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GROWTH AND YIELD PERFORMANCE AND GENOTYPE X ENVIRONMENT INTERACTION OF CABBAGE VARIETIES UNDER ORGANIC PRODUCTION IN BENGUET

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ABSTRACT

Five cabbage varieties viz Ace Green, Gladiator, Lucky Ball, Rare Ball and Scorpio were evaluated at representative locations in Benguet: Balili, La Trinidad (1,332 m asl); Bonglo, Atok (2,085 m asl); and Tulodan, Atok (2,330 m asl) following the Philippine National Standards (BAFPS, 2003) for organic vegetable production. Genotype x Environment (G x E) analysis was done on yield to determine stability of the varieties across locations and seasons using the Additive Main Effects Multiplicative Interaction (AMMI) model.

The cabbage varieties had varied performance in the different locations during the wet and dry seasons. The highest yielding, most stable and preferred cabbage varieties across locations and seasons were Rare Ball, Lucky Ball and Scorpio. These varieties are recommended for organic production in the three agro-ecological zones of Benguet.

Keywords: *growth and yield performance, genotype by environment interaction, cabbage varieties and organic production*

INTRODUCTION

Cabbage (*Brassica oleraceae* var. *capitata* L.) is a cool season crop which grows best under cool, moist weather conditions (Thompson, 2002). It was ranked as one of the top 20 vegetable crops grown globally (FAO, 1988). There are more than two million hectares planted with cabbage and other brassicas produced globally, producing an average yield of 29 tons per hectare (FAOSTAT, 2011). In the Philippines, Benguet and Mountain Province are the prime producers (PSA, 2013).

Cabbage production system in Benguet is chemical-based. The Department of Agrarian Reform (2013) reported that due to conventional farming, agricultural productivity has been declining over the years. Yield remains very low due to declining soil fertility brought about by the excessive use of synthetic fertilizers. Added to the problems is the high price of farm inputs. Surveys of vegetable growers revealed that about 40% of the total production cost is due to farm inputs.

Due to the negative effects of chemical farming, an alternative system of production such as organic farming is relevant and important at present. According to Briones (1997), organic farming uses organic fertilizers and diverse cropping system. One of the benefits of organic farming that can be of great help to farmers is that organically grown vegetables command higher prices than conventionally-produced ones, thus, having potential of generating higher income for the producer. Compared to the former-organically produced products have higher nutritive values and, lesser insecticide residues, taste better and provide greater satisfaction to the consumers (Crinnion, 2011; Hajslova *et al*., 2005; Kersti *et al*., 2009).

One of the factors that contributes to the success of the organic vegetable industry in the highlands is the availability of varieties that are adapted to organic production. Varieties of cabbage planted in Benguet are conventionally-produced in other countries such as Japan and China and imported by seed companies. Thus, there is a need to evaluate these varieties under local low input and organic conditions. Organic practitioners here identified a few vegetable varieties for organic production (Pablo and Tad-awan, 2005) but data on their performance under organic production are wanting.

Evaluating cabbage varieties for adaptation and yield will help farmers, breeder and seed companies select and develop varieties best suited to the local environment and market. To be selected, a variety should be high yielding, resistant to pests and diseases, early maturing and adapted to the locality to increase profit and reduce expenses (Adeniji *et al*., 2010; Lammerts *et al*., 2002).

The few vegetable varieties adapted under organic production is one of the gaps identified during the regional R and D consultations. In answer to this need, this research aimed at selecting cabbage varieties specifically adapted for organic production in three locations of Benguet during the dry and wet seasons.

MATERIALS AND METHODS

Varieties and sources

Five cabbage varieties were sourced out from different seed companies (Table 1).

Table 1. Cabbage varieties and source of seeds

Variety	Seed Company	Country of Origin
Ace Green	Nong Woo Bio Co.	China
Gladiator	Allied Botanical Corp.	Philippines
Lucky Ball	Kaneko Seeds Co.	Japan
Rare Ball	Kaneko Seeds Co.	Japan
Scorpio (check)	Sakata Seed Corp.	Japan

Experimental sites and seasons

Table 2 summarizes the conditions of the experimental trials. Dry season cropping was from October to February while wet season planting was from May to July. The temperature ranges in the different locations were within the 15-20 °C requirement for cabbage production (DA-BAR, 2012).

Experimental Design, Land Preparation, Fertilizer Application and Planting

The experiment was laid-out in a Randomized Complete Block Design (RCBD) with three replications. An effective area of 75 m^2 per location was prepared and divided into three blocks consisting of five plots with 1 m x 5 m dimension. BSU Growers' Compost (Laurean and Nagpala, 2012) was applied at a rate of 3.75 kg/5 m^2 (75% of the recommended rate) one week before transplanting. The seeds were sown in seedling trays prior to transplanting. One month old seedlings were transplanted in the field at a distance of 30 cm x 30 cm between hills and rows which allowed 30 seedlings planted per plot. Irrigation followed after transplanting to prevent transplanting shock.

Cultural management practices

Cultural management practices stipulated in the Philippine National Standards (BAFPS, 2003) for organic vegetable production were followed. *Mokosaku* or wood vinegar was sprayed at a rate of two tbsp/li of water (Villanueva, 2012). At least 10% diversity was maintained by planting marigold, onions, corn and zinnia along the border plots.

The data gathered were:

1. Number of days from transplanting to head initiation was recorded when the shoot leaves started to bend inwardly and up.

2. Heading percentage was determined per plot using the formula:

$$\text{Heading (\%)} = \frac{\text{Number of plants with formed heads}}{\text{Total Number of plants}} \times 100$$

Table 2. Agro-ecological zone, elevation and meteorological data from October 2012-February 2013 of the different experimental locations for cabbage varieties

Location	Agro-Ecological Zone	Elev. (MASL)	Mean Temperature (°C)		Mean Light Intensity (Fc)	Mean Light Humidity (%)
			Min	Max		
La Trinidad	Low mountain	1,332	13.55	23.44	1720.38	81.00
Bonglo, Atok	Mid-mountain	2,085	13.00	21.33	804.83	61.11
Tulodan, Atok	High mountain	2,330	11.14	20.32	945.22	60.82

3. Circumference of heads (cm). Equatorial circumference was measured at the mid-section of the head while polar circumference was measured from the bottom to the tip of the head with the use of a tape measure.

4. Average head weight (g) was obtained by dividing the weight of marketable head by the number of marketable head per plot.

5. Weight of marketable heads (kg/plot) was the weight of harvested heads without any defects.

6. Weight of non-marketable heads (kg/plot) was the weight of heads that are small, rotten, cracked and with other defects and not fit for sale.

7. Total yield (kg/plot) was the sum of the weight of the marketable and non-marketable heads.

8. Computed marketable yield (t ha^{-1}) was computed using the formula:

$$\text{Yield (tons/ha)} = \frac{\text{Total yield/plot}}{5\ m^2 \times 1000} \times 10{,}000$$

9. Postharvest data include weight loss and shelf life:

9.1. Weight loss (%). Initial weight of cabbage heads was taken one day after harvest, then heads were weighed weekly thereafter. Weight loss (%) was determined using the following formula:

$$\text{WL (\%)} = \frac{\text{Initial Wt} - \text{Final Wt}}{\text{Initial Wt}} \times 100$$

9.2. Shelf life. Sample heads were taken just after harvesting for postharvest evaluation. The number of days from display to the day the heads were still fit for consumption was recorded.

10. Diamond-back moth infestation was recorded at 60 days after transplanting using the following rating scale (Cardona, 2009):

Rating	Number of Leaves Damage	Remarks
1	No damage	Highly resistant
2	1-3 leaves damaged	Resistant
3	4-6 leaves damaged	Moderately resistant
4	Most of the leaves damaged	Moderately
5	All of the leaves damaged	Susceptible

11. Cutworm infestation was recorded at 30 days after transplanting and heading stage using the following rating scale (Cardona, 2011):

Rating	Number of Leaves Damage	Remarks
1	No damage	Highly resistant
2	1-3 leaves damaged	Resistant
3	4-6 leaves damaged	Moderately resistant
4	Most of the leaves damaged	Moderately susceptible
5	All of the leaves damaged	Susceptible

12. Clubroot incidence was evaluated at harvest stage using the following rating scale (Tad-awan and Basquial, 2008):

Scale	Description
1	No clubroot
2	Slight incidence (1-19% of plants are infected)
3	Moderate incidence (20-39% of plants are infected)
4	Severe incidence (40-59% of plants are infected)
5	Extreme incidence (60% or more of plants are infected)

Sensory Evaluation

Cabbage heads were evaluated by a panel composed of farmers and consumers. Evaluation was based on color, size, appearance and general acceptability following the 1-5 scale as follows:

Rating	Description
1	Like very much
2	Like moderately
3	Neither like nor dislike
4	Dislike moderately
5	Dislike very much

Return on Cash Expense (ROCE)

The return on cash expense was computed based on the formula:

$$\text{ROCE (\%)} = \frac{\text{Net income}}{\text{Total cost of production}} \times 100$$

Preference for cabbage varieties

The preference for cabbage varieties was gathered through interviews with 50 respondents composed of the farmer cooperators, consumers and organic and conventional farmers in Atok and La Trinidad using a structured questionnaire. The characteristics of cabbage considered were size, shape, color, appearance and shelf-life, resistance to pests and diseases and yield performance.

Statistical Analysis

Data were analyzed using the analysis of variance (ANOVA) for RCBD. Treatment means were compared using the Least Significance Difference (LSD) at 5% level of probability.

Genotype x Environment (G x E) analysis was done using the Crop Stat Version 2.2.2007.3. Among the features of the program are across sites and Additive Main Effects Multiplicative Interaction (AMMI) analysis and pattern analysis of G x E Interaction (IRRI, 2009).

In the analysis of the G x E interaction of the vegetable varieties and the different environments, the AMMI model was used. Summary statistics and graphical displays in the form of biplots to show trends and patterns were generated using AMMI model. An AMMI1 biplot has main effects for its abscissa and the first Interaction Principal Component Analysis axes (IPCA1) for its ordinate while an AMMI2 biplot has IPCA1 for its abscissa and IPCA2 for its ordinate (Gauch, 2006). In the biplot, the angles between the vectors that represent genotypes and environments show the interaction, and the distances from the origin indicate the degree of interactions that the genotypes show throughout the environments or vice versa (Kandus *et al.*, 2010).

RESULTS AND DISCUSSION

Heading Characteristics of the Cabbage Varieties

Days to head formation. Cabbage varieties did not vary as to days to head formation across locations, years and seasons (Table 3). During the dry season (DS) in La Trinidad, Ace Green and Gladiator were the earliest to form heads in 37 days after transplanting (DAT). At Bonglo, Ace Green, Gladiator and Scorpio (check) were the earliest to form heads in 47 days while in Tulodan, all entries formed heads in 63 days. The same trend was observed during the wet season (WS) in Bonglo and Tulodan.

Cabbage varieties grown in La Trinidad formed heads earlier than those varieties grown in Bonglo and Tulodan. Ace Green, Gladiator, Lucky Ball and Rare Ball formed heads earlier than Scorpio in all locations. It was also observed that the cabbage varieties formed heads earlier during the dry season than during the wet season. This shows that under a growing environment where the elevation is lower with higher temperature, light intensity and relative humidity, early heading is evident.

Heading percentage. High heading percentage is desired since it could mean high yield. It was only in La Trinidad during the DS of 2011-2012 that heading percentage significantly differed among the cabbage varieties where Ace Green had significantly higher heading percentage than Scorpio but Rare Ball did not differ from it (Table 3). However, the highest heading percentage across locations and seasons was observed from Scorpio. This may be attributed to the adaptability of Scorpio

in the locality being the variety commonly planted by farmers for more than 10 years. Lucky Ball had also consistent high heading percentage across locations and seasons. Generally, higher heading percentage was observed during the dry season.

Equatorial circumference. The cabbage varieties grown in the different locations had variable head circumferences (Table 3). Ace Green, Lucky Ball and Rare Ball formed wide heads when grown across locations and seasons. Lucky Ball and Rare Ball exhibited the widest heads while smallest heads were manifested by Scorpio.

Yield and Yield Components. Yield is one of the major determinant parameters for selecting and basis for recommending a particular variety. This character plays an important role for variety commercialization and income generation. Yield of the different cabbage varieties varied across locations (Table 4). The cabbage varieties grown in the three locations produced yields ranging from 9 to 49 t ha^{-1}. The higher yield obtained could be due to the favorable growing conditions in which the optimum mean temperature for growth and quality head development is 15-18 °C (Adeniji *et al.*, 2010), higher soil pH and good soil porosity. Since cabbage is a cool season crop with moderately low optimum temperatures and high water requirement for optimum performance, yields are greatly reduced under higher temperatures (Muleke *et al.*, 2014). Higher yield was also observed during the wet season when water is readily available.

Average head weight. Among the cabbage varieties grown in La Trinidad, Ace Green significantly produced the heaviest heads during the dry season trial in 2011-2012 (Table 4). During the wet season trial, Lucky Ball had heaviest heads while the lightest heads were obtained from Scorpio. In Bonglo, Scorpio produced the heaviest heads during the dry season in 2011-2012 but had lighter heads in the successive trials.

Considering the performance across the three locations, Rare Ball produced the heaviest heads. As to performance according to season, Scorpio produced the heaviest heads during dry and wet season trials in 2011-2012 while in 2012-2013 dry and wet season trials, Lucky Ball and Rare Ball had the highest head weights. According to Janko *et al.* (2011), head weight is a variable trait that is influenced by environmental factors. This is especially pronounced if head weight is regarded as yield that is a function of growing period length and plant density.

Head weight was observed to be related with compactness. Lucky Ball and Rare Ball have compact heads which may have resulted in heavy heads. On the other hand, Gladiator and Ace Green have loose heads which may result in lighter heads.

Marketable yield. Marketable yield ranged from 8 to 24 t ha^{-1} during the dry season and from 14 to 45 t ha^{-1} during the wet season (Table 4). Rare Ball and Ace Green produced the highest marketable yield during dry season trial in La Trinidad in 2011-2012 but produced lower yields during the wet and dry season trials in 2012-2013. Rare Ball, as compared with Scorpio, produced higher marketable yield for two consecutive dry season trials but had lower yields during the wet season trial. Lucky Ball significantly outyielded Scorpio. The cabbage varieties grown in Tulodan had the highest marketable yield ranging from 8 to 46 t ha^{-1} followed by those grown in La Trinidad at 14 to 41 t ha^{-1} and those grown in Bonglo at 9 to 31 t ha^{-1}. Generally, the cabbage varieties had higher yield when grown during the wet season.

Higher marketable yield was obtained from Rare Ball during the dry season and Lucky Ball and Gladiator during the wet season in La Trinidad, Lucky Ball and Scorpio during the dry season and Rare Ball and Scorpio during the wet season in Bonglo, and Rare Ball and Lucky Ball during both seasons in Tulodan.

Rare Ball significantly outyielded check variety Scorpio in La Trinidad during the dry season in 2011-2012, in Bonglo during the wet season in 2011-2012, and in Tulodan in both seasons in 2012-2013 but Scorpio had significantly higher marketable yield than Rare Ball during wet season in 2011-2012.

The marketable yield obtained in the study is within the world yield range of 10-40 t ha^{-1} as reported by Ogbodo *et al.* (2009). This implies the

Table 3. Days to head formation, heading percentage and head circumference of cabbage varieties evaluated during the dry (DS) and wet season (WS) trials (2011-2013) under organic production in the different locations

Character/Variety	La Trinidad (1,332 m asl)			Bonglo, Atok (2,085 m asl)				Tulodan, Atok (2,330 m asl)				Mean
	2011-2012	2012-2013		2011-2012		2012-2013		2011-2012		2012-2013		
	DS	DS	WS	DS	WS	DS	WS	DS	WS	DS	WS	
Days to head formation												
Ace Green	37	55	60	47	60	55	60	63	62	56	62	56
Gladiator	37	55	60	47	60	55	60	63	62	56	62	56
Lucky Ball	38	55	60	48	60	55	60	63	62	56	62	56
Rare Ball	38	60	60	48	60	58	60	63	62	58	62	57
Scorpio	38	61	60	47	60	60	63	63	62	60	63	58
Heading Percentage												
Ace Green	94.43*	86.21	87.44	79.65	63.34	86.86	83.90	89.87	79.94	93.83	92.86	85.30
Gladiator	73.55*	82.14	87.92	85.90	60.79	84.49	92.86	89.73	81.32	89.43	95.83	84.00
Lucky Ball	72.34*	90.54	85.84	82.57	63.29	90.83	90.85	93.54	78.52	84.73	97.33	84.58
Rare Ball	84.00ns	85.71	80.89	89.17	56.72	90.28	93.80	89.98	79.41	86.75	93.86	84.60
Scorpio	86.94	90.45	90.50	94.45	59.90	91.43	92.31	94.99	82.83	91.08	96.19	88.28
LSD (0.05)	6.45	18.14	16.42	15.50	28.76	7.11	14.32	7.08	8.46	19.46	9.85	
CV (%)	4.16	11.07	10.08	6.46	10.13	3.53	5.69	2.78	3.79	11.59	5.49	
Head Circumference (cm)												
Ace Green	34.93	31.92*	47.93*	47.15	38.20	26.14ns	37.25ns	46.93	40.27	32.88*	41.05ns	38.60
Gladiator	32.77	29.11ns	47.53*	44.90	39.33	23.04**	36.60ns	44.80	42.78	35.10*	45.35ns	38.38
Lucky Ball	33.07	34.45**	46.73*	46.45	40.25	32.95**	37.35ns	46.35	45.30	36.78ns	44.93ns	40.42
Rare Ball	34.27	34.15**	47.07*	44.70	39.78	31.07**	38.55ns	42.88	43.02	39.37**	46.95*	40.16
Scorpio	30.90	29.67	37.13	45.30	39.63	27.20**	32.08	45.40	42.30	27.32	38.53	35.95
LSD (0.05)	5.82	1.99	5.42	4.04	11.38	3.45	8.72	5.97	3.60	4.06	7.00	
CV (%)	9.32	3.31	6.36	3.18	10.39	5.43	8.63	4.75	4.47	6.29	8.57	

*-significant; **-highly significant; ns-not significant

Table 4. Average head weight, marketable, non-marketable and total yield of cabbage varieties evaluated during the dry (DS) and wet season (WS) trials (2011-2013) under organic production in the different locations of Benguet

Character/Variety	La Trinidad (1,332 m asl)				Bonglo, Atok (2,085 m asl)				Tulodan, Atok (2,330 m asl)				Mean
	2011-2012		2012-2013		2011-2012		2012-2013		2011-2012		2012-2013		
	DS	WS	DS	WS	DS	WS	DS	WS	DS	WS	DS	WS	
Days to head weight (g)													
Ace Green	364.44*	375.42*	654.27ns	470.00	297.50ns	264.83	340.00*	486.00	534.50	371.96**	576.38ns	430.48	
Gladiator	255.50ns	404.08*	659.25ns	667.50	295.00ns	256.37	330.00*	434.00	584.67	403.92**	704.83ns	454.11	
Lucky Ball	238.70ns	444.75**	725.52*	528.75	360.00ns	307.33	530.00ns	502.00	668.67	432.75ns	719.63ns	496.19	
Rare Ball	335.74*	529.50**	637.92ns	600.84	460.00**	309.00	570.00ns	478.00	576.83	425.10ns	773.33*	517.84	
Scorpio	234.26	251.00	591.77	711.25	343.50	292.33	545.00	504.00	671.00	431.78	614.50	471.85	
LSD (0.05)	122.80	64.47	103.00	146.70	59.59	65.08	64.52	73.59	121.10	26.27	131.60		
CV (%)	8.77	12.26	8.37	8.87	6.11	8.20	5.02	5.51	10.59	3.38	10.31		
Marketable Yield (t ha^{-1})													
Ace Green	19.83*	13.85	36.24ns	8.72	14.17ns	12.95*	17.87*	9.00	30.66**	16.44*	33.77ns	19.41	
Gladiator	16.14ns	14.18	37.65ns	12.37	14.00ns	14.04ns	17.62*	8.03	33.04**	17.97*	41.43ns	20.59	
Lucky Ball	16.80ns	16.46	41.19*	9.72	17.95ns	14.61ns	28.34ns	9.10	39.34ns	20.30**	42.20ns	23.27	
Rare Ball	20.88*	17.08	35.63ns	10.72	22.44*	14.33ns	31.32ns	8.00	34.00*	24.21**	45.56*	24.02	
Scorpio	15.40	15.86	33.23	12.73	17.14	14.58	29.68	10.00	39.34	10.09	36.01	21.28	
LSD (0.05)	1.64	2.80	6.28	5.88	3.60	1.78	3.84	8.06	4.06	3.88	8.02		
CV (%)	9.67	7.95	9.08	9.76	7.58	4.56	5.53	16.45	6.14	9.63	10.69		
Non-marketable Yield (t ha^{-1})													
Ace Green	2.40	3.10	5.63*	0.68	2.49ns	1.98**	2.53ns	0.72**	1.40**	2.33ns	3.11ns	2.40	
Gladiator	1.90	2.23	4.53ns	0.98	2.52ns	2.08*	2.18*	0.65ns	2.04**	2.23ns	3.68ns	2.27	
Lucky Ball	1.77	3.21	5.20*	0.86	2.21ns	2.40ns	3.46ns	0.94**	0.80ns	1.95*	3.86ns	2.43	
Rare Ball	1.82	2.69	5.20*	1.30	3.25*	2.35ns	2.88ns	0.56*	0.62**	2.27ns	3.93*	2.44	
Scorpio	1.72	2.85	4.65	1.50	2.10	2.49	3.02	0.61	0.94	2.47	3.31	2.33	
LSD (0.05)	0.36	0.42	0.54	0.60	1.36	0.44	0.88	0.54	0.20	0.50	0.64		
CV (%)	11.14	7.90	5.75	10.06	7.66	6.81	11.24	13.95	9.08	11.98	9.38		
Total Yield (t ha^{-1})													
Ace Green	22.23*	16.95ns	41.87ns	9.40	16.68ns	14.93*	20.40*	9.72	32.06**	18.77*	36.89ns	21.81	
Gladiator	18.04ns	16.41ns	42.19ns	13.35	16.52ns	16.12ns	19.80*	8.68	35.08*	20.21*	45.11ns	22.86	
Lucky Ball	18.57ns	19.67ns	46.43*	10.58	20.18ns	17.01ns	31.80ns	10.04	40.14ns	22.25**	46.06ns	25.70	
Rare Ball	22.70*	19.77ns	40.83ns	12.02	25.70**	16.68ns	34.20ns	8.56	34.62**	26.47**	49.49*	26.46	
Scorpio	17.11	18.71	37.87	14.23	19.24	17.07	32.70	10.61	40.28	12.55	39.33	23.61	
LSD (0.05)	1.72	2.34	6.60	5.87	1.71	1.78	3.88	8.49	2.05	3.12	8.24		
CV (%)	9.27	6.79	8.37	8.87	6.25	4.80	5.02	16.07	6.00	8.26	10.31		

*-significant; **-highly significant; ns-not significant

great potential of organic cabbage production in Benguet.

Non-marketable yield. The lowest non-marketable yield at 0.56 t ha^{-1} was taken from Rare Ball grown during the dry season in Tulodan. In La Trinidad, low non-marketable yield was observed from Gladiator during the dry and wet seasons. In Bonglo, Ace Green had lower non-marketable yield during the dry season. The cabbage varieties had lower non-marketable yield when grown during the dry season in all locations.

Total yield. Generally, the highest yielders in the different locations and seasons were Rare Ball, Lucky Ball and Scorpio (Table 4). High yield of these varieties could be attributed to their compact and heavy heads. The result may suggest the suitability and adaptability of Rare Ball, Lucky Ball and Scorpio for organic production in the three locations. The environment of Tulodan gave the highest yield ranging from 9 to 49 t ha^{-1}. High yield of the cabbage varieties was also obtained in La Trinidad ranging from 16 to 46 t ha^{-1}. The cabbage varieties grown in Bonglo produced lower yield ranging from 9 to 34 t ha^{-1} which could be attributed to moderate infestation of insect pests like cutworm and diamond-back moth.

Postharvest Characters

Weight loss. Variability in weight loss was observed among the cabbage varieties grown in the different locations (Table 5). For cabbage varieties grown in La Trinidad, low weight loss in three consecutive trials was recorded from Gladiator as compared to Scorpio. In Bonglo, still Gladiator had the lowest weight loss during the dry and wet season trials in 2011-2012 but had the highest weight loss during the wet and dry season trials in 2012-2013. In Tulodan, the lowest weight loss during dry season trial was recorded from Lucky Ball and Rare Ball while the lowest weight loss during the wet season trial was registered from Ace Green and Scorpio. Overall, Ace Green had lower weight loss than the other varieties including Scorpio. The result implies that the weight loss may depend on the location and cropping season.

Shelf life. One important character in selecting a particular variety is storability under ambient condition or the number of days from display to the day the heads are still fit for consumption. Long storage life is preferred by most growers, retailers and consumers. Shelf-life of the cabbage varieties grown in the different locations and growing season ranged from 11 to 16 days (Table 5). Generally, average shelf life of 15 days was recorded from varieties Gladiator, Lucky Ball, Rare Ball and Scorpio.

Reaction of Cabbage Varieties to Insect Pests and Diseases

Reaction to cutworm. The cabbage varieties grown in La Trinidad and Tulodan were resistant to cutworm infestation while those grown in Bonglo were moderately resistant (Table 6).

Reaction to diamond-back moth. In La Trinidad and Tulodan, the varieties grown were resistant to diamond-back moth while the cabbage varieties grown in Bonglo were moderately resistant (Table 6).

Clubroot incidence. There was slight clubroot incidence in the test varieties in La Trinidad while no clubroot infection was observed in the varieties grown in Bonglo and Tulodan (Table 6). The growing environment in the sites may not be favorable for the development of the disease. Clubroot commonly attacks crucifers causing abnormality to the root system. Wet, cool and acidic soils are favorable for the development of clubroot with optimum temperature for germination of spores and for disease development at 18 °C- 25 °C. Infection can occur, however, when temperature is as low as 12 °C or as high as 25 °C (Hansen, 2000; Ferriera and Boley, 1993).

Return on cash expense (ROCE)

The cost of production and returns per 1000 m^2 during the last trial or wet season of 2012-2013 are shown in Table 7. The production of the cabbage varieties under organic conditions resulted in positive ROCE. Rare Ball and Lucky Ball production in Tulodan had the highest ROCE which is attributed to the high marketable yield. In La Trinidad, high ROCE was obtained from growing Lucky Ball. The lowest ROCE was noted on Ace Green and Gladiator planted in Bonglo. Generally, cabbage varieties planted in Bonglo had low ROCE due to the comparatively low marketable yield obtained.