

EVALUATION OF THE PERFORMANCE OF THREE CABBAGE (*Brassica oleraceae* var. *Capitata* L.) VARIETIES

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ABSTRACT

Three cabbage varieties, 'Benelli', 'Cairo' and 'Paradox', were evaluated in a replicated small plot trial at the Gladstone Road Agricultural Centre during 2012. The factorial experiment was established in a completely randomised design, using three cabbage varieties harvested at four different dates. Significant differences for head width and head length were obtained among the varieties tested, with significant interaction between harvest date and variety. There was no significant effect for cabbage weight. The results obtained showed that the variety 'Paradox' produced the longest head length and largest head width. In addition, the highest head weight and best yield potential (37.7 tonnes/hectare) were obtained from this same variety.



Cabbage variety 'Benelli' grown at the Gladstone Road Agricultural Centre during 2012.

Introduction:

Cabbage (*Brassica oleraceae* var. *Capitata* L.) belongs to the Brassicaceae family and is one of the most important of the green leafy vegetables grown under temperate to tropical climate conditions (Singh *et al.*, 2010). According to worldwide estimates, there are more than two million hectares under production, with an average yield of 27.8 tonnes per hectare (FAOSTAT, 2010). The cabbage is a crop plant that is easily grown on a wide range of soil types and is adaptable to many different climatic conditions (Smith, 1995). The cabbage has been ranked by the Food and Agriculture Organisation among the top twenty vegetable crops grown,

establishing it as an important food source, globally (FAO, 1988). It is high in water content, fibre, protein, calcium and iron, and is a rich source of vitamin A and vitamin C (Adeniji *et al.*, 2010; Meena *et al.*, 2010). This leafy vegetable is used mainly in salads, as a fresh food item, but is also cooked with other foods, and is suitable for processing into products such as sauerkraut.

The cabbage is a cool season crop which grows best under cool, moist weather conditions (Thompson, 2002). This leafy vegetable can grow well on a wide range of soil types provided adequate moisture and fertiliser is supplied. It is fairly easy to grow a successful crop of cabbages, as long as varieties suitable to the growing environment are selected and the proper cultural and pest management practices are followed.

There is much variation among cabbage types, with colours ranging from green to purple, and leaves from smooth to crinkly. The head shape may be flat, round or pointed, with variations among these shapes. Maturity can range from early to late in the growing season. Green, round-headed cabbages are the most common types.

Cabbage varieties have been bred to produce good yielding mature heads very early in the season (Cervenski *et al.*, 2011). For farmers growing cabbage in both tropical and temperate climates, varieties with a short growing season, or less number of days to maturity, are more advantageous for meeting early market demands (Adeniji *et al.*, 2010). Tanaka and Niikura (2006) have concluded the same, in their analysis of the development characteristics related to the earliness of head formation in cabbage. They reasoned that, in order to address market demands, head shape, size and density must correlate with earliness of head formation.

Cabbage is a significant crop in The Bahamas, is widely grown, and is a good source of income for local farmers. Production of this crop is almost year round, produced mainly by small and medium-sized farmers. Cabbage is produced on approximately 75 hectares (185 acres) of farmland, constituting some 4.0% of the total area under vegetable production (Ministry of Agriculture, 1996). Local yields have been estimated at about 12.6 tonnes per hectare (10,282 lb per acre) (Ministry of Agriculture, 1996). Cabbage is a hardy vegetable crop that does well under growing conditions of The Bahamas, if suitable varieties are selected. Among the major considerations in selecting improved varieties suitable for cultivation on Bahamian soils are head shape and size.



Developing cabbage head of the purple variety 'Cairo', grown at the Gladstone Road Agricultural Centre during 2012

Objective:

The object of this study was to evaluate the yield and quality characteristics of three commercial cabbage varieties in order to determine the best suited to growing conditions within The Bahamas.

Materials and Methods:

This experiment was conducted at the Gladstone Road Agricultural Centre, New Providence, during the 2011-2012 winter vegetable growing season. The 3 x 4 factorial experiment was established in a completely randomised design, using three cabbage varieties harvested at four different dates. The three cabbage varieties were replicated four times. Each replicate consisted of a double row of thirty plants with a plant to plant spacing of 45 cm (18 inches) and a spacing of 50 cm (20 inches) between the double rows. Distance between each double row was 1.5 m (60 inches). For each variety, ten cabbages were harvested randomly from a single replicate on each of several harvest dates.

The seeds used in this experiment were ‘Benelli’, ‘Cairo’ and ‘Paradox’. ‘Benelli’ and ‘Paradox’ are green-headed cabbages with flat to round heads and an average mature weight of about 2.7 kg (6.0 lbs). ‘Cairo’ is a purple-headed cabbage with a perfectly round shape, and is smaller and more compact than ‘Benelli’ and ‘Paradox’. ‘Paradox’ is suitable for long term storage, while ‘Benelli’ and ‘Cairo’ are both fresh market hybrids. The three cabbage varieties are all distributed by the Seedway Seed Company.

The varieties were planted in a field seedbed on 11 November, 2011 and transplanted to field plots in double rows on the 5 December, after 19 days of growth. Three weeks after transplanting, fertiliser of the formulation 8-18-8 was banded along the growing plants in one application. Weeds were controlled by hand cultivation. The cabbage plots were sprayed on a weekly basis with a combination of Xentari® and Bravo® with Nutrileaf® liquid fertiliser in a 20-20-20 formulation. The plots were irrigated with a drip irrigation system which supplied water throughout the growing season.

Harvesting took place on the 3rd, 10th, 17th and 20th of February, 2012; respectively, 60, 67, 74 and 77 days after transplanting to the field. Only heads of marketable size were harvested. Outer leaves were stripped from the heads and the weights recorded. Head width (diameter) was measured with a ruler across the horizontal section of the cabbage head. Head length was measured longitudinally from the top of cabbage to the bottom.

The mean daily maximum and minimum temperatures for the trial period were 27.1°C (80.8°F) and 19.6°C (67.3°F), respectively. The total rainfall for the period was 93.8 mm (3.69 in). Mean monthly sunshine duration for the period was 7.8 h. Weather information (Table 1) was obtained from the Meteorological Department of The Bahamas.

Table 1. Weather data on rainfall, hours of sunshine and mean maximum and minimum temperatures for New Providence for the period of November 2011 to March 2012, courtesy of the Meteorological Department of The Bahamas.

| Month | Total rainfall (mm/inches) | Mean monthly radiation (h) | Mean maximum temperature (°C/°F) | Mean minimum temperature (°C/°F) |
|---------------|----------------------------|----------------------------|----------------------------------|----------------------------------|
| November 2011 | 20.1/0.79 | 8.1 | 28.2/82.7 | 21.6/70.8 |
| December 2011 | 22.9/0.9 | 7.0 | 26.9/80.4 | 19.8/67.6 |
| January 2012 | 6.6/0.26 | 8.0 | 26.1/78.9 | 17.8/64.0 |
| February 2012 | 44.2/1.74 | 8.1 | 27.2/81.0 | 19.2/66.6 |

Note: Monthly mean values have been rounded up to the nearest tenth

Statistical Analyses:

All experimental results were analysed using Instat+™ and ASSISTAT. Instat is an interactive statistical package, copyright © 2006, Statistical Services Centre, University of Reading, UK. All rights reserved. ASSISTAT, Version 7.6 beta (2012), website – <http://www.assistat.com>, by Francisco de Assis Santos e Silva, Federal University of Campina-Grande City, Campina Grande, Brazil.



Two views of the cabbage variety trial established at the Gladstone Road Agricultural Centre during 2012

Results:

Analysis of variance (Table 2) for the three cabbage varieties indicated significant differences for cabbage head width and head length. No significant effect was determined for cabbage weight. Harvest date had no significant effect on any of the yield responses. Cabbage head width and head length were both influenced by significant interactions among variety and harvest date.

Table 2. Analysis of Variance (ANOVA) of weights, head width and head length of three cabbage varieties. Error mean square has 119 df. *, ** and *** denote statistical significance at 5, 1 and 0.1% level of confidence, respectively. ns indicates differences between means not significant. -----Significance levels-----

| Source | df | Weight of cabbage (g) | Head width (cm) | Head length (cm) |
|------------------------|-----|--------------------------|--------------------|---------------------|
| Variety | 2 | ns | * | * |
| Harvest date | 3 | ns | ns | ns |
| Harvest date x Variety | 6 | ns | ** | ** |
| Error | 108 | | | |
| Std Err | | 24.0 | 0.31 | 0.26 |

The mean values for yield and yield contributing characteristics of the three cabbage varieties are shown in Table 3. The variety ‘Paradox’ had a higher cabbage head width, head length and weight than the other two varieties, though the differences were not always significant statistically. No significant difference was observed in the cabbage head weights. All three varieties produced very solid heads. ‘Cairo’, though a small cabbage, was actually heavier than it looked. It had a dense head, with leaves wrapped tightly around its small central core. Its head weight was comparable to the large green types ‘Benelli’ and ‘Paradox’.

The mean weight for each of the three cabbage varieties was expressed as g per head. These figures were extrapolated to reveal the yield potential of the three varieties, expressed as tonnes per hectare and pounds per acre (Table 3). The varieties ‘Cairo’ and ‘Paradox’ appeared to be similar in yield capability, while ‘Benelli’ yielded the least of the three.

Table 3. Mean values of three cabbage varieties evaluated at the Gladstone Road Agricultural Centre during 2011.

| Variety | Head weight (g) | Head width (cm) | Head length (cm) | Yield potential (tonnes/ha) | Yield potential (lbs/acre) |
|---------|-----------------|-----------------|------------------|-----------------------------|----------------------------|
| Benelli | 1432.8a | 15.9a | 13.8ab | 35.4 | 31,526 |
| Cairo | 1519.0a | 14.6b | 13.2b | 37.5 | 33,444 |
| Paradox | 1526.7a | 16.0a | 14.4a | 37.7 | 33,620 |

The variety ‘Paradox’ produced the longest head length and largest head width. Plate 1 illustrates the method used to determine the head width and head length of the three cabbage varieties.



Plate 1. Mature compact heads of cabbage cut to show how measurements were calculated; width (left) in horizontal section and length in vertical section (right).

Mean values for cabbage head width and cabbage head length for the different harvest dates are shown in Table 4. There was no significant interaction between variety and harvest date for cabbage head weights, so no comparison of means was done for this yield component. The interactive effect of harvest date and variety for the two yield components indicate significant variation with each harvest date. Mean values for the varieties ‘Benelli’ and ‘Paradox’ appear to be more uniform over the harvest dates, compared to ‘Cairo’.

Table 4. Mean values of yield responses of three cabbage varieties assessed over 4 harvest dates during February, 2012

| Harvest date | Head width (cm) | | | Head length (cm) | | |
|--------------|-----------------|--------|---------|------------------|--------|---------|
| | Benelli | Cairo | Paradox | Benelli | Cairo | Paradox |
| 3 February | 17.6aA | 12.2bB | 16.6aA | 14.6aA | 11.3bC | 15.3aA |
| 10 February | 12.3bB | 17.9aA | 17.8aA | 11.5bB | 16.4aA | 15.8aA |
| 17 February | 16.9aA | 15.6aA | 12.9bB | 13.7aA | 13.9aB | 11.3bB |
| 20 February | 16.7aA | 12.5bB | 16.5aA | 15.4aA | 11.0bC | 15.2aA |

The t-test at a level of 5% probability was applied. For each harvest date, means within rows bearing different uppercase letters differ significantly at 5% level of confidence. For each variety, means within columns bearing different lowercase letters differ significantly at 5% level of confidence. The t-test of comparison of means was not applied for the cabbage head weights as there was no significant interaction between variety and harvest date for this yield component.

The post-harvest quality characteristics of the three cabbage varieties are displayed in Table 5. All three cabbage varieties matured from transplanted seedlings to the first harvestable heads at dates much earlier than the stated harvest dates for each of them. The cabbage head weights were generally smaller than accepted weights for these varieties.

Table 5. Post-harvest quality characteristics of three cabbage varieties evaluated at the Gladstone Road Agricultural Centre during 2011.

| Variety | Stated days to maturity from transplanted seedlings | Actual days to maturity from transplanted seedlings | Head colour | Head shape | Head size (kg/head) | Head width (cm) | Head length (cm) | Visible signs of insect damage, disease or chlorosis |
|---------|-----------------------------------------------------|-----------------------------------------------------|-------------|-----------------------------|---------------------|-----------------|------------------|------------------------------------------------------|
| Benelli | 78 | 60 | Green-blue | Slightly flattened to round | 1.43 (3.16 lb) | 15.9 (6.3 in) | 13.8 (5.4 in) | none |
| Cairo | 85 | 60 | purple | Round | 1.51 (3.34 lb) | 14.6 (5.7 in) | 13.2 (5.2 in) | none |
| Paradox | 105 | 60 | Gray-green | Round, large | 1.52 (3.37 lb) | 16.0 (6.3 in) | 14.4 (5.6 in) | none |

Discussion:

Cabbage yield and yield characteristics are determined by several factors, such as variety, plant spacing, environmental conditions and market requirements, among others. Days to maturity, or earliness, in cabbage is largely determined by variety, and is a desirable characteristic when varieties with short growth cycles are required to meet market demands (Cervenski, *et al.*, 2012). Differences in daylight hours and temperatures also affect the number of days to maturity (Greenland *et al.*, 2000). The actual days to maturity from transplanted seedlings to harvestable cabbage heads were much earlier than the stated days to maturity for the three cabbage varieties evaluated. Results from this experiment showed that the varieties ‘Benelli’, ‘Cairo’ and ‘Paradox’ could produce marketable size cabbage heads within 60 days, much earlier than the stated days to maturity of 78, 85 and 105, respectively. According to Tanaka and Niikura (2006), early head formation in cabbage enables early harvesting in both hot and cold climates shortly after the season begins.

The cabbage variety ‘Paradox’ presented the highest mean yields of marketable heads of cabbage per hectare (Figure 1) at 37.7 t/ha compared to ‘Benelli’ at 35.4 t/ha and ‘Cairo’ at 37.5 t/ha. According to FAOSTAT estimates, the average global yield in 2010 for cabbage was 27.8 t/ha, which is well below the results obtained by this study, under experimental conditions.

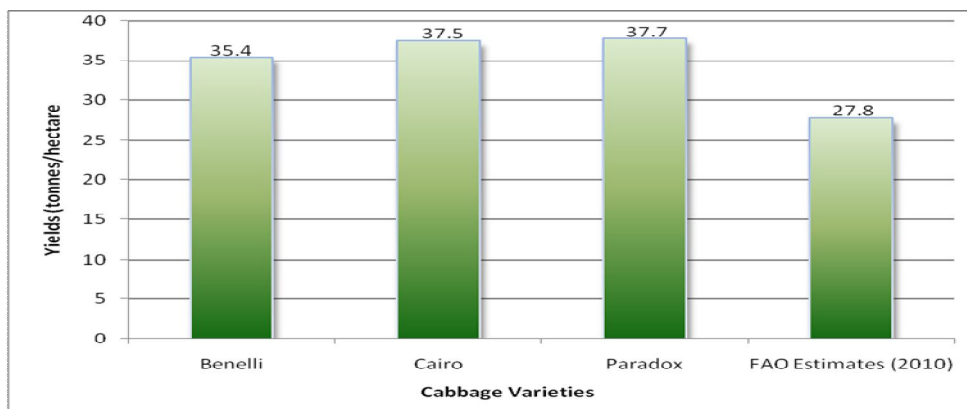


Fig. 1. Average yields of three cabbage varieties evaluated at the Gladstone Road Agricultural Centre during 2012. FAO global yield estimates for cabbage in 2010 are found in the column at far right.

Overall, yields from the three improved varieties were superior to yields that are commonly expected from locally grown cabbages. Average head weights ranged from 1.43 kg (3.16 lb) for 'Benelli' to 1.52 kg (3.37 lb) for 'Paradox'. Head weights were very similar among the three varieties. These cabbages are classified as medium-sized, based on USDA standards for grades of cabbage (USDA-AMS, 1997). The head weights and other yield characteristics of the varieties in this study are consistent with Greenland *et al.*, (2000), who determined that cabbages for the fresh market must have high head densities, small to medium-sized heads, and good appearance. In general, the three cabbage varieties were uniform and tightly formed. There were no visible signs of insect damage, wilting or chlorosis on any of the leaves. From these results, it can be seen that with superior cabbage varieties and improved growing conditions, increased yields could be obtained from this leafy vegetable crop.

Conclusion:

It can be concluded that, from the results obtained in this study, the variety 'Paradox' is preferable to the other two cabbage varieties. This determination is based on its superior head weight, head width, head length and best yield potential. In general, the three varieties displayed good to excellent quality characteristics. The earlier these varieties are harvested, the less likely they are to be exposed to insect pest and disease problems. As the local market appears to favour smaller sized cabbages, local farmers may select from any of these three varieties, which were harvested early with smaller heads, but were fully matured.

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