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Growth, Yield and Consumer Acceptance of Sweet Pepper (*Capsicum annuum* L.) as Influenced by Open Field and Greenhouse Production Systems

Nkansah GO, Norman JC and Martey A*

Crop Science Department, Forest and Horticultural Crops Research Centre (FOHCREC), Okumaning-Kade in the Eastern Region, University of Ghana, Ghana

Abstract

A study was conducted on sweet pepper (*Capsicum annuum* L.) on growth, yield and consumer acceptance as influenced by open field and greenhouse production systems at the University of Ghana Forest and Horticultural Crops Research Centre, Okumaning – Kade in the Eastern Region of Ghana. The experiment was conducted in the minor season (dry season) from October 2014 to March 2015. A 2 × 9 factorial was laid out in Randomized Complete Block Design with three replications. The experiment consisted of two production systems: greenhouse and open field and nine varieties of sweet pepper: California Wonder, Yolo Wonder, Kulkukan, F1 Nobile, Crusader, Guardian, Embella 733- EM and Caribbean Red, Pepper 1) with three replications. Data were recorded on plant height (cm), girth (mm), leaf number, number of fruits per plant, fruit weight per plant (kg), length of fruits (cm), diameter of fruits (cm), pericarp thickness (mm), number of locules per fruit and yield (t/ha). All the parameters measured differed significantly except pericarp thickness of fruits. In the greenhouse Kukulkan (21.34t) recorded the highest yield (t/ha) followed by California Wonder (20.99t) and Yolo Wonder (8.20t) had the least. In the open field it revealed that the yield of California Wonder (12.57t) gained the highest, followed by Crusader (10.57t) and pepper 1 (5.02) had the least weight. Fruits were ranked for its acceptability by consumers (rank=1 - very poor quality to 9 - Extreme excellent quality). California wonder (rank -8) was highly accepted by consumers compared to Caribbean Red (rank 4- moderate quality) in both greenhouse and open field conditions.

Keywords: Sweet pepper; Greenhouse; Open field; Consumer acceptability

Introduction

Sweet pepper *(Capsicum annum* L.*)* belongs to the family Solanaceae, which is an important group of vegetables grown extensively and also widely cultivated in almost every country of the world [1]. It thrives best in warm climate, where frost is not a problem during the growing seasons. In general, it requires temperatures ranging from 25-35°C [2]. The sweet pepper of commerce also known as Bell pepper [3], is one of the most varied and widely used foods in the world; it originated in Mexico and Central America regions and Christopher Columbus encountered it in 1493 [4]. Sweet pepper is the world's second most important vegetable after tomato [5]. It is one of the most important vegetable grown in other parts of sub-humid and semi-arid tropics [6]. In 2007, over 26 million metric tons of pepper was produced globally (U.S. Dept. of Agriculture, 2008a). China ranked first, producing more than 50% of the world's pepper, while the United States (U.S.) ranked sixth with about 855,000 metric tons produce (U.S. Dept. of Agriculture, 2008a).

The fruits of sweet pepper are harvested either at green mature stage or at colouring stage and are a very good source of vitamin A and C and other nutrients having great demand in big cities and other urban areas of the country. One medium green bell pepper can provide up to 8% of the recommended daily allowance of Vitamin A, 180% of Vitamin C, 2% of calcium and 2% of iron [4]. Sweet pepper contributes substantially to our diet, it is a good source of vitamins A, C (More than that obtained from tomato), E, B1, B2, and D [7]. A phenolic compound called capsaicin is responsible for the pungency in peppers. Pepper is grown as an annual crop due to its sensitivity to frost and is actually herbaceous perennial and will survive and yield for several years in tropical climates [8,4]. According to Norman [9], the growing of sweet pepper in West Africa is confined to urban centers but recently large scale or commercial productions has been undertaken under irrigation in the rural areas. It is very vulnerable to frost and grows poorly at temperatures between 5 and 15°C [10]. The optimum temperature range for sweet pepper growth is 20 to 25°C. There are several factors that influence the growth and yield of pepper, some of which include temperature, relative humidity, day length, photoperiod etc. Along with other factors which affect the per unit area production like nutrition, cultivar, growing system and soil fertility, plant density has its significance [11]. Plant densities and arrangements in the open field strongly decide the utilization of intercepted solar radiation mainly due to leaf area index. It is therefore imperative to note that green pepper in Ghana is suited for most of the ecological zones with good climatic and edaphic parameters to support it growth in the open-field cultivations whereas greenhouse technologies enable the cultivation of a large number of species in a specific geographic area. In a controlled environment, climatic conditions are optimal for certain species, regardless of the external environment [12]. Greenhouses increase crop yields by as much as four to ten times as plants grown under open field conditions; the quality of the product is normally higher than open field and the dependency on chemicals is drastically reduced. The main reasons for increased yields lie in the nature of the growing environment as well as the genetics of some greenhouse varieties. Cultivation in the open field also tend to be much easier and less costly hence production of fresh vegetables by numerous people in this system of production. In Israel, for instance, research is usually carried out in

***Corresponding author:** Martey A, Crop Science Department, Forest and Horticultural Crops Research Centre (FOHCREC), Okumaning-Kade in the Eastern Region, University of Ghana, Ghana, Tel: +233 30 250 0381; E-mail: marteyabraham48@yahoo.com

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fully climate controlled greenhouse (http://www.arc-avrdc.org/pdf_files/Some(17-N).pdf Greenhouses have been utilized in Europe, U.S.A, Canada and several other countries for many decades for improved yields [13] and this can also be incorporated into our environment. In agriculture, quality determination of produce is based on a multitude of features [14]: flavour (sweetness, acidity); appearance (colour, size, shape, blemishes, glossiness); and texture (firmness, mouth feel). These features may be influenced by the system of production since crops are exposed to varied external environmental conditions. There are many vegetable crops including pepper that are adapted in all parts of West Africa of which Ghana is no exception. Pepper in Ghana, for instance, is grown in all the ecological zones of the country; coastal savanna, rain forest up to the guinea savanna zones in the open field and green house technology is only applicable in the research stations and the few well established farms have adopted for production of various vegetables. For each of these systems of production there are little or no records to ascertain the growth, yield and preference or the choice acceptable by the consumer. There are climatic conditions such as prevailing high and low temperatures, energy, high or low rainfall, waterlogging, higher relative humidity and strong winds that are limiting factors for growing sweet pepper under open field. In the green house when the growth parameters are not properly regulated and these may affect the quality of fruit produced which intends to affect consumer demands and acceptance. The fruit set of pepper is greatly influenced by humidity and temperature. Low humidity and high temperatures results in poor fruit set due to dropping of flower buds, flowers and small fruits caused by their abscission because of their excessive transpiration, also night temperatures below 15.6°C and above 32.2°C prevent fruit set [9]. According to Sinnadurai [3], sweet pepper requires milder climate for good production unlike hot pepper that requires high temperatures and very hot weather decreases flower initiation and this affects the fruit yield. Flower production is significantly increased when the night temperatures during the growing season is between 12-21°C and fruits also develops sun scalds when grown in the dry season in the open field.

Adopting ways of increasing production of green pepper has brought to the light the use of controlled environment (green houses, poly houses etc.). The greenhouse systems are important since they can be used all year round to increased yield even in the lean seasons. Nevertheless, export and local market both demand high quality sorted fruits and vegetables, which preserve their fresh condition on the market. Additionally, there is an increased demand for fruits and vegetables that are beneficial for healthy life style as well as rich in ingredients that positively influence the prevention of any health malfunction.

Since most of the agricultural products changes of inner content and outer properties after harvesting, therefore, it is crucial to determine the optimal production system that may enhance quality and acceptability of fruit by consumers or end users. To make pepper cultivation successful and accepted by consumer's different systems of production must be tested. Chandra et al., [15] and Singh et al., [16,17] indicated that polyhouses, poly-tunnels and plastic-mulching are most suitable solutions for yield increase of sweet pepper. Protected structures act as physical barrier and play a key role in integrated pest management by preventing spreading of insects, pests and viruses causing severe damage to the crop [18].

It is therefore imperative to note that about 95% of plants, either food crops or cash crops are grown in open field. Since time immemorial, man has learnt how to grow plants under natural environmental conditions. In some of the regions where the climatic conditions are extremely adverse and no crops can be grown, greenhouse technology is the technique of providing favourable environment condition to the plants; it is rather used to protect the plants from the adverse climatic conditions such as wind, cold, precipitation, excessive radiation, extreme temperature, insects and diseases. According to Wiltshire [13], greenhouses increase crop yields by as much as 4 to 10 times compared with plants grown under open field conditions. The quality of the produce from greenhouse is normally higher than open field and the dependency on chemicals is drastically reduced and this is brought about by the nature of the growing environment as well as the genetics or the type of varieties cultivated. Yield of crops may differ from the cultivar or variety used.

Therefore, it is imperative to note that, very limited information is available for growing sweet pepper through protected technology or green house and on the open field in Ghana; hence the study was conducted to make information available on the former and latter production systems as well as their acceptance by consumers. The objectives of the study was to determine consumer acceptance of sweet pepper grown under greenhouse and open field conditions and to also determine optimum growth and yield of sweet pepper as influenced greenhouse and open field production system.

Materials and Methods

The experiment was conducted during the minor cropping season of 2015 on the University of Ghana Forest and Horticultural Crops Research Centre (FOHCREC) at Kade in the Eastern Region of Ghana. It is located in the semi deciduous forest agro-ecological zone of Ghana in the Kwaebibrim District. Kwaebibirim is noted for bimodal rainfall pattern with two peaks that is major and minor rainfall. The trial was conducted in the greenhouse and open field simultaneously; therefore, this experiment was conducted in the minor season, from October, 2014 to March, 2015. A 2 × 9 factorial experiment was laid out in Randomized Complete Block Design with 18 treatments in three (3) replications. The two factors involved in the trial included, two (2) production systems; open field and green house production systems and nine (9) varieties of sweet pepper (California Wonder, Yolo wonder, Guardian pepper, Embella 733, F1 Nobili, Pepper 1, Caribbean red, Kulkukan and Crusader).

The seedlings were raised at the green house. The seeds were sown in seed trays (seed per cell) of 120 cells per seed tray. The seed trays were filled with carbonated rice husk (Biochar). A 1919-19 N-P-K foliar fertilizer was applied 2 weeks after germination at the rate of 10 g per 1litre of water to seedlings to boost growth. Seedlings were transplanted at 6 weeks after sowing, at 5-6 true leaf stage; transplants were dipped into starter solution to facilitate root formation and early establishment. Seedlings were transplanted out simultaneously on the open field and the green house on 26th December, 2015 at planting distance of 30cm within rows and 40 cm between rows per bed. Distance between beds was 1 m. Plants were irrigated in the greenhouse using the loop system which is part of the environdome greenhouse setup. In the open field system, supplementary hand watering (1 liter per plant) was applied fortnightly to maintain moisture throughout the growth period.

Data were collected on the following parameters: growth parameters, yield parameters and acceptability test; plant height, stem diameter, number of leaves per plant, days to 50% flowering, biomass dry weight, Number of fruits per plants, Fruit Yield (t/ha), Fruit Length, Fruit Width, Pericarp thickness, Number of Locules, Seed number, and Consumer Acceptability test of sweet pepper based on the following rankings from 1-9 on Texture, Absence of defects, brightness, size and glossiness as stated by Aoun et al., [19]. Acceptability Chart; 1=very poor quality, 2=Poor quality, 3=Moderate quality, 4=Moderate to strong quality, 5=Strong quality, 6=Strong to very strong quality, 7=Very strong quality, 8=Very strong to extremely strong quality and 9=Extreme excellent quality. The data obtained were subjected to analysis of variance i.e. ANOVA by using Genstat Discovery. Means were separated using Least Significant Difference (LSD) at 5%. Further analysis was done using correlation analysis and simple linear regression analysis.

Results and Discussion

All growth parameters, yield parameters and acceptability test differed significantly due to the different varieties tested under different locations as shown by the analysis of variance. All parameters showed significant results except number of locules per fruits.

Plant height (cm)

There was a significant increase in plant height at both locations. In the greenhouse at 6 WAT, Kukulkan had the highest height (93.7) followed by Caribean Red (65.7) with Embella 733 recording the shortest height and in the open field but at 6 WAT Kukulkan recorded the highest height (43.9) and Crusader also followed with 38.9 whereas Pepper 1 (26.7) had shortest height (Table 1). Plant height helps it in light attraction in that the taller the plant, the easier it attracts light. Ogbodo [20] who revealed that tall plant have easy access to intercept light for photosynthesis.

Stem diameter (cm)

Significance differences were observed in terms of stem diameter in both greenhouse and open field at 6 WAT among varieties. In the greenhouse Kukulkan had the thickest stem diameter (1) followed by Crusader (0.94) and Yolo wonder (0.76) the thinnest stem diameter. On the other hand, Kukulkan (0.89) recorded thickest stem diameter in the open field followed by Guardian pepper (0.86) with Pepper 1(0.79) recorded the thinness stem diameter (Table 1). There were no interaction among varieties and locations.

Number of leaves per plant

Significant differences were observed among the number of leaves both in the greenhouse and the open field. At 6 WAT, Kukulkan had the highest number of leaves (94.0) per plant followed by Caribbean Red (62.0). Embella 733 and F1 Nobili had the lowest number of leaves (33.0 and 30.0) respectively in the greenhouse. In the of open field, at 6 WAT highly significant difference was observed among treatment with both Kukulkan and Crusader recording the highest number of leaves (39.0) followed by Embella 733 (34.0) and Caribbean Red (33.0). California Wonder had the lowest leaves number (29.0) (Table 1). There was interaction between production system and varieties. The probable tallness of plant height, stem thickness and improved number of leaves of sweet pepper grown in the greenhouse compared to the open field may be attributed favorable environmental conditions as Heurn, indicated that crops inside greenhouse are better protected from outside influences with adequate water. It was also found that, in many parts of the world, insect nets or screens are commonly used in crop production for reducing excessive solar radiation, weather effects on produce, or to keep away insects (http://www.aces.edu/go/87). Medany et al., [21] reported increased in Leaf area in sweet pepper.

Sweet pepper biomass dry weight (g)

In the greenhouse at the vegetative growth stage (i.e. 4 WAT), the highest dry biomass weight was Kukulkan (5.3), Crusader (3.4) and California Wonder (3.0). Both Caribbean Red and Embella had the same biomass weight (2.8). P1 (2.4), Yolo Wonder (2.5) and Guardian pepper (2.6) recorded the lowest dry biomass weight. Whereas, in the open field the highest biomass weight was Kukulkan (3.9), Crusader (3.2) Guardian pepper (3.1) with the lowest biomass recorded in Caribbean Red (1.9), Embella 733 (2.1), and Yolo Wonder (2.1). There was significant interaction among the system of production and varieties at both vegetative and reproductive stages. at the reproductive growth stage (i.e. 6 WAT), the California Wonder (8.9) Kukulkan (8.6) and Embella 733 (8.5) recorded the highest biomass weight followed by Caribbean Red (7.5) and F1 Nobili (7.4). The lowest dry biomass weight was found in Crusader (5.5) and Guardian pepper (6.9). While, in the open field, Kukulkan (9.3) and F1 Nobili (7.1) had the highest dry biomass weight followed by Crusader (5.8), Pepper 1 (5.7) and Caribbean Red (5.6) while Embella 733 (5.3) recorded the lowest biomass weight (Table 1). Significant difference ware observed among the production systems as the greenhouse had highest biomass weight compared to the open field at both growth stages.

Variety	PH (6 WAT) (cm)		Plant girth (6 WAT) (cm)		Number of leaves (6 WAT)		Biomass dry weight/ plant (g)		Days to 50% flowering		Number of fruits/ plant		Yield (t/ ha)	
	Open Field	Green house	Open Field	Green house	Open Field	Green house	Open Field	Green house	Open Field	Green house	Open Field	Green house	Open Field	Green house
Caribbean R.	33.5	65.70	0.81	0.78	33.00	52.00	1.90	2.80	37.00	35.00	27.00	40.00	5.76	14.79
Crusader	38.9	59.80	0.85	0.94	33.90	43.00	3.20	3.40	27.00	23.00	11.00	12.00	10.56	17.29
California	29.70	53.50	0.88	0.79	29.00	41.00	2.70	3.00	28.00	22.00	9.00	13.00	12.57	20.99
Embella	27.00	42.10	0.85	0.79	34.00	33.00	2.10	2.80	27.00	23.00	9.00	13.00	7.05	13.76
F1 Nobili	33.60	43.30	0.84	0.79	28.00	30.00	2.50	2.90	29.00	22.00	8.00	13.00	6.31	9.23
Guardian	32.00	45.60	0.86	0.89	33.00	41.00	3.10	2.60	23.00	24.00	10.00	10.00	9.18	11.14
Kukulkan	43.90	93.70	0.89	1.00	39.00	94.00	3.90	5.30	34.00	32.00	30.00	33.00	9.22	21.34
Pepper I	26.70	44.50	0.79	0.83	30.00	41.00	2.30	2.40	29.00	22.00	7.00	12.00	5.02	14.82
Yolo W	28.50	43.40	0.80	0.76	29.00	37.00	2.10	2.30	26.00	25.00	9.00	10.00	7.53	8.20
LSD(0.05)														
Var	7.2		0.10		9.5		0.4		1.6		7.6		2.29	
PS	3.3		0.04 NS		4.5		0.2		0.7		3.6		1.08	
Var × PS	9.9		0.14 NS		13.5		0.6		2.3		10.8NS		3.24	

Var - variety, PS – production System, Var × PS – variety * production system, NS – Not significant

Table 1: Performance of sweet pepper under greenhouse and open field.

Days to 50% flowering and number of fruits per plant

Significant differences were observed among treatment both in the greenhouse and open field. In the greenhouse, California Wonder, Pepper 1, F1 Nobili (22) was significantly influenced by flowering. Caribbean Red and Kukulkan (32 and 35) were found to be late flowering varieties compared to the open field varieties, where significant difference were also observed and Guardian (23) and Yolo Wonder (26) were found to flower early followed by Crusader (27) and Embella 733 (27). Caribbean Red (37) and Kukulkan (34) showed late flowers (Table 1). Significant interaction existed between production system and the varieties. i.e. the greenhouse showed earlier flowers than the open field.

Number of fruits per plants

Number of fruits per plants was significantly affected all the treatments both in greenhouse and the open field. Fruit number per plant differed significantly in the greenhouse among the varieties. Caribbean Red (40) and Kukulkan (33) had the highest number of fruits per plants. California Wonder, Embella 733, and F1 Nobili each had 13 fruits per plant. Yolo Wonder and Guardian had the lowest number of fruits per plants while Fruit number per plant differed significantly in the open field where, Kukulkan (30.0) and Caribbean Red (27.0) had the highest number of fruits per plants followed by Crusader (11.0) and Guardian pepper (10.0). California Wonder, Embella 733 and Yolo Wonder (9.0) each had equal number of fruits per plants. P1 (7.0) and FN (8.0) also had lowest number of fruits per plants (Table 1). There was significant difference observed between production systems that showed that greenhouse recorded higher fruit number compared to the open field. There was no significant interaction between the variety and the location. Kanwar et al., [22] found higher number of fruits per plant in bell pepper under greenhouse growing condition.

Fruit yield (t/ha)

The highest fruit yield (t/ha) was significantly obtained by Kukulkan (21.34) followed California Wonder (20.99) and Crusader (17.29) which was superior in its effect in the greenhouse. Caribbean Red (14.79), Embella 733 (13.76) and Guardian (11.4) also differed significantly with Yolo Wonder (8.20) and F1 Nobili (9.23) attained the lowest fruit yield in the greenhouse compared to the open field where significant difference observed revealed that California Wonder (12.57) recorded the highest yield followed by Crusader (10.57) and Kukulkan (9.22). Low fruit yield recorded in the open field was observed in Pepper 1 (5.02) and Caribbean Red (5.76) respectively. The greenhouse recorded the highest fruit weight compared to the open field. There was significant interaction found between production system and the varieties tested (Table 1). The greenhouse, however, had significant results among all the varieties studied as this was in confirmation with Kurubetta and Patil [23] reported that sweet pepper hybrids under different protected cultivation recorded significant results among all the tested hybrids. There was also a high yield difference between the greenhouse varieties and the open field varieties ranging from 50%-150% respectively and this may be due to the favourable environmental condition as Zakaria [24], revealed that the fully controlled greenhouse increased the fresh yield of sweet pepper by 176.8% and 228.5% as compared to partially controlled environment. Chandra et al., [15] Singh et al., [16,17] indicated that polyhouses and poly-tunnels are most suitable solutions for yield increase of sweet pepper since the crops are being protected. Brar et al., [25] reported highest yield in *Capsicum var*. bombay under polyhouse condition.

Fruit length (cm)

In the greenhouse, however, California Wonder (8.75) and Crusader (7.11) had the longest fruit length followed by F1 Nobili (6.91), The shortest fruit length therefore was Caribbean Red (3.23) compared to open field significance difference was observed among the treatments. California Wonder (6.51) and Crusader (6.19) as well recorded the longest fruit length followed by Pepper 1 (5.63), Embella 733 (5.61), F1 Nobili (5.49) and Yolo Wonder (5.37). But Caribbean Red (3.00) and Kukulkan (3.39) had the shortest fruit length (Table 2). No significant interaction found among treatments. Khokhar et al., [26] reported significant difference in fruit size both length and width in different tomato hybrids under study.

Fruit width (cm)

In the greenhouse the width significantly increased with Pepper 1 (6.34), Yolo Wonder (6.08) and Crusader (6.05) recording the longest fruit width followed by Guardian (5.66), EM (5.48), FN (5.42) and California Wonder (5.36) while the shortest fruit width was observed in Caribbean Red (2.57) and Kukulkan (2.86) compared to the open field, significant difference were observed on all the varieties with Pepper 1 (5.54), Yolo Wonder (5.26) and California Wonder (5.24) had the longest fruit width followed by Crusader (5.18), F1 Nobili (5.14), Guardian (5.08) and Embella 733 whereas Caribbean Red (2.57) and Kukulkan (2.86) had the lowest width (Table 2). Significant difference was observed among the productions system, that is, both in the greenhouse and the open field. The greenhouse had longest fruits width compared to the open field. No significant interaction found among treatments. Singh et al., [27], stated that hybrid Tanvi produced maximum fruit diameter, no. of fruits/plant, individual fruit weight and yield in protected cultivation.

Pericarp thickness (mm)

Highly significance difference was observed among the treatments which influenced pericarp thickness both in the greenhouse and the open field. Also the interaction effects highly significantly affected the pericarp of the fruit. In the greenhouse pericarp thickness differed significantly of which Guardian (4.0), Crusader (4.0), California Wonder (4.0), Embella 733 (4.0) had the thickest pericarp thickness followed by P1 (3.5) and the thinnest pericarp thickness was observed in Caribbean Red and Kukulkan both had equal pericarp thickness whereas in the open field, significant difference was observed among treatments. GD (4.2), Yolo Wonder (4.0) recorded the largest pericarp thickness. Significant difference also existed among Embella 733 (3.5), F1 Nobili (3.4), and Crusader (3.3) and California Wonder and Pepper 1 (3.0). Both Kulkukan and Caribbean Red (2.0) respectively had the thinnest pericarp thickness (Table 2). There was significant interaction found between production system and the varieties. Chaudhry et al., [28] also found variation in pericarp thickness in tomato studies. Seed number per fruits differed significantly among all the varieties used in this study.

Number of locules per fruits

There was no significant difference observed among treatments. No significant interaction among varieties and production system (Table 2). Muhammad [29], confirmed that non-significant result recorded in case of number of locules at 0.05% level of significance but the results are contrary to the findings of Khokhar et al., [25].

Seed number per fruits

Seed number per fruits differed significantly among all the varieties used in this study. In the greenhouse, Embella 733 (193), F1 Nobili (164) Crusader (124) gained the highest seed number. Yolo Wonder (99), Pepper 1 (76) and Caribbean Red (70) also varied significantly whereas California Wonder (45) had the lowest seed number per fruits whereas, in the open field, highly significant difference was observed among the treatments. The highest seed number was observed in Embella 733 (228) and F1 Nobili (161). Significant difference was also seen among Guardian (142), Crusader (119), Yolo Wonder (99), Caribbean Red (70) and Pepper 1 (76) with the least seed number observed in California Wonder (45) (Table 2). Significant difference was observed among the productions system both in the greenhouse and the open field. The greenhouse varieties had the lowest seed number per fruits compared to the open field which recorded the maximum seed number per fruits. There was significant interaction found between production system and the varieties. Baer and Smeets [30] and Bakker [31] found no correlation between seed number and fruit size in sweet pepper which confirms this research that there is no correlation between seed number and fruit yield. Marcelis and Baan [32] who reported that under normal growing conditions the amount of seed per fruit is highly variable.

Acceptability of fruits

Size of fruit; Significant differences were observed among the acceptance level of fruits based on fruit size of which California Wonder and Crusader were highly accepted (8=Very strong to extremely strong quality) for the greenhouse varieties but the same varieties were accepted at the rank of 5 (Strong quality) and 6 (Strong to very strong quality) in the open field respectively (Figure 1). Consumers accepted these sweet pepper fruits more the greenhouse because of its size (bigger), high quality and more appealing nature. Brightness of fruit; Significant differences were observed among the acceptance level of fruits based on fruit brightness of which California was highly accepted (8=Very strong to extremely strong quality) for the greenhouse varieties and same varieties were accepted at the rank of 4 (Strong quality) in the open field varieties (Figure 2). Consumers accepted these sweet pepper fruits more from the greenhouse because of its more appealing nature.

Variety	Fruit length (cm)		Fruit diameter (cm)		Pericarp thickness (mm)		Number of Locules per fruit	
	Open Field	Green house	Open Field	Green house	Open Field	Green house	Open Field	Green house
Caribbean R.	3	3.23	2.57	2.8	2	2	3	3
Crusader	6.19	7.11	5.18	6.05	3.3	4	3	3
California	6.51	8.75	5.24	5.36	3	4	2	2
Embella	5.38	6.75	5	5.48	3.5	4	4	4
F1 Nobili	5.49	6.91	5.14	5.42	3.4	4	4	4
Guardian	5.43	6.65	5.08	5.66	4.2	4	3	3
Kukulkan	3.39	3.83	2.86	3.22	2	2	4	4
Pepper I	5.63	6.67	5.54	6.34	3	3.5	3	3
Yolo W	5.37	6.42	5.26	6.08	4	4	3	4
LSD(0.05)								
Var	0.98		0.34		0.15		0.0 NS	
PS	0.46		0.16		0.7		0.0 NS	
Var × PS	1.9NS		0.49NS		0.22		0.0 NS	

Var - variety, PS – production System, var *PS – variety * production system, NS – Not significant

Table 2: Performance of sweet pepper under greenhouse and open field.

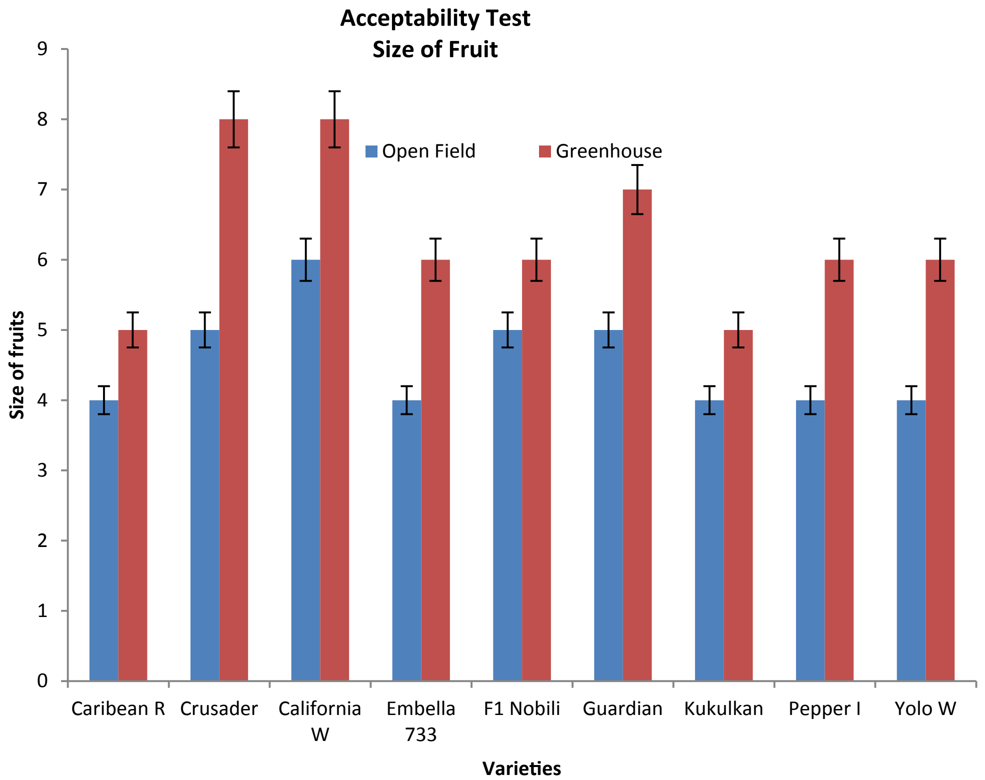

Figure 1: Consumer acceptance of sweet pepper varieties based on fruit size, the results were an average of 2 levels of production systems and 9 sweet pepper varieties.

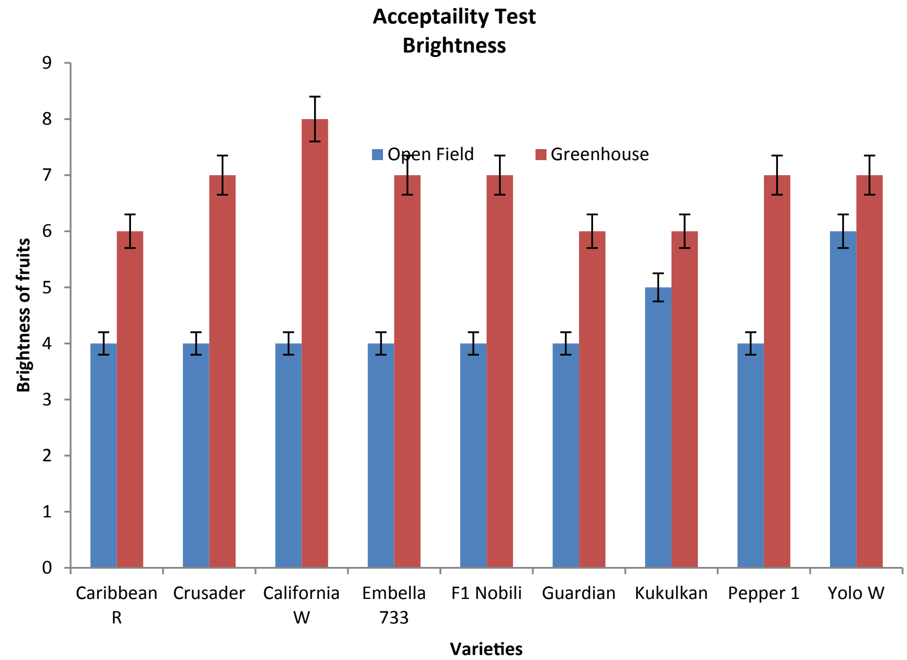

Figure 2: Consumer acceptance of sweet pepper varieties based on brightness of fruits, the results were an average of 2 levels of production systems and 9 sweet pepper varieties.

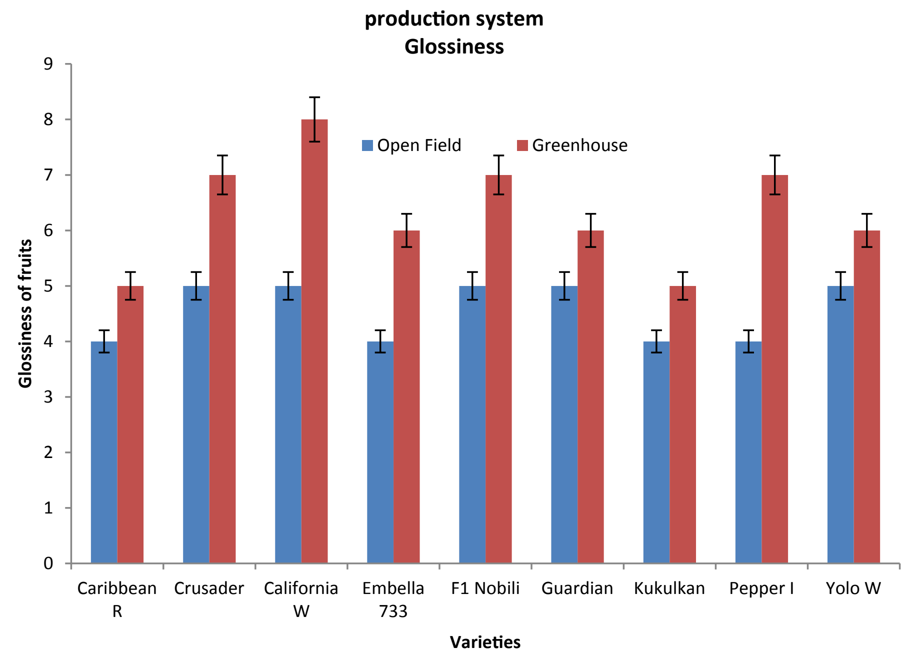

Figure 3: Consumer acceptance of sweet pepper varieties based on glossiness of fruits, the results were an average of 2 levels of production systems and 9 sweet pepper varieties.

Glossiness of fruit; Significant difference were also observed among the acceptance level of fruits based on fruit glossiness of which California Wonder and Crusader were highly accepted on the scale of (8 = Very strong to extremely strong quality) for the greenhouse varieties but same varieties were accepted at different rank of 5 (Strong quality) and 6 (Strong to very strong quality) respectively. Consumers accepted these sweet pepper fruits more especially the greenhouse because of its smooth surface and more appealing nature. Caribbean Red and Kukulkan (Rank 4 and 5) significantly recorded the lowest acceptance level both in greenhouse and open field at the rank of 5 and 4 (Moderate to strong quality and Moderate quality). (Figure 3) The current results revealed that greenhouse specifically improved the physical appearance of the fruits in relation to the open field treatments. In general it was therefore found in the consumer acceptability was based on physical appearance characteristics such as colour, size, shape, lack of blemishes, and glossiness are the main indices of consumers demand for particular products.

Jovicich et al., [33] also reported similar research findings in Florida that an averaged year-round wholesale fruit prices went up three 3 times greater than colored field-grown fruits and 5 times greater than field-grown green fruits. There is a report that greenhouse-grown colored bell peppers in Mexico established 60% premium over field bell peppers from Mexico [34]. Jovicich et al. [35] found that greenhouse production is a profitable venture which is in conformity with this research.

Relationship between fruit yield and fruit length

The relationship between Fruit yield and Fruit length shows that Y=fruit yield kg/ha and x=fruit length (cm). The equations indicate that yield response to production system is almost linear. There was a highly significant negative relationship between fruit yield (tons/ha) and fruit length of sweet (Figure 4).

Relationship between fruit yield and fruit length

Fruit width of 3-4 cm were found to be the upper limit for higher fruit yield for sweet pepper grown in protected cultivation during the experimental period (November-March). Moreso, the maximum fruit width that enhanced fruit yield in the open field was found to be around 2 cm.

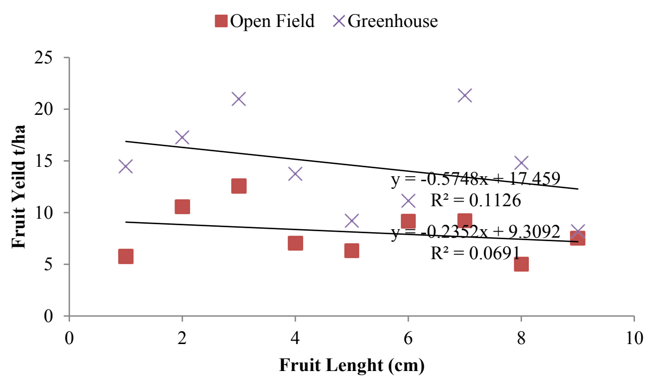

Figure 4: Linear relationship between Fruit yield (t/ha) and Fruit Length averaged over 2 levels of Production system.

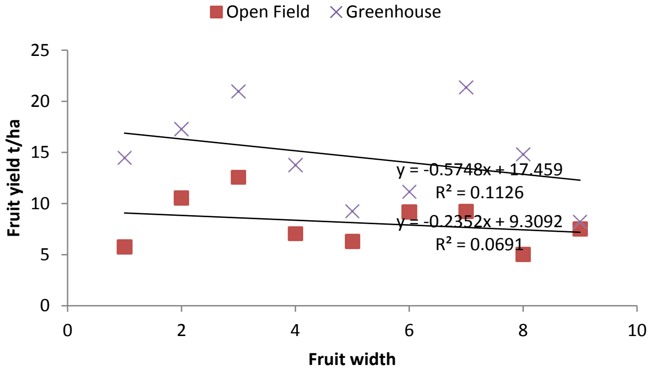

Figure 5: Linear relationship between Fruit yield (t/ha) and Fruit Width averaged over 2 levels of Production system.

Also, a negative significant relationship between fruit yield (tons/ha) and fruit width (cm) which showed width was significant yield component for measuring of sweet pepper yield (Figure 5).

Conclusion

It is therefore concluded that, significant difference were observed both in the greenhouse and the open field. In the greenhouse Kukulkan recorded the highest yield (t/ha) followed by California Wonder and Yolo Wonder had the least whereas the open field shown that the yield of California Wonder gained the highest, followed by Crusader and pepper 1 had the least weight.

Also, consumers demand for greenhouse sweet pepper is very high since large, high quality fresh pepper is produced and readily available all year round.

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