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Evaluation of Improved Exotic Head Cabbage (*Brassica Oleracea* Var *Capitata* L.) Varieties at Adola Rede Areas, Southern Oromia, Ethiopia

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Evaluation of exotic varieties was carried out to select the most adaptable and high yielding improved or exotic varieties. Field experiments were conducted during the 2017 and 2018 short rainy season at three locations with supplemental irrigation. A randomized complete block design with three replications was used; each plot consisted of five rows and eight plants per row having spacing of 40cm*50cm on a plot size of 2.5 m* 2.8 m. Improved exotic cabbage varieties Olsen, Royal, Monarch and DSA Copenhagen market were used for the study. A widely cultivated variety (Gloria) was included as check. The two years combined data analysis results revealed that for each seasons and locations days to head initiation, days to 80% maturity, plant height, number of expanded true leaves, diameter of head, untrimmed head mass, trimmed head mass, head yield with wrapper, head yield without wrapper and total head yield had differently significance (P<0.05) among the varieties. But there was non-significance difference (P> 0.05) mean of head height of each variety. The maximum days to head initiation (72 days) were attained by Gloria variety where the minimum (63.83, 64.25, 65.08 and 65.91 days) duration was observed by Olsen, Royal, DSA and Monarch varieties, respectively. While the maximum days (100.5 days) to maturity was recorded by Gloria variety and the minimum days (93 days) were recorded by Olsen variety. Regarding the plant height the highest (30.74 cm) result was attained by Monarch variety and the minimum (21.93 cm) was recorded by Gloria variety. As combined analysis of improved varieties over locations and years means revealed that the highest (17 leaves) expanded true leaves were obtained from Monarch variety. However, the lowest true leaves (8, 9, and 10) were obtained from Royal, Olsen and DSA varieties. Similarly the highest (21.16 cm) diameter of head was recorded by Royal variety, while the rest improved varieties were with minimum head height. There was non-significant difference between varieties on height of head. The maximum (4735 g) untrimmed head mass was observed by Royal variety, while the minimum (2180 g) was recorded by DSA Copenhagen variety. Regarding the trimmed economic head mass the maximum (3960 g) was recorded by Royal variety and the minimum (1310.3 g) was by DSA Copenhagen variety. The highest (78.69 t ha-1) yield without wrapper was recorded by Royal variety while the lowest (53.39 t ha-1) yield without wrapper was recorded by DSA Copenhagen variety. And also the highest (164.14 t ha-1) total yield was observed by Royal variety and the lowest (129.49 t ha-1) total yield was recorded by DSA Copenhagen variety. Generally, as a conclusion and recommendation, for head cabbage growers at Adola Rede and similar agro ecologies improved varieties of Royal and Monarch were selected and recommended for better early maturing, maximum head yield, head shape, head size, and low incidence of loose heads.

Key words: Improved cabbage varieties, growth, head yield, yield components

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INTRODUCTION

Cabbage *(Brassica oleracea* L. var. *capitata)* is a member of the Brassicaceae (Mustard) family. This family includes broccoli, Brussels sprouts, cauliflower, kale, mustard (greens), and collards. Collectively, these crops are referred to as cole crops or crucifers. Now, cabbage and many of the cole crops are cultivated throughout the world for use fresh and in processed products. Nutritionally, 1 cup of raw cabbage contains 93 percent water and is a good source of dietary fiber as well as vitamins A and C. Worldwide, China is the leading producer and consumer of cabbage. In the United States, 80,000 acres of cabbage valued at almost $280 million was harvested in 1997 [1].

Ethiopia has significant agro-ecological variability that shapes crop production areas across the country. Cabbage (*Brassica oleraceae* var. *capitata*) is one of the most important leafy vegetables worldwide [6]. It originated in Northern Europe, the Baltic Sea coast [3] and the Mediterranean region [6], where it has been grown for more than 3000 years and is adapted to cool moist conditions [7, 8]. Cabbage is cultivated for its head, which consists of water (92.8%), protein (1 .4 mg), calcium (55.0 mg) and iron (0.8 mg); the leaves are eaten raw in salads or cooked. The optimum mean temperature for growth and quality head development is 1 5 - 1 8°C, with a minimum temperature of 4°C and a maximum of 24°C. Cabbage grows well on a range of soils with adequate moisture and fertility. It tolerates a soil pH range of 5.5 - 6.8 and it is a heavy feeder.

The importance of head cabbage in tropical and subtropical regions has increased considerably in recent decades. Recent estimates indicate Africa has 1 00,000 ha planted with head cabbage [9]. Based on sales of commercial seed, at least 40,000 ha of white-headed cabbage is grown in Kenya, Uganda and Tanzania; 1 0,000 ha in Malawi, Zambia and Zimbabwe; 4000 ha in Ethiopia; and 3000 ha in Cameroon. [10] Reported that vegetables can be planted throughout the year provided there is reliable soil moisture. Cabbage is one of the most important vegetable in Kenya, and is grown by smallholder farmers for food and source of income.

Cabbage is believed to have originated in Western Europe and it was the first cole crop to be cultivated. Prior to cultivation and use as food, cabbage was mainly used for medicinal purposes. In addition to the fresh market, cabbage is now processed into Kraut, egg rolls and cole slaws and there is the potential for other specialty markets for the various types including red, savoy and mini cabbage. Cabbage is an excellent source of Vitamin C. In addition to containing some B vitamins, cabbage supplies some potassium and calcium to the diet. 250 mL of raw cabbage contains 21 kilocalories and cooked 58 [3].

The importance of head cabbage in tropical and subtropical regions has increased considerably in recent decades. Recent estimates indicate Africa has 1 00,000 ha planted with head cabbage [9]. Based on sales of commercial seed, at least 40,000 ha of white-headed cabbage is grown in Kenya, Uganda and Tanzania; 1 0,000 ha in Malawi, Zambia and Zimbabwe; 4000 ha in Ethiopia; and 3000 ha in Cameroon. Almost all white-headed cabbage is produced for local urban markets. Mozambique imports considerable quantities of headed cabbage from South Africa and until recently also did so from Zimbabwe. [4] Reported a total production of head cabbage in Tanzania to be about 208, 919 ton in 1996.

Evaluating cabbage varieties for adaptation and yield will help farmers, breeders and seed companies to select and develop varieties best suited to the local environment and market. Improved cabbage cultivars are not yet sufficiently put under production and most of the areas in the zone are using unknown variety (the broadleaved cabbage).

The area was a highly potential for these vegetable productions. Most of the farmers produce head cabbage widely using unknown variety and source; as a result the production is characterized by low yield due to the high yielding and disease/insect pest resistant variety and shortage of improved and even lack of access. Therefore variety development and promoting those technologies is very necessary in order to change the life and income of the farmers.

MATERIALS AND METHODS

Description of the Study Sites

The field trials were conducted during 2017 and 2018 main cropping season at Shakiso Boke, Dole and Odabuta locations of Adola Rede district. The average climatic condition of the area is sub humid moisture and moist condition, with relatively short growing season. Adola district belongs to the agro-ecological classification of hot to warm sub-moist mid-lands. The experimental area is situated averagely at an altitude of 1768 meters above sea level and is located 469 km south of Addis Ababa along the Hawassa road. The district was characterized by three agro-climatic zones, namely high land, mid land and low land with different coverage. The main rainy season is from May to October. The mean annual rain fall and temperature of the district was about 978 mm and 12-34 ^{0}c respectively.

Treatments and Experimental Design

Field experiments were conducted in April main cropping season having relatively short rainy season. A

randomized complete block design with three replications was used; each plot consisted of five rows and eight plants per row having spacing of 40cm*50cm on a plot size of 2.5 m* 2.8 m. Cabbage seedlings was raised on flat bed for four weeks and then transplanted to the sides of the ridges with 0.50 m space between plants. Cabbage varieties those were commercially available on the market Olsen, Royal, Monarch and DSA Copenhagen market were marketed and used in the study. A widely cultivated variety (Gloria) was included as check. Weeding was carried out manually and frequently to maintain weed free plots. Fertilizer NPS was applied during transplanting and also after transplanting. Urea was applied at the rate of 138 kg ha^{-1} in a split application at transplanting and 30 days after transplanting.

Data Management and Statistical Analysis

Measurements of plant height, number of expanded true leaves (leaves with a clearly visible petiole before head initiation), average head mass (gm.) as untrimmed head mass and trimmed mass, diameter of head (cm), head height (cm), days to 50% head initiation, days to 90 % maturity and total fresh marketable yield was recorded from samples of each treatments. At harvest, total mass (with and without wrapper leaves) was recorded. The diameter and height of the head was obtained by cutting the head longitudinally.

Statistical Analysis

Analysis of variance procedures was used on every measured parameter to determine the significance of differences between means of treatments using the SAS systems software for each parameters, and separated by the least significant difference (LSD) using the statistical package. Yield and yield related data was statistically analyzed using the Proc Glm function of SAS and means were compared using LSD at a probability level of 5 % [5].

RESULTS AND DISCUSSIONS

Days to 80% head initiation, maturity, plant height, head diameter, head height, trimmed and untrimmed head mass, yield with wrapper and yield without wrapper and total yield of the plot was measured and converted to hectares.

Phenological and growth variables of cabbage

Our combined over location and season Anova result indicated that different cultivars had significant ($P<0.05$) influence on days to head initiation, days to 80% maturity, plant height and number of expanded true leaves in all consecutive two years (Table 1).

From the Anova analysis the result showed that the maximum days to head initiation (72 days) was attained by Gloria variety where the minimum (63.83, 64.25, 65.08 and 65.91 days) duration was observed by Olsen, Royal, DSA Copenhagen and Monarch varieties, respectively on both locations for two years (Table 1). Similarly the maximum (100.5 days) to maturity was recorded by Gloria variety while the minimum (93 days) was by Olsen variety. Regarding the plant height the highest (30.74 cm) result was observed by Monarch variety and where by the minimum (21.93 cm) was recorded by Gloria variety. (Figure 1)

Yield component and yield variables of head cabbage

The combined over location and year Anova result also indicated that different cultivars had significant ($P<0.05$) influence on diameter of head, untrimmed and trimmed head mass, and yield of head cabbage in all locations and consecutive two years (Table 2). But Non-significant differences ($p >0.05$) were found among the varieties for head height (Table 2).

The longest (21.16 cm) diameter of head was recorded by Royal variety, while the rest variety was with small head height (Table 2). These results suggest large genetic difference among the variety and that environmental differences between varieties influence the expression of crop growth characters. But the height of the head didn't show significant different between each varieties.

The analysis of variance over seasons and locations revealed highly significant ($p < 0.01$) different results on untrimmed and trimmed head mass. The maximum (4735 gm.) untrimmed head mass was observed by Royal variety, followed by Monarch (3309.2 gm.) variety. While the minimum (2180 gm.) untrimmed mass was recorded by DSA Copenhagen variety (Table 2). Regarding the trimmed economic head mass the maximum (3960 gm.) was recorded by Royal variety and the minimum (1310.3 gm.) trimmed head mass was by DSA Copenhagen variety (Figure 2).

The analysis of variance over seasons and locations revealed highly significant ($p < 0.05$) results was recorded by different varieties on yields (Table 2). From the Anova analysis the result showed that the maximum (86.52 t ha^{-1}) yield with wrapper was attained by Monarch variety where the minimum (63.71 t ha^{-1}) was observed by DSA Copenhagen variety on both locations for consecutive two years (Table 2). Similarly the maximum (78.69 t ha^{-1}) yield with out wrapper was recorded by Royal variety and followed by maximum (68.84 t ha^{-1}) yield by Monarch variety. While the minimum (53.39 t ha^{-1}) yield without wrapper was recorded by DSA Copenhagen variety (Figure 3).

Table 1. Mean value of varieties to different variables across location and year

Treatments	DHI	DM	ETLV	PH
Olsen	63.83[b]	93.58[b]	9.41[b]	25.44[b]
Royal	64.25[b]	98.50[ab]	8.58[b]	22.10[cd]
Monarch	65.91[b]	96.75[ab]	17.08[a]	30.74[a]
DSA	65.08[b]	96.58[ab]	10[b]	23.88[bc]
Gloria	72.25[a]	100.50[a]	9.41[b]	21.93[d]
Mean	66.26	97.18	10.90	24.82
Lsd	4.08	6.86	1.63	1.93
CV (%)	7.52	8.63	18.33	9.52

Means within the same column followed by the same letter (s) are not significantly different at 5% level of significance; LSD = Least Significant difference; NS= Not significant; CV= Coefficient of Variation; DHI=days to head initiation, DM=days to maturity, ETLV=average expanded leaves, PH=plant height

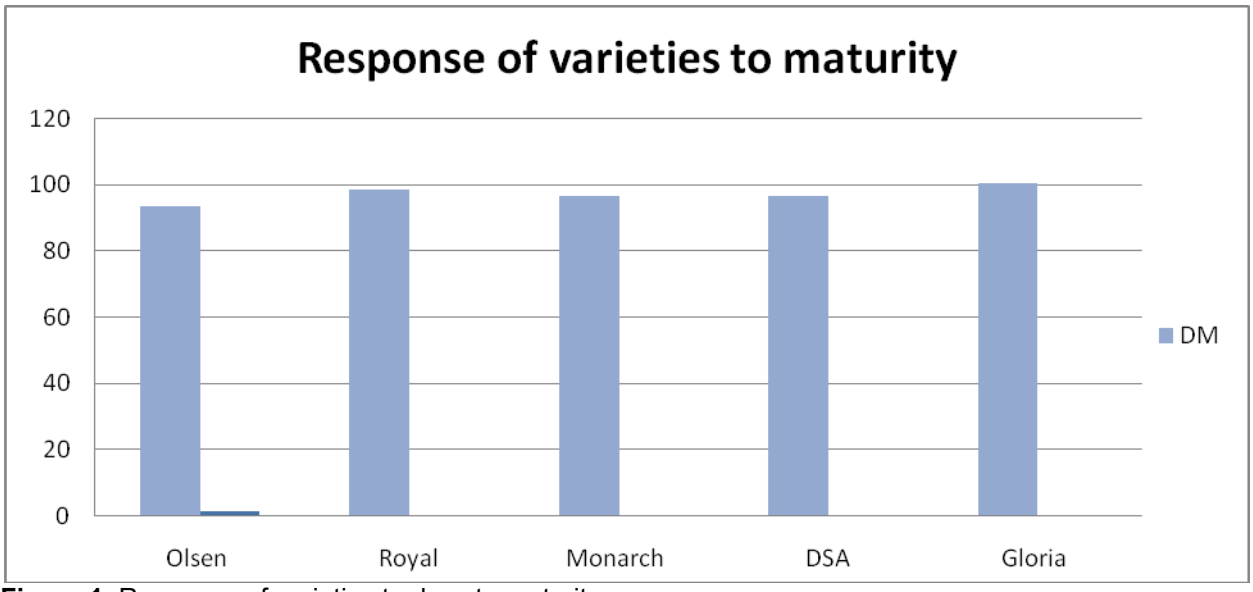

Figure 1. Response of varieties to days to maturity

And also the maximum (164.14 t ha^{-1}) total yield was observed by Royal variety and the minimum (129.49 t ha^{-1}) total yield was recorded by DSA Copenhagen variety. However Gloria and DSA Copenhagen variety showed yield reduction, indicating their unsuitability for cultivation during the short rainy season of the areas. Hence the area was characterized by inconsistent rainfall and high temperatures around 12-34 °C. The adaptation of Royal and Monarch to the short rainy season was evident in the head yields (Table 3).

Our study in the short rainy season showed that cabbage production in Adola areas and the cultivation of Royal and Monarch varieties evaluated during the short rainy season with supplemental irrigation could provide considerable maximum head yield. This could be evident that sufficient genetic variation exists among the cabbage varieties evaluated.

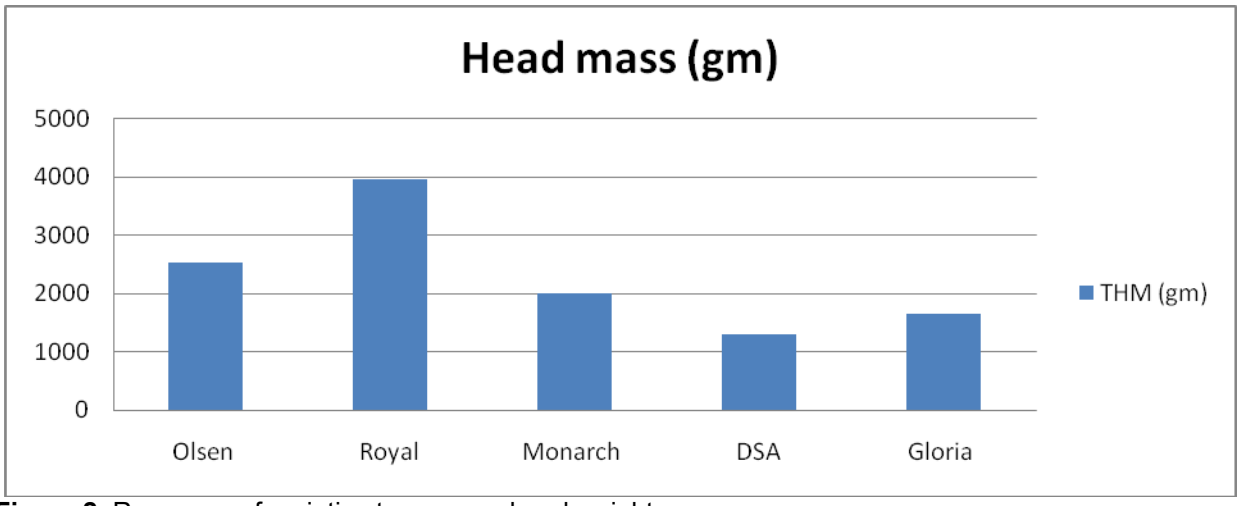

Figure 2. Response of varieties to average head weight

Table 2. Mean value of diameter of head, and height of head, untrimmed head mass, trimmed head mass.

Treatments	DH	HH	UTHM	THM
Olsen	18.91^{b}	17.20	2746.7^{bc}	2540^{b}
Royal	21.16^{a}	18.54	4735^{a}	3960^{a}
Monarch	18.88^{b}	17.65	3309.2^{b}	2007.4^{c}
DSA	18.72^{b}	17.63	2180^{c}	1310.3^{d}
Gloria	17.60^{b}	16.38	2717.5^{bc}	1658.1^{cd}
Mean	19.06	17.48	3137.66	2295.16
Lsd	1.96	NS	594.88	483.95
CV (%)	12.57	15.90	23.17	25.77

Means within the same column followed by the same letter (s) are not significantly different at 5% level of significance; LSD = Least Significant difference; NS= Not significant; CV= Coefficient of Variation; DH=diameter of head, HH=height of head, UTHM=untrimmed head mass, THM=trimmed head mass.

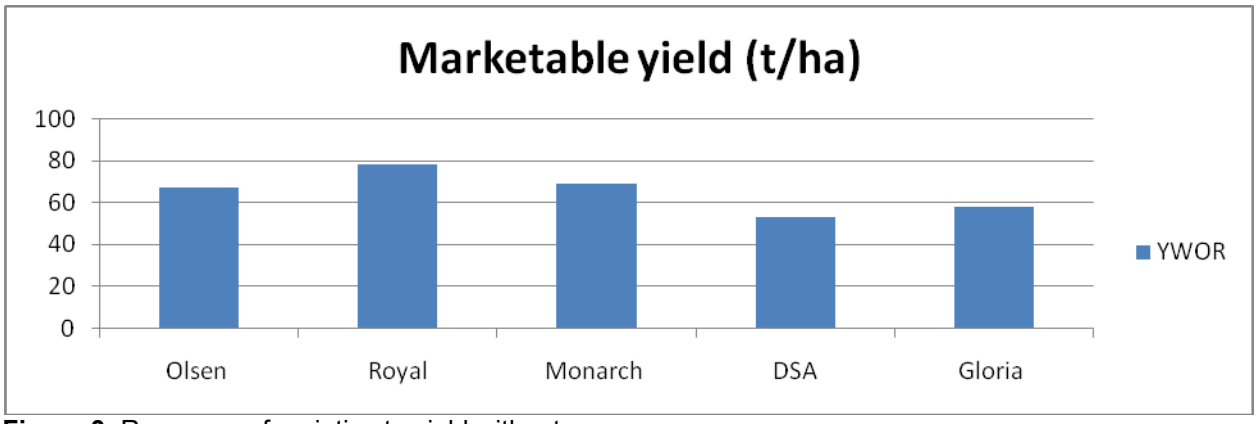

Figure 3. Response of varieties to yield without wrapper

SUMMARY AND CONCLUSION

The importance of head cabbage in tropical and subtropical regions has increased considerably in recent decades. Absence of improved variety and management practices introduction and adaptation studies of high yielding varieties with all agronomic management practices are very critical. Therefore, the present study

was initiated to select and Recommend high yielding, adaptable, frost, and insect and disease tolerant varieties. Accordingly, one widely cultivated variety with four improved head cabbage variety were evaluated at Adola district of shakiso boke, Dole and Oda buta locations for two years using randomized complete block design with three replications on a plot size of 2.5 m*2.8m per treatment unit.

The combined analysis across location and season shows that days to head initiation, days to 80% maturity, plant height and number of expanded true leaves was significantly ($P<0.05$) influenced by variety in all consecutive two years. And also summary of Anova revealed that combined over location and season indicated that different cultivars had significantly ($P<0.05$) different result on diameter of head, untrimmed and trimmed head mass, and yield of head cabbage in all locations and years between each tested variety.

The maximum (78.69 t ha^{-1}) yield without wrapper was recorded by Royal variety and followed by maximum (68.84 t ha^{-1}) yield by Monarch variety. While the minimum (53.39 t ha^{-1}) yield without wrapper was recorded by DSA Copenhagen variety. And also the maximum (164.14 t ha^{-1}) total yield was observed by Royal variety and the minimum (129.49 t ha^{-1}) total yield was recorded by DSA Copenhagen variety.

Generally from this study we get that the Royal and Monarch varieties were best in its all tested characters over the other varieties. *Therefore as a recommendation, head cabbage growers at Adola Rede and similar agro ecology farmers should grow head cabbage varieties of Royal and Monarch varieties for their better early maturing, maximum head yield, good head shape, firmness, marketable head size, and low incidence of loose heads.*

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