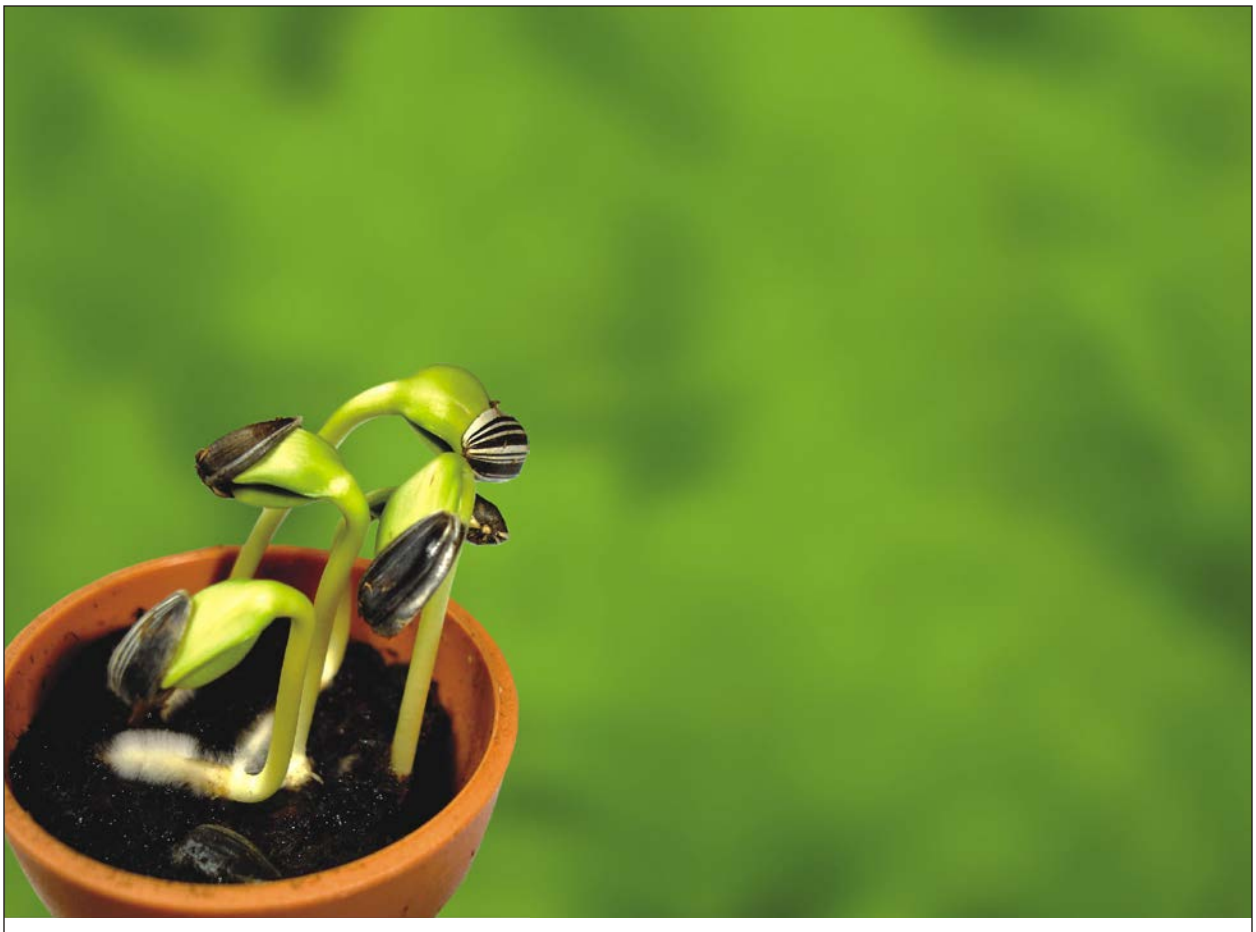

International Journal of Plant Breeding and Genetics

ISSN 1819-3595

Academic Journals Inc.

www.academicjournals.com

International Journal of Plant Breeding and Genetics 6 (4): 228-237, 2012
ISSN 1819-3595 / DOI: 10.3923/ijpbg.2012.228.237

Flowering and Fruiting Behavior of Long Cayenne Pepper (*Capsicum frutescens* L.)

[1]O.O. Idowu-Agida, [2]D.J. Ogunniyan and [1]E.O. Ajayi
[1]National Horticultural Research Institute, P.M.B. 5432, Ibadan, Nigeria
[2]Institute of Agricultural Research and Training, P.M.B. 5029, Ibadan, Nigeria

Corresponding Author: D.J. Ogunniyan, Institute of Agricultural Research and Training, P.M.B. 5029, Ibadan, Nigeria

ABSTRACT

Variability in crop traits creates options for breeders to develop improved cultivars. Many landraces of long cayenne pepper exist in Nigeria but none is recommended for cultivation. Collection, screening and conservation of landraces are therefore vital for the crop improvement. An experiment was carried out at the National Horticultural Research Institute, Ibadan, Nigeria, Latitude 7°22' N Longitude 3°58' E from April 2008 to March 2009 to investigate the extent of variation in reproductive pattern, reproduce-ability and morphology of flowers, fruits and seeds so as to determine markers suitable for pepper improvement. Seeds of long cayenne pepper collected from 25 locations in Southwestern Nigeria were extracted from the fruits, air-dried, bulked and packaged as accession from each location. Six week old seedlings of the pepper were transplanted into 3.6×2.4 m seed beds that were 1 m apart. The plants were spaced 60×60 cm. Plants of the first trial were rainfed; and of the second, were irrigated twice a week when rain stopped. Observations were on flower, fruit and seed traits. Data collected were subjected to analysis of variance combined, across the two trials and means significant were separated by Least Significant Difference. A wide diversity existed within the pepper species on flowering and fruiting pattern. Fruit wall thickness and pedicel length were suggested as morphological markers, number of fruit/plant and seed/fruit; not 1000-seed weight were suitable as markers to select variants for pepper improvement. Any of fruit length, fruit width and days to flowering and fruiting was efficient only when employed together with other markers. Time of cultivation had significant effect on days to first and 50% flowering and fruiting, fruit pedicel length, fruit/plant and fruit weight/plant; but not on fruit length, width and fruit wall thickness; number of seed/plant and 1000 seed weight.

Key words: *Capsicum frutescens*, genetic variation, pepper accessions, pepper reproduction, selection index

INTRODUCTION

Pepper is grown as a popular spice everywhere in the tropics (Berke *et al*., 2005) and very many distinct cultivars had been developed. There are many cultivars with wide variations in morphological characteristics (Ado, 1988, 1990) useful in pepper improvement programmes especially for yield and fruit quality. *Capsicum* has a great genetic diversity which has been little exploited (Pickersgill, 1989; Manju and Sreelathakumary, 2002; Grubben and Tahir, 2004). There are over 200 local selections of pepper grown in Nigeria but certainly no cultivars are recommended (Erinle, 1989). Also, in the future, many landraces are likely to disappear as

African growers switch to improved cultivars. Consequently, there is the need to collect *Capsicum* landraces for conservation in GenBank (Grubben and Tahir, 2004).

Hot pepper is widely cultivated in Nigeria where it ranks among vegetables as third after tomatoes and onions (Erinle, 1989). The long Cayenne pepper (*Capsicum frutescens* L.) is among the three major hot peppers grown in the country. It is moderate moisture loving perennial tropical crop often grown as annual (Grattan and Grieve, 1993) that bears fruits of different sizes, which are initially green, yellow at physiological maturity and red when ripe or light yellow, yellow at maturity and light red when ripe. It could also be green initially, brown at maturity and bright red when mature or green when just developing, yellow at maturity and finally red or purple (Messiaen, 1992). The flower of pepper is single with greenish-white corolla and up to 15 mm in diameter. Its fruit varies in length from 1-15 cm and in width from 1-4 cm. The average weight of a fully mature fruit is about 20 g. Pepper seed is flattened; kidney shaped, about 3-5 mm in length and pale yellow. Weight of 1000 seeds varies from 1.7 to 5.5 g (Rice *et al*., 1990; Messiaen, 1992).

Flowering is a vital physiological process in crop existence and assurance for reproduction (Marcelis *et al*., 2005). Time of flowering is particularly of great importance in annual crops, because it is a component of the adaptation of a cultivar to an environment. It also determines fruit set and crop yield (Ishiyaku *et al*., 2005; Ferrara *et al*., 2011). Pepper is prevalently an autogamous species with frequent cross-pollination brought about by insects and to a lesser extent by wind. Although pepper is predominantly self-pollinating; out-crossing can reach 60% (Csillery *et al*., 1986; Tay, 1989). Plant growth and development, especially flowering, is dependent on the interaction of many complex processes which are influenced by both genetic and environment (Uarrota, 2010). Anthesis in pepper commences 30-42 days after planting and rise to peak of 39 flowers per week and first fruits are ready for harvesting 30 days later (Gibbon and Pain, 1985; Khah and Passam, 1992). Earliness in arable crop is an important agronomic trait since it has been reported to open the possibility of successful sole cropping in areas with short rainy season and multiple cropping within a year. It is also beneficial in relay cropping in areas with relatively longer rainfall (Adeyanju and Ishiyaku, 2007).

Nigeria is the largest pepper producer in tropical Africa. Grubben and Tahir (2004) reported FAO statistics estimation of tropical Africa production of pepper at 1 million tonnes, with Nigeria sole cropping yield of 0.8 t ha^{-1}. Apart from being consumed fresh, dried or processed, pepper is used in cosmetics, local medicine, pharmaceutical and ornamental industries, for personal defence of police officials (Pickersgill, 1989; Grubben and Tahir, 2004) and to control pests in the storage of agricultural products. Capsicum has a high nutritional and economic value (Berke *et al*., 2005) but the average yield in Nigeria is still very low as a consequence of use of unimproved local varieties. With improved cultivars (Akinwale *et al*., 2010) and appropriate agronomic management (Ouda and Mahadeen, 2008; Nasto *et al*., 2009; Law-Ogbomo and Egharevba, 2009), yields of vegetables can be increased considerably (Grubben and Tahir, 2004).

Flowering in crops and yield stability depend on the photoperiod sensitivity of the various cultivars (Abdulai *et al*., 2012). Therefore, genetic variation in flowering among landraces of pepper can provide raw material for improvement. Understanding the agronomic traits of crop is also vital for assessing the feasibility of selection of two or more traits for crop improvement (Udensi *et al*., 2012). Information on inheritance of days to flowering helps breeders develop strategies for improvement of seed yield and their adaptation to various agroclimatological zones (Adeyanju *et al*., 2007). Hence, understanding the days to flowering, days to fruiting, anthesis-fruit set interval and other important fruit traits is vital in selecting suitable traits to help breeders

develop strategies for improvement of fruit and seed yields of the crop. This will be exploited in the development of pepper varieties that can flower and fruit well thereby ensuring availability of pepper for the teaming population in tropical Africa. In spite of this, collection of the numerous un-exploited landraces of pepper, which none is recommended in Nigeria and characterization based on flowering and fruit production pattern are imperative. Hence, the study investigated the extent of variations in reproductive pattern, reproduce-ability and morphology of flowers and fruits of *Capsicum frutescens* in Southwestern Nigeria to select suitable reproductive and morphological markers for selection and improvement of the crop.

MATERIALS AND METHODS

An experiment was carried out at the National Horticultural Research Institute, Ibadan, Nigeria, Latitude 7°22' N Longitude 3°58' E from April 2008 to March 2009. The experimental field had been under continuous cultivation for over 30 years. Seed were extracted from the fruits of long cayenne pepper were collected from 25 locations in Southwestern (SW) Nigeria (Table 1), air-dried, bulked and packaged as accession from each location. A total of 180 seeds per accession were sown 1.5 cm deep in trays containing top soil mixed with manure. The experiment was repeated to confirm the results of the first trial. A nursery was established to raise seedlings for each field evaluation in the two trials. Seeds were sown in the nursery for the first trial on 25 April 2008 and for the second on 7 August 2008. Soil of the experimental plots was analyzed before the

Table 1: Description of the locations in SW Nigeria where the 25 accessions of long cayenne pepper were collected in 2008

		Location		
Accession	Collection site	Lat. (N)	Long. (E)	Agroecology
AB/108/OG	Abeokuta	7°15'	3°35'	Southern Rainforest
AD/108/EK	Ado-Ekiti	7°48'	5°41'	Northern Rainforest
AG/208/OG	Ago-Iwoye	6°82'	3°92'	Southern Rainforest
AK/108/OD	Akure	7°15'	5°05'	Northern Rainforest
AR/208/EK	Aramoko	7°43'	5°38'	Northern Rainforest
IF/308/EK	Ifaki	7°71'	5°90'	Northern Rainforest
IF/208/OD	Ifon	7°42'	5°55'	Southern Rainforest
IG/108/KW	Igbaja	8°36'	4°41'	Southern Guinea Savanna
KR/308/OD	Ikare	7°52'	5°76'	Northern Rainforest
IK/108/OS	Ikire	7°36'	4°19'	Southern Rainforest
KR/208/OS	Ikirun	7°92'	4°67'	Southern Rainforest
KL/408/EK	Ikole	7°60'	5°54'	Southern Guinea Savanna
ID/108/LG	Ikorodu	6°62'	3°05'	Southern Rainforest
II/308/OS	Ile-Ife	7°47'	4°57'	Southern Rainforest
IL/208/KW	Ilorin	8°05'	4°55'	Southern Guinea Savanna
OD/108/OY	Odo-Oba	7°40'	3°50'	Southern Guinea Savanna
OF/208/KW	Offa	8°13'	4°42'	Southern Guinea Savanna
OG/208/OY	Ogbomoso	7°46'	3°56'	Southern Guinea Savanna
OM/308/KW	Omu-Aran	8°45'	4°40'	Southern Guinea Savanna
OR/480/OD	Ore	7°32'	5°40'	Southern Rainforest
OS/408/OS	Osogbo	7°77'	4°55'	Southern Rainforest
OT/308/OG	Otta	7°95'	4°78'	Southern Rainforest
SG/408/OG	Sagamu	6°85'	3°65'	Southern Rainforest
SK/308/OY	Saki	8°68'`	4°79'	Southern Guinea Savanna
SS/408/OY	Sasa	7°22'	3°58'	Southern Guinea Savanna

6 week old seedlings were transplanted into seed beds measuring 3.6×2.4 m on 6 June 2008 for the first; and 18 September 2008 for the second trial. The soil physical and chemical data of the soil include The soil was a slightly acidic (pH 6.2) sandy-loam containing 0.04% N, 26.44 mg g^{-1} P and 0.39 cmol kg^{-1} K.

The plants were spaced 60×60 cm representing 27,778 plants ha^{-1}. Plants of the first trial were rainfed. Rain stopped at the end of October during the second trial, thus plots were irrigated to field capacity twice a week. A total of 5.85 g of N as urea, 1.01 g P as single superphosphate and 5.92 g of K as muriate of potash were applied per plant to obtain 130, 80 and 110 kg ha^{-1} of N-P-K recommendation (Grubben and Tahir, 2004) at 3, 6, 9 and 12 weeks after transplanting. Fertilizers were applied in four splits because the field had been over cultivated. The fruits were harvested when red.

Observations were made on all, except the boundary crops on flower, fruit and seed characteristics in the two trials (IPGRI, 1995). Data collected were average fruit length and width, fruit wall thickness using micrometer screw gauge, fruit pedicel length, day to first and 50% flowering and day to first and 50% fruiting, number of fruit/plant, fruit yield and seed/fruit and 1000 seed weight. Data were subjected to analysis of variance, combined, across the two trials and means were separated by Least Significant Difference (SAS, 2004).

RESULTS

Flower, fruit and seed diversity among the accessions: A wide diversity existed among the pepper cultivated species on floral, fruit and seed morphology. The description of the diversity at various stages of development is in Table 2. Generally, the accessions showed similar expression for a number of qualitative traits determined at anthesis. The flowers were 100% uniform in all the parameters considered. Mean fruit set occurrence ranged from intermediate (94.1%) to high (5.9%). A total of 90% of the fruits were elongated; 10% were triangular. The fruit shape at blossom end was pointed except only 3.2% which was blunt. All the fruit traits considered at harvest were 100% uniform except fruit surface. About 43% of the fruits were smooth; 57% were semi-wrinkled. Seeds from all the fruits of all the accessions were smooth.

The parameters that are metric were highly variable (Table 3). There were significant differences among the cultivars in fruit length and width and pedicel length of the fruits. Acc. OT/308/OG, SG/408/OG, AD/108/EK and IL/208/KW had significantly higher fruit length; IK/108/OS' had the least, whereas the other accessions had values within the two extremes. Acc. IG/108/KW OR/408/OD, OT/308/OG, OF/208/KW, IL/208/KW, AG/208/OG, SG/408/OG, OG/208/OY and SK/308/OY were significantly different from 'AB/108/OG' which was among the accessions with least fruit width. 'OF/208/KW' was significantly higher in fruit pedicel length than all other test accessions; there was no difference in the fruit wall thickness.

Table 2: Description of flowers at anthesis, fruits at, and seeds after, harvest of 25 accessions of long cayenne pepper collected from SW Nigeria in 2008

Traits	Description
Flower at anthesis	Pendant, white, rotate, no-spot, pale blue anther, white filament, same level of stigma exertion
Calyx at harvest	No pigmentation, no annular constriction, intermediate margin
Fruit at harvest	Intermediate to high fruit set, elongated to triangular, obtuse at pedicel attachment, no neck at base, pointed to blunt blossom ends, no appendage, slightly cross-sectional corrugations, smooth to semi wrinkled surface, no anthocyanin spot or stripe, green before, and red at, ripening
Seed after harvest	Straw and smooth

Table 3: Variations in fruit characters of 25 accessions of long cayenne pepper collected from SW Nigeria in 2008

Accession	Fruit length (cm)	Fruit width (cm)	Fruit wall thickness (mm)	Fruit pedicel length (cm)
AB/108/OG	9.9	3.9	1.7	1.4
AD/108/EK	10.6	5.1	1.5	1.0
AG/208/OG	7.8	5.3	2.0	0.8
AK/108/OD	9.9	4.3	1.8	1.1
AR/208/EK	9.0	4.0	1.7	0.8
IF/308/EK	8.4	5.1	2.0	1.0
IF/208/OD	8.2	4.2	2.2	1.3
IG/108/KW	9.2	6.3	1.7	1.0
KR/308/OD	10.1	4.7	1.8	1.8
IK/108/OS	7.1	4.8	1.7	1.0
KR/208/OS	9.7	4.9	1.8	1.6
KL/408/EK	9.0	4.7	2.3	1.4
ID/108/LG	9.0	4.4	2.0	1.3
II/308/OS	8.4	4.9	1.7	1.2
IL/208/KW	10.6	5.8	2.3	0.9
OD/108/OY	8.9	5.0	2.5	1.2
OF/208/KW	8.7	5.9	2.7	2.6
OG/208/OY	8.1	5.2	1.7	1.1
OM/308/KW	9.8	4.3	2.0	1.3
OR/480/OD	8.4	6.1	2.2	1.1
OS/408/OS	9.6	5.0	2.0	1.0
OT/308/OG	11.1	5.8	1.7	1.1
SG/408/OG	11.0	5.3	1.8	1.2
SK/308/OY	8.8	5.2	2.0	1.2
SS/408/OY	9.7	4.1	1.7	1.0
LSD (0.05)	2.5	1.2	ns	0.8
Mean	9.2	5.0	1.9	1.2
MSE	2.2	1.0	0.8	0.7
CV(%)	23.6	20.4	42.8	60.3

MSE: Mean square error, CV: Coefficient of variation

Flowering and fruiting pattern: Flowering and fruiting pattern of the 25 accessions of long cayenne pepper collected from SW Nigeria in 2008 are in Table 4. There were significant difference among the accessions on days to 50% flowering and 50% fruiting and anthesis-fruit set interval but not in days to first flowering and fruiting. 'OD/108/OY' produced first flower almost 99 days and was among those that had least days to 50% flowering. Acc. KL/408/EK, II/308/OS, IL/208/KW, IK/108/OS, IF/308/EK and AG/208/OG were significantly higher in days to 50% flowering than the rest accessions. Anthesis-fruit set interval varied significantly among the accessions and ranged from 9 to 15.9 days. 'KL/408/EK' and 'OS/408/OS' had least; anthesis-fruit set interval; 'IL/208/KW', ' ID/108/LG' and 'AD/108/EK' had highest whereas the rest accessions had values within the range. 'IL/208/KW' was among the accessions that had significantly higher days to 50% fruiting and was significantly different from Acc. AK/108/OD, AR/208/EK, OM/308/KW and OS/408/OS.

Fruit and seed yield aspects: Fruit and seed yield of the crop varied among accessions (Table 5). Accession IF/308/EK produced least number of fruits (9.4) and fruit yield (63.6)/plant. SK/308/OY produced highest (19.2) fruit/plant but IF/208/OD yielded highest (130.9)/plant. There was no

Table 4: Flowering and fruiting pattern of 25 accessions of long cayenne pepper collected from SW Nigeria in 2008

Accession	Days to first flowering	Days to 50% flowering	Anthesis-fruit set interval	Days to first fruiting	Days to 50% fruiting
AB/108/OG	100.5	112.2	13.6	108.5	125.8
AD/108/EK	99.8	111.3	15.5	108.5	126.8
AG/208/OG	99.9	113.8	13.2	110.0	127.0
AK/108/OD	101.8	110.2	12.6	108.2	122.8
AR/208/EK	101.0	111.8	12.0	109.2	123.8
IF/308/EK	99.8	113.7	10.5	108.5	124.2
IF/208/OD	100.5	113.0	12.0	109.5	125.0
IG/108/KW	100.8	111.2	14.0	109.5	125.2
KR/308/OD	102.3	112.8	11.2	109.3	127.0
IK/108/OS	101.2	114.0	13.5	108.8	127.5
KR/208/OS	99.5	112.8	11.4	110.5	124.2
KL/408/EK	99.7	116.5	9.0	110.3	125.5
ID/108/LG	100.7	111.8	15.9	110.0	127.7
II/308/OS	101.7	114.5	11.0	109.5	125.5
IL/208/KW	100.5	114.0	16.0	108.8	130.0
OD/108/OY	98.8	111.8	12.2	109.5	124.0
OF/208/KW	101.2	112.2	12.1	109.2	124.3
OG/208/OY	101.2	112.3	13.9	109.7	126.2
OM/308/KW	100.5	112.3	11.5	108.3	123.8
OR/408/OD	101.8	111.8	12.4	110.8	124.2
OS/408/OS	103.4	111.8	10.0	107.7	121.8
OT/308/OG	102.8	113.0	13.8	111.8	126.8
SG/408/OG	101.8	112.2	13.6	110.3	125.8
SK/308/OY	101.8	112.2	12.1	108.7	124.3
SS/408/OY	101.8	111.5	13.7	109.3	125.2
LSD (0.05)	ns	3.5	1.1	ns	6.2
Mean	101.0	112.6	12.3	109.4	125.4
CV(%)	3.8	2.8	2.7	3.1	4.3
MSE	3.9	3.1	3.0	3.4	5.4

Table 5: Mean fruit and seed yield aspects of 25 accessions of long cayenne pepper collected from SW Nigeria in 2008

Accession	No. of fruit plant^{-1}	Fruit yield plant^{-1} (g)	No. of seeds fruit^{-1}	1000 seed weight (g)
AB/108/OG	16.5	84.2	70.1	3.2
AD/108/EK	13.3	81.2	81.4	3.3
AG/208/OG	13.9	78.4	72.3	3.2
AK/108/OD	19.0	111.7	76.6	3.3
AR/208/EK	14.8	88.6	88.1	3.2
IF/308/EK	9.4	63.6	82.8	3.3
IF/208/OD	18.5	130.9	74.1	3.2
IG/108/KW	12.6	68.6	81.1	3.3
KR/308/OD	15.3	82.6	68.1	3.2
IK/108/OS	18.1	108.7	184.1	3.3
KR/208/OS	12.3	64.6	87.5	3.2
KL/408/EK	13.0	79.9	71.9	3.3
ID/108/LG	12.6	73.7	74.3	3.2
II/308/OS	16.5	85.0	70.5	3.2
IL/208/KW	12.8	68.4	81.8	3.3
OD/108/OY	13.2	76.2	78.2	3.3

Table 5: Continue

Accession	No. of fruit plant^{-1}	Fruit yield plant^{-1} (g)	No. of seeds fruit^{-1}	1000 seed weight (g)
OF/208/KW	11.4	72.8	68.3	3.3
OG/208/OY	14.6	82.7	82.2	3.3
OM/308/KW	16.2	93.7	77.8	3.2
OR/480/OD	18.1	116.3	59.0	3.3
OS/408/OS	18.0	84.4	79.6	3.3
OT/308/OG	12.1	69.4	87.6	3.3
SG/408/OG	11.3	66.6	71.2	3.3
SK/308/OY	19.2	105.2	80.7	3.3
SS/408/OY	16.6	98.4	64.9	3.3
LSD (0.05)	6.2	25.7	61.6	ns
Mean	14.8	85.4	76.6	3.3
CV	37.2	40.9	66.1	3.4
MSE	5.5	34.9	53.9	0.1

ns: Not significant

Table 6: Effect of season on some important flowering and fruiting traits of 25 accessions of long cayenne pepper collected from SW Nigeria in 2008

Traits	First trial	Second trial	Mean	LSD (0.05)
Days to 1st flowering	113.20	88.60	100.90	4.40*
Days to 50% flowering	127.40	97.60	112.50	3.60*
Days to 1st fruiting	122.20	96.50	109.40	3.80*
Days to 50% fruiting	146.30	103.90	125.10	6.20*
Fruit length (cm)	9.50	8.98	9.24	0.63^{ns}
Fruit width (cm)	5.01	4.91	4.96	0.29^{ns}
Fruit wall thickness (mm)	1.96	1.89	1.93	0.24^{ns}
Fruit pedicel length (cm)	1.04	1.32	1.18	0.21*
No. of fruit/plant	9.48	20.11	14.80	1.60*
Fruit weight/plant (g)	60.82	110.11	85.45	39.90*
No. of seed/plant	74.40	88.64	81.52	15.65^{ns}
1000-seed weight (g)	3.25	3.24	3.25	0.03^{ns}

*Significantly different at p = 5%, ns: Not significant

significant difference among the accessions only in 1000-seed weight. Number of seed/plant ranged from 59 to 184 fruit. Acc IF/308/EK, AG/208/OG, AG/208/OG, AR/208/EK, IG/108/KW, KR/308/OD, KR/208/OS, ID/108/LG, IL/208/KW, OD/108/OY, OF/208/KW, OG/208/OY, OT/308/OG and SG/408/OG produced low fruit/plant. 'IF/208/OD' yielded highest fruit/plant; 'SG/408/OG', 'KR/208/OS' and 'IF/308/EK' were among accessions with least fruit/plant. 'IK/108/OS' had significant higher seeds/fruit.

Effect of cultivation time on some traits of the pepper flowers, fruits and seeds: Time of cultivation has a pronounced effect on days to first and 50% flowering and fruiting, fruit pedicel length, number of fruit/plant and fruit weight/plant but not on fruit length, width and fruit wall thickness; number of seed/plant and 1000 seed weight (Table 6).

DISCUSSION

Most of the accessions showed similar expression for a number of qualitative traits determined at anthesis. Anthesis is the onset or developmental period during which a flower is fully open and

functional. The onset of anthesis is spectacular in many species of crops because it determines the reproduce-ability of the crop through pollination. Some aspects of fruit and seed were similar across trials since the fruits were collected around a region that is culturally and economically homogenous. The farmers who had over the years selected those cultivars that showed desirable traits grow seeds from their stocks. Seed supply system is still traditional in the region (Ogunniyan and Eludoyin, 2009), thus, farmers' varieties are well established.

The variation in the floral and fruit morphology of the landraces collected and studied confirmed the wide diversity of the crop in SW Nigeria. These observed morphological traits of the accessions confirmed earlier description of the crop (Messiaen, 1992; Oluoch and Marandu, 2008). The significant difference that characterized seed yield among the accessions showed there were varieties in the collection area which reacted differently to different environments created by difference in the time of cropping. Different genotypes respond differently to the same environmental condition. This is so because the variability in environment and their interaction highly influence the performance of genotypes in relation to yield potential (Egesi *et al*., 2007). 'IF/208/OD' and 'IK/108/OS' were, respectively, selected as superior accession in fruit/plant and seeds/fruit.

Coefficients of Variability (CVs) of fruit length and width were, respectively, 23.6 and 20.4%. The CVs were high for the fruit wall thickness and pedicel length recording 42.8 and 60.3% respectively but the MSEs were low. This clearly indicates that the deviation of values of these traits from the population grand mean was high and not necessarily due to experimental error. Then, it can be deduced that either or both fruit wall thickness and pedicel length can be used as morphological marker to select variants for pepper improvement. Fruit length and width shall be efficient when employed with some other markers.

Variations in days 50% flowering and fruiting and not in days to first flowering and fruiting explain the differences in the physiological development of the crop's accessions. Acc. KL/408/EK, II/308/OS, IL/208/KW, IK/108/OS, IF/308/EK and AG/208/OG with higher days to 50% could be selected in planting in the high rainfall area whereas those with shorter days to 50% could be selected for low rainfall environments. 'KL/408/EK' and 'OS/408/OS' were promising accessions due to the shortness in anthesis-fruit set interval. Earliness is important in crop cultivation in areas with short rainy season and multiple cropping within a year and beneficial in relay cropping in areas with relatively longer rainfall (Adeyanju and Ishiyaku, 2007; Kabura *et al*., 2009). Considering days to 50% flowering and anthesis-fruit set interval, 'KL/408/EK' could be breeder's choice. Though variation existed, both the CVs and MSEs were low in all the phenological characters considered. Hence, none of these traits can adequately be used to select alone for breeding purposes; but any of them may be concurrently used with fruit parameters, particularly fruit wall thickness and pedicel length. All the yield and yield contributing parameters considered were significantly different except 1000-seed weight. Number of fruit/plant and seed/fruit had moderately high CVs, qualifying them as selection indices for pepper improvement. But 1000 seed weight is not a suitable selection index. Effects of time of cultivation on fruit wall thickness, pedicel length, length and width and number of seed/fruit and 1000 seed weight were not significant. Pepper flowers and fruits earlier in the second trial owing to the fact that pepper is a sun-loving crop that performs better with moderate rainfall. The first trial was in the middle of rainy season when too much rain delayed flowering and fruiting and caused abortion and rot of flowers. Seed yield was also higher in the second than the first for the same reasons.

CONCLUSIONS

A wide diversity exists within the pepper species cultivated in SW Nigeria on floral, fruit and seed morphology. Fruit wall thickness and pedicel length can be used as reproductive and morphological markers. Fruit length and width, days to 50% flowering and fruiting shall only be efficient when employed with some other markers to select for pepper breeding and improvement purposes. Number of fruit/plant and seed/fruit qualify as selection indices for pepper improvement. But 1000-seed weight is not a suitable selection index. Pepper flowers and fruits earlier in the drier period. Time of cultivation had significant effect on some important traits of reproduction but not on fruit wall thickness, pedicel length, length and width as well as number of seeds and fruit 1000-seed weight.

REFERENCES

Abdulai, A.L., H. Parzies, M. Kouressy, M. Vaksmann, F. Asch and H. Brueck, 2012. Yield stability of photoperiod sensitive sorghum (*Sorghum bicolor* L. Moench) accessions under diverse climatic environments. Int. J. Agric. Res., 7: 17-32.

Adeyanju, A.O. and M.F. Ishiyaku, 2007. Genetic study of earliness in cowpea (*Vigna unguiculata* L. Walp) under screen house condition. Int. J. Plant Breed. Genet., 1: 34-37.

Adeyanju, A.O., M.F. Ishiyaku and L.O. Omoigui, 2007. Inheritance of time to first flower in photo-insensitive cowpea (*Vigna unguiculata* (L.) Walp.). Asian J. Plant Sci., 6: 435-437.

Ado, S.G., 1988. Evaluation of *Capsicum* in Nigeria. PGR *Capsicum* Eggplant Newslett., 17: 16-17.

Ado, S.G., 1990. Pepper production guide. Horticultural Crops Research Programme. Institute of Agricultural Research Samaru, pp: 12.

Akinwale M.G., B.O. Akinyele, A.G.O. Dixon and A.C. Odiyi, 2010. Genetic variability among forty-three cassava genotypes in three agro ecology zones of Nigeria. J. Plant Breed. Crop Sci., 2: 104-109.

Berke, T., L.L. Black, N.S. Talekar, J.F. Wang and P. Gniffke *et al*., 2005. Suggested cultural practices for Chili pepper. International Cooperators Guide. AVRDC World Vegetable Centre.

Csillery, G., L. Quagliotti and A. Rota, 1986. Natural cross-pollination experiment on pepper in Piedmont, Italy. *Capsicum* Newslett., 5: 38-39.

Egesi, C.N., P. Ilona, F.O. Ogbe, M.O. Akoroda and A. Dixon, 2007. Genetic Variation and Genotype x Environment Interaction for Yield and Other Agronomic Traits in Cassava in Nigeria. Agron. J., 99: 1137-1142.

Erinle, I.D., 1989. Present status and prospect for increased production of tomato and pepper in Northern Nigeria. In Tomato and pepper production in the tropics. Proceedings of the International Symposium on Integrated Management Practices, March 21-26, 1986, Asian Vegetable Research and Development Center, Taiwan, pp: 536-548.

Ferrara, A. , S. Lovelli, T. Di Tommaso and M. Perniola, 2011. Flowering, growth and fruit setting in greenhouse bell pepper under water stress. J. Agron., 10: 12-19.

Gibbon, D. and A. Pain, 1985. Crops of the Drier Region of the Tropics. Longman, London, New York, pp: 134-139.

Grattan, S.R. and C.M. Grieve, 1993. Mineral Nutrient Acquisition and Response by Plants Growth in Saline Environments. In: Handbook of Plant and Crop Stress, Parassaki, M. (Ed.)., Marcel Dekker, New York, pp: 78-86.

Grubben, G.J.H. and I.M. Tahir, 2004. *Capsicum* species. In: Plant resources of Tropical Africa. 2. Vegetables, Grubben,.J.H. and Denton, O.A. (Eds.)., PROTA Foundation, Wageningen, Netherlands, Backhugs Publishers, Leiden, Netherlands, pp: 154-163.

IPGRI, 1995. Descriptors for *Capsicum* (*Capsicum* sp.). IPGRI, Rome, Italy.

Ishiyaku, M.F., B.B. Singh and P.Q. Craufurd, 2005. Inheritance of time to flowering in Cowpea (*Vigna unguiculata* (L.) Walp.). Euphytica, 142: 291-300.

Kabura, B.H., P.E. Odo and A. Abubakar, 2009. Performance of some tomato (*Lycopersicon esculentum* Mill.) varieties under heat period in Northern Nigeria. J. Agron., 8: 45-48.

Khah, E.M. and E.C. Passam, 1992. Flowering, fruit set and development of the fruit and seed of sweet pepper (*Capsicum annuum* L.) cultivated under conditions of high ambient temperature. J. Hortic. Sci., 67: 251-258.

Law-Ogbomo, K. and E. Egharevba, 2009. Effects of planting density and NPK fertilizer application on yield and yield components of tomato (*Lecopersicum esculentum* Mill) in forest Location. World J. Agric. Sci., 5: 152-158.

Manju, P.R. and I. Sreelathakumary, 2002. Genetic variability, heritability and genetic advance in hot chilli (*Capsicum chinense* Jacq.). J. Trop. Agric., 40: 4-6.

Marcelis, L.F.M., E. Heuvelink, L.R.B. Hofman-Eijer, J.D. Bakker and L.B. Xue, 2005. Flower and fruit abortion in sweet pepper in relation to source and sink strength. J. Exp. Bot., 55: 2261-2268.

Messiaen, C.M., 1992. The Tropical Vegetable Garden: Principles for Improvement and Increased Production with Application to the Main Vegetable Types. Macmillan Ltd., United Kingdom, pp: 514.

Nasto, T.H., A. Balliu and N. Zeka, 2009. The influence of planting density on growth characteristics and fruit yield of peppers (*Capsicum annuum* L.). J. Acta Hortic., 830: 609-912.

Ogunniyan, D.J. and O.S. Eludoyin, 2009. Evaluation of arable crop seed supply systems in South-West Nigeria. J. Agric. Soc. Res., 9: 68-77.

Oluoch, M.O. and Y.F. Marandu, 2008. Field guide for vegetable evaluation research. AVRDC Report, World Vegetable Center, Arusha, Tanzania.

Ouda, B.A. and A.Y. Mahadeen, 2008. Effect of fertilizers on growth, yield, yield components, quality and certain nutrient contents in broccoli (*Brassica oleracea*). Int. J. Agric. Biol., 10: 627-632.

Pickersgill, B., 1989. Genetic resources of *Capsicum* for Tropics. In Tomato and pepper production in the tropics. Proceedings of the International Symposium on Integrated Management Practices, March 21-26, 1989, Asian Vegetable Research and Development Center, Taiwan, pp: 2-9.

Rice, R.P., L.W. Rice and H.D. Tindall, 1990. Fruit and Vegetable Production in Warm Climates. The Macmillan Press Ltd., London, Basingstoke, pp: 181-203.

SAS, 2004. SAS Institute User`s Guide: Statistics, Version 9.0. SAS Institute Inc., Cary, North Carolina, USA., pp: 1028.

Tay, D.C.S., 1989. Genetics resources of tomato and pepper at AVRDC. In Tomato and pepper production in the Tropics. Proceedings of the International Symposium on Integrated Management Practices, March 21-26, 1989, Asian Vegetable Research and Development Center, Taiwan, pp: 10-12.

Uarrota, V.G., 2010. Response of cowpea (*Vigna unguiculata* L. Walp.) to water stress and phosphorus fertilization. J. Agron., 9: 87-91.

Udensi, O., E.V. Ikpeme, E.A. Edu and D.E. Ekpe, 2012. Relationship studies in Cowpea (*Vigna unguiculata* L. Walp) landraces grown under humid lowland condition. Int. J. Agric. Res., 7: 33-45.