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Flower Abortion and Fruit Yield Responses of Two Varieties of Chilli Pepper (*Capsicum frutescens* L.) to Different Planting Dates and Plant Densities

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Authors' contributions

This work was carried out in collaboration between all authors. All authors read and approved the final manuscript.

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ABSTRACT

Field and laboratory experiments were carried out between April 2014 and March 2015 to evaluate the effects of planting date and density on flower abortion and fruit yield of two chilli varieties. The field trial was laid out in 2x3x3 factorial experiment in a Randomized Complete Block Design (RCBD) with 3 replications. The factors studied included two chilli varieties (Shito Adope and Legon-18); three planting dates (May 12, 2014; June 13, 2014; and September 29, 2014); and plant spacing at three levels (60 cm x 30 cm; 70 cm x 30 cm; 80 cm x 30 cm). The field study was conducted at the Crops Research Institute-Kwadaso Station, Kumasi, Ghana. Growth and yield were evaluated during the study period. Legon-18 exhibited higher performance than Shito Adope for parameters such as plant height, branch numbers, canopy width and fruit yield, number. In contrast, Shito Adope took fewer days to attain 50% flowering and fruit set. Shito Adope also recorded higher flower drops. Dates of sowing significantly affected growth and seed quality parameters with the May and June recording taller plants, more branches, wider canopies, and higher fruit yield. Early flowering and fruit set were attained during the same period; while flower drops were more prevalent during the first and third dates of sowing. Planting density showed no

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significant effect on all parameters studied except plant height, with the widest spacing (80 x 30) recording the tallest plant heights. The results indicates that for periods with extremely high temperatures should be avoided as they tend to increase the rate of flower drops.

Keywords: Flowering; temperature; maturity; yield; environment and photosynthates.

1. INTRODUCTION

Chilli pepper is a widely cultivated crop in West Africa and is also consumed globally as fresh or processed spice. It is an important source of income and an important foreign exchange earner in both developed and developing countries [1]. According to MiDA [2], Ghana is the 5th largest exporter of chilli peppers to the European Union (EU) with an annual export increase of 17 per cent since the year 2000. The crop is also cultivated for its medicinal and nutritional values. In traditional medicine, chili pepper is used to ease digestion, stimulate the gut, combat constipation, and relieve pain. The main chemical agent, capsaicin plays a potential role in the development of pain-killers [3]. In spite of the reported increase in income from chilli pepper production, the average yield remains low in most West African countries [4]. Nigeria and Ghana ranked 8th and 25th place in the world and the two are also the leading chilli producers in West Africa with a production volume of 500,000 MT and 110,000 MT, respectively, in 2012 [5]. These yields are quite low when compared to the world average of chilli pepper suggesting that further improvement of pepper yield in West Africa is needed [6]. Major constraints associated with pepper production include environmental stress such as temperature, rainfall, humidity, soil fertility and pH, and biotic factors including pests and diseases [7]. In addition, the use of inappropriate agronomic practices, and inadequate knowledge in improved farm management techniques by small-holder farmers are factors contributing to low productivity of chilli peppers [8]. Plant spacing is very important in any crop production system. Optimum plant spacing ensures proper growth and development of plants resulting in maximum yield of crops and economic use of land. The yield of pepper has been reported to be dependent on the number of plants accommodated per unit area of land [9]. Wubs et al. [10] reported that sufficient light, higher CO_2 concentrations, and lower planting density increase the availability of assimilates per plant and decrease flower and fruit abortion. The abscission of flowers and fruits is an important yield-limiting factor in pepper [11]. Planting time is also very crucial in any crop production system since it determines the extent of incidence and severity of disease infestation which in turn effects on crop growth and yield. Islam et al. [12] mentioned that growth parameters and yield components traits of sweet pepper were significantly increased at earlier planting dates. Similarly, Bevacqua and Vanleeuween [13] stated that planting date had a significant effect on crop performance, and that the best stand establishment and highest yield were associated with the earliest planting dates.

Against this background therefore, to increase chilli pepper production in Ghana there is the need to consider the development of appropriate plant spacings coupled with suitable planting times. The overall objective of this study was therefore to evaluate the effects of planting date and plant density on growth, flower abortion and yield traits of two varieties of chilli pepper.

2. MATERIALS AND METHODS

2.1 Description of the Study Area

The field study was carried out at the Crops Research Institute (CRI)-Kwadaso Station, located near Kumasi, Ghana. Kwadaso is located in the Ashanti Region and is situated between Latitude 6°42'N and Longitude 1°39'W and falls within the semi-deciduous forest ecological zone of Ghana. The soils at the location are characterized by ferric acrisols with well-drained structure. The location has a bimodal rainfall pattern, with the major season stretching from April to July, and the minor season from August to November.

2.2 Experimental Design and Procedure

The field trial was laid out in a 2x3x3 factorial arrangement in a Randomized Complete Block Design (RCBD) with three replications. The factors were varieties at two levels (*Shito Adope* and *Legon-18*); planting dates at three levels (12th May; 13th June ; 29th September, 2014); and plant spacing at three levels (60 cm x 30 cm; 70 cm x 30 cm; 80 cm x 30 cm). Each variety was cultivated on a plot of land measuring 460 m^2 (20 m x 23 m) during each planting season. The isolation distance between the two field plots was 250 meters apart to avoid cross pollination between the varieties [14]. Each variety was planted on three different plot sizes, measuring 36 m^2 (6 mx6 m); 42 m^2 (7 mx6 m), and 48 m^2 (8 mx6 m), to conform to the three planting densities. The plant population within each experimental plot was 200 plants and the experimental plots were separated by one meter rows. Two raised nursery beds with sterilized, well-drained loamy soils were prepared for the sowing of seeds. Due to the nature of the study, seeds were sown at different dates (10th April, 12th May, and 20th August 2014). The nursery beds were covered with palm fronds to provide shade and protect the young seedlings from harsh weather conditions. All recommended nursery management practices including irrigation, weeding and thinning were carried out as and when necessary. Transplanting of seedling was carried out four weeks after sowing. A week prior to transplanting, the shade was gradually removed to expose the young seedlings to harsh environmental conditions. The insecticide brand *Golan 20 SP*, with active ingredient of 20% acetamiprid was applied at the rate of 20 mL/15 L of water to control insect pests; and a systemic fungicide, Victory 72 WP, with active ingredients, 8% metalaxyl and 64% mancozeb, was used at the recommended rate of 40 g/15L water to control fungal diseases.

2.3 Land Preparation and Cultural Practices

The sites were cleared, ploughed and harrowed. These activities were carried out to manage weeds, provide good soil aeration, seedlings establishment and adequate root penetration. Field layout was done a day prior to transplanting. Transplanting for the major season was carried out on 12th May and 13th June 2014, respectively; while transplanting for the minor season was carried out on 29th September 2014. Manual weeding (hoeing and hand pulling) was carried out two weeks after transplanting and continued at three weeks interval until the final harvest. Irrigation was also done once every month using sprinklers to maintain adequate soil moisture and to promote uniform growth and development. A basal application of NPK (15:15:15) was applied two weeks after transplanting through band placement at the rate of 35 kg ha^{-1} [5 g per plant]. The second fertilizer (Ammonia nitrate, 34% N) application was carried out six weeks after transplanting at the rate of 48 kg ha^{-1} [3 g per plant]. After transplanting, the field was sprayed with Golan 20 SP and Victory 72 WP at four weeks interval at the recommended rates of 20 mL/15 liter of water and 40 g/15 L water, respectively to control insect pests and fungal diseases. All other recommended crop husbandry practices were carried out, as and when necessary. Harvesting of matured fruits began at 12 weeks after transplanting (WAP) and was carried out manually by hand picking. The harvesting exercise was carried out over a four weeks period. Care was taken to prevent damage to the branches due to their brittle nature. Fruits from 30 sample plants were harvested separately from each plot and were placed in polythene bags for post-harvest data collection and analysis.

2.4 Data Collection

The following vegetative, reproductive and yield data were collected during the pre-harvest stages of the study:

2.4.1 Plant height

A total of 30 tagged plants were chosen from six middle rows of each plot. Using a meter rule, the measurements were taken from the base to the apex of the plant and the weekly mean recorded.

2.4.2 Number of branches

The number of branches per plant was taken by counting the number of primary branches on the main stem of each of the thirty tagged plants and the mean recorded plants.

2.4.3 Canopy spread

Using a meter rule, the canopy width data was taken by measuring two perpendicular distances across the widest point of the leaf on each of the thirty tagged plants and the mean recorded.

2.4.4 Stem girth

Using a Vernier caliper, stem diameter was measured at the base of each of the thirty tagged plants and recorded in millimeters (mm).

2.4.5 Days to 50% flowering

The days to 50% flowering was recorded by visually observing and counting the number of plants with opened flowers within each plot. The data was taken when 50% of the plants had opened flowers and the days were determined by using the date of transplanting as baseline.

2.4.6 Days to 50% fruit set

The days to 50% fruit set was recorded by visually observing and counting the number of plants with set fruits within each plot. The data was taken when 50% of the plants had fruits set and the days were determined by using the date of transplanting as reference point.

2.4.7 Number of aborted flowers (flower drops)

The number of aborted flowers was recorded weekly from the thirty tagged plants. Data collection was achieved by carefully placing a screen net around each of the tagged plant to trap the aborted flowers. The exercise was carried out from flower initiation up to first harvest and the sum total of all aborted flowers was computed.

2.4.8 Number of fruits per plant

The fruit number per plant was obtained by counting all the harvested fruits from each tagged plant and recorded.

2.4.9 Fruit weight per plant

Using an electronic balance, the mean fruit weight was determined by weighing the total harvested fruits per plant from each of the thirty tagged plants and dividing by the total number of fruits per plant.

2.4.10 Fruit yield per hectare (total fruit yield)

The total fruit yield per hectare was calculated using the following formula:

$$Total\ fruit\ yield\ (MT/ha) = \frac{Wfp\ (kg)\ x\ TA\ (10000m2)}{Ap(m2)} \div 1000$$

Where: Y_{tf} = Total fruit yield per hectare (MT/ha); W_{fp} = Weight of fruit per plant; TA = Total area expressed in hectare (10,000 m^2); A_P = Area occupied by individual plant.

2.5 Statistical Analysis of Data

Data collected during the study were analyzed using Analysis of Variance (ANOVA) with the aid of the statistical package, STATISTIX Version 9.0. Means separation was carried out using Tukey's Honest Significant Difference (HSD) at 5% level of probability.

3. RESULTS

3.1 Plant Height

Effects of variety and planting date on plant height of chilli pepper at 9WAT are given in Table 1. There were significant variety x planting date interactions for plant height. Legon-18 planted in May produced the tallest plant (58.8 cm), though not significantly different from Legon-18 planted in June (54.9) whereas Shito Adope planted in September produced the shortest (43.1 cm). Between the varieties, Legon-18 recorded the tallest height (53.9 cm) while Shito Adope recorded the shortest height (44.9 cm) (Table 1). Between the planting dates, May planting produced the tallest plants, though not significantly different from June planting. Planting in September produced the shortest plants.

There were also significant differences in planting spacing for plant height (Table 2). Plants planted at a spacing of 80 cm x 30 cm produced the tallest plants (52.61 cm), though not significantly different from those planted at a spacing of 70 cm x 30 cm. The shortest plants (47.10 cm) were produced by plants planted at a spacing of 60 cm x 30 cm.

Table 1. Effects of variety and planting date on plant height of chilli pepper at 9WAT

	Plant height (cm) at 9WAT		
Planting Dates(2014)	**Shito Adope**	**Legon-18**	**Mean**
May	46.4	58.8	52.6
June	45.3	54.9	50.1
September	43.1	48.1	45.6
Mean	44.9	53.9	

Tukey HSD (0.05):Varieties = 2.41; Planting dates = 3.56;Varieties x Planting dates = 6.20

Table 2. Effect of planting spacing on plant height of chilli pepper

Plant Height (cm)	
Planting Density	**Plant Height (cm)**
SP_1 (60 x 30)	47.10
SP_2 (70 x 30)	50.10
SP_3 (80 x 30)	52.61
Tukey's HSD (0.05)	3.56

3.2 Number of Branches per Plant

The variety x planting date interactions were significant for number of branches per plant (Table 3). Legon-18 planted in June (10.5) produced the highest number of branches per plant, significantly greater than the other treatments except Legon-18 planted in May (10.3). The least number of branches per plant was produced by Shito Adope planted in May (5.1), though not different from Shito Adope planted in September (5.6) (Table 3). Between varieties, Legon-18 produced the highest number of branches per plant (9.6) significantly greater than Shito Adope which produced the least (5.9) (Table 3). Between the planting dates, planting in June resulted in the production of the highest number of branches, significantly different from those produced by planting in May which in turn was different from those planted in September which produced the least.

3.3 Canopy Spread

The interaction effects between variety and planting date exhibited significant difference for plant canopy spread (Table 4). Legon-18 planted in June (47.7 cm) produced the widest canopy spread at 4WAT, significantly bigger than the other treatments except Legon-18 planted in May (44.8 cm). The least canopy spread was produced by Shito Adope (34.0 cm) planted in September and Legon-18 (35.5 cm) also planted in September. Between varieties, Legon-18 produced the widest canopy spread (42.7 cm) significantly different from the least produced by Shito Adope (39.3 cm). Among the planting dates, planting in May (43.9 cm) or June (44.3 cm) produced the widest canopy spread, significantly different from that produced by September planting which produced the least canopy spread (34.8 cm).

3.4 Stem Girth

There were significant variety x planting date interactions for stem girth (Table 5). Legon-18 planted in June (9.3 mm) produced the biggest stem girth, significantly greater than the other treatments except Legon-18 planted in September. The smallest girth was produced by Shito Adope planted in June (5.8 mm), though not different from Shito Adope planted in September. Between varieties, Legon-18 produced significantly bigger stems than Shito Adope. Between the planting dates however, there were no differences in stem girth.

Table 3. Effects of variety and planting date on the number of branches per plant of chilli pepper

Number of branches at 8WAT			
Planting Dates(2014)	**Shito Adope**	**Legon-18**	**Mean**
May	5.1	10.3	7.7
June	7.0	10.5	8.8
September	5.6	8.1	6.9
Mean	5.9	9.6	
Tukey HSD (0.05): Varieties =0.39; Planting dates =0.57; Varieties x Planting dates = 0.99			

Table 4. Effects of variety and planting date on the canopy spread of chilli pepper

Canopy spread (cm) at 8WAT			
Planting Dates(2014)	**Shito Adope**	**Legon-18**	**Mean**
May	43.1	44.8	43.9
June	40.9	47.7	44.3
September	34.0	35.5	34.8
Mean	39.3	42.7	
Tukey HSD (0.05): Varieties = 3.00; Planting dates = 4.44; Varieties x Planting dates = 7.74			

3.5 Number of Days to 50% Flowering

A variety x planting date interactions were significant for the number of days to 50% flowering (Table 6). Shito Adope planted in May was the earliest to flower (27.9 days), significantly different from the other treatments except Shito Adope planted in June. Legon-18 planted in September took the longest time to flower (42.3 days) though not different from Legon-18 planted in June. Between varieties, Shito Adope was the earliest to flower significantly earlier than Legon-18 which took the longest time to floweer. Between the planting dates, May plantings were the earliest to flower, significantly different from June and September plantings.

3.6 Days to 50% Fruit Set

Significant variety x planting date interactions for number of days to 50% fruit set were found (Table 7). Legon-18 planted in June took the longest time to achieve 50% fruit set, though not different from that achieved by Legon-18 planted in September. Shito Adope planted in May took the shortest time to achieve 50% fruit set. Between varieties, Shito Adope took less time to attain 50% fruit set whiles Legon-18 took more time to achieve same 50% fruit set. Among planting dates, May plantings took fewer days to achieve 50% fruit set (40.3) whereas September plantings took more days to achieve 50% fruit set.

3.7 Number of Flowers Aborted

There was significant variety x planting date interactions for mean number of days to 50 % fruit set (Table 8). Legon-18 planted in June recorded the least number of aborted flowers though not different from that achieved by Shito Adope planted in June. Shito Adope planted in May recorded the highest number of aborted flowers yet similar to those resulting from Legon-18 planted in September. Between varieties, Shito Adope aborted significantly more flowers than Legon-18. (Table 8). Among planting dates, May and September plantings recorded more aborted flowers, significantly greater than those from June planting.

Table 5. Effects of variety and planting date on stem girth of chilli pepper

Stem girth (mm) at 8WAT			
Planting Dates(2014)	**Shito Adope**	**Legon-18**	**Mean**
May	7.3	7.7	7.50
June	5.8	9.3	7.60
September	7.1	8.4	7.80
Mean	6.7	8.5	7.60
Tukey HSD (0.05):Varieties = 0.56;Planting dates = 0.82; Varieties x Planting dates = 1.4			

Table 6. Effects of variety and planting date on the number of days to 50% flowering of chilli pepper

Days to 50% flowering			
Planting Dates(2014)	**Shito Adope**	**Legon-18**	**Mean**
May	27.9	37.3	32.6
June	29.4	41.7	35.6
September	32.9	42.3	37.6
Mean	30.07	40.43	
HSD (0.05): Varieties = 1.63; Planting dates = 2.40; Varieties x Planting dates = 4.19			

Table 7. Effects of variety and planting date on the number of days to 50% fruit set of chilli peppers

Days to 50% fruit set			
Planting Dates(2014)	**Shito Adope**	**Legon-18**	**Mean**
May	32.4	48.2	40.3
June	32.6	51.2	41.9
September	36.9	50.9	43.9
Mean	33.97	50.10	
HSD (0.05): Varieties = 1.69; Planting dates = 2.49; Varieties x Planting dates = 4.35			

Table 8. Effects of variety and planting date on the number of flowers aborted of chilli pepper

	Number of flowers aborted		
Planting Dates(2014)	**Shito Adope**	**Legon-18**	**Mean**
May	16.3	13.5	14.90
June	11.9	9.5	10.70
September	15.6	16.0	15.80
Mean	14.60	13.0	
HSD (0.05): Varieties = 1.60; Planting dates = 2.33; Varieties X Planting Date= 4.05			

3.8 Number of Fruits per Plant

There were significant variety x planting date interactions for number of fruit per plant (Table 9). The highest number of fruits (38.4) was produced by Shito Adope planted in May whilst the least number (18.6) was produced by Legon-18 planted in September. Plants of Legon-18 planted in June were similar in number of fruit per plant to those of Shito Adope planted in May. Between varieties, Shito Adope produced the highest mean fruit number (31.0), significantly different from the least number of fruits (25.1) produced by Legon-18 (Table 9). Among the planting dates, higher numbers of fruits per plant (32.25) were recorded by May planting, though not significantly different from those of the June plantings. The least number of fruits per plant (22.95) were produced September plantings.

3.9 Fruit Weight per Plant

Effects of variety and planting date on the mean fruit weight of chilli pepper varieties are presented in Table 10. There was significant variety x planting date interactions for fruit weight per plant. Legon-18 planted in June produced the highest fruit weight (88.8 g) though not significantly different from those of Legon-18 and Shito Adope planted in May. Plants of Legon-18 planted in September produced the least fruit weight (45.2 g). Between varieties, Legon-18 produced the highest mean fruit weight (69.1 g) significantly greater than Shito Adope which recorded the least fruit weight (60.1 g) (Table 10). Among the planting dates, May plantings produced the highest fruit weight (77.55 g), significantly greater than the least produced by September plantings (46.15 g).

3.10 Total Fruit Yield (t/ha)

There was significant variety x planting date interactions for total fruit yield (Table 11). Legon-18 planted in June produced the highest yield (4.3 mt ha^{-1}), significantly different from the least yield (2.2 mt ha^{-1}) produced by Legon-18 planted in September. Among the varieties, Legon-18 produced the highest total fruit yield (3.33 mt ha^{-1}) significantly greater than the lowest yield (2.86 mt ha^{-1}) was produced by Shito Adope (Table 11). Between the planting dates, the highest total fruit yield (3.70 mt ha^{-1}) was produced by May plantings, though not significantly different from those of June plantings. The lowest total fruit yield (2.25 mt ha^{-1}) was produced by September plantings.

Table 9. Effects of variety and planting date on the mean fruit number of chilli pepper varieties

	Mean fruit number per plant		
Planting Dates(2014)	**Shito Adope**	**Legon-18**	**Mean**
May	38.4	26.1	32.25
June	27.4	30.6	29.1
September	27.3	18.6	22.95
Mean	31.0	25.1	
HSD (0.05): Varieties = 3.67; Planting dates = 5.42; Varieties x Planting dates = 9.44			

Table 10. Effects of variety and planting date on the mean fruit weight of chilli pepper

	Mean fruit weight (g)		
Planting Dates(2014)	**Shito Adope**	**Legon-18**	**Mean**
May	82.2	72.9	77.55
June	51.1	88.8	69.95
September	47.1	45.2	46.15
Mean	60.1	69.1	64.55
HSD (0.05): Varieties = 7.6; Planting dates = 4.1; Varieties x Planting dates = 19.49			

Table 11. Effects of variety and planting date on the total fruit yield of chilli peppers

	Total fruit yield (mt ha^{-1})		
Planting Dates(2014)	**Shito Adope**	**Legon-18**	**Mean**
May, 2014	3.9	3.5	3.70
June, 2014	2.4	4.3	3.35
September, 2014	2.3	2.2	2.25
Mean	2.86	3.33	
HSD (0.05): Varieties = 0.37; Planting dates = 0.55; Varieties x Planting dates = 0.96			

4. DISCUSSION

Rudall P. Anatomy of flowering plant: An introduction to structure and development. Cambridge University Press 1994. There were variations between varieties for plant height and stem diameter at the different growth stages. The observed differences could be attributed to the differences in genetic constitution of the varieties. Wubs et al. [15] reported that the ultimate height attained by different lines depended greatly on their growth characters. Similar findings were observed by Wien et al. [16] and Islam et al. [17] who stated that the increase in plant height could be due to the varietal variability to absorb nutrients from the soil. Of the two varieties, Legon-18 produced taller plants at all growth stages. The mean height recorded at maturity for Legon-18 was 53.9 cm. This is in agreement with the findings of Bevacqua and Vanleeuween [18] and AVRDC [19] who reported that the average plant height of pepper at maturity ranges from 32.1-68.3cm. Furthermore, Legon-18 recorded the biggest stem girth (8.5mm) at eight weeks after transplanting (WAT). Bevacqua and Vanleeuween [18] also reported similar findings by indicating that taller heights were positively correlated with thicker stem girths in pepper cultivars. Tindall [20] also stated that increase in stem width often accompanied increase in height and caused a reduction in lodging. Plant heights also differed between planting dates with the May planting (first planting date) recording the tallest plants. This agrees with the results of Jovicich et al. [21], who stated that growth parameters of sweet pepper were significantly increased at earlier sowing dates. The observed differences in height at the different planting times could also be attributed to the effects of varying environmental conditions at the different planting periods. Similar findings were reported by Vos and Frinking [16] who indicated that the growth of a crop variety is influenced by environment. Jovicich et al. [21] also observed that the growth of sweet pepper was affected by rainfall, temperature, daylight and relative humidity. The interactive effects of the variety and planting date on plant height and stem diameter demonstrated that the growth of pepper largely depended on the genetic make-up and the environmental conditions under which it is grown [22]. Branches were more profuse in Legon-18 compared to Shito Adope and this could be related to the genetic make-up of the varieties. Delelegn [23] indicated that variety was one of the major factors determining the number of primary branches in hot peppers. El-Tohamy et al. [17] also reported that the differences observed in branching of pepper plants may be due to genetic variations or environmental influence which could explain the differences in branching observed for the different planting dates. The widest plant canopies were produced by Legon-18 at the different growth stages. Canopy variation is essential as it influences the yielding potential of a crop; as varieties with wider canopy spreads tend to produce heavier fruits than those with narrower canopies due to increased photosynthesis and consequently increased assimilates production [23]. Orak and Ilker [24] also indicated that a large canopy width provides leaf area surfaces which enhance the interception of solar radiation, with subsequent increase in the amount of photosynthetic activities. The observed differences in canopy width among the chilli varieties may be due to differences in genetic make-up. This is in agreement with [25] and [19] who reported that the width of canopies among pepper varieties is oftentimes associated with genetic variations among varieties.

Significant differences were observed between varieties for days to 50% flowering and days to 50% fruit set. The observed variations in days to 50% flowering and 50% fruit set could be attributed to both genetic make-up of the cultivars and the environmental conditions. Shito Adope took fewer days to attained 50% flowering and 50% fruit set than Legon-18. Delelegn et al. [26] reported that earliness or lateness in the days to 50% flowering could be due to their inherited characters and the early adaptation to the growing environment to enhance their growth and development. DeWitt and Bosland [27] also observed that earliness to flowering and fruiting is related to the genetic base of the variety. Days to 50% flowering and 50% fruit set also varied between the different planting dates. The earliest flowering and fruit set were observed in the May plantings and could be due to the prevailing temperatures in June (28.3°C- day temperatures) which that favoured the flower initiation and development of the crop. Uarrota [28] indicated that flower formation and fruit set in plants are dependent on the interaction of many complex processes which are influenced by the genetic and environmental factors. In contrast, the longer days to 50% flowering and fruit set observed during the late sowing date might have been influenced by higher temperatures experienced in November and December (31.6°C and 32.8°C- day temperatures). According to AVRDC [14], fruit set is delayed when daily temperatures exceeds 32°C for extended periods. Konsens et al. [29] and Khah and Passam [30] also reported a reduction or delay in fruit set during periods of high temp eratures.

There were observed variations between varieties and planting dates for number of flower aborted. Of the two varieties, Shito Adope recorded a higher number of flowers aborted as compared to Legon-18. These findings revealed that flower abortion is influenced by a crop's genetic make-up and physiological processes within a plant. These results agree with the findings of Tarchoun et al. [31], who stated that abortion of floral structures depends on variety. The dates of planting also affected the number of flowers aborted and could be related to the high temperatures observed in relation to certain planting times. Similar results were reported by Erickson and Markhart [32], who indicated that moisture and temperature stress induced high flower abortion in peppers. Van Doon and Stead [33] also observed that flower retention and fruit set are highly sensitive to environmental factors, particularly temperatures. There were significant interactive effects of varieties and planting dates for mean number of fruit, fruit weight per plant, and total fruit yield per hectare**.** The observed differences in fruit number between varieties could be explained by the genetic diversity of the two varieties. DeWitt and Bosland [27] observed that variations in fruit number per plant is affected by the canopy architecture; because, as the number of branches increased, there might be a possibility of increasing the number of fruit producing buds which are the positions for fruit production. The variations in fruit weight and total fruit yield between the two cultivars points to the fact that fruits with larger sizes tend to possess more weight than those with smaller sizes. According to Mariame and Gelmesa [34], variations in fruit yield in pepper could be attributed to differences in genetic variability and their agro ecological adaptations. This is in agreement with the observed low performance of the two varieties during the September planting, a period that was characterized by extremely high temperatures and low soil moisture. Nkansah et al. [18] reported similar results, indicating that the observed differences in fruit number and weight during different growing seasons can be attributed to differences in the amount of rainfall. The findings of Square [35] and Tiryaki and Andrews [36], also corroborate the present findings that observed climatic variables, especially temperatures and rainfalls are important in determining crop productivity and that extremely high or low temperatures can negatively affect plants growth and yield.

5. CONCLUSIONS

Legon-18 exhibited higher performance than Shito Adope in terms of vegetative growth and yield parameters including plant height, number of main branches, canopy width, stem girth, fruit weight per plant and fruit yield per hectare. Shito Adope, on the other hand, took fewer days than Legon-18 to attain 50% flowering and fruit set, an indication of early maturity. Shito Adope also recorded high numbers of flowers aborted as well as high number of fruits per plant. May and June plantings recording higher vegetative and reproductive performance than September planting.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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