Effect of Pod Maturation on Vegetative Growth, Fruit Yield and Seed Germination of Okra *(Abelmoschus esculentus* (L.) Moench)

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Résumé

Berchie, Nketiah .J, Djietror, Akrofi, & Osei, C. K. *Effet de la Maturation des Gousses sur la Croissance Vegetative, la Production des Fruits et la Germination des Graines du Gombo (Abelmoschus esculentus* (L) Moench). Une expérience a été faite pour déterminer l'effet que l'étape de la maturité de la gousse exerce sur la croissance végétative, la production et la germination de graines de trois variétés du gombo ; à savoir "Accra No.2 ", "Clemson Spineless" et "Labadi Dwarf." Les gousses ont été récoltées 6, 12, 18, 24 et 30 jours après l'antithèse. La production des fruits verts des plantes récoltées 6 jours après l'antithèse était deux fois celles des fruits récoltés 30 jours après l'antithèse. Le pourcentage des graines qui ont germé s'est néanmoins lévé au fur et à mesure que l'âge des gousses s'élevait. Le pourcentage moyen de la germination était 0,0; 4,0; 38,0; 79,0 et 84,0 obtenu des gousses récoltées 6, 12, 18 , 24 et 30 jours respectivement après l'antithèse. Les plantes sur lesquelles on a permis aux gousses de sécher ont révélé une croissance arrêtée. Il est alors recommandé que la récolte des gousses soit faite au sixième jour après l'antithèse dans le cas des fruits verts et 24 jours dans celui de la production des graines.

Mots clés : Maturité des gousses, production des gousses, germination des graines, gombo, *Abelmoschus esculentus* (L.) Moench.

Abstract

An experiment was conducted to determine the effect of stage of pod maturity on vegetative growth, yield and seed germination of three varieties of okra; Accra No. 2, Clemson Spineless and Labadi Dwarf. Pods were harvested 6,12,18,24 and 30 days after anthesis. Fresh fruit yield of plants harvested 6 days after anthesis was two times those harvested 30 days after anthesis. Percentage germination however, increased with pod age, with mean percentage germination of 0.0, 4.0, 38.0, 79.0, and 84.0 obtained from pods harvested at 6,12,18,24 and 30 days after anthesis, respectively. Plants on which pods were allowed to dry showed stunted growth. It is therefore recommended that pods should be harvested at 6 days after anthesis for fresh fruits and 24 days for seed production.

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Keywords: Pod maturity, pod yield, seed germination, okra, *Abelmoschus escunlentus* (L.) Moench.

Introduction

Okra *(Abelmoschus esculentus* (L) Moench) is a vegetable that is widely used in the preparation of soups and sauces. The crop is thought to be of African origin (Cobley and Steele, 1976; Purseglove, 1984). The immature pods may be cooked and eaten or dried and stored for future use as food. They are also fried and eaten as vegetable. The young shoot and leaves are also edible. Sinnadurai (1977) reported that the tender spiced or whole dried fruits are preferred in Northern Ghana and the fresh young tender fruits are preferred in the Southern sector. In most parts of tropical Africa, the crop has been grown for thousands of years (Tweneboah, 1998). Kohle and Cheven (1967) and Spartis (1972) observed in their separate studies that okra plants on which pods are harvested at their tender stages produced three times as many pods as did plants on which pods were allowed to mature. Wright (1989) observed that a number of interactions occur during the growth and development of most plants. Among such interactions are: reduction in vegetative growth as fruits develop as well as reduction in fruit growth by developing vegetative sinks and reduced flower initiation caused by developing fruits.

On seed germination, Manohar (1969) observed that a greater proportion of okra seeds become viable with advancing pod age. He reported 0,7,53 and 97 per cent germination for seeds from pods which were harvested 6,11,16 and 21 days respectively after flower opening. Chauhan *et al.* (1971) recommended that fruits of "Pusa Sawani" (okra) pods should be harvested for consumption 6-9 days after flowering for tenderness, maximum protein content (2.08%) and low crude fibre. For seed purposes, fruits should be harvested 30 days after anthesis where pods are fully matured and dry with seed germination rate of 85-86%. Unfortunately, many farmers lack knowledge on the manipulation of harvest time for higher fresh fruit yield. Knowledge of maturity time to harvest okra for seed also needs to be known. These data are required to enable farmers obtain maximum fruit yield and reduce field deterioration when producing seed. The objectives of the experiment were to determine the effect of stage of pod maturity on vegetative growth, pod yield and seed germinability in okra and to recommend the best stages for maximum yield and germination.

Materials and methods

Three cultivars of okra were used for the experiment. These were Clemson Spineless, Accra No. 2 and Labadi Dwarf. These materials were obtained

from the Faculty of Agriculture of the University of Ghana, Legon. The experiment was conducted at the SINNA's Garden, Department of Crop Science, University of Ghana. The experiment was arranged in a split plot design with cultivars as main plots and stage of pod maturity as sub-plots. There were three replicates of each treatment. Thirty-three plants represented each treatment in a replicate and data were taken on 20 plants (i.e four plants per each stage of pod maturity). Stages of pod maturity were 6,12,18, 24, and 30 days after anthesis.

Sowing and crop protection

Seeds were soaked in water and lighter ones discarded. The rest were primed with water for 24 hours to hasten germination. About 2.0g Furadan 3G (Carbo-furan) granules were incorporated into the soil together with seeds at planting to reduce leaf damage by insects and root-knot nematodes (Obeng-Ofori, 1982). Three seeds were sown per hill direct in the field at a spacing of 80cm x 60cm and at a depth of about 2cm. The plants were thinned to one seedling per hill two weeks after germination. Dithane M.45 at 4g stock powder per liter of water and 0.2% Cymbush solution were applied to control fungi and leaf hoppers, respectively at intervals of 2 weeks after germination up to the time of flowering.

Fertilizer application and flower tagging

Sulphate of ammonia was surface applied to the plants at 208 kg ha^{-1} 10 days after germination. Compound fertilizer, NPK (15:15:15), was surface applied at 416 kg ha^{-1} at 30 and 40 days after germination. Flowers were tagged when they opened and pods formed from them were harvested at the different stages of maturity.

Germination experiment

Pods harvested from the various maturity stages were given post-harvest ripening treatment by air-drying for one week. Seeds extracted from the pods were sown in a sterilized glass Petri dish containing Whatmann's No. 1 filter paper moistened with distilled water. There were three replications with each Petri dish carrying 20 seeds forming an experimental unit. Germination was recorded daily until no more occurred for three consecutive days. Seeds were considered germinated if radicle extended beyond 2mm. The germination test was carried out under room temperature (25°C).

Data collected

Data collected included: mean height of plants at the different maturity stages at the termination of the experiment, mean number of branches observed at the different maturity stages, mean plant yield (No. of pods), percentage germination of seeds from pods harvested at the different maturity stages and mean duration of germination of pods harvested at the different maturity

stages.

Data analysis

Analysis of variance for a split plot design was used. Figures in percentages were transformed with Arcsine transformation prior to analysis. Duncan's multiple range test (DMRT) was used to separate treatment means.

Results

Fibre development was observed at the tip of the fruit from the ninth day for all the cultivars. Significant differences were observed for the mean number of days taken for the appearance of the first flower after sowing for the three cultivars (p=0.05, DMRT). Accra No.2 had the largest mean of 54 days, Labadi Dwarf, 51 days and Clemson Spineless, 48 days (Table 1). Significant differences were also observed on the mean heights of plants at the different stages of pod maturity (p=0.05, DMRT) (Table 2). Pod age also had a significant effect on branching (p=0.05, DMRT). Earlier harvesting of pods resulted in more branching as compared to the late harvesting (Table 3). Significant differences were obtained for the mean height of the three cultivars (p=0.05, DMRT) even though no significant difference was obtained for the branching of the three cultivars (Table 4).

Table 1. Number of days to first flowering.

Cultivar	*Mean number of days to first flowering*
Accra No. 2	54a
Labadi Dwarf	51b
Clemson Spineless	47c

Means bearing the same letters are not significantly different (p=0.05) by Duncan's multiple range test.

Significant differences were observed on the number of pods harvested at the different pod ages (p=0.05, DMRT). The earliest harvesting produced about 2.33 times as many pods as the latest harvesting (Table 5). Significant differences were also observed for the number of pods produced by different cultivars (p=0.05, DMRT) with Labadi Dwarf having the largest number of 36 pods, Accra No. 2, 32 pods and Clemson Spineless 28 pods (Table 6).

Mean percentage germination increased with increasing pod maturity. Later harvested pods gave the largest percentage germinability (Table 7).

Significant differences were observed on the percentage germination of the cultivars at the different stages of pod maturity (p=0.05, DMRT) (Table 8). Accra No. 2 gave the highest percentage germination at each stage of pod maturity except in the 24 days old pods where the same values were obtained for Accra No.2 and Clemson Spineless and 30 days old pods where no significant difference was observed for all the three varieties. Seed of Clemson Spineless

Table 2. Plant height at various maturity stages.

Pod age (No of days)	*Mean Plant height (cm)*			*Mean (all varieties) (cm)*
	Accra No. 2	*Labadi dwarf*	*Clemson spineless*	
6	174a	176a	144a	165a
12	143b	147b	115b	135b
18	140b	129c	90c	119c
24	127bc	116c	83c	109d
30	118c	95d	67d	93e

Figures in a column bearing the same letters are not significantly different (p=0.05) by Duncan's multiple range test.

Table 3. Number of branches at various maturity stages.

Pod age (No of days)	*Mean No. of branches*			*Mean (all varieties)*
	Accra No. 2	*Labadi dwarf*	*Clemson spineless*	
6	17a	12a	9a	12a
12	12b	10b	7b	10b
18	9bc	9b	6bc	8c
24	7cd	6c	5bc	6d
30	6d	4d	5c	5e

Figures in a column bearing the same letters are not significantly different (p=0.05) by Duncan's multiple range test.

Table 4. Mean number of branches and mean height of various cultivars.

Cultivar	*No. of branches*	*Mean height (cm)*
Accra No. 2	10	141a
Labadi dwarf	8	132a
Clemson spineless	6	99b
	N.S.	

Figures in a column bearing the same letters are not significantly different (p=0.05) by Duncan's multiple range test.

extracted from 12 day old pods did not germinate.

Table 5. Effect of stage of pod maturity on yield (No. of pods).

Pod age (No of days)	*Mean plant yield*			*Mean (all varieties)*
	Accra No. 2	*Labadi dwarf*	*Clemson spineless*	
6	46a	52a	44a	47a
12	37b	43b	32b	37b
18	29c	34c	24c	29c
24	25c	28d	21bc	25d
30	19d	23e	18d	20e

Figures in a column bearing the same letters are not significantly different (p=0.05) by Duncan's multiple range test.

Table 6. Effect of cultivar on yield.

Cultivar	*Yield (No of pods)*
Labadi dwarf	36a
Accra No. 2	32b
Clemson spineless	28c

Figures in a column bearing the same letters are not significantly different (p=0.05) by Duncan's multiple range test.

Table 7. Effect of stage of pod maturity on seed germination.

Pod age (No of days)	*Mean germination (%) Accra No. 2*	*Labadi dwarf*	*Clemson spine-less*	*Mean (all variet-ies)*
6	0a	0a	0a	0a
12	9b	6b	0a	4b
18	48c	33c	33b	38c
24	84d	68d	84c	79d
30	85d	84e	85c	84d

Figures in a column bearing the same letters are not significantly different (p=0.05) by Duncan's multiple range test.

Table 8. Interaction effect of pod maturity and cultivar on percentage germination.

Pod age (No of days)	*Accra No.2*	*Labadi dwarf*	*Clemson spineless*
	Germination (%)		
6	0a	0a	0a
12	9b	6b	0a
18	48d	33c	33c
24	84f	68e	84f
30	85f	84f	85f

Figures bearing the same letters are not significantly different (p=0.05) by Duncan's multiple range test.

Table 9. Interaction effect of variety and pod maturity on number of branches.

Pod age (No of days)	*Accra No.2*	*Labadi dwarf*	*Clemson spineless*
	Number of branches		
6	17a	12b	9bc
12	12b	10bc	7cde
18	9bc	9bc	6cdef
24	7bcde	6cdef	5ef
30	6cdef	4f	5ef

Figures bearing the same letters are not significantly different (p=0.05) by Duncan's multiple range test.

Significant differences were observed for the number of branches obtained at the different stages of pod maturity for the three cultivars (p=0.05, DMRT). Accra No. 2 gave the highest number of branches for pods harvested at six days after flower opening (Table 9).

The number of days taken for seeds from the various pod ages to germinate decreased with pod maturity. Significant differences were observed for the mean number of days taken for germination to be completed at the different pod ages (Table 10).

Table 10. Effect of stage of pod maturity on days to germination.

Pod age (No. of days)	*Days after sowing in petri dish*			*Mean (all varieties)*
	Accra No. 2	*Labadi dwarf*	*Clemson spineless*	
6	-	-	-	-
12	8a	8a	-	8a
18	7b	6b	8a	7b
24	6bc	6b	7a	6b
30	6c	4c	5b	5c

Figures in a column bearing the same letters are not significantly different (p=0.05) by Duncan's multiple range test.

Effect of post-harvest ripening on germination

Post-harvest ripening was very necessary in improving the percentage germination of seeds from fruits harvested in its immature state. No germination occurred for seeds extracted from 6-24 day old pods and tested immediately in all the cultivars. However, a mean of 79.0% was observed for 24 day old pods given post-harvest ripening. Means of 66.7%, 25% and 8.3% germination were observed for pods harvested from 30 day old pods which were tested immediately for Accra No 2, Clemson Spineless and Labadi Dwarf respectively. A mean of 84.6% was, however, obtained for pods harvested at 30 days old and given post-harvest ripening treatment.

Discussion

Results from the study showed that early or frequent harvesting of okra pods increased plant height and number of branches produced. Late harvesting of pods reduced plant height and number of branches in all varieties. This could be attributed to more photosynthates being transferred for pod development rather than for plant growth. Seed maturity increased pod yield with plants whose pods were harvested six days after flower opening producing over two times as many pods as did plants whose pods were harvested 30 days after flower opening. This study showed a reduction in vegetative growth by developing fruit. Prolonged pod maturity also suppressed flower initiation and consequent fruit production. Spartis (1972) observed that okra plants harvested every three to four days produced as many as three times the number of pods as did plants on which pods were allowed to mature. He also reported that during the period when the seeds are maturing, a major part of assimilates is used to support the fruits, and few if any new flowers are borne. This was observed in the present study where alternate fruiting occurred on plants whose pods were harvested late. The plants bore heavily for a short

time followed by a period of no pod development that was again followed by a short period of heavy bearing. Okra farmers should therefore harvest their fresh fruits early, about six days after anthesis for high pod yield. This reduces the stress on the plant which is associated with maturing fruits resulting in less fruit yield, stunted plant growth and early plant death. The mean yield for Labadi Dwarf at the termination of the experiment was the largest followed by Accra No. 2 and Clemson Spineless. This may be due to the fact that even though there was no significant difference in the mean height of Labadi Dwarf and Accra No. 2, there was a significant difference in the number of days to first flower opening between Labadi Dwarf, 51 days and Accra No. 2, 54 days. Fruiting therefore started earlier in Labadi Dwarf compared to Accra No. 2. Clemson Spineless plants were the shortest as compared to the other two cultivars. This might have accounted for its lowest yield even though it was the earliest cultivar of the three. It is worth noting that in okra, pods are borne on the stem of the plant.

Percentage germination increased with pod age, with the highest percentage germination of 84.6% being obtained from 30-day old pods as compared to 0% germination from six day old pods. Even though pod yield for 24 day old pods were significantly greater than 30 day old pods, no significant difference was observed in the percentage germination for 24 and 30 day old pods from Accra No. 2 and Clemson Spineless and the mean for all varieties. Pods harvested at 24 days were given post harvest ripening after harvest for one week, which enabled the seeds to further develop within the pods without suppressing plant's growth. Logah (1980) experimenting on the effect of post-harvest ripening on the germination of garden egg indicated that there were generally high percentages of germination in all fruits ripened to the soft red stage. This finding has a practical implication of harvesting okra pods at 24 days after flower opening and giving them postharvest ripening for one week to improve the germination. Hartmann *et al.* (1990) reported that for germination to be initiated, three conditions must be fulfilled. These are; viability of seeds, presence of appropriate environmental conditions (water, appropriate temperature, oxygen and light) as well as overcoming any primary dormancy if present. They described the internal processes leading to removal of primary dormancy as after-ripening. Poor germination and failure of seeds tested immediately after extraction from the pod to germinate may also be due to the presence of primary dormancy conditions. For seed production, earlier harvesting of mature pods meant for seeds results in increased pod yield, reduced incidence of pod infestation and increased the lifespan of the plants.

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