

Table 5. Weight loss and shelf-life of cabbage varieties evaluated during the dry (DS) and wet season (WS) trials (2011-2013) under organic condition 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	DS	WS	WS	DS	WS	WS
Weight loss (%)							
Ace Green	26.00ns	16.96*	20.75ns	13.50	9.72ns	18.93ns	25.08
Gladiator	20.00*	12.25**	19.86ns	10.71	8.26ns	24.50*	25.23
Lucky Ball	32.50ns	26.80*	27.41*	13.96	13.13*	21.52ns	18.74
Rare Ball	21.67ns	13.91**	28.38*	14.51	12.49ns	19.80ns	21.88
Scorpio	39.67	21.43	22.76	14.65	8.69	18.34	20.28
LSD (0.05)	27.97	0.64	3.81	13.47	4.19	4.39	8.13
CV (%)	8.67	1.53	5.76	20.04	14.44	9.40	3.17
Shelf-life (days)							
Ace Green	11	15	15	15	15	15	14
Gladiator	11	15	15	15	15	15	14
Lucky Ball	11	15	15	16	15	15	14
Rare Ball	12	15	15	15	15	15	14
Scorpio	13	15	15	16	15	15	15
LSD (0.05)	12						14
CV (%)	8.93						15

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

Sensory evaluation

Newly harvested heads of the cabbage varieties were evaluated by a panel composed of farmers and consumers (Table 8). For the color and appearance of heads, Lucky Ball, Rare Ball and Scorpio were liked moderately while the rest of

the varieties were rated neither liked nor disliked. On head size, all varieties were rated neither liked nor disliked except Lucky Ball which was rated liked moderately. For the general acceptability, all varieties except Gladiator were liked moderately by the evaluators.

Table 6. Reaction to cutworm, diamond-back moth and clubroot of cabbage varieties 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)
Reaction to cutworm at 15 DAT			
Ace Green	Resistant	Moderately resistant	Resistant
Gladiator	Resistant	Moderately resistant	Resistant
Lucky Ball	Resistant	Moderately resistant	Resistant
Rare Ball	Resistant	Moderately resistant	Resistant
Scorpio	Resistant	Moderately resistant	Resistant
Reaction to diamond-back moth			
Ace Green	Resistant	Moderately resistant	Resistant
Gladiator	Resistant	Moderately resistant	Resistant
Lucky Ball	Resistant	Moderately resistant	Resistant
Rare Ball	Resistant	Moderately resistant	Resistant
Scorpio	Resistant	Moderately resistant	Resistant
Reaction to clubroot			
Ace Green	Slight incidence	No clubroot incidence	No clubroot incidence
Gladiator	Slight incidence	No clubroot incidence	No clubroot incidence
Lucky Ball	Slight incidence	No clubroot incidence	No clubroot incidence
Rare Ball	Slight incidence	No clubroot incidence	No clubroot incidence
Scorpio	Slight incidence	No clubroot incidence	No clubroot incidence

Table 7. Computed cost of production, gross income, net income and return on cash expense of 1,000 m² area of cabbage

Location/Variety	Cost of Production(PhP)	Marketable Yield (kg/1000 m ²)	Gross Income(PhP)	Net Income (PhP)	ROCE (%)
Balili, La Trinidad					
Ace Green	58,000.00	3,600	126,000.00	68,000.00	117.24
Gladiator	58,000.00	3,700	129,500.00	71,500.00	123.28
Lucky Ball	58,000.00	4,110	143,850.00	85,850.00	148.02
Rare Ball	58,000.00	3,500	122,500.00	64,500.00	111.21
Scorpio	58,000.00	3,300	115,500.00	57,500.00	99.14
Bonglo, Atok					
Ace Green	58,000.00	1,700	59,500.00	1,500.00	2.59
Gladiator	58,000.00	1,762	61,670.00	3,670.00	6.33
Lucky Ball	58,000.00	2,834	99,190.00	41,190.00	71.02
Rare Ball	58,000.00	3,132	109,620.00	51,620.00	89.00
Scorpio	58,000.00	2,968	103,880.00	45,880.00	79.10
Tulodan, Atok					
Ace Green	58,000.00	3,377	118,195.00	60,195.00	103.78
Gladiator	58,000.00	4,143	145,005.00	87,005.00	150.01
Lucky Ball	58,000.00	4,220	147,700.00	89,700.00	154.66
Rare Ball	58,000.00	4,556	159,460.00	101,460.00	174.93
Scorpio	58,000.00	3,601	126,035.00	68,035.00	117.30

*Total cost of production includes material inputs and labor cost; average selling price of cabbage heads was PhP 35/kg

Table 8. Sensory evaluation based on color, size, appearance and general acceptability of fresh heads of cabbage varieties evaluated under organic production

Entry	Color	Size	Appearance	General Acceptability
Ace Green	Neither liked nor disliked	Neither liked nor disliked	Neither liked nor disliked	Liked moderately
Gladiator	Neither liked nor disliked	Neither liked nor disliked	Neither liked nor disliked	Neither liked nor disliked
Lucky Ball	Liked moderately	Liked moderately	Liked moderately	Liked moderately
Rare Ball	Liked moderately	Neither liked nor disliked	Liked moderately	Liked moderately
Scorpio	Liked moderately	Neither liked nor disliked	Liked moderately	Liked moderately

Preference for cabbage varieties

Preference was assessed by the evaluators based on horticultural characteristics. Table 9 presents the reasons for preference of cabbage varieties by the evaluators composed farmer-partners, organic and conventional farmers, and consumers. Scorpio, Rare Ball and Lucky Ball were the most preferred varieties by the evaluators. Scorpio, however, was selected by all evaluators due to its high yield; and dark green, compact and medium size heads.

Genotype x Environment Interaction and Stability Analysis in Cabbage Varieties Evaluated Across Locations and Seasons

Dry season trial

AMMI 1 bi-plot for total yield. Varieties with yielded higher than the grand mean were Gladiator, Lucky Ball and Rare Ball (Fig. 1). The environment giving the highest yield was Bonglo (2,050 m asl). The different environments or the locations differ in main effects which means, yields obtained were different in each environment. The genotypes with PC1 scores close to zero expressed general adaptation whereas the larger scores depicted more specific adaptation to environments with PC1 scores of the same sign (Ebdon and Gauch, 2002). Cabbage varieties Ace Green, Gladiator and Lucky Ball, therefore, are adapted in all locations. Positive interaction with location and its prevailing environment could be exploited with specific adaptation (Annichiarico, 2002).

AMMI 2 bi-plot for total yield. For the AMMI 2 model, IPCA 2 scores were considered in interpreting G x E (Fig. 1). A bi-plot is generated

using genotypic and environmental scores of the two AMMI components (Vargas and Crossa, 2000). When IPCA 1 was plotted against IPCA 2, the genotypes score closer to the center would mean said genotypes are more stable than those farther from the center (Purchase, 1997). The AMMI 2 bi-plot (Fig. 2) shows that Lucky Ball is a stable variety while Ace Green and Scorpio located far from the center may be considered unstable. As to the specific adaptation, Lucky Ball and Rare Ball are adapted in Tulodan; Ace Green in Balili, La Trinidad and Gladiator in Bonglo.

Another interpretation of the AMMI 2 bi-plot is to visualize the IPCA scores (Yan and Kang, 2003). According to the analysis, ideal genotypes are those that should have large IPCA 1 scores (high mean yield) and small (absolute) IPCA2 scores (high stability). Also, ideal test environment should have large IPCA 1 scores or more power to discriminate genotypes in terms of the phenotypic main effect and small (absolute) IPCA 2 scores or more representative of the overall environments (Yan *et al.*, 2000; Yan and Rajacan, 2002). Based on this interpretation, the ideal cabbage varieties are Lucky Ball and Rare Ball. The ideal test environment which can discriminate the cabbage varieties is Tulodan with an elevation of 2,330 m asl with temperature range of 10-20 °C and relative humidity of 60% during the conduct of the trial. However, the best environment where all varieties are adapted is Balili, La Trinidad.

Wet season trial

AMMI 1 bi-plot for total yield. As shown in Fig.2, the variances in total yield of the different

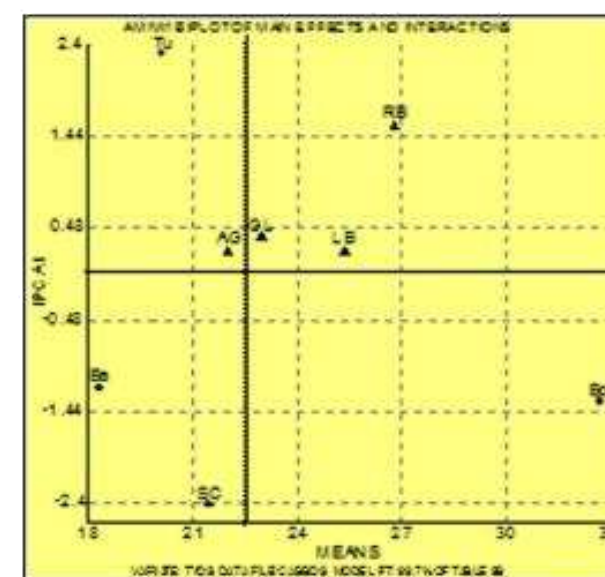
Table 9. Number and percentage of evaluators and reasons for preference of cabbage varieties evaluated under organic production

Variety	Evaluator		Reasons for Preference
	Frequency (n=50)	Percentage (%)	
Ace Green	40	80	Dark green, small and compact heads
Gladiator	35	70	Slightly compact and small heads
Lucky Ball	46	92	High yield, large and compact heads, long shelf-life, moderate resistance to cutworm
Rare Ball	48	96	High yield, large and compact heads, long shelf-life
Scorpio	50	100	High yield, dark green compact and medium size-heads

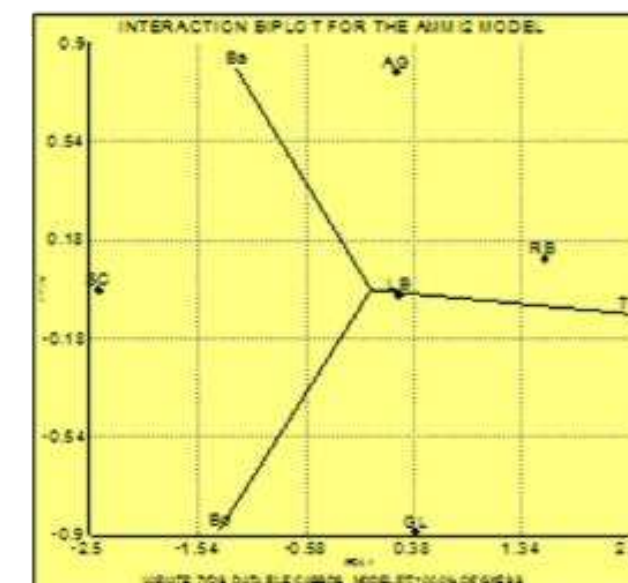
varieties during the wet season are due both to main and interaction effects as can be observed in the AMMI 1 biplot. Lucky Ball and Rare Ball had the highest yield while 'Ace Green' is the lowest yielder. In the AMMI 1 biplot, it can be observed that Lucky Ball has a positive interaction with Tulodan while Gladiator has positive interactions with Balili.

AMMI 2 bi-plot for total yield. Strong positive

interactions observed in the AMMI 2 biplot are that of Ace Green with Balili, Scorpio with Bonglo and Rare Ball with Tulodan (Fig. 2). This means adaptability of the cabbage varieties in the specific locations for organic production during the wet season. The ideal cabbage variety during the wet season is Lucky Ball. The ideal test environment which can discriminate the cabbage varieties is Bonglo. However, the best environment where all varieties are adapted is Tulodan.

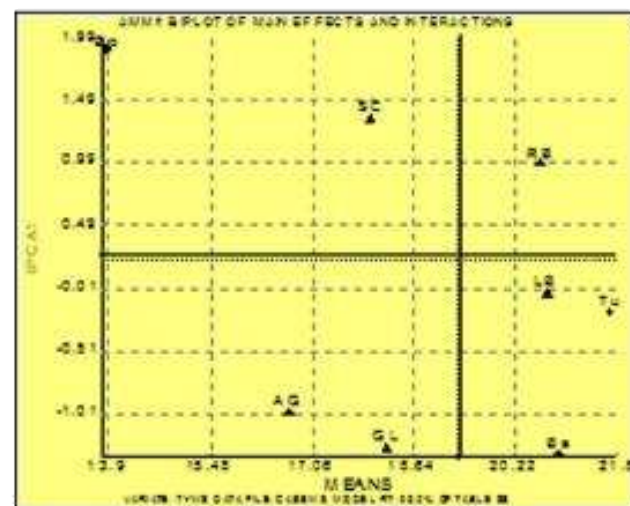


Genotypes: AG – Ace Green
RB – Rare Ball
Environments: Ba – Balili (La Trinidad)
Grand mean: 22.56 t ha⁻¹

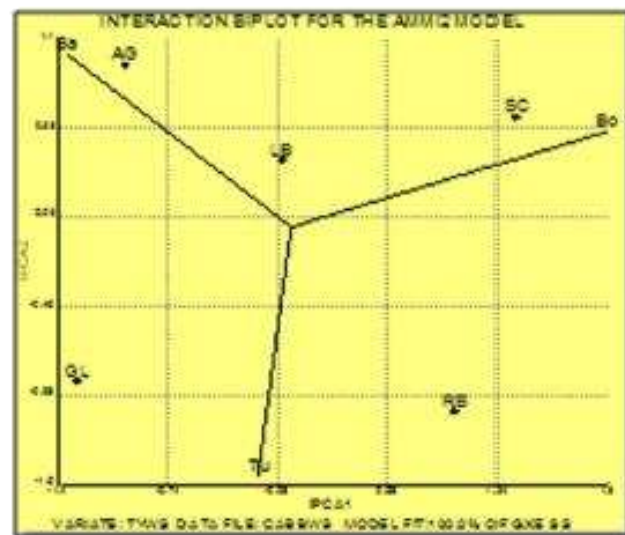


GL – Gladiator LB – Lucky Ball
SC – Scorpio Bo – Bonglo
Tu – Tulodan

Fig. 1. AMMI 1 (left) and AMMI 2 (right) biplots of five cabbage varieties evaluated for total yield in three environments during the dry season trial



Genotypes: AG – Ace Green
RB – Rare Ball
Environments: Ba – Balili (La Trinidad)
Grand mean: 19.45 t ha⁻¹



GL – Gladiator LB – Lucky Ball
SC – Scorpio
Bo – Bonglo
Tu – Tulodan

Fig 2. AMMI 1 (left) and AMMI 2 (right) biplots of five cabbage varieties evaluated for total yield in three environments during the wet season trial

CONCLUSIONS AND RECOMMENDATIONS

The best yielding and most preferred varieties in the different locations and seasons are Rare Ball, Lucky Ball and Scorpio. These varieties have dark green, compact and medium-sized heads. Growing Rare Ball and Lucky Ball particularly in Tulodan resulted in the highest return on cash expense on account of the highest yield obtained.

As to the stability based on G x E analysis during the dry season, Lucky Ball is the most stable. As to G x E interactions, Gladiator has a positive interaction with Tulodan while Scorpio and Lucky Ball has positive interactions with La Trinidad and Bonglo. During the wet season, Lucky Ball is the most stable and has a positive interaction with Tulodan while Gladiator has positive interaction with La Trinidad.

Lucky Ball is recommended for organic production during the dry season. Rare Ball and Lucky Ball are also recommended specifically in Tulodan, Ace Green in La Trinidad and Gladiator in Bonglo. For wet season cropping, Lucky Ball is also recommended in the three locations. Specifically, Ace Green, Scorpio and Rare Ball are recommended in La Trinidad, Bonglo and Tulodan, respectively.

CONFLICT OF INTEREST

We wish to confirm that there are no known conflicts of interest associated with this publication and there has been no financial support from the different seed companies distributing the varieties for this work that could have influenced its outcome.

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