

Prediction of Agronomic Characteristics and Estimation of Head Weight Based on Head Length and Width in Cabbage (*Brassica oleraceae*) Grown in the Derived Guinea Savannah

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Article Details: Received: 2024-11-11 | Accepted: 2025-02-21 | Available online: 2025-05-31



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Cabbage is a high-value leaf vegetable. Its productivity is determined by soil and climatic factors, biotic and abiotic stresses. Few investigations have been carried out to predict head weight considering the relationship between head weight, head length, and width. Regression analysis is an inferential statistic that can predict plant growth and development. The production and consumption of cabbage in urban and peri-urban locations is increasing. Information on the prediction of head weight using agronomic traits that are directly related to head weight in rainforest-savannah agroecology is limited. The aim of this research was to determine variability for agronomic and head yield traits, quantify the association between head yield and yield component traits, and predict the relationship between head weight (Y) and head length, head width and plant length. Five hybrids were evaluated during 2022 and 2023 in a randomized complete block design with three replications. Data was analysed for variability, correlation, and regression analyses using Statistical Analysis software (2012). Findings showed that the hybrids responded linearly to the environment (year). 'Montra' and 'Paske' performed best for marketable head weight. Montra is promising for head length and width. Phenotypic improvement in head length will enhance head width and marketable head weight. The coefficient for predicting the marketable head weight was 12.22. If the head length and width are known, they are multiplied by 12.22, then the head weight can be predicted. This model is ideal for the prediction of head weight in commercial farms if the length and width are known.

Keywords: cabbage, marketable head weight, character association, head length, head width and prediction equation

1 Introduction

Cabbage (*Brassica oleracea* var. *capitata* [L.]) is a member of the family Cruciferae the third most popular vegetable worldwide (Obidola, 2019) and a high-value leaf vegetable in sub-Saharan Africa. Head cabbage production and consumption is highest in Europe, Asia, and the Americas (Obidola, 2019). Also, Morocco, Angola, Egypt, Kenya, Ethiopia, South Africa and Rwanda are the top cabbage producers in Africa. China produced 71 million metric tonnes (MMT⁻¹), representing 48% of the world's production (USDA, 2022). Cabbage is grown in temperate, tropical and sub-tropical climates. In sub-Saharan Africa, the most suitable conditions for growth and head yield are the cool moist climate conditions. Cabbage is widely cultivated in the northern part of Nigeria especially during the winter season in the Plateau (1,200 m asl)

and other agro-ecologies. Nigeria produced 2.4 MMT⁻¹ of cabbage heads during 2020 farming (Adelanwa & Medugu, 2015), making it the largest producer of cabbage in Africa. Head cabbage is an annual leafy vegetable characterized by dense-leaved heads. Its external leaves are dark green and succulent (Kibar et al., 2014), round and smooth, and slightly notched at the margin. The leaves lack pubescence but are covered with a waxy coating, which gives the leaf surface a grey-green or blue-green pigmentation. In Africa, cabbage is grown as a sole crop during the main season under rain-fed and off-season in urban and peri-urban locations. High head yield is determined by altitude, soil and climatic factors, biotic and abiotic factors and a production cycle of four and six months is common. Cool and humid weather is ideal for vegetative growth and head yield. In addition,

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light is important for growth, photo-morphogenesis and photosynthetic and biosynthesis. Changing patterns of temperature (between 4 to 21 °C) negatively impact growth and head yield. Fluctuating precipitation (excess water and drought) and heat stress during the main season limit productivity and constitute emerging threats to production in the rainforest-savannah agroecologies in sub-Saharan Africa (Mwasha, 2000). Cabbage is a heavy feeder that needs nitrogen, especially during the early head formation stage, and sufficient phosphorus and potassium during the early stages of expansion of the outer leaves (Adeniji et al., 2010). The individual cabbage head weighed 875.54 g, while the cabbage head yield between 25 to 35 t.ha⁻¹, 48.2 t.ha⁻¹, and 50 t.ha⁻¹ was recorded under different cropping systems (Adelanwa & Medugu, 2015). The 100 g of fresh cabbage head contains water (92%), carbohydrates (6%), protein (1%), vitamin C (44%) and K (72%) and negligible fat. The total soluble solids in the cabbage head varied from 3.17 to 5.33 while the juice pH_(H₂O) ranged from 5.68 to 6.54 moles.m⁻². The phytochemical analysis of cabbage revealed its anticancer role through the isothiocyanate compound. Cabbage production is hindered by diamondback, caterpillar, and cabbage looper attacks, as head rot (*Sclerotinia sclerotiorum*) and Black rot (*Xanthomonas campestris*) diseases. Head splitting is a non-pathogenic associated with heavy precipitation while loose heads are associated with a preponderance of larvae.

The standard specifications for cabbage heads differ depending on the market preferences of specific countries. Cabbage heads are culled when they attain market specifications (head length, width, and weight) and are sold in grocery stores without innovations for extension of shelf life. The horticultural traits of economic importance are earliness, head length and width, head hardness, storability, freshness, and head weight. Consumers' preferred traits are head size and shape, head crispiness, colour, taste, smell, freshness and absence of malformations in the head (Adeniji et al., 2010). Cabbage head yield is influenced by genetic and environmental factors, including climate shocks. The prediction of head yield based on the head metric traits is important for productivity and economic returns provided that environmental factors are favourable. However, not many investigations have been carried out to predict head weight and the relationship between head weight, head length and width. The statistical model can detect the relationship among cabbage head dimensions and can contribute to head size selection and estimation of head yield.

The crop modelling uses quantitative measurements of eco-physiological processes to predict plant growth

and development, and yield based on environmental conditions. The regression analysis is a form of inferential statistics which describes the mathematical relationship between each independent and dependent variable. The P value for the coefficient helps determine whether the relationship observed in a sample also exists in a larger population. The slope of regression indicates the steepness of a line, and the intercept indicates the location where it intersects an axis. The multiple regression analysis quantifies the relationship between two or more independent variables and one dependent variable. This assumes homogeneity of variation (homoscedasticity), independent observation, normality, and linearity.

In sub-Saharan Africa, urban and peri-urban production of cabbage is increasing. In addition, urban demand for cabbage head is increasing due to increasing awareness of its' nutritional benefits and appealing taste (Laczi et al., 2016). However, cabbage head yield is declining due to abiotic and biotic stresses in many agroecologies. Additionally, knowledge is limited on the prediction of head weight using agronomic traits that are directly related to head weight in the rainforest-savannah agroecologies with low altitudes. The aim of this research was to:

- a) evaluate the morphological, agronomic, and head yield variability among the cabbage hybrids;
- b) quantify the association between head length, head width and marketable head weight;
- c) predict the relationship between head weight (Y) and head length (X₁), head width (X₂) and plant length (X₃) under field conditions.

This study adds to our knowledge of cabbage improvement for accurate prediction of head yield in the derived guinea savannah agroecology.

2 Materials and Methods

The experimental site is at the Teaching and Research Farm, Federal University Oye Ekiti, Nigeria (Longitude: 5° 29' E Latitude: 7° 48' N and 535.5 m asl) in the derived guinea savannah agroecology. Five cabbage hybrid varieties (Table 1) developed and commercialized by breeder seed companies in Europe and Asia were received from agrodealers in Nigeria. The seedlings were raised in multi-cell seedling trays for four weeks in a polyhouse. The soil was sterilized and cooled before use. Sterilized soil was filled into a multi-cell seedling tray and watered to field capacity before planting. A seed was planted in each cell, and the seedling trays were kept under shade for 48 hours to trigger germination, seed germination took place five days after planting. Two weeks after planting, one (1) g of urea (46% N) was dissolved in one (1) l of

water and sprayed onto the seedlings using a handheld sprayer. The experimental field was manually tilled with a handheld cutlass, and hoes and rakes were used to remove weeds, stumps, heavy stones and debris to create a friable and good soil tilth. The experimental field was laid out using a randomized complete block design with 3 replications under rain-fed during the 2022 and 2023 seasons. Each plot is a double row of 4 m long and 1 m wide. Each replicate was separated by a 1.5 m distance. The experimental area was 15 m by 12 m (180 m²). Four weeks after nursery establishment, the vigorous seedling was transplanted to the field using the ball of the earth method. Planting holes were made at 60 cm between rows and a plant-to-plant distance of 0.40 m. Each cabbage seedling was planted per hole in the evening. The experiment was maintained as rain-fed. Five days after transplanting, weak and withered seedlings were removed and replaced with vigorous plants (supplying). At seven days after transplanting one (1) g of Urea (45% N) was dissolved in one (1) l of water and sprayed on the plant (foliar application). The experiment was protected with organic insecticide (*Azadirachta indica* leaf extract). The neem leaves were soaked in 2 l of warm water for 72 hours, thereafter the solution was filtered through a funnel and sieved to separate the liquid extraction from the solid plant materials. The extract was filled into 15 l of knapsack sprayer and sprayed at 7d intervals for four weeks. Weeds were controlled manually weeding; this was done frequently to maintain weed-free plots. A compound fertilizer N₂O : P10 : K10 was applied to the cabbage plants at 8 weeks after transplanting at the rate of 5 g per plant by side placement.

2.1 Measurement of Cabbage Horticultural Characteristics

Horticultural characteristics were measured at culling. These include leaf height (cm) and leaf width (cm) at culling, number of head culled/plots, marketable head weight and non-marketable head weight (kg), head firmness, head shape, head height and head width (cm), and number of loose heads. The leaf length at culling was measured with a linen tape from the leaf base to the tip and the leaf width was determined at the widest points of each leaf on five randomly picked leaves per plot.

The leaf area (cm²) was estimated according to the formula:

$$\text{leaf area (cm}^2\text{)} = \text{leaf length} \times \text{leaf width} \times 0.75 \quad (1)$$

At culling, five cabbage heads were randomly picked/plotted, thereafter a longitude cut was made on each cabbage head using a sharp knife. The head length and width were measured from the point of attachment of

the stem to the tip of the head using linen tape (cm). The individual head weight (Kg) was measured using a Salter weighing balance in kg. Cabbage heads devoid of bruises and attacks by insects and diseases were weighed for determination of marketable head weight. The non-marketable head weight (kg) was measured by weighing all rotten, deformed, split cabbage heads on a Salter weighing balance.

Head firmness (Z): head compactness was computed as described by Adeniji et al. (2010):

$$Z = \frac{C \times 100}{W^3} \quad (2)$$

where: C – weight of the head; W – average length and width of the cabbage head

Categorization of cabbage head according to Adeniji et al. (2010) as (Very firm = 4.0, compact = 3.0, loose = 2.0, very loose = 1.0, spherical = 0.8 to 1.0, drumhead = 0.60, conical head = 1.0 and above).

Head shape (H/D): This was computed as the ratio of head length (HL) to head width as described by Adeniji et al. (2010).

$$H/D = \frac{HL}{HD} \quad (3)$$

The number of loose heads was estimated by counting the number of cabbage plants showing symptoms associated with loose heads/plots. The incidence and severity of Black rot disease (*Xanthomonas campestris*) was scored according to Williams (1985). Data was summarized and input into Microsoft Excel format and analysed for phenotypic differences among the hybrids. The PROC GLM procedure of Statistical Analysis Software Version 9.0 (SAS, 2012) was used for the determination of differences among the cabbage hybrids based on measured horticultural characteristics. The mean values were separated using Tukey's HSD test of the Statistical Analysis Software Version 9.0 (SAS, 2012).

The simple linear regression was applied to detect the relationship among head length (X) and head weight (Y), head weight (Y) and head width (X) head width and head weight. The second-degree polynomial regression was applied to detect the relationship of head length (X₁) and head width (X₂) on head weight (Y), head length, head width and plant height on head weight was done by R software and the strength of the relationship (R) was measured.

Head weight (*Hwt*) – as a function of head length:

$$Hwf = \int HI \quad (4)$$

Head weight (*Hwt*) – as a function of head width (*Hd*):

$$Hwf = \int Hw \quad (5)$$

where: *HI* – head length; *Hw* – head width

The simple linear regression equation:

$$Y = B_0 + B_1X + E \quad (6)$$

where: *Y* – dependent variable; *B₀* – intercept; *B₁* – slope of the regression line; *X* – explanatory variable; *E* – residual

The second polynomial regression equation:

$$Y = B_0 + B_1X_1 + B_2X_2 + E \quad (7)$$

where: *Y* – dependent variable; *B₀* – intercept constant; *B₁* – linear effect parameter; *B₂* – the quadratic equation; *X₁* – explanatory variable; *X₂* – residual

The strength of relation (*R*) – coefficient of determination:

$$R = \frac{\sum_{i=1} (xi - x)(yi - y)}{\sqrt{\sum_{i=1} (x - x)^2 \sum_{i=1} (y - y)^2}} \quad (8)$$

3 Results and Discussion

3.1 The Physical and Chemical Properties of Soil

The soil (0–30 cm) from the Teaching and Research Farm has a pH of 5.7 (slightly acidic soil), organic matter (0.82) and nitrogen content (0.08) and is described as sandy-loam (Table 1). This necessitates the use of inorganic

fertilizers. The weather pattern retrieved from Aqua crop software showed that the amount of precipitation was the least (5.73 mm) at 180 d while the highest amount (42.12 mm) of precipitation was recorded at 270 d. The average temperature was in the range from 23.32 °C to 26.44 °C. The relative humidity was least at 5.31 but highest at 42.12.

3.2 Performance for Horticultural Traits

High productivity is the sequel to a combination of productive cabbage hybrids, rich soil, adequate weather for growth and high head yield. The hybrids showed statistically significant mean squares ($p < 0.05$) for head length, head width and marketable head weight. This suggests inherent variation among the hybrids for agronomic traits. The hybrids × year interaction returned insignificant ($p > 0.05$) mean squares for agronomic traits (Table 2). The hybrids accounted for a higher proportion of variability compared with the hybrids × year interaction. The head length was long (22.00 cm) in ‘Montra’, followed by ‘Tycoon’ with a mean value of 20.80 cm. ‘Copenhagen’ had the lowest head height (15.47 cm) (Table 3). Among the cabbage hybrids, ‘Copenhagen’ had the least head width (14.76 cm) while other hybrids viz. ‘Montra’, ‘Tycoon’, ‘Amarisa’ and ‘Pakse’ had mean values of 24.80 cm, 24.10 cm, 24.03 cm, and 23.40 cm respectively. The top three cabbage hybrids for marketable head weight (kg.plot⁻¹) are ‘Pakse’ (21.00 kg), ‘Montra’ (19.37 kg) and ‘Tycoon’ (16.17 kg). Marketable head weight was lowest in ‘Copenhagen’ with 8.17 kg.plot⁻¹. Two hybrids viz. ‘Pakse’ and ‘Montra’ performed best for marketable head weight and individual head weight respectively. This implies that ‘Montra’ and ‘Pakse’ had a high photosynthetic rate under the prevailing weather which account for higher head weight. In a separate study, ‘Copenhagen’ produced the highest head weight compared to other cabbage hybrids in Kenya (Janko et al., 2010) and Tanzania (Adeniji et al., 2010), this was accompanied by large head size.

Table 1 Commercial name, characteristics, and source of the five cabbage hybrid varieties used in field evaluation during the 2023 season

| Commercial name | Characteristics | Genetic status | Source |
|-----------------------|--|----------------|---------------------------|
| Cabbage Montra | medium maturing variety, medium head yield and disease resistance | hybrid | Western Europe |
| Copenhagen | early maturing variety, small to medium head yield and disease resistant | hybrid | East African (Disengoff) |
| Tycoon F1 | early to medium variety head yield and resistance to diseases | hybrid | Techinsem Company |
| Amarisa | medium maturing variety, high head yield, and disease resistant | hybrid | East African Seed company |
| Pakse | early maturing, high head yield and resistant to diseases | hybrid | East-West Seed Company |

Table 2 Physical and chemical properties of the soil from the experimental area

| Soil properties | Values |
|--|------------|
| pH (in H ₂ O), 1 : 1 | 5.7 |
| OM (%) | 0.82 |
| N (%) | 0.08 |
| Available Phosphorus (Bray Method) | 219.33 |
| Exchangeable Mg (C.mol ⁻¹) | 0.19 |
| Exchangeable K (C.mol ⁻¹) | 0.48 |
| Exchangeable Na (C.mol ⁻¹) | 0.07 |
| Exchangeable Ca (C.mol ⁻¹) | 2.93 |
| Effective cation exchange capacity | 3.68 |
| Zn (ppm) | 1.12 |
| Cu (ppm) | 1.01 |
| Mn (ppm) | 107.7 |
| Fe (ppm) | 180.07 |
| Particle size | Fine |
| Sand (%) | 68 |
| Silt (%) | 20 |
| Clay (%) | 11 |
| Textural class | Sandy-loam |

In another study according to Getachew et al. (2022) reported that 'Copenhagen' produced cabbage heads with long heads and high marketable head yields at a spacing of 60 × 40 cm. Significant differences among the hybrids for head length, head width, individual head weight and marketable head weight among the hybrids suggest the possibility of selecting hybrids with large head sizes (head length and width), high individual head weight and marketable head weight to be grown by cabbage farmers. 'Montra' and 'Tycoon' were better for head length. The cabbage hybrids showed similar performance for leaf length, leaf width and Z-score, this is due primarily to almost equal mean

values recorded for these morphological characters. Early worm infestation was responsible for loose heads recorded in the Copenhagen hybrid. The head shape is important in the packaging of cabbage heads. The ratio of the cabbage head length to head width (H/D) is a determinant of head shape. The score for H/D represents the head shape, which suggests the ratio of the length. The cabbage head shape ranges from 0.83 to 1.06. About the scale for scoring cabbage head shape (Equation 2), the 'Montra' hybrid recorded had a score of 1.06 which represents a conical shape while other hybrids had scores ranging from 0.84 to 0.88. Findings showed that 'Copenhagen' had a spherical head shape while other hybrids were conical. The insignificant mean squares were recorded among the cabbage hybrids for individual head weight, head weight per plot, Z-score, leaf length, leaf width and leaf area. As shown in Fig. 1, two hybrids namely 'Montra' and 'Tycoon' recorded high mean values for individual head weight while 'Paské' and 'Copenhagen' had higher numerical values for head weight. 'Tycoon' hybrid recorded the highest mean value for leaf length while leaf width was widest in 'Montra' (Fig. 1). 'Paské' hybrids recorded the highest Z-score among the hybrids evaluated. The coefficient of variability was low in head length compared to head width. The R^2 value for the ratio of head length to head width showed a larger magnitude (0.80) compared to (0.73) for marketable head weight.

3.3 Distribution of the Cabbage Hybrids by the Plant Showing Defoliated Leaves, Loose Heads and Incidence of Cabbage Black rot Disease (CBB) (*Xanthomonas campestris*)

The reaction of the five cabbage hybrids to CBB disease showed that Cabbage Amerisa had the highest incidence (60 plants) while the Copenhagen hybrid had the lowest incidence (Fig. 2). Cabbage loose head is caused by cutworms which prevent the plant from heading. The incidence of cabbage loose head was

Table 3 Mean separation for head height, head width, marketable head weight and head width among five cabbage hybrid varieties during 2022 and 2023 cropping season

| Hybrid | Head height (cm) | Head width (cm) | Marketable head weight (kg. plot ⁻¹) | Ration of head height (H) to head width (w) |
|----------------|------------------|-----------------|--|---|
| Cabbage Montra | 22.00a | 24.80a | 19.36ab | 0.88b |
| Pakse | 19.56b | 23.43a | 21.00a | 0.83b |
| Tycoon | 20.80ab | 24.10a | 16.16ab | 0.86b |
| Amarisa | 19.80b | 24.03a | 13.33ab | 0.82b |
| Copenhagen | 15.46c | 14.70b | 8.16b | 1.05a |

Values in columns followed by the same letter are not significantly different at 5% level of probability

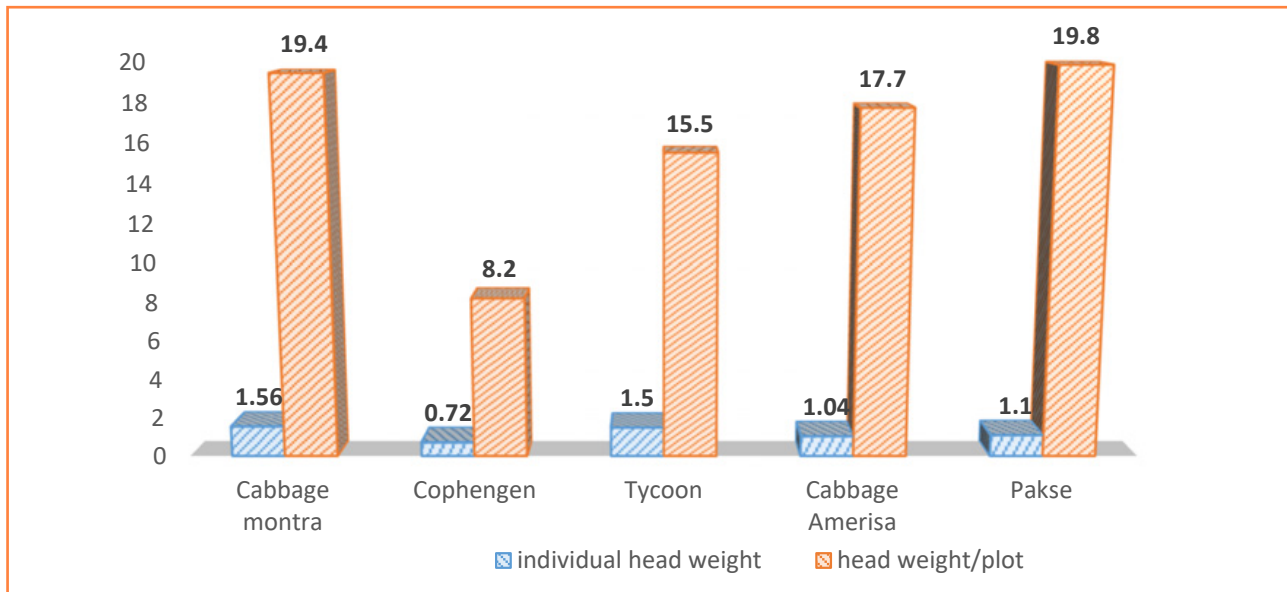


Figure 1 Mean values for individual head weight among the cabbage hybrids evaluated during 2024 cropping season

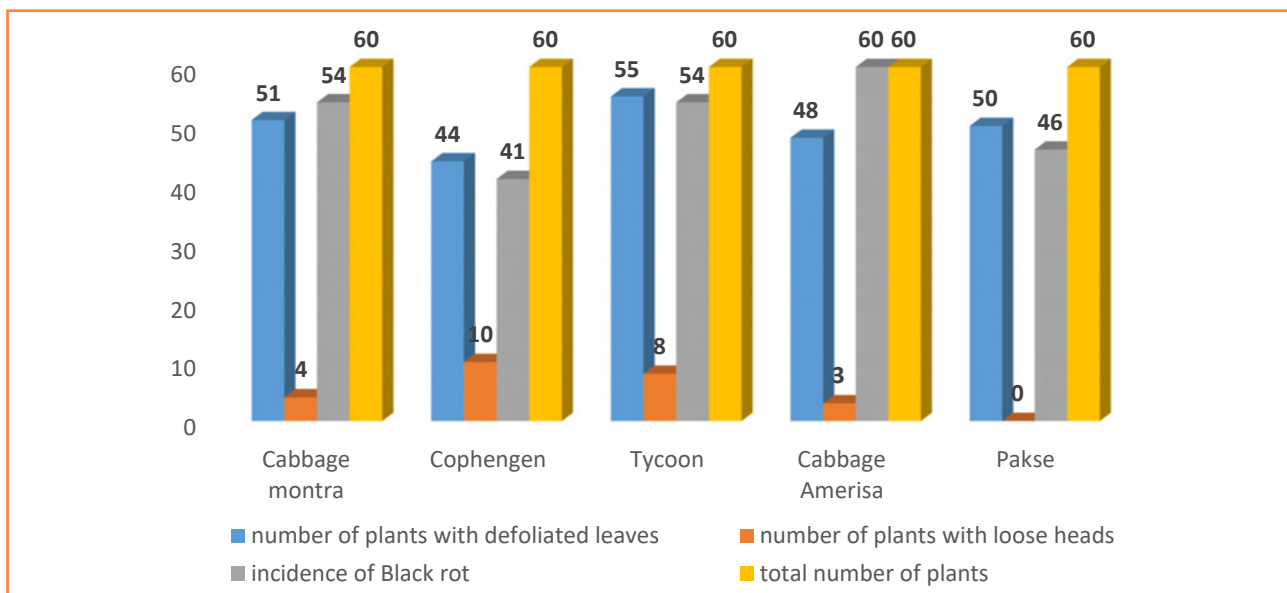


Figure 2 Mean values of the cabbage hybrids by the mean number of defoliated leaves, loose heads and incidence of Black rot disease

highest in Copenhagen hybrid. Defoliated leaves on cabbage leaves are due to cabbage looper, and cabbage worm. The cabbage Tycoon followed by Montra had the highest proportion of defoliated leaves. Forty-four (44) Copenhagen hybrid plants out of 60 plants were attacked by biting and chewing insects.

3.4 Correlation Analysis Between Head Yield and Yield Component Traits

The correlation analysis shows an association between two characters, positive or negative, strong or weak. The prediction of head yield in humid agroecology is imperative to ensure sustainable production, planning

and precision farming. A significantly positive correlation coefficient between head length and head width ($r = 0.89^{**}$) (Table 4), head length and marketable head weight ($r = 0.70^{**}$). This suggests that when the cabbage head length increases, so does the head width. Also, when the marketable head weight increases the fruit length increases, and other parameter(s) are subject to a proportional trend. A significantly negative correlation coefficient between head length and the ratio of head length to head width ($r = -0.56^{*}$). The ratio of the head length to width which relates to the head shape is negatively associated with head length, head width and marketable head weight. An explanation for this is that

Table 4 Pearson correlation coefficient between head length, head width, marketable head weight/plot and the ratio of head length to head width

| Character | Head length | Head width | Marketable head weight | Head/Width |
|------------------------|-------------|------------|------------------------|------------|
| Head length | 1.00 | | | |
| Head width | 0.89** | 1.00 | | |
| Marketable head weight | 0.70** | 0.78** | 1.00 | |
| Head/width | -0.56* | -0.86** | -0.59* | 1.00 |

* significant at 5% level of probability, ** significant at 1% level of probability

the cabbage head shape does not have any association with head length, head width and head weight.

3.5 Prediction of Marketable Head Weight (Y) Using Head Length, Head width and Plant Height as Independent Variable (X_1 , X_2 and X_3)

3.5.1 Linear Regression Analysis of Head Length (X) on Marketable Head Weight (Y)

The relationship between cabbage head length (X) and head weight (Y) is presented in Fig. 3a. The estimated linear regression of head length on head weight shows a significantly positive multiple regression ($R^2 = 0.50$, $P < 0.003$) analysis. The value of the intercept is -16.00. The prediction for the linear regression equation between head weight (Y) and head width (X) is given as:

$$Y = -16 + 1.6X \quad (9)$$

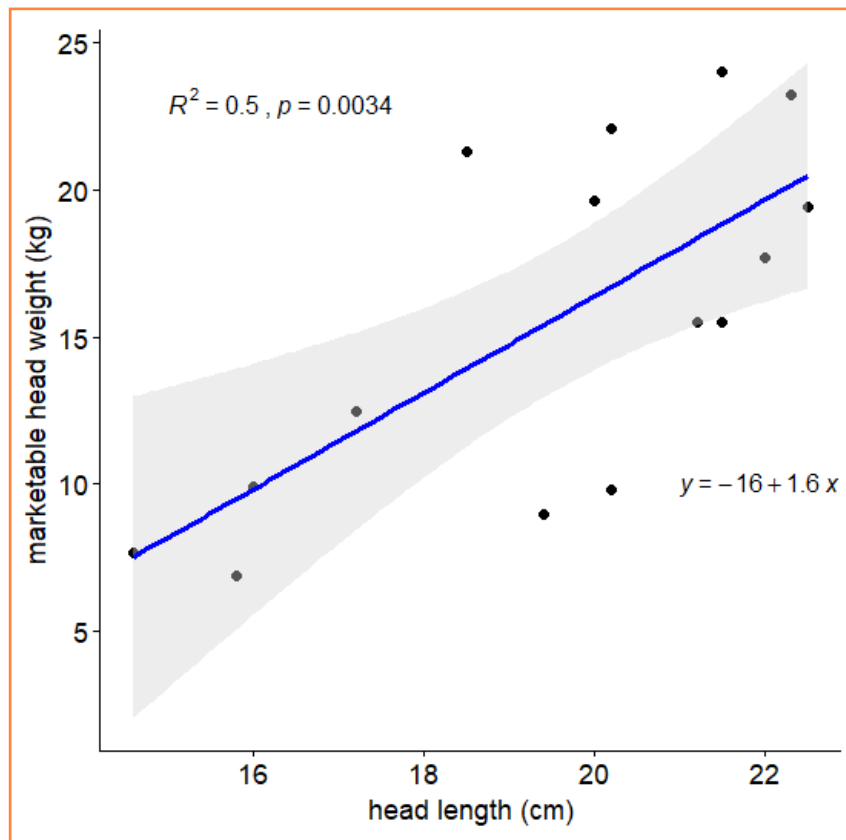


Figure 3a Linear regression analysis of head height (X) on marketable head weight (Y)

A negative intercept value implies that the line of best fit crosses the Y-axis below zero indicating that the dependent variable has a negative value when the independent variables are zero. The closer the points are to the line of best fit, the stronger the association between the two traits. In this investigation, as the head length increased by one unit, the head weight increased by 1.6 units. The strength of the association is moderate (50%). In a separate study, Olfati et al. (2010) reported a significantly positive multiple regression when they investigated the relationship between head weight, head length and leaf area of cabbage and broccoli using non-destructive methods.

3.5.2 Linear Regression Analysis of Head width (X) on Head Weight (Y)

The linear relationship between head weight (Y) and head width (X) (Fig. 3b) indicates that the proportion of variability in head weight (Y) was indeed explained by the linear function of the independent variable (head width). The intercept value is -8.60, and the R^2 value for this relationship is 57% at the probability of 0.001. The prediction equation for this linear regression between head weight (Y) and head width (X) is:

$$Y = -8.6 + 1.1X \quad (10)$$

This association is moderately strong (57%). If the fruit width was increased by one unit, the head

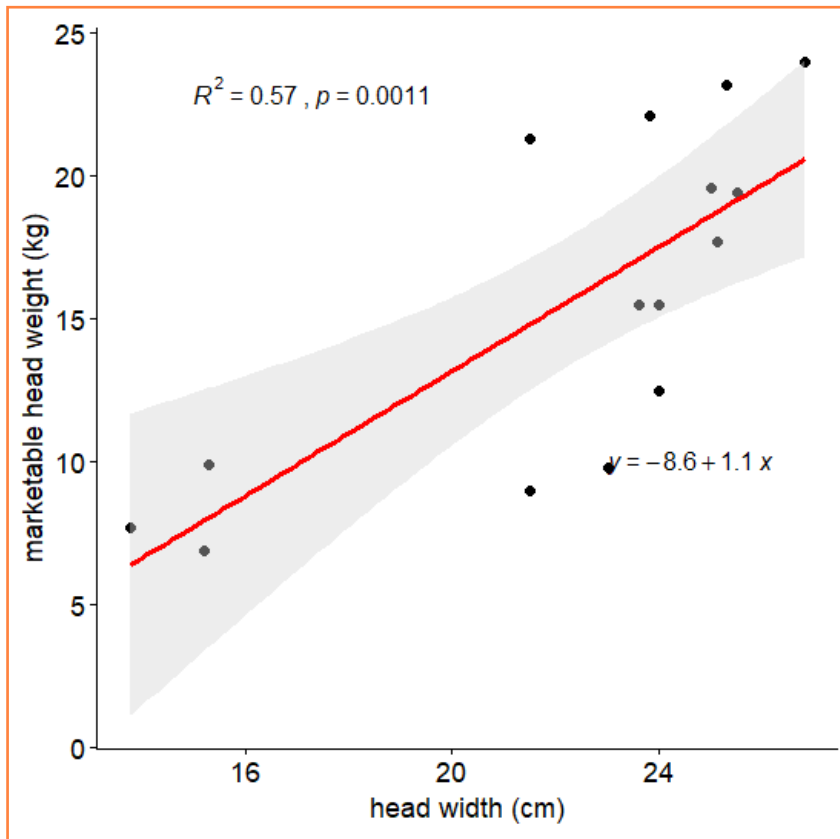


Figure 3b Scatter diagram in linear regression analysis of head width (X) on head weight (Y), the intercept and prediction equation

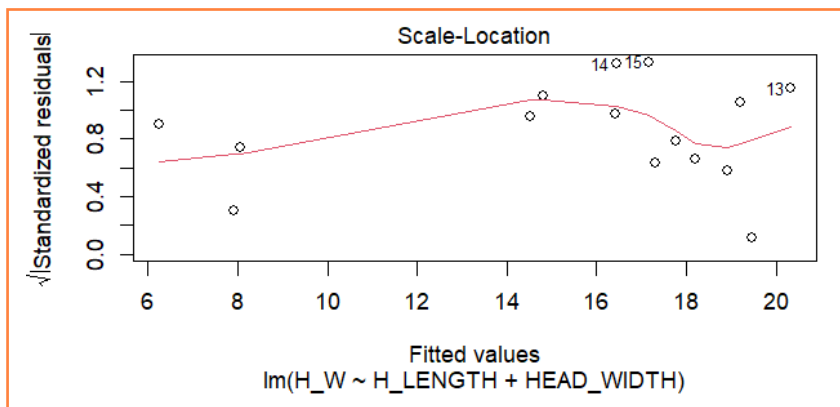


Figure 3c Scatter diagram in multiple regression analysis of head length (X_1), head width (X_2) on marketable head weight (Y)

weight increased by about 1.1 times. The head weight was about 1.1 times the product of the head width. This model can be used for the estimation of real head weight in future research and commercial production.

Sampson (2010) reported a high and positive correlation coefficient between head width and head weight in cabbage hybrids subjected to varying nitrogen sources.

3.6 Multiple Regression Analysis of Head Length (X_1), Head width (X_2) and Plant Length on Marketable Head Weight (Y)

The multiple relationship of head weight (Y) as a function of head length (X_1), head width (X_2) and plant length (X_3) showed a statistically significant model. The R^2 value of 0.60, adjusted R square of 0.40 and negative intercept of -10.57 were recorded. The prediction equation for the contribution of head length, head width and plant length to head weight is given as:

$$Y = -10.57 + 0.27 (X_1) + 0.93 (X_2) + 0.01 (X_3) \quad (11)$$

3.7 Multiple Regression Analysis of Head Length (X_1), and Head width (X_2) on Marketable Head Weight (Y)

The multiple relationship of head weight (Y) as a function of head length (X_1) and head width (X_2) showed a statistically significant model. The R^2 value of 0.60 was obtained, and a negative intercept of -10.99 at $P < 0.003$ (Fig. 3c and Fig. 3d) was recorded. The prediction equation for the contribution of head length and head width to head weight is given as:

$$Y = -10.99 + 0.31 (X_1) + 0.92 (X_2) \quad (12)$$

The R^2 of 60% of the total variation in head yield of the five cabbage hybrids was accounted for by a linear function involving X_1 and X_2 . Similarly, the multiple relationship of head weight (Y) as a function of head length (X_1), and head width (X_2) suggests that the head length and head width contributed to head weight, and some portion of variability in the dependent variable (Y) is indeed explained by the linear function of the independent variable (60%). The result agrees with the investigation of Kenneth

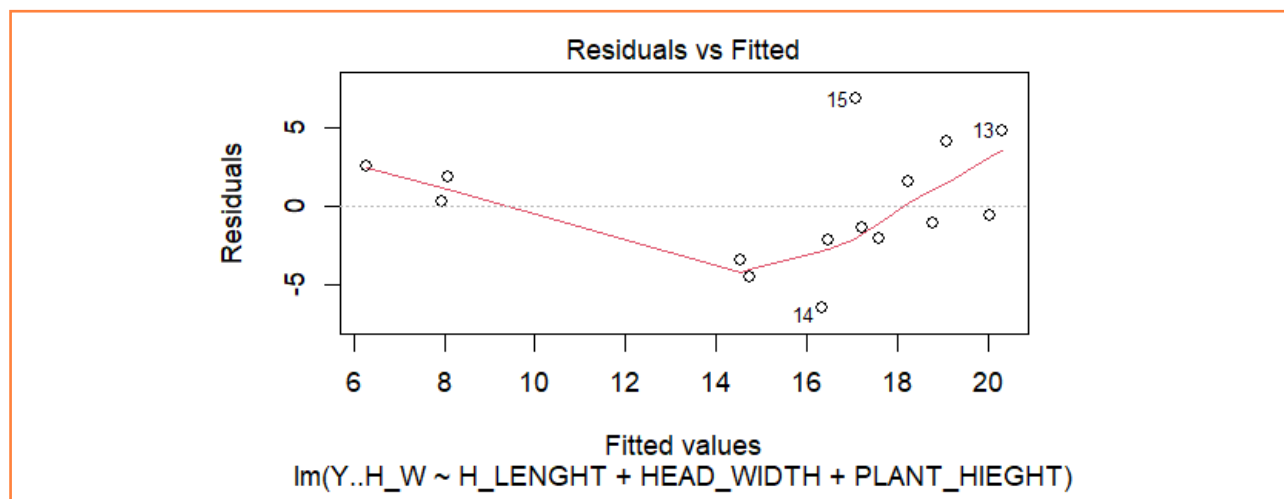


Figure 3d Scatter diagram in multiple regression analysis of head length (X_1), head width (X_2) and plant height (X_3) on marketable head weight (Y)

(2012) who reported similar results when he worked on the performance of three cabbage varieties.

The study concluded that both head length and width are positively associated with marketable head weight. Paske' and 'Montra' outperformed other hybrids for head size, and may be recommended for cultivation in the derived guinea savannah. Phenotypic improvement in head length or head width will compensate for larger head size. The coefficient for predicting the marketable head weight was 12.22. If the head length and width are known, they are multiplied by 12.22, then the head weight can be estimated. The prediction equation may enhance productivity of commercial cabbage growers in derived guinea savannah.

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