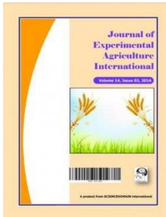

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Seed Quality Responses of Two Chilli Pepper Varieties (*Capsicum frutescens* l.) to Different Planting Dates

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Authors' contributions

This work was carried out in collaboration between all authors. Author MTMC designed the study, performed the statistical analysis, wrote the protocol, and wrote the first draft of the manuscript. Authors BKB and PKT managed the analyses of the study. Author PKT managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

Field and laboratory experiments were carried out between April 2015 and March 2016 to evaluate the effects of planting dates on seed physiological quality and health characteristics of two varieties of chilli pepper. The field trial was laid out in 2x3 factorial experiment in a Randomized Complete Block Design (RCBD) with three replications. The factors studied included two chilli varieties (Shito Adope and Legon-18) and three planting dates (May 12, 2015; June 13, 2015 and September 29, 2015). The field study was conducted at the Crops Research Institute-Kwadaso Station, Kumasi, Ghana. There were significant varieties x planting dates interaction for the number of days to 50% flowering and number of days to 50% fruiting traits. Shito Adope planted in June took the shortest time to flower, significantly earlier than the other treatment combinations yet similar to that of Shito Adope planted in May. For fruit set, Shito Adope planted in May took the shortest time to set fruit, significantly earlier than the other treatment combinations yet similar to that of Shito Adope planted in June. Varieties x planting dates interaction had significant for the number of fruits per plant trait. Shito Adope planted in May produced the highest number of fruits per plant although not different

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from the number produced by Legon-18 planted in June. Higher seed germination percentages (89.9%) were recorded by seed produced from May planting. September planting resulted in high seed yield parameters such as number of seeds per fruit (77.3), seed weight per fruit (0.40g) and 1000 seed weight (5.00g). Non-significant interactions between the treatments for seed vigor were found. The highest occurrence of fungal pathogens was observed on seeds arising from May planting while the least occurrence was recorded on seeds arising from September planting. The study concluded that the genotype and environmental conditions interactively influenced flowering and seed quality traits. Shito Adope, planted in May recorded the highest number of aborted flowers whereas Legon-18 planted in September produced the highest number of seeds per fruit as well as the heaviest seed weight per fruit. The higher germination percentage was however recorded by seed produced from May planting.

Keywords: Genotype; environment; flower abortion; fruit set; seed yield; germination.

1. INTRODUCTION

Chilli pepper (*Capsicum frutescens* L.) is an annual herb belonging to the Solanaceae family which is a widely cultivated crop in West Africa and is also consumed globally as fresh or processed spice [1]. It is an important source of income for smallholder farmers as well as a good foreign exchange earner many countries of the world [2]. Nutritionally pepper fruits have high antioxidant levels and vitamins, especially ascorbic acid (vitamin C) and b-carotene (pro-vitamin A) [3]. In Ghana, pepper is among the four widely cultivated vegetables in terms of production volume [4], and it is 5th largest exporter of chilli peppers to the European Union (EU) [5]. Despite the enormous economic and nutritional benefits of chilli peppers, production in Ghana is still low, a result of the poor quality of seed used in production. The poor quality of such seed has been attributed to the use of inappropriate agronomic practices, such as irregular plant spacing and unsuitable planting times, during its generation [6]. Van Gastel et al. [7] indicated that the general crop husbandry practices adopted by farmers influenced the quality of seeds produced. Furthermore, [8] reported that the abscission of flowers and fruits was a very important yield-limiting factor in pepper seed production which was linked to the plant spacing employed. [9], also stressed that plant spacing had a direct effect on fruit and seed quality. Generally, optimum plant spacing was very important in any crop production system since it ensured proper growth and development of the plants and resulted in yield maximization and economic use of land [10]. Time of planting of crops was also very crucial in any crop production system since it determined the extents of severity of crop diseases, crops capacity for light absorption and crops utilization of water, with ultimate consequences on crop growth and yield [1]. Bevacqua and Vanleeuween [11] also indicated that, the best stand establishment and highest yield were associated with the earliest planting dates confirming the significant effect of planting date crop performance. The overall objective of the study was therefore to evaluate the effects of planting date and plant density on the physiological quality and health characteristics of seeds of two chilli varieties.

2. MATERIALS AND METHODS

2.1 Experimental Location

The field trial was carried out at the Crops Research Institute (CRI)-Kwadaso Station, Kumasi, Ghana. Kwadaso, located in the Ashanti Region of Ghana and situated between Latitude 6°42'N and Longitude 1°39'W also falls within the Semi-Deciduous Forest ecological zone. The soil at the location is characterized by ferric acrisols with a well-drained structure. The rainfall pattern is bimodal with the major rainy season starting in March, with a peak in May. The region experiences a slight dry period in July - August. The minor rainy season commences in September, peaks in October and dwindles down in November.

2.2 Experimental Design and Treatments

The field trial was laid out in a 2x3 factorial arrangement in a Randomized Complete Block Design (RCBD) with three replications. The factors were varieties at two levels (*Shito Adope* and *Legon-18*); and planting dates at three levels (12^{th} May; 13^{th} June; 29^{th} September, 2015). Each variety was cultivated on a plot of land measuring 460m^2 (20m x 23m) during each both major and minor seasons. The isolation distance between the two field plots was 250 meters apart to avoid cross pollination between the varieties [12]. The plant population within each experimental plot was 200 plants and the experimental plots were separated by one meter rows.

2.2.1 Shito adope

This variety has the following characteristics: Plant height = 45 cm; Plant Spread = 52 cm; number of days to flowering = 60 days; Plant growth habit = Compact & flat at top; Immature fruit color = green; Mature fruit color = red; Average length of fruit with pedicel = 8.31cm; Average length of fruit without pedicle = 6.52 cm; Average fruit weight = 3.48 grams; Pungency = Very Hot; Yield fresh weight = 30 t/ha; Yield dry weight: 9.3t/ha.

2.2.2 Legon 18

This variety has the following characteristics: Plant height = 48 cm; Plant Spread = 56 cm; number of days to flowering = 55 days; Plant growth habit = Compact & flat at top; Immature fruit colour = green; Mature fruit colour = red; Average length of fruit with pedicel = 24.31cm; Average length of fruit without pedicle= 18.52 cm; Average fruit weight = 6.48 grams; Pungency = Very Hot = Yield fresh weight = 40 t/ha; Yield dry weight: 11.3t/ha.

2.3 Nursery Management

Two raised nursery beds containing 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 2015). 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 seedlings were carried out four weeks after sowing. An insecticide, *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.

2.4 Preparation of Experimental Field and Crop Husbandry Practices

The sites were cleared, ploughed and harrowed. Field layout was done a day prior to transplanting. Transplanting for the major season was carried out on 12th May and 13th June 2015, respectively; while transplanting for the minor rainy 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 done two weeks after transplanting through band placement at the rate of 35 kg ha^{-1} [5g per plant]. The second application (Ammonia nitrate, 34% N) was carried out six weeks after transplanting at the rate of 48 kg ha $^{-1}$ [3g per plant]. After transplanting, the field was sprayed with *Golan 20 SP* and *Victory 72 WP* at four -week interval at the recommended rates of 20 ml/15 liter of water and 40g/15L water, respectively, to control insect pests and fungal diseases. Harvesting of matured fruits began at 12 weeks after transplanting (WAP) and was carried out manually by hand picking. Fruits from 30 tagged plants were harvested from each plot and placed in polythene bags for post-harvest data collection and laboratory analysis. Data were collected on climatic information, number of days to 50% flowering, number of aborted flowers, number of days to 50% fruit set, number of fruits per plant, number of seeds per fruit, seed weight per fruit, 1000 seed weight, seed germination.

2.5 Seed Vigor Determination

Conductivity test was used in determining the vigor of the seeds. Four replicates of 50 seeds of each entry were drawn at random and tested for electrical conductivity. Seeds were placed in Erlenmeyer flasks containing 75 ml ultra-pure deionized water equilibrated to 25 °C, then maintained at 25 °C for 24 h. After 24 h of soaking, the flasks was swirled for 10-15 sec and seeds then taken out of water with a clean forcep. An electrical conductivity dip cell was inserted into the seep water until a stabilized reading achieved and recorded. The mean of the two control flasks (sterilized distilled water) when measured served as background reading. Conductivity was calculated using the formula below [13].

$$\text{Conductivity } (\mu S/cm^{-1}g^{-1}) = \frac{\text{(Conductivity reading - background reading) check}}{\text{(Weight (g) of replicate)}}$$

According to Milosevic et al., if the calculated value is < 25 $\mu S/cm^{-1}g^{-1}$, seed has a high vigor, thus, the seed is suitable for early sowing in unfavorable conditions; 25–29 $\mu S/cm^{-1}g^{-1}$, seed can be used for early sowing with risk in unfavorable conditions; 30–43 $\mu S/cm^{-1}g^{-1}$, seed is not suitable for early sowing especially in unfavorable conditions; > 43 $\mu S/cm^{-1}g^{-1}$, seed has a low vigour i.e.it is not suitable for sowing.

2.6 Seed Health Determination

Seed health test was carried out using the Blotter test method [14]. Four hundred seeds from each treatment were plated on well water-soaked blotters (4 petri-dish). Seeds were incubated for 7 days in an incubation room at 20°C + 1-2°C under 12hr alternating cycles of light using Near Ultra Violet light bulbs and darkness. At the end of the incubation period, each seed was thoroughly examined under a stereomicroscope for the total fungus population of each treatment. A further identification of fungi spores (fruiting bodies) was made using the compound microscope as described by [15].

2.7 Data Analysis

Data were subjected to Analysis of Variance (ANOVA) with the aid of STATISTIX Version 9.0 statistical package. Means separation were carried out using Tukey's Honestly Significant Difference (HSD) at 5% level of probability.

3. RESULTS

3.1 Climatic Information of Study Location

The highest rainfall was recorded in the month of April (280.1mm); followed by June (264.9mm) and September (206.5mm). The lowest rainfall data (16.7mm) was recorded during the month of December. Monthly temperatures during the same period ranged from the lowest (22.7ºC) in September 2015 to the highest temperature (32.8ºC) in December 2015 (Table 1).

3.2 Chemical Properties of Soils from Study Location

The soils were generally slightly acidic with satisfactory levels of organic matter. Nitrogen and phosphorus and potassium were however low in contents. The contents of Ca, Mg were also low (Table 2).

3.3 Effects of Variety and Planting Date on Number of Days to 50% Flowering

The varieties x planting dates interaction were significant for the number of days to 50% flowering traits (Table 3). Shito Adope planted in June took the shortest time to flower, significantly earlier than the other treatment combinations yet similar to that of Shito Adope planted in May (Table 3). Legon-18 planted in September and June on the other hand took the longest time to flower. Between the varieties, Shito Adope plants significantly flowered earlier than plants of Legon-18. Among the planting dates, planting in May led to significantly earlier flowering of plants than June and September plantings (Table 3).

3.4 Effects of Variety and Planting Date on the Number of Aborted Flowers

A significant variety x planting date interactions were found for the number of flower aborted trait (Table 4). Shito Adope, planted in May recorded the highest number of aborted flowers significantly greater that the number from Legon-18 planted in June and Shito Adope, also planted in June (Table 4). Between the varieties, Shito Adope exhibited more flower abortion than Legon-18. Among the planting dates, September and May plantings recorded similar high flower abortions which were significantly greater than flower abortions recorded under June planting.

3.5 Effects of Variety and Planting Date on Number of Days to 50% Fruit Set

There were significant varieties x planting dates interaction for the number of days to 50% fruit set trait (Table 5). Shito Adope planted in May took the shortest time to set fruit, significantly ($p \leq 0.05$) earlier than the other treatment combinations yet similar to that of Shito Adope planted in June (Table 5). However, Legon-18 planted across all the planting dates took the longest time to set fruit, significantly different from those of Shito Adope. Between the varieties, Shito Adope plants set fruit significantly earlier than the plants of Legon-18. Among the planting dates, planting in May led to a significantly earlier fruit setting than in September planting although similar to that of June planting.

Table 1. Monthly weather data at study location (Kwadaso Station) for 2015

Months	Weather data		
	Rainfall (mm)	Temp. max. (ºC)	Temp. min. (ºC)
January	40.1	31.0	24.4
February	48.0	32.0	24.6
March	70.1	31.5	24.3
April	280.1	28.1	24.3
May	132.5	30.1	24.3
June	264.9	28.3	23.8
July	113.0	29.5	23.9
August	92.0	30.5	23.8
September	206.5	28.9	22.7
October	173.3	31.2	23.4
November	139.0	31.6	23.8
December	16.7	32.8	22.9

Source: Soil Research Institute, Kwadaso

Table 2. Chemical properties of soils sampled from the experimental site at Crops Research Institute, Kwadaso Station, Kumasi

	Soil chemical properties								
	pH	Total N	Org. M	Exchangeable Cations (cmol/kg)			Exc. Acidity	E.C.E.C	Available-Bray's
Sites	(1:1 H_20)	(%)	(%)	Ca	Mg	K	($Al,^+$)	(Me/100g)	P (ppm)
Field plot 1	6.21	0.13	1.54	2.87	0.6	0.12	0.18	3.75	78.37
Field plot 2	5.82	0.13	1.73	1.74	0.7	0.22	0.30	3.52	81.09

Table 3. Effects of variety and planting date on the number of days to 50% flowering

Planting dates	Days to 50% flowering		
	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	30.1	40.4	35.3

HSD (0.05): Varieties = 1.63; Planting dates = 2.40; Varieties x Planting dates = 4.17

Table 4. Effects of variety and planting date on the number of flowers aborted of chilli pepper

Planting dates	Number of flowers aborted		
	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	14.6	13.0	

HSD (0.05): Varieties = 1.60; Planting dates = 2.33; Varieties x Planting dates = 4.05

Table 5. Effects of variety and planting date on the number of days to 50% fruit set

Planting dates	Days to 50% fruit set		
	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	34.0	50.1	42.0

HSD (0.05): Varieties = 1.69; Planting dates = 2.49; Varieties x Planting dates = 4.35

3.6 Effects of Variety and Planting Date on Number of Fruit per Plant

The interaction of varieties x planting dates was significant for the number of fruits per plant trait (Table 6). Shito Adope planted in May produced the highest number of fruits per plant although not different from the number produced by Legon-18 planted in June. The least number of fruits per plant was produced by Legon-18 planted in September, significantly less than those produced by Shito Adope planted in May (Table 6). Between the varieties, Shito Adope produced significantly more fruits per plant than Legon-18. Among the planting dates, planting in May resulted in the production of a high number of fruits per plant, significantly greater than that from September planting yet similar to June planting.

3.7 Effects of Variety and Planting Date on the Number of Seed per Fruit

The interaction effects between variety and planting date had shown significant difference on number of seeds per fruit trait (Table 7). Legon-18 planted in September produced the highest number of seeds per fruit (77.3), significantly different from the least seed number (52.4) produced by Shito Adope planted in June (Table 7). Between the varieties, Legon-18 produced the highest seeds per fruit (73.4), significantly greater than the least produced by Shito Adope (60.2). Among planting dates, the highest number of seeds per fruit (71.30) was produced by September plantings, significantly different from the least produced by June plantings.

3.8 Effects of Variety and Planting Date on the Seed Weight per Fruit

There was significant variety x planting date interactions for seed weight per fruit (Table 8). Legon-18 planted in May and September as well as Shito Adope planted in September produced significantly the highest seed weight per fruit. (Table 8). The least seed weight were produced by Shito Adope planted in May and June and Legon-18 planted in June. Between varieties, Legon-18 produced the highest seed weight (0.37g) significantly greater than the least produced by Shito Adope (0.33g). Among planting dates, the highest seed weight per fruit (0.40g) was obtained from September plantings, significantly greater than the least produced by June planting. Seed weight from May planting was similar to that obtained from September planting.

3.9 Effects of Variety and Planting Date on the 1000 Seed Weight

A variety x planting date interactions was significant for 1000 seed weight trait (Table 9). Shito Adope planted in September produced the highest 1000 seed weight though similar to that produced by Shito Adope planted June (Table 9). The least seed weight were produced by Legon-18 planted in May which was not different from that produced by Shito Adope planted in May. Between varieties, Shito Adope produced the highest 1000 seed weight (5.03g) significantly greater than the least produced by Legon-18 (4.50g). Among planting dates, the highest 1000 seed weights were obtained from June and September plantings, significantly greater than the least obtained from May planting.

3.10 Effects of Variety and Planting Date on the SEED Vigor (%)

There were no significant interactions between the treatments for seed vigor. Similarly, there were no significant differences between the main effects for seed vigor. Electrical conductivity values were 30.34 $\mu S/cm^{-1}g^{-1}$ for Legon-18 and 31.4 $\mu S/cm^{-1}g^{-1}$ for Shito Adope.

3.11 Effects of Variety and Planting Date on the Seed Germination (%)

There were significant variety x planting date interactions for percent seed germination. Seeds of Legon-18 planted in June gave the highest germination, significantly greater than the other treatment combinations. The lowest seed germination was produced by Legon-18 planted in September (Table 10). Significant differences were also observed between planting dates for percent seed germination. The highest seed germination percentage (89.9%) was produced by seeds planted in June, significantly different from seeds planted in September and May. The lowest seed germination percentage (82.8%) was produced by seeds planted in September. For varieties, there were also significant differences between the two varieties. Seed of Shito Adope produced the highest germination, significantly different from that produced by seeds of Legon-18.

Table 6. Effects of variety and planting date on mean number of fruits per plant of chilli pepper

Planting dates	Mean number of fruits per plant		
	Shito Adope	Legon-18	Mean
May	38.4	26.1	32.3
June	27.4	30.6	29.1
September	27.3	18.6	23.0
Mean	31.0	25.1	28.05

HSD (0.05): Variety = 3.67; Planting Date = 5.42; Variety x Planting Date = 9.44

Table 7. Effects of variety and planting date on the mean seed number per fruit of chilli pepper

	Mean seed number per fruit		
Planting dates(2014)	Shito Adope	Legon-18	Mean
May	63.1	69.4	66.20
June	52.4	73.5	62.94
September	65.0	77.3	71.30
Mean	60.2	73.4	

HSD (0.05): Varieties = 3.53; Planting dates = 5.23; Varieties x Planting dates = 9.1

Table 8. Effects of variety and planting date on the seed weight per fruit of chilli pepper

Planting dates	Mean seed weight per fruit (g)		
	Shito Adope	Legon-18	Mean
May	0.3	0.4	0.35
June	0.3	0.3	0.30
September	0.4	0.4	0.40
Mean	0.3	0.4	

HSD (0.05): Varieties. = 0.03; Planting Dates = 0.50; Varieties. x Planting Dates = 0.09

Table 9. Effects of variety and planting date on the 1000 seed weight of chilli pepper

Planting dates	1000 seed weight (g)		
	Shito Adope	Legon-18	Mean
May	4.6	4.0	4.30
June	5.2	4.8	5.00
September	5.3	4.7	5.00
Mean	5.0	4.5	

HSD (0.05): Varieties. = 0.03; Planting Dates = 0.50; Varieties. x Planting Dates = 0.09

Table 10. Effects of planting date on percent seed germination of chilli pepper

Planting dates (2014)	Seed germination (%)		
	Shito Adope	Legon-18	Mean
May	88.1	88.2	88.1
June	89.3	90.5	89.9
September	85.5	80.1	82.8
Mean	87.6	86.3	

HSD (0.05): Varieties. = 0.2; Planting Dates = 0.6; Varieties. x Planting Dates = 0.5

3.12 Effects of Variety and Planting Date on the Occurrence of Fungal Pathogens on Chilli Pepper

A total of three fungal pathogen species were identified on the two chilli varieties (Table 11). The pathogens included *Collectotrichum graminicola, Curvularia lunata and Rhizopus spp.* Of the three pathogens, *Collectotrichum graminicola* recorded the highest pathogen incidence on the two chilli varieties, whiles *Rhizopus* spp. was the least. Generally, the

Table 11. Variety and planting date effects on occurrence of fungal pathogens on two Chilli varieties

Variety	Planting date	Pathogenic fungi			
		Collectotrichum graminicola	***Curvularia lunata***	***Rhizopus* spp.**	**Totals**
Legon-18	May	280	104	26	410
Legon-18	June	290	56	38	384
Legon-18	September	180	62	0	242
Shito Adope	May	602	138	148	888
Shito Adope	June	303	94	28	425
Shito Adope	September	178	82	38	298
Totals		1,833	536	278	

highest occurrence of fungal pathogens was observed on seeds cultivated in May while the lowest occurrence was recorded on seeds cultivated in September. For varieties Shito Adope, recorded greater pathogenic load than Legon-18. The highest pathogenic fungal load was recorded on Shito Adope planted in May.

4. DISCUSSION

The interactions of varieties and dates of planting affected the number of days to 50% flowering and the number of days to 50% fruit set traits. According to Uarrota [16], the flower formation and fruit set in plants are dependent on the interaction of many complex processes which are influenced by genetic and environment factors. Generally, the least days to 50% flowering and 50% fruit set traits were associated with May, the earliest date of sowing. This could be due to the fact that the early sowing date provided suitable environmental conditions that favored physiological development of the pepper. In contrast, the longer days to 50% flowering and 50% fruit set traits observed for the September planting i.e. the late sowing date, might have been influenced by higher temperatures. AVRDC [17] reported that fruit set usually delayed when night temperatures were greater than 24°C or daily temperatures exceeded 32°C for extended periods. Konsens et al. [18] and Khah and Passam [19] also stated that delays in fruit set during periods of high temperatures. For the varieties, the observed variations for days to 50% flowering and days to 50% fruit set could be attributed to the genetic make-up of the cultivars. Shito Adope took fewer days to attained 50% flowering and 50% fruit set than Legon-18. Delelegn et al. [20] mentioned 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 [21] also observed that the fewer number of days to 50% flowering and 50% fruit set is an indication of earliness; a desirable trait for varietal selection and release.

The number of flowers aborted also varied for varieties and planting dates. Of the two varieties, Shito Adope recorded a higher number of flower abortions than Legon-18 and could be related to the differences in the genetic make-up of the varieties [22]. Differences in flower abortion could also be due to the competition for assimilates between young vegetative organs and floral structures [23-24]. For the time of planting, the environmental conditions such as temperature and rainfall could have influenced the extent of the flower abortion. In the present study, September plantings resulted in high flower abortions and this could be explained by the high temperatures and low rainfall experienced during the flowering periods of November and December. Similar results arising from moisture and temperature stresses were reported in sweet pepper [25]. Falcetti et al. [26] also indicated that severe and prolonged water stress could result in poor flower-cluster development and reduced pistil and pollen viability and subsequent fruit set. Van Doon and Stead [27] further stated that flower retention and fruit set were highly sensitive to environmental factors, particularly temperatures.

The observed variations in the number of seeds and the seed weight per fruit could also be attributed to differences in the genetic composition of the cultivars. The present study identified Legon-18 as the highest performer in terms of fruit mass, seed weight and seed number and the results suggest that these traits are positively associated and are influenced by genotype. This corroborated the report of Alan and Eser [28], who indicated that pepper fruit size and fruit set positively correlated with seed number. The size and weight of seeds were very important parameters since they determined food reserved within the seed coat and influenced the rate of germination and vigor [29]. Furthermore, *Capsicum* species with heavier seed weight tended to have more food reserves which could prolong seed viability. For seed number per fruit and seed weight per fruit, the observed differences among planting dates might be due to the fact that each of the growing seasons was characterized by fluctuating environmental conditions including rainfall, temperature, relative humidity and soil moisture. Among the different dates of planting, the September planting recorded both the highest seed number and heaviest seed weight per fruit. This same period (November – December) was characterized by moderate rainfall, lower humidity and suitable temperature; all of which tended to favor seed formation and development. According to Rashid and Singh [30], periods of moderate rainfall and humidity were much more suitable for quality seed production of most vegetables. The observed interactive effects point to the genotypes' adaptation and response to the changing environmental conditions, as exhibited by the superior performance of Legon-18 over Shito Adope during the three planting seasons.

In terms of seed quality, the vigor values in the present study indicated that the seeds were of medium vigor and as such could not survive under unfavorable environmental conditions [31]. For seed germination, however, significant variations were observed among the sowing dates and these could be attributed to the environmental differences. Doijode [32] indicated that seed germination rapidly decreased if seeds were exposed to adverse environmental conditions. Delelegn and Belew [20] also reported similar results in a study involving ten hot pepper varieties.

Seed health is an important factor in the control of plant diseases since infected seeds are less viable, has low germination, reduced vigor and subsequently reduced yield [7]. Pest and disease infestation not only led to a reduction in yield, but also affected the quality of seeds. A total of three fungal pathogen species were identified during the present study. *Collectotrichum graminicola* recorded the highest pathogen incidence; while *Rhizopus* spp. was the least. The fungi identified on seed samples are a reflection of the possible diseases that could affect the seeds and seedlings emerging from such infected seeds. According to Al-Kassim and Monawar [33], *Rhizopus* and *Collectotricum* are pathogenic to chilli seeds and cause diseases such as seed rot, damping off, root rot, fruit rot, wilt and foliar diseases.

5. CONCLUSION

The genotype and environmental conditions interactively influenced flower abortion and seed quality traits including number of seed per fruit, seed weight per fruit and 1000 seed weight. Shito Adope, planted in May recorded the highest number of aborted flowers. Legon-18 planted in September produced the highest number of seeds per fruit as well as the heaviest seed weight per fruit. However, the higher germination percentages were recorded by seed produced from May planting.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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