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**THE EFFECT OF VARIETY AND PLANT DENSITY ON POT
MARIGOLD FLOWER YIELD (*Calendula officinalis* L.) IN
AGRO-ECOLOGICAL CONDITIONS OF BIJELO POLJE**

SUMMARY

Collecting medicinal plants from their natural habitats cannot meet the needs of the increased demand for natural medicinal raw materials in the global market, which caused the expansion of medicinal plants cultivation. This paper deals with the influence of the three varieties of pot marigold; “Plamen Plus”, “Bački Petrovac” and “Orange King” in different sowing density on pot marigold yield.

By studying the effects of the variety and plant density on a total yield of fresh inflorescence of marigold, it was found out that variety has a statistically significant effect on yield. The variety “Plamen plus” has achieved the higher yield (5724 kg ha⁻¹) comparing with the other two varieties which did not differ significantly, although the lowest yield was obtained by the variety “Orange King” (3243 kg ha⁻¹).

Keywords: *Calendula officinalis*, pot marigold, variety, yield

INTRODUCTION

Collecting medicinal plants from their natural habitats cannot meet the needs of increased demand for natural medicinal raw materials on the world market. Today the efforts are made to meet these needs by medicinal plants cultivation/plantation coupled with field inspection, in order to obtain healthy, not pesticide contaminated raw material, uniform quality, sufficient quantity and meet the agreed deadlines (Mrđa et al., 2007; Buha, 2012).

Pot marigold (*Calendula officinalis* L.) is an annual or, less commonly, biennial herbaceous plant. It is successfully cultivated in areas with moderately warm and moderately humid climate. The sowing forecast is, in fact, the forecast of the date when the sowing layer of soil will be warmed up to the biological minimum required for seed germination (Otorepec, 1980). It grows well on poor soils, but does not

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provide high-quality yields as in deep soils, with average amount of nutrients. The plants grown under optimal conditions have a higher tolerance to stress factors (Kastori et al., 2013). A significant effect of irrigation on marigold yield has been noticed by Pirzada and Shokran (2012). Adamović (2011) raised the possibility of marigold double cropping, while Popovic et al. (2017) indicated the positive effect of marigold cultivation on poor and neglected soils, with extensive cultivation practices and minimal investments. Pot marigold blooms from June until the first strong frosts. The blossoms are orange or yellow-orange (Stepanovic et al., 2011). The pot marigold flowers yield depends on locality, variety selection and stand density (Hojden et al., 1990; Biesiada et al., 2006; Crnobarac et al., 2008; Parađiković et al. 2013). Since it, leaves the land early, the pot marigold is a good pre-crop to other cultures in crop rotation (Kišgeci, 2008). For the pot marigold growing, it is necessary to use the seed that gives abundant flower yield, quality flower heads (*Calendulae anthodium*) or tongue-shaped ray or ligulate flowers (*Calendulae flos*) rich in active substances, as well as varieties resistant to diseases and pests (Baciu et al., 2010). The pot marigold flower is used in medicine, including the traditional medicine, and in cosmetic industry (Pirzada and Shokran, 2012; Torbaghan, 2012). Even dried flowers of pot marigold should maintain their lovely orange colour. Moreover, it should have a discreet, pleasant scent. The drug must be free of any organic or inorganic additives (Jevdović et al., 2011). It belongs to the oldest medicinal plants that have been used from the ancient times (Król, 2011), but pot marigold is also used for decorating green spaces (parks) and in various floral arrangements (Selaru, 2007).

Pot marigolds are planted out in early spring, usually by mid-April. Crnobarac et. al. (2011) carried out the sowing in the area of Novi Sad on April 13, whereas in the research conducted by Parađiković et al. (2013), sowing was carried out in Brod-Posavina County on 22 May. Sowing date forecast achieves best results when there is a possibility of comparative measurements of meteorological parameters on the production parcel (Otošević, 1980).

In investigating the influence of variety and plant density on fresh flower yield and dynamics of yield formation per harvest Crnobarac et. al. (2008) reported that, on average for all varieties, the highest yield was achieved at 50 cm row spacing, and that why we decided to apply the same row spacing. Sowing was done manually at 4.0, 5.0, 6.7 and 10 cm distances in the row, at a depth of about 3 cm, with two seeds per hill. In 3- 5 leaves phase, plants were thinned to final plant distance in the row (Jaćimović et al., 2007).

There is a difference in yields of different varieties due to genetic differences between varieties, the influence of the environmental factors as well as the interaction between the genotype and environmental factors. Planting density is one of the important factor affecting yield components. Therefore, the aim of this paper is to show the influence of variety and distance in row on pot marigold yield in agro-ecological conditions of Bijelo Polje (Montenegro).

MATERIAL AND METHODS

The field experiment was conducted in 2010 at experimental field in Lješnica. Three varieties were investigated: Plamen Plus (from the Czech Republic), Bački Petrovac and Orange King (material originating from Serbia). The crop was sown on 8 May 2010 at 50 cm spacing between the rows. Due to climatic characteristics at the experimental site, sowing was carried out on 8 May. During the growing season, standard crop maintenance measures were carried out (hoeing, weeding). The flowers were plucked by hand in 7 successive harvest time, beginning from 17 July.

The variance analysis was used to process the obtained results, in line with the plan of setting up the experiment, which was organized as a three factor split-split design. The significance of differences between treatments was determined by using the LSD test at the significance threshold of 1% and 5%.

The experiment was established on weak acid and poor lime soil, very rich in humus with low content of available phosphorus and medium content of available potassium.

The experiment locality is on 650 m above sea level, with moderate continental type of climate. Unlike the ten-year average, in the year of setting up the experiment, total monthly precipitation in the vegetation period was not uniformly distributed, so that in August it was only 16 mm. In experimental year the highest daily mean and maximum air temperature occur in the seventh month (Table 1). The same as in the long-term average.

Table 1. The monthly sum of rainfall (mm) and average monthly air temperature (°C) in 2010 at Bijelo Polje

Months	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Total monthly rainfall	101.3	80.0	69.7	79.8	79.6	56.2	85.1	16.0	80.0	68.4	131.1	147.3
Maximum monthly temperature	18.0	14.8	22.8	25.6	27.9	34.1	33.9	36.0	30.6	23.2	22.8	19.5
Mean monthly air temp.	-2.4	-2.2	1.4	5.8	10.5	14.4	15.6	15.0	10.8	7.2	2.2	-0.6

*Source: Hydrometeorological Institute of Montenegro

RESULTS AND DISCUSSION

The analysis of the fresh flowers yields in each harvest indicate that the harvest time did not have statistically significant impact on yield, and yields were stable in all 7 harvests. The lowest yield in our experiment was accomplished in the fourth harvest due to increased air temperature and reduced precipitation (Tab. 1) which is in accordance with statements by Kastori *et al.* (2013) that, among natural factors, water stress and extreme air temperatures most often affect the plant growth. The yield of flowers in average and in each harvest was the highest on variety Plamen Plus (818 kg ha⁻¹), compared to other two varieties that did not differ significantly.

This is observed as regularity in almost all the harvests. The highest yield in average for all varieties and harvests amounted to 654 kg ha⁻¹ in a single harvest and it was obtained at the minimum distance in row of 4 cm. It should be emphasized that from the second to the fifth harvest, the effect of plant distance in the row was different, indicating a stronger interaction. Variety Plamen plus in average obtained statistically highest yield in each harvest at 4 cm distance in row (1000 kg ha⁻¹), and variety Orange king at 6.7 cm distance in row, whereas distance in row did not have a statistically significant effect on the variety Bački Petrovac.



Figure 1. The application of agro-technical measures during the experiment (Photo: Jasmina Balijagić)

Table 2. Effect of harvest time, variety and distance in row on pot marigold fresh flower yield (kg/ha)

Harvest (H)	Variety (V)	Distance in row cm (D)				Average HV	Average H
		4	5	6.7	10		
1	PLAMEN PLUS	1221	1061	619	1216	1029	643
	BAČKI PETROVAC	898	245	550	713	602	
	ORANG KING	349	117	457	267	298	
	Average HD	823	474	542	732		
2	PLAMEN PLUS	909	752	740	1218	905	629
	BAČKI PETROVAC	544	236	522	482	446	
	ORANG KING	576	172	869	528	536	
	Average HD	676	386	710	743		
3	PLAMEN PLUS	1027	532	694	784	759	590
	BAČKI PETROVAC	469	820	655	527	618	
	ORANG KING	358	271	577	368	394	
	Average HD	618	541	642	560		
4	PLAMEN PLUS	286	732	832	803	663	510
	BAČKI PETROVAC	274	677	362	657	493	
	ORANG KING	206	273	721	291	373	
	Average HD	255	561	638	584		
5	PLAMEN PLUS	904	862	500	678	736	549
	BAČKI PETROVAC	510	912	299	434	539	
	ORANG KING	296	718	168	313	374	
	Average HD	570	831	322	475		
6	PLAMEN PLUS	1213	604	475	790	771	561
	BAČKI PETROVAC	330	123	316	444	303	
	ORANG KING	639	658	557	584	610	
	Average HD	727	462	449	606		
7	PLAMEN PLUS	1440	515	664	825	861	643
	BAČKI PETROVAC	494	224	216	730	416	
	ORANG KING	788	435	824	557	651	
	Average HD	907	391	568	704	Average V	
Average VD	PLAMEN PLUS	1000	722	646	902	818	589
	BAČKI PETROVAC	503	462	417	570	488	
	ORANG KING	459	378	596	415	462	
	Average D	654	521	553	629		

LSD	Harvest	Variety	Distance	Harvest* Variety	Harvest* Distance	Variety* Distance	Harvest* Variety* Distance
1%	237	148	130	384	370	242	638
5%	173	111	99	289	280	183	484
F probability	0.591	<.001	0.027	0.082	<.001	0.002	

Table 3. Effect of variety and distance in row on pot marigold fresh flower total yield of all harvests

Variety (V)	Distance in row (D)				Average V
	4	5	6.7	10	
PLAMEN PLUS	7000	5057	4524	6314	5724
BAČKI PETROVAC	3519	3237	2920	3987	3415
ORANG KING	3212	2644	4173	2908	3234
Average D	4577	3646	3872	4403	

LSD	Variety	Distance	Variety* Distance
1%	820	886	1444
5%	541	656	1075
F probability	<.001	0.023	0.023

The study of the effects of the variety and plant density on a total fresh flowers yield of all harvests (Table 3) has shown that the variety has a statistically significant effect on yield. Variety Plamen plus had a significantly higher yield (5724 kg ha^{-1}), in relation to other two varieties which did not differ significantly, although the variety “Orange king” obtained the lowest yield (3243 kg ha^{-1}). Crnobarac et.al. (2008) also found that fresh flowers yield in average and on each row spacing was the highest on variety Plamen Plus. Although there were significant differences in yield affected by distance in row, there is no general regularity of its effect, due to the high interaction with varieties. Namely, the variety Plamen plus gave significantly highest yield at 4 cm distance in row, variety Orang king at 6.7 cm distance in row, while distance in row did not significantly affect the variety Bački Petrovac, although the yield was highest at 10 cm distance. A significant effect of plant density on yield was also determined by Parađiković et al. (2013).

CONCLUSIONS

According to field experiment data of influence of variety and distance in row on pot marigold yield in agro-ecological conditions of Bijelo Polje it could be made following conclusions.

The municipality of Bijelo Polje represents area of hills and valleys along the rivers and this environment enable plantation and economically feasible yields of pot marigold flowers.

The highest yield in average was recorded by variety Plamen plus, at all applied distances in row. Variety Plamen Plus obtained the highest yield at 4 cm distance in row.

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