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Effect of Inter Row and Intra Row Spacing on Yield and Yield Components of Mung Bean (Vigna radiata L.) in Northern Ethiopia

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Abstract - A field experiment was carried out during 2015 at Humera Agricultural Research Center, Humera, Ethiopia, to evaluate the growing performance of mung bean under varying inter-row and intra-row spacing. The experiment was arranged in a split plot design with three replications. The treatments included four inter row spacing (20 cm, 25 cm, 30 cm 35 cm and 40 cm) were randomized in the main plots and four intra-row spacing (5 cm, 10 cm, 15 cm, and 20 cm) randomized in the sub-plots. Data on traits such as plant height at maturity, number of branches per plant, number of pods per plant, number of seeds per pod, 1000-seed weight and seed yield were recorded. Results indicated significant interaction effect of inter row and intra row spacing on days to 50% maturity number of pods per plant, plant height and seed yield. On the other hand number of branches per plant, number of seeds per pod and 1000-seed weight were not significantly affected by the interaction effect of inter and intra row spacing. Maximum seed yield was obtaining in inter row and intra row spacing of 30 cm and 5 cm respectively while maximum plant height was recorded in inter row spacing of 40cm and intra row spacing of 5 cm. As a result of main effect, the highest number of branches and seeds per plant were recorded at 40 cm inter row spacing. The main effect of intra row spacing was also significant on number of seeds per pod and 1000-seed weight with the maximum values recorded at 20 cm spacing. To conclude, 30 cm inter row spacing and 5 cm intra row spacing would be the best spacing for maximum yield achievement.

Key Words: Mung bean, inter row, intra row, interaction, yield components

1. Introduction

Ethiopia grows various types of pulse crops. These crops represent a vital component of agricultural food crops consumed in the country. Mung bean (*Vigna radiata* L. Wilczek) is one of the important and extensively grown pulse crops. The importance of growing the crop is associated to its high protein content and other essential minerals, especially micronutrients. Furthermore, this crop has the ability to fix atmospheric nitrogen (Delfin et al., 2008) and short duration maturity period which made it preferable crop for resource poor farmers in dryland areas of the tropics and subtropics. Hayat et al., (2008) reported that N_2-fixation under normal soil fertility condition by mung bean valued 47 kg ha^{-1}. Its seed contains 22.5% protein, 9.4% moisture, 2.05% fat, 6.95% fiber and 343.5 kcal/100g energy (Abas and Shah, 2007). In addition, the protein and carbohydrates of mung bean are more easily digestible than proteins derived from other legumes. Mung bean is also lower in phytic acid which is commonly found in cereal and other legume crops and has a negative impact on iron (Fe) and zinc (Zn) bioavailability (Nair et al., 2013).

Despite holding such great promise in human nutrition and soil fertility improvement, the productivity of mung bean worldwide including in Ethiopia is quite low. This low yield is attributed to numerous factors including cultivation on marginal lands making it prone to a number of abiotic stresses, growing low yielding varieties and inappropriate agronomic practices. Use of good yielding varieties and applying the best agronomic practices are the best ways to increase yield of any crops. Among the agronomic practices, optimum plant population is a prerequisite for obtaining higher productivity (Rafiei, 2009). The significance of using optimum inter and intra row spacing has been recognized by several researchers. Kabir and Sarkar (2008) reported that highest seed yield of mung bean was obtained maintaining 30 cm × 10 cm spacing between rows and plants, respectively. Plant density of 40 plants m^{-2} at 25 cm x10 cm planting was the optimum fo achieving higher productivity (Singh et al., 2011). The results of Ahmadi (2016) showed a seed rate of 25 kg ha^{-1} is optimum to obtain maximum mungbean yield. Seed yield of mung bean per unit area tended to increase up to 30 plants m^{-2} and further increase in density did not result any further in yield per unit area (Jahan and Hamid 2004). These authors also reported a decline in seed yield as the density of plants increased to 60 plants m^{-2}. Nawale (2001) concluded that the optimum plant population for mung bean was 666,667 plants per hectare obtained through the configuration of 30 cm and 10 cm between rows and plants within row, respectively. Therefore, there is need to develop integrated crop production, pest and disease management strategies that are cost effective and ecosystem friendly.

Mung bean is a recent introduction to the area where this study was conducted. The effect of different agronomic practices including inter and intra-row spacing are not well studied. Such studies have paramount importance for promotion of the crop in line with the country's effort to diversify agriculture for improved nutrition and food security. Keeping this in view, the present study was initiated to determine optimum intra and inter-row spacing in order to increase the seed yield of mung bean under the existing climatic and edaphic conditions.

2. Materials and Methods

A field experiment was conducted at Humera Agricultural Research Center, Northern Ethiopia, to evaluate the comparative production potential of intra and inter-row spacing. The soil of the experimental plot is clay with pH of 8.1, total nitrogen 0.043%, available phosphorus (P) 5.1 ppm, organic matter 0.65%, available potassium (K) 220.5 ppm and Cation Exchange Capacity of 30.8 meq 100 g^{-1}. The experimental site is characterized with hot semi-arid climate having mean annual minimum and maximum temperature of 20 ^{0}C and 37 ^{0}C, respectively. The average annual rainfall of the area is about 620mm.

The experiment was laid out in a split plot design maintaining three replications in a plot size of 20 m^2. Inter row spacing were randomized in the main plots and intra-row spacing in the sub-plots. The inter-rows spacing were 20 cm, 25 cm, 30 cm 35 cm and 40 cm and the intra-rows spacing were 5 cm, 10 cm, 15 cm, and 20 cm. The crop was sown manually on a well-prepared seedbed dibbling three seeds per hill. Soon after the germination, a single seedling per hill was kept to obtain a uniform stand of the crop. Crop management practices such as weeding, fertilization and plant protection measures were kept normal and uniform in all treatments.

Ten plants were randomly selected to record plant height, number of branches per plant, number of pods per plant and number of seeds per pod in each plot. Grain yield was recorded from each plot. The collected data were compiled and subjected to analysis of variance using Genstat statistical computer package. Least significant difference (LSD) test was employed at 5% probability to compare the difference among treatment means.

3. Results and Discussion

A. Interaction Effect of Inter and Intra Row Spacing

Days to Maturity

The analyzed data are presented in Table 1 and 2. The inter-row spacing and intra-row spacing interactions were significant for some measured morphological and yield characters, which revealed those parameters performed quite dependently of the densities used in this experiment. Of the phonological parameters, which are the duration of life stages of plants, days to 50% maturity showed significant difference due to the interaction effect of inter-row spacing and intra-row spacing. Mung bean crop planted at inter row spacing of 20cm maintaining intra row spacing of 5cm, 10cm, 15cm and 20cm reached 50% maturity earlier than the other treatments. On the other hand, the crop matured was delayed where the crop was planted at wider inter row spacing of 30 cm and 40 cm and intra row spacing of 20cm. The effect of inter and intra row spacing on mung bean phenology has been reported by different authors. Ahmed et al (2011) reported that mung bean crop planted maintaining inter and intra row spacing of 30cm and 20cm,respectively, matured earlier than in inter and intra row spacing of 40 cm and 10 cm, respectively.

Number of Pods

Number of pods per plant is among the key factors for determining the yield performance in pulse crops. Data regarding number of pods per plant given in Table 1 reveal that there were significant differences ($P \leq 0.05$) among the interaction effect of the different planting configuration. The number of pods ranged between 29.1 and 44.7, indicating 65% variation across the different planting configuration. Of the different planting spacing, highest pods were obtained in plots spaced 25cm and 5cm between rows and plants, respectively. On the other hand, the lowest numbers of pods per plant were recorded in plants spaced 35cm and 20cm between rows and plants respectively. Effects of inter row and intra row spacing on number of pods were also reported by number of researchers. Ihsanullah *et al.* (2002) reported that maximum pods per plant were recorded in 20 cm and 15 cm inter and intra row spacing, respectively. The same author also observed minimum number of pods per plant in 43 cm and 7 cm inter and intra row spacing, respectively. On the other hand, Singh *et al.* (2012) observed non significant variation in plant height between 30cm and 15cm and 45cm 15cm, inter and intra row spacing, respectively.

Table 1:Interaction effect of inter and intra-row spacing on mung bean yield parameters

Inter-row spacing (cm)	Intra-row spacing (cm)	Days to 50 % maturity	Number of pods per plant	Plant height (cm)	Seed yield (kg/ha)
20	**5**	50bc	39.6abcd	37.5abc	2215abcde
20	**10**	50bc	40.8abc	36.7abcd	1804bcdef
20	**15**	50bc	40.0abcd	36.7abcd	1564fg
20	**20**	50bc	44.4a	35.77abcd	1599fg
25	**5**	50bc	44.7a	33.4bcd	2337abc
25	**10**	50bc	33.5efg	36.2abcd	1924abcdef
25	**15**	51bc	43.1a	38abc	1808bcdef
25	**20**	53ab	33.7efg	29.7d	1747cdef
30	**5**	54a	41.2abc	38.4abc	2457a
30	**10**	54a	35.1def	32.8bcd	2385ab
30	**15**	55a	32.7fg	33.5bcd	1711ef
30	**20**	56a	36.1cdef	31.3cd	1502fg
35	**5**	50bc	43.4a	38.5ab	2333abcd
35	**10**	49c	41.5ab	37.9abc	1887abcdef
35	**15**	50bc	36.0cdef	37.0abc	1540fg
35	**20**	50bc	29.1g	34.5bcd	1720def
40	**5**	55a	34.1efg	42.2a	1743cdef
40	**10**	54a	38.1bcde	38.6ab	1638ef
40	**15**	54a	29.5g	36abcd	1557fg
40	**20**	56a	43.9a	37.8abc	1019g
SEM (±)		0.517	1.85	3.598	152.684
CV		1.7	8.4	6	10.2

Means followed by the same letters within a column are not significantly different at $P<0.05$

Plant Height

Abiotic factors and genetic characteristics of crops play crucial role in determining growth including plant height. Data pertaining to plant height in Table 1 reveals that plant height at maturity was significantly influenced by inter and intra row spacing. Planting mung bean maintaining intra row and intra row spacing of 40 cm and 5 cm, respectively, recorded the highest plant height (42.2 cm), whereas the lowest plant height (29.7) was recorded in inter and intra row spacing of 25cm and 20 cm, respectively. There are contrasting report regarding the effect of intra and inter row spacing on mung bean plant height. Daniel and Kumar (2015) report maximum plant height at maturity (36.73 cm) on plants spaced 30 cm inter row and 15 cm intra rows distance. Mansoor *et al*. (2010) observed tallest mung bean plants (72.20 cm) at 20 cm row spacing while shortest plants (67.50 cm) were recorded in 40 cm row spacing. Singh *et al.* (2012) observed significant increase in plant height with decrease in spacing between inter and intra rows which were in disagreement with Mathur *et al*. (2007).

Seed Yield

Grain yield is the ultimate outcome of various physiological, biochemical, phonological and morphological events occurring in the plant system (Mansoor *et al.*, 2010). The influence of intra and inter row spacing on seed yield of mung bean is presented in Table 1. Analysis of variance revealed that the interaction effect of inter and intra row spacing had significant ($P<0.05$) effect on seed yield. Among the spacing, 30 cm spacing between rows and 5 cm spacing between plants produced significantly highest yield. On the contrary, minimum seed yield was recorded in plants spaced 40 cm between rows and 20 cm between plants. This result is in agreement with the findings of Daniel and Kumar (2015) who reported that maximum grain yield was recorded in 20 x15 cm while minimum seed yield was recorded in 40x15 cm between plants and rows, respectively. On the other hand, Foysalkabir *et al.* (2016) reported that maximum seed yield (1.63 t ha 1) in 30 cm × 10 cm spacing treatment while, the lowest (1.10 t ha 1) was found in 20 cm × 10 cm spacing treatment. Comparing three row spacing viz. 30 cm, 45 cm and 60 cm, Rasul *et al.* (2012) reported that mung bean sown at inter-row spacing of 30 cm gave maximum seed yield (675.84 kg ha^{-1}) while minimum seed yield was recorded at inter-row spacing of 60 cm. Meanwhile Yadev *et al.* (2014) recommended 30 cm inter row and 10 cm intra row spacing for maximum seed yield and harvest index.

B. Main effect of Inter row and intra row spacing on morphological and yield characteristics of Mung bean

Days to 50% flowering

The analysis of variance presented in Table 2 revealed that the main effect of inter row and intra row spacing has caused to significant variation in days to 50% flowering among the different treatments. Mung bean crop sown at inter row spacing of 20 cm took short time to reach 50% flowering which late 50% flowering was obtained at 40 cm inter row spacing. In the same way, mung bean crop planted at 20 cm intra row spacing reached 50% flowering late compared to the other intra row spaces.

Number of branches per plant

Results of the analysis of variance showed that number of branches per plant of mung bean varied significantly due to the main effect of inter-row spacing. However, number of branches per plant was not significantly affected by intra-row spacing. The highest number of branches per plant were recorded from 30 cm and 40 cm inter-row spacing whereas the lowest was obtained from 20 cm inter-row spacing (Table 2). Regarding the effect of inter row and intra row spacing on number of branches per plant, Kumar (2005) reported maximum number of branches per plant in 40x15cm spacing whereas minimum number of branches per plant was in 20x15cm spacing. Mansoor *et al.* (2010) observed maximum number of branches per plant in plants grown with 20 cm inter row spacing.

Number of seeds per pod

Number of seeds per pod is one of the most important factors that determine the final yield of crops. The data pertaining to effects of inter row spacing on number of seeds per pod (Table 2) ranged between 9.49 and 12.09, a 21.5% variation, across inter-row spacing. The lowest number of seeds per plant were recorded in 25cm inter row spacing while the highest number of seeds plant were recorded in 40 cm inter row spacing. This result is in agreement with the finding of Rasul *et al.* (2012) who reported highest 1000-seeds weight at 45 cm and 60 cm inter row spacing compared to 30 cm inter row spacing. Similarly, numbers of seeds per pod were also significantly affected by main effect of intra row spacing. Mung bean crops planted at 20cm intra row spacing gave the highest number of seeds per pod (11.02) while minimum numbers of seeds per pod were recorded in intra row spacing of five cm.

Thousand seeds weight (g)

Table 2 depicts the main effect of inter row spacing and intra row spacing on 1000- seed weight. The analysis of variance revealed that 1000-seeds weight was significantly affected by the main effect of intra row spacing variation but not by inter row spacing. Maximum 1000- seeds weight was recorded in mung bean plants grown in intra row spacing of 20cm followed by 15 cm intra row spacing. On the other hand, minimum 1000-seeds weight was recorded in plants growing at 5 cm intra row spacing. The effect of inter row and intra row spacing on mung bean 1000-seeds weight is reported by numbers of researchers. Foysalkabir and Quamruzzaman (2016) observed maximum number of 1000-seeds weight from inter and intra row spacing of 30 cm and 10 cm, respectively.

Table 2: Main effect of inter and intra row spacing on yield contributing characters of mung bean

spacing	Days to 50% flowering	Number of branches	Number of seeds/pod	1000 seed weight (g)
Inter row (cm)				
20	27.3^{c}	2.9^{b}	9.57^{b}	38.5
25	27.8^{bc}	2.8^{b}	9.49^{b}	38
30	30.5^{a}	3.6^{ab}	11.19^{a}	38.2
35	28.3^{b}	2.9^{b}	9.84^{b}	38
40	30.9^{a}	4.0^{a}	12.09^{a}	38.1
SEM (±)	0.286	0.515	0.604	1.532
Intra row Spacing (cm)				
5	29^{b}	2.9	9.74^{b}	37.5^{b}
10	29^{b}	3.2	10.41^{ab}	37^{ab}
15	29^{b}	3.4	10.57^{ab}	38.7^{a}
20	30^{a}	3.5	11.02^{a}	39^{a}
SEM (±)	0.403	NS	0.382	0.338
CV	1.7	21.2	10	2.4

Means followed by the same letters within a column are not significantly different at $P<0.05$

Conclusions

Mung bean is a short duration crop that can thrive best in areas characterized with short duration. Yield potential of the crop is markedly affected due to lack of proper agronomic practices, mainly plant population among others. The present investigation was conducted to evaluate growth and yield performance of mung bean to inter row and intra row spacing. From the oresent study, it can be concluded that inter row of 30 cm and intra row spacing of 5 cm gave significantly better final seed yield.

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