean genotype (65%). The lowest cross ability degree occurred between the Merak variety of mungbean and the yellow seed ricebean (44%).

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Table 1: The degree of cross ability of hybridization between 4 mungbean genotypes and 2 ricebean genotypes.

Type of crossing	Number of crossed flowers	Harvested pods number	Degree of cross ability (%)
Manyar x RBK	240	156	65.0
Manyar x RBM	246	158	64.2
Merak x RBK	232	103	44.4
Merak x RBM	230	110	47.8
Sampeong x RBK	248	157	63.3
Sampeong x RBM	246	159	64.6
Vima x RBK	234	113	48.3
Vima x RBM	236	122	51.7

RBK- yellow seed ricebean, RBM- red seed ricebean.

Hybridization was successful with mungbean as the female receptor but was unsuccessful if the ricebean was used as the female receptor (Table 2). The incompatibility with ricebean as the female receptor could be because it lack a compound suitable for the germination of mungbean pollen (Thiyagu *et al.,* 2008 and Somta *et al.,* 2006). Another possibility could be the relative length of the stylus in mungbean and ricebean, where that of mungbean is shorter, being 1.6 mm compared with 1.4 for ricebean. Barathi *et al*. (2006) demonstrated that even though pollen can germinate, fertilization of the ovum may not be possible if the stylus is too long. Hence fertilization of the ova of ricebean may be difficult for this reason.

The different cross ability level of *Vigna* species has been reported by Bharathi *et al*. (2006) and Chen *et al*. (1977). Some researchers have successfully crossed mungbean and ricebean but they have reported a low level of cross compatibility (Chowdhury and Chowdhury, 1978, Ahn and Hartmann 1978, Thiyagu *et al*., 2008). The relatively high cross compatibility that we report in Table 1 implies that the two species can be successfully hybridized, provided that the timing of anthesis and stigma receptivity is the same for both parents.

Table 2: The degree of cross ability of mungbean as female receptor and ricebean as female receptor.

Type of crossing	Degree of cross ability (%)	
	Mungbean as female	Ricebean as female
Manyar x RBK	63.9	0
Manyar x RBM	61.7	0
Merak x RBK	44.4	0
Merak x RBM	49.1	0
Sampeong x RBK	60.6	0
Sampeong x RBM	62.5	0
Vima x RBK	46.2	0
Vima x RBM	50.6	0

RBK- yellow seed ricebean, RBM- red seed ricebean.

Backcrossing between hybrids and mungbean as female parent was also successful (Table 3). The cross ability degree of backcrossing was lower than for interspecific hybridization between mungbean and ricebean (Table 1). The highest degree of cross ability was achieved between hybrids and their female parent (62% for (Sampeong x RBM) x Sampeong) and 61.5% for (Manyar x RBK) x Manyar). The lowest degree of cross ability occurred with hybrids from crosses between the Merak variety of mungbean and yellow seed ricebean and the female parent (Merak x RBK) x Merak (38.3 %).

Hybridization is considered successful if the offspring characteristics are different from their parents, especially the female parent. The quantitative and qualitative characters of the hybrids were different from those of the parents (Table 4). This provides further evidence that interspecific hybridization between mungbean and ricebean has been successful. In this regard, both species have the same chromosome number (2n = 2x = 22), an important factor in facilitating successful interspecies crossing (Gopinathan and Babu, 1985).

Table 3: The degree of cross ability of backcross between hybrids and mungbean as female parent.

Type of crossing	Number of crossed flowers	Harvested pods number	Degree of cross ability (%)
(Manyar x RBK) x Manyar	192	118	61.5
(Manyar x RBM) x Manyar	191	113	59.2
(Merak x RBK) x Merak	188	72	38.3
(Merak x RBM) x Merak	183	74	40.4
Merak x (Merak x RBM)	190	86	45.3
(Sampeong x RBK)xSampeong	198	115	58.1
(Sampeong x RBM)xSampeong	193	120	62.2
(Vima X RBK) x Vima	184	85	46.2
(Vima X RBM) x Vima	189	87	46.0
Vima x (Vima x RBM)	188	83	44.2

Note : RBK = yellow seed ricebean, RBM = red seed ricebean.

Table 4: The characteristics of parents and hybrids of interspecific hybridization between mungbean and ricebean.

Characteristics	Mungbean as female parent	Ricebean as male parent	Hybrids (F1)
Seed color	Green	Red	Brown
Plant height (cm)	58	106	83
Number of pod plant^{-1}	23	64	46
Maturity date (days)	62	86	68
Protein content (%)	27	18	29
Carbohydrate content (%)	16	54	28
Resistance to bruchus pest	Susceptible	Tolerant	Tolerant

The production of hybrids with characteristics that vary from their parents has also been reported between cowpea having short and stiff pods and longbean having long and soft pods producing offspring with characteristic combinations of both parents (Ujianto *et al.*, 2012). The research results of Chen *et al*. (1982) indicated that characteristics of interspecific hybridization among four species of vigna food legumes showed incorporation of their parent characteristics.

Tables 5 and 6 show that all offspring from the population crosses showed high seed germination ability (more than 80% required for certification standard). Seed germination of hybrids (F1) from crosses between the Manyar variety of mungbean and yellow seed ricebean (MR x RBK) or with red seed ricebean (MR x RBM) was not significantly different from that of their parents. Seed germination of hybrids from crosses between the Sampeong variety of mungbean with red seed ricebean (F1 S x RBM) was not significantly different from the male parent. Likewise, with backcross offspring between the first offspring with the female parent, seed germination was not significantly different.

Table 6 shows that the seed germination ability among female parents, Merak (MK) and Vima (V) varieties of mungbean, with red seed ricebean (RBM) as male parent is not significantly different either in the first or second generation. Seed germination in offspring from crosses of the Merak variety mungbean and red seed ricebean in F2 (MK x RBM) and the Vima variety mungbean with red seed ricebean in F2 (V x RBM) is higher than in the BC1 backcross except with V x (F1 (V x RBM). Seed germination of offspring from all cross combinations was more than 90%. This suggests that the offspring from crosses seeds have high viability.

Table 7 shows that the potential ratio values were between 0.25 and 0.75. None of the values were less than 0.25, indicative of low dominance, nor in the range 0.75 – 1.25, typical of high dominance (Ullah *et al*., 2010, Peter and Frey, 1966). Therefore the data in Table 7 imply partial dominance and that one parent has greater influence than the other parent. As there were progeny having character

Tabel 5: Seed germination of progeny population of result of crossing between mungbean (Manyar and Sampeong varieties) and ricebean (yellow and red seeds).

Genotype	Seed germination (%)	
	Mean	Standard error
Manyar (MR)	95.50 abcd	1.60
Sampeong (S)	89.17 a	1.59
Yellow seed ricebean (RBK)	94.17 bcde	1.60
Red seed ricebean (RBM)	95.56 cde	0.91
F1 (MR x RBK)	90.83 ab	1.59
F1 (MR x RBM)	93.33 abcde	1.93
F1 (S x RBK)	94.17 bcde	0.84
F1 (S x RBM)	92.50 abcd	0.83
BC1 (F1(MR x RBK) x MR)	94.44 bcde	0.64
BC1 (F1(MR x RBM) x MR)	94.44 bcde	0.64
BC1 (F1(S x RBK) x S)	91.11 abc	0.91
BC1 (F1(S x RBM) x S)	92.78 abcd	1.40
F2 (MR x RBK)	97.98 e	0.41
F2 (MR x RBM)	97.50 de	0.30
F2 (S x RBK)	96.90 de	0.46
F2 (S x RBM)	96.55 de	0.49

The numbers followed by the same letter in the same column indicates no significant difference based on Duncan's Multiple Range Test at the 5% significance level.

Table 6: Seed germination of progeny population of the result of crossing between mungbean (Merak and Vima varieties) and ricebean (red seed).

Genotype	Seed germination (%)	
	Mean	Standard error
Merak (MK)	95.56 ab	0.91
Vima (V)	97.22 ab	1.06
Red seed ricebean(RBM)	95.56 ab	0.91
F1 (MK x RBM)	95.00 ab	0.56
F1 (V x RBM)	96.11 ab	1.06
BC1 (F1(MK x RBM) x MK)	94.58 a	1.05
BC1 (MK x F1(MK x RBM))	94.58 a	1.25
BC1 (F1V x RBM) x V	94.58 a	1.42
BC1 V x (F1V x RBM)	95.00 ab	0.68
F2 (MK x RBM)	98.33 b	0.28
F2 (V x RBM)	98.33 b	0.38

The numbers followed by the same letter in the same column indicates no significant difference based on Duncan's Multiple Range Test at the 5% significance level.

Table 7: Gene action of some observed quantitative traits of some crossing types.

	Crossing types	Low parent	Parent mean	High parent	F1	Ratio
Plant	MR x RBK	68.60	99.15	129.70	75.60	0.385
Height	MR X RBM	68.60	92.90	117.20	73.90	0.391
(cm)	MK x RBM	62.40	87.70	113.00	51.00	0.725
	S x RBK	68.40	99.05	129.70	72.20	0.438
	S x RBM	68.40	92.80	117.20	78.70	0.289
	V x RBM	41.80	79.55	117.30	54.50	0.332
Maturity	MR x RBK	68.86	81.83	94.80	71.20	0.410
Date	MR X RBM	68.86	82.28	95.70	71.50	0.402
	MK x RBM	61.91	76.79	91.66	63.26	0.455
	S x RBK	70.56	82.68	94.80	74.50	0.337
	S x RBM	70.56	83.13	95.70	74.40	0.347
	V x RBM	59.21	75.44	91.66	64.14	0.348
Number	MR x RBK	18.70	36.95	55.20	21.40	0.426
of pods	MR X RBM	18.70	37.15	55.60	20.70	0.446
Plant^{-1}	MK x RBM	15.61	34.15	52.69	17.40	0.452
	S x RBK	15.40	35.30	55.20	22.80	0.314
	S x RBM	15.40	35.50	55.60	22.80	0.316
	V x RBM	14.62	33.66	52.69	17.60	0.422
Seed	MR x RBK	9.63	19.22	28.80	12.40	0.356
Weight	MR X RBM	9.63	18.22	26.80	10.60	0.444
Plant^{-1}	MK x RBM	8.40	18.95	29.50	9.40	0.453
(g)	S x RBK	7.90	18.35	28.80	10.80	0.361
	S x RBM	7.90	17.35	26.80	11.70	0.299
	V x RBM	7.60	18.55	29.50	10.60	0.363

The gene actions for all crosses were partly dominant.

combinations of both parents the production of a new superior variety should be possible.

CONCLUSION

Hybridization was successful with mungbean as the female receptor but was unsuccessful if the ricebean was used as the female receptor. Backcrossing between hybrids and mungbean as female parent was also successful. The cross ability degree of backcrossing was lower than for interspecific hybridization between mungbean and ricebean. All offspring from the population crosses showed high seed germination ability. The gene action of all observed quantitative characters was partially dominant.

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