

MARKET DEMAND FOR HEAD SIZE OF CABBAGE AND SUITABLE PLANT SPACING FOR DOWN SIZING IT TO MEET THE DEMAND

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ABSTRACT

Most of the cabbage varieties commercially available in Sri Lanka produce larger heads (1,500-2,000 g) under the recommended plant spacing. Since consumer preference is towards medium size heads, farmers maintain different plant densities, which are higher than that of the recommendation and produces variable sizes of heads. Researchers worldwide indicated that there is a direct effect of plant spacing on head size of cabbage. The first step of this experiment was undertaken to study the market demand on head size while the second step was conducted to evaluate different plant spacing to identify the most suitable density to obtain a higher yield with preferable head size. However, a trader and consumer survey conducted in Badulla District identified that most of them preferred medium size heads (750 – 1,000 g) than larger sizes. The field experiment was carried out at a research field in Bandarawela in up country intermediate zone to identify the suitable plant density to produce marketable heads (750 -1,000 g) thereafter. Four different spacing viz. 50 x 30 cm (66,667 plants/ha), 40 x 40 cm (62,500 plants/ha), 40 x 30 cm (83,333 plants/ha) and 30 x 30 cm, (111,111 plants/ha) were evaluated and compared with the DOA recommended spacing of 50 x 40 cm (50,000 plants/ha). The most popular cabbage variety “Green Coronet” was cultivated with four replicated plots in a Randomized Complete Block Design (RCBD). Although higher yield was obtained at the highest density, their per plant head size was lower than preferred. Experimental results revealed that higher yield (78.41 t/ha) and preferable size of heads can be obtained at the plant spacing of 40 x 30 cm (83,333 plants/ha).

Key words: Cabbage, plant density, spacing, head size, consumer preference.

INTRODUCTION

Cabbage (*Brassica oleracea* var. *capitata*) is an important crop in the Up Country vegetable farming system because of comparatively low cost of

production and high marketability. Average yield of cabbage in Sri Lanka (24.9 mt/ha) is comparatively better than many other countries, and the recommendation of the Department of Agriculture (DOA) has contributed to this. Among recommended practices, in cabbage cultivation, present spacing has been produced larger heads of more than 1.5 kg (Agstat, 2014). Since consumer preference is towards medium size heads, farmers maintain different plant densities, which are higher than that of the recommendation and produces variable sizes of heads. Among the cultural practices, direct effect can be observed with increase or decrease in plant population because cabbage plant bears a single head (Purushottam and Khatiwada, 2001; Panda, 2008). Hence with altered plant spacing will be able to produce marketable size heads. Prabhakar and Srinivas (1990) recorded higher cabbage head yield with closer spacing (50x 30 cm 66,667 plants/ha) than wider spacing 50 x 40 cm (50,000 plants/ha) and 50 x 50 cm (40,000 plants/ha). Therefore, identification of consumer preferred head size and production of such heads with suitable plant spacing is a very important quality assurance step in cabbage production. The first step of this experiment was undertaken to study the market demand on head size while the second step was conducted to evaluate different plant spacing to identify the most suitable density to obtain a higher yield with preferable head size.

MATERIALS AND METHODS

Consumer preferred head size

A social survey to assess the consumer and dealer preferences for cabbage head sizes. Twenty five consumers and dealers were randomly selected from 5 major cabbage growing areas in Badulla District viz. Welimada, Uva Paranagama, Hali Ella, Bandarawela and Haputale. Data were collected using a structured questionnaire. Data from the market survey were statistically analyzed using the Statistical Package for the Social Scientist (SPSS). The results were presented in tables and charts with values presented in percentages using Microsoft Excel 2007.

Evaluation of suitable plant spacing to produce preferable heads

To identify the optimum plant spacing for cabbage to produce consumer and trader preferred cabbage head size, the field experiment was carried out at the Regional Agricultural Research and Development Centre (RARDC) Bandarawela

in the District of Badulla (IU_{3C}) during 2014/2015 season. Four different spacing viz. 50 x 30 cm (66,667 plants/ha), 40 x 40 cm (62,500 plants/ha), 40 x 30 cm (83,333 plants/ha) and 30 x 30 cm, (111,111 plants/ha) were evaluated and compared with the DOA recommended spacing of 50 x 40 cm (50,000 plants/ha). The most popular cabbage variety “Green Coronet” was cultivated with four replicates plots having the size of 2.4 x 2.5 m, arranged in a Randomized Complete Block Design (RCBD).

Dry weight of weeds present in each plot was determined by drying them in an electric oven at 80 °C for 48 hours. Canopy diameter, root length and marketable head weight without wrapper leaves were determined at harvesting stage. Head diameter and height were measured by splitting the heads longitudinally. Head compactness was determined by counting number of wrapped leaves from the outermost leaf to mid stem. Insect counts were made in two week intervals by counting Armyworm (*Spodoptera litura*), Diamond back moth (*Plutella xylostella*) and Semi lopper (*Trichoplusia ni*) caterpillar population in 10 heads. Data were analyzed by scoring method. Data of field experiment were analyzed by analysis of variance (ANOVA) procedures of the Statistical Analysis System (SAS version 9.1). Means were separated by Duncan multiple range test at $p < 0.05$.

RESULTS AND DISCUSSION

Consumer preferred head size

Figure 1 indicates the preference for size of the cabbage heads purchased by consumers and traders. Among different sizes observed 64% of consumers were willing to buy 750-1,000 g (medium) heads while rest preferred size percentage of both < 750 g (small) and >1,000 g (large) heads. The study showed that the marketability of cabbage is mostly depending on the consumer preference. Data indicated that, 84% of traders preferred medium size cabbage heads for marketing and 16% preferred small size heads (Figure 1).

As Figure 2 demonstrates, majority of consumers and traders dislike sliced cabbages. It is revealed that consumers and traders willing to buy or sell required amount as a whole head other than using sliced heads.

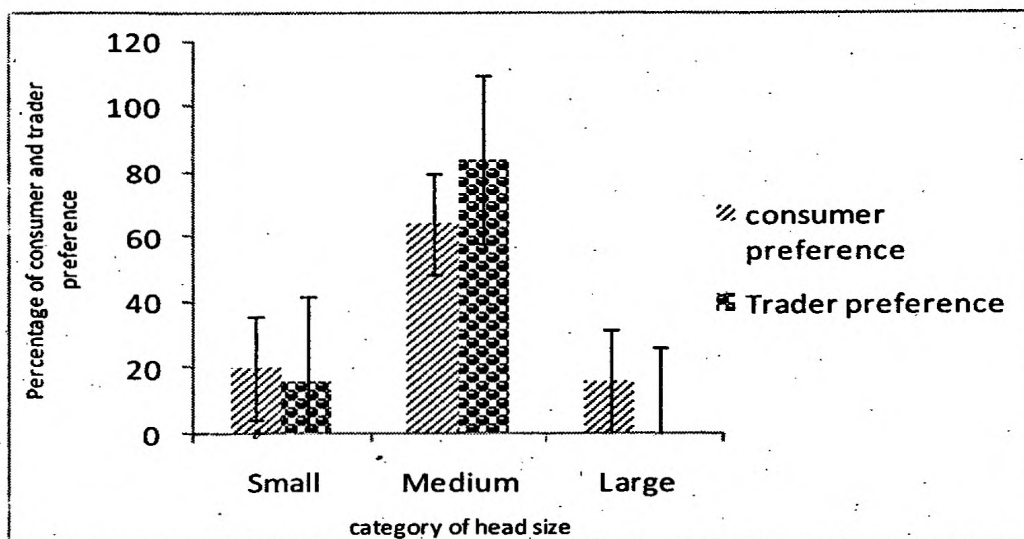


Figure 1: Preference for size of cabbage for consumption and marketing.

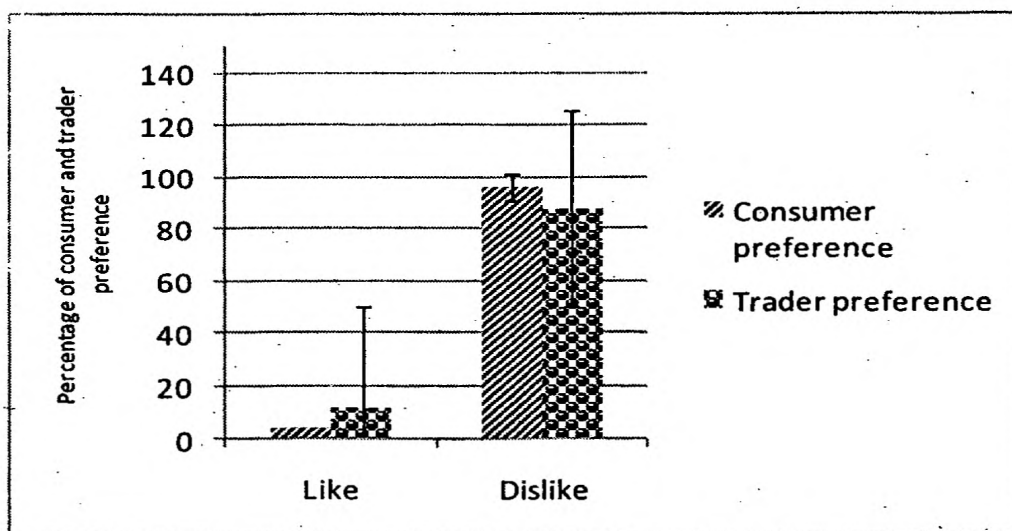


Figure 2: Preference for sliced cabbage by consumers and sellers in percentage

Problems related to large size cabbage heads

Both consumers and traders stated that storage difficulties, drop of outer leaves, spoilage, high weight and low demand were common problems with large size cabbage heads (Table 1). Majority of consumers and traders stated that the problem of spoilage of outer leaves in large size cabbages adds extra work to remove and clean. Large size of heads associated with personal preference and in addition they are too large for a small family. Some of them complained about the

heaviness in transport. Large head also occupies a large space in domestic refrigerators during storage. There is no any prominent one reason for reject large size heads and consumers and dealers equally complained about several reasons equally.

Table 1. Problems reported by consumers and traders during purchasing and marketing of large size cabbage heads

Problems reported by consumers and traders	Response (%)
Storage problem	20
Drop of leaves	24
Spoilage	13
Low demand as a family pack	23
Heaviness in transport	20

Outlook preference of cabbage for marketing and consuming

The results revealed that most of the consumers and dealers preferred cabbage heads for marketing with light green outer leaves (Table 2). Because, those minimize the problems occurred during marketing. Majority of the consumers and dealers preferred to handle cabbage heads with innermost outer leaves. It gives a good appearance and protection to the head. Due to losing of outer leaves in large size cabbages results more whitish inner leaves expose to outside tends to have more fungal and bacterial infections. It makes post-harvest losses due to formation of brownish patches with compact damages. Most of the consumers preferred 750-1,000 g head size of cabbage having light green outer leaves (Table 2).

Plant density had a significant effect on canopy diameter of cabbage (Table 3); the highest diameter was obtained at the lowest plant density (50,000 plants/ha; 50 x 40 cm spacing) and the lowest was found with the highest density (111,111 plants/ha- 30 x 30 cm spacing). Increasing the density up to 83,333 plants/ha, the head diameter reduction was 12% compared to DOA recommended density while the highest density showed 23.6% size reduction. This could attribute to the low availability of space, nutrients and water for plants at higher densities. These results are in agreement with Laczi *et al.*(2013) who reported that highest canopy diameter was obtained in lowest plan density 66,667 plants/ha (50 x30 cm) in Chinese cabbage (*Brassica oleraceae* var. *peknensis*).

Table 2. Percentage of preference of consumers and traders for outlook and head size of cabbage heads

Outlook preference of consumers and traders	Weight of cabbage purchase (g)				Total
	< 500	500-750	750-1,000	> 1,000	
With Light green outer leaves	6	10	56	16	88
Without outer leaves	2	2	8	0	12
Total	8	12	64	16	100

Evaluation of suitable plant spacing to produce preferable head size

Meanwhile, root length of cabbage was significantly influenced by plant density (Table 3). Increasing plant density from 50,000 plants/ha (50x40 cm) to 111,111 plants/ha (30 x 30 cm), increased the root length by 18 %. The increased plant density might induce their root distribution in search of water and nutrients (Stoffela *et al.*, 1990).

Table 3. Effect of plant density on root length and canopy diameter at harvesting stage.

Plant spacing	Mean canopy diameter(cm)	Root length (cm)
50cm x 40 cm	40.3a	15.2c
50cm x 30 cm	35.5b	16.2bc
40cm x 40 cm	38.6a	17.3ab
40cm x 30 cm	35.3b	17.2ab
30cm x 30 cm	30.8c	17.9a
CV%	10.94	8.95
P value	0.0001	0.00004

Note: CV= co-efficient of variation; Mean in each column followed by the same letters are not significantly different (p=0.05).

Pest and disease incidences and weed infestation

Results revealed no significant differences of insect pest incidences among treatments at the initial stages (four and six weeks after transplanting (WAT)) of

crop growth (Table 4). At 12 WAT, the highest insect damage of 64 %, compared to control, was reported in the highest density (111,111 plants/ha). This is probably due to the changing microclimate around the plants in higher densities which favours the development and multiplication of insects. Meanwhile, the insect damage increment was only 34% in plant density of 83,333 than DOA recommendation. There is no any cabbage disease identified during the cropping season.

Table 4. Effect of plant density on major insect pest damage.

Plant spacing	Insect pest damage (Scored data)				
	4WAT	6 WAT	8 WAT	10 WAT	12 WAT
50cm x 40 cm	0.79	0.976a	1.191ab	0.882b	0.853c
50cm x 30 cm	0.888	0.888a	1.062b	0.968b	0.968bc
40cm x 40 cm	0.844	0.947a	1.458a	1.320a	1.206ab
40cm x 30 cm	0.888	1.032a	1.306ab	1.091ab	1.141ab
30cm x 30 cm	0.982	1.132a	1.270ab	1.270a	1.400a
CV%	33.625	37.444	45.891	37.414	37.271

Note: CV= co-efficient of variation; Mean in each column followed by the same letters are not significantly different ($p=0.05$).

Weed population decreased with increasing plant density and higher weed dry weight was obtained at lower densities (Table 6). Similar results were reported by Karkanis *et al.* (2011) ; in their study where weed biomass decreased with increasing cabbage plant population. The study showed that weed biomass decreased with increasing plant population in cabbage, the highest weed biomass (200.10 g) was obtained at density of 42,850 plants/ha at (70 x 30 cm single rows).

Marketable Yield

The highest marketable head yield (86.4 t/ha) was obtained from the highest plant density while the lowest yield (65.9 t/ha) was from the lowest plant density (Table 6). With the increase in plant density from 50,000 to 111,111 plants/ha, the yield increment was 31%. Similar experiments (Moniruzzam, 2011) revealed that cabbage yield was progressively increased with increased plant density.

Table 5. Effect of plant density on dry weight of weeds

Plant spacing	Dry weights of weeds (g/m ²)		
	5 WAT	8 WAT	11 WAT
50cm x 40 cm	38.66a	48.88a	143.92a
50cm x 30 cm	32.55b	35.47b	139.08a
40cm x 40 cm	29.30bc	38.30b	90.08b
40cm x 30 cm	26.30a	28.94bc	70.14bc
30cm x 30 cm	23.44d	18.60c	34.11c
CV%	11.85	19.844	27.476
P value	0.0006	0.0005	0.0003

Note: CV= coefficient of variance; Mean in each column followed by the same letters are not significantly different (p=0.05).

Table 6. Yield and quality of cabbage, grown at different plant densities.

Plant spacing	Head diameter (cm)	Head height (cm)	Head compact ness	Weight of head/plant (g)	Yield/ha (mt)
50,000	16.24a	11.70	40.66	1330.0a	65.91c
66,667	14.22bc	10.49	39.41	1093.33bc	69.08bc
62,500	15.58ab	11.45	42.66	1180.0ab	71.66bc
83,333	12.77cd	10.71	38.00	938.33c	78.41ab
1,11,111	11.70d	10.19	39.75	738.33d	86.39a
CV%	14.78	15.057	15.37	22.698	15.757
P value	0.0001	0.1357	0.448	0.0001	0.0006

Note: CV= coefficient of variance; Mean in each column followed by the same letters are not significantly different (p=0.05).

Plant density showed direct influence on the head size of cabbage (Table 7). The highest head weight (1330 g) was obtained in the lowest plant density compared to other densities tested. Although per plant yield was higher at lower densities, it did not increase the per hectare yield because more number of plants in higher densities compensate the per head yield reduction. Wider spacing produce larger and heavier heads (Karkanis *et al.*, 2011). Although higher yield was obtained at the highest density, their per plant head size was lower than preferred. Consumer preferable head size (938.33g) was obtained from 83,333 plants per hectare (938.33g). However, in the present investigation an average yield of 80 t/ha (fresh weight) was obtained at the plant density of 83,333 plants/ha (40 x 30

cm). By using this density, farmers can harvest a higher yield also.

Diameter, height and compactness of heads

Plant density significantly influenced on the head diameter. Lower head diameter was observed in lower plant densities (Table 6). Similar results were observed by Sarker *et al.*, (2002) in their experiment in Pakistan. However, plant density did not effect on head compactness and head height.

CONCLUSIONS

Most of the consumers as well as traders like 750 to 1,000 g cabbage heads and there are many problems associated with large size heads or sliced cabbages. Higher marketable yield (78.41 t/ha) and consumer preferred head size could be obtained with plant spacing of 40 x 30 cm where the plant density is 83,333 plants/ha.

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