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EVALUATING THE PERFORMANCE OF THREE MUNGBEAN VARIETIES GROWN UNDER VARYING INTER-ROW SPACING

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ABSTRACT

A field trial was conducted to establish the proper inter-row spacing and suitable variety evaluation in Faisalabad, Pakistan. Three mung bean varieties V_1, V_2, V_3 (NM-92, NM-98, and M-1) were grown at three inter-row spacings (S_1- 30 cm, S_2- 60 cm and S_3- 90 cm) respectively. Experiment was laid out in Randomized Complete Block Design (RCBD) with split plot arrangement randomizing varieties in the main and inter-row spacing in the sub-plots. The data recorded were analysed statistically using Fisher's analysis of variance technique and Least Significant Difference (LSD) test at 5% probability level. Highest seed yield was obtained for variety V_2 at 30 cm spacing. Among varieties V_2 exhibited the highest yield 727.02 kg ha^{-1} while the lowest seed yield 484.79 kg ha^{-1} was obtained with V_3. The spacing 30 cm showed highest seed yield 675.84 kg ha^{-1} as compared to other spacing treatments. Low potential varieties and improper agronomic practices may be a serious cause of low productivity in pulses. The interaction of V_2S_1 exhibited significantly higher yield than other treatments. The lowest seed yield was obtained at V_3S_1 (462.8 kg ha^{-1}). The higher yield in V_2S_1 was characterized by more number of plants in narrow spacing of 30 cm (37 plants m^{-2}), plant height of 51.4 cm, higher number of fruit bearing branches (7 per plant), the highest number of pods per plant (18.86), number of seeds per pod (10.06), 1000 grain weight (4.8 g), the highest biological yield (4894.2 kg ha^{-1}) with a harvest index of (17.75) and the highest number of nodules per plant (15) were the components of high yield formation for mung bean variety V_2 under the inter-row spacing of 30cm. So it can be concluded that mung bean variety Nm-98 should be grown at inter row spacing of 30 cm under the agro-climatic conditions of Faisalabad.

Key words: Mung bean, row space, yield and varieties.

INTRODUCTION

The world population is increasing at alarming rate and obviously overwhelming majority of this populous world is suffering due to the insufficient and imbalanced diet. The plant scientists are facing the challenge that how to meet the food requirement of this unchecked population (Thirtle *et al*., 2003). As resources are squeezing and population is hiking therefore crop scientists are focusing on improved management practices and advanced crop husbandry techniques (Lipton, 2001). In this acute context, pulses are excellent option of dietary protein. Pulses when used as food with other cereals they definitely meet the requirement of a balanced diet. Pulses are used with zeal as delicious food in the poor countries and in the modern world they are utilized to maintain a good health. Being leguminous, they maintain soil fertility by fixing atmospheric nitrogen in available form through symbiosis with rhizobial strains. Pulses are also important component of animal feed and their dried straw is used as hay. In pulses, mungbean (*Vigna radiata* L.) is a vital crop (Khattak *et al*., 2004). This warm season legume is a native of India and is still grown on a large acreage there. Often called green gram or golden gram in international publications, it is also cultivated in several countries of Asia, Africa, and South America.

Mungbean (*Vigna radiata* L.) commonly known as green gram is an ancient and well-known pulse crop of Pakistan (Govt. of Pakistan, 2009). It is produced for both human consumption and as fodder. Its seed contains 24.3% protein and 0.67% fats (Lee *et al*., 1997). Mungbean is usually grown at low to medium elevations in the tropics as a rainfed crop. It ranks second to drought resistance after soybean (Ali *et al*., 2001; Ghafoor *et al*., 2003). Mungbean can be grown as manure, hay, cover crop, and forage or intercropped in cereals, sugarcane, sunflower or jute. Green gram seed yield decreases when it is intercropped, but the total productivity of the system and land use efficiency markedly increases by intercropping (Ali, 1992). On an average, it fixes atmospheric nitrogen @ 300 kg ha^{-1} annually (Sharar *et al*., 2001).

In spite of its importance as food and feed, very little attention has been paid to its quantitative and qualitative improvement in the country. It is one of the major Rabi/ Kharif pulses and ranks second to chickpea (*Cicer arietinum* L.). In Pakistan, it was grown on an area of 256.0 thousand hectares with an annual production of 140.8 thousand tons, and an average seed yield of 550 kg ha^{-1} (Govt. of Pakistan, 2009). This is far below its potential yield of 1971 kg ha^{-1} achieved from field trials at NIAB, Faisalabad (Sadiq *et al*., 1999). Research on all pulse crops remained neglected until 1980, due to which work on mungbean (*Vigna radiata* L.) improvement has not been systematized. Its per hectare yield obtained at farmers field is low, because no systematic efforts have been made in the past to develop a package of technology, which may ensure high seed yield of this crop. Important reasons for low average yield of mungbean on farmer's field are the continuous cultivation of traditional low potential cultivars, use of low seed rate and improper agronomic practices e.g. Inter-row spacing (Ansari *et al*., 2000).

Among many other crop production constraints, appropriate varieties and inter-row spacing are the most important, which contribute substantially to the seed yield of mungbean (Ismail and Hall, 2000; Khan *et al.,* 2001). Research studies also revealed that most of the growth and yield contributing attributes are significantly and positively correlated with the grain yield of many crop plants viz., mash bean (Mahmoodul-Hassan *et al.,* 2003; Khan *et al.,* 2004), chickpea (Arshad *et al.,* 2004), Mungbean (Siddique *et al.,* 2006), soybean (Malik *et al.,* 2006, 2007) and sunflower (Vahedi *et al.,* 2010).

The whole scenario and context clearly reflect that due emphasis must be given to these parameters so that the threats to the management practices which reduce yield per unit area can be encountered. Therefore, the present study was initiated to find out the optimum requisite inter row spacing of mungbean (*Vigna radiata* L.) varieties under agro-climatic conditions of Faisalabad.

MATERIALS AND METHODS

Investigations, to evaluate the performance of mungbean (*Vigna radiata* L.) varieties grown under varying inter-row spacing were conducted at the Agronomic Research Area, University of Agriculture, Faisalabad during Autumn on a sandy clay loam soil. Experiment was laid out in Randomized Complete Block Design (RCBD) with split plot arrangement randomizing varieties in the main and inter-row spacing in the sub-plots. The experiment was replicated thrice using the net plot size of 3.6 m x 7.0 m. The experiment comprised of the following treatments:

A. Varieties (main plot)

V_1= NIAB MUNG-92
V_2 = NIAB MUNG-98
V_3 = MUNG-1

B. Inter-Row Spacing (sub-plot)

S_1 = 30 cm
S_2 = 45 cm
S_3 = 60 cm

Seedbed was prepared uniformly for the whole experiment. The sowing was carried out in respective plots in first week of August 2009-10 according to the treatments. The whole N and P @ 25 & 50 kg ha^{-1}, respectively, were side drilled as basal dose immediately after seeding. By thinning, plant-to-plant distance was kept at 8 cm. All other agronomic practices were kept normal and uniform. The crop was harvested on 18th October when 90% pods were matured. Then harvested crop was properly dried in the sun before threshing.

The data recorded were tabulated and analyzed statistically using Fisher's analysis of variance technique and Least Significant Difference (LSD) test at 5% probability level was applied to compare the differences among treatments' means (Steel *et al*., 1997).

RESULTS AND DISCUSSION

An experiment was conducted to see the influence of various Inter-row spacing on different varieties of mungbean. The data pertaining to growth and yield parameters along with their statistical interpretations are presented and discussed

Number of plants (m^{-2}): An optimum plant population is considered the foundation for having increased yield. The results regarding number of plants m^{-2} obtained at harvest are presented in Table 1, which show that plant population was significantly affected by varying inter-row spacing. The inter-row spacing of 30 cm (S_1) gave the maximum plant population per unit area (37.56) which was significantly different from 45 cm inter-row spacing (28.78) and the inter- row spacing of 60 cm (19.44), while there was non-significant difference in plant population of all the varieties. This happened due to the narrow row spacing of plants sown at 30 cm, as in m^2 area more rows are accommodated for less inter-row spacing of 30 cm than those of 45 cm and 60 cm. Varieties did not affect the number of plants per unit area, exhibiting it as a physically controlled factor and not genetically controlled because the germination of seeds were almost the same for all varieties. Environment required for seed germination and subsequent plant growth and development were almost similar throughout the field and the plants of both cultivars had equal opportunities to be benefited from soil and climatic resources. These results are in line with finding of Hussain *et al*. (2011). The interaction between the factors was, also, found to be non-significant.

Plant height (cm): Environmental factors and genetic characteristics of plants play an important role in determining the plant height. Data on plant height at maturity of three mungbean varieties as influenced by varying inter-row spacing are presented in Table 2. The results in Table 2 reveal that different varieties and inter-row spacing affected the plant height significantly. The maximum plant height was observed in variety V_2 (NM-98) which was 51.89 cm on an average and the plant heights of V_1 (NM-92) & V_3 (M-1) were 47.71 and 48.31 cm respectively. The data in Table 2 also show that the plant height was significantly affected by inter-row spacing and maximum plant height was observed at a plant spacing of 45 cm (50.83 cm) while the average plant height at maturity of 30 and 60 cm inter-row spacing were 49.36cm and 47.72 cm, respectively.

Table 1. Effect of varieties and inter-row spaces on the yield and yield components of mungbean

Treatments	No of plant (m^2)	Plant height (cm)	Nodules/ plant	Branches / plant	Pods/ plant	Seeds/ pod	1000 seed weight (g)	Biological yield (kg ha^{-1})	Seed yield (kg ha^{-1})	Harvest index (%)
V_1	28.55	47.71^{b}	8.80^{b}	5.24^{b}	15.76^{b}	9.37^{b}	52.78	2826.25	687.55^{b}	26.14^{a}
V_2	28.00	51.89 a	13.02^{a}	6.77^{a}	17.09^{a}	10.98^{a}	46.11	4391.50	727.02^{a}	19.66^{b}
V_3	29.22	48.31^{b}	10.31^{b}	6.35^{a}	17.33^{a}	9.68 b	45.17	4246.01	484.79^{c}	11.44^{c}
LSD	Ns	0.7743	2.119	0.5705	1.126	1.235	Ns	Ns	4.846	2.999
S_1	37.56^{a}	49.36^{b}	11.34	6.24^{a}	17.35	9.11^{b}	46.31^{b}	4131.4^{a}	675.84^{a}	19.97
S_2	28.78^{b}	50.73 a	9.76	6.20^{a}	15.84	10.37^{a}	48.46^{a}	4003.5^{a}	628.24^{b}	19.19
S_3	19.44^{c}	47.72 c	11.02	5.93^{b}	16.97	10.55^{a}	49.30^{a}	3328.9^{b}	595.29^{c}	20.09
LSD	2.351	0.6496	Ns	0.2516	Ns	0.4235	2.142	335.2	5.129	Ns
V_1S_1	38.33	48.4 e	9.13	5.60 d	14.60^{c}	8.50	49.80	3174.6	771.38^{b}	24.49
V_1S_2	28.33	49.8^{cd}	8.06	5.00^{e}	14.53^{c}	9.50	53.00	2817.4	701.16^{c}	27.81
V_1S_3	19.00	44.9^{f}	9.20	5.13^{e}	18.13^{ab}	10.00	55.50	2486.7	590.12^{e}	25.13
V_2S_1	37.00	51.4^{b}	15.00	7.00^{a}	18.86^{a}	10.06	45.80	4894.2	793.29^{a}	17.75
V_2S_2	28.33	53.8^{a}	10.66	6.90^{a}	16.00^{bc}	11.40	44.66	4563.4	687.86^{d}	19.10
V_2S_3	18.60	50.4^{bc}	13.40	6.4b c	16.40^{bc}	11.40	47.80	3716.9	699.93^{c}	22.13
V_3S_1	37.33	48.2^{e}	9.90	6.13 c	18.60^{a}	8.70	43.26	4325.3	462.80^{g}	10.66
V_3S_2	29.66	48.8^{de}	10.66	6.60^{ab}	17.00^{ab}	10.13	47.73	4629.6	495.70^{f}	10.66
V_3S_3	20.66	47.8^{e}	10.46	6.26^{bc}	16.40^{bc}	10.20	44.53	3783.0	495.80^{f}	13.02
LSD	Ns	1.125	Ns	0.4358	2.157	Ns	Ns	Ns	8.884	Ns

Means followed by the same letters within a column do not differ significantly ($P < 0.05$)
V_1 = NIAB MUNG-92, V_2 = NIAB MUNG-98, V_3 = MUNG-1, S_1 = 30 cm, S_2 = 45 cm, S_3= 60 cm

The interaction of varieties and inter-row spacing was also found to be significant: where the maximum plant height (53.8 cm) was observed in variety V_2 (NM-98) grown at inter-row spacing of 45 cm, while lowest plant height (44.9 cm) was observed in variety V_1 (NM-92) at 60 cm inter-row spacing. The maximum plant height was because of plant enjoying of full benefit of available resources and sunlight as compared to dense population. The minimum plant height was recorded in case of variety NM-92, this variation might be due to genetic characteristics of this variety for this trait. Almost similar results were reported by Maqsood *et al.* (1999).

Number of nodules per plant: The data pertaining to the number of nodules per plant (Table 3) show that the varieties differed significantly from each other in nodulation process of plant. The inter-row spacing of plants did not significantly affect the nodulation process and likewise the interaction among varieties and inter-row spacing also could not affect the number of nodules significantly.

The maximum number of nodules (13.02) was produced by the variety- V_2 (NM-98) and lowest number of nodules (8.80) were produced by the variety- V_1 (NM-92) which was statistically at par with V_3 (M-1). This difference might be due to genetic variability and other environmental factors of the varieties under cultivation.

Number of fruit bearing branches per plant: Branching is basically a genetic character but environmental conditions may also influence the number of branches per plant and play an important role in enhancing seed yield. Data given in Table-4 reveal that the number of fruit bearing branches per plant was affected significantly by varying inter-row spacing and varieties as well as by the interaction of varieties and inter-row spacing. The varieties V_2 (NM-98) and V_3 (M-1) produced more number of fruit bearing branches (6.77) & (6.35), respectively and were statistically at par, while the V_1 variety (NM-92) produced minimum (5.24) number of fruit bearing branches per plant. The inter-row spacing of 30 cm affected the plant to produce more number of fruit bearing branches (6.24) and was statistically at par with that of inter-row spacing of 45 cm which produced 6.20 numbers of fruit bearing branches. The lowest number of branches per plant (5.93) was produced at inter-row spacing of 60 cm. The interactions of inter-row spacing and varieties were also significantly different and the variety V_2 (NM-98) produced maximum number of branches per plant (7.0) at inter-row spacing of 30 cm and was statistically at par with V_2S_2 (6.9) where NM-98 was grown at inter-row spacing of 45 cm and V_3S_2, where M-1 variety was grown at inter-row spacing of 45 cm which produced 6.6 fruit bearing branches per plant. The minimum (5.00) and (5.13) number of fruit bearing branches were produced by NM-

92 grown at inter-row spacing of 45 cm and 60 cm, respectively. The number of fruit bearing branches is a genetically controlled factor so it differed significantly among the varieties. The inter-row spacing also affected the fruit bearing branches, which might be due to variable availability of light, nutrients, etc. in case of varying spacings. These results are in agreement with those of Khan (2000), Waheed (1996) and Zaidi (1998) who stated significant differences for this character among various cultivars and inter-row spacing.

Number of pods per plant: Number of pods per plant is a key factor for determining the yield performance in leguminous plants. The productive capacity of mungbean plant is ultimately considered by the number of pods per plant. A perusal of Table 5 shows that varieties significantly differed for number of pods per plant. The maximum number of pods per plant (17.33) was produced by variety V_3 M-1 which was statistically at par with Variety NM-98, which produced 17.09 pods per plant on an average. The lowest numbers of pods per plant (15.76) were produced by variety NM-92. The effect of inter-row spacing was non-significant on the number of pods per plant. The interaction of varieties and inter-row spacing also significantly affected the number of pods per plant. V_2S_1 combination i.e. NM-98 sown at inter-row spacing of 30 cm produced maximum pods per plant and was statistically at par with V_3S_1, V_3S_2 and V_1S_3. Past findings of scientists were reported about 15-26 pods of mungbean under similar ecological conditions (Razzaq, 1995; Zaidi, 1998).

Number of seeds per pod: Number of seeds per pod is considered an important factor that directly imparts in exploiting potential yield recovery in leguminous crops. Data regarding number of seeds per pod given in Table 6 reveal that varying inter-row spacing and varieties had a significant effect on the number of seeds per pod and the combination of varieties and inter-row spacing also showed a significant effect on the number of seeds per pod. The highest number of seeds per pod (10.98) were produced by variety V_2 (NM-98) and the lowest (9.37) seeds per pod were produced by variety V_1 (NM-92). The varieties NM-92 and M-1 were however, statistically at par. The data further show that inter-row spacing S_3 and S_2 were statistically similar and produced significantly more number of seeds per pod (10.55 and 10.37, respectively) than produced by S_1 (30 cm) inter-row spacing treatment.

The combination of varieties and inter-row spacing also affected the number of seeds per pod significantly. The variety NM-98 (V_2) produced the maximum seeds per pod (11.4) at inter-row spacing of 45 cm and 60 cm. The lowest number of seeds per pod (8.5) were produced by variety NM-92 at 30 cm which was statistically identical to the number of seeds per pod (8.7) produced by M-1 (V_3) at 30 cm inter-row spacing.

1000-Seed weight (g): Among the various parameters contributing towards final yield of a crop, 1000-seed weight is of prime importance. Data presented in Table 7 reveal that varieties had significant effect on the 1000-seed weight. Maximum 1000-seed weight (52.78 g) was recorded from variety NM-92, while minimum (45.17g) was recorded of variety M-1. Among the inter-row spacing treatments, the maximum 1000-seed weight (49.30 g) was obtained at 60 cm inter-row spacing. The interaction between both the factors was also significant, where the maximum 1000-seed weight (55.5 g) was obtained when variety NM-92 was sown at inter-row spacing of 60 cm which was statistically at par. Whereas the minimum 1000-seed weight (43.26 g) was noted in case of M-1 variety grown in 30 cm apart rows. The difference of 1000-seed weight at different inter-row spacing might be due to better availability of resources for photosynthesis and facing of less competition at wider inter-row spacing.

Biological yield (kg ha^{-1}): The productivity of a crop is largely determined by the biological yield. Production of large amount of biomass is among one of the attributes of seed yield. Data regarding biological yield per hectare given in Table 8 reveal that there were significant differences among the inter-row spacing that affected the biological yield. The inter-row spacing of 30 cm and 45 cm produced 4131 & 4003.5 kg ha^{-1} of biological yield, respectively and these were statistically at par. The inter-row spacing of 60 cm gave minimum biological yield (3328.9 kg ha^{-1}). Biological yield was not significantly affected by various varieties and combinations of varieties and inter-row spacing were also found to be non-significant. The more biomass produced at narrower row spacing was due to more plant population contributing to the final biomass production.

Seed yield (kg ha^{-1}): Dry matter production and its transformation into economic yield is the ultimate outcome of various physiological, biochemicals, phenological and morphological events occurring in the plant system. Seed yield of a variety is the result of interplay of its genetic make up and environmental factors in which plant grow. Data pertaining to the seed yield (Table 9) elucidate that varieties, inter-row spacing and combinations of these significantly affected the seed yield of mungbean. Maximum seed yield (727.02 kg ha^{-1}) was obtained from variety V_2 (NM-98). The lowest seed yield (484.79 kg ha^{-1}) was obtained from variety V_3 (M-1). It might be due to genetic differences among the varieties. These findings are quite in line with the findings of Abbas (2000) who had reported significant differences in the yield of various cultivars. Crop sown at inter-row spacing of 30 cm gave maximum seed yield (675.84 kg ha^{-1}) while lowest seed yield (595.29 kg ha^{-1}) was obtained at inter-row spacing of 60 cm. These results are in line with the findings of Agarcio (1985), Panwar and Sirohi (1987), Ali *et al*. (2010).

Interactive effect of varieties and inter-row spacing was also found to be significant. The highest seed yield (793.29 kg ha^{-1}) was obtained when variety V_2 (NM-98) sown at inter-row spacing of 30 cm while the lowest seed yield (495.7kg ha^{-1}) was obtained when V_3 (M-1) was sown at inter- row spacing of 45 cm and 60 cm.

Harvest index (%): Harvest index is a measure of physiological productivity potential of a crop variety. It is the ability of a crop plant to convert the dry matter into economic yield. It is the ratio of seed yield to biological yield and those varieties that had more seed yield and less biological yield than other would have higher harvest index value. Higher the harvest index value more will be the production efficiency or vice versa. The calculated values of Harvest index presented in Table 10 indicate that varieties differed significantly on account of conversion efficiency of assimilates. The maximum value of harvest index (26.14%) was obtained with the variety V_1 (NM-92). The minimum harvest index value (11.44%) was obtained from variety V_3 (M-1). These findings are in agreement with those recorded by Malik *et al*. (1986) and Taleei *et al*. (1999) who also reported significant differences in harvest index among different varieties.

Conclusion: From the present studies it can be concluded that the variety NM-98 out crossed the other varieties in the performance and the inter row spacing of 30 cm showed significantly better results towards final yield. Hence it can be recommended that mungbean variety NM-98 should be grown preferably in 30 cm apart rows under the agro-climatic conditions of Faisalabad in order to achieve maximum yield.

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