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The Evaluation of Chrysanthemum Clones Under Low Elevation

Lia Sanjaya[*)], Budi Marwoto, Kurniawan Budiarto and Eka Fibrianty

Indonesian Ornamental Crops Research Institute (IOCRI), West Java, Indonesia

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[*)] Corresponding author:
E-mail: liasanjaya63@gmail.com

ABSTRACT

Cultivation of chrysanthemum at low elevation was one effort to expand potential production areas. Under these circumstances, several environmental conditions might not be as conducive as in highland and deviate the plant from the original characters and potential yield. Fifteen promising variants derived from an unconventional breeding program were evaluated at two different elevations; 1100 and 250 m above sea level (asl) at Cianjur-West Java, Indonesia during hot season from April to September 2016. The experiment was designed as progenital selection to seek the adaptive genotypes on the targeted sites. The results showed that varietal differences existed among the tested clones when grown under highland and lowland. At lowland (250 m asl), all clones showed growth retardation expressed by the reduction of flower qualities with different degrees among genotypes. In standard group, only 2015-9 and 2015-15 that produced unchanged flower color, with acceptable plant height standard for cut flower. While in spray type, all tested clones produced flower with degraded floret color.

INTRODUCTION

Chrysanthemum is one the top marketed cut flowers in the world. In Europe, the market for this commodity has shown a substantial growth over the last decade and the growth seems likely to continue (Steen, 2014). In tropical regions like Indonesia, the plants were usually grown commercially in highlands, referring environmental adaptation to their temperate origins (Sanjaya, Marwoto, & Soehendi, 2015). The agribusiness of this commodity in the country has reached the attention in the last decades. Since 2006, chrysanthemum has taken over roses for the most marketed domestic fresh cut flower and raised the floriculture contribution for more than 9 trillion rupiahs of national GDP in 2015 (Kurniasih, Ruswandi, Karmana, & Qosim, 2016).

The concern of many local governments to establish new floriculture production centers in their potential regions has made the significant increase of the harvested areas not only in Java but Sulawesi and Sumatera islands as well. Through continuous assistance from pertinent sectors, the newly developed production areas have now started to export their products to several countries (Khaerunnisa, Rukmana, & Jusni, 2017). The demands are not only for the new varieties with various colors and shapes but also efficient production technologies that can be applied specifically to the targeted area to increase the productivity.

Planting at low and medium elevations is one challenging question from many stakeholders that should be answered to widen the prospective production area. Under low and medium elevations, several environmental conditions might deviate from and not be as conducive as those in highland where the plants might get the optimum growth (Arjana, Situmeang, & Suaria, 2015). There was no available scientific report related to successful chrysanthemum plantation with a set of environmental condition on such targeted site. Most of literatures dealt with single physical factor regime with the constant of other factors under controlled environment as reported by several authors, Kahar (2008); Kjaer & Ottosen (2011); Körner & Challa (2004); van der Ploeg, Kularathne, Carvalho, & Heuvelink (2007); Wang, Guo, & Jin (2009), and many others. Under lowland condition, a complex

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interaction among the factors might happen, act simultaneously to the plant and deviate the plant from the original characters and potential yield (Hatfield & Prueger, 2015).

Unconventional breeding programs conducted on chrysanthemum through particle bombardment have produced many promising variants for further evaluation. Evaluation of these newly developed generations on low land conditions was then served as a progenital selection to seek the adaptive genotypes on the targeted site. The idotype clones are expected to have adaptability performances such as insignificant growth and yield quantity and qualities with no changes in commercially important characters compared to those when planted at optimum high elevations. Obtaining the adaptive genotypes will serve as the basis for the environment and culture assessments for product improvement.

MATERIALS AND METHODS

The research was conducted under plastic house conditions in two different elevations; 1100 and 250 m asl. The highland experimental site (1100 m asl) was located at Cipanas Research Station of Indonesian Ornamental Crops Research Institute (IOCRI), while the lowland site (250 m asl) was located at Sukamantri, Karang Tengah, Cianjur-West Java. The research was conducted during hot season from April to September 2016. The 15-tested genotypes coded as 2015-1 to 2015-15 were the selected clones with the general flower characteristic presented in Table 1.

Table 1. Flower characteristic of chrysanthemum clones used in the study

Clone codes	Flower shape	Flower type
2015-1	Decorative	Standard
2015-2	Decorative	Standard
2015-3	Decorative	Standard
2015-4	Single	Spray
2015-5	Decorative	Standard
2015-6	Single	Spray
2015-7	Single	Spray
2015-8	Single	Spray
2015-9	Decorative	Standard
2015-10	Decorative	Standard
2015-11	Single	Spray
2015-12	Single	Spray
2015-13	Anemone	Spray
2015-14	Single	Spray
2015-15	Decorative	Standard

Planting Material Preparation

The plantlet establishment of the 15-selected clones was carried out by inoculating the shoot tip in half strength MS medium containing 0.5 mg L^{-1} IAA for direct shoot regeneration. The newly emerging shoots were then subcultured in ½ MS + 0.1 mg L^{-1} IAA for further multiplication and root formation. The rooted plantlets were then acclimatized under protected greenhouse and maintained under standard cultural practices. The acclimatized plantlets were served as mother stocks for cuttings production. The harvested cuttings were rooted in carbonized rice husk under long day condition and served as the planting material in the experiment.

Soil and Planting Bed Preparation

The soils inside the plastic houses were tilled and the weeds were disposed outside from the plastic house. After the soils were mixed with 30 t ha^{-1} manures and 10 t ha^{-1} bamboo humus, planting beds with the width of 1 m and the length of the plastic house was constructed. The planting bed had 25 cm in height with the distance between planting beds was 60 cm. For about 40 g m^{-2} NPK (16:16:16) were mixed gently with the top soil. Finally, planting beds were then poured with water to keep the humidity. Long day instrument was provided by the installment of 11 watts LED lamps that were arranged 1.5 m above the planting bed and the distance between lamps was 2 x 2 m.

Planting and Plant Maintenance

The planting material used was rooted cutting after 18 days in the rooting process. The cutting was planted with the density of 49 plants m^{-2}. After planted, the cuttings were poured with water to facilitate humidity and avoid plant stress. The water supply was given using sprinkle system every 2-3 days until harvesting period. The long day conditions were applied starting from the day of planting for 4 h during night time from 10.00 pm to 02.00 am for 30 days. After 30 days, the long day treatment was terminated and the plants were forced to flower in neutral day length. Additional fertilizers using NPK (16:16:16) were applied after 30 and 60 days of planting. The half dosage of pesticide (insect, fungi, and bactericides) were applied twice a week together with foliar fertilizers to prevent pest and disease attacks.

The parameter observed included plant height, leaf length and width, floret color, length, and width, peduncle length, flower height and diameter.

The data gathered were analyzed using ANOVA and the mean comparison was facilitated using LSD (α = 5 %).

RESULTS AND DISCUSSION

Plant Performances under Highland Condition

The fifteen chrysanthemum clones performed differently under their optimum environment in highland conditions. Under the standard type group, clone no. 2015-5 showed the tallest plant with less leaf area than 2015-2 and 2015-10. The clone had shortest flower neck, bigger flower, and flower height yet with smaller floret than 2015-5 and 2015-10 (Table 2). Among the tested clones, 2015-2 was considered medium in plant height with widest leaf area, wider floret thirdly after 2015-5 and 2015-10 and bigger flower size and height. In spray type group, the phenotypic performances among the tested clones were more diverse. For example, clone no. 2015-7 was the shortest plant, with shorter flower neck, but medium in term of leaf area and flower diameter. While 2015-13 that was the tallest with shorter flower neck, medium leaf, and floret area, had the smallest flower size. The plant which had a higher value in plant height or leaf size was not necessarily to have a bigger flower with bigger floret size and vice versa. These results inferred that there was no fixed correlation among the parameters observed as an indication of the characteristic relationship.

The different phenotypic performances among the evaluated chrysanthemum clones when grown at highland indicated the different genetic backgrounds of each clones. Each genotype interacted with a set number of environmental factors inside the plastic house and responded differently from one to another in terms of direction and degree of growth patterns (Gantait, Pal, & Ghosdastdar, 2012). The different response of each genotype represented the different capacity of each genotype to take the maximum advantage of the given environment to support optimum physiological conditions as reflected on organ formation and development and other physiological responses (Baskaran, Jayanthi, Janakiram, & Abirami, 2009).

Aside from flower shape, a big flower size in standard type was preferable in the market (Carvalho, Abi-Tarabay, & Heuvelink, 2005) as shown by clone no. 2015-2 and 2015-5. Both had short flower neck and flower height with bigger floret area, thus made the clones look more compact. The clones were considered had taller plants that were more favorable for cut flower (Ochiai et al., 2015). In spray type, the clones no 2015-8, 2015-11 and 2015-14 had the bigger flowers and floret size that were preferable, yet had shorter plants compared to the rest tested spray type clones. While 2015-13 had the smallest flower as a common characteristic of anemone shape that was usually with a bigger disc. These characteristics were also considered preferable though flower color was also important depended on the consumer preferences (Nurmalinda & Hayati, 2014).

Plant Performances under Lowland Condition

Unlike grown in highland, all evaluated chrysanthemum clones showed slower in growth when grown under lowland conditions. Varietal differences were also shown in all parameters observed. The clone no. 2015-5 was the tallest among the tested standard types, though the value was lesser from those when grown under highland (Table 3). In other parameters, however, 2015-2 showed largest flower diameter, leaf and floret size secondly below 2015-10. In spray types, clone no. 2015-13 was also still the tallest, although the value was not significantly different with 2015-5. The clone no. 2015-8 had the lowest and 2015-2015-11 was categorized as medium in term of leaf area. Both clone, however, had the highest flower diameter in spray type group.

In lowland, the plants were surrounded by various environmental factors that might not be favorable compared to highland. More sunlight and higher temperature with lower air humidity were the most prominent condition under the plastic house in the lowland. These unfavorable conditions might interfere the physiological status of the plant and would undergo certain adaptation mechanism to cope up with the circumstances (Adams, Valdés, & Fuller, 2009). The adaptation included high respiration rate and stomatal closure under high temperature and light intensity. High respiration as consequences, would use the photosynthetic product by releasing the water for the heat compensation from the environment (Walker & Cousins, 2013). The use of a photosynthetic product for excessive respiration then reduced the availability of assimilates to form new tissues and organs (Pärnik, Ivanova, & Keerberg, 2007). While stomatal closure limited the release of water due to transpiration, but at the same time reduced the photosynthetic rate, since the CO_2 uptake was also diminished (Luo et al., 2009).

Table 2. Vegetative and reproductive characteristics of chrysanthemum clones grown under highland

Clone Codes(s)	Plant height (cm)*)	Leaf length (cm)*)	Leaf width (cm)*)	Flower neck (cm)*)	Floret color (RHS Color Chart)	Flower height (cm)*)	Flower diameter (cm)*)	Floret length (cm)*)	Floret width (cm)*)
2015-1	90.7 ab	12.5 bc	7.7 bc	0.9 ab	Purple 77C	3.4 c	12.4 d	4.7 d	1.2 b
2015-2	100.8 b	15.8 e	7.8 bc	1.3 b	Yellow 12 A	4.5 d	14.1 f	5.2 de	1.8 c
2015-3	89 a	11.8 b	7.8 bc	2.7 e	White N155A	3.5 c	13.3 ef	5.1 de	1.7 c
2015-4	90.2 ab	14.1 d	8.3 c	1.2 b	Greyed Purple 187C	2.1 a	5.6 b	2.0 a	1.1 ab
2015-5	123.2 d	14.4 de	7.1 ab	1.4 bc	Yellow 12A	4.5 d	13.8 ef	5.7 ef	1.8 c
2015-6	115.8 cd	12.2 bc	6.8 a	1.6 bc	Yellow Orange 16C	2.2 a	6.7 c	1.9 a	1.0 ab
2015-7	96.7 ab	12.9 c	7.3 b	1.1 ab	Greyed Purple 187C	1.8 a	5.8 bc	1.7 a	0.9 a
2015-8	99.2 b	10.7 a	6.6 a	1.3 b	Red Purple 71B	1.9 a	7.4 c	2.7 b	1.2 b
2015-9	106.5 bc	13.9 d	7 a	1.8 cd	White 155C	2.8 bc	12.5 de	4.9 d	1.4 bc
2015-10	89.8 a	13.3 cd	7.8 bc	1.7 c	Yellow 5A	2.6 b	13.3 ef	5.9 f	1.6 c
2015-11	104.4 b	13.3 cd	6.7 a	1.4 bc	Red Purple 60A	2.1 ab	7.4 c	2.1 a	1.1 ab
2015-12	101.8 b	15.3 e	7.8 bc	0.7 a	Purple 77C	2.3 a	5.8 bc	1.8 a	0.9 a
2015-13	123.6 d	14.1 d	7.6 b	1.0 ab	Yellow 5A	3.0 bc	4.7 a	3.7 c	0.9 a
2015-14	97.2 ab	14.4 de	7.9 bc	1.7 c	Yellow Orange 15D	2.4 ab	7.3 c	2.7 b	1.3 b
2015-15	101.8 b	11.7 b	7.4 b	2.3 de	White N155A	3.7 c	12.7 de	5.8 ef	1.3 b

Remarks: *) Values in the same column followed by different letters differ significantly under LSD ($\alpha \leq 5$ %)

Table 3. Vegetative and reproductive characteristics of chrysanthemum clones grown under lowland

Clone Codes(s)	Plant height (cm)*)	Leaf length (cm)*)	Leaf width (cm)*)	Flower neck (cm)*)	Floret color (RHS Color Chart)	Flower height (cm)*)	Flower diameter (cm)*)	Floret length (cm)*)	Floret width (cm)*)
2015-1	76 ab	11.5 b	6.8 c	0.7 ab	Purple 77D	3.1 c	10.8 e	4.2 d	0.9 b
2015-2	96.8 d	13.7 d	6.8 c	1.1 b	Yellow 7A	3.9 d	12.4 f	4.9 e	1.2 c
2015-3	71 a	10.1 a	6.3 bc	2.4 d	White N155A	3.1 c	11.3 e	4.8 d	1.2 c
2015-4	80.6 abc	10.7 ab	6.2 bc	0.9 ab	Greyed Purple 187D	1.9 ab	3.8 ab	1.7 a	0.8 ab
2015-5	108 e	13.3 cd	6.8 c	1.1 b	Yellow 9A	4.1 d	11.3 e	5.3 e	1.1 c
2015-6	95.8 cd	11 ab	6.1 bc	1.4 bc	Yellow Orange 14C	1.9 ab	5.6 c	1.4 a	0.8 a
2015-7	86.4 c	11.6 b	5.9 ab	0.9 ab	Greyed Purple 187D	1.6 a	4.1 b	1.3 a	0.7 a
2015-8	80.8 ab	11.4 b	5.3 a	1.1 b	Red Purple 71C	1.7 ab	6.8 d	2.5 b	0.9 b
2015-9	96.5 d	13 cd	6.7 c	1.5 bc	White 155C	2.2 ab	10.9 e	4.3 d	1.1 c
2015-10	86.8 cd	13 cd	6.1 bc	1.9 c	Yellow 3A	2.3 b	11.8 f	5.2 e	1.2 c
2015-11	84.4 bc	12 b	6.6 bc	1.2 bc	Red Purple 60B	1.9 ab	6.2 cd	1.8 a	0.8 ab
2015-12	80.8 abc	13.1 cd	6.7 bc	0.6 a	Purple 84C	1.9 ab	4.5 b	1.6 a	0.7 a
2015-13	103.4 de	12.3 bc	6.5 bc	0.7 ab	Yellow 3A	2.6 b	3.2 a	3.2 c	0.7 a
2015-14	73.2 a	13.1 cd	6.8 c	1.6 c	Yellow 12B	2.1 ab	5.9 c	2.2 b	0.9 b
2015-15	76.8 abc	10.2 a	6.2 bc	2.0 cd	White N155A	3.3 c	10.9 e	4.9 e	1.1 c

Remarks: *) Values in the same column followed by different letters differ significantly under LSD ($\alpha \leq 5$ %)

Most of the chrysanthemum clones reached less than 100 cm in term of plant height and only clones no. 2015-5 (standard type) and 2015-13 (spray type) that reached more than 100 cm (Table 2). Two clones, namely 2015-3 (standard type) and 2015-14 (spray type) were the poorest with the values of 71 and 73.2 cm, respectively. These two clones were out graded based on the national standard for a cut flower when planted under lowland conditions. The minimum standard stalk length (harvested plant height) required at least 75 cm for a cut flower of chrysanthemum (FMA & SAF, 2016). While based on the flower size, the minimum diameter was 4 cm for standard type (Yoginugraha, Wijaya, & Nada, 2017). Thus, all the evaluated standard clones produced acceptable flower size though they were grown under lowland conditions.

Comparison between Chrysanthemum Grown at Highland and Lowland

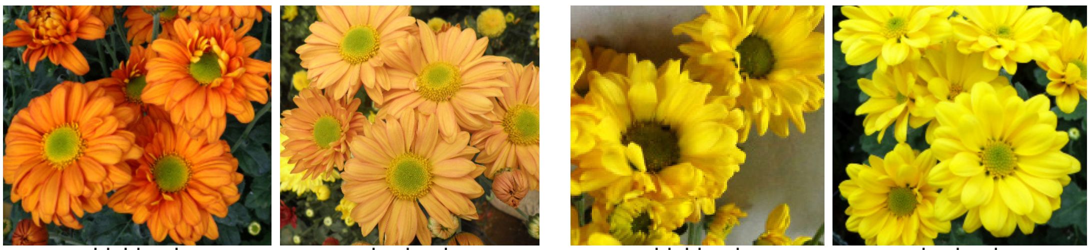
The growth performance on vegetative and reproductive characteristics of the evaluated chrysanthemum clones grown at highland and lowland was presented in Table 4. All of the clones showed growth retardation indicated by the reduction of flower qualities when grown under lowland condition, though the degrees were different. Only on flower neck and flower height, the reduction of the values in all evaluated clone was not significant. These conditions inferred that flower neck length and flower height was less influenced by planting sites, though the application of certain growth regulators such as GA_3 and PBZ might modify the plant responses (da Silva Vieira et al., 2011; Rochmatino, Santoso, & Dwiati, 2010).

In standard type group, the reduction in plant height and leaf was clearly shown all of the clones, except clones no. 2015-2 and 2015-10 (Table 4). In 2015-10, the insignificant reductions were also observed in leaf length, flower neck and flower height. A similar phenomenon was also observed in flower diameter. No clone had an insignificant change in term of flower size and floret width. In respect to the flower color, the basis petal color of white seemed to be the most consistent. Clones no. 2015-3, 2015-9 and 2015-15 had no change in floret color (Fig. 1), while the floret colors of other clones became paler when planted at lowland.

A spray type group, all of the clones showed decrease in plant height and leaf length significantly when grown under lowland conditions (Table 4). In term of leaf width, 2015-11 was the most persistent while 2015-8 had insignificant change in flower diameter. Clones no. 2015-6, 2015-7, 2015-12 and 2015-13 showed relatively stable performance in floret length compared to the others. No spray type clone had white floret and all clones produced flower with degraded floret color under lowland as shown by clones 2015-6 and 2015-14 (Fig. 2).

highland lowland highland lowland
2015-9 2015-15

Fig. 1. Consistent floret color of clones no. 2015-9 and 2015-15 under highland and lowland



highland lowland highland lowland
2015-6 2015-14

Fig. 2. Degraded floret color of clones no. 2015-6 and 2015-14 when planted under lowland from those under highland

Table 4. Comparison of vegetative and reproductive characteristics of chrysanthemum clones grown under highland and lowland

Clone Codes(s)	Planting site[**)]	Plant height (cm)[*)]	Leaf length (cm)[*)]	Leaf width (cm)[*)]	Flower neck (cm)[*)]	Floret color (RHS Color Chart)	Flower height (cm)[*)]	Flower diameter (cm)[*)]	Floret length (cm)[*)]	Floret width (cm)[*)]
2015-1	HL	90.7 b	12.5 b	7.7 b	0.9 a	Purple 77C	3.4 a	12.4 b	4.7 a	1.2 b
	LL	76 a	11.5 a	6.8 a	0.7 a	Purple 77D	3.1 a	10.8 a	4.2 a	0.9 a
2015-2	HL	100.8 a	15.8 b	7.8 b	1.3 a	Yellow 12 A	4.5 a	14.1 b	5.2 a	1.8 b
	LL	96.8 a	13.7 a	6.8 a	1.1 a	Yellow 7A	3.9 a	12.4 a	4.9 a	1.2 a
2015-3	HL	89 b	11.8 b	7.8 b	2.7 a	White N155A	3.5 a	13.3 b	5.1 a	1.7 b
	LL	71 a	10.1 a	6.3 a	2.4 a	White N155A	3.1 a	11.3 a	4.8 a	1.2 a
2015-4	HL	90.2 a	14.1 b	8.3 b	1.2 a	Greyed Purple 187C	2.1 a	5.6 b	2.0 a	1.1 b
	LL	80.6 a	10.7 a	6.2 a	0.9 a	Greyed Purple 187D	1.9 a	3.8 a	1.7 a	0.8 a
2015-5	HL	123.2 b	14.4 b	7.1 a	1.4 a	Yellow 12A	4.5 a	13.8 b	5.7 a	1.8 b
	LL	108 a	13.3 a	6.8 a	1.1 a	Yellow 9A	4.1 a	11.3 a	5.3 a	1.1 a
2015-6	HL	115.8 b	12.2 b	6.8 b	1.6 a	Yellow Orange 16C	2.2 a	6.7 b	1.9 a	1.0 a
	LL	95.8 a	11 a	6.1 a	1.4 a	Yellow Orange 14C	1.9 a	5.6 a	1.4 a	0.8 a
2015-7	HL	96.7 b	12.9 b	7.3 b	1.1 a	Greyed Purple 187C	1.8 a	5.8 b	1.7 a	0.9 a
	LL	86.4 a	11.6 a	5.9 a	0.9 a	Greyed Purple 187D	1.6 a	4.1 a	1.3 a	0.7 a
2015-8	HL	99.2 b	10.7 a	6.6 b	1.3 a	Red Purple 71B	1.9 a	7.4 a	2.7 a	1.2 b
	LL	80.8 a	11.4 a	5.3 a	1.1 a	Red Purple 71C	1.7 a	6.8 a	2.5 a	0.9 a
2015-9	HL	106.5 b	13.9 a	7 a	1.8 a	White 155C	2.8 a	12.5 b	4.9 a	1.4 b
	LL	95.5 a	13 a	6.7 a	1.5 a	White 155C	2.2 a	10.9 a	4.3 a	1.1 a
2015-10	HL	89.8 a	13.3 a	7.8 b	1.7 a	Yellow 5A	2.6 a	13.3 b	5.9 b	1.6 b
	LL	86.8 a	13 a	6.1 a	1.9 a	Yellow 3A	2.3 a	11.8 a	5.2 a	1.2 a
2015-11	HL	104.4 b	13.3 b	6.7 a	1.4 a	Red Purple 60A	2.1 a	7.4 b	2.1 a	1.1 b
	LL	84.4 a	12 a	6.6 a	1.2 a	Red Purple 60B	1.9 a	6.2 a	1.8 a	0.8 a
2015-12	HL	101.8 b	15.3 b	7.8 b	0.7 a	Purple 77C	2.3 a	5.8 b	1.8 a	0.9 a
	LL	80.8 a	13.1 a	6.7 a	0.6 a	Purple 84C	1.9 a	4.5 a	1.6 a	0.7 a
2015-13	HL	123.6 b	14.1 b	7.6 b	1.0 a	Yellow 5A	3.0 a	4.7 b	3.7 a	0.9 a
	LL	103.4 a	12.3 a	6.5 a	0.7 a	Yellow 3A	2.6 a	3.2 a	3.2 a	0.7 a
2015-14	HL	97.2 b	14.4 b	7.9 b	1.7 a	Yellow Orange 15D	2.4 a	7.3 b	2.7 a	1.3 b
	LL	73.2 a	13.1 a	6.8 a	1.6 a	Yellow 12B	2.1 a	5.9 a	2.2 a	0.9 a
2015-15	HL	101.8 b	11.7 b	7.4 b	2.3 a	White N155A	3.7 a	12.7 b	5.8 b	1.3 a
	LL	76.8 a	10.2 a	6.2 a	2.0 a	White N155A	3.3 a	10.9 a	4.9 a	1.1 a

Remarks: [*)] Values in the same column in each clone code differ significantly under paired T-student test ($\alpha \leq 5\%$); [**)] HL = Highland, LL = Lowland

Environmental factors under lowland contributed the unfavorable conditions for the chrysanthemum plant to grow optimally and produced qualified flowers. The high temperature with low relative humidity during the experiment caused the slow growth rate of the plants. Poor growth consequently decreased the productivity and quality of the flower (Carvalho, Abi-Tarabay, & Heuvelink, 2005). On the contrary, the chrysanthemum plants at highland conditions had lesser environmental constraints to exhibit their maximum phenotypic potentials. Certain genotypes were less affected by particular growth indicators, but the great reduction was found in other features (van der Ploeg, Carvalho, & Heuvelink, 2009). In standard type group, clone no. 2015-10 showed an insignificant decrease in plant height, leaf length, flower neck and flower height. The flower, however, was changed in terms of color and size when planted under lowland. The floret color remained unchanged when the basis color was white as shown by clones no. 2015-3, 2015-9, and 2015-15 though with a significant decrease in flower diameter.

In spray type group, clone no. 2015-4 showed insignificant reductions in plant height, flower neck, flower height and floret length, though the clone was considered shorter among the group members. This clone showed a great reduction in floret length and flower diameter. Only clone no. 2015-8 had relatively stable features in flower diameter and floret length though the reduction in plant height was also significant in the lowland. The impact of environmental changes on the character deviation was merely manifested in these group as reflected from the absence of stable genotypes with persistent character including flower color when planted under lowland conditions. Further studies in the future to find out the adaption mechanism of chrysanthemum under high temperature regimes and breeding for heat-tolerance character were needed to widen the possibility planting chrysanthemum in lowland conditions.

CONCLUSION

Evaluation of chrysanthemum under highland and lowland conditions revealed that varietal differences were existed among the tested clones. In standard type group, 2015-5 had the tallest plants with shortest flower neck, bigger flower and flower height, while the largest flower was produced by 2015-2 when grown at highland conditions. In spray type, the phenotypic performances among the evaluated clones were even more diverse in these optimal environments. Under lowland conditions, most of the clones showed growth retardation with reduced flower qualities. In standard group, only 2015-9 and 2015-15 that produced unchanged flower color, with acceptable plant height. In spray type, however, all evaluated clones produced flower with degraded floret color.

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