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SHORT COMMUNICATION

Effect of mother corm (*Crocus sativus* L. *Iridaceae*) on the productivity of daughter saffron corm in the Northern Black Sea region of Ukraine

Antonina Panfilova*, Vira Mykolaichuk, Margaryta Korkhova and Valerii Artiushenko

Department of Plant Growing and Horticulture, Mykolaiv National Agrarian University,
54008, 9 Georgiy Gongadze Str., Mykolaiv, Ukraine
*****Email: antoninapanfilova6@ukr.net

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ABSTRACT

The study aimed to determine the effect of mother corm size on the productivity and yield structure of daughter corms of saffron (Crocus sativus L.) under a three-year cultivation system in the Southern Steppe zone of Ukraine (Mykolaiv region). A field experiment was established in August 2019 using three size fractions of corms: large (25.46 ± 1.82 mm), medium (18.5 ± 0.96 mm), and small (7.40 ± 0.21 mm), and harvesting with morphometric analysis was conducted in June 2022. The results showed that the size of the initial planting material had a decisive influence on productivity. However, yield structure differed significantly among treatments: the proportion of large, potentially flowering daughter corms was highest with small mother corms (49.1% by mass) and lowest with large mother corms (18.3%). Thus, large planting material is recommended to maximize total corm yield, whereas the inclusion of small mother corms is advisable when the goal is to obtain a higher proportion of flowering corms, which is important for both saffron planting material producers and flower-oriented farms.

Keywords: Diameter, mass, number of shoots, saffron, yield,

Saffron (*Crocus sativus* L. *Iridaceae*) is a high-value crop. However, its yield and quality depend on a complex of factors, among which the size of mother corms plays a decisive role. The study by Mykolaichuk and Korkhova (2023) demonstrated that water-soluble exudates of saffron affect the germination of winter wheat seeds, confirming the biological specificity of the crop. In another study, Mykolaichuk *et al.* (2022) proved that both water-soluble and volatile exudates of *C. sativus* flowers under conditions of the Northern Black Sea region exhibited significant allelopathic activity, inhibiting seed germination of test crops and affecting primary root system formation. Globally, considerable attention in *C. sativus* cultivation is paid to corm size in determining productivity and plantation longevity (Shahini *et al*., 2023; Eihe *et al*. 2019). Ralli *et al.* (2024) established that larger mother corms ensured higher numbers and mass of daughter organs and contributed to longer plantation exploitation. Optimal light intensity reduced reserve depletion in mother corms and increased daughter organ yield of *C. sativus*, as shown by Zhou *et al.* (2022). The aim of this study was to determine the effect of mother corm size on productivity and yield structure of daughter corms of *C. sativus* in three-year plantations under Southern Steppe conditions.

The study was conducted from 2019 to 2022 at the experimental field of Mykolaiv National Agrarian University, located in the village of Senchyne, Mykolaiv region, which belongs to the Southern Steppe of Ukraine and the Northern Black Sea (Pontic) region. The soil at the experimental site was southern chernozem, residual slightly solonetzic heavy loam formed on loess. The humus content in the 0-30 cm layer was 3.1-3.3%; the soil solution reaction was neutral (pH 6.8-7.2). The nitrate content in the topsoil was 15-25 mg/kg; available phosphorus was 41-46 mg/kg; and exchangeable potassium was 389-425 mg/kg of soil. Humus content was determined by the Tyurin method (State standards of Ukraine 7855:2015, 2015), and the pH of the soil extract was measured potentiometrically (State standards of Ukraine 7540:2014, 2014). Available phosphorus and exchangeable potassium were determined by the Machigin method (State standards of Ukraine 4114:2002, 2002). All measurements were performed in triplicate. The experiment began in August 2019. Planting material was large (A), averaging 25.46±1.82 mm in diameter; medium (A2) diameter of 18-22 mm, and small (A3) 7.40±0.21 mm. The planting scheme provided for 15 cm row spacing, 15 cm spacing between plants within a row, and a planting depth of 15 cm. Plant density was 45 plants per 1 m^2. The total accounting plot area was 25 m^2. The experiment was established in four replications; plots were arranged systematically in four tiers to ensure reliability. Plot shape was rectangular. Harvesting and accounting of the formed daughter corms were carried out in June 2022, corresponding to completion of the three-year vegetation cycle.

Morphological characteristics of daughter corms were assessed by measuring morphometric parameters: basal plate diameter (the diameter of the flattened bottom structure of the corm from which roots emerge), diameter 1, mm (expressed as M±m, where M is the arithmetic mean and m is the standard error of the mean), and diameter 2 (max), mm (M±m), and corm height using an ET50 caliper manufactured by MITUTOYO (Japan) with an accuracy of 0.05 mm. To clarify these dimensions, diameter 1 was defined as the mean corm diameter at its minimum cross-section, whereas diameter 2 (max) was measured as the maximum corm diameter at its widest part. The mass of individual corms, representing their fresh physical weight and serving as an integral indicator of nutrient reserve accumulation, was determined using Sartorius Entris 224-1S laboratory electronic balances manufactured by Sartorius (Germany) with an accuracy of 0.01 g. The number of shoots per corm was recorded visually. After harvest, daughter corms were sorted into fractions (large, medium, small) visually based on morphometric parameters and mass. Productivity was evaluated by recording the number and mass of corms per unit area (g/m^2, $pcs./m^2$). Each replication measured 30 corm samples per fraction. Average monthly air temperature and precipitation were compared to long-term regional averages to assess meteorological conditions during the research. Table 4 shows average monthly temperature (°C) and precipitation (mm) for *Crocus sativus* L. agriculture in the Southern Steppe of Ukraine (2019-2022). Results were analyzed using variation statistics. We set the statistical significance level at $p \leq 0.05$. The arithmetic mean (M), standard error of the mean (m), and phenotypic range were calculated. Data were handled using SPSS 25.0, which allowed variance analysis and mean value comparison. The arithmetic mean (M), standard error of the mean (m), and phenotypic range were calculated. One-way ANOVA was used to assess the effect of mother corm size on morphometric traits, shoot number, and corm mass within each daughter fraction (Tables 1 and 2). For Table 3, the yield structure by daughter-corm fraction was additionally assessed using the chi-square test for both number distribution and fresh-mass share. For Table 4, monthly precipitation and temperature values were compared among years using one-way ANOVA.

The morphometric parameters of the daughter corms were directly influenced by the size of the initial mother corm. When evaluating the large daughter corm fraction, those originating from the largest mother corms (A1) exhibited the widest basal plate diameter (6.23±0.44 mm) and maximum diameter (29.12±0.72 mm) compared to those produced by small mother corms (A3), which measured 5.24±0.25 mm and 28.67±1.36 mm, respectively. Conversely, the height of large daughter corms was notably greatest when they developed from small mother corms (A3: 28.08±1.19 mm) rather than large ones (A1: 18.88±2.53 mm). Across the smaller classifications (Medium 1, Medium 2, and Small), A1 mother corms consistently produced daughter corms with larger basal plates and maximum diameters than A3 mother corms (Table 1). One-way ANOVA confirmed statistically significant differences among mother-corm fractions for daughter-corm diameter 1 in the large, medium 1, and small fractions, for height in the large fraction, and for diameter 2 (max.) in the medium 1 fraction (Table 1).

When analyzing reproductive potential and biomass accumulation, further distinctions based on mother corm size were evident (Table 2). Multiple shoot formation was primarily observed in the large daughter corm fractions across all treatments; the highest average number of shoots occurred in progeny from small mother corms (A3: 2.60±0.38 pcs.), closely followed by A1 (2.53±0.36 pcs.) and A2 (2.27±0.21 pcs.). The medium and small daughter corm fractions universally demonstrated limited shoot formation, generally producing only a single shoot (1.00 to 1.33 pcs.) regardless of the mother corm size. Furthermore, mother corm size drastically impacted the mass of the resulting daughter corms within the same size classifications. Large daughter corms derived from A1 mother corms had a significantly higher mass (18.88±0.53 g) than those from A2 (11.20±0.53 g) and A3 (11.17±1.15 g). This trend of greater biomass accumulation from A1 planting material remained consistent across all size classes; for instance, the mass of “Medium 2” and “Small” daughter corms from A1 mothers (11.62±0.57 g and 7.43±0.38 g, respectively) was vastly superior to the corresponding fractions from A2 and A3 mother corms, which consistently weighed less than 1.5 g and 0.5 g, respectively. ANOVA also confirmed that mother corm size significantly affected daughter-corm mass in all fractions, whereas the number of shoots differed significantly only in the medium 1 fraction (Table 2).

Productivity and yield structure of corms in the third year of vegetation

After three years of vegetation, the quantity and fresh mass of corms per unit area were used to measure yield and daughter corm distribution by size group. Data research showed that initial planting material size greatly affected total productivity. Planting large mother corms (fraction A1) maximized planting material. In this treatment, the number of daughter corms per 1 m² was 2,672.31, with a total mass of 6,423.89 g. The least efficient method was planting small mother corms (fraction A3), yielding 1,798.25 g/m² and 503.66 pcs./m². The indicators of group A2, using medium mother corms, were in an intermediate position: 3,356.24 g/m² total mass and 1,838.02 pcs./m². The overall yield mass in treatment A1 was 1.9 times that in A2 and 3.6 times that in A3. Yield structure, or the proportion of each size fraction to total fresh mass, also varied greatly between treatments. The yield structure was dominated by “medium 1” in all treatments. Treatment A1 had a total mass share of 3,696.02 g/m² (57.5%), A2 had 1,076.66 (32.1%), and A3 had 712.56 (39.6%). The “medium 2” percentage contributed less, with 1,174.15 g/m² (18.3%) in A1, 754.08 (22.5%) in A2, and 149.54 (8.3%) in A3 (Table 3).

An important pattern was identified regarding the share of large daughter corms, which are potentially flowering. This share was maximal when small mother corms (A3) were used and minimal when large mother corms (A1) were used. In treatment A3, the mass of large daughter corms was 883.57 g/m², representing 49.1% of the total yield mass in this group. In treatment A2, the share of large corms was 1,340.29 g/m² (39.9%), whereas in treatment A1, despite the highest absolute mass (1,175.02 g/m²), their relative share was the lowest – only 18.3%. Analysis of the share of corms capable of forming flowers (combined fraction “large” + “medium 1”) showed that it was highest in treatment A3. The total mass of these fractions was 883.57+712.56=1,596.13 g/m², which corresponds to 88.8% of the total yield mass in this treatment. By number, the large and medium 1 fractions in treatment A3 yielded 86.54 and 199.40 pcs./m², respectively, for a total of 285.94 pcs./m². This represents 56.8% of the total 503.66 pcs./m² corms produced in this treatment. In A1, the mass value was lower: 1,175.02+3,696.02=4,871.04 g/m² (75.8% of the total mass). Numerically, treatment A1 produced 102.11 large and 938.08 medium 1 corms (totaling 1,040.19 pcs./m²), which accounted for 38.9% of the total 2,672.31 pcs./m². The lowest share of flowering corms by mass was recorded in A2: 1,340.29+1,076.66=2,416.95 g/m² (72.0%). However, its numerical share was 46.3%, derived from 138.46 large and 713.02 medium 1 corms (851.48 pcs./m² total) out of the 1,838.02 pcs./m² total yield. Therefore, mother corm size determined not only the overall level of productivity but also the qualitative structure of the yield.

Assessment of the effect of weather and climatic conditions during the study period on the vegetation of *C. sativus*

Analysis of agroclimatic conditions during the study period (2019-2022) in comparison with long-term averages showed certain deviations that could have affected vegetation and productivity of *C. sativus*. The mean annual air temperature over the three years of the study was close to the long-term norm (11.57°C). In 2019 this indicator was 12.2°C, in 2020 – 12.1°C, and in 2021 – 10.8°C. Interannual fluctuations were minor, indicating relative stability of the thermal regime during the study period. Total precipitation during the vegetation of *C. sativus* over the study years deviated from the long-term norm (420.3 mm). The wettest year was 2021, with 556.9 mm of precipitation. The year 2019 was also wetter than normal (495.2 mm), whereas 2022 was drier (372.5 mm). The year 2020 was characterized by precipitation close to the long-term average (426.3 mm). The next two vegetation years (2020-2021 and 2021-2022) were cooler, with a mean temperature of 6.0°C, but wetter, with precipitation totals of 256.7 mm and 288.1 mm, respectively (Table 4).

The obtained results confirmed that the size of mother corms directly determined the number and mass of daughter organs in three-year *C. sativus* plantations. Larger mother corms formed a greater number of shoots and were characterized by a greater mass of daughter corms, whereas small corms limited productivity (Rudavska *et al.*, 2023; Ibragimov *et al.*, 2014). Similar relationships have been established in other studies. Thus, Koocheki *et al.* (2019) and Longchar *et al.* (2025) proved that mother corm size affected the mechanism of germination and phosphorus uptake, and removal of excess buds contributed to optimization of growth processes. Mother corms of greater mass ensured increased formation of flowers and stigmas, (Oshergina and Ten, 2023; Turbekova *et al.*, 2022) while simultaneously promoting more intensive multiplication of daughter corms – this was shown by Douglas *et al.* (2014) and Shuvar *et al.* (2021).

Ahmadian *et al.* (2024) found that mother corm size and fertilization mechanism affected daughter-organ formation. Under Southern Steppe circumstances, larger corms yielded more regardless of vegetation year, indicating that nutrition and planting material factors are integrated. Jalali *et al.* (2022) stressed that mother corm mass and planting depth directly affect flower yield and daughter corms. In the Southern Steppe of Ukraine, planting depth was constant, but yield response to initial corm mass matched those authors’ findings. Hakimzadeh and Esfandiari (2025) found that mother corm mass and cultivation system affected saffron morphophysiology. Gupta *et al.* (2021) and Rani *et al.* (2024) indicate that bulb size impacts plant resilience to diseases, particularly bulb rot, which may optimize saffron production in varied climates, especially in high humidity. In conclusion, the study and numerous additional studies revealed a uniform pattern: *C. sativus* mother corm size impacts growth intensity, daughter organ morphometry, yield structure, and yield mass.

CONFLICT OF INTEREST STATEMENT

The authors declare that there is no competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Table 1: Morphometric parameters of daughter corms of *C. sativus* depending on mother corm size (third year of vegetation), M±m

Mother fraction	Daughter fraction	Morphometric parameters, mm			
		Basal plate diameter (mm)	Diameter 1 (mm)	Diameter 2 (max.) (mm)	Height (mm)
A1 (Large)	Large	6.23±0.44	25.46±1.82	29.12±0.72	18.88±2.53
	Medium 1	5.56±0.35	22.70±0.73	20.00±0.56	16.02±0.36
	Medium 2	4.64±0.25	14.37±0.58	13.33±0.55	11.62±0.57
	Small	2.90±0.14	7.40±0.21	7.28±0.26	7.43±0.38
A2 (Medium)	Large	6.06±0.18	29.73±0.59	28.46±0.76	19.38±0.40
	Medium 1	5.26±0.21	19.53±0.96	17.94±0.93	16.56±0.58
	Medium 2	3.90±0.19	14.11±0.39	12.78±0.53	12.23±0.38
	Small	2.81±0.14	7.25±0.34	7.34±0.21	7.33±0.26
A3 (Small)	Large	5.24±0.25	20.73±0.73	28.67±1.36	28.08±1.19
	Medium 1	4.81±0.14	17.14±0.43	17.52±0.59	16.89±0.73
	Medium 2	4.17±0.61	14.19±0.92	12.50±0.49	11.74±0.49
	Small	2.70±0.10	10.48±0.36	7.80±0.40	6.61±0.19
ANOVA p-value	Large	0.060	<0.001	0.891	<0.001
ANOVA p-value	Medium 1	0.107	<0.001	0.036	0.562
ANOVA p-value	Medium 2	0.413	0.961	0.525	0.644
ANOVA p-value	Small	0.545	<0.001	0.413	0.095

Note: M±m represents the arithmetic mean (M) plus or minus the standard error of the mean (m).

Table 2: Effect of mother corm size on the number of shoots and mass of daughter corms of *C. sativus* (third year of vegetation)

Mother fraction	Daughter fraction	Number of shoots (pcs) (M±m)	Mass (g) (M±m)
A1 (Large)	Large	2.53±0.36	18.88±0.53
	Medium 1	1.33±0.13	16.02±0.36
	Medium 2	1.07±0.07	11.62±0.57
	Small	1.00±0.00	7.43±0.38
A2 (Medium)	Large	2.27±0.21	11.20±0.53
	Medium 1	1.07±0.07	4.10±0.39
	Medium 2	1.00±0.00	1.49±0.11
	Small	1.00±0.00	0.48±0.05
A3 (Small)	Large	2.60±0.38	11.17±1.15
	Medium 1	1.00±0.00	5.04±1.61
	Medium 2	1.00±0.00	1.45±0.12
	Small	1.00±0.00	0.37±0.03
ANOVA p-value	Large	0.753	<0.001
ANOVA p-value	Medium 1	0.019	<0.001
ANOVA p-value	Medium 2	0.372	<0.001
ANOVA p-value	Small	1.000	<0.001

Table 3: Effect of mother corm size on the productivity of daughter corms of *Crocus sativus* in the third year of vegetation (g/m²)

Daughter corm indicator	A1 (large)	A2 (medium)	A3 (small)
Large			
number, pcs./m²	102.11	138.46	86.54
fresh mass, g/m²	1,175.02	1,340.29	883.57
Medium 1			
number, pcs./m²	938.08	713.02	199.40
fresh mass, g/m²	3,696.02	1,076.66	712.56
Medium 2			
number, pcs./m²	917.31	534.81	110.77
fresh mass, g/m²	1,174.15	754.08	149.54
Small			
number, pcs./m²	714.81	451.73	107.31
fresh mass, g/m²	178.70	185.21	52.58
Total number	2,672.31	1,838.02	503.66
Total fresh mass	6,423.89	3,356.24	1,798.25
Chi-square p-value (number distribution)	<0.001	–	–
Chi-square p-value (fresh-mass share)	<0.001	–	–

Table 4: Average monthly temperature (°C) and precipitation (mm) during the cultivation years of *C. sativus* in the Southern Steppe of Ukraine, 2019-2022

Month	**Precipitation, mm**				**Temperature, °C**			
	2019	**2020**	**2021**	**2022**	**2019**	**2020**	**2021**	**2022**
January	43.0	24.2*	6.7*	21.0*	-1.5	+0.4*	-1.1*	+0.8*
February	7.8	110.*	26.8*	5.4*	+1.6	+2.7*	+2.4*	+2.4*
March	5.8	9.8*	47.0*	8.4*	+5.8	+7.0*	+1.8*	+1.8*
April	46.0	5.0*	7.0*	22.6*	+10.3	+9.3*	+9.6*	+9.6*
May	55.0	49.2*	61.6*	30.4*	+17.6	+13.9*	+15.4*	+15.4*
June	178.0	90.2	104.8	24.8	+23.8	+21.9	+21.7	+21.7
July	26.0	28.4	82.6	23.4	+22.9	+24.1	+23.4	+23.4
August	54.0	30.0	49.0	43.2	+23.3	+24.9	+24.4	+24.4
September	2.4	21.0	32.4	85.0	+17.6	+20.5	+15.4	+15.8
October	39.4*	39.6*	48.4*	10.9	+11.2*	+11.7*	+9.3*	+15.2
November	7.8*	1.7*	39.2*	40.2	+7.0*	+4.4*	+6.1*	+5.3
December	30.0*	17.2*	51.4*	57.2	+3.0*	+3.8*	+1.2*	+2.6
Annual precipitation, mm	495.2	426.3	556.9	372.5				
Precipitation during vegetation period, mm	77.2	256.7	288.1	87.8				
Mean annual temperature, °C					12.2	12.1	10.8	11.53
Mean annual temperature, °C					12.2	12.1	10.8	11.53
ANOVA p-value across years	0.709	–	–	–	0.987	–	–	–

Note: * – vegetation period of *C. sativus*