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Full Length Article

Induced Synchrony in Pod Maturity in Mungbean (*Vigna radiata*)

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ABSTRACT

The aim of this work was to study γ-radiation induced synchony in the maturity of mungbean and correlation of days to flowering and pod maturity between two diverse mungbean genotypes. The results showed reduced synchronous flowering with no correlation between flowering and maturity period. The mungbean genotypes 'K851' and 'Sona' had reduced flowering and late maturity in mutated lines with an exception of early maturity in 10 Gy in 'Sona'. Degree of indetermination (DDd) was controlled by both additive and dominant gene effects with predominance of additive component. Constant genotypic variance and high broad sense heritability for days to first flowering (D_1), days to first pod maturity (D_2) and DDd from first pod maturity to 90% pod maturity (DDd_2) indicated an opportunity for successful selection of mungbean genotypes for uniform pods maturity. Selection of elite mutant lines with synchronous maturity (SM) would be possible in the M_3-M_4 generations.

Key Words: *Vigna radiate*; *Vigna mungo*; Greengram; synchronous; Mutagenesis; Indetermination

Abbreviations: IM: Induced mutagenesis, SM: Synchronous Maturity, SF: Synchronous flowering, SY: Seed yield, Vg: Genotypic variance, Vp: Phenotypic variance, h^2: Heritability, Rg: Genotypic correlation, DM: Days to Maturity, DF: Days to flowering, D_1: Days to first flowering, D_2: Days to first pod maturity, D_3: Days to 90% pod maturity, DDd: Degree of indetermination, HT: High temperature and HI: Harvest Index.

INTRODUCTION

Mutation breeding is a useful technique for creation and selection of desirable variability in a crop and could be a driving force for evolution besides selection in a crop like mungbean, where designed cross pollination is tedious. Mutations could be induced through physical and chemical mutagens (Ahloowalia *et al*., 2004; Chopra, 2005; Jain, 2005; Sangsiri, 2005). Several authors previously reported positive effect of synchronous pod maturity in seed yield (Afzal *et al*., 2003; Pierre *et al*., 2003; Hamid *et al*., 2004; Chen *et al*., 2008). Induction of flowering and synchronous transformation from vegetative phase to the floral initiation is an important stage of synchronous maturity (Corbesier *et al*., 2003). The time of pod maturation is an important factor in the synchronous pod maturation and the information on the degree of indetermination of growth duration may help to adopt suitable and efficient plant breeding strategies to develop high yielding mungbean genotypes with synchronous growth habit (Sharma-Natu & Ghildiyal, 2005). The term degree of indetermination has been used to describe variation from days to first flowering (D_1) to days to 90% pod maturity (D_3) in mungbean (*Vigna radiata* L. Wilczek) (Khattak *et al*., 2001). Despite the importance of synchronous maturity, mungbean pod ripening is not synchronous (Yeates *et al.,* 2000). Uneven pod maturity leads to low yield and low harvesting index (HI) in mungbean (Bushby & Lawn, 1992; Egli & Bruening, 2006). A high harvest index means high proportion of total biomass production. Thus in order to increase the seed yield, selection of higher harvest index genotypes could be achieved through synchronous maturity. The inverse effects on seed yield due to high leafiness and asynchronous flowering have been observed (Bisht *et al*., 1998 & 2005).

Opportunities exist to obtain potential mutants with synchronous maturity through induced mutagenesis. Such mutagenesis would help develop mungbean cultivars fit in as a main pulse crop in fertile lands in Asian countries, without competing directly with major crops like wheat, rice and cotton. The objective of this experiment was to study the synchrony in pod maturity in terms of degree of indetermination.

MATERIALS AND METHODS

This work presented here was conducted to study novel mungbean mutants with synchronous maturity. To achieve this aim, two mungbean genotype, 'K851' ('Amrit'

*'Pusa Baisakhi') and 'Sona' ('4453-3' *'type 1') were selected. Induced mutagenesis (dose: 10 Gy, 20 Gy, 30 Gy & 40 Gy) was performed with γ-radiation (Cobalt 60) using 100 uniform (for each dose) and healthy seeds of 'K851' and 'Sona' for the M_1 generation. The treated and control (un-treated) seeds were sown in the field and seeds of M_1 plants and control were harvested separately and planted in plant progeny rows in M_2 generation.

Data were collected from 15 randomly selected plants of uniform size for the following characters (Khattak *et al*., 2001):

1. Days to first flower (D_1).
2. Days to first pod maturity (D_2).
3. Days to 90% pod maturity (D_3).
4. Degree of indetermination (DDd) for pod maturity was calculated as below:

(i). DDd from first flower to 90% pod maturity (DDd_1) = (D_3-D_1)*100/D_3.

(ii). DDd from first pod maturity to 90% pod maturity (DDd_2) = (D_3-D_2)*100/D_3.

Statistical analysis. Statistical analysis (2 mungbean genotypes & 5 treatment doses) was performed according to Factorial Random Block Design in M_1 generation. In M_2 generation the statistical analysis was performed simply through randomised block design. Statistical software SPSS (version 15) was used for Pearson multivariate tests for correlation studies. Analysis of genotypic (Vg) and phenotypic variance (Vp), broad sense heritability (h^2BS) and genotypic correlation (Rg) was done following (Kumar *et al*., 2008).

RESULTS

Eleven synchronously matured mutants were observed in 'K851' and 7 in 'Sona'. The synchronously maturing plants were isolated mostly in 30 Gy and to a lesser extent in 10, 20 and 40 Gy doses of γ-radiations. The variation was significant (P<0.008) in 'K851' and (P<0.001) in 'Sona' for flowering, maturity and DDd for pod maturity (Table I). The mean squares revealed that D_2, D_3 and DDd from first flower to 90% pod maturity (DDd_1) were controlled by higher residual effect in 'K851' than 'Sona'. The estimates of broad sense heritability were high, exceeding to 89.9 in D_1, D_2, D_3 and DDd (Table II). The genotypic variance (Vg) ranged between 8-22% and constant for D_1, D_2 and DDd_2 indicated additive, whilst a high Vg for D_3 and DDd_1 indicated dominance.

The mean days to flowering was the minimum (41.1) at 20 Gy and ranged between 41.3-43.6 days in 'K851'. In 'Sona', the mean days to flowering was also in the minimum (42.6) at 20 Gy and ranged between 43.1-44.9 days (Table III). The mean days to maturity was also minimum (59.8) at 20 Gy and ranged between 60.2-65.1 days in 'K851'. However in 'Sona', the mean days to maturity was the minimum in control (65.3) and ranged between 65.5-69.1 days. A lower degree of indetermination from first flower to 90% pod maturity in 'K851' ranged between 44.9-45.8 in 20, 30 and 40 Gy than control (50.0) was observed, whilst in 'Sona', a lower DDd_1 in 10 Gy (44.9) than control (45.7) and a lower DDd_2 in 10 Gy (14.4) than control (17.1) was observed (Table III).

Table I. Mean squares from linear regression analysis of 'K851' and 'Sona' mutagen treated seeds

Parameter	df	Mode: K851	Model: Sona
		Mean Square	Mean Square
Regression	4	484.682 **	487.292 **
Residual	3	14.932	1.130
Total	7		

df: degrees of freedom; **P<0.001)

Table II. Mean (±standard error), co-efficient of variation (CV), genotypic (Vg) and phenotypic variance (Vp) and heritability (h^2BS) of days to flowering and the maturity days of mungbean of 'K851' and 'Sona'

Parameter	Min	Max	Mean±S.E	St.dev	CV (%)	Vg	Vp	h^2BS (%)
D_1	31	39	36.3±0.9	2.8	7.7	8.0	8.9	89.9
D_2	52	62	57.5±0.9	2.9	5.1	8.5	9.4	90.2
D_3	64	79	70.3±1.5	4.7	6.7	22.4	23.9	93.7
DDd_1	44.9	54.4	48.3±1.1	3.3	6.9	11.3	12.4	91.4
DDd_2	12.5	21.5	18.1±0.9	2.8	15.9	8.2	9.2	90.1

Table III. Mean scores of days to 50% flowering and days to maturity of 'K851' and 'Sona'

Variety (dose in Gy)	Days to flowering			Days to maturity			*DDd_1	*DDd_2
K851								
	Mean	Min	Max	Mean	Min	Max		
0 (Control)	43.6	32	50	60.2	56	64	50.0	12.5
10	41.3	31	52	61.0	54	68	54.4	20.5
20	41.1	35	54	59.8	52	64	45.3	18.7
30	42.8	38	50	64.9	57	69	44.9	17.3
40	43.6	39	51	65.1	59	72	45.8	18.0
Sona								
0 (Control)	44.9	38	50	65.3	58	70	45.7	17.1
10	43.2	38	48	65.5	59	69	44.9	14.4
20	42.6	36	50	66.3	58	72	50.0	19.4
30	43.1	37	49	68.9	60	76	51.3	21.0
40	43.8	39	51	69.1	62	79	50.6	21.5

*DDd from first flower to 90% pod maturity (DDd_1) and first pod maturity to 90% pod maturity (DDd_2)

Table IV. Correlation coefficients among seed yield and its contributing traits of 15 selected mutant lines in M_2 generation of 'K851' and 'Sona'

Parameters	D_1	D_2	D_3	DDd_1	DDd_2
Days to first flower (D_1)					
Days to first pod maturity (D_2)	0.70*				
Days to 90% pod maturity (D_3)	0.61	0.86**			
DDd first flower to 90% pod maturity (DDd_1)	-0.5	0.03	0.27		
DDd first pod maturity to 90% pod maturity (DDd_2)	0.16	0.18	0.65*	0.45	

Significant at *P<0.05 and ** P<0.01

The correlation was significant (r=0.7) between mean days to flowering to days to first flower and first pod maturity for 'K851' and 'Sona' (Table IV). Highly significant correlation (r=0.9) between the mean days to flowering in 'Sona' to D_2 and D_3 was also observed. The D_3 was significantly correlated (r=0.6) with DDd_2 in both 'K851' and 'Sona'. A negative correlation (-0.5) between D_1 and DDd_1 was observed in both 'K851' and 'Sona' (Table IV).

DISCUSSION

Synchronous maturity is a primary breeding objective that ensures cost effective single harvesting, contributes in productivity (i.e., increases photosynthate production) and reduces common diseases like Cercospora Leaf Spot and Yellow Mosaic in mungbean (Khattak *et al*., 2001 & 2006a). The objective of the current study was to evaluate the induced synchrony in pod maturity in mungbean in terms of degree of indetermination, which was highlighted from significant correlation between days to first flower, first pod maturity, 90% pod maturity and degree of indetermination from first pod maturity to 90% pod maturity indicating synchronous flowering and uniform pod maturity. Uniformity in pod maturity with low degree of indetermination could be useful to grow mungbean as a catch crop with no competition with major crops like wheat, rice and cotton (Khattak *et al*., 2001). Synchronous maturity in mutant mungbean was reported using 500 Gy γ-radiation dose by Wongpiyasatid *et al*. (1998). This study further illustrates a decrease in synchronous flowering period from 18 days in control to 12 days in 30 and 40 Gy, whilst decrease in flowering period from 12 days in control to 10 days in 10 Gy was also observed. In 'K851' the flowering took a week less (12) days than the control (18 days). On the contrary, at higher dose, lateness of 4 to 8 days in pod maturity was observed in both 'K851' and 'Sona' with an exception of early pod maturity in 10 Gy (10 days) than control (12 days). Even though flowering period extended 1-2 days longer than control, the mean days to flowering was minimum in 20 Gy in both the varieties, indicating the positive effect of mutagen treatment on synchronous flowering. Early pod maturity and low degree of indetermination of pod maturity could be useful for mungbean to grow as a catch crop with uniform pod maturity with no competition with rice, wheat and cotton etc. Previously, Bisht (1998) also reported about the normal duration of synchronous flowering ranged between 11-15 days in mungbean.

In the current study, increase in maturity period at high mutagen dose indicated negative correlation between D_1 and DDd_1 at higher mutagen dose. Previously, Bisht (1998) also reported no correlation between days to flowering and days to maturity, the features of synchronous genotypes. The results further illustrate that earliness in flowering period did not influence the maturity period of the mutants due to prolong time taken in early pod set by mutant lines to achieve the harvesting stage. The days to maturity has been considered important for the selection of better mungbean lines including 'BUmug-1', 'BARImug 2', 'BARImug 3', 'Barimung -5', 'NM 51', 'NM 92', 'NM 93', 'AVRDC', 'Pusa Baisakhi', 'Ramzan' and 'VC 6372' (45-8-1) in terms of seed yield, early maturity and synchronous fruiting pattern (Afzal *et al*., 2003; Karim *et al*., 2003; Hamid *et al*., 2004; Sarwar *et al*., 2004; Khattak *et al*., 2006a). Such a degree of determination and Synchronous flowering would help improve the harvest index and consequently seed yield in mungbean (Sharma-Natu & Ghildiyal, 2005).

In the current study, analysis of variance indicated a higher residual effect in 'K851' and could indicate the possibility of higher dominance in 'K851' than 'Sona'. The high residual effect in 'K851' could indicate the effect of dominance and environment in degree of indetermination from first flower to 90% pod maturity and degree of indetermination from first pod maturity to 90% pod maturity. On the contrary, high residual effect could also be due to effect of high temperature on delayed flowering and maturity and could be a mechanism to skip flowering due to high temperature (Karim *et al*., 2003). The effect of high intensity light and high temperature has also been reported to completely inhibit the pod setting, whilst viability of pollen grains in low light and high temperature leading to early flowering (Karim *et al*., 2003). Given the effect of high temperature on pollen grains, the genotypes with more synchrony in pod maturity could be more prone to less flowering and reply on more flower production in short time interval between flushes (Khattak *et al*., 2006b). The effect of dominance on degree of indetermination from first pod maturity to 90% pod maturity was previously reported by Khattak *et al*. (2001). In the current study, constant genotypic variance in days to first flower, days to first pod maturity and degree of indetermination from first pod maturity to 90% pod maturity indicated additive effect and high heritability for days to flowering and maturity in 'K851' and 'Sona' and selection of mutant lines could be made for M_3 generation. The role of additive and digenic interaction on days to first flower, days to first pod maturity, days to 90% pod maturity and degree of indetermination from first flower to 90% pod maturity has been reported on synchronous and plant height (Khattak *et al*., 2002 & 2004).

CONCLUSION

To date no research has been reported on reduced synchronous maturity based on degree of indetermination using mutated lines. The present study indicated reduced synchronous flowering with no correlation between flowering and maturity period in 'K851' and 'Sona'at lower mutagen dose based on degree of indetermination. A constant genotypic variance and high broad sense heritability estimates of days to first flower, days to first pod maturity and degree of indetermination from first pod maturity to 90% pod maturity may indicate higher success in selection for uniform pods maturing mungbean genotypes for M_3-M_4 generations.

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