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Variability and Association Studies on Yield and Yield Characters in Aromatic Nsukka Yellow Pepper (*Capsicum annuum* L.)

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ABSTRACT

Two field evaluations were conducted at the Teaching and Research Farm of the Department of Crop Science, University of Nigeria, Nsukka, during the 2009 and 2010 cropping seasons to determine the pattern of genetic variability and character association in Nsukka yellow pepper (*Capsicum annuum* L.). A population of Nsukka yellow pepper was assembled from the farmers and sorted into 18 families which were evaluated in 2009 season in progeny rows. Forty nine promising genotypes selected from 2009 study formed the experimental materials evaluated in 2010 season for seven metric characters namely, fruit length, fruit girth, number of fruits per plant, single fruit weight, plant height, number of leaves per plant, and fruit yield per plant. The descriptive analysis revealed a considerable variability in the population that could warrant initiating a selection programme for its improvement. The simple correlation analysis showed that number of fruits per plant correlated significantly (P = 0.01) with fruit yield, while the association of fruit yield and other traits were positive but non-significant in 2009. In 2010, correlation analysis showed that number of leaves per plant (0.405**), fruit girth (0.477**), single fruit weight (0.683**) and number of fruits per plant (0.745**) were highly correlated with fruit yield, while plant height (0.129) and fruit girth (0.08) had positive but non-significant correlation with fruit yield. This result implied that selection of breeding lines based on number of fruits per plant, single fruit weight, fruit length, number of leaves per plant would significantly increase yield. The results of the path coefficient analyses implicated the number of fruits per plant for exerting the highest direct effects on fruit yield, followed by single fruit weight in both years. Thus, number of fruits per plant and single fruit weight could serve as criteria for selection of yield improvement in *Capsicum* species.

Keywords: correlation, fruit yield, gene introgression, path analysis, traits

INTRODUCTION

In the present study, the researchers are concerned with assessing the level of variability inherent in populations of Nsukka yellow pepper for 2009 and 2010 cropping seasons. This study also investigated the intensity of the association among the yield and yield components and estimated the direct and indirect effects of the traits on yield.

Nigeria is one of the important countries in the world for pepper genetic resources and the large numbers of aboriginal varieties grown across the country provides an important source of variation for the poor-resource farmers in tropical West Africa. The Nsukka yellow pepper (*Capsicum annuum* L.) is one of the pepper landraces popularly cultivated in the Southeast agro-ecological zone which has been known for its characteristic aroma and distinctive yellow colour. These two classic horticultural attributes constitute the selling points of the pepper and have endeared the crop to both urban and rural dwellers. Today, Nsukka yellow pepper has gained a premium status in the Nigerian markets as a vegetable of high importance and a major source of income to rural women in the Southeast agro-ecological zone, especially in Nsukka where its production is highly restricted (Ajayi and Eneje 1998; Onwubuya *et al*. 2009).

Previous investigators have shown that a tremendous variability exists in pepper germplasm (Abu and Uguru 2006; Adetula and Olakojo 2006, Idowu-agida 2009) that can be exploited for its improvement. According to Allard (1960), pepper is a self-pollinating species. However, the fairly high rate of mutation and out-crossings events in *Capsicum* species is believed to be responsible for the high variability observed in the population (Grubben and El-Tahir 2004; Bozokalfa *et al.* 2009). This tends to amplify the potentials of such variability in crop improvement programmes, in relation to fruit yield which is the primary consideration of most breeding programmes.

To undertake a planned breeding study that targets fruit yield improvement, the plant breeder must possess adequate knowledge of the level of variability in the population, the degree of character association and the relative importance of the yield components so that selection of candidates can be made with ease. This is extremely important because yield as a complex trait is associated with a number of components and any changes that is envisaged must be accompanied by changes in one or more characters that are positively correlated (Griffing 1956).

Correlation measures the intensity of the association between two traits and allows the selection of traits that are efficient in a breeding programme. Several simple correlation studies have been reported in pepper (Todorova *et al*. 2003; Abu and Uguru 2006), but correlation coefficients alone may not reveal the relative importance of the causal factors in relation to the dependent variable (fruit yield) since it merely measures the mutual association between two variables without regard to causation. Thus, knowledge of the direct and indirect effects of traits on yield as revealed by path coefficient analysis (Dewey and Lu 1959) could help the plant breeder to develop selection schemes that will emphasis those traits that have positive effects on yield and tremendously improve the efficiency of selection. The apparent dearth of information in these respects further

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Table 1 Monthly mean temperature, rainfall and relative humidity during the experimental period at Nsukka for 2009 and 2010 seasons.

Weather record	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.
2009									
Total rainfall (mm)	180.60	283.69	152.51	248.17	260.33	175.76	387.10	103.18	0.00
Min. temp (°C)	21.60	21.42	20.83	20.58	20.84	20.10	20.26	19.30	18.84
Max. temp (°C)	31.37	30.23	29.13	28.65	27.48	27.89	28.39	29.85	32.71
Relative humidity (%)	71.20	72.24	73.67	74.71	75.00	74.59	74.84	62.77	57.02
2010									
Total rainfall (mm)	161.80	212.34	247.39	158.48	404.15	203.95	183.63	193.31	0.00
Min. temp (°C)	23.07	22.23	21.47	21.0	21.16	20.73	20.84	21.23	18.32
Max. temp (°C)	32.83	30.39	29.13	27.94	27.55	28.13	28.97	30.03	32.10
Relative humidity (%)	68.49	71.15	73.34	73.91	74.94	74.47	72.23	68.87	54.70

Source: Meteorological Unit, University of Nigeria Nsukka, Nigeria.

makes selection studies not only cumbersome but largely ineffective particularly in aboriginal varieties such as Nsukka yellow pepper where out-crossing rates are quite alarming (Grubben and El-Tahir 2004; Bozokalfa *et al.* 2009). Hence, the present work was designed to study the extent of variability and the nature of association among the traits of Nsukka yellow pepper genotypes as a prelude to the commencement of an improvement programme for this high valued crop.

MATERIALS AND METHODS

A population of Nsukka yellow pepper was assembled from the growers in Nsukka and sorted into 18 families based on fruit characteristics for evaluation in 2009 planting season. Based on individual plant performance, 49 genotypes were selected and re-evaluated in 2010 to determine the extent of variability in the population, the nature of association existing between the fruit yield and yield components and the relative importance of the traits. This study was conducted at the teaching and research farm of the University of Nigeria, Nsukka (Latitude 06° 52′ N, Longitude 07° 24′ E and altitude of 447.2 m above sea level).

Land preparation involved manual clearing of a piece of land that was previously under fallow. Ridges measuring 18 × 20 m (progeny rows) were raised and organic manure was applied by broadcast at the rate of 20 tonnes/ha. Five-weeks old seedlings were transplanted on the progeny rows and the distance between plant to plant was maintained at 0.45 m, with each row comprising 40 plants. Weed control was also done manually to maintain farm sanitation. Selection of genotypes with promising attributes was done on individual plant basis and with consideration to the expression of genetic potentials. Data were taken on all the plants in each progeny row which included, plant height (cm) and number of leaves per plant at 50% flowering, while number of fruits per plant, single fruit weight (g), fruit length (cm), fruit girth (cm), and fruit yield per plant (kg/ha) were collected at harvest and averaged over the number of plants in each row.

Data collected on these traits were analysed using descriptive statistics to determine the variability inherent in the population. The correlation analysis was carried out on the important growth and yield traits to investigate the relationship among the yield components using the SPSS for Windows Version 16 (SPSS, Int., Chicago, USA). The correlation coefficients were partitioned into direct and indirect effects using the Analysis of Moment of Structures for Windows Version 16 (AMOS, Development Corp., Spring House, USA) software programme.

RESULTS

The monthly meteorological data for the experimental period in 2009 and 2010 cropping seasons is presented in **Table 1**. The maximum and minimum temperatures were 32.71^{0}C and 32.83°C and 18.84°C and 18.32°C for 2009 and 2010 seasons, respectively. The distribution of rainfall was highly variable with the highest amount in 2009 being recorded in October (387.10 mm) and highest relative humidity of 75%. While in 2010, the highest amount of rainfall was observed for August (404.15 mm), and a steady decrease till December when no further rain was recorded.

Table 2 Performance of Nsukka yellow pepper genotypes with respect to some yield traits evaluated in 2009 planting season.

Genotype	PHT	NOL	FL	FG	SFW	NF	FYD
Ny-01	24.58	64.58	4.96	7.08	4.74	26.08	5986.07
Ny-02	23.33	56.90	4.64	6.83	4.15	34.14	6374.03
Ny-03	24.07	63.45	5.23	7.34	5.08	22.86	5262.14
Ny-04	21.69	50.19	5.03	7.04	5.23	40.74	9652.81
Ny-05	22.74	60.14	4.96	7.20	5.55	30.21	7693.45
Ny-06	24.55	57.41	5.00	7.11	5.22	35.88	8612.92
Ny-07	22.15	47.45	4.77	7.19	4.75	39.95	8458.71
Ny-08	21.42	49.50	5.32	7.46	5.23	44.92	10836.69
Ny-09	22.74	47.57	4.81	6.49	4.92	23.24	5138.15
Ny-10	21.18	49.37	4.89	6.89	5.03	27.26	6088.28
Ny-11	26.04	62.84	4.95	6.95	5.81	25.59	6648.67
Ny-12	22.01	54.65	4.87	6.86	4.73	25.19	5287.47
Ny-13	22.07	44.21	5.07	6.74	5.09	23.79	5145.26
Ny-14	20.76	40.56	4.93	7.03	5.28	26.33	6336.26
Ny-15	28.22	68.15	5.09	7.63	5.36	46.33	11328.2
Ny-16	24.65	59.00	4.90	7.99	5.62	28.0	7007.74
Ny-17	20.22	41.44	5.03	7.58	4.91	21.38	4529.77
Ny-18	23.05	54.00	4.78	6.49	3.77	27.36	4857.29
Mean	23.08	53.97	4.96	7.11	5.03	30.51	6958.00
CV (%)	8.67	15.16	3.23	5.49	9.74	25.76	29.58

PHT = plant height (cm), FL = fruit length (cm), FG = fruit girth (cm), SFW = single fruit weight (g), NOF = number of fruits/plant, FYD = fruit yield/plant (kg/ha).

Assessment of variability among the genotypes during 2009 and 2010 seasons

Considerable wide range of variation was observed for most of the traits measured across the years (**Table 2**). For instance, the coefficients of variation were reasonably higher for number of leaves per plant (15.16%), number of fruits per plant (25.76%) and fruit yield per plant (29.58%), with the least coefficient of variation obtained for fruit length (3.2%) and fruit girth (5.49%). Ny-15 (11328.20 kg/ha), gave the highest fruit yield, and was closely followed by Ny-08 (10836.69 kg/ha) and Ny-04 (9652.81 kg/ha) in that order. Ny-15 gave the highest number of fruits per plant (46.33), plant height (28.22 cm), and number of leaves per plant (68.15), whereas Ny-17 produced the least number of fruits per plant (21.38), least plant height (20.22 cm) and considerable low number of leaves per plant (41.44). Ny-17 (4529.77 kg/ha) and Ny-18 (4857.29 kg/ha) gave the lowest fruit yields. In 2010 evaluation, the genotypes Ny-08-2, Ny-07-2, Ny-06-2 and Ny-07-3 recorded the highest fruit yield of 20373.96, 14988.27 and 10946.91 kg/ha, respectively (**Table 3**). It is also observed that these genotypes gave higher values for most of the agronomic parameters studied. Higher coefficients of variation were noted for plant height (19.73%), number of leaves per plant (15.49%), single fruit weight (13.24%), number of fruits per plant (34.76) and fruit yield per plant (38.08%).

Correlation analysis

The results of the correlation analysis for 2009 and 2010 are presented in **Table 4**. The correlation study showed that

Table 3 Performance of Nsukka yellow pepper genotypes with respect to some yield traits evaluated in 2010 planting season.

Genotype	PHT	NOL	FL	FG	SFW	NF	FYD
Ny-08-1	21.86	50.03	5.25	8.15	4.88	44.18	5884.30
Ny-15-1	18.23	49.49	5.81	7.16	4.07	26.69	4737.75
Ny-10-1	33.31	65.07	5.04	7.85	4.02	32.95	5927.85
Ny-11-1	49.35	60.70	4.82	7.47	3.79	23.05	3866.28
Ny-12-1	22.23	45.27	4.85	7.09	3.99	20.95	3762.29
Ny-01-1	24.39	52.46	4.81	7.32	3.93	23.20	4087.59
Ny-14-1	24.10	52.86	4.86	7.89	4.42	40.14	3533.87
Ny-06-1	25.96	60.90	5.80	8.30	6.28	24.48	6717.99
Ny-18-1	23.50	45.14	4.90	7.74	4.56	30.29	5989.18
Ny-18-2	21.75	38.42	4.77	7.48	4.83	19.98	4188.03
Ny-15-2	24.25	58.25	4.81	7.57	4.51	29.40	5978.07
Ny-16-1	22.36	45.42	4.16	6.99	3.90	30.24	5241.25
Ny-05-1	19.81	47.58	4.48	6.87	3.65	25.08	4015.15
Ny-05-2	28.48	60.55	5.18	7.55	4.59	28.73	6038.51
Ny-17-1	20.92	45.72	4.39	7.56	3.81	23.81	4005.82
Ny-10-2	24.84	52.93	4.55	7.41	4.04	30.28	5632.88
Ny-04-1	19.45	49.39	4.85	7.89	3.59	26.65	4139.59
Ny-16-2	25.12	61.63	4.54	7.40	3.66	31.26	5146.60
Ny-03-1	23.15	40.42	4.27	6.72	3.53	29.36	4545.32
Ny-11-2	22.42	52.95	5.26	7.77	5.00	32.67	7369.04
Ny-16-3	22.24	43.17	4.52	7.52	4.24	29.95	5447.46
Ny-08-2	26.14	60.52	4.83	8.53	6.38	71.36	20373.96
Ny-17-2	19.93	42.12	5.16	7.95	4.66	28.40	5928.30
Ny-13-1	20.30	33.28	4.74	7.46	4.42	22.64	4391.56
Ny-15-3	23.80	58.36	5.43	7.50	4.97	46.55	6725.55
Ny-09-1	24.92	50.28	5.45	7.47	4.23	22.81	4144.92
Ny-01-2	26.21	54.92	4.77	7.80	4.69	23.39	4756.86
Ny-13-2	21.79	52.28	5.72	7.60	4.37	25.58	4965.73
Ny-02-1	24.65	56.08	5.09	7.71	4.79	27.92	5942.96
Ny-03-2	19.24	43.11	5.97	8.22	4.37	22.38	4323.57
Ny-12-2	22.09	47.40	5.39	7.65	4.08	26.40	4762.19
Ny-04-2	24.78	60.02	5.87	7.63	4.03	39.37	4131.14
Ny-12-3	27.63	41.44	5.56	7.77	3.94	44.79	4543.99
Ny-04-3	22.86	55.97	5.41	7.75	4.33	42.22	7877.88
Ny-07-1	22.57	42.27	4.76	7.52	3.81	35.57	6162.94
Ny-09-2	22.19	36.91	5.32	7.51	4.18	41.16	7439.26
Ny-07-2	27.96	60.56	5.57	8.10	5.45	59.87	14988.27
Ny-06-2	22.50	59.92	5.45	7.65	4.96	56.14	10946.91
Ny-18-3	25.90	55.77	5.66	7.65	4.37	52.00	7117.95
Ny-02-2	26.30	58.10	5.10	7.33	4.45	22.95	4426.22
Ny-06-3	20.34	42.2	5.48	7.44	4.39	23.55	4594.21
Ny-03-3	24.07	45.27	5.53	7.14	4.09	20.14	3649.41
Ny-11-3	21.78	40.20	5.42	7.36	4.59	26.85	5412.79
Ny-07-3	27.55	62.65	5.41	7.52	4.34	51.60	10103.88
Ny-05-3	21.07	43.87	5.44	7.43	4.54	48.87	5453.68
Ny-15-4	20.70	50.43	5.49	7.35	4.19	45.96	4895.51
Ny-14-2	19.81	50.10	5.08	7.51	3.93	44.33	4211.13
Ny-10-3	20.78	48.65	6.05	7.40	4.34	41.60	5331.91
Ny-13-3	21.52	46.38	6.14	7.63	4.40	43.10	4120.03
Mean	23.82	50.56	5.17	7.58	4.38	33.89	5725.26
CV%	19.73	15.49	9.28	4.49	13.24	34.76	38.08

PH = plant height (cm), NOL = number of leaves/plant, FL = fruit length (cm), FG = fruit girth (cm), SFW = single fruit weight (g), NF = number of fruits/plant, FYD = fruit yield/plant (kg/ha).

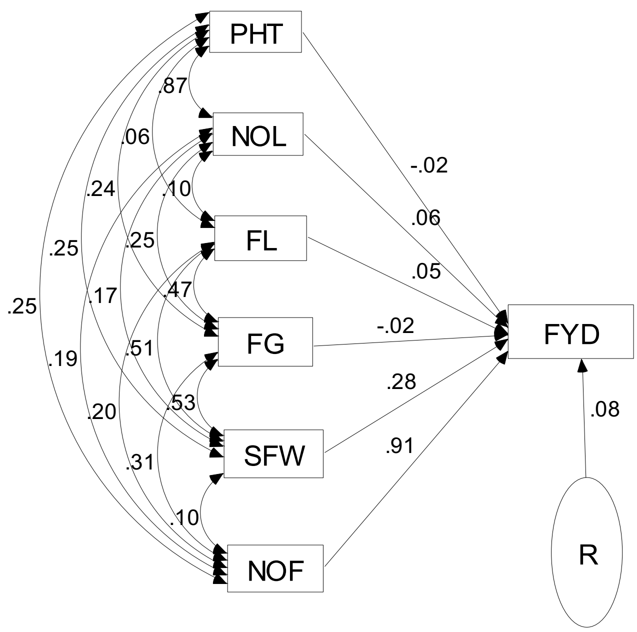

Fig. 1 Path diagram showing the direct and indirect effects of the yield contributing factors to total fruit yield of Nsukka yellow pepper (*Capsicum annuum* L.) in 2009 season.

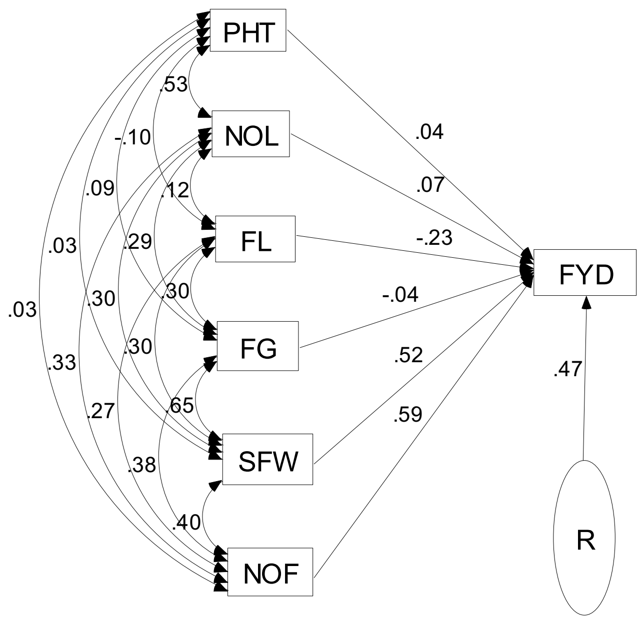

Fig. 2 Path diagram showing the direct and indirect effects of the yield contributing factors to total fruit yield of Nsukka yellow pepper (*Capsicum annuum* L.) in 2010 season.

number of fruits per plant had highly significant correlation (r = 0.948**) with fruit yield. The correlation between fruit girth, single fruit weight, fruit length and plant height with fruit yield were high but not significant. Highly significant (r = 0.868**) association was observed between plant height and number of leaves per plant, whereas the association of fruit length (r = 0.511*) and fruit girth (r = 0.530*) with single fruit weight was positive and significant, and between themselves (r = 0.471*).

In 2010 season, the correlation studies revealed that all except plant height and fruit length gave highly significant positive association with fruit yield per plant (**Table 4**). The highest correlation coefficient was observed between fruit yield and number of fruits per plant (r = 0.745**), and was followed by single fruit weight (r = 0.683**), fruit girth (r = 0.477**) and number of leaves per plant (r = 0.403**). Although plant height and fruit length both associated positively with fruit yield, such relationships were not significant. Significant positive correlation was also recorded when fruit length (r = 0.303*) and fruit girth (r = 0.646**) were correlated with single fruit weight and between themselves (r = 0.296*). Other highly significant correlations were found between plant height and number of leaves per plant (r = 0.533**) and between single fruit weight and number of fruits per plant (r = 0.400**), while the association between plant height and fruit length (r = -0.104) was negative but non-significant (**Table 4**).

Path coefficient analysis

The path analysis on the 2009 data revealed that, fruit number per plant (p = 0.91) and single fruit weight (p = 0.28) exerted maximum direct positive effects toward fruit yield (**Table 5**), while fruit girth and plant height (p = -0.02) each recorded negative direct effects on fruit yield. However,

Table 4 Correlation coefficients of some yield characters of Nsukka yellow pepper (*Capsicum annum* L.) evaluated in 2009 (upper) and 2010 (lower) seasons.

Character	1	2	3	4	5	6	7
PHT	1	0.868**	0.057	0.243	0.248	0.253	0.328
NOL	0.533**	1	0.099	0.253	0.166	0.188	0.263
FL	-0.104	0.123	1	0.471*	0.511*	0.205	0.370
FG	0.094	0.293*	0.296*	1	0.530*	0.312	0.444
SFW	0.025	0.304*	0.303*	0.646**	1	0.102	0.391
NOF	0.033	0.331*	0.273	0.379**	0.400**	1	0.948**
FYD	0.129	0.405**	0.078	0.477**	0.683**	0.745**	1

*Correlation is significant at 0.05 (2-tailed)
** Correlation is significant at 0.01 level of probability (2-tailed)
PHT = plant height (cm), NOL = number of leaves/plant, FL = fruit length (cm), FG = fruit girth (cm), SFW = single fruit weight (g), NOF = number of fruits/plant, FYD = fruit yield/plant (g)

Table 5 Direct and indirect effects of the path coefficient analysis of some yield traits characters of Nsukka yellow pepper evaluated in 2009 season.

Variable	Indirect effects to fruit yield						Total effects		Total correlation on fruit yield
	1	2	3	4	5	6	Indirect	Direct	
PHT		0.0522	0.003	-0.0048	0.07	0.2275	0.3479	-0.02	0.3279
NOL	-0.0174		0.005	-0.005	0.0476	0.1729	0.2031	0.06	0.2631
FL	-0.0012	0.006		-0.0094	0.1428	0.182	0.3202	0.05	0.3702
FG	-0.0048	0.015	0.0235		0.1484	0.2821	0.4642	-0.02	0.4442
SFW	-0.005	0.0102	0.0255	-0.0106		0.091	0.1111	0.28	0.3911
NOF	-0.005	0.0114	0.01	-0.0062	0.028		0.0382	0.91	0.9482

(Residual, R = 0.08)
PHT = plant height (cm), NOL = number of leaves/plant, FL = fruit length (cm), FG = fruit girth (cm), SFW = single fruit weight (g), NOF = number of fruits/plant.

Table 6 Direct and indirect effects of the path coefficient analysis of some yield traits characters of Nsukka yellow pepper evaluated in 2010 season.

Variable	Indirect effects to fruit yield						Total effects		Total correlation on fruit yield
	1	2	3	4	5	6	Indirect	Direct	
PHT		0.0371	0.023	-0.0036	0.0156	0.0177	0.0898	0.04	0.1298
NOL	0.0212		-0.0276	-0.0116	0.156	0.1947	0.3327	0.07	0.4027
FL	-0.004	0.0084		-0.012	0.156	0.1593	0.3077	-0.23	0.0778
FG	0.0036	0.0203	-0.069		0.338	0.2242	0.5171	-0.04	0.4771
SFW	0.0012	0.021	-0.069	-0.026		0.236	0.1632	0.52	0.6832
NOF	0.0012	0.0231	-0.0621	-0.0152	0.208		0.155	0.59	0.745

(Residual, R = 0.47)
PHT = plant height (cm), NOL = number of leaves/plant, FL = fruit length (cm), FG = fruit girth (cm), SFW = single fruit weight (g), NOF = number of fruits/plant.

their positive indirect effects via number of leaves per plant, fruit length, single fruit weight and number of fruits per plant counteracted the negative direct effects towards fruit yield. The residual factor which measures the extent to which the causal factors implicated in the path analysis have explained the variability in fruit yield was found to be p = 0.08. The path diagram showing the cause and effect relationship of yield and its components for 2009 data is shown in **Fig. 1**. Similarly, in the 2010 season, highest direct effects were contributed by number of fruits per plant (p = 0.59), and this was followed by single fruit weight (p = 0.52), number of leaves (p = 0.07) and plant height (p = 0.04). The direct, indirect and total effects of some yield components of Nsukka yellow pepper is presented in **Table 6**. The positive indirect effects exerted on fruit yield via number of leaves per plant, single fruit weight, and number of fruits per plant counteracted the negative direct effects of fruit length and fruit girth to register a positive contribution on fruit yield. The seven-trait path analysis revealed a residual effect of p = 0.47 (**Fig. 2**).

DISCUSSION

The high coefficient of variation observed in the study in the two years implied that there is wide degree of variability in the Nsukka yellow pepper population with respect to number of leaves per plant, single fruit weight, plant height, number of fruit per plant and fruit yield that can be manipulated for its improvement. This variation forms the basis for improvement through selection since the success of any selection studies lies in the amount of variability present in a population. These findings are in line with the reports by Kumar *et al.* (2003) who also obtained coefficients of variability of 23.51%, 23.75% for fruit length and fruit width respectively in their studies. Naturally, peppers are self-pollinated species characterised with homozygous lines (Allard 1960), but the high rate of out-crossing events reported in this crop by several researchers provide enough evidence to support the vast variability of its characters. Although presently there is lack of agreement on the range of variability in *Capsicum* species, research evidence shows that it could vary from 2-90% (Grubben and El-Tahir 2004) or 7-90% (Bozokalfa *et al.* 2009) depending on the activity of the insect pollinators. The cross pollination event has resulted in considerable variability in the germplasm, which is advantageous for its improvement. The performance of the genotypes in 2009 and 2010 seasons with respect to fruit yield were strongly influenced by the level of development of the agronomic traits. The present result suggests that genotypes characterised with higher values of yield components gave higher yield, evidencing the importance of these traits as yield determinants. Griffing (1956) had noted that the genes that govern yield are not known; therefore a breeder relies on the yield components to effect changes in yield. By extension, fruit yield in *Capsicum* species is governed by plant height, number of leaves, fruit length, single fruit weight, number of fruits among others. It is not surprising that in the present study, the genotype, Ny-15 in 2009 which had the highest plant height, number of leaves per plant, number of branches per plant, fruit length; single fruit weight and number of fruits per plant consequently produced the highest fruit yield. It is not unlikely also that taller genotypes supported more number of branches and in turn, produced more number of leaves which are indispensable for higher rate of photosynthesis. It also suggests that since fruits are borne on nodes which are held on the branches, higher number of branches would create more structures for node formation and fruit production. Similarly, in 2010, the genotypes, Ny-08-2, Ny-07-2, Ny-07-3 and Ny-06-2 recorded high values for most of the traits to register high fruit yield. Much of the differences in the performances of the genotypes with respect to fruit yield are attributable to their inherent genetic potentials as shown in their agronomic traits which gave them advantage over the others. This finding is in agreement with the reports of other workers (Griffing 1956; Tembhurne *et al*. 2008a, 2008b) and further reinforces the hypothesis that fruit yield in *capsicum* species is governed by yield components.

Correlation study helps the breeder to indentify and select effective traits on which selection can be based for improvement in yield. The linear relationship between plant height, number of leaves per plant, fruit length, fruit girth and single fruit weight in 2009 evaluation further proves their worth in determining fruit yield in *Capsicum* species. The magnitude of the association of fruit yield and number of fruits per plant was high, followed by single fruit weight, as was reported by Tembhurne *et al*. (2008b) in their evaluation of the performance of fourteen varieties of pepper in India. The results of the 2010 findings apparently created a clearer picture of the intensity of the association existing between yield and its components. Highly significant positive relationship exists between fruit yield and number of leaves per plant, fruit girth, single fruit weight and number of fruits per plant. This result is in line with the reports of Abu and Uguru (2006), and Tembhurne *et al*. (2008b). The positive and significant association of growth characters (plant height and number of leaves) suggests that taller plant produces more number of leaves which is a very critical requirement for photosynthesis in plants. It is not unexpected for one to also observe that fruit length and fruit girth both had highly significant positive correlation with single fruit weight because longer and wider fruits tend to produce heavier fruits. This indicates that increase in fruit size was accompanied with increase in fruit weight. Similar results were obtained by Kumar *et al*. (2003) who also reported that fruit length and fruit width showed significant positive correlation with fruit weight. Our study also agrees partly with the work of He and Wang (1989) who established positive correlation between weight and diameter of the fruit but differed in that their report also included a negative association between fruit weight and fruit length in pepper. The significantly positive correlation between fruit yield and number of leaves per plant, number of fruits per plant, single fruit weight and fruit length further buttressed the fact that these traits have yield implication in *Capsicum* species (Abu and Uguru 2006; Tembhurne *et al*. 2008b).

Although correlation analysis provides useful information about the intensity of the association between two characters, however, such information could be misleading especially if the correlation is as a result of the consequence of the indirect effects of other traits. Partitioning the correlations into direct and indirect effects provides a better guide to breeders to identify traits that deserve high weightage during selections programmes. The number of fruits per plant exerted consistently the highest direct effects on yield, followed by single fruit weight in both years, implying that selection of breeding lines for yield improvement program would be effective if these traits are given substantial recognition. Similar results were reported by Dahiya *et al*. (1991) and Sharma *et al*. (2010). The greater influence of the number of fruits per plant on yield can be better visualised by considering the amount of variability in fruit yield that it explained when considered separately. For instance, number of fruits per plant component directly explained about 95.97% of the variability in fruit yield and the remaining part, 4.03% is accounted for by the indirect effects through the other traits. Similarly, in 2010, it was 79.19% and 20.81% for the direct and indirect components, respectively. These results suggest the importance of number of fruits per plant in determining the yield potentials in *Capsicum* species. Our findings are in line with the reports obtained in tomato by Yadav and Singh (1998) who also reported a positively correlated relationship between number of fruits per plant and fruit yield per plant.

In 2009, the path coefficient analysis revealed positive indirect effects of plant height through number of leaves per plant, fruit length; single fruit weight and number of fruits per plant probably counteracted the negative direct effects to register positive correlation on fruit yield. This means that direct selection for plant height would rather retard progress, but selection for these traits must be made through number of leaves per plant, fruit length, single fruit weight and number of fruits per plant for it to be effective. In the same way, selection of breeding lines based on fruit girth may not be effective for the same reason. The results of the 2010 path analysis also showed that fruit length and fruit girth both have negative direct effects on fruit yield. This however illustrates the fact that some traits may not necessarily increase yield in their own right, but acts via other traits toward increasing productivity. Such traits should be considered in a comprehensive yield programme since they also played useful roles on yield. This finding espoused the reports of Kumar *et al*. (2003).

The residual factor which measures the degree to which the causal factors accounted for the variability in the dependable variable was determined to be 0. 08 and 0.47 in 2009 and 2010, respectively, which are comparable with what other workers have obtained in studies on chilli (Nandadevi and Hosamani 2003), and in cowpea (Uguru 1996), indicating that 99.08% and 53% of the variability in fruit yield has been reasonably explained. It also implies that the most important yield determining traits were captured in the study.

CONCLUSION

This study indicated that there is wide range of variability in the fruit yield and vegetative characters of Nsukka yellow pepper genotypes across the two years which provides a good prospect for its improvement through selection. Further, for any breeding programme with target to increase fruit yield to produce the expected results, considerable emphasis has to be placed on number of fruits per plant, single fruit weight, number of leaves per plant and fruit length as indicated in this study. These traits could serve as criteria for selection of genotypes for yielding potentials. It is also evident that, number of fruits per plant exerted the highest influence on fruit yield, followed by single fruit weight, and the other traits in that order. However, selection for these traits alone may not bring about the desired level of increase in fruit yield because even those traits that registered negative direct effects also had positive contribution though indirectly via other traits towards fruit yield. Therefore, for a comprehensive fruit yield improvement programme to succeed, all the yield characters should be emphasised since all the variables jointly played invaluable roles in establishing the end product.

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