# The Effects of sowing date and plant density on seed and flower yield of Pot Marigold (*Calendula officinalis* L.)

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**Abstract**

Medicinal herbs have been used to promote health for centuries, and have increased in popularity and sales in the last 10-20 years. Pot marigold (*Calendula officinalis L.*) is a medicinal herb whose dried flower heads are used to heal wounds. In order to understand the effects of sowing dates and plant density on grain and flower yield of pot marigold, an experiment was conducted at Agricultural Research Center of Islamic Azad University, Birjand Branch in 2005. Three sowing dates (30 March, 14 April and 30 April) and three plant densities (plant distances on row were 10, 20 and 30 centimeters) were compared in a split- plot design based on randomized complete blocks with 3 replications. Seed and flower yield were significantly different at planting dates and plant densities. Sowing date had significant effects on flower and seed harvest index. The latest sowing date had the highest flower and seed harvest index. Plant density did not have any significant effect on flower harvest index, but the effect on seed harvest index, was significant. In total, the result showed that the first sowing date with 25plants/$m^2$ had the highest grain and flower yield.

**Keywords**: marigold, sowing date, plant density, harvest index, yield, seed, flower number, flower diameter

## Introduction

Iran plains have different climates, so different plant species (more than 7500) grow in these areas. Some of these species are useful as medicinal herbs. According to harmful effects of chemical and synthetic medicines in human, using medicinal products of plants has increased. Medicinal herbs have been used to promote health for centuries, and have increased in popularity and sales in the last 10- 20 years.

Pot marigold (*Calendula officinalis*) is a perennial or annual herb originating from southern Europe and eastern Mediterranean areas. The plant has many traditional culinary and herbal uses. The dye obtained from the flowers is used to color and flavor foods like rice, soup, cheese and butter. An infusion made from the crushed foliage has antiseptic properties and is used for healing skin wounds (ADAS consulting Ltd., 2002).

Some results have shown that organic extract of flowers from pot marigold possesses anti-HIV properties of therapeutic interest (Kalvatchev et al., 1997).

The seed of *Calendula* contains 18-22% oil and this contains 55-60% calendic acid. Some research has shown that the oil can be successfully used in paint formulations (Kalvatchev et al., 1997).

For the agronomy of a new crop to be refined successfully, there must be a detailed understanding of its interaction with major agronomic, genetic and climate factors (ADAS consulting Ltd., 2002). To access maximum yield, we require deciding appropriate sowing date. The effect of environmental factors on plant physiological process causes sowing date to be varied in different places and varieties (Hadley and Summer Field, 1983; Sandhu, 1984).

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In the very early sowing dates, low temperatures and freezing injury cause the seedling to become weak. Very late sowing dates have undesirable effects on plant's growth and development. This results from reducing plant growth season. In this condition plant anthesis might be done in high temperatures (Majumdar, 1986).

According to a trial that was conducted on *Calendula officinalis* in Chillan, Chile this plant can be sown there from June to October (www. alerce. inia. cl/agriculturatec/ Documentos/).

Plant density is an important factor in determination of plant yield. Totally, in low density the plants can not completely use environmental factors such as light, water and soil; however intra-species competition in high density decreases the yield.

Martin and Deo (1999) in a trial at Lincoln, New Zealand on *Calendula officinalis* studied the effects of plant density on seed and flower yield. Total flower yield was not significantly different at populations over 46 plants/$m^2$, but declined with lower plant populations. The number of fully opened flower heads collected off each plot increased from 164 to 650 per $m^2$ with increasing plant population. Seed yield increased with increasing plant population from 128 g/$m^2$at 9 plants/ $m^2$ to 300g/$m^2$ at the highest populations.

Cromack and Smith (1998) studied the effect of plant populations (10 to 80 plants/$m^2$) on *Calendula officinalis*. In this experiment, the effect of plant density on yield was significant, which increased up to a plant density of 40 $m^{-2}$.

In an experiment that was conducted by Borm and van Dijk (1994) seed yield was increased with raising plant population up to 40 plants/$m^2$. Robbelen et al. (1994) reported seed yield increasing up to 60 plant/ $m^2$.

This experiment was conducted to determine appropriate sowing date and plant density of *Calendula officinalis* in Birjand, Iran. In addition, the effects of these two factors on seed and flower yield and some morphological characteristics were studied.

## Materials and methods

This experiment was conducted at Agricultural Research Center of Islamic Azad University, Birjand Branch in 2005. Longitude, latitude and altitude of Birjand are 59° 13′, 32˚ 53′ and 1480 m, respectively. The climate of Birjand is dry and warm, because it is at the vicinity of Loot plain. Maximum and minimum temperature averages in Birjand are 27.5 and 4.6 degrees centigrade. Annual rainfall average is 170mm. Maximum and minimum humidity averages are 59.6% and 23.5%.

Soil texture in experiment place was sandy- loam and soil pH was 8.1. Electrical conductivity of irrigation water was 2.6 mmoh/cm. Applied fertilizers consisted of decomposed animal manure (10 t/ha pre-planting), Urea (80 kg/ha pre-planting and 80 kg/ha one month after sowing) and Ammonium phosphate (100 kg/ha pre-planting).

Sowing was conducted on the two sides of ridge. The distance between ridges was 80 cm, therefore the planting interval rows were 40 cm. Experimental design was split-plot based on randomized complete block with 3 replications. Three sowing dates (30 March, 14 April and 30 April) were main- plot and three plant densities (plant distances on row were 10, 20 and 30 centimeter that produced plant densities: 25, 12.5 and 8.33 plants per $m^2$, respectively) were sub-plot. Irrigation interval was 7 days. According to seed importance, seed has been harvested as well as its flower. Each plot had 6 rows. The first and final rows were considered as marginal effect. Two rows were considered for seed harvesting and two for flower. Analysis of variance was conducted using Mstatc software.

## Results and Discussion

### 1-Yield

There was no significant difference between flower yield in sowing dates of 30 March and 14 April (105.8 and 112.5 g/$m^2$, respectively), but these yields were more than sowing date of 30 April (80.7 g/$m^2$) (Tables 1 and 2). In these sowing dates, seed yield was 276.5, 198.5 and 167.8 g/$m^2$, respectively and there was significant difference between them. Seed and flower had the highest yield in earlier sowing date. Because it's growth season was be longer than the others and plant could enjoyed suitable climate in early spring.

Flower and seed yield were not significantly different at the two lowest plant populations (Table 3). Flower and seed yield were the highest at 25 plants/$m^2$ (125.4 and 233.6 g/$m^2$, respectively). These results suggest, although *calendula* is a indeterminate plant, insufficient plant per $m^2$ couldn't be compensated by more branching in low density.

Martin and Deo (2000) also reported that flower yield increased from 0.5 to 1.4 kg/$m^2$ by increasing plant population from 9 to 26 plants/$m^2$, but didn't significantly differ at the highest population.

In separately experiments done by Cromack and Smith (1998) and Borm and van Dijk (1994) a significant effect of plant density (up to 40 plants/$m^2$) on flower yield was found.

An experiment that was conducted in Norfolk, Virginia demonstrated that densities above 40 plant/$m^2$ offered little extra benefit in terms of increased seed yield. Indeed, mutual shading of lower leaves and

flower heads of *Calendula* may have impeded yield formation (ADAS consulting Ltd., 2002).

In this experiment biomass yield was determined by flower and seed, separately. Results suggested biomass yield has similar changes in seed and flower. On the whole, the earliest sowing date and the highest plant density have the greatest biomass yield (Tables 2 and 3).

**2-Harvest index**

Flower harvest index in 30 March sowing date was lower than the others (Table 2).This suggests that increasing growth season through earlier sowing date, caused increase plant vegetative structures to be greater than increasing plant reproductive structures.

The effect of plant density on flower harvest index was not significantly different (Tables 1 and 3). This suggests that producing reproductive and vegetative structures increased equally, as plant population increased.

Seed harvest index was increased by postponing sowing date (Table 2). Just like flower, this suggest that increasing growing season through early sowing date, caused increase plant vegetative structures to be greater than increasing plant reproductive structures.

Considering the fact that seed harvest index decreased when plant population increased (Table 3), and plant population did not have a significant effect on flower harvest index, it can be concluded that although flower production has increased in high density, flower fertilization decreased. Therefore, increasing seed yield was less than flower yield.

**3- Flower number and diameter**

The effect of sowing date and plant population on flower number per plant and per $m^2$ was significant (Table 4). Late sowing date decreased flower number per plant (Table 5).

The effect of plant population on flower number per plant and per $m^2$ was reverse. When plant population increased, flower number per plant decreased, but per $m^2$ increased (Table 6) which results from increasing interplant competition.

Flower diameter was significantly different at plant populations and sowing dates. Flowers produced in late sowing dates were larger (probably because less flower production per plant in late sowing date causes less competition between flowers) (Table 5).

Increasing plant population significantly decreased flower diameter. This is because of increasing competition and mutual shading (Table 6).

## Conclusion

In this experiment early sowing date and more plant population had the highest flower and seed yield. More flower yield of early sowing date was the result of increasing growth period and suitable climate condition in early spring. These caused more flowers and seeds produced per $m^2$. Results showed although *calendula* is an indeterminate plant, insufficient plant per $m^2$ couldn't be compensated by more branching in low density. In total, sowing at 30 March with 25 plants/$m^2$, to be recommended for marigold in Birjand.

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**Table 1:** Mean square for the effects of sowing date and plant density on grain and flower yield, biomass and harvest index of Pot Marigold

| S.O.V | d.f | Flower yield | Seed yield | Biomass (with seed) | Biomass (with flower) | Seed HI | Flower HI |
|---|---|---|---|---|---|---|---|
| Replication | 2 | 867.0 $^{ns}$ | 2765.7 * | 2403.2 $^{ns}$ | 1209.7 $^{ns}$ | 35.9 ** | 19.5 $^{ns}$ |
| Sowing date (A) | 2 | 2535.6 * | 28243.1 ** | 250878.3 ** | 131587.1 ** | 28.1 * | 194.0 * |
| 1$^{st}$error | 4 | 342.4 | 157.8 | 714.3 | 1264.6 | 1.6 | 12.3 |
| Plant density (B) | 2 | 4532 ** | 3664.8 * | 94126.3 ** | 103494.2 ** | 138.4 ** | 13.8 $^{ns}$ |
| A × B | 4 | 553.1 $^{ns}$ | 1047.4 $^{ns}$ | 14219.4 $^{ns}$ | 11765.0 * | 13.1 $^{ns}$ | 46.4 $^{ns}$ |
| 2nd error | 12 | 219.1 | 910.4 | 5417.8 | 2674.9 | 10.7 | 17.6 |

ns: Non significant *: Significant at the 5% level **: Significant at the 1% level

**Table 2:** The effects of sowing date on flower and seed yield and harvest index of Pot Marigold

| Sowing date | Dry flower yield (g/m$^2$) | Seed yield (g/m$^2$) | Biomass yield with seed (g/m$^2$) | Biomass yield with flower (g/m$^2$) | Seed HI | Flower HI |
|---|---|---|---|---|---|---|
| 30 March | 105.8 a | 276.5 a | 728.2 a | 557.4 a | 38.6 c | 19.0 b |
| 14 April | 112.5 a | 198.5 b | 492.6 b | 406.7 b | 40.4 b | 27.7 a |
| 30 April | 80.7 b | 167.8 c | 405.5 c | 318.2 c | 42.2 a | 26.2 a |

Means followed by the same letters in each column are not significantly different at the 5% level of probability

**Table 3:** The effects of plant density on flower and seed yield and harvest index of Pot Marigold

| Plant density (m$^2$) | Dry flower yield (g/m$^2$) | Seed yield (g/m$^2$) | Biomass yield with seed (g/m$^2$) | Biomass yield with flower (g/m$^2$) | Seed HI | Flower HI |
|---|---|---|---|---|---|---|
| 25 | 125.4 a | 233.6 a | 659.6 a | 551.3 a | 36.3 b | 23.7 a |
| 12.5 | 84.3 b | 193.4 b | 473.2 b | 364.2 b | 40.8 a | 23.5 a |
| 8.33 | 89.2 b | 215.8 ab | 493.5 b | 366.9 b | 44.1 a | 25.7 a |

Means followed by the same letters in each column are not significantly different at the 5% level of probability

**Table 4:** Mean square for the effects of sowing date and plant density on number of flower and flower diameter of Pot Marigold

| S.O.V | d.f | Flower number per plant | Flower number per m$^2$ | Flower diameter |
|---|---|---|---|---|
| Replication | 2 | 49.5 $^{ns}$ | 15431.2 $^{ns}$ | 6.3 * |
| Sowing date (A) | 2 | 500.0 * | 118907.3 ** | 10.7 * |
| 1$^{st}$error | 4 | 28.7 | 6490.8 | 0.8 |
| Plant density (B) | 2 | 2612.6 ** | 234118.8 ** | 12.0 ** |
| A × B | 4 | 93.3 ** | 23566.0 ** | 3.0 $^{ns}$ |
| 2nd error | 12 | 10.0 | 3257.4 | 1.1 |

ns: Non significant *: Significant at the 5% level **: Significant at the 1% level

**Table 5:** The effects of sowing date on flower number and diameter of Pot marigold

| Sowing date | Flower number per plant | Flower number per m$^2$ | Flower diameter (mm) |
|---|---|---|---|
| 30 March | 49.2 a | 645.4 b | 32.1 b |
| 14 April | 54.8 a | 762.5 a | 33.5 a |
| 30 April | 40.1 b | 532.6 c | 34.2 a |

Means followed by the same letters in each column are not significantly different at the 5% level of probability

**Table 6**: The effects of plant density on flower number and diameter of Pot marigold

| Plant density (m$^2$) | Flower number per plant | Flower number per m$^2$ | Flower diameter (mm) |
|---|---|---|---|
| 25 | 33.3 c | 833.1 a | 32.1 c |
| 12.5 | 44.1 b | 551.6 b | 33.2 b |
| 8.33 | 66.7 a | 555.9 b | 34.4 a |

Means followed by the same letters in each column are not significantly different at the 5% level of probability

# اثر تراکم و تاریخ کاشت بر عملکرد دانه و گل همیشه بهار (*Calendula officinalis*)

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## چکیده

گیاهان دارویی سالهاست که برای درمان بیماری ها مورد استفاده قرار می گیرند و به ویـژه در طـی ۱۰ تـا ۲۰ سـال اخیـر اهمیت زیادی پیدا کرده اند. همیشه بهار یکی از گیاهان دارویی است که گل های آن در درمان زخم ها کاربرد دارد. به منظور تعیین تراکم و تاریخ کاشت مناسب این گیاه آزمایشی در سال ۱۳۸٤ در مزرعه آموزشی تحقیقاتی دانشگاه آزاد اسلامی واحـد بیرجند انجام شد. طرح آزمایشی از نوع اسپلیت پلات در قالب بلوک های کامل تصادفی با سه تکرار بـود. سـه سـطح تـاریخ کاشت (۱۰ فروردین، ۲۵ فروردین و ۱۰ اردیبهشت) به عنوان کرت اصلی و سه سطح تراکم (فواصل بوتـه روی ردیـف ۱۰، ۲۰ و ۳۰ سانتیمتر) به عنوان کرت فرعی در نظر گرفته شد. در این آزمایش تاریخ کاشت و تراکم اثر معنی داری روی عملکرد گل خشک و عملکرد دانه داشت. در تاریخ کاشت های ۱۰ و ۲۵ فروردین عملکرد گل خشک بیـشتری از تـاریخ کاشـت ۱۰ اردیبهشت حاصل شد. همچنین تاریخ کاشت ۱۰ فروردین بیشترین عملکرد دانه را داشت. در بـین تـراکم هـای کاشـت نیـز تراکم ۲۵ بوته در متر مربع بیشترین عملکرد گل خشک و دانه را داشت. در این آزمایش با تاخیر در کاشت، شاخص برداشت گل و دانه افزایش معنی داری نشان داد. شاخص برداشت گل در بوته به طور معنی داری تحت تاثیر تراکم قرار نگرفـت، امـا شاخص برداشت دانه در بوته با افزایش تراکم کاهش معنی‌داری نشان داد. در این آزمایش علاوه بر صفات مربوط به عملکرد، تعداد و قطر گل نیز در تیمارهای مختلف مقایسه گردید.

**کلمات کلیدی**: همیشه بهار، تاریخ کاشت، تراکم، عملکرد، شاخص برداشت، تعداد گل، قطر گل، دانه