Legume Res., 36 (2) : 105 - 110, 2013

AGRICULTURAL RESEARCH COMMUNICATION CENTRE
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DEVELOPMENT OF SUPER EARLY GENOTYPES IN GREENGRAM [*VIGNA RADIATA* (L.)Wilczek]

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Received: 23-10-2012 Accepted: 17-02-2013

ABSTRACT

Greengram [*Vigna radiata* (L.)Wilczek] also known as mungbean in South Asia, is an important pulse crop of the *Vigna* group. Among the major production constraints, terminal heat stress during summer season and pre-harvest sprouting during rainy season considerably reduce its productivity. If the crop duration of greengram is shortened by 10-15 days without significant yield penalty, the losses caused by these stresses can be avoided in its major production base. Two extra short duration genotypes of greengram were developed at Indian Institute of Pulses Research, Kanpur which matured significantly early (45-48 days) during summer as well as rainy seasons as compared to 60-65 days of the earliest maturing check varieties (PDM139 and Sona Yellow). The genotype IPM 205-7 was developed from the cross 'IPM 2-1 x EC 398889' and IPM 409-4 from 'PDM 288 x IPM 3-1' following the pedigree method of selection. Both the genotypes showed resistance to mungbean yellow mosaic India virus (MYMIV) and have been registered with NBPGR as INGR11043 and INGR11044, respectively. The major morphological characteristics of these genotypes are short and erect plants, dark green ovate leaves, light yellow flowers, small black pods on maturity, and shining green seeds. These genotypes can be directly released as cultivars after their adaptation test and can also be useful donors for earliness and MYMIV resistance.

Key words: Germplasm enhancement, Greengram, Mungbean, MYMIV, Super early genotypes.

INTRODUCTION

Greengram [*Vigna radiata* (L.) Wilczek], is economically one of the most important pulse crops of the *Vigna* group and is cultivated in many parts of Asia, Australia, West Indies, South and North America, and tropical and subtropical Africa (Ali and Kumar 2006). Being rich in quality protein, minerals and vitamins, it is an inseparable ingredient in the diets of vast majority of vegetarian population in the Indian subcontinent. India is the largest producer of greengram in the world and accounts for 65% acreage and 54% production (Pratap *et al;* 2012). Being the third largest pulse crop in India, it occupies 3.55 million hectares area with total production of 1.80 million tonnes and productivity of 512 kg/ha (AICRP 2012). Commonly known as mungbean in South Asia, greengram is suited to a large number of cropping systems where short-season window between two main-season crops exists. Its ability to fix atmospheric nitrogen (58-109 kg/ha) in symbiotic association with *Rhizobium* bacteria not only enables it to meet its own nitrogen requirement but also benefits succeeding cereal crops in various cropping systems (Ali, 1992).

Keeping in view its short crop cycle, low input requirements and ability to survive in a wide range of adverse soil and climatic conditions, there is an ample scope of growing this crop across the seasons (spring, summer, winter and rainy seasons) in different parts of India. Therefore, research in greengram has been focused on development of disease resistant, short-duration and photo-thermo insensitive cultivars during the last three decades. This has helped in expanding the area of this crop in new niches, particularly in rice-wheat system in

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north west plain zone (NWPZ) in India (Ali and Kumar, 2004). However, the major constraint for further expansion of greengram as a summer crop in rice-wheat system is a short season window with very hot weather (maximum temperatures touching 44^{0}C) conditions. Heat stress during the reproductive phase adversely affects pollen viability, fertilization, pod set and seed development leading to abscission of flowers and pods and substantial losses in grain yield (Hall, 2004). Similarly during rainy season, the crop invariably witnesses rains at the time of pod maturity, leading to deterioration of seed quality and pre-harvest sprouting (Singh *et al*, 2011). This has a direct negative impact on both, productivity and marketability of the crop. If the crop duration of improved cultivars is shortened by 10-15 days without a significant yield penalty, the crop can avoid the adverse effects of terminal heat stress during summer season and adverse effect of untimely rains at harvest time during rainy season. Keeping this in view, Two extra short duration breeding lines, IPM 205-7 (INGR 11043) and IPM 409-4 (INGR 11044) were developed. These lines will be useful as donor for development of super early greengram genotypes as well as in related *Vigna* species. Being resistant to mungbean yellow mosaic India virus (MYMIV), these may also be released as cultivars after adaptation tests through multi-location evaluation.

MATERIALS AND METHODS

Genotype development and pedigree

The plant materials consisted of two early maturing mungbean genotypes isolated from two different crosses, IPM 2-1 x EC 398889 and PDM 288 x IPM 3- 1, which were initially developed during the rainy seasons of the years 2002 and 2004, respectively. While the genotypes IPM 2-1, IPM 3-1 and PDM 288 used for making the above crosses themselves were breeding lines (IPM 2-1 and IPM 3-1 derived from the cross IPM 99-125 x Pusa Bold 2 and PDM288 from an unknown cross), EC 398889 was a selection from AVRDC germplasm. IPM 99-125, involved in the lineage of both the crosses, is a product of an interspecific cross between *V. radiata* (Pant Mung 2) x *V. mungo* (AMP 36) and this genotype has been released for commercial cultivation in north east plain zone (NEPZ) of India and has green, shining, small seeds and is resistant to MYMIV. The parental genotypes were chosen for hybridization on the basis of seed quality (bold, green and shining seeds preferred), disease resistance and plant type. All the parents were medium late in maturity (55-65 days). Selections based upon visual observations were carried out starting from the F_2 generation consisting of approximately 700 plants of each cross. Superior single plants were harvested individually and plant-to-progeny rows were sown in the next generations. Two sowings of the material were taken each year (spring and rainy season) to hasten the advancement of generations. An early maturing single plant was selected in F_7 generation in 2008 from the first cross and F_6 plant in the same year from the second cross which were named as IPM 205-7 and IPM 409-4, respectively. These single plants were harvested separately and their seeds were multiplied in isolation in the subsequent seasons to have enough seeds of the fixed lines.

Seed purification and increase

Plant-to-row progenies of the single plants of IPM 205-7 and IPM 409-4 were sown till 2010 and single plant selections were done at each step to select the best early maturing and agronomically superior plants. In 2011 (spring season), individual seed production plots were raised for both the genotypes. Recommended package of practices was followed to raise a good crop. These plots were carefully rougued to remove the off-type plants based upon morphological observations including hypocotyl pigmentation, flower colour, leaf and stem pubescence, pod wall colour and other phenotypic traits as described in the National Test Guidelines (AICRP, 2011). At maturity, 300 single plants were selected from each plot. Plants were not harvested from the border rows to avoid any contamination due to mechanical mixture. Individual plants were threshed manually and the seeds were cleaned and dried separately. Each individual plant progeny was subjected to table evaluation and comparison of the seed was done with the original seed lot for the respective genotype. Individual plant progenies were grown as progeny rows in the next season to assess distinctness, uniformity and stability of the trait. Uniform seeds from similar progenies were mixed. These seeds are the primary source for the both the genotypes, IPM 205-7 and IPM 409-4.

Recording of data and statistical analysis

The two fixed lines (IPM 205-7 and IPM 409-4) were evaluated for their performance alongwith five standard check cultivars of greengram during

rainy season in 2010 and seven checks during summer season in 2011. The experiments were laid out in a complete randomized block design with three replications. Each plot consisted of 7 rows of 4 m length spaced 30 cm apart while the average plant-to-plant spacing within a row was maintained at 10 cm by thinning out the plants at four-leaves stage. Recommended package of practices was followed for raising a good crop. Data were recorded on 24 phenological traits as described in the National Test Guidelines (AICRP, 2011) for the purpose of botanical description and characterization of genotypes. However, for statistical analysis, only three traits *viz.*, days to 50% flowering, days to 75% maturity and seed yield were considered for which data were recorded on plot basis. Statistical analysis was done using the software SPAR 2.0 (IASRI, 2005).

On the basis of available data, the genotypes were proposed for registration as unique germplasm to National Bureau of Plant Genetic Resources (NBPGR), Indian Council of Agricultural Research, New Delhi during 2011.

RESULTS AND DISCUSSION

Both genotypes, IPM 205-7 and IPM 409-4, matured in 45-48 days and have been classified into the extra early maturity group. The genotype IPM 205-7 has short-statured, erect and determinate plant type (Table 1). Its leaves are dark green, ovate and medium sized with greenish purple veins while the flowers are light yellow in colour. The pods are present above the canopy and are short, black and curved while seeds are green, shining, straight and oval in shape. The genotype IPM 409-4 also has short-statured erect plants with green, ovate and entire leaves and a green stem with purple splashes. The flowers are of light yellow colour while the pod habit is intermediate. Pods are short, straight and black on maturity and seeds are green and shining. Both the germplasm lines have synchronous maturity and are also resistant to Mungbean Yellow Mosaic India Virus (MYMIV) under natural field conditions.

In the 2010 rainy season trial, all the seven genotypes including two test entries and five standard check cultivars did not differ significantly in seed yield performance and days to 50% flowering.

TABLE 1. Phenotypic descriptors of registered germplasm as per National Test guidelines (AICRP, 2011).

Character	IPM 205-7	IPM 409-4
Registration number	INGR 11043	INGR 11044
Pedigree	IPM 02-1 x EC 398889	PDM 288 x IPM 03-1
Hypocotyl: Anthocyanin coloration	Present	Absent
Time of flowering	early	Early
Plant growth habit	Erect	Erect
Plant habit	Determinate	Determinate
Stem colour	Green with purple splashes	Green
Stem pubescence	Present	Present
Leaflet lobes (terminal)	Absent	Absent
Leaf shape (terminal)	Ovate	Ovate
Leaf colour	Green	Dark green
Leaf vein colour	Greenish purple	Greenish purple
Petiole colour	Green with purple splashes	Green with purple splashes
Leaf size (at 5th node from the base)	Small	Medium
Flower: Colour of petal (standard)	Light yellow	Light yellow
Pod colour at maturity	Black	Black
Pod pubescence	Absent	Absent
Pod position	Intermediate	Above canopy
Plant Height	Short	Short
Pod curvature of mature pod	Straight	Curved
Pod length	Short	Short
Seed shape	Oval	Oval
Seed colour	Green	Green
Seed lusture	Shining	Shining
Seed size	Medium	Medium
Pod colour at pre-maturity	Green	Green with pigmented suture

TABLE 2. Means, range and F value for agronomic traits of IPM 205-7 and IPM 409-4 alongwith eight check varieties at Kanpur (India) during kharif, 2010.

Genotype	Days to 50% flowering	Days to 75% maturity	Seed yield(kg/ha)
IPM 205-7	32.33	46.67	872.67
IPM 409-4	33.37	47.33	808.33
IPM 99-125	37.67	63.33	716.67
PDM 139	35.33	59.67	883.33
NM 1	35.33	60.33	725.00
ML 5	37.33	62.00	608.00
Pant M 4	37.33	66.00	783.33
Range	32.33-37.67	46.67-66.00	608.00-883.33
Mean +SEm	35.2±0.59	56.63±0.83	763.83±77.29
CD at 1% level	2.49	3.51	325.26
CV (%)	2.91	2.55	17.52
F Value at 1%	ns	**	ns

However, all these entries differed significantly for days to 75% maturity (Table 1). The data showed that both the genotypes, IPM 205-7 and IPM 409-4 matured in 47 days while the earliest maturing check variety PDM 139 matured in 60 days, thus these novel lines had 13 days advantage in maturity duration (Table 2). Development of early maturing genotypes is one of the prime breeding objectives in greengram improvement programmes because such genotypes can fit well in different crop rotations and multiple cropping systems (Ali and Kumar, 2006). While comparatively longer duration genotypes (65-70 days) are suitable for cultivation in the rainy season, short duration genotypes (<60 days) are preferred for spring and summer seasons as well as specific niches such as rice fallows. During spring/summer season, cultivation of super early lines (~50 days) after the harvest of wheat in northern and potato in the central India may save at least one to two irrigations and also one spray of pesticide for control of pod fly and pod borers, leading to considerable monetary savings. Besides this, it may also help the crop to escape terminal heat stress, which can otherwise lead to premature flower drop and significant yield loss due to poor pod set. It is well known that greengram thrives well in the temperature range of 30-40^{0}C but above 40^{0}C, there is a significant flower shedding (Tickoo *et al*, 1996). Flowers in greengram are borne in clusters of 10 to 20 in axillary or terminal racemes and come in different flushes. Flower shedding is very common in this crop under adverse conditions and the extent of flowers' shedding has been reported up to 79 percent (Kumari and Varma, 1983). Flowers'

TABLE 3. Means, range and F value for agronomic traits of IPM 205-7 and IPM 409-4 alongwith eight check varieties at Kanpur (India) during summer, 2011.

Genotype	Days to 50% flowering	Days to 75% maturity	Seed yield(kg/ha)
IPM 205-7	33.33	47.00	960.00
IPM 409-4	32.00	45.00	876.67
PDM 139	36.00	56.67	1066.67
IPM 99-125	36.00	61.33	1010.67
IPM 2-14	38.67	58.67	830.00
IPM 02-3	37.33	59.33	1000.00
Pant M 2	36.67	61.00	996.67
Sona Yellow	36.33	59.00	1166.67
Pusa 9531	38.00	57.00	1026.67
Pusa Vishal	36.33	61.00	1216.67
Range	32.00-38.67	45.00-61.33	876.67-1216.67
Mean +SEm	36.07±0.74	55.76±0.94	987.33±52.45
CD at 1% level	3.01	3.78	211.01
CV (%)	3.55	2.92	9.2
F Value at 1%	ns	**	**

shedding in this crop increases under high temperature, precipitation, and desiccating winds during the flowering period (Tickoo *et al*, 1996). Sinha, 1977, Rainey and Griffiths (2005) reported abscission of reproductive organs as the primary determinant of yield under heat stress in many annual grain legumes. Because of scarcity of irrigation water and intense heat wave during the months of April and May coinciding with the reproductive phase of greengram in spring/summer season sown crop, extra short duration genotypes which can mature in about 50 days have an increased importance. Such genotypes when sown after the harvest of winter season crops can complete their life cycle well before the onset of intense heat wave escaping extreme temperatures during the pod filling and maturity stage. Development of extra short duration genotypes, IPM 205-7 and IPM 409-4, addresses this objective. These genotypes are the result of intensive breeding and selection efforts and their lineage involves diverse parents.

These genotypes were superior in per day productivity also as IPM 205-7 recorded a seed yield of 18.70 kg/ha/day and IPM 405-7 recorded 17.07 kg/ha/day as compared to PDM 139 which produced only 14.80 kg/ha/day. During the summer season in 2011, while there was non-significant difference for days to 50% flowering, the genotypes differed significantly for days to 75% maturity and seed yield (Table 3). The genotypes IPM 205-7 and IPM 409-4 matured 10-12 days earlier i.e., in 47 and 45 days, respectively while the earliest check varieties, PDM 139 and Sona Yellow matured in 57 days. Although, it was observed that the seed yield of the super early genotypes was significantly lower (960 kg/ha for IPM 205-7 and 877 kg/ha for IPM 409-4) as compared to the best check variety Pusa Vishal (1217 kg/ha), the per day productivity of these genotypes, 21.33 kg/ha/day in case of IPM 205-7 and 18.65 kg/ha/day in case of IPM 409-4, was comparable with the above-mentioned best check variety (19.94 kg/ha/day).

Yellow mosaic disease caused by Mungbean Yellow Mosaic Virus (MYMV) and Mungbean Yellow Mosaic India Virus (MYMIV) is one of the most destructive diseases of greengram throughout the world. In northern part of India, MYMIV is prevalent (Naimuddin *et al*, 2011a and b). Both the breeding lines were also subjected to field screening against MYMIV infestation over the seasons. It was observed that during both, summer and rainy seasons there were no visible symptoms of the disease on the leaves and therefore these were categorized as highly resistant to MYMIV with a disease score of 1. The check varieties used in the present study gave variable reactions. While Narendra Mung and Sona Yellow was moderately susceptible with a disease score of 5 (yellow mottling and discoloration of 15.1 to 30% leaf area), ML 5 and Pusa Vishal were moderately resistant with a disease score of 3 (yellow mottling covering 5.1 to 15 % leaf area). The other genotypes were highly resistant and did not show any visible disease symptoms on the leaves.

It is interesting to note that IPM 99-125 is involved in the parentage of both the crosses which itself is a product of an interspecific cross between *V. radiata* (Pant Mung 2) x *V. mungo* (AMP 36). Distant crosses are expected to yield more genetic variability and hence transgressive segregants which can manifest their effects in several generations and also in the crosses where they are involved are expected. When sown under local Kanpur conditions (20°27'N latitude, 80°14'E longitude and 152.4 m amsl), both the genotypes matured 10-19 days earlier than the check varieties. While IPM 205-7 and IPM 409-4 matured in 45-48 days, the check varieties matured in 55-67 days.

Recognizing their potential as a cultivar and also a donor, IPM 205-7 has been registered as INGR 11043 and IPM 409-4 as INGR 11044 during 2011, both for extra early maturity (Pratap *et al*., 2013). Keeping in view the comparable yield, resistance to MYMIV and extra early maturity, these genotypes can be evaluated for their possible release as cultivars besides using them as donors in hybridization programme for the development of extra early maturing and high yielding varieties of greengram. Such genotypes can also fit well in different crop rotations and cropping systems. These genotypes can also be used to derive basic information on the allelic relationship with the earlier reported genes for earliness for better information of genetic system for flower onset in *Vigna* in general and greengram in particular.

ACKNOWLEDGEMENT

The guidance and support of Dr. N. Nadarajan, Director, IIPR and Dr. S.K. Chaturvedi, Head, Crop Improvement Division, IIPR and technical support of Rakesh are gratefully acknowledged.

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