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An Analysis of Yield Gains through Breeding High-Yielding Varieties in Urdbean and Mungbean

ARBIND K CHOUDHARY[1]*, REVANAPPA SB AND VIJAYAKUMAR AG[2]

IIPR Regional Research Centre cum Offseason Nursery, Dharwad, Karnataka, India

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ABSTRACT

One varietal trial each in urdbean and mungbean, each comprising 10 varieties released during succeeding years since 1975, was conducted following randomized complete blockdesign (RCBD) in three replications during kharif 2013. The analysis of variance showed significant differences among varieties in each trial. Significant genetic advances were observed for earliness in newly released varieties of both urdbean (~ 4 days) and mungbean (4.6 days), implying substantial gain in per day productivity. Newly released varieties urdbean (DBGV-5 and IPU 2-43) did not display any yield advancement over the oldest one (T-9). However, a significant genetic gain in yield (62.60 kg/ha) was recorded in mungbean due to a recently released variety 'DGGV-1', indicating about 60% contribution of improved varieties towards increase of national average yield (105 kg/ha) during the period 1990-2015. In conclusion, the increased area coverage under HYVs having multiple disease resistance and better agronomic practices could reasonably explain the productivity (average yield) gains in both urdbean and mungbean.

Key word: Yield increase, genetic enhancement, high-yielding varieties, urdbean, mungbean, agronomic practices

INTRODUCTION

Urdbean [*Vigna mungo* (L.) Hepper] and mungbean [(*Vigna radiata* (L.) Wilczek] are the two important short duration annual pulses of India. Their seeds contain 25-28% protein. Although their protein is deficient in sulphur-containing amino acids (cysteine and methionine), methionine content in urdbeanseeds is more than mungbean. Seeds of both these grain legumes are used for different purposes. The major portion is utilized in making dal, curries, soup, sweets and snacks (Katiyar *et al.*, 2009; Singh *et al.*, 2009). In South India, the important preparations of urdbean grains include *idli* and *dosa*after mixing with rice (Katiyar *et al.*, 2009). The germinated seeds of mungbean have nutritional value as high as protein-rich mushroom. Besides this, sprouting enhances thiamine, niacin and ascorbic acid concentration of mungbean seeds (Singh *et al.*, 2009).

Urdbean and mungbean are cultivated in all the five agro-climatic zones (North East plain zone, North West plain zone, Central Zone, South Zone and North hill zone) of India. Being warm season pulses both can be grown in spring, summer or rainy seasons. However, maximum area is occupied under kharif season mostly as intercrop with sorghum, pearl millet, maize, pigeonpea, cotton, and the like. Their intercropping with tall cereals and pigeonpeaboth in low and high input agriculture leads to smothering effect on weed flora (Katiyar *et al.*, 2009; Singh *et al.*, 2009).

These two crops account for 26.60% and 20.17%of the total pulses area (23.55 m ha) and production (17.15 mt), respectively. The disproportionate contribution towards total pulse production owes to low productivity of both urdbean (604 kg/ha) and mungbean (498 kg/ha) compared to average production (728 kg/ha) of total pulses during 2014-15 (AICRP on MULLaRP, 2016).

The varietal improvement programme got impetus after the inception of All India Coordinated Pulses Improvement Project (AICPIP) in 1966-67. The major thrust was placed on development of early maturing, high-yielding varieties (HYVs) with resistance to mungbean yellow mosaic virus (MYMV) and powdery mildew (PM) diseases. As a result, a number of improved varieties have been released during the last five decades (AICRP on MULLaRP, 2016). Since the last four decades (1974-75 to 2014-15),over 95% and 75% productivity gains have occurred in urdbean and mungbean, respectively (Fig. 1). The yield gains may be ascribed to cultivation of improved varieties and adoption of better agronomic package of practices. Furthermore, the potential yield of improved varieties in front line demonstrations has been reported to be more than twice of the

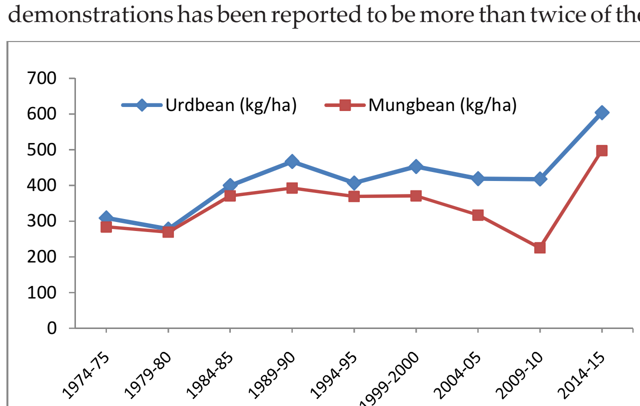

Fig. 1: National Productivity (kg/ha) of urdbean and mungbean since 1974-75.
(Source: AICRP on MULLaRP, 2016)

[1]Present address: ICAR Research Complex for Eastern Region, Patna, Bihar, India
[2] AICRP ON MULLaRP, University of Agricultural Science, Dharward, Karnataka, India
*Corresponding Author Email: akiipr23@yahoo.com

present national average, indicating substantial scope for enhancing productivity of these two crops.The present investigation was undertaken to assess the extent of genetic gains among some released cultivars of both urdbean and mungbean.

Table 1: Description of urdbean and mungbean varieties used in the study

Variety	Pedigree	Year
	Urdbean	
DBGV-5	TAU-1 × LBG-20	2012
TAU-1	T 9 × U 196	1985
DU-1	Irradiated progeny of single cross TAU-1 × 169	2008
VBN-5	VBN 1× UK 17	2006
LBG-685	LBG 402 × (NM/CKM)	1999
TU-94-2	TPU 3× TAUs (Mutation)	1998
LBG-752	LBG402 × LBG20	2009
IPU-02-43	DPU 88-31 × DUR-1	2008
T-9	Local selection from Bareilly (U.P.)	1975
COBG653	DU2× VP20	2009
	Mungbean	
DGGV-1	Selection from Shining mung	2014
DGGV-2	Chinamung × TM -98-50	2014
DGGS4	Selection 4 × TM 98-50	2014
Selection-14	Selection from Bidar Local	1990
IPM-02-14	IPM99125×Pusa bold2	2010
TM-96-2	Kopergaon × TARM 2	2007
KKM-3	China mung × WGG 2	2009
SML-668	Selection from NM 94	2002
C0-6	WGG 37×CO 5	1999
DGGV-3*	GG-4 × TM 98-50	2013

*An advance breeding line.

MATERIALS AND METHODS

Ten varieties each of black gram and green gram were used in the present study. The detailed description of these varieties is given in Table 1. Two separate varietal trials were formulated in randomized complete block design (RCBD) at Regional Research Centre cum Offseason Nursery, Dharwad (Karnataka) under the Indian Institute of Pulses Research (IIPR), Kanpur during kharif season, 2013. Each variety was replicated thrice with inter-row and inter-plant spacing of 30 cm and 10 cm, respectively. Plot size for each entry was kept at 7.20 m^2 (6× 0.3 m × 4.0 m). The soil of the centre is black clay loam.

The basal dose of fertilizers @ 20 kg N, 40 kg P_2O_5 and 40 kg K_2O was provided to raise good crops. The trials were sown during the 2^{nd} fortnight of June 2013. Plants were thinned out at 15 days after sowing to maintain optimum inter-plant distance.

Data were recorded on days to flowering (50%), maturity period (days) and yield/plot (kg) in each replication for each variety on per plot basis. Yield/plot data were transformed into yield/ha (kg). The analysis of variance was performed as per Singh and Choudhary (1977) by using an online available statistical package (OPSTAT). The phenotypic and genotypic variances were computed as suggested by Burton and Dewane (1952). The estimates of other genetic parameters such as broad sense heritability (h^2) and genetic advance (GA) were calculated as per Hanson *et al.* (1956) and Johnson *et al.* (1955), respectively. Expected genetic advance (gain) was calculated at 10% selection intensity.

RESULTS AND DISCUSSION

The analysis variance (ANOVA) showed highly significant differences for days to flowering, maturity period and yield/ha ($P \leq 0.01$) among the released varieties in black gram (data not presented). In green gram, however, the difference for yield among varieties was not so conspicuous ($P \leq 0.05$). In urdbean (Table 2), the variety 'T-9' (1416 kg/ha) yielded the highest followed by 'COBG 653' (1236 kg/ha) and 'IPU 2-43' (1134 kg/ha).

However, the first two varieties were late maturing (> 84 days) compared to 'IPU 2-43 (< 80 days). The variety 'LBG 685' which recorded the lowest yield (384 kg/ha) had medium maturity period (> 83 days). In green gram, the variety 'DGGV-1' (642 kg/ha) outyielded all others followed by 'TM96-2' (578 kg/ha)

Table 2: Mean performance of urdbean and mungbean varieties.

Crop	Variety	Characters		
		Yield (kg/ha)	Maturity period (50%)	Days to flowering (days)
Urdbean	DBGV-5	1,058	43.00	82.67
	TAU-1	1,099	41.67	79.67
	DU-1	840	42.67	81.33
	VBN-5	1132	46.33	**86.67**
	LBG-685	**385**	44.00	83.67
	TU-94-2	754	41.00	81.00
	LBG-752	929	43.33	83.33
	IPU02-43	1134	**40.33**	**79.67**
	T-9	**1,417**	42.33	84.33
	COBG-653	1,237	**47.00**	85.00
	SEm	75.36	0.44	0.41
	LSD (P=0.05)	225.65	1.31	1.24
	cv (%)	13.07	1.76	0.87
Mungbean	DGGV-1	**642**	40.67	72.33
	DGGV-2	**393**	**39.67**	74.67
	DGGS-4	436	41.33	**70.33**
	Selection-4	484	39.67	73.67
	IPM 02-14	543	42.33	75.33
	TM 96-2	578	44.00	77.67
	KKM-3	533	41.33	72.67
	SML-668	472	41.00	75.33
	C0-6	561	**44.67**	**79.33**
	DGGV-3	519	40.00	72.67
	SEm (±)	43.24	0.37	0.34
	LSD (P=0.05)	129.46	1.11	1.00
	cv (%)	14.51	1.55	0.78

and 'CO-6' (561 kg/ha). The variety 'DGGV-2' was the lowest yielder (393 kg/ha). 'DGGS-4' appeared to be the earliest maturing variety (70.33 days), whereas 'CO-6' recorded maximum maturity period (>79 days).

Numerical estimates of genetic parameters are presented in Table 3. The estimates of phenotypic variance were higher than genetic variance for all the characters in both black gram and green gram, showing the positive effects of growing environment on the expression of phenotypic differences among varieties under study. However, the numerical values were substantially large in urdbean compared to mungbean. This was expected as the yearly range for release of urdbean varieties (1975-2012) included in the trial was more conspicuous (37 years) than that of mungbean varieties (1990-2014; 24 years).

All the characters except yield/ha in green gram recorded high (>80%) broad sense heritability (h^2). The expected genetic advance (GA) for maturity period was slightly more in green gram (4.55 days) than black gram (3.82 days). However, urdbean recorded significantly higher genetic advance (443 kg/ha) for yield than mungbean (63 kg/ha). As both are highly autogamous crops, the expected genetic advance is likely to be realized in the next generation. The GA (%) for yield in black gram (44.40%) was substantially higher than that of mungbean (12.12%); for maturity period, however, a reverse trend was observed (Table 3).

Table 3: Numerical estimates of genetic parameters

Characters	Numerical estimates of genetic parameters				
	Genetic variance	Phenotypic variance	Heritability (%)	Genetic advance	Genetic advance (%)
Urdbean					
Days to flowering (50%)	4.40	4.98	88.35	3.47	8.04
Days to maturity	5.18	5.70	90.87	3.82	4.61
Yield (kg/ha)	77423	94461	81.96	443.35	44.40
Mungbean					
Days to flowering (50%)	2.86	3.27	87.46	2.78	6.72
Days to maturity	7.02	7.36	95.38	4.55	6.11
Yield (kg/ha)	3370	8979	37.53	62.60	12.12

An Analysis of Genetic Gain

There was no significant difference in the yield (Table 2) of urdbean varieties 'T-9' (1417 kg/ha) and 'COBG-653' (1237 kg/ha) which were respectively released in the year 1975 and 2009 (Table 1), implying no yield gain through breeding. Similarly, the difference in yield between 'COBG-653' (1237 kg/ha) and 'IPU 2-43' (1134 kg/ha) was non-significant; although 'IPU 2-43' showed significant maturity advantage (> 5 days) over 'COBG-653', indicating significant gain in earliness and per day productivity in urdbean. In mungbean, there was significant yield difference between 'DGGV-1' (642 kg/ha) and 'Selection-4' (484 kg/ha), and 'DGGV-1' also showed maturity advantage at least by one day over 'Selection-4'. Within the limit of critical difference, the realized yield of three varieties, namely 'DGGV-1' (642 kg/ha), 'CO-6' (561 kg/ha) and 'IPM 2-14' (543 kg/ha) was almost equivalent. However, 'DGGV-1' was the earliest to mature (~ 72 days) compared to 'CO-6' (> 79 days) and 'IPM 2-14' (> 75 days). Therefore, breeding has indeed been successful in enhancing the potential yield and per day productivity of improved varieties (1990→2014).

During the period of 40 years (1975-2015), national productivity of black gram almost doubled from 309 kg/ha to 604 kg/ha (Fig. 1). It appears that increased area coverage under HYV shaving multiple resistance to diseases like MYMV and PM that is evident from substantial increase of breeder seed production (Katiyar *et al*., 2009; MULLaRP, 2016) and adoption of better agronomic practices accounted for over 95 per cent gain in productivity although genetic enhancement for yield in newly released cultivars (IPU 2-43 and COBG 653) did not occur over T-9, a variety released as early as 1975 (Table 1). In mungbean, genetic advance for yield (62.60 kg/ha) that did occur due to newly released varieties (DGGV-1, CO-6 and IPM 2-3) besides above-mentioned factors resulted in the productivity gain of 105 kg/ha (1990→ 2015).

CONCLUSION

Breeders have been successful in developing early maturing varieties having multiple disease resistance with little yield penalty in blackgram, indicating significant improvement in per day productivity. In green gram, besides disease resistance and per day productivity breeding has also resulted in marginal genetic advance (62.60 kg/ha) for yield due to recently released improved varieties. The increased area under HYVs having MYMV and PM resistance and adoption of better agronomic practices could account for over 95% and 75% gain in national productivity of urdbean and mungbean, respectively. The present study also indicates that there is only limited variation in the present-day varieties of both urdbean and mungbean.

To have further advancement in yield through breeding, widening of the genetic base of germplasm is needed that may be achieved through pre-breeding, wild introgression and attempting multi-parent intercrosses (MIC). The products of such endeavours (breeding materials, advance breeding lines), if evaluated precisely under targeted environment (for which variety is intended to be released), may result in expected genetic advance for yield and other economic attributes (Sultana *et al*., 2014).

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