International Journal of Agriculture and Crop Sciences.
Available online at www.ijagcs.com
IJACS/2013/5-4/362-365
ISSN 2227-670X ©2013 IJACS Journal

IJACS

Ornamental value of *Calendula officinalis* "Yellow Gitana" as a result of nitrogen-fertilizer and plant density

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ABSTRACT: In order to study the effect of different levels of nitrogen and plant density on morphological characteristics and flower longevity of calendula (*Calendula officinalis* cv.Yellow Gitana), an experiment was conducted at research field of Faculty of Agriculture, Lorestan University, Khorramabad, Iran in 2009. The experiment was carried out as a split plot arrangement based on a randomized complete block design with three replications. Nitrogen level was the main factor with four levels (0, 50, 100 and 150 kg ha^{-1}) and plant density was the sub-factor with three levels (50, 33, 25 plant m^{-2}). Results showed that plant width, stem diameter, flower diameter, number of flowering stem $plant^{-1}$ and flower longevity increased with increasing nitrogen levels and decreasing plant density. Application of 150 kg ha^{-1} nitrogen and 25 plant m^{-2} produced maximum plant width, stem diameter, flower diameter, number of flowering stem $plant^{-1}$ and flower longevity with 28.6 cm, 5.7 mm, 46 mm, 36 and 93.5 h, respectively, and this treatment could be recommended to achieve the best morphological characteristics and flower longevity in calendula as a bedding ornamental plant under temperate climatic conditions of Khorramabad, Iran.

Key words**:** Calendula, Longevity, Morphological characteristics

INTRODUCTION

Calendula officinalis L. (Asteraceae), known as pot marigold, is an annual ornamental herb (Dole and Wilkins, 2005). It grows wild in the Southern, Eastern and Central Europe and in the North-West Africa (Cromack and Smith, 1998). It is usually multi-stemmed with a strong tap root. The vegetative parts of the plant are mid green while the stems are angular and covered in fine hairs. The flower color varies from a pale yellow to deep orange (Dole and Wilkins, 2005). There are ray and disc florets in the inflorescence. The composite flowers could be yellow or orange, which blossom in the spring-summer seasons (Gilman and Howe, 1999). Calendula is widely grown in Iran as a flowering bedding plant. It can also be grown as a cut flower or pot plant. Moreover, calendula is recorded in the world's reliable pharmacopeia as one of the most important medicinal plants (Cromack and Smith, 1998).

In one hand, nitrogen fertilizer is known as an effective environmental factor on productivity of agricultural and ornamental plants. On the other hand, 22000 kilocalories un-renewable energy is consumed to produce one kilogram nitrogen fertilizer (Duffy et al. 1992). Cheapness of energy has caused low price of nitrogen fertilizer in Middle East and its irregular use. Moreover underground water and river pollution due to nitrate must be taken into consideration. Also using an appropriate plant density is necessary for maximum utility of existing factors. Thus many researches have been done to determine the best level of nitrogen fertilizer and plant density and their effects on vegetative and generative parameters of agricultural and ornamental plants. However, much little has been carried out on morphological characteristics and flower longevity of calendula. Most researches on calendula have been done on the effects of abovementioned factors on seed and oil characteristics (Arganosa, et al. 1998). Dolatshahi (2008) investigated the effects of three levels of nitrogen (0, 100 and 200 kg ha^{-1}) on calendula and found that the desirable plant height, number of stems $plant^{-1}$, fresh and dry weight of aerial plant organs and flower diameter were obtained with the application of 200 kg ha^{-1}. Desirable stem diameter and number of petals were found with the application of 100 kg ha^{-1} nitrogen. Similarly, Rahmani et al. (2008) studied the effects of four levels of nitrogen (0, 30, 60 and 90 kg ha^{-1}) on calendula and concluded that the application of 90 kg ha^{-1} nitrogen produced maximum head diameter.

The objective of this research was to determine the effect of different levels of nitrogen and plant density on morphological characteristics and flower longevity in calendula as a bedding ornamental plant under temperate climatic conditions of Khorramabad, Iran.

MATERIALS AND METHODS

This study was conducted at research field of Faculty of Agriculture, Lorestan University, Khorramabad, Iran (33°29′ N and 48°22′ E, 1125 m above sea level) in 2009. The field soil properties of the top 300 mm, taken just before sowing, were silty clay loam with pH of 7.65, K 355 mg kg^{-1}, P 16.8 mg kg^{-1}, total N 0.07% organic carbon 0.77%, EC 0.73 ds m^{-1}, $CaCO_3$ 31.7% and base saturation 44. About 200 kg ha^{-1} triple super phosphate was added to the soil just before sowing (after soil analysis).

The experimental design was split-plot with three replications. The main plots were nitrogen with four levels (0, 50, 100 and 150 kg ha^{-1}) and the sub-plots were plant density with three levels (20 × 10 cm, 20 × 15 cm and 20 × 20 cm resulted in 50, 33 and 25 plants m^{-2}, respectively). Each sub-plot (experimental unit) had 4 m length and 1.2 m width in which six lines of the plants were cultivated.

Calendula seeds were sown manually as the usual dry planting method in March. After emergence of seedling, plants were thinned according to the desired plant densities. Nitrogen fertilizer in the form of urea (46% N) was applied in two equal splits, half at 35 days after sowing and remaining half at 65 days after sowing. Weeds were controlled manually. All the intercultural operations were done in proper time. In this research flower longevity, number of petals $flower^{-1}$, flower diameter, plant width, stem diameter, number of flowering stems $plant^{-1}$ and flowering time were recorded. At the flowering time, 15 plants were selected at random from each sub-plot to collect data on plant height, plant width, stem diameter, flower diameter. Flowering time was calculated from time of sowing until onset of flowering. Flower longevity was recorded from flower opening until flower wilting.

Statistical significance between mean values was assessed through analysis of variance (ANOVA) and a conventional Duncan's Multiple Range Test at $P<0.05$ using MSTAT-C software (Michigan State University, East Lansing, MI, USA).

RESULTS AND DISCUSSION

Results of analysis of variance (ANOVA) showed that nitrogen fertilizer had significant effect on flower longevity ($P<0.01$) and flower diameter ($P<0.05$) (Table 1). Mean comparison (Table 2) showed that application of 150 kg ha^{-1} nitrogen resulted in the highest plant width, plant height, stem diameter, flowering time, number of petals $flower^{-1}$ and flower longevity (26.51 cm, 28.50 cm, 5.39 mm. 77.22 days, 71.1 petals and 88.97 h, respectively). The highest number of flowering stems $plant^{-1}$ (32.4) was found with application of 100 kg ha^{-1} nitrogen which was not significantly different from those with application of 150 kg ha^{-1} nitrogen. The highest flower diameter (45.1 mm) was found with application of 150 kg ha^{-1} nitrogen which was not significantly different from those with application of 50 kg ha^{-1} and 100 kg ha^{-1} nitrogen.

Table 1. A summary of ANOVA of the effects of nitrogen levels and plant densities onmorphological characteristics and flower longevity of Calendula (Mean squares)

S.O.V.	D.F.	Flower longevity	No. of petals/flower	Flower diameter	Flowering time	No. of flowering stems $plant^{-1}$	Stem diameter	Plant height	Plant width
Replicates	2	12.045	4671.067	24.128	1.750	0.355	0.737	11.534	4.797
Nitrogen (A)	3	107.491**	3189.870^{ns}	21.980*	18.620^{ns}	41.580^{ns}	0.818^{ns}	25.885^{ns}	9.247^{ns}
Error (A)	6	8.649	2103.462	3.095	7.676	41.755	0.317	16.574	12.463
Density (B)	2	93.370**	217.859^{ns}	15.620*	14.083**	226.572**	1.027*	9.203^{ns}	40.845**
A×B	6	10.234^{ns}	581.489*	1.911^{ns}	1.231^{ns}	22.289^{ns}	0.008^{ns}	3.747^{ns}	0.473^{ns}
Error	16	10.373	206.413	2.978	0.611	10.921	0.167	3.817	3.539
CV	-	3.84	9.97	3.95	1.04	11.00	8.22	7.42	7.42

** significant at 1% ($p<0.01$), * significant at 5% ($p<0.05$), ^{ns} not significant ($p<0.05$)

ANOVA showed that plant density had significant effects on plant width, number of flower stems $plant^{-1}$, flowing time, flower longevity ($P<0.01$) and stem diameter and flower diameter ($P<0.05$) (Table 1). Mean comparison (Table 2) showed that the highest plant width, stem diameter, flower longevity and flower diameter (27.19 cm, 5.28 mm, 76.33 h and 45 mm, respectively) were found in density of 25 plants m^{-2}. The highest number of Flower stems $plant^{-1}$ and flower longevity (33.3 stems and 85.83 h, respectively) was found in density of 25 plants m^{-2}, which was not significantly different from density of 33 plants m^{-2}.