Yield Determinants of a Promising Mungbean Line under Various Planting Densities

MD. MOTIOR RAHMAN and A. AHAD MIAH
Department of Agronomy and Horticulture,
Universiti Pertanian Malaysia,
43400 UPM Serdang, Selangor D. E., Malaysia

*Bangladesh Agricultural Research Institute,
Joydebpur, Gazipur 1701, Bangladesh

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ABSTRACT
A field experiment was conducted during September to November, 1992 at the Regional Agricultural Reseach Station (RARS), Ishurdi, Bangladesh, to evaluate the growth performance of a mungbean line (cv. Mosk-1) under varying plant population densities. The treatments consisted of 20 x 10*, 30 x 10*, 40 x 10*, 50 x 10*, 60 x 10* and 70 x 10* plants ha
1. The lowest plant population density recorded the highest total dry matter (TDM) plant
1, crop growth rate (CGR), and pods plant
1, while higher plant population (i.e. 50 or 60 plants m
2) produced the highest grain yield (> 1.30 t ha
1) and higher TDM per unit area. TDM, leaf and pod dry matter were positively correlated with grain yield. In contrast, stem and petiole dry matter showed negative correlation with grain yield.

INTRODUCTION
Yield of mungbean (Vigna radiata (L) Wilczek) is generally low due to inherent low yield potential of the existing cultivars. Besides short growth duration, particularly the slow rate of dry matter accumulation prior to flowering, unfavourable canopy structure, nonresponsiveness to fertilizer application, etc. are limiting factors for low productivity (Hamid et al, 1991). Planting density is one of the principal factors affecting the grain yield of leguminous plants (Nakaseko et al, 1979; Graham and Chatel, 1983). Optimum plant density has major and direct effects on vegetative growth and seed yields of legumes (Singh and Yadav, 1978; Rowden et al, 1981; Herbart and Baggerman, 1983). Leaf area index (LAI) is an important determinant of dry matter production and, hence, yield. Higher LAI value can usually be achieved by increasing plant population density and nutritional supply (Kuo et al, 1978). However, studies on growth pattern and understanding the various physiological processes under variable plant population densities in relation to seed yield of mungbean to evalu-
ate the physiological basis of yield variations in mungbean, and to find the optimum plant population density required to achieve higher yield.

**MATERIALS AND METHODS**

A field experiment was conducted at the Regional Agricultural Research Station (RARS), Ishurdi, Bangladesh, during September to November, 1992, where the soil is a sandy loam with pH 7.0-7.5. The cultivar used was Mosk-1, a promising mungbean line. The treatments were different planting distances: i) 25 x 20 cm, ii) 25 x 13.2 cm, iii) 25 x 10 cm, iv) 20 x 10 cm, v) 20 x 8.33 cm, vi) 20 x 7.14 cm corresponding to 20 x 10^4, 30 x 10^4, 40 x 10^4, 50 x 10^4, 60 x 10^4, 70 x 10^4 plants ha^-1. The sowing was done in the first week of September, 1992. The experiment was laid out in a randomized complete block design with four replications. After emergence of the crop, ten randomly selected plants from each plot were taken at eight day intervals until maturity for the determination of growth parameters. Data on yield attributes were recorded from ten randomly selected plants from each plot. Grain yield was assessed by harvesting an area of 16 m^2 from the centre of each plot and converting the result into tons per hectare (t ha^-1). Collected data were analyzed statistically by using analysis of variance and Duncan’s Multiple Range Test at 5% level of probability was applied to compare differences among the treatment means (Gomez and Gomez, 1984).

**RESULTS**

**Dry Matter Accumulation**

TDM accumulation showed significant variation among the treatment variables. The highest and lowest TDM per plant were recorded from the lowest and highest plant population densities respectively. In contrast, TDM per unit area was inversely related with TDM per plant. The rate of dry matter production was similar in all plant population densities up to 10 days after emergence (DAE) after which it differed significantly until harvest (Fig. 1). Dry matter production slowed a little before the pre-flowering stage (30 DAE) but thereafter a sharp increase in dry matter production was observed up to pod development stage (50 DAE), when all treatments recorded higher dry matter production indicating attainment of physiological maturity.

**Partitioning of Dry Matter**

Table 1 shows the relative contribution of dry matter accumulation. At the vegetative phase the leaf accounted for 50-58%, petiole 12-16% and the stem 30-34% of TDM accumulation. On the other hand, at the reproductive phase the stem accounted for 14-18%, reproductive organs 34-38%, and the leaves and petioles 34-38% and 10-14% respectively. For plant population densities of 50 x 10^4 and 60 x 10^4 plants ha^-1 the photosynthetic organs, i.e. leaves and petioles, contributed 34-38% and 10-14% to TDM respectively. For plant population densities of 50 x 10^4 and 60 x 10^4 plants ha^-1 the photosynthetic organs at both vegetative and reproductive phases contributed more and the reproductive organ slightly more than other plant densities.

**Crop Growth Rate (CGR)**

CGR was significantly affected by variation in plant population densities. The highest and lowest CGR were obtained from the lowest and highest plant densities respectively (Fig. 2). Crop growth rate was slow during the early vegetative phase up to the pre-flowering stage (30 DAE). Thereafter, it increased sharply with the growth of the plant. The maximum CGR was recorded at pod development stage (50 DAE) in all treatments, after which it declined rapidly.
YIELD DETERMINANTS OF A PROMISING MUNGBEAN LINE

TABLE 1
Relative contribution of different plant components as percentage of total dry matter at the vegetative and reproductive phases of mungbean

<table>
<thead>
<tr>
<th>Plant ha⁻¹</th>
<th>Vegetative phase</th>
<th>Reproductive phase</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Stem</td>
<td>Leaf</td>
</tr>
<tr>
<td>20 x 10⁴</td>
<td>34</td>
<td>50</td>
</tr>
<tr>
<td>30 x 10⁴</td>
<td>32</td>
<td>52</td>
</tr>
<tr>
<td>40 x 10⁴</td>
<td>31</td>
<td>55</td>
</tr>
<tr>
<td>50 x 10⁴</td>
<td>31</td>
<td>57</td>
</tr>
<tr>
<td>60 x 10⁴</td>
<td>30</td>
<td>58</td>
</tr>
<tr>
<td>70 x 10⁴</td>
<td>31</td>
<td>56</td>
</tr>
</tbody>
</table>

* Reproductive organ

Harvest index (HI) was significantly affected due to variation in plant densities. The highest HI was obtained from 60 x 10⁴ plants ha⁻¹ and it was statistically at par with 50 x 10⁴ plants ha⁻¹. The lowest HI was obtained from the highest plant population density.

Correlation Between Yield and Other Characters

Correlation analysis (Table 3) showed that pods per plant was positively correlated with stem dry matter (SDM), CGR, and HI, and negatively with plant height (PH), leaf dry matter (LDM), pod dry matter (PDM), TDM, and yield. Plant height showed positive correlation with all traits excepts SDM and CGR. SDM showed strong negative correlation with all traits except pods per plant, SDM and CGR. Similarly, LDM showed positive correlation with all traits except pods per plant, SDM and CGR. CGR showed negative correlation with all traits except pods per plant, PH, LDM, PDM, TDM, HI and negatively with pods per plant, SDM and CGR.

DISCUSSION

Grain yield per unit area is a function of yield of individual plant times plant density. Per plant yield is governed by number of pods per plant,
### TABLE 2
Yield and yield attributes of mungbean under varying levels of plant density

<table>
<thead>
<tr>
<th>Plant density (plants ha⁻¹)</th>
<th>Yield (t ha⁻¹)</th>
<th>Pods plant⁻¹ (no.)</th>
<th>Seeds pod⁻¹ (no.)</th>
<th>1000 seed wt (g)</th>
<th>Plant height (cm)</th>
<th>TDM (t ha⁻¹)</th>
<th>HI</th>
</tr>
</thead>
<tbody>
<tr>
<td>20 x 10⁴</td>
<td>0.77e</td>
<td>22a</td>
<td>9.0</td>
<td>24.0</td>
<td>35.8c</td>
<td>1.85d</td>
<td>0.42b</td>
</tr>
<tr>
<td>30 x 10⁴</td>
<td>0.97d</td>
<td>18ab</td>
<td>9.0</td>
<td>24.0</td>
<td>38.7c</td>
<td>2.30c</td>
<td>0.42b</td>
</tr>
<tr>
<td>40 x 10⁴</td>
<td>1.13c</td>
<td>16abc</td>
<td>8.5</td>
<td>23.8</td>
<td>40.5bc</td>
<td>2.68b</td>
<td>0.42b</td>
</tr>
<tr>
<td>50 x 10⁴</td>
<td>1.33a</td>
<td>15bc</td>
<td>8.5</td>
<td>23.6</td>
<td>44.5ab</td>
<td>3.00a</td>
<td>0.44a</td>
</tr>
<tr>
<td>60 x 10⁴</td>
<td>1.39a</td>
<td>13bc</td>
<td>8.3</td>
<td>23.5</td>
<td>45.0ab</td>
<td>3.10a</td>
<td>0.45a</td>
</tr>
<tr>
<td>70 x 10⁴</td>
<td>1.25b</td>
<td>10c</td>
<td>8.2</td>
<td>23.5</td>
<td>48.7a</td>
<td>3.15a</td>
<td>0.40c</td>
</tr>
</tbody>
</table>

Means followed by the same letter are not significantly different at 0.01 level of significance.

### TABLE 3
Interrelationships among different traits in mungbean

<table>
<thead>
<tr>
<th>PH</th>
<th>SDM</th>
<th>LDM</th>
<th>PDM</th>
<th>TDM</th>
<th>CGR</th>
<th>Y</th>
<th>HI</th>
</tr>
</thead>
<tbody>
<tr>
<td>PP</td>
<td>-0.97**</td>
<td>0.64**</td>
<td>-0.64**</td>
<td>-0.64**</td>
<td>-0.95**</td>
<td>0.86**</td>
<td>-0.86**</td>
</tr>
<tr>
<td>PH</td>
<td>-0.72**</td>
<td>0.72**</td>
<td>0.72**</td>
<td>0.95**</td>
<td>-0.72**</td>
<td>0.87**</td>
<td>0.91*</td>
</tr>
<tr>
<td>SDM</td>
<td>-0.99**</td>
<td>0.99*</td>
<td>-0.99**</td>
<td>-0.84**</td>
<td>-0.60**</td>
<td>0.91*</td>
<td>0.53*</td>
</tr>
<tr>
<td>LDM</td>
<td>-0.99**</td>
<td>0.99*</td>
<td>-0.84**</td>
<td>-0.60**</td>
<td>0.91*</td>
<td>0.53*</td>
<td>0.21</td>
</tr>
<tr>
<td>PDM</td>
<td>-0.86**</td>
<td>0.84**</td>
<td>-0.95**</td>
<td>0.86**</td>
<td>0.91*</td>
<td>0.53*</td>
<td>0.21</td>
</tr>
<tr>
<td>TDM</td>
<td>-0.86**</td>
<td>0.97**</td>
<td>0.86**</td>
<td>0.97**</td>
<td>0.91*</td>
<td>0.53*</td>
<td>0.21</td>
</tr>
<tr>
<td>CGR</td>
<td>-0.79**</td>
<td>0.41*</td>
<td>0.41*</td>
<td>0.41*</td>
<td>0.44*</td>
<td>0.41*</td>
<td>0.44*</td>
</tr>
</tbody>
</table>

PP - Pods plant⁻¹; PH - Plant height; SDM - Stem dry matter; LDM - Leaf dry matter; PDM - Pod dry matter; TSN - Total dry matter; CGR - Crop growth rate; Y - Seed yield

Number of seeds per pod and seed size. Both yield and yield attributes were markedly influenced by plant density. Hamid et al. (1991) reported that optimum density of mungbean for higher yield should be somewhere in between 50 and 60 plants m⁻². They also reported that more widely spaced plants developed more branches but the contribution of secondary and tertiary branches towards grain yield was negligible. Radjit and Adisarwanto (1988) also reported that high plant densities (66 plant m⁻²) produced significantly increased grain yield in mungbean. In case of closer row spacing, plants develop few branches, most of the pods developing on the main stem.

High dry matter production is one prerequisite for greater productivity in crop plants. In addition, developmental factors affecting the accumulation of dry matter and subsequent partitioning of assimilates are of great importance in determining the final yield in crops (Duncan et al., 1978). Dry matter accumulation after flowering in mungbean greatly influences seed yield, for most of the photosynthate produced at this stage is used for pod and seed development and would be a desirable trait for efficient genotypes. Similar results were reported by Hamid et al. (1991). Motior et al. (1992) reported that chickpea genotypes having the capability of producing more dry matter in leaf and petiole than stem during both the vegetative and reproductive phases had higher initial crop growth rates, and a rapid and sharp increase in grain development after anthesis, all of which were found to
be important characters for higher productivity. Motior
et al. (1993) also found similar results in lentil. Grain yield may be considered as a func-
tion of biomass accumulation and its partition-
ing to grain (Sinclair and Horie, 1989)

The ultimate partitioning of dry matter be-
tween reproductive and vegetative parts is indi-
cated by the harvest index (HI). One of the most
fundamental factors affecting this is the capacity
to mobilize photosynthate to the plant organs
having economic value. A higher proportion of
leaf dry matter to be mobilized during the early
reproductive phase of development will enhance
the harvest index. Measurement of harvest index
can help identify and define the translocation
capacity, and thereby, help identify varieties with
partition potential (Kuo et al., 1978). Harvest
index depends on the relative durations of the
vegetative and reproductive phases, and during
the reproductive phase, the relative partitioning
of current assimilate, and the degree of
remobilization of stored assimilate to reproduc-
tive organs (Lawn, 1989).

The results of correlation between yield and
other characters are in partial agreement with
the findings of Perigio et al. (1989) and AVRDC
(1975). Perigio et al. (1989) reported that in the
case of cultivar differences in mungbean, pods
per plant showed positive correlation with seed
yield and it is one of the most important yield
component character to select any cultivar.
AVRDC (1975) reported that yield is positively
correlated with pods m⁻² and they used only 10,
30 and 50 plants m⁻². However, in that study pods
per plant did not play a positive role and com-
pensate yield due to variable plant densities.

Our study shows that percentage of leaf dry
matter (photosynthetic organ), pod dry matter
(reproductive organ), total dry matter and har-
vest index are very important traits for achieving
higher yield. The results of the experiment re-
vealed that different growth parameters like CGR
and TDM can make a crop more or less produc-
tive when grown under variable plant population
densities, and that for maximum yield realization
of mungbean the optimum plant stand lies be-
tween 50 x 10⁴ or 60 x 10⁴ plant ha⁻¹ provided the
crop is sown at an optimum time.

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