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Short Communication

Technique for crossing and advancing multiple generations for mungbean (*Vigna radiata* L.)

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Abstract

Mungbean (*Vigna radiata* L.) Wilczek ($2n=2\times=22$) is an important grain legume cultivated in South-east Asia, Africa, South America and Australia. About 90% of mungbean production occurs in South Asia, where India is the largest producer. It is consumed in various forms like, seed as a good source of easily digested dietary proteins and amino acids. Young pods and sprouts are consumed as vegetable for vitamin and mineral supplement. Its plant parts are used as fodder for animal and green manure to improve soil health in rice-wheat cropping system. It is grown as a sole crop as well as a major component in various cropping systems owing to its ability to fix atmospheric nitrogen, rapid growth, and early maturity. Mungbean being a photo insensitive crop is grown in a wide range of climatic variations and ideal for catch, inter and relay cropping in many countries. Because of wide adoptability at various temperature ranges, this crop is likely to be most suitable under currently rising global temperature.

1. Introduction

Mungbean (*Vigna radiata* L.) Wilczek ($2n=2\times=22$) is an important grain legume cultivated in South-east Asia, Africa, South America and Australia[1]. About 90% of mungbean production occurs in South Asia, where India is the largest producer. It is consumed in various forms like, seed as a good source of easily digested dietary proteins and amino acids. Young pods and sprouts are consumed as vegetable for vitamin and mineral supplement [2]. Its plant parts are used as fodder for animal and green manure to improve soil health in rice-wheat cropping system [3-5]. It is grown as a sole crop as well as a major component in various cropping systems owing to its ability to fix atmospheric nitrogen, rapid growth, and early maturity. Mungbean being a photo insensitive crop is grown in a wide range of climatic variations [6] and ideal for catch, inter and relay cropping in many countries[7]. Because of wide adoptability at various temperature ranges, this crop is likely to be most suitable under currently rising global temperature[8].

Mungbean is a short duration crop and easily amenable for important breeding traits like, quality amino acids, higher yields and resistance to abiotic and biotic stresses. To promote an effective mungbean breeding program, a broader genetic base is required to increase its potential for crop improvement. Inter-specific and intra-specific hybridization can be used to transfer desirable traits. Crossing programme needs critical temperature and humidity for successful pod setting. The desired traits in mungbean population can be achieved within few years if 3 to 4 generations of crossed materials could be advanced in one year. Due to prolonged winter (15^{th} November to 15^{th} February) and hot summer (April to June) the neither crossing programmes nor generation advancement is possible. Therefore, hardly two generations can be advanced, one during kharif and other during summer. Shuttle breeding programme is well established in important crop like wheat [9,10] where harvested seeds are sent to other places where climate is favorable to the crop. However, the potential of shuttle breeding is not yet utilized in other crops. The area of mungbean cultivation has been increased due to reduced soil organic matter and remunerative price [11]. Many important traits with strong interaction with the environment in the specific niche area need to be incorporated from the desirable germplasm to locally adopted mungbean genotypes. Rapid enhancement of trait in the population is possible only by attempting desired crosses and subsequent generation advancement facilities.

Polyhouse is a metal structure covered by polythene. Polyhouse protects the crops from sudden change in weather and regulates the environment inside the Polyhouse. This helps to grow the crops with minium external pressure. Thus, monitoring and control forms the core element of a polyhouse deployment. Polyhouse facility has been constructed under ICAR project for various studies in several Universities and Institutes. The mungbean seeds of 10 genotypes were harvested from field in month of November and immediately sown in the first week of December (2011) in soil (Land) under polyhouse. The appropriate fertilizer doses of DAP (10 Kg/ 100 m^2) mixed into soil as a basal dose. The proper spacing 30 cm × 10 cm (row to row and Plant to plant distance respectively) and minimum 100 plant population for individual genotype was maintained. Irrigation was provided as when required. For temperature control there was a water cooler with an exhaust fan in polyhouse. The water cooler and exhaust fan were occasionally used to flush out the warm air during day time after February month. This experiment was repeated by sowing seeds of a 10 genotypes in first week of March (2012). The performance of plant growth under polyhouse in off-season (2 cycles) were recorded as germination percentage, days to flowering initiation, formation of pods per cluster, number of pods per plant and number of seeds setting per pod (Table 1 & 2).

Table 1: Germination, flowering and fruiting behavior of different genotypes of mungbean under polyhouse conditions (December, 2009-February, 2010)

Genotype	Germination (%)	Days to flowering	No. of pods/Cluster	No. of Clusters/Plant	No. of pods/Plant	No. Seeds/ Pod
Kopergoan	75.0a	38a	2.7a (1-6)	10.0b (3-25)	24a(8-52)	10.0c (3-12)
HUM 8	72.0a	41c	3.1c (1-7)	8.0a (3-18)	25a (12-50)	8.0a (3-11)
HUM 12	75.5b	42c	3.2d (1-7)	8.5a (3-19)	27b (13-53)	9.0b (3-13)
HUM 16	83.0d	40b	2.6a (1-6)	11.0b (7-24)	29c (13-55)	9.0b (2-12)
ML 1720	86.5e	37a	2.8b (1-6)	13.0c (7-25)	26b (13-52)	10.0c (4-13)
ML 1731	80.0c	39b	2.7a (1-6)	12.0c (5-24)	24a (12-52)	9.0b (3-12)
Pant M-2	82.0c	38a	3.2d (1-6)	9.0a (2-21)	27b (11-54)	8.8b (3-12)
Pant M-4	79.0c	40b	3.1c (1-7)	10.0b (3-21)	29c (11-55)	11.0d (3-12)
Pant M-5	72.0a	42c	3.0c (1-5)	8.0a (2-22)	24a (9-53)	9.0b (3-11)
SML 668	78.0b	40b	2.9b (1-6)	10.0b (3-20)	27b (12-50)	10.0 c (4-12)
LSD (0.05)	3.41	1.22	0.16	1.20	1.38	0.61

Data with the same letter, per column, are not significantly different (LSD test, $P < 0.05$). Values in parentheses indicated range.

Table 2: Germination, flowering and fruiting behavior of different genotypes of mungbean under polyhouse conditions (March, 2010-May, 2010)

Genotype	Germination (%)	Days to flowering	No. of pods/Cluster	No. of Clusters/Plant	No. of pods/Plant	No. Seeds/ Pod
Kopergoan	73.0b	40a	2.8b (1-6)	11.0b (3-25)	33.0b (8-52)	9.5c (3-12)
HUM 8	70.0a	42b	3.2c (1-7)	10.0b (3-18)	30.0b (12-50)	8.5a (3-11)
HUM 12	75.5b	45c	3.4d (1-7)	9.0a (3-19)	27.0a (13-53)	9.5c (3-13)
HUM 16	81.0d	42b	2.8b (1-6)	12.5c (7-24)	37.5c (13-55)	9.0b (2-12)
ML 1720	84.5e	39a	2.5a (1-6)	14.0d (7-25)	42.0d (13-52)	10.2d (4-13)
ML 1731	76.0c	39a	2.9b (1-6)	12.5c (5-24)	37.5c (12-52)	9.1b (3-12)
Pant M-2	79.0d	40a	3.3c (1-6)	9.7a (2-21)	29.1a (11-54)	9.0b (3-12)
Pant M-4	78.0c	42b	3.4d (1-7)	10.6b (3-21)	31.8b (11-55)	9.9d (3-12)
Pant M-5	77.0c	43b	3.1c (1-5)	8.6a (2-22)	25.8a (9-53)	8.9b (3-11)
SML 668	74.0b	45c	3.2c (1-6)	10.5b (3-20)	31.5b (12-50)	9.8c (4-12)
LSD (0.05)	2.96	1.58	0.23	1.22	3.66	0.38

Data with the same letter, per column, are not significantly different (LSD test, $P < 0.05$). Values in parentheses indicated range.

The grwoth of mungbean genotypes are shown in figure 1. The performances of all the genotypes were good under polyhouse condition during both crop cycles December to February and March to May. The differences in values for above parameters were only due to genotypes. Significant differences could not be recorded for above parameters between two cycle of same genotypes under polyhouse. In both cycle germination percentages of ML 1720 genotype were 86.5 and 84.5 respectively that was significantly higher as compared to others genotypes. The genotype ML 1720 was also superior for other parameters. So, these two cycles' periods can be used for advancing the generations.

Seeds of Kopergoan were sown under polyhouses for 7 crop cycles from October to April in 2012-13 The performances of Kopergaon were recorded as germination percentage, days to flower initiation, days to maturity, number of pods per plant and number of seeds per pod. The mean values were based on 100 observations of each parameter.

Table 3 revealed germination percentage (78%), average number of pods per plant (33) and average number of seeds per pods (10.5) were significantly higher as well as days to flowering (35) and days to maturity (62) were earlier in seed sown during April as compared to other. Seeds sown during December showed significantly lower germination (65%), average number of pods per plant (23), seeds per pod (8) delayed in days to flowering (42) and days to maturity (70).

Table 3: Performance of Kopergoan under different crop cycles in polyhouse

Date of sowing	Germination (%)	Days to flowering	Days to maturity	Number of pods/Plant	Number of seeds/ pod
October	75c	36a	62a	25a	9.0b
November	73b	38b	65b	24a	8.5a
December	65a	42c	70c	23a	8.0a
January	65a	44c	70c	25a	8.8b
February	70b	39a	65b	27b	9.5b
March	76c	37a	64a	30c	10.0c
April	78c	35a	62a	33d	10.5c
LSD (0.05)	4.83	3.01	2.87	3.1	0.75

Data with the same letter, per column, are not significantly different (LSD test, $P < 0.05$).

For making crosses (both inter-specific and intra-specific) from diverse parents of mungbean and urdbean, seeds were shown during first week of February (2011) in cemented pots containing 10 Kg fertile soil. Plant populations were 5 plants per pot. The seeds of pollen parents i.e. PU 31, HUM 12 and ML 1720 were sown at 5 days interval, three times for availability of sufficient pollen at time of crossing. The crossings were made during last week of March (2011). Total 7 cross combinations were made-Two inter-specific (mungbean × urdbean) and 5 intra-specific (mungbean × mungbean). Maximum 10-12 buds per plant were used for making cross. Crossings were made in 50 plants of individual genotypes. Two days old unopened buds were selected for emasculation. Emasculation was done during evening (5-7 pm) and pollination was done at next day early morning (5-7 am) [13]. Before pollination water was sprayed on style of emasculated buds to provide sufficient moisture for sticking dehisced pollen on stigma and its germination. Precautions were taken to avoid self-pollination by tagging the emasculated bud and also by removal of opened and self pollinated buds. The following parameters like pod set percentage, number of seeds / pod and germination percentage of F_1 seeds were recorded (Table 4).

Table 4: Success of season crossing in different cross combination in month of January and germination of F_1 seeds (in March).

Cross combination	No. of flowers crossed	No. of pods sett	Pod setting (%)	Number of seeds/pod	Germination % of F_1seeds
Kopergoan × Pant U 31	500	80a	16.0a	2.5a (1-6)	40.0a
HUM 16 × Pant U 31	500	70a	14.0a	2.4a (1-6)	42.0a
Kopergoan × ML 1720	500	185b	37.0b	6.0c (1-8)	52.0c
Kopergoan × HUM 12	500	175b	35.0b	5.0b (1-7)	46.0b
HUM 8 × HUM 12	500	158b	31.6b	4.5b (1-5)	55.0c
HUM 8 × ML 1720	500	165b	33.0b	4.0b (1-5)	52.0c
HUM 12 × ML 1720	500	160b	32.0b	5.0b (1-7)	43.5a
LSD (0.05)		43.22	8.65	1.25	5.37

Data with the same letter, per column, are not significantly different (LSD test, $P < 0.05$). Values in parentheses indicated range.

The parent's mungbean as female (Kopergoan) and urdben (PU 31), as male F_1 Pods, and F_1 plant of mungbean (Kopergoan) × urdbean (PU 31) are shown in figure 2. Out of two inter-specific crosses were made between mungbean and urdbean, pods set were significantly higher in combination of Kopergoan × PU 31 (16%) as compared to HUM 16 × PU 31 (14%). Whereas, out of 5 intra-specific crosses were made between mungbean genotypes, pods set were significantly higher in combination of Kopergoan × ML 1720 (37%) as compared to others and lowest pods set were recorded 31.6 % in HUM 8 × HUM 12. Average number of seeds per pod was significantly higher in Kopergoan × ML 1720 (6) and lowest in HUM 16 × PU 31 (2.4). The F_1 seeds germination was significantly higher in HUM 8 × HUM 12 (55%) and lowest in Kopergoan × PU 31 (40%). The F_1 plant of inter-specific cross were intermediate in plant types, delayed in maturity and only few flower buds were fertile rest of buds were sterile. The crossed and F_1 plants pods were constricted and bearing 1- 6 seeds. No variation observed in plant types of intra-specific crosses, instead of numbers of flowers was more in F_1 plant but pod setting was very less as compared to their parents.

Fig. 1 Mungbean and Urdbean plant grown under polyhouse conditions.

Fig. 2 a. Parent-mungbean ; b. Parent-Urdbean; c. Pods setting in cross plants; d. F_1 Plants obtained from mungbean × urdbean cross.

Problem of insect-pests and diseases were also encountered during the investigation under polyhouse. It was noticed that pod borer (*Helicoverpa armigera*) attack occurred during the month of February. Infection of powdery mildew (*Erysiphae polygoni*) occurred during December to January. Prolonged winter, November to March in the Northern India hampers the germination and growth of the mungbean due to its tropical nature. Polyhouse conditions helped to maintain the warm and humid environment during the winter month to perform crossing and advancing of segregating generations. National phytotron facilities available at

IARI, New Delhi are limited for the priority areas and not for the regular programme. At the same time it is difficult for the concerned breeder staying at for off places to visit the crop for making crosses. Polyhouse facility can be created by spending few thousand rupees. Advancing minimum two generations in the polyhouse during winter and two during summer and Kharif in the field. Using polyhouse facilities 4 generations could be advanced in a year even without shuttling material to the favorable environment. This facility would help the resident crop breeder to deliver the desired material within three to four years that usually takes seven to eight years in the normal course. This can also be used for developing mapping population by RIL.

2. Summary

An attempt was made for inter-specific and intra-specific crosses between mungbean × urdbean and mungbean × mungbean under polyhouse conditions during off season (March). Out of two inter-specific cross combinations, maximum 16 % crosses were successful as pods set in Kopergoan × PU 31. Whereas, out of 5 intra-specific cross combinations, maximum 37 % pods set of crossed buds in combination of Kopergoan × ML 1720. The performance for seeds germination, days to flowering, days to maturity, average number of pods/cluster, average number of pods/plant and average number of seeds/pod of 10 diverse genotypes of mungbean were raised in during December- February and March- May under poly house not differ significantly. Adverse effect of environments on above parameters of mungbean genotypes were minimized under polyhouse. ML 1720 genotype was superior over others genotypes. The Kopergoan genotype was sown for 7 cycles to understand the effect of environments on October to April, seed germination (October to April) that varies 65-78 % and mean values of pods/ plant was varied from 23-33. On the experiments conducted under polyhouse, 4 generations , two during off-season (December-March and March-May) could be advanced and by taking two crops in field one during summer and other during kharif.

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