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Agronomic Characteristics and Seed Yield of Mung Bean Cultivars Differing in Seed Color using Organic and Conventional Farming in Indian Subtropical Region

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ABSTRACT

A field study of two mung bean (*Phaseolus aureus* L.) varieties, namely China mung and AML-2, was conducted in Bidar district of Karnataka State, India to compare phenotypic characteristics and grain yield using organic and conventional farming. Fourteen agronomic traits were analyzed to select the best cultivar for their use in plant breeding. Of the various traits analyzed, plant height, number of pods/plant, seed maturation and seed yield were considered as the most pronounced features. There was a positive correlation ($r = 1.000$, $P \leq 0.01$) between plant height, number of seeds/pod, pod number/plant and seed yield. The yield component, which is the largest and most consistent, was pods/plant, which showed a close positive relationship to seed yield. The seed yield in yellow cultivar ALM-2 was higher (8.64 q/ha) than that of green cultivar China mung (7.41 q/ha). ALM-2 was identified as a high-yielding cultivar and a potential source to be included in future breeding activities.

Keywords: agronomic trait, breeding source, seed maturation, seed yield

INTRODUCTION

Legumes more commonly refer to the family *Leguminosae* and subfamily *Papilionoideae*. They are the most important staple foods, particularly in developing countries, due to their relatively low cost, long conservation time, and high nutritional value. Legumes are consumed as mature grain, as immature seed, as well as a vegetable (both leaves and pods). They also have the valuable ability of fixing nitrogen from the atmosphere as a result of symbiosis with nitrogen-fixing bacteria. Grain legumes such as chickpea, pigeon pea, mung bean, black gram and lentils are commonly referred to as pulses in the Indian subcontinent. Mung bean (*Phaseolus aureus* L.) is considered as the most important legume as its protein quality is similar to or better than legumes such as chickpea, black gram, peas, pigeon pea, etc. and also due to its high level of proteins and carbohydrates (Kataria *et al.* 1989; Jood *et al.* 1998).

Mung bean is a small herbaceous annual varying between 30 and 90 cm in height. The leaves are trifoliate. The flowers of different hues of yellow are produced in a cluster on the stem. The pods contain almost globular, small and green seeds. The cotyledons, known as *dhal*, are yellow in color. Mung bean takes about three months for maturation and harvest. The unripe-green pods are used as a vegetable, grains as a pulse and straw husk as fodder for cattle (Anonymous 2003; Rao *et al.* 2006). Unlike other pulses, it is easily digestible without producing flatulence (Reddy *et al.* 1984; Champ *et al.* 1986).

In Thailand and the Philippines, mung bean is the most important grain legume. In Sri Lanka it ranks second, while in India, Burma, Bangladesh and Indonesia it is the third most important grain legume. Mung bean has been grown in India since ancient times. It is used as a pulse in the preparation of *dhal*, a soup porridge eaten with a cereal or other traditional cuisines, and is a main protein source for the vegetarian diet. Mung bean is also used for bean sprouts, starch noodles, mung bean soup, and weaning foods (Singh *et al.* 1989; Singh and Singh 1992). Most of India's farms are 'organic by default'. Majority of small farmers have no choice except to farm without chemical fertilizers or pesticides and a significant number of them have chosen to farm organically, as their forefathers have done for thousands of years (Ecoworld 2004). The major problem in India is the poor productivity of soils because of the low level content of the organic matter due to drastic reduction in soil nutrients in the areas where fertilizer is used intensively (Veeresh 1999). The organic farming within the country is promoted by Governmental and non-governmental organizations to overcome food crisis (Narayanan 2005). Since mung bean matures in about 60 to 80 days after sowing, it is an excellent crop for rotation in different cropping systems. Several researchers studied the genotypic and phenotypic diversity, relative contribution of different characters towards seed yield and correlation between different yield components such as plant height, number of seeds/pod, number of pods/plant, seed weight of 100-seeds and seed yield/plant in mung beans (Manivannan 2002; Patil *et al.* 2003; Bisht *et al.* 2005; Makeen *et al.* 2007; Das *et al.* 2010). Mung bean cultivars varying in seed coat-color have differed polyphenol and mineral content (Tajoddin *et al.* 2010, 2011). The polyphenols present in the seed coat is involved in the defense mechanism of seeds and thus may influence the grain-yield too. Of the various mung been cultivars analyzed, a green cultivar China mung, which is grown maximally by the farmers for its yield (collected from the Agricultural Research Station, Gulbarga, India) and a yellow cultivar, ALM-2 (locally conserved variety) was subjected to field study to investigate the phenotypic characteristics and correlate yield components to explore high-yielding cultivar by using organic and conventional farming systems.

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Original Research Paper

Table 1 Agronomic traits related to growth and development of ALM-2 and China mung cultivars.

Cultivar	Seed color	Number of branches	Color of leaves	Days to first flowering	Days to first pod	Maturation of pods (days)	Color of flowers	Pod length (cm)
ALM-2	Yellow	5	Dark green	35	43	80	Pale yellow	9
China mung	Green	3	Light green	30	38	75	Yellow	10

Table 2 Agronomic traits related to yield contribution of ALM-2 and China mung cultivars.

Cultivar	Plant height (cm)	Pods/plant	Seeds/pod	100-seed weight (g)	Yield/plant (gram)	Seed yield (g/ha)
ALM-2	72	53	15	3.70	29.42	8.64
China mung	60	37	14	4.67	24.19	7.41

$r = 1.000$, $P \leq 0.01$

MATERIALS AND METHODS

Experimental material and design

The field study was carried out in the rain-fed fields of Bidar district of Karnataka state, India for four consecutive rainy seasons during 2007 to 2010. The crop was grown as first (*kharif*) crop sown in June. Generally the climate of the Bidar district is dry with temperatures ranging from 12°C in the winter to 40°C in summer. During monsoon season (June-September), temperature varies from 20 to 30°C and rainfall up to 850 mm with an average precipitation of 5.29 (mm/day) (BCCI 2011). Mung been variety ALM-2 and China mung were sown in a rainfed field of black soil and cultivated by organic farming practice. The organic compost that is prepared by following Indian traditional method was used. A-10% cattle dung, 50% agricultural residues and 40% soil were loaded into a rectangular brick pit in several layers and allowed to form compost mix. Fertilizers and pesticides were not used. Mung bean was sown in early June as a rainy season crop, and harvested during September. Seeds were sown at a spacing of 60 cm row to row and 10 cm plant distance with a seed rate of 25 kg/ha. Agronomic traits; plant height, pods/plant, seeds/pod, 100 seed weight, color of flower and seeds, number of branches, color of leaves, days to the first flowering and first pod, maturation of pods, pod length, yield/plant and seed yield were monitored randomly at regular interval of 8 days till harvesting. Seed yields were determined after crops were harvested manually. The experimental layout was a randomized with three replications.

Statistical analysis

The values were expressed in mean ± SD. Statistical analyses were performed by an analysis of variance (ANOVA) and correlation analyses by SPSS v. 14 (USA).

RESULTS

Agronomic traits related to growth and development

A positive relationship (r = 1.000, $P \leq 0.01$) between plant height, seed/pod, pods/plant and seed yield is observed. The mung bean cultivars ALM-2 and China mung grew and developed well but with a clear noticeable difference during plant development (**Fig. 1A, 1B**). These cultivars developed a large biomass with big trifoliate leaves and robust stem before start of flowering. The time of first flower opening among the ALM-2 and China mung cultivars ranged from 30 to 35 days after sowing, with the earliest appearance of flowering recorded for China mung (**Table 1**). The first pod among the cultivars was observed eight days after flower opening. Similarly, the number of branches ranged between 3 and 5. The ALM-2 cultivar showed higher branching (5 branches) as it is compared to that of the china mung (3 to 4 branches). The two mung bean cultivars were found to differ in their flowers color. The flower-color of ALM-2 was pale yellow whereas, it was observed to be dark yellow for China mung (**Fig. 1C, 1D**). The pod length of two cultivars ranged between 9 and 10 cm. During maturation of seeds, the color of the seeds changed from pea-green to yellow in ALM-2 cultivar, where as in china mung, the color remained green (**Fig. 1E-J**).

Table 3 Agronomic traits of mung bean cultivars.

Agronomic traits	Makeen *et al.* (2007)	Das *et al.* (2010)	Present study
Days to the first flowering	---	34-48	30-35
Maturation of pods (days)	65	56-82	75-80
Plant height (cm)	48	---	60-72
Pod length (cm)	7	---	9-10
Pods/plant	38	12-48	33-57
Seeds/pod	12	4-12	14-15
100-seed weight (g)	---	2.18-3.30	3.70-4.67
Yield/plant (g)	---	1.77-10.85	24.19-29.42

Agronomic traits related to yield contribution

The plant height of two mung bean cultivars ranged from 60 to 72 cm. The highest seeds/pod and yield/plant were recorded for ALM-2 cultivar (**Table 2**). The highest number of pods/plant was recorded for cultivar ALM-2 (53 pods/plant) against the cultivar China mung (37 pods/plant). The seed weight for 100 seeds values of tested mung bean cultivars were found to be in the range of 3.70-4.67 g/100 seeds. The highest yield of 8.64 q/ha was found to be in ALM-2 cultivar which was higher than that observed for China mung cultivar (7.41 q/ha).

DISCUSSION

During seed maturation, the color changed from pea-green to yellow in ALM-2. Variations in seed colors were found to be due to sap-soluble pigments and to the color and number of chloroplasts (Sen and Ghosh 1959). The seed weight/100 seeds of tested mung bean cultivars are in agreement with the values reported by Singh *et al.* (1989) for mung bean cultivars (4.5 g/100 seeds). However, Naik *et al.* (2002) reported seed weight values in the range of 2.53-6.21 g/100 seeds.

The information of the relationship among plant characters is useful for selecting the traits to combine for yield improvement. This study showed a positive relationship between plant height, seeds/pod, pods/plant and seed yield. Theoretically, the cultivar that growth height is considered to potentially generate a higher seed yield. It is evident from the results of the present investigation that the traits plant height, pods/plant and seeds/pod directly influence the seed yield. The yield component which is the largest and most consistent is pods/ plant, a close positive relationship ($P \leq 0.01$) to seed yield has been reported in our studies. Although a higher100-seed weight can compensate for low pod number, the association of 100-seed weight with yield is inconsistent and has low reliability as selection criteria for yield. These results are in agreement with previous observations (**Table 3**). Natarajan *et al.* (1988), Raje and Rao (2000), Manivannan (2002), Makeen *et al.* (2007) and Das *et al.* (2010) also reported a positive correlation between plant height, number of seeds/pod, number of pods/plant and 100-seed weight with seed yield in mung bean cultivars. Gupta and Gupta (1977), and Pathak and Dixit (1992) also reported a positive relationship between plant height, pods/

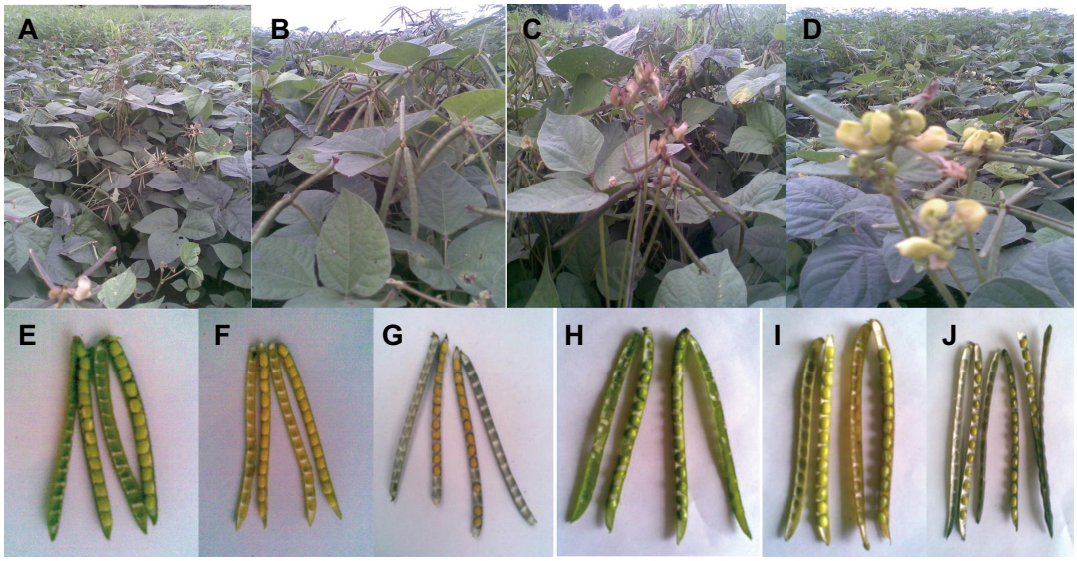

Fig. 1 Phenotypic diversity in mung bean cultivars. (**A**) ALM-2, (**B**) China mung. Colors of flowers in mung bean cultivars. (**C**) ALM-2 (pale yellow), (**D**) China mung (dark yellow). Seed maturation in mung bean cultivar ALM-2. (**E**) Green- immature seeds, (**F**) mature seeds-turning yellow, (**G**) yellow-mature dry seeds. Seed maturation in mung bean cultivar China mung. (**H**) Green- immature seeds, (**I**) mature green seeds, (**J**) green-mature dry seeds.

plant and seed yield in sesame cultivars. In the present investigation, cultivar ALM-2 was found to be interesting for its use in breeding to improve grain yield.

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