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EFFECT OF DIFFERENT SOURCES AND LEVELS OF POTASSIUM ON YIELD AND CAROTENOIDS CONTENT OF AFRICAN MARIGOLD (*TAGETES ERECTA* LINN.) cv. 'MAXIMA YELLOW'

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Abstract

A field experiment was conducted at the Department of Floriculture and Landscape Architecture, Horticultural College and Research Institute, Dr. Y. S. R. Horticultural University, Venkataramannagudem, West Godavari district (A.P.), India; during *kharif* 2014-15 to investigate the effect of different sources (muriate of potash and sulphate of potash) and levels of potassium (0, 40, 80, 120, 160, 200 and 240 kg ha^{-1}) on flower yield and carotenoids content in African marigold (*Tagetes erecta* Linn.) cv. 'Maxima Yellow'. Based on the results obtained, it was concluded that potassium applied at the rate of 240 kg/ha in the form of sulphate of potash recorded significantly the highest flower yield per hectare (223.66 q/ha). Significant differences were observed in carotenoids content of flower petals between the sources of potassium applied at the same level at all stages of flower harvest. However, the carotenoids content in the flower petals was recorded significantly the highest when sulphate of potash (K_2SO_4) was used as source of potassium at the rate of 240 kg ha^{-1} (28.53, 38.53 and 24.57 µg/100g of flower petals respectively at early, peak and final stages of harvest) which was at par with the application of potassium at the rate of 200 kg/ha in the form of sulphate of potash (25.38, 35.71 and 22.50 µg/100g of flower petals respectively at early, peak and final stages of harvest).

Key words : Marigold, muriate of potash, sulphate of potash, carotenoids, yield.

Introduction

African marigold (*Tagetes erecta* Linn.) a member of Asteraceae family is one of the commercially exploited flower crops for its loose flower production. Its habit is of free flowering, short duration to produce marketable flowers with wide spectrum of attractive colours, shapes and sizes with good keeping quality has attracted the attention of flower growers. However, marigold is commercially grown mainly for its loose flower production. Marigold flowers are used in making garlands, flower decorations during several social and religious functions and further the petals are used in the pigment extraction industry besides its use in the dry flower making. Recently, marigold is grown commercially for the extraction of carotenoid pigments mainly xanthophylls. The carotenoid pigments extracted from flower petals are added to poultry feed for the intensification of yellow colour of the egg yolk. Lutein, a major constituent of xanthophylls is also used for colouring of food stuffs. The pigment extraction industry requires very large quantities of flowers for full capacity utilization to meet the production requirements of pigments and antioxidants. Hence, there is a need to produce the flowers round the year to meet both the industrial and domestic market requirements.

Potassium plays a major role in increasing the flower yield and quality. However, most of the times the source of potassium used is muriate of potash, which is derived from muric acid (HCl). But in the recent times, it was observed that muriate of potash has bleaching effect on the pigments, hence, it is thought that there is a possibility for reduction in the carotenoids content, which is the vital pigment in marigold flower petals and has lot of demand both in the domestic as well as international trade. Keeping all these considerations in view, an experiment was planned and carried out with different sources and levels of potassium to find out the optimum source and level of potassium and its influence particularly on the flower yield and carotenoid content of African marigold cv. 'Maxima

Yellow', which is under commercial cultivation in and around this region.

Materials and Methods

The field experiment consisting of thirteen treatments with three replications in a Randomized Block Design was carried out in a sandy loam soil (consisting of organic carbon 0.24%, available nitrogen 186 kg ha^{-1}, available phosphorus 32.5 kg ha^{-1} and available potassium 215 kg ha^{-1}) in the Department of Floriculture and Landscape Architecture, Horticultural College and Research Institute, Dr. Y. S. R. Horticultural University, Venkataramannagudem, West Godavari district (A.P.), India; during *kharif* 2014-15. The treatments were consisting of two sources of potassium, *viz*., Muriate of potash (KCl or MOP) and sulphate of potash (K_2SO_4 or SOP) at six levels (40, 80, 120, 160, 200 and 240 kg ha^{-1}) with control (no external application of potassium *i.e*., 0 kg ha^{-1}). The gross plot size was 3.0 × 3.0 m and the treatments were allotted randomly in each plot.

The marigold seeds were sown in portrays filled with a mixture of soil, neem cake and vermicompost. One month age old seedlings of uniform size and vigour were used for transplanting in the main field at a distance of 40 cm between the two rows and 30 cm between plant to plant with in the row. Immediately after transplanting a light irrigation was given to the crop for better establishment of the seedlings in the field. Well decomposed farm yard manure @ 20 tonnes per hectare was applied to all the plots uniformly in the last ploughing and incorporated into the soil before transplanting. Two sources of potassium *i.e*., muriate of potash (MOP) and sulphate of potash (SOP) were applied separately and in different levels. The fertilizers were applied in five split doses at 15 days interval after transplanting as per the treatment details (15, 30, 45, 60 and 75 days after transplanting). Plots without any dose of potassium application were considered as control plots. Entire dose of phosphorus (200 kg ha^{-1}) was applied as a basal dose just before transplanting and the nitrogen (200 kg ha^{-1}) was applied in five splits at every 15 days interval along with the application of potassium fertilizers.

Well matured and fully opened flowers were harvested without stalk during the morning hours *i.e*., before 10.00 AM. The sample flowers were separated for further estimation of carotenoids in the flower petals. Carotenoids were extracted at three (early, peak and final) stages of harvesting of flowers and followed the Standard Methods of Bio-chemcial Analysis explained by Thimmaiah (1999) for estimation of total carotenoids.

Results and Discussion

The analyzed data pertaining to yield parameters are presented in table 1. Significant differences were observed in the yield per plant with different sources and levels of potassium application in African marigold cv. 'Maxima Yellow'. A gradual increase in the yield was observed with graded levels of application of potassium under different sources. Among all the treatments, control recorded significantly the lowest yield per plant (131.70 g). Application of potassium at the rate of 240 kg/ha in the form of sulphate of potash has recorded significantly the highest yield per plant (239.86 g), which was at par with the application of potassium at the rate of 200 kg/ ha. Application of potassium at the rate of 160 kg/ha has recorded intermediate results, whereas, application of potassium at the rates of 40, 80 and 120 kg/ha recorded lowest yields, which were at par with control. Based on the results obtained, it may be concluded that there were no significant differences in the flower yield per plant between the sources of potassium *i.e*., muriate of potash and sulphate of potash applied at the same level. The yield per plant has increased with an increase in the level of potassium application, which was in conformity with the results obtained by Kishore *et al*. (2010) in African marigold.

Significant differences were observed in the flower yield per plot with different sources and levels of potassium application in African marigold cv. 'Maxima Yellow'. A gradual increase in the yield per plot was observed with graded levels of application of potassium under different sources. Among all the treatments control recorded significantly the lowest yield per plot (5.62 kg). Application of potassium at the rate of 240 kg/ha in the form of sulphate of potash has recorded significantly the highest yield per plot (14.03 kg). Potassium applied in the form of muriate of potash has recorded significantly the lowest yields per plot when compared to sulphate of potash applied at the same level. Further, it was interesting to notice that the higher level of potassium applied in the form of muriate of potash has produced significantly no different yields with the next lower level of treatment of potassium applied in the form of sulphate of potash except with the application of potassium at the rate of 40 kg/ha. Based on the results obtained, it may be concluded that there were significant differences in the yield per plot between the sources of potassium applied at the same level. It was also noticed that the yield per plot increased with an increase in the level of potassium applied. The yield per plot increased with increased level of potassium fertilizer application under different sources. The yield per plot was significantly higher with the application of sulphate of potash than muriate of potash. It might be due to the fact that the completely water soluble nature of sulphate of potash needs no further transformation in the soil and could easily be absorbed by the plants. Further, due to its synergistic effect with other elements sulphur could increase the absorption of potassium or it could react with nitrogen and potassium (Farrag *et al*., 1990). Sulphur helps in the transformation of energy and activation of enzymes in the carbohydrate metabolism and subsequently plays a greater role in the partitioning of the photo assimilates and helps to increase the plant height (47.86 cm), primary branches per plant (11.73), plant spread (49.50 cm), single flower weight (8.90 g), number of flowers per plant (36.63), dry weight of the flowers (8.65 g) and finally increased the yield per plot (14.03 kg) (the data presented in the parenthesis are not represented from the table). Pal and Ghosh (2010) also reported similar findings earlier in African marigold.

Significant differences were observed in the yield per hectare with different sources and levels of potassium application in African marigold cv. 'Maxima Yellow'. A gradual increase in the yield per hectare was observed with graded levels of application of potassium under different sources. Among all the treatments, control recorded significantly the lowest yield per hectare (89.33 q), which was at par with the application of potassium at the rate of 40 kg/ha in the form or muriate of potash. Application of potassium at the rate of 240 kg/ha in the form of sulphate of potash has recorded significantly the highest yield per hectare (223.66 q). Potassium applied in the form of muriate of potash has recorded significantly the lowest yields per hectare when compared to sulphate of potash applied at the same level. Further, it was also interesting to notice that the higher level of potassium applied in the form of muriate of potash has produced significantly no different yields per hectare with the next lower level of treatment of potassium applied in the form of sulphate of potash except with the application of potassium at the rate of 40 and 80 kg/ha which were at par with 80 and 120 kg/ha. Potassium applied in the form of muriate of potash has recorded significantly the lower yields per hectare when compared to the application of sulphate of potash at the same level. Based on the results obtained, it could be concluded that there were significant differences between the sources and levels of potassium application on yield per hectare. The sulphate of potash has recorded significantly higher yields per hectare in comparison to the muriate of potash applied. It is an established fact that the solubility of sulphate of potash *per-se* is higher than muriate of potash. Hence, the readily available form has increased the translocation of photo assimilates in to the floral organs thereby increased flower yield per hectare was recorded. Another reason for increased flower yield with sulphate of potash might be due to absence of chloride toxicity, which was normally met with muriate of potash. Similar findings were also reported earlier by Kumar and Kumar (2008), Singh *et al*. (2009) and Pushkar and Rathore (2011) in African marigold.

Table 1 : Effect of different sources and levels of potassium on the flower yield of African marigold cv. 'Maxima Yellow'.

Treatments	Yield per plant (g)	Yield per plot (kg)	Yield per hectare (q)
40 kg K_2O/ha as KCl	145.26	6.39	102.00
40 kg K_2O/ha as K_2SO_4	147.80	7.42	118.33
80 kg K_2O/ha as KCl	150.90	7.74	123.33
80 kg K_2O/ha as K_2SO_4	156.30	8.11	129.33
120 kg K_2O/ha as KCl	164.43	8.55	136.00
120 kg K_2O/ha as K_2SO_4	173.36	9.23	147.00
160 kg K_2O/ha as KCl	184.60	9.82	156.66
160 kg K_2O/ha as K_2SO_4	190.30	10.21	162.66
200 kg K_2O/ha as KCl	210.83	10.95	174.66
200 kg K_2O/ha as K_2SO_4	222.66	11.85	189.00
240 kg K_2O/ha as KCl	228.96	12.51	199.66
240 kg K_2O/ha as K_2SO_4	239.86	14.03	223.66
Control (0 kg K_2O/ha)	131.70	5.62	89.33
Mean	**180.53**	**9.42**	**150.00**
S.Em±	10.92	0.44	7.21
CD at 5%	32.06	1.31	21.17

The data pertaining to carotenoids content in flower petals are presented in table 2. A gradual increase in carotenoids content of flower petals was observed with graded levels of potassium application from 0 to 240 kg/ha under different sources. Further, significant differences were observed in carotenoids content of flower petals with different sources and levels of potassium applied at early, peak and final stages of harvesting. Among all the treatments, control recorded significantly the lowest carotenoids content (4.44, 13.77 and 4.10 µg/100g respectively at early, peak and final stages of harvesting), which was at par with the application of potassium at the rate of 40 kg/ha in the form of muriate of potash at all stages of flower harvest. Application of potassium at the rate of 240 kg/ha in the form of sulphate of potash has recorded significantly the highest carotenoids content (28.53, 38.53 and 24.57 µg/100g, respectively at early, peak and final stages of harvest) in the flower petals, which was at par with the application of potassium at the rate of 200 kg/ha in the form of sulphate of potash at all the three stages of flower harvest. Significant differences

Table 2 : Effect of different sources and levels of potassium on carotenoids content (µg/100 g) in flower petals of African marigold cv. 'Maxima Yellow'.

Treatments	Carotenoids content in the flower petals (µg/100 g)		
	Early stage of harvesting	Peak stage of harvesting	Final stage of harvesting
40 kg K_2O/ha as KCl	5.52	16.52	4.63
40 kg K_2O/ha as K_2SO_4	14.93	25.26	12.73
80 kg K_2O/ha as KCl	7.23	17.68	6.20
80 kg K_2O/ha as K_2SO_4	18.68	28.68	16.85
120 kg K_2O/ha as KCl	7.68	17.90	6.74
120 kg K_2O/ha as K_2SO_4	19.84	29.84	17.80
160 kg K_2O/ha as KCl	8.50	18.85	7.54
160 kg K_2O/ha as K_2SO_4	20.65	31.31	18.89
200 kg K_2O/ha as KCl	10.43	20.43	9.29
200 kg K_2O/ha as K_2SO_4	25.38	35.71	22.50
240 kg K_2O/ha as KCl	12.15	22.81	10.51
240 kg K_2O/ha as K_2SO_4	28.53	38.53	24.57
Control (0 kg K_2O/ha)	4.44	13.77	4.10
Mean	**14.15**	**24.41**	**12.49**
S.Em±	1.21	1.35	1.30
CD at 5%	3.57	3.99	3.85

were observed in the carotenoids content of flower petals between the sources of potassium applied at the same level at all stages of flower harvest. Based on the results obtained it could be concluded that there was a gradual increase in the carotenoids content with graded levels of potassium applied from 0 to 240 kg/ha at all the stages of harvesting the flowers. Further, it was also noticed that there were significant differences between the sources of potassium applied *i.e.*, sulphate of potash and muriate of potash, at the same level of application. From the present result, it was evident that potassium plays a key role in increasing the carotenoids content of marigold flower petals. Apart from this, it was also observed that sulphate of potash has significantly increased the carotenoids content of flower petals when compared to muriate of potash. This might be due to the fact that potassium and sulphur play a crucial role in the process of carotenoids biosynthesis by activating several enzymes that regulate the carbohydrate metabolism as well as the formation of precursors of isopentinyl diphosphate (pyruvate and glyceraldehyde-3-phosphate). Further, it was also observed that the carotenoids content in the flower petals has decreased at the final stage of harvest when compared to early and peak stage of harvest. This might be due to the fact that maximum numbers of separated carotenoids in fully matured flowers than in over matured flowers. Similar results were reported earlier by Ahmad *et al*. (2010) in African marigold, Sedghi *et al*. (2011) and Hashemabadi *et al*. (2012) in calendula.

From this study, it can be concluded that if the crop is grown for quality flower yield and pigment (carotenoids) extraction then, it is recommended to apply potassium at the rate of 200 kg/ha in the form of sulphate of potash to avoid the chloride injury with the use of muriate of potash.

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