Research Article

Effect of Potassium and Maleic Hydrazide on Growth and Flower Quality of Chrysanthemum (*Dendranthema grandiflorum*)

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Abstract | An experiment on the effect of potassium and maleic hydrazide on growth and flower quality of chrysanthemum (*Dendranthema grandiflorum*) was carried out at Ornamental Nursery, Department of Horticulture, Khyber Pakhtunkhwa Agricultural University, Peshawar during 2011. Suckers of chrysanthemums were planted during the first week of January and transplanted in 20 cm clay pots in July. The experiment was laid out in Randomized Complete Block Design with two factors replicated three times. Different levels of potassium (0, 100, 200 and 300 mg pot^{-1}) and maleic hydrazide (0, 500, 1000 and 1500 ppm) were used. The results revealed that potassium levels significantly influenced all the parameters except the stem diameter. Minimum days to flowering (118.1), maximum plant height (45.83 cm), number of leaves plant^{-1} (54.1), fresh flower weight (44.29 g) and dry flower weight (5.12 g) was obtained with the application of 200 mg K_2O pot^{-1}. In case of maleic hydrazide, the plants grown under control treatment took minimum days (112.9) to flowering, maximum plant height (47.06 cm) and number of leaves (57.89) plant^{-1}. Maximum fresh flower weight (47.85 g) and dry flower weight (5.80 g) was observed with 1500 ppm maleic hydrazide. The interaction between "potassium" and "maleic hydrazide" showed significant effects for some of the growth parameters. It can be concluded that potassium at the rate of 200 mg pot^{-1} and maleic Hydrazide at 1500 ppm provided the best results for quality chrysanthemum flower production under the agro climatic conditions of Peshawar, Pakistan.

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Introduction

Chrysanthemum (*Dendranthema grandiflorum* L.) belongs to the family *Asteraceae* and is a popular flower of great commercial importance, as well as, aesthetic value throughout the world (Sanunewa, 2011). There are more than 5000 different varieties with different names, grown all around the world. However, chrysanthemums first started growing in Asia. The term chrysanthemum is derived from two Greek words "Chrysos" means gold and "anthos" meaning flower. The oldest variety of chrysanthemum is the Chinese chrysanthemum, which was a daisy-like plant. It was cultivated for nearly 2,500 years before it made its way to Europe. However, chrysanthemum as a pot crop has been developed in 1940's (Kessler, 1996). Chrysanthemums are those delicate and enhancing flowers which are popular in white, yellow and different shades of pink (Gokongwei, 2009).

Chrysanthemum is the flower of tropical and sub-tropical regions of the world (Haque et al., 2007). It is one of the major cut flowers in the world (Budiarto et al., 2007; Kazaz et al., 2010).

Chrysanthemum cultivation is possible throughout the year (Bres and Jerzy, 2008). The demand for the flower is 35% of the overall market, second just to roses in Australia (Budiarto et al., 2007). It is grown in many parts of the world owing to its economic values, excellence and aesthetic beauty (Navale et al., 2010). The chrysanthemum flower symbolizes long life, joy, optimism and fidelity. Red chrysanthemum symbolizes love; white shows loyal love and truth, while yellow means slighted love. Each white petal is a ray flower. Chrysanthemums range in height from two inches to six inches (5 to 180 cm), depending on the species (Newsletter, 2009).

Chrysanthemum, more than any other flower, seems to represent the fall season in the garden (Souvestre, 2009). These plants, which also are commonly called mums, have been cultivated for centuries and are popular with gardeners around the world. In Pakistan its peak blooming period is December (Anjum et al., 2007).

Pot chrysanthemum requires well-drained, well-aerated media that has good moisture-holding capacity and can firmly anchor the root system. The pH for root media should be 5.8 to 6.2 with 1 to 1.5 EC, Electrical Conductivity (Catalogue, 2011). The optimum temperature for the cultivation of pot chrysanthemum lies between 17 and 22°C. In actual practice, growers maintain a constant temperature regime, with both day and night temperature at about 20°C.

Chrysanthemums are triggered to bloom only when the nights are long enough. During the summer, when days are long and nights are short, chrysanthemums grow vegetatively (Souvestre, 2009). The plants should be watered when necessary. Plants in pots are normally watered once a day. The quantity of water should be just that it wets the whole pot. They are very sensitive to water logged conditions. If moisture is excessive it may favor disease infection and may impede root respiration (Sanunewa, 2011).

Potassium is one of the sixteen essential nutrients required for plant growth and reproduction (Thompson, 2011). It is often referred to as "the regulator" as it controls and regulates 60 different enzyme systems in plants. Potassium plays a significant role in enhancing the crop quality (Kaleem et al., 2009). It improves resistance of plants to diseases and insects (Rehm and Schmitt, 2002). Potassium plays an efficient role in proper root growth and aids plants in the production of starches. Potassium helps the plant to resist drought and drastic effects of excessive temperature. It aids roses and other flowering plants by encouraging strong stems and well-developed flowers. Another important function of potassium is the regulation of water use in plants. This osmoregulation process affects water transport in the xylem, maintains daily cell turgor pressure, affects cell elongation for growth and most importantly it regulates the opening and closing of stomata which affects transpiration cooling and uptake of carbon dioxide for photosynthesis and food function (Mcafee, 2003). Potassium plays a vital role in protein and peptide bond synthesis and carbohydrate metabolism, and also participates in rapid cell division and differentiation (Belokar et al., 1992).

Maleic hydrazide is used in Horticulture and agriculture field as a growth inhibitor and weed killer. Maleic hydrazide is that plant growth regulator, which inhibits plant cell division but not enlargement of the existing cells. When applied to plants it moved through cuticles and reach to the tissue where cell division occurs (FAO, 2001). It intensifies the green color of leaves. Maleic hydrazide is freely translocated in plants, with mobility in both xylem and phloem (Komossa and Sandermann, 1995). It is used to control sprouting in potatoes and onions, suckers in tobacco, growth of weeds and grasses in ornamental plants (Red Facts, 1994).

Materials and Methods

An experiment on the "Effect of potassium levels and various concentrations of maleic hydrazide on growth and flower quality of chrysanthemum cv. White Gola" was conducted at Ornamental Nursery, Khyber Pakhtunkhwa Agricultural University Peshawar, during 2011. The experiment was laid down in Randomized Complete Block Design with two factors factorial arrangement. There were 16 treatments replicated three times. The whole experiment consisted of 48 treatments. Five plants per treatment were planted in the pots with 20 cm length and 20 cm width containing 2.6 kg of the soil media. The two factors Potassium and maleic hydrazide each had four levels i.e. Potassium Control, 100, 200 and 300 mg pot^{-1} whereas, Maleic hydrazide Control, 500, 1000 and 1500 ppm pot^{-1}. After four days of transplantation all the experimental plants were uniformly fertilized with potassium using potassium sulphate (K_2SO_4) as a source. The maleic hydrazide solution was sprayed using a hand sprayer, when the average height of transplants was 30-40 cm. Suckers of chrysanthemum were planted during the first week of January. Healthy plants of uniform size were selected for the study and transplanted to 20 cm clay pots in July. Sand, clay, canal silt and farm yard manure was used as potting media mixed at 1:1:1:1 ratio. Before the process of fertilization soil samples were randomly taken from different pots and compost was prepared. These samples were analysed in department of soil and environmental sciences laboratory, Khyber Pakhtunkhwa Agricultural University Peshawar for different physio-chemical attributes and found that potassium 180mg kg^{-1}, Lime content 15.85%, Electric conductivity 0.42 ms cm^{-1} and pH 7.69. The texture was silt-Loam. To assess the relation between potassium and maleic hydrazide on growth and flowering of chrysanthemum different parameters were investigated. Computer statistical software MSTATC (Michigan State University, USA) was used for calculating both ANOVA and LSD (Steel et al., 1997).

Results and Discussion

Days to flowering

Days to flowering were significantly affected by different levels of potassium and maleic hydrazide, while the interaction between potassium levels and maleic hydrazide was non-significant (Table 1). Minimum days (118.08) to flowering were recorded in plants fertilized with potassium at the rate of 200 mg pot^{-1}, followed by plants received 100 mg K pot^{-1}. While, maximum days (127.79) to flowering were observed in plants grown as control. Comparing the mean of various maleic hydrazide concentrations, the minimum days (112.89) to flowering were recorded in plants in control, which was statistically different from the rest of the treatments. While, maximum days (131.49) to flowering were observed in plants treated with 1500 ppm maleic hydrazide. Potassium is usually needed for the better growth and production of flowers (Woodson and Boodson, 1983). The findings of the research were in accordance with Baloch et al. (2010), who reported fewer days to flowering in zinnia with the application of higher dose of potassium. Bradfield et al. (1975) also reported that potassium at optimum level initiates the early production of flowers. Potassium is an essential input to the early flowering of the plant. In fact potassium initiates the availability of phosphorous which accelerates early flowering. Potassium improves the reproductive growth of the plant and plays an essential role in flower production (Thompson, 2011). Maleic hydrazide sometimes inhibits apical flowering. Maleic hydrazide delays flower formation because it inhibits the production of gibberellic acid which causes early flowering. Delaying flowering is the result of growth inhibition rather than the direct effect on flowering stimulus (Naylor and Davis, 1950). The results are also in agreement with Navale et al. (2010) who found that maleic hydrazide at higher concentrations delays flowering in chrysanthemum due to suppression of the apical dominance.

Table 1: *Days to flowering of chrysanthemum as affected by application of potassium and maleic hydrazide*

Maleic hydrazide (ppm)	Potassium (mg pot^{-1})				Means
	Control	100	200	300	
Control	118.13	112.72	109.44	111.25	112.89 C
500	130.87	117.33	112.10	126.92	121.80 B
1000	125.47	126.10	126.00	128.87	126.61AB
1500	136.70	132.55	124.77	131.94	131.49 A
Means	127.79 A	122.18 AB	118.08 B	124.74 A	

LSD value for potassium and maleic hydrazide at 1% level of significance = 5.77; Means followed by same letters are not significantly different by using LSD at 1 % (upper case) level of significance.

Plant height (cm)

The potassium levels and various concentrations of maleic hydrazide had a significant effect on plant height (cm), while their interaction was found non-significant (Table 2). Mean values of potassium showed that maximum plant height (45.83 cm) was noted in plants received 200 mg K pot^{-1}, followed by plants (41.83 cm) and (39.80 cm) received potassium at the rate of 100 and 300 mg K pot^{-1} respectively. While minimum plant height (36.19 cm) was observed in the control.

Mean values of various maleic hydrazide concentrations indicated that maximum plant height (47.06 cm) was noticed in control plants, closely followed by the plants (42.16 cm) received 500 ppm maleic hydrazide, which was statistically at par with each other. While minimum plant height (34.26 cm) was noticed in plants treated with 1500 ppm concentration. Increase in plant height due to potassium occurred due to the fact that it helps in the production and growth of new cells and causes stem elongation due to meristematic growth cells. The increment in plant height due to pot application might be due to the vigorous vegetative growth. Potassium fastens the synthesis and translocation of carbohydrates in the plant (Javid et al., 2005). The findings were supported by Naggar (2009), who recorded an increased in plant length of Dianthus with the application of potassium. Doddagoudar (2002) also reported the maximum plant height of China Aster with the application of NPK at optimum level. The results were in partial agreement with (Patil, 1995) who reported that the maleic hydrazide as a growth retardant reduces the influence of auxin due to which cell division and cell elongation is reduced and ultimately decreased the plant height. Latimer (2009) mentioned that maleic hydrazide reduces the plant height by inhibiting the gibberellins production and other plant hormones which initiates the cell elongation. These findings were also in line with Navale et al. (2010), who reported that maleic hydrazide at 1250 ppm reduced the plant height of chrysanthemum. These findings were also in accordance with that of Pasian (1999) who clearly declared that maleic hydrazide inhibits the division and elongation of plant cells so it is used as a height controller in floriculture for most of the pot plants.

Table 2: *Plant height (cm) of chrysanthemum as affected by application of potassium and maleic hydrazide*

Maleic hydrazide (ppm)	Potassium (mg pot^{-1})				Means
	Control	100	200	300	
Control	43.93	50.97	48.21	45.13	47.06 A
500	31.90	42.13	44.62	49.97	42.16 AB
1000	34.47	42.27	49.16	34.77	40.17 AB
1500	34.42	31.97	41.33	29.32	34.26 B
Means	36.19 B	41.83 AB	45.83 A	39.80 AB	

LSD value for potassium and maleic hydrazide at 5% level of significance = 6.07; LSD value for maleic hydrazide at 1% level of significance = 8.18; Means followed by same letters are not significantly different by using LSD at 1 % (upper case) and 5 % (lower case) level of significance.

Number of leaves plant^{-1}

Potassium levels and various concentrations of maleic hydrazide had significant effect on number of leaves plant^{-1}, and their interaction was also found significant Table 3. Maximum numbers of leaves (54.09) were counted in plants received 200 mg K pot^{-1} followed by plants (51.39) treated with 100 mg K pot^{-1}. Minimum numbers of leaves (45.86) were counted in plants grown under control treatment.

Table 3: *Number of leaves plant^{-1} of chrysanthemum as affected by application of potassium and maleic hydrazide*

Maleic hydrazide (ppm)	Potassium (mg pot^{-1})				Means
	Control	100	200	300	
Control	52.30	60.46	64.40	54.40	57.89 A
500	48.89	46.83	58.75	49.52	51.00 B
1000	42.92	47.00	49.41	48.53	46.97 C
1500	39.33	51.27	43.78	45.61	44.99 C
Means	45.86 C	51.39 AB	54.09 A	49.51B	

LSD value for potassium and maleic hydrazide at 1% level of significance = 2.70; LSD value for interaction at 1% level of significance = 5.41; Means followed by same letters are not significantly different by using LSD at 1 % (upper case) level of significance.

The various maleic hydrazide concentrations showed that maximum numbers of leaves (57.89) plant^{-1} were obtained in plants in control, which showed a significant variation with the rest of the maleic hydrazide concentrations. While minimum number of leaves (44.99) was counted in plants treated with 1500 ppm maleic hydrazide.

The interaction of potassium and maleic hydrazide showed a significant effect on the number of leaves plant^{-1} of chrysanthemum. The higher number of leaves (64.40) plant^{-1} were counted in plants fertilized with only 200 mg potassium, while less number of leaves (39.33) were counted in plants received 1500 ppm of maleic hydrazide grown under control. The increase in the number of leaves plant^{-1} may be due to the reason that potassium assimilates nitrogen into proteins which causes vegetative growth. Potassium is compulsory in nitrogen uptake which is responsible for vegetative growth. At highest levels of potassium the plant height and number of leaves were reduced because of the toxic effects of potassium (Sathi and Yahyai, 2008). Belorkar et al. (1992) reported that the application of potassium increased the uptake of nutrients causing more photosynthesis which ultimately resulted in maximum chlorophyll content and more number of leaves plant^{-1}. More vegetative growth occurred due to potassium because it is highly mobile in leaves and easily distributed in the plant (Wang, 2007). Similarly, Naggar (2009) also reported that potassium application increased the production of more number of leaves plant^{-1} in Dianthus. The present findings are also in line with the results of Doddagoudar (2002), who mentioned the maximum number of leaves plant^{-1} of China Aster at optimum level of potassium application. Navale et al. (2010) also reported a significant reduction in the number of leaves plant^{-1} in chrysanthemum with the application of Maleic hydrazide at the concentration of 1250 mg/l. In the same way Weaver (1972) also stated that maleic hydrazide at higher concentrations significantly reduced the number of leaves and retarded the cell division and enlargement of cells. Similarly Aswath et al. (1994) also found less number of leaves in China aster at the application of 1500 ppm concentration of maleic hydrazide.

Fresh flower weight (g)

Potassium and various concentrations of maleic hydrazide had a significant effect on fresh flower weight (g), while their interaction also showed a significant effect Table 4. The maximum fresh flower weight (44.29 g) was observed in plants receiving 200 mg K pot^{-1}, followed by plants obtained 100 mg K pot^{-1} (39.88 g), which was at par with 300 mg K pot^{-1} (37.05 g). Minimum fresh flower weight (32.48 g) was observed in plants of control.

Table 4: *Fresh flower weight (g) of chrysanthemum as affected by application of potassium and maleic hydrazide*

Maleic hydrazide (ppm)	Potassium (mg pot^{-1})				Means
	Control	100	200	300	
Control	13.00	23.67	41.37	18.25	24.07 C
500	34.97	43.70	38.62	36.67	38.49 B
1000	46.83	41.25	43.00	42.08	43.29 AB
1500	35.13	50.90	54.20	51.19	47.85 A
Means	32.48 C	39.88 AB	44.29 A	37.05 BC	

LSD value for potassium and maleic hydrazide at 1% level of significance = 4.90; LSD value for interaction at 1% level of significance = 9.81; Means followed by same letters are not significantly different by using LSD at 1 % (upper case) level of significance.

The maleic hydrazide concentrations showed that maximum fresh flower weight (47.85 g) was noted in the plants got 1500 ppm maleic hydrazide, followed by plants (43.29 g) treated with 1000 ppm maleic hydrazide, which varies significantly from the other treatments. Minimum fresh weight (24.07 g) was noted in plants grown under control. The interaction of potassium and maleic hydrazide indicated that maximum fresh flower weight (54.20 g) was recorded by the plants obtained 200 mg potassium and 1500 ppm maleic hydrazide, while minimum fresh flower weight (13.00 g) was recorded in plants grown as control.

The increment in the flower weight as a result of potassium because potassium helps in the synthesis of protein which consequently affects the cell division in the reproductive part of the plant. Potassium enhances the uptake of phosphorous which influences the flowers. These results were in line with Panchal et al. (2010), who reported the maximum flower weight of chrysanthemum with the nutrient solution containing sufficient potassium. The findings were also in partial agreement with the study of Naggar (2009) who reported significant increase in the fresh weight of flowers in Dianthus with the foliar spray containing 20% potassium and other macro and micro elements. Joiner and Smith (1960) also reported that potassium at the rate of 300 and 400 ppm improved the flower weight significantly. The results were in similarity with Pal and Gosh (2010), who recorded fresher flower weight (5.58 g) in marigold with the application of 200 kg ha^{-1} potassium.

The increase in fresh flower weight due to maleic hydrazide might be due to the reason that it induces reproductive growth by suppressing the vegetative growth. The findings of the study were in line with Haque et al. (2007) who reported increased flower weight in chrysanthemum due to application of growth retardants.

Dry flower weight (g)

Potassium levels and various concentrations of maleic hydrazide had a significant effect on dry flower weight (g) of chrysanthemum. The interaction of both the factors potassium and maleic hydrazide was also found significant Table 5.

Table 5: *Dry flower weight (g) of chrysanthemum as affected by application of potassium and maleic hydrazide*

Maleic hydrazide (ppm)	Potassium (mg pot^{-1})				Means
	Control	100	200	300	
Control	2.55	4.67	4.22	2.67	3.52 C
500	2.58	4.67	4.28	4.33	3.96 BC
1000	4.28	3.61	5.28	5.40	4.64 B
1500	6.43	4.99	6.74	5.06	5.80 A
Means	3.96 B	4.48 AB	5.12 A	4.36 B	

LSD value for potassium at 5% level of significance = 0.671; LSD value for maleic hydrazide at 1% level of significance = 0.902; LSD value for interaction at 1% level of significance = 1.80; Means followed by same letters are not significantly different by using LSD at 1 % (upper case) and 5 % (lower case) level of significance.

The potassium levels showed that maximum dry flower weight (5.12 g) was found in plants under the treatment of 200 mg K_2O pot^{-1}, followed by dry flower weight

(4.48 g) obtained from plants treated with 100 mg K. whereas, minimum dry flower weight (3.96 g) was observed in the plants grown in control treatment. In the case of maleic hydrazide concentrations, the mean values of the data indicated that maximum dry flower weight (5.80 g) was noticed in plants received 1500 ppm maleic hydrazide which showed a significant difference with the rest of the maleic hydrazide treatments, followed by plants treated with 1000 ppm (4.64 g). On the other hand, minimum dry flower weight (3.52 g) was noted in the plants grown under control treatment.

As pertained to the interaction between potassium levels and maleic hydrazide concentrations, maximum dry flower weight (6.74 g) was recorded in plants supplied with 200 mg K and 1500 ppm maleic hydrazide. In contrast minimum dry flower weight (2.55 g) was observed in control. Potassium improves the flower quality attributes of the plant. The application of potassium fertilizer enhanced the dry flower weight as compared to the control treatment (Naggar, 2009). Additionally the results were in partial agreement with Joiner and Smith (1960), who studied that potassium application improves the flower quality including dry weight of the flower in chrysanthemum. The adjacent increased in dry flower weight occurred in chrysanthemum with fresh flower weight. The outcome of the study was partially supported by Haque et al. (2007) reported drier flower weight of chrysanthemum caused by the use of growth retardants.

Conclusions

Based on the current research work, it was concluded that the best results for some of the vegetative growth parameters were achieved at 200 mg K pot^{-1} and no maleic hydrazide treatment. The application of 200 mg K+1500 ppm maleic hydrazide in combination significantly influenced the quality of flower. It recommended that Potassium at the rate of 200 mg pot^{-1}may be used for better vegetative and floral growth of chrysanthemum while maleic hydrazide at the rate of 1500 ppm may be used for quality flower production under agro-climatic conditions of Peshawar-Pakistan.

Author's Contribution

Nagina Zeb conducted the research and trials under the supervision of Muhammad Sajid and Abdul Mateen Khattak whose guidance was there in conduction of experiment and data of the parameters studied. Imtiaz Hussain contributed in the Data collection and statistical analysis of the data. Nagina Zeb and Imtiaz Hussain prepared the manuscript for submission.

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