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Optimum Time for Harvesting Yardlong Bean *(Vigna sesquipedalis)* for High Yield and Quality of Pods and Seeds

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ABSTRACT

A study was carried out to determine the most appropriate time of harvesting yardlong bean pods for fresh vegetable and dry seeds for planting, based on physiological characteristics including moisture content and weight of pods and seeds, as well as germination capacity of seed and seedling vigour. Three distinct, but overlapping stages were identified during pod and seed development and maturation. During 0 to 15 days after flower opening (DAFO), pod and seed size increased rapidly and showed maximum fresh weights. During 15 to 25 DAFO, pod and seed moisture contents decreased to 245 g kg^{-1} and 290 g kg^{-1}, respectively, and seed germination increased to maximum level. Optimum time for harvesting fresh pods was 15 DAFO when pod and seed moisture content rations were 847 g kg^{-1} and 602 g kg^{-1} respectively. Pods at 20 DAFO offered the best compromise for maximizing dry seed yield, germination and seedling vigour.

Key Words: Fresh pod yield; germination percentage; harvest date; seed yield; *Vigna sesquipedalis*

INTRODUCTION

Yardlong bean [*Vigna unguiculata L. (Walp.) subsp. sesquipedalis*] is an important leguminous vegetable mostly cultivated in China, Southeast Asia, the Caribbean, Central and West Africa (FAO, 1993; Piluek, 1994). Two growth habit types exist, namely the dwarf and climbing types. The latter takes longer time to commence pod production but is less determinate and also more common as a commercial crop (Rice *et al*., 1990). Fresh pods are harvested for use as a green vegetable. The pods are rich in calcium, phosphorus, sodium, and potassium. Also fair amounts of vitamin A, thiamine and ascorbic acid are present (Piluek, 1994).

Pods must be picked at maximum size, but when smooth and before seeds mature (Lim, 1998). At this stage, the pods can be snapped easily and cooked in various ways and seasoned. Small-scale farmers commonly allow the late pods to dry, to provide seed for planting. Delayed harvesting of mature pods results in high incidence of pod borer (*Maruca testularis*) damage (Poffley, 1993).

There is a lack of information on optimum time for harvesting yardlong beans for fresh pods and dry seeds. Research on the time of harvesting has been mostly on time of commencement of harvesting (Rice *et al.,* 1990) and changes in colour of pods (Lim, 1998). During development and maturation of pods and seeds, changes occur in moisture content, physical and physiological properties. From limited study on this subject, it has been reported that yardlong bean seeds at maximum dry weight of pods had moisture content of 50% (Leon & Withers, 1986). Similarly, in snap bean (*Phaseolus vulgaris*), Bailly *et al*. (2001) reported that at physiological maturity seed moisture content was 50 to 55%. In Thailand, differences in seed germination and soil emergence of yardlong bean seeds obtained from pods harvested at 18 to 22 days after flower opening were not significant (Santipracha & Santipracha, 1997). The researchers recommended that harvesting should be done at 20 days after flower opening. Our hypothesis is that under any prevailing growing conditions, there should be optimum times for harvesting yardlong bean pods, to produce high yield and quality of fresh immature pods for consumption and for the production of good quality seeds for planting.

The objective of this study was to determine the optimum time to harvest yardlong bean pods for high yield and quality of fresh pods and dry seeds, through monitoring of changes in dry matter during development and maturation of pods and seeds and determination of seedling vigour subsequently.

MATERIALS AND METHODS

Two field experiments were carried out at the University of Ghana Farm, Legon, during the dry season, from September 2000 to January 2001 and from October 2001 to February 2002. In both years, the experimental areas were ploughed and harrowed. The soil was sandy loam and belongs to Adenta series, a savannah acrisol (Anonymous, 1990). The climatic conditions during the periods of studies were typically hot and humid (Table I).

Seeds of a climbing type of yardlong bean, cultivar 'Sinna', which is the commonly available cultivar in Ghana, were used. Three seeds were planted and thinned to one plant per hill at two weeks after seedling emergence. The pods were harvested at six dates after flower opening. A randomised complete block design was used with four replications. Each treatment was comprised of a four-row plot with rows spaced 90 cm apart and plants were 50 cm apart within a row (Rice *et al*., 1990). There were 15 plants in each row.

Supplementary irrigation was supplied from a sprinkler every other day for the first six weeks, after which watering was reduced to two times a week. Irrigation was done to keep the available soil moisture content at 60 to

70% throughout the study period. Compound fertilizer N, P and K was applied three weeks after emergence of seedlings respectively at 30, 40 and 30 kg ha^{-1}. A second application of N was made two weeks later at the rate of 30 kg N ha^{-1}. Weeds were manually hoed two weeks after seedling emergence and then routinely carried out whenever necessary to ensure weed-free conditions. Each plant was staked with a 3 m tall wooden pole when plants were three weeks old. The vines were made to climb the poles. Insecticides, agrothoate (dimethoate) and cymethoate, were applied (each @ 3 mL L^{-1}) to control insects two weeks after emergence. A week after flowering, actellic was applied, to control post-flowering insects. Pods were harvested over a period of four weeks.

At flowering, flowers were tagged to indicate the intended date of pod harvest. Pods were harvested at five-day intervals from 10 to 35 days after flowering. Data were recorded from randomly selected 10 plants from the two central rows of each plot. Fresh weight of individual pods were taken immediately after harvest, seeds were manually separated and weighed. Seed weight was divided by the number of seeds per pod and then multiplied by 100 to compute the fresh weight of 100 seeds at each harvest for each plant. The pods and seeds were dried in hot air oven at 40°C to a constant weight for pods and 9 to 10% moisture content for seeds. Pod and seed moisture contents were calculated as differences between their fresh and dry weights, expressed as percentages of fresh weights. Only the first 20 pods from each plant were used in the determination of pod and seed weights, moisture content and seeds per pod. The rest of the pods from each plant were counted and weighed in bulk at each harvest. Seed germination was carried out in a laboratory using four replications of 100 seeds each for each harvest seed lot. Germination studies were carried out in petridishes lined with wet paper towels. The temperature in the laboratory was 26±1.0°C and the relative humidity was 88±4%. The seeds were declared germinated when the radicle appeared and the germinated seeds were planted on a seedbed a day after germination. Seedling vigour was determined as dry weight of 2-week old seedlings.

Statistical data analysis was carried out using Genstat statistical package (Genstat, 2002). Analysis of variance of data from the separate studies did not indicate significant year or year x treatment interactions. Data on seed germination was transformed into arcsines before carrying out analysis of variance. Means separation was carried out using the least square difference whenever the variance ratio showed significance.

RESULTS

Fresh pods and seed weights increased sharply from 10 days after flower opening (DAFO) and peaked at 15 DAFO, but their corresponding dry weights were highest at 25 and 35 DAFO and not significantly different for 20 to 35 DAFO values (Table II). Pod and seed moisture contents decreased significantly ($P<0.001$) with age of pod (Table III). The pod moisture content dropped rapidly between 15 and 25 DAFO. There was however, a steady drop in seed moisture content from 10 to 35 DAFO.

Three distinct, slightly overlapping stages were evident during pod and seed development and maturation. The first stage of pod and seed development occurred at 0 to 15 DAFO and was characterized by rapid dry matter accumulation with moisture content of 847 g kg^{-1} for pods and 602 g kg^{-1} for seed. The second stage, which occurred at

Table I. Climatic conditions at Legon during periods of studies

Month and Year	Temperature (°C)		Relative humidity (%)	Rainfall (mm)	Sunshine (h)
	Min	Max.			
September 2000	24	31	74.0	35.7	12.1
October 2000	24	30	72.5	30.4	12.0
November 2000	24	32	69.5	15.2	12.2
December 2000	24	32	60.5	8.6	12.1
January 2001	25	31	64.5	2.0	12.0
October 2001	24	31	76.8	34.2	12.0
November 2001	24	32	68.0	40.5	12.2
December 2001	25	32	60.3	10.2	12.1
January 2002	24	30	56.3	5.5	12.0
February 2002	25	33	66.5	14.2	12.1

Table II. Effect of date of harvest on fresh and dry weights of pods and seeds

Harvest date (DAFO)[a]	Fresh pod weight (g)	Fresh weight of 100 seeds (g)	Dry pod weight (g)	Dry weight of 100 seeds (g)
10	8.2	11.2	0.8	2.3
15	16.2	35.7	2.5	14.7
20	6.4	26.3	3.1	15.0
25	4.6	23.0	3.4	15.6
30	4.0	18.8	3.3	15.6
35	3.9	18.0	3.2	15.8
LSD (*P=0.05*)	1.6	3.7	0.5	1.0

[a] Number of days after flower opening

Table III. Effect of harvest date on pod and seed moisture content, percentage germination and seedling size

Harvest date (DAFO)[a]	Pod moisture content (g kg^{-1})	Seed moisture content (g kg^{-1})	Percent seed germination[b]	Seedling dry weight (g)
10	897	798	0 (0)	-
15	847	602	43.5 (0.45)	1.7
20	537	439	81.0 (0.95)	2.3
25	245	290	88.1 (0.99)	2.2
30	193	174	87.0 (0.98)	2.2
35	158	100	88.0 (0.99)	2.2
LSD (*P=0.05*)	63	80	(0.16)	0.4

[a] Number of days after flower opening
[b] Arcsine-transformed values in brackets.

Table IV. Effect of harvest date on pod and seed number and yield per plant

Harvest date (DAFO)[a]	Number of pods per plant	Fresh pod Yield per plant (kg)	Seeds per pod	Number of seeds per plant	Dry seed yield per plant (g)
10	108	0.90	12	1330	27.2
15	83	1.34	13	1073	159.7
20	72	0.47	14	993	149.4
25	66	0.31	14	814	144.2
30	67	0.25	15	884	144.9
35	61	0.27	15	1014	168.1
LSD (*P=0.05*)	8.4	0.15	1.0	99	32.3

[a] Number of days after flower opening

15 to 25 DAFO, started with rapid drop in fresh weights of both pods and seeds and ended at physiological maturity, when pods reached maximum dry weight. Pod and seed moisture content dropped to about 245 g kg^{-1} and 290 g kg^{-1} respectively during this phase. The third stage was characterized by a gradual loss of moisture, with seed moisture content of 100 g kg^{-1} at 35 DAFO.

The developing seed started to germinate at 15 DAFO and percentage germination increased significantly (P<0.001) with age of pods, but was not significantly different for seeds from pods harvested at 20 to 35 DAFO (Table III). Seedling vigour rated as seedling dry weight was significantly (P<0.05) higher for seeds from pods harvested at 20 to 35 DAFO than for seeds from pods harvested at 15 DAFO. However, pods harvested at 20 to 35 DAFO produced similar weights of seedlings.

The highest pod yield per plant of 1.34 kg was obtained for pods harvested at 15 DAFO, followed by 10 DAFO and these were significantly (P < 0.05) higher than pod yields from other harvest dates (Table IV). Pod yields when harvesting was at 20 to 35 DAFO were not significantly different. The number of pods per plant was highest for 10 DAFO harvest, which was 23% to 42% higher than number of pods produced at the other harvest dates. Dry seed yield increased significantly (P<0.05) from 27.2 g, when pods were harvested at 10 DAFO to 168.1 g from pod harvests at 35 DAFO. The latter yield was not significantly different from yield of 15 to 30 DAFO harvests. The number of dry seeds per pod increased with age of pod. At 10 DAFO, the number of seeds per plant was higher because of the high number of pods per plant, but the seeds were not physiologically mature and none germinated.

DISCUSSION

Three stages of pod and seed development observed in this study were of longer duration than those reported for cowpea as 0 to 10, 11 to 20 and 20 to 25 DAFO, respectively (Palanisamy *et al.*, 1986; Lassim & Chin, 1987). The moisture content of 500 g kg^{-1} at maximum pod dry weight reported for cowpea (Palanisamy *et al.*, 1986), corresponded to 20 DAFO in this study.

Seed germination was highest at physiological maturity (25 DAFO) as observed for cowpea (Lassim & Chin, 1987) and snap bean (Bailly *et al*., 2001). Lassim and Chin (1987) found that cowpea seeds were capable of germination as early as 13 DAFO and germination increased with time, peaking at 17 DAFO. Seedling dry weight was highest at 20 DAFO in the present study. In a related study, seedling dry weight was highest for yardlong bean seeds from pods harvested at 20 DAFO and this was significantly higher than seeds from pods harvested on other harvest dates. Furthermore, seeds from pods harvested at 20 DAFO, when planted, also gave the highest yield of fresh pods per plant (Santipracha & Santipracha, 1997).

For high yield and market quality of fresh pods, it has been recommended that yardlong bean pods be harvested before seeds mature and at maximum length of pod, but before seeds become visible as bumps on the outside of the pod (Poffley, 1997). Maximum pod length may coincide with maximum fresh weight of pods, which was consistent with pods harvested at 15 DAFO in the present study. There is a lack of information on duration of harvesting of yardlong bean pods. It would be necessary to relate total fresh yield to duration of harvest period, to explain differences in pod yields reported (Rice *et al.*, 1990). Greenhouses in the Netherlands have produced marketable pod yield of 8 kg m^{-2} (Grubben, 1994), but commonly yields of 3 kg m^{-2} have been reported (Poffley, 1997). The highest fresh pod yield per plant of 1.34 kg in this study was equivalent to 2.85 kg m^{-2}. It is recommended that optimum date for harvesting pods to obtain high yield and quality of seeds should be based on seed yield, germination capacity of seed and seedling vigor. Considering these three attributes, harvesting pods of yardlong bean was most appropriate at 20 DAFO under the prevailing growing conditions.

CONCLUSION

Changes in dry matter and moisture contents of pods and seeds are useful indicators for determining optimum time for harvesting yardlong bean for vegetable use and for dry seed production. Timely harvest is important to avoid problems of fibrous fresh pods, poor seed germination and subsequent poor seedling vigour. Pods must be harvested at 15 DAFO for vegetable use and at 20 DAFO for dry seed production.

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