RESEARCH ON THE INFLUENCE OF SOME TECHNOLOGICAL FACTORS ON PRODUCTION COMPONENTS OF BIOMASS IN MAIZE (*ZEA MAÏS L.*) FOR BIOENERGY UNDER THE FOREST-STEPPE CONDITIONS OF MOLDOVA

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Abstract

Maize is an important source of renewable biomass for energy that can be done during 150-180 days. The energetic content of maize is not constant because of biological variability and management factors. The research was done in 2008 and 2009, at Ezăreni Farm under the pedo-climatic conditions of Moldova forest-steppe and had in view the influence of sowing density, mineral fertilization and hybrid on production of dry matter (DM) at the cultivated maize in order to obtain biofuels. The results showed that under the conditions tested, the highest DM production at the whole plant (17.48 t / ha) was obtained in PR 37M34 hybrid, the density of 64,500 plants / ha and fertilization with $N_{60}P_{40}$, production growth is of 40% compared to the control sample. At the same hybrid and density, but at the fertilization with $N_{100}P_{40}$ highest production of cobs (8.52 t / ha) was obtained, with 28% more compared to the control sample. The highest percent of the total production of cobs was obtained in DR 440 hybrid, the density of 64,500 plants / ha in the unfertilized variant.

Key words: maize hybrids, seeding, fertilization, productivity

Maize is an important source of renewable biomass for energy that can be done during 150-180 days, unlike the long period needed for the production of conventional fuels. The use of alternative sources of energy will reduce dependence on conventional sources and lead to increased agricultural development areas. The biomass from maize is considered a "clean" fuel, the studies showing that the pollution associated with the burning of the maize is less than that from fossil fuels. Moreover, maize is very effective in taking CO_2 and producing O_2 through photosynthesis during the growing period.

The energetic content of maize is not constant because of the biological variability and management factors. The factors that could influence the energy content of maize are: the variety of maize (hybrid), climatic conditions during the growing and harvesting period, method of drying, storage conditions, etc. Internationally there are many studies on the obtaining and importance of bio-fuel, including maize (Pimental, D., Patzek, T.W., 2005; Farrell, A.E. *et al*, 2006; Amon, T. *et al*, 2007; Dhugga, K.L., 2007, Vermerris, W. *et al*, 2007; Vîntu, V. *et al*, 2008).

MATERIAL AND METHOD

The studies were done in 2008 and 2009, at Ezăreni Farm (47°05'- 47°10' north latitude and 27°28' -27°33' east longitude), which belongs to the Teaching Station of the University of Agricultural Sciences and Veterinary Medicine Iasi. From the climate perspective, the years of experimentation were characterized by values of temperature and precipitation with relatively small deviations from the multi-annual average. The soil is a poorly regraded cambic chernozem containing in the Ap horizon: 41,8%-clay, 2,24%-humus, 6,68-pH and Nt-0,178%.

The research followed the influence of planting density, mineral fertilization, of hybrid on the production of the whole plant, cobs and stalks, as well as the percentage of cobs of the total production, of the cultivated maize in order to obtain biofuel.

In order to achieve these goals there was organized at Ezăreni Farm a trifactorial experience (2x4x6 type) disposed after the method of subdivided parcels in three repetitions, the area of a variant being 21.0 m^2 (4,2 m x 5m). The studied factors were: A- planting density, with 2 graduations (a_1-64500 plants /ha and a_2-75000 plants/ha), B- fertilization, with 4 graduations (b_1-non-fertilized; b_2-$N_{60}P_{40}$; b_3-$N_{80}P_{40}$ şi b_4-$N_{100}P_{40}$) and C-hybrid, with 6 graduations (c_1-PR38V91; c_2-PR37M34; c_3-LG2306; c_4-LG3330; c_5-DR440 and c_6-DR4626). The sowing date was 18 April 2008 and 29 April 2009.

RESULTS AND DISCUSSIONS

Analyzing the influence of the factors on the production of whole plant at the maize grown for biofuels (t*able 1*), we observed that the best dose of fertilizer, at the density of 64,500 plants per hectare was $N_{60}P_{40}$ where we obtained increases from 3% to 40%. For the density of 75,000 plants per hectare, the fertilizer dose of $P_{40}N_{100}$ has led to the highest increases of up to 19%.

At the $N_{60}P_{40}$variant of fertilization were obtained productions between 12.82 t/ha (LG 2306) and 17.48 t/ha (PR 37M34) at the density of 64,500 plants per hectare and at the density of 75,000 plants per hectare the production ranged between 11.47 t/ha (PR 38V91) and 13.57 t/ha (DR 440).

At $N_{80}P_{40}$ fertilization, we recorded productions from 12.45 to 16.30 t/ha at density of 64,500 plants per hectare, and 11.21 to 13.79 t/ha at 75,000 plants per hectare.

Table 1

Influence of experimental factors on the production of dry matter (the whole plant)

Density (plants /ha)									
64500 plants/ha						75000 plants/ha			
Fertilization	Used hybrid	Production (t/ha d.m.)			% of the control sample	Production (t/ha d.m.)			% of the control sample
		2008	2009	Media		2008	2009	Media	
Unfertilised control sample	PR 38V91	11,85^{Mt}	13,04^{Mt}	12,45^{Mt}	100	5,94^{o}	12,59	9,27^{oo}	74
	PR 37M34	15,98	13,14	14,56	117	11,67	13,07	12,37	99
	LG 2306	12,96	13,08	13,02	105	9,79	12,76	11,28	91
	LG 3330	12,95	12,45	12,70	102	6,94^{o}	12,98	9,96^{o}	80
	DR 440	10,88	12,96	11,92	96	9,68	11,90^{oo}	10,79	87
	DR 4626	14,79	12,54	13,67	110	11,64	11,46^{ooo}	11,55	93
$N_{60}P_{40}$	PR 38V91	13,62	13,76*	13,69	110	9,38	13,55	11,47	92
	PR 37M34	20,89***	14,06**	17,48***	140	11,90	13,41	12,66	102
	LG 2306	12,14	13,50	12,82	103	12,17	13,33	12,75	102
	LG 3330	14,9	13,44	14,17	114	10,29	13,33	11,81	95
	DR 440	14,98	13,18	14,08	113	14,19	12,95	13,57	109
	DR 4626	14,47	13,25	13,86	111	12,09	12,96	12,53	101
$N_{80}P_{40}$	PR 38V91	9,87	15,02***	12,45	100	7,59^{o}	14,82***	11,21	90
	PR 37M34	17,84**	14,75***	16,30**	131	12,51	14,04**	13,28	107
	LG 2306	14,83	13,58	14,21	114	12,99	13,84*	13,42	108
	LG 3330	13,09	13,62	13,36	107	12,31	13,79*	13,05	105
	DR 440	14,14	13,65	13,90	112	14,42	13,13	13,78	111
	DR 4626	13,2	13,77*	13,49	108	13,14	13,46	13,30	107
$N_{100}P_{40}$	PR 38V91	11,18	15,49***	13,34	107	7,28^{o}	16,82***	12,05	97
	PR 37M34	17,93**	16,05***	16,99***	137	14,53	14,78***	14,66	118
	LG 2306	15,85	14,33***	15,09*	121	11,05	15,75***	13,40	108
	LG 3330	11,84	14,15**	13,00	104	10,01	14,26	12,14	98
	DR 440	14,84	13,96*	14,40	116	12,9	13,39	13,15	106
	DR 4626	16,65*	14,02**	15,34*	123	15,97	13,74*	14,86	119
	DL 5%	*4,15*	*0,71*	*2,43*		*4,15*	*0,71*	*2,43*	
	DL 1%	*5,50*	*0,94*	*3,22*		*5,50*	*0,94*	*3,22*	
	DL 0,1%	*7,15*	*1,22*	*4,19*		*7,15*	*1,22*	*4,19*	

The fertilization dose of $N_{100}P_{40}$ led to productions ranging from 13.00 to 16.99 t/ha d.m. at the density of 64,500 plants/ha, and at 75,000 plants/ha yields ranged from 12.05 to 14.86 t/ha dry matter.

The most productive hybrid was 37M34 PR, where we obtained the highest increases of production in all fertilization variants studied, the planting density of 64,500 plants/ha. Thus, at the fertilization with $N_{60}P_{40}$ were obtained 17.48 t/ha, at the dose of fertilization with $N_{80}P_{40}$ were obtained 16.30 t/ha and at the fertilization with $N_{100}P_{40}$ we gained 16.99 t/ha d.m.

At the density of 75,000 plants per hectare we achieved lower production, compared with the 64,500 plants per hectare, the most productive hybrids being 37M34 PR and DR 4626. From the PR 37M34 hybrid, we obtained yields with higher doses with N_{80} and N_{100} on P_{40} agrofund, resulting in increases of 7-18% compared to the control sample and from the DR 4626 hybrid highest production was obtained from the fertilization with $N_{100}P_{40}$ by 14.86 t/ha d.m.

The production of maize cobs (*Table 2*) at the unfertilised control variant ranged from 6.64 to 8.53 t/ha at the density of 64,500 plants per hectare and from 5.17 to 8.34 t/ha at the density of 75,000 plants per hectare.

At the fertilization with $N_{60}P_{40}$ we obtained productions between 6.61 and 8.01 t/ha at the density of 64,500 plants per hectare and from 5.67 to 7.61 t/ha at 75,000 plants/ha.

Table 2

Influence of the experimental factors on the cobs production

Density (plants/ha)									
64500 plants/ha						75000 plants/ha			
Fertilization	Used hybrid	Production (t/ha d.m.)			% of the control sample	Production (t/ha d.m.)			% of the control sample
		2008	2009	Media		2008	2009	Media	
Unfertilised control sample	PR 38V91	6,87^{Mt}	6,41^{Mt}	6,64^{Mt}	100	3,91º	6,42	5,17º	78
	PR 37M34	8,30	6,37	7,34	110	6,64	6,34	6,49	98
	LG 2306	6,90	6,49	6,70	101	5,78	6,25	6,02	91
	LG 3330	7,22	6,56	6,89	104	4,29º	6,45	5,37	81
	DR 440	7,98	7,01*	7,50	113	5,80	6,11	5,96	90
	DR 4626	8,82	6,53	7,68	116	6,73	6,08	6,41	96
$N_{60}P_{40}$	PR 38V91	8,11	6,75	7,43	112	4,6º	6,74	5,67	85
	PR 37M34	8,67	7,04*	7,86	118	7,76	6,73	7,25	109
	LG 2306	6,33	6,89	6,61	100	6,43	6,71	6,57	99
	LG 3330	8,89	6,96*	7,93	119	5,86	6,57	6,22	94
	DR 440	8,72	7,29**	8,01*	121	8,50	6,71	7,61	115
	DR 4626	8,53	6,92	7,73	116	6,11	6,89	6,50	98
$N_{80}P_{40}$	PR 38V91	6,54	7,78***	7,16	108	4,53º	7,58***	6,06	91
	PR 37M34	9,36*	7,22**	8,29*	125	7,00	6,94*	6,97	105
	LG 2306	7,33	6,71	7,02	106	7,37	6,72	7,05	106
	LG 3330	7,90	7,04*	7,47	113	7,47	6,76	7,12	107
	DR 440	8,74	7,44***	8,09*	122	8,42	6,76	7,59	114
	DR 4626	7,52	7,20**	7,36	111	7,23	7,09*	7,16	108
$N_{100}P_{40}$	PR 38V91	6,69	8,11***	7,40	111	4,61º	9,45***	7,03	106
	PR 37M34	8,80	8,26***	8,53**	128	8,40	7,53***	7,97	120
	LG 2306	7,48	7,22**	7,35	111	6,46	8,69***	7,58	114
	LG 3330	8,15	7,44***	7,80	117	6,09	7,20**	6,65	100
	DR 440	8,68	7,34**	8,01*	121	8,06	6,74	7,40	111
	DR 4626	8,99	7,27**	8,13*	122	9,43*	7,24**	8,34*	126
	DL 5%	2,18	0,52	1,35		2,18	0,52	1,35	
	DL 1%	2,90	0,70	1,80		2,90	0,70	1,80	
	DL 0,1%	3,74	0,93	2,34		3,74	0,93	2,34	

The fertilization dose with $N_{80}P_{40}$ led to the formation of productions ranging from 7.02 to 8.29 t/ha of 64,500 plants / ha and 6.06 to 7.59 t/ha in density of 75,000 plants / ha.

At the fertilization with $N_{100}P_{40}$ we obtained productions between 7.35 and 8.53 t/ha at 64,500 plants / ha and from 6.65 to 8.34 t/ha in density of 75,000 plants per hectare. The hybrids with the best reaction to the density of 64,500 plants per hectare was PR 37M34, from which we obtained the highest yields. The hybrid which used the best the dose of $N_{60}P_{40}$fertilization was DR 440, with 8.01 t/ha at low density and 7.61 t/ha at density of 75,000 plants per hectare.

The most productive hybrid at the fertilization with $N_{80}P_{40}$ was PR 37M34 at the density of 64,500 plants per hectare with 8.29 t/ha, while the density of 75,000 plants per hectare the best reaction was from the DR 440 hybrid to a production of 7.59 t/ha.

The highest yield, at the fertilization with N_{100} P_{40} occurred in PR 37M34 hybrid, with 8.53 t/ha at low density and DR 4626 hybrid with 8. 34 t/ha at high density.

The production of stalks, under conditions of unfertilisation, had values ranging from 4.43 to 7.22 t/ha in density of 64,500 plants per hectare and 4.10 to 5.88 t/ha in density of 75,000 plants per hectare. The most productive was 37M34 PR hybrid *(table 3*).

At the $N_{60}P_{40}$ variant of fertilization, we obtained productions between 6.08 and 9.62 t/ha, at density of 64,500 plants per hectare, the most productive being PR 37M34 hybrid.

At the density of 7,500 plants per hectare, the production ranged from 5.41 to 6.18 t/ha, the hybrid with higher production being LG 2306.

The fertilization with $N_{80}P_{40}$ led to productions ranging from 5.29 to 8.01 t/ha in density of 64,500 plants per hectare, the highest yield being obtained PR 37M34 hybrid, while the density of 75,000 plants per hectare yields ranged from 5.15 to 6.37 t/ha for LG 2306 hybrid.

The use of fertilization with $N_{100}P_{40}$ led to productions ranging from 5.20 to 8.47 t/ha for PR 37M34 hybrid, when using a density of 64,500 plants per hectare. The density of 75,000 plants per hectare yields were obtained between 5.02 to 6.69 t/ha, the largest being the PR 37M34 hybrid.

Table 3

Influence of the experimental factors on the stalks production

Density (plants/ha)									
64500 plants/ha						75000 plants/ha			
Fertilization	Used hybrid	Producţia (t/ha s.u.)			% faţă de martor	Producţia (t/ha s.u.)			% faţă de martor
		2008	2009	Media		2008	2009	Media	
Unfertilised control sample	PR 38V91	4,98^{Mt}	6,63^{Mt}	5,81^{Mt}	100	2,03	6,17^{o}	4,10	71
	PR 37M34	7,68	6,76	7,22	124	5,03	6,73	5,88	101
	LG 2306	6,06	6,60	6,33	109	4,01	6,51	5,26	91
	LG 3330	5,73	5,89^{o}	5,81	100	2,65	6,53	4,59	79
	DR 440	2,9	5,95^{o}	4,43	76	3,88	5,78^{oo}	4,83	83
	DR 4626	5,97	6,01^{o}	5,99	103	4,91	5,38^{ooo}	5,15	89
$N_{60}P_{40}$	PR 38V91	5,51	7,01	6,26	108	4,78	6,81	5,80	100
	PR 37M34	12,22***	7,02	9,62***	166	4,14	6,68	5,41	93
	LG 2306	5,81	6,62	6,22	107	5,74	6,62	6,18	106
	LG 3330	6,01	6,47	6,24	107	4,43	6,76	5,60	96
	DR 440	6,26	5,90^{o}	6,08	105	5,69	6,23	5,96	103
	DR 4626	5,94	6,33	6,14	106	5,98	6,06^{o}	6,02	104
$N_{80}P_{40}$	PR 38V91	3,33	7,24*	5,29	91	3,06	7,24*	5,15	89
	PR 37M34	8,48*	7,53**	8,01*	138	5,51	7,10	6,31	109
	LG 2306	7,5	6,87	7,19	124	5,62	7,12	6,37	110
	LG 3330	5,19	6,58	5,89	101	4,84	7,02	5,93	102
	DR 440	5,4	6,21	5,81	100	6	6,37	6,19	107
	DR 4626	5,68	6,57	6,13	106	5,91	6,37	6,14	106
$N_{100}P_{40}$	PR 38V91	4,49*	7,38**	5,94	102	2,67	7,37*	5,02	86
	PR 37M34	9,13*	7,80***	8,47**	146	6,13	7,25*	6,69	115
	LG 2306	8,37	7,11	7,74*	133	4,59	7,06	5,83	100
	LG 3330	3,69	6,71	5,20	90	3,92	7,05	5,49	94
	DR 440	6,16	6,62	6,39	110	4,84	6,64	5,74	99
	DR 4626	7,66	6,75	7,21	124	6,54	6,50	6,52	112
	DL 5%	4,98	0,56	1,19		2,53	2,03	1,55	
	DL 1%	7,68	0,74	2,55		3,36	5,03	2,05	
	DL 0,1%	6,06	0,96	3,30		4,33	4,01	2,65	

Report cobs/stalks ranged from 63/37 to 45/55 and the density of 64,500 plants per hectare, DR 440 hybrid under conditions of unfertilization having the best percentage of cobs.

The density of 75,000 plants per hectare, the cobs/stalks ratio was between 49/51 and 58/42, the PR 38V91 hybrid having the best percentage of cobs at $N_{100}P_{40}$ fertilization (*table 4*).

CONCLUSIONS

Under the experimental conditions studied, the best production of the whole plant was obtained from 37M34 PR hybrid, the variant of $N_{60}P_{40}$ fertilization, density of 64,500 plants per hectare (17.48 t/ha dry matter).

The highest production of maize cobs was obtained from the same hybrid at the same density, but at $N_{100}P_{40}$ fertilization version (8.53 t/ha dry matter).

The $N_{60}P_{40}$ variant of fertilization, at density of 64,500 plants per hectare, 37M34 PR hybrid obtained the largest stalk production (9.62 t/ha dry matter).

The best cobs/stalks ratio, of the total biomass production was obtained in DR 440 hybrid, the density of 64,500 plants per hectare, at the fertilized variant (63/37).

Table 4

Influence of the experimental factors on the cobs/stalks of the total d.m

Density (plants/ha)							
64500 plants/ha					75000 plants/ha		
Fertilization	Used hybrid	Cobs/Stalks			Cobs/Stalks		
		2008	2009	Media	2008	2009	Media
Unfertilised control sample	PR 38V91	58/42	49/51	53/47	66/34	51/49	56/44
	PR 37M34	52/48	48/52	50/50	57/43	49/51	52/48
	LG 2306	53/47	50/50	51/49	59/41	49/51	53/47
	LG 3330	56/44	53/47	54/46	62/38	50/50	54/46
	DR 440	73/27	54/46	63/37	60/40	51/49	55/45
	DR 4626	60/40	52/48	56/44	58/42	53/47	55/45
$N_{60}P_{40}$	PR 38V91	60/40	49/51	54/46	49/51	50/50	49/51
	PR 37M34	42/58	50/50	45/55	65/35	50/50	57/43
	LG 2306	52/48	51/49	52/48	53/47	50/50	52/48
	LG 3330	60/40	52/48	56/44	57/43	49/51	53/47
	DR 440	58/42	55/45	57/43	60/40	52/48	56/44
	DR 4626	59/41	52/48	56/44	51/49	53/47	52/48
$N_{80}P_{40}$	PR 38V91	66/34	52/48	58/42	60/40	51/49	54/46
	PR 37M34	52/48	49/51	51/49	56/44	49/51	53/47
	LG 2306	49/51	49/51	49/51	57/43	49/51	53/47
	LG 3330	60/40	52/48	56/44	61/39	49/51	55/45
	DR 440	62/38	55/45	58/42	58/42	51/49	55/45
	DR 4626	57/43	52/48	55/45	55/45	53/47	54/46
$N_{100}P_{40}$	PR 38V91	60/40	52/48	55/45	63/37	56/44	58/42
	PR 37M34	49/51	51/49	50/50	58/42	51/49	54/46
	LG 2306	47/53	50/50	49/51	58/42	55/45	57/43
	LG 3330	69/31	53/47	60/40	61/39	50/50	55/45
	DR 440	58/42	53/47	56/44	62/38	50/50	56/44
	DR 4626	54/46	52/48	53/47	59/41	53/47	56/44

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