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RESEARCH ON SAFFLOWER (*Carthamus tinctorius* L.) CROP IN THE CONDITIONS OF SOUTHEASTERN ROMANIA

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Abstract

Safflower is an important crop for agriculture and industry (food, pharmaceuticals, cosmetics, etc.).
The paper includes results regarding the influence of variety and fertilizer level on the safflower seeds yield and yield components obtained in the 2013-2014 agricultural year. The experiment was conducted at the Experimental farm Moara Domnească of U.A.S.V.M. Bucharest. Observations and biometric measurements in dynamics were performed on plant height, number of branches per plant, number of heads per plant, seeds yield, thousand seed weight.
Significant differences were observed between varieties and between fertilizer levels. The highest seeds yield was for fertilizer level $N_{90}P_{60}K_{60}$, i.e. between 2064.32 kgha^{-1} variety CW 88 OL and 2184.2 kgha^{-1} variety Zanzibar.
The results obtained are important for the study of adaptability of safflower varieties CW 1221, CW 88 OL and Zanzibar in the conditions provided by Southeastern Romania.

Key words*: Carthamus tinctorius L., fertilization, variety, yield, 1,000 seeds weight.*

INTRODUCTION

Safflower is a thistle-like annual plant with a strong erect central stem, glabrous, with many primary branches which may produce secondary and tertiary branches.
Each branch ends with a globular flower head (capitulum) provided with spines.
The leaves are ovate-obovate, alternate, the lower ones are sessile and acuminate. The inflorescence is a dense capitulum of flowers, invested with involucres of green ovoid bracts. The florets are small, tubular, sessile composed on type 5.
Stem height, number of branches, presence of spines on the leaves and on flower heads varies depending on the variety and environmental conditions. The fruit is an achene smooth, shiny and angular which differ depending on the variety (Dajue and Mündel, 1996; Axinte et al., 2006).
Safflower has been cultivated since ancient times in China, Egypt and India. In the Middle Ages it was grown in Europe, Central America and South America. In the United States safflower started to be cultivated in the year 1925 (Walsh et al., 2008).
Safflower culture has importance to agriculture, the main reason of this cultivation being the following: high resistance to drought and soil salinity; tolerance to high temperatures and drought; mature seeds are not shaken and cannot be eaten by birds because of their specific inflorescence; it can be introduced into crop rotation in any agricultural system, including organic, having a deep root system; cultivation and harvesting can be fully mechanized; and it has lower production costs. (Gilbert, 2008; Cucu, 2014).
Safflower seeds are used in food industry for the production of oil. Depending on the variety there are two kinds of oil: oil with a high content of linoleic acid, and oil with a high content of oleic acid. Safflower seeds are used both in the pharmaceutical industry, because of their therapeutic properties, and in varnish and paint industry (O'Brien, 2008; Dajue and Mündel, 1996).
Flowers are also used in food industry as a spice and natural food colouring, being less expensive than saffron (*Crocus sativus*). In textile industry, flowers are used for their yellow, red, red-purple, olive and mustard, pigments and in pharmaceutical and cosmetic industry for their many therapeutic properties (Dajue and Mündel, 1996).
The flour obtained from seed has high protein content and can be used in bakery industry and

for animal feed. Seeds can also be used as food for birds (Salunkhe, 1992; Dajue and Mündel, 1996).
The cakes remaining after oil extraction can be used as organic fertilizer (Buia et al., 1965).

MATERIALS AND METHODS

Research was conducted on a reddish preluvosoil at the Experimental Field Moara Domnească-Ilfov. The experiment was placed within a factorial plots design with three replications.
Factor A – three varieties of safflower: CW 88 OL, CW 1221 and Zanzibar.
Factor B-fertilizer level with 5 graduations ($N_0P_0K_0$ - Control, $N_{60}P_0K_0$, $N_{90}P_0K_0$, $N_{90}P_{60}K_0$, $N_{90}P_{60}K_{60}$).
Oats was the previous crop before safflower.
All three safflower varieties were sown in the second decade of March, at a depth of 5 cm at a distance of 50 cm between rows and 8-10 cm between plants (density corrections were made at row).
During the growing season, biometric measurements were performed on plant height, number of branches, number of heads to highlight their growth and development in relation to technological factors and climatic conditions; plots yield and the qualitative indices of the yield (1000 seeds weight, hectoliters weight) were also measured.

Table 1. Climatic conditions in the 2013-2014 agricultural year at Moara Domneasca, Ilfov

	Temperature (°C)		Rainfall (mm)	
Month	Year 2013-2014	Normal	Year 2013-2014	Normal
October	14.00	11.00	81.70	35.80
November	8.30	5.30	17.60	40.60
December	-0.20	0.40	1.20	36.70
January	-0.50	-0.30	33.20	30.00
February	1.20	-0.90	7.60	32.10
March	8.90	4.40	37.30	31.60
April	13.40	11.20	116.00	48.10
May	19.30	16.50	88.00	67.70
June	19.90	20.20	113.00	86.30
July	22.80	22.10	38.00	63.10
August	24.10	21.10	26.20	50.50
September	18.40	17.50	60.60	33.60
Sum/Average	12.47	10.71	620.40	556.10

Temperatures and rainfalls are very important for the sowing date, growth and development of safflower. In first period of safflower vegetation temperatures and rainfall above normal annual averages were recorded (Figure 1). The average annual temperature for 2014 was 12.47°C, being higher by 1.76°C degrees than the normal average temperature (10.71°C) (Table 1). The amount of rainfall for 2014 was 620.40, i.e. 64.3 higher than the multiannual average values (Table 1). During the months of March, April, May and June higher values than normal for these months were recorded and in July and August, the values were lower than normal (64.2 mm to 113.6 mm) (Figure 1).

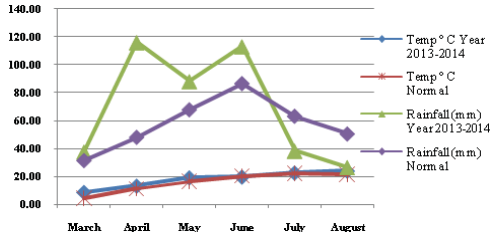

Figure 1. Climatic conditions for March-August 2014 at Moara Domneasca, Ilfov

RESULTS AND DISCUSSIONS

The growth and development of safflower plants.

Following the ***biometric measurements*** performed in the dynamics of plants height, we noticed a significant difference between the fertilization levels, with values between 79.40 cm in the Zanzibar variety (unfertilized variant) and 90.57 cm in the variant fertilized with $N_{90}P_{60}K_{60}$ in the CW1221 variety. Safflower height increased proportionally in relation to the fertilizer level in all varieties. The average value per variety was 87.15 cm in CW88OL, followed by CW1221 with 86.87 cm and Zanzibar with 85.7 cm (Table 2).
The measurement of the number of main branches per plant showed high variability between species and between fertilize levels, being 4.34 in the Zanzibar variety (without fertilization) and 7.51 in the CW88OL variety fertilized with $N_{90}P_{60}K_{60}$.
The CW88OL variety recorded no significant differences in the number of main branches per plant between the fertilizer levels. The highest average value per variety was 6.62 main branches per plant in CW88OL, followed by variety CW1221 with 6.29 branches and variety Zanzibar with 5.44 (Table 3).

Table 2. Fertilizer level influence on safflower plant height (cm) - Moara Domnească, 2014

Fertilizer level	Variety								
	CW88OL			CW1221			Zanzibar		
	cm	%	Difference	cm	%	Difference	Cm	%	Difference
N_0 P_0K_0	84.17	100.00	Control	83.37	100.00	Control	79.40	100.00	Control
$N_{60}P_0K_0$	85.27	101.30	1.10	85.40	102.43	2.03	84.30	106.17	4.90
$N_{90}P_0K_0$	87.23	103.64	3.07	87.47	104.92	4.10	87.50	110.20	8.10
$N_{90}P_{60}$ K_0	88.73	105.42	4.57	87.53	105.00	4.17	87.60	110.33	8.20
$N_{90}P_{60}K_{60}$	90.37	107.36	6.20	90.57	108.64	7.20	89.70	112.97	10.30
Avarage	87.15	103.55	2.98	86.87	104.20	3.5	85.70	107.93	6.3
	LSD 5%=1.563; LSD 1%=2.222; LSD 0.1%=3.218			LSD 5%=1.586; LSD 1%=2.254; LSD 0.1%=3.264			LSD 5%=1.821; LSD 1%=2.588; LSD 0.1%=3.748		

Table 3. Number of main branches per plant of safflower crop - Moara Domnească, 2014

Fertilizer level	Variety								
	CW88OL			CW1221			ZANZIBAR		
	Main branches / plant	%	Difference	Main branches / plant	%	Difference	Main branches / plant	%	Difference
N_0 P_0K_0	6.26	100.00	Control	5.10	100.00	Control	4.34	100.00	Control
$N_{60}P_0K_0$	6.37	101.81	0.11	6.03	118.24	0.93	5.38	123.96	1.04
$N_{90}P_0K_0$	6.47	103.30	0.21	6.40	125.56	1.30	5.52	127.19	1.18
$N_{90}P_{60}$ K_0	6.48	103.57	0.22	6.67	130.72	1.57	5.76	132.72	1.42
$N_{90}P_{60}K_{60}$	7.51	119.97	1.25	7.25	142.22	2.15	6.21	143.09	1.87
Avarage	6.62	105.73	0.36	6.29	123.35	1.19	5.44	125.39	1.10
	LSD 5%=2.457; LSD 1%=3.493; LSD 0.1%=5.059			LSD 5%=0.963; LSD 1%=1.369; LSD 0.1%=1.982			LSD 5%=0.026; LSD 1%=0.037; LSD 0.1%=0.053		

The number of heads per plant (Table 4) varied between 4.00 in the Zanzibar unfertilized variant and 13.40 in the CW88OL variant fertilized with $N_{90}P_{60}K_{60}$. Thus, there was a significant difference between the fertilizer levels and between the varieties.

The maximal values for all varieties were recorded in the variant fertilized with $N_{90}P_{60}K_{60}$.

The average values of the formed heads /plant/ varieties were the following: variety CW88OL - 10.45 heads/plant, variety CW1221 - 9.61 heads/plant, and variety Zanzibar - 7.50 heads/plant.

Achene yield

The influence of the variety and fertilizer level on the safflower yield is represented in Table 5

The Achene yield was highest in all varieties for the fertilizer level with $N_{90}P_{60}K_{60}$, being between 1.764,46 $kgha^{-1}$ in CW88OL and 1.828,75 kg ha^{-1} in Zanzibar.

Table 4. Fertilizer level influence on capitulum number per plant of safflower crop - Moara Domnească, 2014

Fertilizer level	Variety								
	CW88OL			CW1221			ZANZIBAR		
	heads /plant	%	Difference	heads /plant	%	Difference	heads /plant	%	Difference
N_0 P_0K_0	7.40	100.00	Control	6.11	100.00	Control	4.00	100.00	Control
$N_{60}P_0K_0$	8.55	115.54	1.15	7.73	126.51	1.62	5.50	137.50	1.50
$N_{90}P_0K_0$	11.00	148.65	3.60	10.00	163.67	3.89	7.00	175.00	3.00
$N_{90}P_{60}$ K_0	11.88	160.54	4.48	11.00	180.03	4.89	9.00	225.00	5.00
$N_{90}P_{60}K_{60}$	13.40	181.08	6.00	13.20	216.04	7.09	12.00	300.00	8.00
Avarage	10.45	141.16	3.05	9.61	157.25	3.5	7.50	187.50	3.5
	LSD 5%=1.986; LSD 1%=2.823; LSD 0.1%=4.087			LSD 5%=1.500; LSD 1%=2.132; LSD 0.1%=3.087			LSD 5%=1.679; LSD 1%=2.386; LSD 0.1%=3.455		

Table 5. Achene yield ($kgha^{-1}$) of safflower crop - Moara Domnească, 2014

Fertilizer level	Variety									Avarage/ fertilizer level		
	CW 88OL			CW 1221			ZANZIBAR					
	$Kgha^{-1}$	%	Difference	$Kgha^{-1}$	%	Difference	$Kgha^{-1}$	%	Difference	$Kgha^{-1}$	%	Difference
N_0 P_0K_0	1214.00	100.00	Control	890.64	100.00	Control	1305.16	100.00	Control	1136.60	100.00	Control
$N_{60}P_0K_0$	1754.00	144.48	540.00	1291.63	145.02	400.99	1605.12	122.98	299.96	1550.25	136.39	299.96
$N_{90}P_0K_0$	1883.20	155.12	669.20	1523.30	171.03	632.66	1883.28	144.29	578.12	1763.27	155.13	578.12
$N_{90}P_{60}$ K_0	1906.80	157.07	692.80	1634.20	183.46	743.56	2166.00	165.96	860.84	1902.33	167.37	860.84
$N_{90}P_{60}K_{60}$	2064.32	170.04	850.32	1878.33	210.90	987.69	2184.20	167.35	879.04	2042.28	179.68	879.04
Avarage	1764.46	145.34	550.46	1443.62	162.09	552.98	1828.75	140.12	523.59	1678.95	147.72	542.35
	LSD 5%=82.716;LSD 1%=117.583 LSD 0.1%=170.254			LSD 5%=27.072; LSD 1%=38.483; LSD 0.1%=55.722			LSD 5%=16.287; LSD 1%=23.152; LSD 0.1%=33.524			LSD 5%=42.025; LSD 1%=59.739; LSD 0.1%=86.500		

Table 6. Thousand seed weight (g) of safflower crop - Moara Domnească, 2014

Fertilizer level	Variety								
	CW 88OL			CW 1221			ZANZIBAR		
	g	%	Difference	g	%	Difference	g	%	Difference
N_0 P_0K_0	41.33	100.00	Control	41.12	100.00	Control	42.47	100.00	Control
$N_{60}P_0K_0$	41.76	101.04	0.43	41.77	101.60	0.66	43.11	101.51	0.64
$N_{90}P_0K_0$	42.62	103.12	1.29	42.51	103.38	1.39	44.67	105.18	2.20
$N_{90}P_{60}$ K_0	43.95	106.33	2.62	43.76	106.43	2.64	45.47	107.06	3.00
$N_{90}P_{60}K_{60}$	44.08	106.65	2.75	44.68	108.67	3.56	46.71	109.98	4.24
Average	42.75	103.43	1.42	42.77	104.01	1.65	44.49	104.75	2.02
	LSD 5%= 0.049; LSD 1%=0.070; LSD 0.1%=0.101			LSD 5%=0.018; LSD 1%=0.026; LSD 0.1%=0.037			LSD 5%=0.020; LSD 1%=0.029; LSD 0.1%=0.042		

Analysis of quality indicators (thousand seeds weight)

Table 6 shows that thousand seed weight was influenced by the variety and fertilizer level. Statistically provided significant differences were observed between the fertilizer levels in all varieties analyzed. The highest average values for thousand seed weight were recorded in the Zanzibar variety - 44.49 g. Fertilization with complex fertilizers increased the thousand seed weight with about 6% to application of NP and 8% to the application of NPK.

CONCLUSIONS

Research performed in 2014 showed that plant growth and yields were influenced by the type and dose of fertilizer.

The achene yield varied between 890.64 $kgha^{-1}$ in the CW1221 control variant fertilization, and 2184.2 $kgha^{-1}$ in Zanzibar on fertilizer level $N_{90}P_{60}K_{60}$.

Fertilization based exclusively on nitrogen resulted in an average increase production of 413.6 kg $kgha^{-1}$.

The application of phosphorus and potassium increased the yield by about 139 kg/ha.

The number of capitulum per plant and thousand seed weight also recorded maximum values in complex fertilizers with NPK (between 12-13.4 capitulum/plant and 44.08 - 46.71g /1000 seeds).

Considering the yield obtained, the safflower varieties studied proved good adaptability to the pedo-climatic conditions of Moara Domnească, Ilfov County.

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