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EFFECT OF HARVEST TIMES ON THE YIELD AND SEED QUALITY OF FRENCH BEAN

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ABSTRACT

A two years field study was carried out in the research field and laboratory of Seed Technology Division, Bangladesh Agricultural Research Institute, Gazipur, Bangladesh during *rabi* season of 2008-10. The aim of this study was to determine the effect of five different dates of harvest viz. H_1: 65 Days after emergence (DAE), H_2: 70 DAE, H_3: 75 DAE, H_4: 80 DAE and H_5: 85 DAE on the seed yield and viability of French bean. The experiment was laid out in randomized complete block design (RCB) with four replications. Results showed that the yield and yield contributing parameters significantly influenced the days to harvesting. The highest seed yields of 1.15 and 1.31 t ha^{-1} were obtained from the harvest of 75 DAE (Days after emergence) in 2008-09 and 2009-10, respectively. On the contrary, seed quality parameters like seed germination, root length and vigour index were also significantly influenced by harvest time. The highest seed germination percentage of 91.33 and 91.56 were recorded from the seed plots harvested at 75 DAE (pods are light brown with few yellow colour) both for the year 2008-09 and 2009-10, respectively. Similarly, the vigour indexes (12.49 and 11.64) were the highest in seed harvested at 75 DAE from the year of 2008-09 and 2009-10, respectively. This might be due to more food reserve and dry matter accumulation on the seed at later harvest. However, seeds harvested in 80 and 85 DAE were also found good for seed yield and seed quality.

Keywords: French bean, Seed maturity, Viability, Seed yield, Vigour index

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INTRODUCTION

French bean (*Phaseolus vulgaris* L.) is an important leguminous crop mostly grown as green vegetable in Bangladesh. It is a nutritious vegetable commonly seen in home gardens and cheap source of calcium, iron and vitamins. The immature pod, tender parts and also dry beans are used as curry and French beans have a possibility to meet a large share of vegetables demand in Bangladesh (BARI, 2007). Singh et al. (1997) reported that French bean is a potential source of proteins, carbohydrates and minerals. Mineral matter, crude fibre and ether extract are concentrated in seed while crude protein and energy are stored in the cotyledons. In Bangladesh, there is a vast scope to grow French bean both in the field and homestead condition especially in Sylhet region. But higher production of crops depends largely on the ability to integrate better crop management into the cultivation systems. To boost yield, quality seed is essential both for vegetables and seed production. Seed maturity, viability and storability are correlated with each other. Early harvested seeds are immature and poorly developed, resulting in poor quality that affects subsequent storability compared to seeds harvested at physiological maturity. Delayed harvesting also results in the loss of yield due to shattering, damage of seed and the risk of rain that affect seed quality. The quality of bean seeds depends on many pre and post-harvest factors, such as the area of production, cultivation techniques, seed maturity, harvesting, threshing, processing and storage conditions. Greven et al. (2004) reported that timing of harvest is an important factor since both seed immaturity and rewetting reduce seed quality. Kumar et al. (2002) reported that seed yield and quality largely depends on the stage of maturity of crops. Therefore, harvesting of seeds at the optimum stage of maturity is important as harvesting either at early or late stage results in lower yields with poor quality seeds. Dharmalingam and Basu (1990) reported that seed development and maturation study is important to ensure good yield associated with viability, vigour and field performance. Moisture content of harvested crops also affects seed quality. Harvesting at high moisture content increases the chances of mycofloral infection on seed, while harvesting at low moisture content increases mechanical damage to seed (Yadav et al., 2005). Mehta et al. (1993) stated that chickpea attained maximum dry matter accumulation (physiological maturity) when most pods were light brown with few yellow green, thereafter, dry weight of seed decreased due to disruption of vascular connection and utilization in various physiological and metabolic processes like respiration.

Seed development is the period between fertilization and maximization of fresh weight accumulation and seed maturation begins at the end of seed development and continues till harvest (Mehta et al., 1993). The seed reaches its maximum dry weight at physiological maturity and seeds should be harvested at this time to ensure their quality in terms of germinability and vigour. If the seeds are retained on mother plant after physiological maturity, physiological changes in seed may lead to formation of hard seeds or off colour seeds in pulse crops. Attainment of physiological maturity is

a genotypic character which is influenced by environmental factors (Mahesha et al., 2001a). Storability of seed is mainly a genetic character and is influenced by pre-storage history of seed, seed maturation and environmental factors during pre and post-harvest stages (Mahesha et al., 2001b**).** Greven et al. (2004) reported that later sowing, higher plant populations, desiccation and earlier harvesting reduced seed size of Dwarf French beans, but significant differences were found in germination and seed vigour.

Muasya (2001) reported that both high temperature and less rainfall could reduce seed quality of common bean. A number of studies revealed that high temperature is more detrimental than limited rainfall. Unfavorable weather conditions may reduce seed quality mainly through reducing the maximum quality attainable during crop development. The seed quality in general did not change significantly between physiological maturity (PM) and harvest maturity (HM), but in some cases the proportion of viable seeds increased between PM and HM, especially when ambient temperatures were relatively low (Muasya et al., 2008). Thus, harvesting of seed crop at optimum stage of seed maturation is essential to obtain better seed quality. There is hardly any literature available on appropriate maturity time (harvest time) of French bean in Bangladesh condition where seed quality will be maximum and that will affect the subsequent viability and storability of seed. Hence, the present study was done with the following objective:

i) To find out appropriate harvest time on the seed yield and quality of French bean and

ii) To investigate the relationship between seed maturity and viability with harvest time in French bean.

MATERIALS AND METHODS

The trial was conducted at the research field and laboratory of Seed Technology Division, Bangladesh Agricultural Research Institute, Joydebpur, Gazipur during *rabi* season from November 2008 to March 2010. The experimental treatments comprised of five different dates of harvesting *viz.*, H_1: 65 Days after emergence (DAE- Department of Agriculture Extension), H_2: 70 DAE, H_3: 75 DAE, H_4: 80 DAE and H_5: 85 DAE. The harvesting stages were characterized by deep green with light yellow colour of pod (65 DAE), 50% green and 50% yellowing of pods (70 DAE), light brown with few yellow colour pods (75 DAE), 90% brown colour of pods (80 DAE) and 100% brown colour and dried pods (85 DAE), respectively. Approximately 100% field emergence was recorded at 10 days after sowing of seed. The French bean (also called Bush bean) variety BARI Jharsheem-1 was used for the trial. The experiment was laid out in randomized complete block design (RCBD) with four replications. The unit plot size was 12 sq.m. The land was fertilized with 23, 75, 75 and 20 kg ha^{-1} of N, P, K and S in the form of Urea, TSP, MoP and Gypsum, respectively (BARI, 2006). Half of N and all other fertilizers were applied at the time of final land preparation. The remaining N was applied at 30

DAS. Seeds were sown in furrows @ 60 kg ha^{-1} in 30 cm rows on 22 and23 November 2008 and 2009, respectively. Before sowing, all seeds were treated with Bavistin @ 0.2x ml kg^{-1} of seed. All intercultural operation *viz.*, weeding (two times one each at 15 and 40 DAE), thinning (1 time), irrigation (two times one each at 30 and 50 DAE) were done. The crop was harvested on February 3 (65 DAE), Feb 8 (70 DAE), Feb 13 (75 DAE), Feb 18 (80 DAE) and Feb 23 (85 DAE). Prior to harvest 5 plants were selected randomly from each plot and uprooted carefully for collecting data on yield contributing characters *viz.* field emergence, 50% of flowering, plant height and pods $plant^{-1}$, and seeds pod^{-1}. After harvesting the collected pods were then sun dried until the moisture content reached 10-12%. Seed yield data collected from individual plots were converted to per hectare of yield. The data on seed quality parameters like seed germination (%), root and shoot length (cm), average seedling dry weight (g) and vigour index (%) were then taken in the laboratory following ISTA rules. The collected data were statistically analyzed following the ANOVA technique using MSTAT-C software. The mean differences among the treatment means were adjudged by Least Square Difference (Gomez and Gomez., 1984). Seed vigour index was calculated by multiplying germination (%) and seedling length (Abdul-Baki and Anderson, 1973). Seed germination was calculated by the following formula (ISTA, 1999):

i) Vigour index (VI) = (MRL + MSL) x PG .....(A)

Where,

VI = Vigour index;

MRL=Mean root length (mm);

MSL= Mean shoot length (mm) and

PG = Percentage germination.

$$\textit{ii) Seed germination (\%)} = \frac{\textit{No. of seed germinated}}{\textit{Total seed}} \times 100 \quad \textit{.....(B)}$$

RESULTS AND DISCUSSION

Results obtained from the two consecutive years of 2008-09 and 2009-10 are presented in table 1-4 and figure 1-4. Two years (2008-10) average maximum and minimum temperature and total rainfall in Gazipur are presented in figure 1 and 2. From the graphs, it was observed that the average maximum temperatures were in the month April in both the years (34^oC) while the lowest minimum temperature was recorded in middle of January which was just above 9^oC. There was almost no rainfall recorded during the growing period (November to February) of French bean in both the years except in the last week of February where a very small amount of precipitation (5 mm) was observed. However, rainfall was recorded in all other months ranging from 5 mm to 160 mm.

Effect of harvest time on the seed yield and yield parameters of French Bean

Results revealed that there were significant differences on plant height, number of pods plant^{-1}, pod length, 1000 seed weight and seed yield both from 2008-09 and 2009-10 (Table 1-2 and Figure 3-6). The highest plant heights (38 and 37.04 cm) were observed from the harvest at 70 DAE in 2008-09 and 2009-10 respectively, while the lowest plant heights (28.30 and 32.02 cm) in both the years were obtained from the harvest at 85 DAE (Table 1). The highest numbers of pods plant^{-1} (21.13 and 22.75) were recorded from the harvest at 85 DAE in both years. Crop harvested at 65 DAE produced the lowest numbers of pods plant^{-1} (17.62 and 18.03) in 2008-09 and 2009-10, respectively. It was observed that the longest pod (15.08 and 15.60 cm) were obtained from the harvest at 70 and 75 DAE, while the shortest pods (13.75 and 13.60 cm) were found from the harvest at 85 DAE in 2008-09 and 2009-10, respectively (Table 2). It was noted that the number of seeds per pods were significantly different in 2009-10, unlike in 2008-09. The highest number of seeds per pods (628) was recorded from the harvest of 75 DAE from 2009-10 (Table 2).

Significantly, the highest 1000 seed weight of 213.80 g and 207.26 gm were recorded from the harvest of 80 and 75 DAE, respectively in 2008-09 and 2009-10, while the lowest 1000 seed weight (137.10 and 141.82 g) were obtained from the harvest at 65 DAE in both the years (Figure 3 and 4). The highest seed yield (1.15 and 1.31 t ha^{-1}) were recorded from the harvest at 75 DAE from 2008-09 and 2009-10, respectively, while the lowest seed yield (0.64 and 0.75 tons) were harvested at 65 DAE in both years (Figure 5 and 6). Number of pods per plant was directly related to seed yield. Therefore, as 75 to 85 DAE harvested plants beard higher number of pods per plant, so it reflected on seed yield on theses harvesting time. The increase in yield in 75 DAE compared to 65 DAE was 79.68% in 2008-09 and 74.66% in 2009-10 which might be attributed to increased pods per plant, seeds per pod and 1000 seed weight (Rani and Kodandaramaiah, 1997). The result is in conformity with the findings of Khatun et al. (2010). The optimum time of harvesting of French bean was also determined by regressing the 1000 seed weight and seed yield with harvesting dates (Figure 3-6). Regression co-efficient study revealed that associations between harvest time and 1000 seed weight (r^2= 0.695 and 0.478) and with seed yield (r^2= 0.84 and 0.593) showed highly significant positive correlations. Singh and Lachanna (1995) reported that early harvested seeds were immature and poorly developed compared to seeds harvested at physiological maturity. The present findings are in agreement with the findings of Khatun et al. (2010)who observed that most pods of chickpea harvested at light brown with a few yellow green stages recorded the highest seed yield. Greven et el. (2004) reported that rain during harvest may reduce seed quality, especially for seeds with <25% seed moisture content. This indicates that seed quality can already be reduced by rewetting before harvest maturity is reached. In field crops, maximum seed quality is gained at physiological maturity at the end of seed filling (Egli, 1998). Padrit et al. (1996) reported that delaying pea harvest could also cause the seed to become too dry and therefore more

easily damaged. Kavak et al. (2012**)** observed that early and late harvests not only decrease physical quality of seed lots but also decrease seed quality**.** Mehta et al. (1993) asserted that cultivars of chickpea attained maximum dry matter accumulation (physiological maturity) at H_2 stage when most of the pods were appeared light brown with few yellow in colour thereafter, dry weight of seed decreased because of restricted supply of nutrients from mother plants to seed due to disruption of vascular connection and utilization in various physiological and metabolic processes like respiration etc. Thus, maximum seed quality of French bean may be obtained during harvest at physiological maturity.

Effect of harvest time on the seed quality parameters of French Bean

Significant influences were observed among the different harvest times of French bean on the seed quality parameters *viz.*, seed germination, root length, shoot length and vigour index in 2008-09 and 2009-10, and average seedling dry weight in 2008-09 while the other parameters did not show any significant variations (Table 3 and 4). Results revealed that the highest seed germination (93.78 and 94.12%) was found from the harvest at 75 DAE in 2008-09 and 2009-10 respectively, while the lowest seed germination (62.67 and 64.11%) was recorded from the harvest at 65 DAE in both years. A similar trend was observed regarding the root and shoot length and average seedling dry weight (Table 3). The highest vigour index (2891) was recorded from the harvest of 75 DAE that was statistically identical with the harvest of 80 (2823) and 85 DAE (2825) from the year 2008-09. The same trend was also observed in vigour index (VI), where the highest VI (3069) was recorded in the seed harvested at 75 DAE followed by the harvest at 80 (2711) and 85 DAE (2712) in 2009-10 (Table 4).

The lowest values of vigour index (6.57 and 6.48) were obtained at 65 DAE for year 2008-09 and 2009-10, respectively. The quality of bean seeds depends on many pre and post-harvest factors, such as area of production, cultivation techniques, seed maturity and harvest as well as threshing, processing and storage conditions of seeds. Therefore, appropriate time of harvesting might be responsible along with other factors for higher seed quality of french bean seed harvested at 75 to 85 DAE. The seed lot showing a higher seed vigour index is considered to be more vigorous (Abdul-Baki and Anderson, 1973). The results are in agreement with the findings of Ayyub et al. (2007) who reported that physiologically mature seeds displayed better viability than immature seeds. The results is also conformity with the findings of Khatun et al. (2009) who asserted that lentil seeds collected at the stage when most of the pods were light brown with a few yellow (H_2 stage) recorded the highest germination percentage, dry weight, root length, shoot length, seedling length and vigour index (vigour index-I and vigour-Il).

CONCLUSION

Seed is the most valuable, basic and vital living input for increasing crop production. It has been scientifically proved that quality seed alone can contribute to the increase of yield by 15-20%. Therefore, quality seed production at appropriate time and seed maturity are a must for successful crop production. However, the present investigation revealed that the highest seed yield (1.15 and 1.08 t ha^{-1}) of French bean (BARI Jharsheem-1) was obtained from third harvest (75 DAE) while pods are shown light brown with few yellow colour in both the years. Regarding seed quality parameters, the study showed that French bean seeds harvested at 75 days after emergence were better in seed quality. Maximum seed germination and vigour index were also observed in seed harvested at 75 days of emergence. However, seeds harvested 80 and 85 DAE were also found good for seed yield and seed quality. To sum up, it can be concluded that harvesting of French bean seed at 75 to 85 days after emergence would be physiologically matured seed that ultimately lead to the highest seed quality as well.

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Table 1. Effect of harvest time on the field emergence, days to 50% flowering and plant height of French bean

Treatments*	Field emergence (%)		Days to 50% flowering		Plant height (cm)	
	2008-09	2009-10	2008-09	2009-10	2008-09	2009-10
H_1	95.25	95.75	45.50a	46.05	35.72 a	36.40a
H_2	95.50	95.50	46.50	45.65	38.00 a	37.04a
H_3	95.00	95.50	45.75	45.85	35.85 a	35.19ab
H_4	95.00	96.25	46.50	46.34	29.55 b	33.62bc
H_5	95.00	96.75	47.00	46.49	28.30 b	32.02c
CV (%)	0.87	-	2.01	-	6.40	3.93
$LSD_{(0.05)}$	NS	NS	NS	NS	4.206	2.110

* H_1: 65 DAE (Days after emergence), H_2: 70 DAE, H_3: 75 DAE, H_4: 80 DAE and H_5: 85 DAE

Table 2. Effect of harvest time on the pods plant^{-1}, pod length and seeds pod^{-1} of French bean

Treatments*	Pods plant $^{-1}$ (nos.)		Pod length (cm)		Seeds pods^{-1} (nos.)	
	2008-09	2009-10	2008-09	2009-10	2008-09	2009-10
H_1	17.62d	18.03b	15.07a	15.33a	5.32	5.27b
H_2	18.92c	18.65b	15.08a	15.40a	5.85	5.47b
H_3	20.03b	20.56ab	14.15ab	15.60a	5.77	6.28a
H_4	20.91ab	20.90ab	14.63ab	14.01b	5.30	5.71ab
H_5	21.13a	22.75a	13.75b	13.60b	5.30	5.69ab
CV (%)	2.15	9.23	3.92	4.04	7.64	7.60
$LSD_{(0.05)}$	0.080	2.868	1.119	0.921	NS	0.666

* H_1: 65 DAE (Days after emergence), H_2: 70 DAE, H_3: 75 DAE, H_4: 80 DAE and H_5: 85 DAE

Table 3. Effect of harvest time on the seed germination, root and shoot length of French bean after harvest

Treatments*	Germination (%)		Root length (cm) RL-2		Shoot length (cm)	
	2008-09	2009-10	2008-09	2009-10	2008-09	2009-10
H_1	62.67c	64.11c	8.39b	7.98c	18.57c	19.60c
H_2	74.89b	73.11b	8.52b	8.17c	19.42b	21.25b
H_3	93.78a	94.12a	9.59a	10.01a	21.25a	22.59a
H_4	92.89a	90.56a	9.58a	8.97b	20.81a	20.96b
H_5	92.56a	92.00a	9.26a	8.55bc	21.26a	20.91b
CV (%)	3.26	3.35	2.5	4.58	2.13	2.85
$LSD_{(0.05)}$	5.121	5.218	0.3859	0.7531	0.8120	1.131

* H_1: 65 DAE (Days after emergence), H_2: 70 DAE, H_3: 75 DAE, H_4: 80 DAE and H_5: 85 DAE

Table 4. Effect of harvest time on the root-shoot ratio, average seedling dry weight and vigour index of French bean

Treatments*	Shoot-Root ratio (cm)		Average seedling dry weight (g)		Vigour index (VI)	
	2008-09	2009-10	2008-09	2009-10	2008-09	2009-10
H_1	2.213	2.457	0.11b	0.11	1687c	1769d
H_2	2.283	2.603	0.12ab	0.11	2092b	2153c
H_3	2.213	2.257	0.14a	0.13	2891a	3069a
H_4	2.177	2.343	0.14a	0.13	2823a	2711b
H_5	2.297	2.450	0.12ab	0.12	2825a	2712b
CV (%)	3.68	5.88	9.88	4.32	2.25	3.93
$LSD_{(0.05)}$	NS	NS	0.019	NS	118.4	183.8

* H_1: 65 DAE (Days after emergence), H_2: 70 DAE, H_3: 75 DAE, H_4: 80 DAE and H_5: 85 DAE

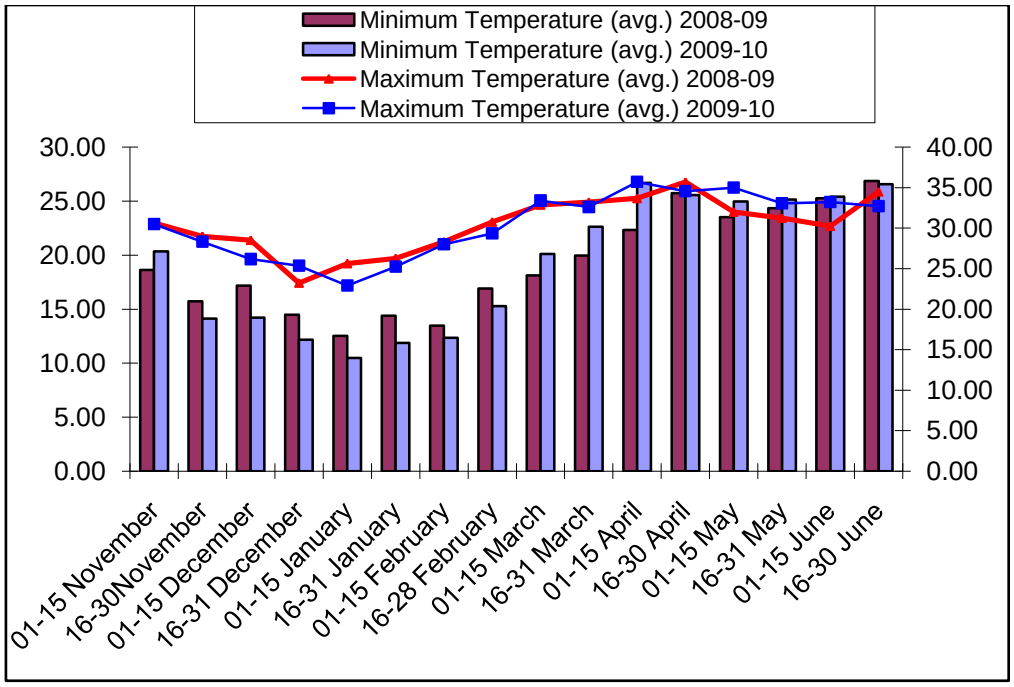

Figure1. Maximum and minimum temperature (^{0}C) from November to June of 2008-10 at Joydebpur, Gazipur

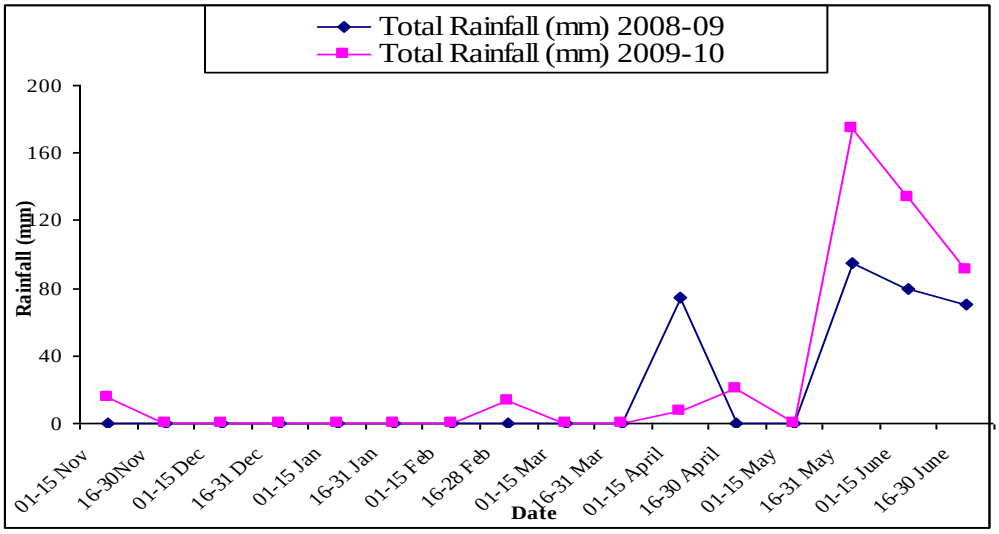

Figure 2. Total rainfall (mm) from November to June of 2008-10 at Joydebpur, Gazipur

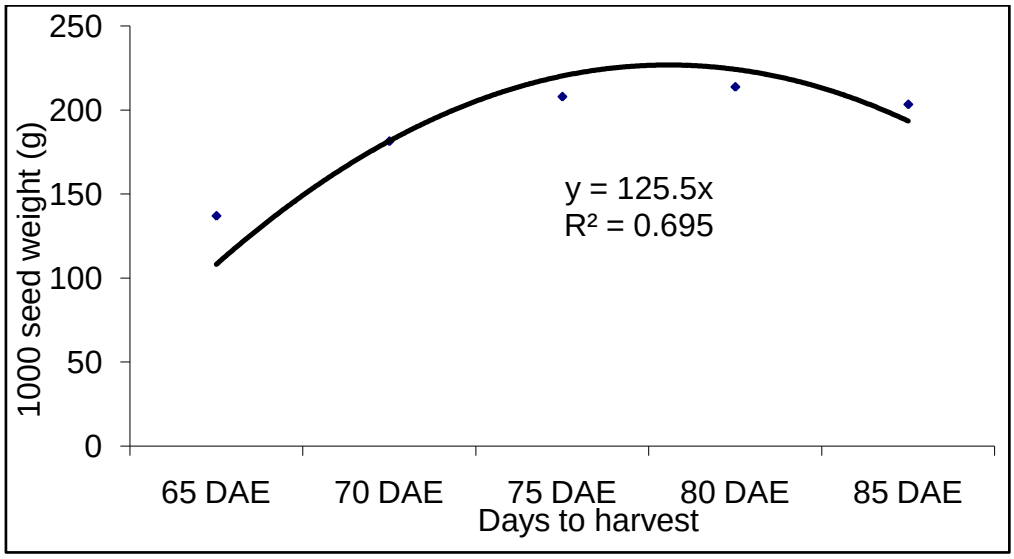

Figure 3. Effect of harvest time on 1000 seed weight of French bean (2008-09)

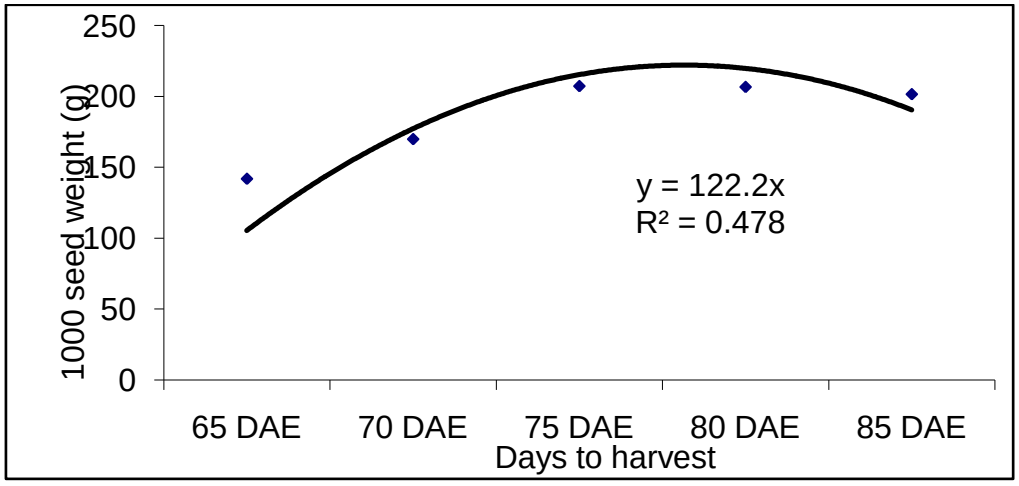

Figure 4. Effect of harvest time on 1000 seed weight of French bean (2009-10)

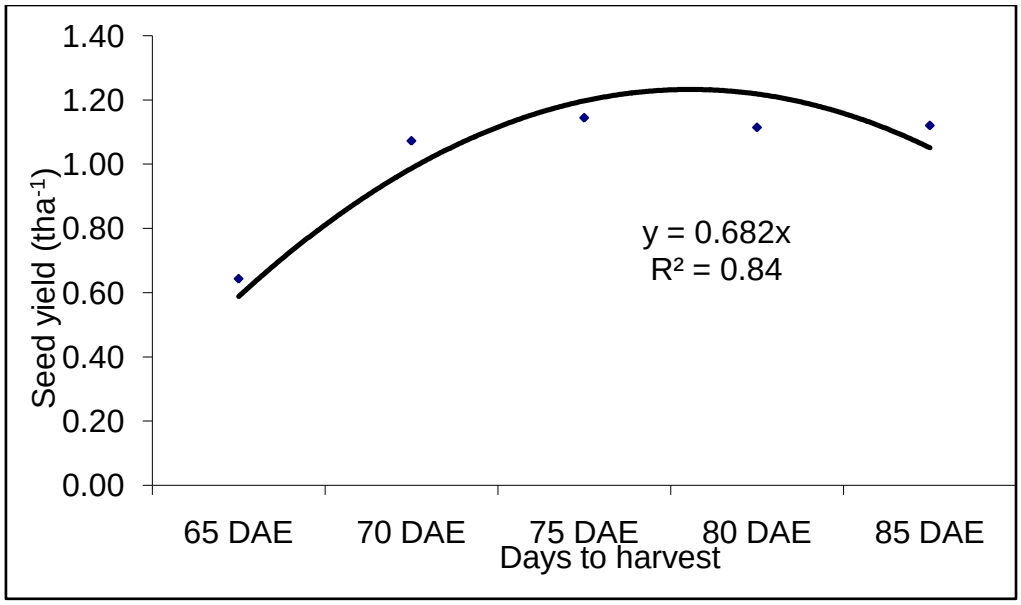

Figure 5. Effect of harvest time on the seed yield of French bean (2008-09)

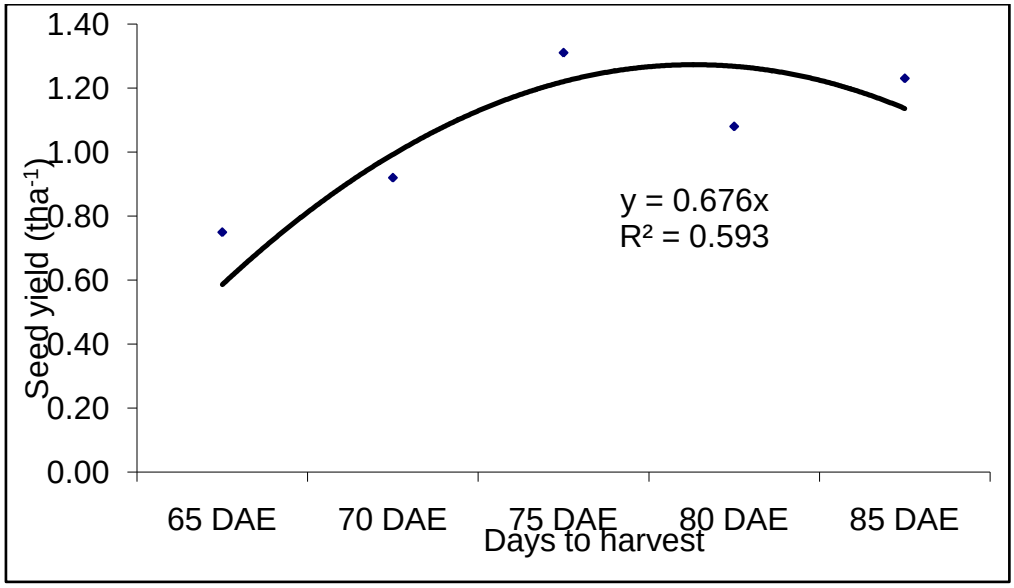

Figure 6. Effect of harvest time on the seed yield of French bean (2009-10)