Yield and Quality of Green Pod Production of Bush Bean (Phaseolus vulgaris L.) As Influenced by Harvesting Time

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Abstract: An experiment was carried out at the Research Farm and Laboratory of Horticulture, Bangabandhu Sheikh Mujibur Rahman Agricultural University (BSMRAU), Salna, Gazipur during October 2005 to February 2006 to optimize the harvesting time for better bush bean production. Marketable yield was 16.62 t ha\(^{-1}\) harvested at 11 days age whereas the export quality yield was 8.53 and 9.12 t ha\(^{-1}\) which was harvested at 7 and 8 days after flowering, respectively. Regarding quality, the highest ascorbic acid (17.40mg/100g) was obtained from 7 days after flowering, while the lowest (11.44mg/100g) in 15 days after flowering. The highest \(\beta\)-Carotene (0.058mg/100g) was obtained from 15 days and the lowest (0.019mg/100g) in 7 days after flowering and the highest amount of sugar (6.62g/100g) was found from pods harvested at 15 days after flowering, while the lowest (4.69g/100g) in 07 days after flowering.

Key words: Bush Bean · Green Pod · Harvest Time · Nutritional Quality

INTRODUCTION

French bean (Phaseolus vulgaris L.), a photo insensitive and self-pollinated vegetable crop under the family of Leguminosae, is commonly known as Forashi sheem or Jhar sheem in Bengali [1]. It is also designated as common bean, kidney bean, navy bean [2]. It is originated from a wild species, Phaseolus aborigineus Burkart [3] which is indigenous in Southern Mexico and Central America [4]. The crop is very important among leguminous vegetables for its tender pods and shelled beans [5]. Beans are commonly classified into bush, half-runner and pole types [6]. The bush bean is the dwarf type of French bean whose green pods and dry seeds are used for consumption. It occupies the third position just after soybean (Glycine max L.) and peanut (Arachis hypogea L.) among major food legumes in the world [7] and second position in terms of production among the bean vegetables [8]. Phaseolus beans are grown for both green vegetables and pulses. Pods of green beans are harvested green as a vegetable or dry as a pulse. For whole beans, there is a trend particularly in Europe to develop varieties which produce a large proportion of very fine (6.6-8.0 mm diameter) or extra-fine (< 6.5 mm) pods [9]. The green pod is nutritionally rich which contains on an average of 1.7 % protein, 4.5 % carbohydrate, 1.8 % fiber, calcium 50 mg, magnesium 29 mg, phosphorous 28 mg and iron 1.7 mg per 100 gm of pod [10]. Apart from protein, French bean also contains vitamins and minerals which can help to partial alleviation of the malnutrition problem. Immature green pods are suitable for use as vegetable. Generally French bean becomes ready for harvest from 40 days onwards after seed germination depending on the cultivar. It takes about 7-12 days after flowering for the pods to be ready for picking. Extra-fine pod increases by hours and would be picked up within short time. It has been reported that for export purpose, pods are harvested on alternate days or at interval of two days. Therefore this experiment was undertaken to determine the optimum harvesting time to secure higher yield and quality of French bean.
MATERIALS AND METHODS

The experiment was conducted at the Horticulture Research Farm and Horticulture Laboratory of BSMRAU, Salna, Gazipur, Bangladesh during the period from October 2005 to February 2006. The experiment site is located at the center of Madhupur Tract (24.09° N latitude and 90.26° longitudes) at 8.5 m above the sea level and under sub-tropical climatic condition. The soil was clay loam in texture with pH 6.30, 1.17% organic matter, 0.08% nitrogen, 31.25 ppm available phosphorus and 100 g of soil contain 0.37 meq of exchangeable potassium, 5.39 meq exchangeable Ca, 1.65 meq exchangeable Mg, 13.60 ppm available sulphur, 2.52 ppm zinc and 0.23 ppm boron. The variety BARI Jhar sheem-2 was used as materials for experiment. The experiment was laid out in a Randomized Complete Block Design with three replications. The plots were raised by 15 cm from the ground level. The unit plot size was 1.8 m x 1.2 m accommodating 48 plants in each plot having row to row and plant to plant spacing of 30 cm and 15 cm respectively. The unit plots and blocks were separated by 0.50 m and 1.0 m respectively. The treatments were: 

H$_1$ = (Harvesting at 07 days after flowering), 
H$_2$ = (Harvesting at 08 days after flowering), 
H$_3$ = (Harvesting at 09 days after flowering), 
H$_4$ = (Harvesting at 10 days after flowering), 
H$_5$ = (Harvesting at 11 days after flowering), 
H$_6$ = (Harvesting at 12 days after flowering), 
H$_7$ = (Harvesting at 13 days after flowering), 
H$_8$ = (Harvesting at 14 days after flowering) and 
H$_9$ = (Harvesting at 15 days after flowering).

RESULTS AND DISCUSSION

The results obtained from the experiment are presented in Table 1. The characters under the study are described below:

**Length of Pod:** Pod length significantly differed among the harvesting time. The longest pod (14.89 cm) was recorded with the treatment of H$_8$ (15 DAF) which was followed by the treatments of H$_6$, H$_7$ and H$_8$ while the lowest pod length (9.08 cm) was obtained by the treatment of H$_1$ (07 DAF) (Table 1). Increasing the length of pod related with the age up to the limit. Yield was highly correlated with pod length and pod weight at the genotypic level opined by Singh *et al.* [16].

**Breadth of Pod:** Breadth of pod significantly differed by the influence of harvesting time. The highest pod breadth (0.910 cm) was recorded with the treatment of H$_9$ (15 DAF) which was statistically similar to the treatments of H$_6$ and H$_7$ while the lowest pod breadth (0.570 cm) was obtained by the treatment of H$_1$ (07 DAF) (Table 1). Increasing the breadth of pod related with the age up to the limit.

**Fresh Pod Dry Matter:** There was found no significant differences in terms of fresh pod dry matter. The maximum fresh pod dry matter (8.69%) was obtained from H$_6$ and the minimum (5.81%) in H$_1$. 

\[
\beta-\text{Carotene (mg/100g)} = 0.216 \times A_{563} + 0.452 \times A_{645} - 1.22 \times A_{645} - 0.304 \times A_{663}
\]

where the absorbance of the filtrate was measured at 453, 505, 645 and 663 nm [14].
Table 1. Effect of harvesting days on length of pod, breadth of pod, fresh pod dry matter (%) and boiled pod dry matter (%) of French bean

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Length of pod (cm)</th>
<th>Breadth of pod (cm)</th>
<th>Fresh pod dry matter (%)</th>
<th>Boiled pod dry matter (%)</th>
<th>Ind. Pod weight (g)</th>
<th>Weight of pod per plot (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>H = 07 DAF</td>
<td>9.08 e</td>
<td>0.570 c</td>
<td>5.81 (2.40)</td>
<td>4.55 g (2.13)*</td>
<td>1.57 h</td>
<td>1.84 h</td>
</tr>
<tr>
<td>H = 08 DAF</td>
<td>10.36 de</td>
<td>0.580 bc</td>
<td>6.03 (2.45)</td>
<td>7.06 f (2.65)</td>
<td>2.11 g</td>
<td>1.97 h</td>
</tr>
<tr>
<td>H = 09 DAF</td>
<td>10.99 c-e</td>
<td>0.706 a-c</td>
<td>7.68 (2.76)</td>
<td>7.98 e (2.82)</td>
<td>2.17 g</td>
<td>2.27 g</td>
</tr>
<tr>
<td>H = 10 DAF</td>
<td>12.09 b-d</td>
<td>0.716 a-c</td>
<td>8.07 (2.83)</td>
<td>8.39 de (2.89)</td>
<td>2.52 f</td>
<td>2.76 f</td>
</tr>
<tr>
<td>H = 11 DAF</td>
<td>12.28 b-d</td>
<td>0.736 a-c</td>
<td>7.18 (2.67)</td>
<td>8.66 d (2.94)</td>
<td>3.42 e</td>
<td>3.59 e</td>
</tr>
<tr>
<td>H = 12 DAF</td>
<td>12.93 a-c</td>
<td>0.776 ab</td>
<td>8.69 (2.94)</td>
<td>10.76 c (3.27)</td>
<td>4.19 d</td>
<td>4.25 d</td>
</tr>
<tr>
<td>H = 13 DAF</td>
<td>13.16 a-c</td>
<td>0.816 a</td>
<td>7.80 (2.77)</td>
<td>11.50 b (3.39)</td>
<td>5.10 c</td>
<td>4.80 c</td>
</tr>
<tr>
<td>H = 14 DAF</td>
<td>13.61 a</td>
<td>0.863 a</td>
<td>7.40 (2.73)</td>
<td>11.76 b (3.42)</td>
<td>5.80 b</td>
<td>5.46 b</td>
</tr>
<tr>
<td>H = 15 DAF</td>
<td>14.89 a</td>
<td>0.910 a</td>
<td>8.37 (2.89)</td>
<td>13.30 a (3.64)</td>
<td>6.49 a</td>
<td>6.17 a</td>
</tr>
<tr>
<td>CV (%)</td>
<td>7.81</td>
<td>10.77</td>
<td>8.08</td>
<td>1.51</td>
<td>1.27</td>
<td>3.46</td>
</tr>
</tbody>
</table>

The figures in a column with the same letter(s) do not differ significantly at 1% level of probability by DMRT

DAF = Days after flowering
* = (Transformed data in the parenthesis)

Boiled Pod Dry Mater: There were no significant differences among the treatments in terms of boiled pod dry matter. The highest boiled pod dry matter (13.30%) was found in H and the lowest (4.55%) in H.

Individual Pod Weight: A significant variation was observed among the harvesting time in respect of individual pod weight. The highest pod weight (6.49 g) was observed from the treatment of H (15 DAF) which was followed by the treatments of H, H and H (Table 1). The lowest individual pod weight (1.57 g) was recorded from the treatment H (07 DAF).

Weight of Pods per Plot: A significant variation was observed by the effect of harvesting time in respect of weight of pods/plot. The highest pod weight/plot (6.17 kg) was observed from the treatment of H (15 DAF) which was followed by the treatments of H, H and H (Table 1). The lowest pod weight per plot (1.84 kg) was recorded from the treatment H (07 DAF).

Green Pod Yield per Hectare: Effect of harvesting time played a significant role in increasing green pod yield ha⁻¹ of French bean. Nine harvesting time contributed to significantly higher green pod yield over other treatments. The highest green pod yield (28.56 t/ha) (Fig. 1) was observed from the treatment H (15 DAF) which was followed by the treatments of H and H, while the lowest (8.53 t/ha) was found in treatment H (07 DAF). But the pod harvested after 11 DAF (H) become fibrous those are not preferable to consumers and exceed the marketable yield. The pod harvested at H and H treatments were suitable for export quality yield. Green pod yield depends on the number of flowering nodes per branch, number of branches per plant and its retention.

Fig. 6.1: Effect of harvesting days on yield (t/ha) of French bean.

H = 07 DAF H = 08 DAF H = 09 DAF H = 10 DAF H = 11 DAF H = 12 DAF H = 13 DAF H = 14 DAF H = 15 DAF = Days after flowering

Ascorbic Acid: Amount of ascorbic acid content in fresh pod of bush bean var. BARI Jharr Sheem-2 varied significantly among the harvested different old age of pod. Regarding the pod age, the highest (17.40 mg/100g) ascorbic acid content was found in the treatment H (07 DAF) which was followed by the treatments H, H and H, while the lowest (11.44 mg/100g) was obtained in H (15 DAF) (Table 2). Ascorbic acid content (mg/100g) was found to be decreased with the advancement of pod age. These results are in agreement with the findings of Shanmungavelu [10], who reported the composition of green pod of French bean. Who also found that 100g
Table 2: Effect of harvesting days on quality of green pod of French bean var. BARI Jhar Sheem-2

<table>
<thead>
<tr>
<th>Treatments (DAF)</th>
<th>Ascorbic acid of fresh pod (mg/100g)</th>
<th>β-Carotene of fresh pod (mg/100g)</th>
<th>β-Carotene of boiled pod (mg/100g)</th>
<th>Total sugar of fresh pod (g/100g)</th>
<th>Total sugar of boiled pod (g/100g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>07</td>
<td>17.40 a</td>
<td>0.019 c</td>
<td>0.012 d</td>
<td>4.69 c</td>
<td>6.21 g</td>
</tr>
<tr>
<td>08</td>
<td>16.28 ab</td>
<td>0.029 bc</td>
<td>0.015 ed</td>
<td>4.98 bc</td>
<td>6.45 g</td>
</tr>
<tr>
<td>09</td>
<td>14.96 a-c</td>
<td>0.036 bc</td>
<td>0.021 b-d</td>
<td>5.26 a-c</td>
<td>6.69 g</td>
</tr>
<tr>
<td>10</td>
<td>13.64 ab</td>
<td>0.040 a-c</td>
<td>0.030 a-d</td>
<td>5.58 a-c</td>
<td>6.85 g</td>
</tr>
<tr>
<td>11</td>
<td>13.20 b</td>
<td>0.045 a-c</td>
<td>0.040 a-c</td>
<td>5.98 a-c</td>
<td>7.01 g</td>
</tr>
<tr>
<td>12</td>
<td>13.20 bc</td>
<td>0.045 a-c</td>
<td>0.040 a-c</td>
<td>5.98 a-c</td>
<td>7.23 g</td>
</tr>
<tr>
<td>13</td>
<td>12.76 bc</td>
<td>0.051 ab</td>
<td>0.043 ab</td>
<td>6.18 a-c</td>
<td>7.46 g</td>
</tr>
<tr>
<td>14</td>
<td>11.86 c</td>
<td>0.055 ab</td>
<td>0.049 a</td>
<td>6.38 ab</td>
<td>7.65 g</td>
</tr>
<tr>
<td>15</td>
<td>11.44 c</td>
<td>0.058 a</td>
<td>0.052 a</td>
<td>6.62 a</td>
<td>7.74 g</td>
</tr>
<tr>
<td>CV (%)</td>
<td>11.34</td>
<td>11.65</td>
<td>14.10</td>
<td>13.44</td>
<td>10.38</td>
</tr>
</tbody>
</table>

The figures in a column with the same letter(s) do not differ significantly at 1 % level of probability by DMRT

DAF = Days after flowering

The tender pod contain ascorbic acid 14 mg/100g. Parthasarathy [5] reported that 100 g edible portion of tender French bean pod contain 11 mg ascorbic acid. Ascorbic acid synthesizes more in fresh pods comparable to aged pods of French bean. It is soluble in water.

B-Carotene of Fresh Pod: Amount of β-Carotene content in fresh pods of bush bean var. BARI Jhar Sheem-2 varied significantly among the harvested different old age of pod. Regarding the pod age, the highest β-Carotene (0.058 mg/100g) content was found in the treatment H_6 (15 DAF) which was followed by the treatments H_9 (14 DAF), H_5 (13 DAF) and H_4 (12 DAF) while the lowest (0.019 mg/100g) was found in H_7 (07 DAF) (Table 2). β-Carotene content (mg/100g) was found to be increased with the advancement of pod age. These results are in agreement with the findings of Salunkhe et al. [17]. They observed the 0.03 mg/100g β-Carotene in Navy beans raw dry bean. It is soluble in fat.

B-Carotene of Boiled Pod: Amount of β-Carotene content in boiled pods of bush bean var. BARI Jhar Sheem-2 was significantly influenced by the harvested different old age of pod. Regarding the pod age, the highest (0.052 mg/100g) β-Carotene content was found in the treatment H_6 (15 DAF) which was followed by the treatments H_9 (14 DAF), H_5 (13 DAF) and H_4 (12 DAF) while the lowest (0.012 mg/100g) was found in H_7 (07 DAF) (Table 2). β-Carotene content (mg/100g) was found to be decreased with the boiling of fresh pod.

Total Sugar Content of Fresh Pod: Total sugar content in fresh pods of French bean var. BARI Jhar Sheem-2 was significantly influenced by the harvested different old age of pod. Regarding the pod age, the highest (6.62 g/100g) sugar content was found in the treatment H_5 (15 DAF) which was followed by the treatments H_9 (14 DAF), H_5 (13 DAF) and H_4 (12 DAF) while the lowest (4.69 g/100g) was found in H_7 (07 DAF) (Table 2). Total sugar content (mg/100g) was found to be increased with the advancement of pod age. These results are in agreement with the findings of Shanmungavelu [10], who reported the 4.5% carbohydrate in French bean pod. Poly saccharides remaining in pods are broken down into free sugars after boiling, resulted increasing of total sugar.

Total Sugar Content of Boiled Pod: Total sugar content in fresh pods of French bean var. BARI Jhar Sheem-2 was not significantly influenced by the harvested different old age of pod. However, the highest (7.74 g/100g) sugar content was found in the treatment H_6 (15 DAF) which was followed by the treatments H_9 (14 DAF), H_5 (13 DAF) and H_4 (12 DAF) while the lowest (6.21 g/100g) was found in H_7 (07 DAF) (Table 2). Total sugar content (mg/100g) was found to be increased with the advancement of fresh pod boiling or cooked.

Relationship Between Length of Green Pod and Harvesting Days at Different Days after Flowering of French Bean: A positive linear relationship was observed between length of green pod and harvesting time at different days of flowering (Fig. 2). It was observed that the equation \( y = 0.6362x + 8.9736 \) gave a good fit to the data and the value of co-efficient of determination \( (R^2 = 0.9612) \) showed that the fitted regression line had a significant regression co-efficient. The \( R^2 \) value indicated that 96% increase of pod length was attributed due to 15 days length of flowering. So, it indicated that length of green pod increased as the period of days after flowering increased.
$H_1 = 07 \text{ DAF, } H_2 = 08 \text{ DAF, } H_3 = 09 \text{ DAF, } H_4 = 10 \text{ DAF, } H_5 = 11 \text{ DAF}$

$H_6 = 12 \text{ DAF, } H_7 = 13 \text{ DAF, } H_8 = 14 \text{ DAF, } H_9 = 15 \text{ DAF, } \text{DAF} = \text{Days after flowering}$
Relationship Between Breadth of Green Pod and Harvesting Days at Different Days after Flowering of French Bean: A positive relationship between breadth of green pod and harvesting time at different days of flowering was found to be linear (Fig. 3). It was observed that the equation \( y = 0.0415x + 0.534 \) gave a good fit to the data and the value of co-efficient of determination \( (R^2 = 0.962) \) showed that the fitted regression line had a significant regression co-efficient. It indicated that breadth of green pod increased as the period of days after flowering increased.

Relationship Between Individual Pod Weight and Harvesting Time of French Bean: A positive linear relationship was observed between individual pod weight and harvesting time at different days of flowering (Fig. 4). It was observed that the equation \( y = 0.638x + 0.5178 \) gave a good fit to the data and the value of co-efficient of determination \( (R^2 = 0.9665) \) showed that the fitted regression line had a significant regression co-efficient. So, it indicated that individual pod weight increased as the period of days after flowering increased.

Relationship Between Green Pod Yield (T/ha) and Harvesting Time of French Bean: A positive linear relationship was observed between green pod yield and harvesting days at different days of flowering (Fig. 5). It was observed that the equation \( y = 2.709x + 3.7794 \) gave a good fit to the data and the value of co-efficient of determination \( (R^2 = 0.9744) \) showed that the fitted regression line had a significant regression co-efficient. The \( R^2 \) value indicated that 97% increase of green pod yield was attributed due to 15 days length of flowering. So, it indicated that green pod yield increased as the period of days after flowering increased.

Relationship Between Ascorbic Acid Content of Fresh Pod and Harvesting Time of French Bean: A negative linear relationship was observed between ascorbic acid content of fresh pod and harvesting time at different days of flowering (Fig. 6). It was observed that the equation \( y = -0.699x + 17.355 \) gave a good fit to the data and the value of co-efficient of determination \( (R^2 = 0.9282) \) showed that the fitted regression line had a significant regression co-efficient. The \( R^2 \) value indicated that 92% decrease of ascorbic acid content was attributed due to 15 days length of flowering. So, it indicated that ascorbic acid content of fresh pod decreased as the period of days after flowering increased.

Relationship Between \( \beta \)-carotene Content of Fresh Pod and Harvesting Time of French Bean: A positive linear relationship was observed between \( \beta \)-carotene content of fresh pod and harvesting time at different days of flowering (Fig. 7). It was observed that the equation \( y = 0.0047x + 0.0169 \) gave a good fit to the data and the value of co-efficient of determination \( (R^2 = 0.9886) \) showed that the fitted regression line had a significant regression co-efficient. The \( R^2 \) value indicated that 98% increase of \( \beta \)-carotene content was attributed due to 15 days length of flowering. So, it indicated that \( \beta \)-carotene content of fresh pod increased as the period of days after flowering increased.

Relationship Between \( \beta \)-carotene Content of Boiled Pod and Harvesting Time of French Bean: A positive linear relationship was observed between \( \beta \)-carotene content of boiled pod and harvesting time at different days of flowering (Fig. 8). It was observed that the equation \( y = 0.0053x + 0.0068 \) gave a good fit to the data and the value of co-efficient of determination \( (R^2 = 0.9831) \) showed that the fitted regression line had a significant regression co-efficient. The \( R^2 \) value indicated that 98% increase of \( \beta \)-carotene content was attributed due to 15 days length of flowering. So, it indicated that \( \beta \)-carotene content of boiled pod increased as the period of days after flowering increased.

Relationship Between Total Sugar Content of Fresh Pod and Harvesting Time of French Bean: A positive linear relationship was observed between total sugar content of fresh pod and harvesting time at different days of flowering (Fig. 9). It was observed that the equation \( y = 0.236x + 4.5411 \) gave a good fit to the data and the value of co-efficient of determination \( (R^2 = 0.9903) \) showed that the fitted regression line had a significant regression co-efficient. The \( R^2 \) value indicated that 99% increase of sugar content was attributed due to 15 days length of flowering. So, it indicated that total sugar content of fresh pod increased as the period of days after flowering increased.

REFERENCES