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CORRELATION STUDIES ON YIELD AND YIELD COMPONENTS OF TWO CULTIVARS OF CABBAGE (*BRASSICA OLERACEA* VAR. *CAPITATA* L.)

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Abstract

A comparative study to determine the degree and direction of linear association (Y = a + mX) among yield and yield components of two cultivars of cabbage, namely Fieldwinner and KK Cross, showed high positive linear correlation between plant weight and head width ($r = 0.84$ for 'Fieldwinner' and 0.90 for KK Cross; $P < 0.01$). The associations between yield parameters for the two cultivars differed. While head width and head solidity negatively correlated ($r = -0.86$) significantly ($P < 0.05$) in cv. Fieldwinner, the association ($r = -0.01$) was insignificant ($P > 0.05$) in cv. KK Cross. In both cultivars, however, head shape index increased with an increase in all the other parameters. Head width, head length, non-wrapper leaf weight, head weight and yield showed positive correlation in cv. KK Cross. Head yield was not significantly ($P > 0.05$) different between the two cultivars. Cultivar Fieldwinner produced elongated head, which were comparatively lower in weight.

Résumé

Abbey, L. & Manso, F.: *Etudes de corrélation sur le rendement et les constituants de rendement des deux variétés de chou* (Brassica oleracea *var.* capitata *L.*) Etude comparée pour déterminer le degré et la direction de l'association linéaire (Y = a + mX) parmi le rendement et les constituants de rendement de deux variétés de chou, à savoir, 'Field winner' et 'KK Cross' montraient une corrélation linéaire positive élevée entre le poids de plante et la largeur de tête ($r = 0.84$ pour 'Field winner' et 0.90 pour 'KK Cross'; $P < 0.01$). Les associations entre les paramètres de rendement pour les deux variétés diffraient. Alors que la largeur de tête et la solidité de pomme correspondaient négativement ($r = -0.86$) et considérablement ($P < 0.05$) en variété 'Field winner', l'association (r = -0.01) étaient négligeable (P >0.05) en variété 'KK Cross'. Dans les deux variétés, cependant, l'indice de la forme de pomme augmentait avec une augmentation dans tous les autres paramètres. Largeur de pomme, longueur de pomme poids de feuille non-emballeuse, poids de pomme et le rendement montraient une corrélation positive en variété KK Cross. Rendement de pomme n'était pas considérablement ($P > 0.05$) différent entre les deux variétés. La variété Fieldwinner produisait une pomme allongée qui était comparativement faible en poids.

Introduction

Taxanomically, *Brassica* species comprise a wide range of morphotypes including succulent modifications of leaves, stems, roots, buds, and floral parts (PROSEA, 1993). Within the family Brassicaceae, cabbage is the most commercially grown in Ghana and elsewhere (Sinnadurai, 1992; Messiaen, 1994) for the head, which comprises overlapping leaves covering a small terminal bud.

Cabbage is believed to have been introduced into Ghana from Europe, and was grown as small-scale enterprise in the 1940s (Sinnadurai, 1992).

However, the area of cultivation (not documented) has increased steadily over the years, especially in and around urban and sub-urban areas as market gardens, home-gardens and truck farming. Recent indications are that the cultivation of cabbage is increasingly becoming an important enterprise and source of livelihood for small-scale farmers. This is due to the increased acceptability and demand for the crop for home consumption and for the food industry in Ghana compared to the indigenous leafy vegetables popular in the rural areas. Production and availability of head cabbage on the Ghanaian market is seasonal, limited by climatic conditions (Vordzorgbe, 1997). Consequently, unknown quantity is imported from Burkina Faso to supplement local production in the off-season.

Head weight of Chinese cabbage positively correlates with surface area of wrapper leaves and leaf number, which are dependent on nitrogen and phosphorous nutrition (Kato, 1981). Wrapper leaves are known to determine the economic yield and posture for compact head formation (Kato, 1967). Thus, selection of cultivars that can tolerate biotic and abiotic stresses while producing compact and heavy head will benefit the Ghanaian market and increase incomes of cabbage growers. Such germplasm evaluation will be facilitated if relationships among the various growth and yield parameters are understood.

Among the cabbage cultivars introduced into the country earlier, KK Cross was found to be the most suitable but susceptible to mild environmental stress, and wide range of pests and diseases (Sinnadurai, 1992). There is, therefore, a need to genetically improve upon the crop and the appropriate agronomic practices recommended for higher head yield and quality for sustainable cabbage supply.

This investigation, therefore, aimed to determine the association between and among yield and yield attributes of head cabbage to identify parameters that influence head yield. Also, growth and yield performance of a newly identified cv. Fieldwinner was compared to the popular cv. KK Cross for possibility of introducing the former into Ghana.

Experimental

The work was carried out at the Experimental Farms of Crops Research Institute, Kwadaso, Kumasi, a semi-deciduous forest region, from June to August 1998.

Cabbage cultivars used for the study were KK Cross and Fieldwinner. Seeds of cv. KK Cross were collected from a local seed vendor, Asgrow Seeds Co. in Kumasi, and those of cv. Fieldwinner were imported from Bejo Zaden B.V., Holland. The seeds were drilled on a raised seedbed sterilized by use of heat produced by burning grass mulch. After the appearance of the first true leaf, seedlings were pricked out onto a heat-sterilized nursery bed. The seedlings were transplanted at the five true-leaf stage at a spacing of 40 cm × 50 cm on a 3-m^2 plot.

Poultry manure at a rate of 10 kg per 3-m^2 plot was worked into the soil before transplanting. Sixty kilogrammes NPK (15-15-15) were supplied to the seedlings 2 weeks after transplanting. The plants were sprayed with Karate 2.5EC at manufacturers' recommended rate to control insect pests as and when necessary. The plants were regularly watered to minimize water-deficit stress. Harvest was at 80-85 days after sowing. The experimental design was randomized complete block with four replications.

Data were collected on 10 sampled plants per replicate at harvest. The recorded parameters were total number of plants, mean plant and head weights, and head yield per hectare. Mean non-wrapper leaf weight, head efficiency ratio (= mean head weight/mean non-wrapper leaf weight), length and width of head, head shape index (= head length/head width), and moisture content of head by gravimetric method were also determined. Head solidity was estimated as the mean head weight/(0.524)(head width)^2 (head length). Statistical analyses were performed by simple linear correlation ($Y = a + mX$) analysis and T-test (Gomez & Gomez, 1984), using MSTAT C software.

Results and discussion

Head shape index (HSI), which describes the external quality in terms of head shape, correlated negatively with all the other measured parameters (Tables 1and 2). Significant ($P < 0.05$) association was found between HSI and total plant weight (TPWt), head weight (HWt), yield and head width (Hw) of cv. Fieldwinner (Table 2), whereas in cv. KK Cross, HSI indicated significant ($P < 0.01$) relationship with only Hw (Table 1). It was observed that Hw linearly increased with decreasing HSI in both cultivars, with a coefficient of determination (R^2) of 61 and 89 per cent for cvs. KK Cross and Fieldwinner, respectively. By definition, Hw is an inverse function of HIS and, therefore, an increase in the value of the former decreases the value of the latter. In cv. Fieldwinner, 39 per cent of the variation in HWt was significantly ($P < 0.05$) accounted for by variation in HSI. Physiologically, leaf width growth of cabbage is enhanced by long photoperiod, high light intensity, and high night temperatures (Kato, 1981) which can influence head shape. Thus, the degree of variation in HSI, as determined by R^2, might be due to the differential response of the two different cultivars (genotypes) to the environmental conditions under which they were grown during the study.

The extent and direction of linear association for percentage moisture content (MC), head solidity (HS) and head efficiency ratio (HER) differed between the two cultivars. These observations could be attributed to the origin, genetic composition, and crop duration of the two cultivars. Workers have indicated that the type and efficiency of head formation in cabbage are dependent on cultivar and growing environment (Kato, 1967, 1981; Kuo & Tsay, 1981). This may explain the differences in MC, HS and, more so, HER found between cvs KK Cross and Fieldwinner. Table 1 shows that MC significantly ($P < 0.01$) increased with TPWt, HWt and Hw of cv. KK Cross. Thus, 60, 74 and 55 per cent of the variations in these parameters were due to differences in MC of cv. KK Cross. Similar relationships were not found in cv. Fieldwinner. Variation in HS of cv. KK Cross did not significantly ($P > 0.05$) relate to other parameters (Table 1), although relationships between TPWt, head length (HI) and Hw were significant ($P < 0.01$) in cv. Fieldwinner (Table 2). Head efficiency ratio increased with decreasing TPWt and non-wrapper leaf weight (NWL), but increased with increases in the values of the other parameters (Tables 1 and 2). However, all these relationships were not significant ($P > 0.05$).

A general trend of positive linear correlation was observed among Hw, HI, yield, NWL and HWt (Tables 1 and 2). Although the associations between TPWt *versus* Hw, HI, yield, NWL and HWt were not very strong, it was significant ($P < 0.05$). Thus, increases in leaf size and leaf number increased HWt, which correspondingly, increased TPWt. This finding confirms the work on Chinese cabbage by Kato (1981). Total plant weight of both cultivars indicated R^2 value of 70 to 80 per cent at $P < 0.01$ with Hw. It was observed that Hw was the best determinant of yield in cv. Fieldwinner, while for cv. KK Cross, Hw and HI were important yield indices. Absolute relationship was found between HWt and yield (Tables 1 and 2). These observations also suggest that cvs. Fieldwinner and KK Cross belong to different groups of cabbage.

Generally, Hw, HWt and TPWt of both cultivars were found to be positively and significantly ($P < 0.05$) correlated with head yield per hectare. The significant ($P < 0.05$) linear relationship between NWL and yield for cv. KK Cross suggests that an increase in total leaf number could increase head weight and yield. This agrees with the work by Kato (1967) who observed that the bigger the wrapper leaves of Chinese cabbage, the more compact and heavier the head.

A t-test to determine differences in yield performance between cvs KK Cross and Fieldwinner indicated similarity in yield and yield

TABLE 1
Linear (Y = a + mX) correlation (r) of yield and yield component of cabbage cv. KK Cross

	MC	*HS*	*HSI*	*HER*	*Hw*	*HI*	*Yield*	*NWL*	*HWT*
TPWt	0.78** (R^2=60.4)	0.28n.s (R^2=7.8)	016 n.s (R^2=36.8)	-0.12 n.s (R^2=0.02)	0.90** (R^2=81.0)	0.68* (R^2=45.7)	0.94** (R^2=88.4)	0.85** (R^2=71.9)	0.94** (R^2=88.4)
HWt	0.86** (R^2=74.0)	0.44 n.s (R^2=19.6)	-0.57 n.s (R^2=32.6)	0.22 n.s (R^2=0.22)	0.87** (R^2=75.0)	0.68* (R^2=46.1)	1.00** (R^2=100.0)	0.72* (R^2=51.7*)	
NWL	0.52 n.s (R^2=27.1)	0.24 n.s (R^2=5.9)	-0.52 n.s (R^2=27.0)	-0.48 n.s (R^2=22.6)	0.70* (R^2=48.7)	0.45 n.s (R^2=19.8)	0.72* (R^2=51.7)	-	
Yield	0.86** (R^2=74.0)	0.44 n.s (R^2=19.6)	-0.57 n.s (R^2=32.6)	0.22 n.s (R^2=4.8)	0.87** (R^2=75.0)	0.68* (R^2=46.1)	-		
HI	0.48 n.s (R^2=22.8)	0.07 n.s (R^2=0.44)	-0.02 n.s (R^2=0.06)	0.24 n.s (R^2=5.9)	0.64* (R^2=40.3)	-			
Hw	0.74** (R^2=55.5)	-0.01n.s (R^2=0.2)	-0.78** (R^2=61.3)	0.21n.s (R^2=4.4)	-				
HER	0.34 n.s (R^2=11.7)	0.01 n.s (R^2=0.01)	-0.13 n.s (R^2=1.6)	-					
HSI	0.57 n.s (R^2=31.9)	-0.03 n.s (R^2=0.12)	-						
HS	0.43 n.s (R^2=18.1)								

TPWt, total plant weight; HWt, head weight; NWL, non-wrapper leaf weight; H1, head length; Hw, head width; HER, head efficiency ratio; HSI, head shape index; HS, head solidity; *, ** significant at $P = 0.05$ and 0.01, respectively; n.s, no significant difference at $P > 0.05$; R^2, coefficient of determination.

TABLE 2

Linear (Y = a + mX) correlation (r) of yield and yield component of cabbage cv. Fieldwinner

	MC	*HS*	*HSI*	*HER*	*Hw*	*HI*	*Yield*	*NWL*	*HWT*
TPWt	-0.17 n.s (R^2=2.8)	-0.63* (R^2=38.4)	-0.70* (R^2=49.1)	-0.01 n.s (R^2=0.01)	0.84** (R^2=70.2)	0.76 (R^2=58.1)	0.72 (R^2=52.1)	0.77** (R^2=58.5)	0.72* (R^2=52.1)
HWt	0.08 n.s (R^2=0.6)	-0.31 n.s (R^2=9.3)	-0.63* (R^2=39.2)	0.61 n.s (R^2=37.1)	0.71* (R^2=50.8)	0.60* (R^2=36.2)	1.00** (R^2=100.0)	0.35 n.s (R^2=12.0)	-
NWL	-0.51n.s (R^2=25.5)	-0.51 n.s (R^2=25.9)	-0.58 n.s (R^2=33.8)	-0.53 n.s (R^2=28.0)	0.60 n.s (R^2=35.9)	0.40 n.s (R^2=15.6)	0.35 n.s (R^2=12.0)	-	
Yield	0.08 n.s (R^2=0.56)	-0.31 n.s (R^2=9.3)	-0.63* (R^2=39.2)	0.61* (R^2=37.1)	0.71* (R^2=50.8)	0.60 n.s (R^2=36.2)	-		
HI	-0.6 n.s (R^2=0.31)	-0.07* (R^2=48.9)	-0.47 n.s (R^2=21.9)	0.21 n.s (R^2=4.4)	0.73** (R^2=53.6)	-			
Hw	0.15 n.s (R^2=2.2)	-0.87** (R^2=75.0)	-0.94** (R^2=88.5)	0.15 n.s (R^2=2.1)	-				
HER	0.51 n.s (R^2=25.6)	0.14 n.s (R^2=2.0)	-0.09 n.s (R^2=0.79)	-					
HSI	-2.0 n.s (R^2=4.0)	0.80** (R^2=64.2)							
HS	-0.12 n.s (R^2=1.5)								

TPWt, total plant weight; HWt, head weight; NWL, non-wrapper leaf weight; H1, head length; Hw, head width; HER, head efficiency ratio; HSI, head shape index; HS, head solidity; *, ** significant at $P = 0.05$ and 0.01, respectively; n.s, no significant difference at $P > 0.05$; R^2, coefficient of determination.

TABLE 3a
T- test for yield and yield components of cabbage cv. KK Cross and Fieldwinner

Cultivar	*TPWt (kg)*	*HWt (kg)*	*NWL (kg)*	*Yield (t ha^{-1})*	*HI (cm)*
KK Cross	1.09	0.69	0.32	34.45	11.06
Fieldwinner	1.06	0.61	0.32	30.56	12.31
Mean	1.08	0.65	0.32	32.51	11.69
S^2d	0.009	0.177	0.001	8.909	0.078
Significant level	n.s	n.s	n.s	n.s	**

TABLE 3b
T- test for yield and yield components of cabbage cv. KK Cross and Fieldwinner

Cultivar	*Hw (cm)*	*HER*	*HSI*	*HS (g. cm^{-3})*	*MC (%)*
KK Cross	15.32	2.22	0.73	0.50	91.39
Fieldwinner	13.23	1.91	0.93	0.55	91.45
Mean	14.28	2.07	0.83	0.53	91.42
S^2d	0.078	0.026	0.001	0.001	0.309
Significant level	**	n.s	**	n.s	n.s

parameters except HSI, HI and Hw (Tables 3a and 3b). Cultivar Fieldwinner had higher HSI of 0.9, indicating an elongated head rather than a broad head as compared with HSI of 0.7 for cv. KK Cross, which is more round.

The results of this study showed that the significant *($P < 0.05$)* linear correlation between important yield characters was greater than those of external qualities. However, the relationship among those characters that were not significant ($P > 0.05$) should not be overlooked, because other forms of non-linear correlation analyses might bring about significant results. The observations made in this study were consistent with those made by Kato (1967, 1981) and Gill *et al.* (1977).

In conclusion, head yield of cabbage is increased by timely planting when climatic conditions are favourable, adopting cultural and management techniques that would enhance leaf size and total plant weight by optimising net assimilation rate, improve rate and quality of head formation, and good head compactness. Genetic improvement of cabbage genotypes should also be based on yield and quality components that were found to be significant ($P < 0.05$) in this study.

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