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EFFECT OF NP DOSES BY NEW CaCO3 AGROFUNDS ON THE FORMATION OF SOYBEAN YIELDS

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Abstract
For the acid soils in the south of the country, it is more than necessary to apply calcareous amendments. Results in this sense were obtained over the years at the main crop plants in the station area. Considering the increasing importance of the soybean crop, it was considered necessary to resume these types of research, as new products based on limestone and dolomite appeared. Significant results were obtained by forming the total biomass of the plant as well as its components. In the case of the Cristina TD (00) variety, the interaction between several $CaCO_3$ formulations and NP fertilizers contributed as follows: plant biomass 6.46 t/ha (100%), pod biomass 4.16 t/ha (63%), and grains were 2.17 (33%). Of the two analyzed factors, NP fertilizer had the most important contribution to this variety, followed by the influence of the four $CaCO_3$ formulations. The interaction between the two factors was always negative demonstrating that there was some competition between the cations. The obtained correlations were in all cases positive, but of different intensities. Through the obtained results, it is recommended that new formulations of $CaCO_3$ be permanently used in the soybean cultivation technology on acid soils.

Key words: grains, $CaCO_3.MgCO_3$, Cristina TD, NP, pods, soybean.

1. INTRODUCTION

Soybean is one of the most important agricultural plants in food and industry (Martinez-Ballesta et al, 2010). Various thinks (Withe & Broadley, 2003) are obtained from soybeans (butter, milk, lecithin), also in animal feed, soybeans are used in the form of meal mixed with maize meal. Being a leguminous, (*Fabaceae*) soybean makes an important contribution to increasing soil fertility. The gains made lately have materialized through more and more performing varieties. The degree of adaptability to different crop areas was also taken into account. In the case of the Cristina TD variety, the following characters were highlighted: plant height 62 cm, number of grains 65/sq.m, number of pods 46/sq.m, and the mass of one thousand grains (MTG) was 193 gr. Calcium is one of the macroelement necessary for the plant, (Karley & Wihite, 2009) which has the role of improving the properties of soils and the various physiological processes in plants (Cramer, & al., 2009; Dayod et al., 2010). The chemical product $CaCO_3$ is especially recommended for soils with an acid reaction such as those in the station. The amounts of $CaCO_3$ in the white luvicsoil are insufficient for plant growth. Therefore, it is unable to contribute and maintain suitable degrees of base saturation of soil colloids. In these conditions, Al^{3+} dominates the exchange sites of the clay,

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contributing to the excessive acidity of the soil. Mobile (soluble) Al^{3+} becomes toxic to most plants. Due to the lack of calcium and the presence of excess aluminum the soil becomes strongly acidic, where the plants develop very little with repercussions on the biomass. Regarding the cultivation soil, $CaCO_3$ improves the following properties: structure, permeability to water and air, the development of microorganisms and input as a fertilizer in plant food (Withe, 2001). Calcium in the form of Ca^{2+} is essential for growth plants and fruit development. The resistance of the plant to diseases is also important due to ensuring the protection of the cell wall (Doblin et al., 2010; Hepler & Winship, 2010). In general, the roles of Ca^{2+} are as follows:
- it is necessary in the growth and development of the plant (Cosgrove., 2005),
- resistance to diseases through the protection of the cell wall (Franceschi & Nakata, 2005),
- biochemical functions and metabolic processes (Dodd et al., 2010; Heinen et al., 2009),
- activates several enzyme systems (Dayod at al., 2010),
- has a role in membrane stability and cell integrity (Karley & Withe, 2009).

Among the plant organs, the leaves contain the highest concentrations, having an essential role in binding the cells into a unitary whole, through the formation between the cells of a membrane made of calcium pectate (Franceschi & Nakata, 2005). Calcium enters the culture soil through the absorbing hairs, namely in the youngest area at the top of the hairs, after which it is taken up by the conducting vessels (xylem) and is transported to the growth tips including the leaves (De Boer & Volkov, 2003). At the level of growth tips and leaves where photosynthesis takes place, $CaCO_3$ activates either alone or together with Mg and other chemical elements, namely: Ca $n.10^{-1}$, in the form of Ca^{2+}; Mg $n.10^{2}$, in the form of Mg^{2+}; K 1.6 as K^{+}; Na^{-2} n10 in the form of Na^{+}; Cl^{-1} n.10 as Cl^{-}. Due to this fact the plants generally have leaves with an intense green colouration (Karley et Withe, 2009). The penetration of $CaCO_3$ into the plant occurs passively with the flow of water and other nutrients. Its circulation through the woody vessels is favored by plant evapotranspiration ETP) and root pressure (Nardini et al., 2007). Considering the totally different behavior compared to the other macroelements, it is necessary to permanently apply $CaCO_3$ at the necessary concentrations.

2. MATERIALS AND METHODS

The experiment was established according to the method of subdivided plots with 2 factors in which the variants were 30 m² each in three repetitions. In this sense, several formulations of calcium carbonate with and without the addition of Mg were used. Factor A - Ca formulations: A_1- Unamended; A_2 - Agrocalcium 2.5 t/ha: the product contains 93.6% $CaCO_3$; A_3 - Doloflor powder 2.5 t/ha: contains 58.87% $CaCO_3$, 38.24% $MgCO_3$; A_4 - Doloflor granules 2.5 t/ha: with the same content; A_5 - Neutrosol 2.5 t/ha 97.5% $CaCO_3$. Factor B - NP formulations: B_1 - unfertilized; B_2 - $N_{40}P_{40}$; B_3 - $N_{80}P_{80}$. As a result of the research carried out, the very good effect of the amendments and doses of nitrogen and phosphorus was found. The technology used was the one recommended by the station. The Cristina TD (00) soybean variety created by S.C.D.A. was used in the experiment. Turda. At full maturity, 100 plants were randomly selected from the 3 repetitions. They were cut and brought to the laboratory to obtain constant humidity. The investigated factors were the following: total biomass, pod biomass, grain biomass and mass of one thousand grains (MTG). Among the determinations made, simple correlations were established, with the help of which their trends could also be observed within the Cristina TD variety. The Excel program was used to express the values, the significance of the correlation coefficient was obtained with r_{max} values of

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5%, 1%, 0.1% of the regression probabilities. Analysis of variance (Anova test) was used in the statistical calculation of all values.

3. RESULTS AND DISCUSSIONS

The influence of climate on soybean plants. In the vegetation period between May and September, the monthly temperature values recorded exceded by 0.8-2.4℃. The multiannual values for the entire vegetation period average temperature was 1.4℃ higher. During the vegetation period, the sum of active temperature degrees was calculated, which this year was 1540℃ in a vegetation period of 138 days. Regarding the regime of low precipitation, it was found that, except for August, the amounts of water were in deficit. During the entire vegetation period, the lack of water was 56 mm, however, the amount of rain fell approached the multiannual values, while in August an excess of 45 mm was recorded. Thanks to this fact, the Cristina TD soybean variety has extended its vegetation period. As a comparison between the climatic factors recorded in the Cristina TD variety and the plant's need at an optimal level expressed by potential evapotranspiration (ETP), a deficit of this need is found at a fairly high level (table 1).

Table 1. Climate factors evolution from soybean vegetation

Month	Temperature, tn^0C				Precipitation, mm			ETP^{**} mm
	N*	2022	±	$\Sigma tn^0 > 10^0C$	N	2022	±	
May	16.3	17.1	0.8	1540	81	77	-4	33
June	19.5	21.6	2.1		94	14	-80	74
July	21.7	23.8	2.1		81	71	-10	141
Aug.	21.3	23.7	2.4		60	105	45	176
Sep.	16.9	16.5	-0.4	Per. Veg.	53	46	-7	66
±	19.14	20.54	1.4	138 zile	369	313	-56	490

**N-normal values,   **ETP-potential evapotraspiration*

Total biomass formation in soybean plants. Considering the influence of the 2 factors on the formation of the total biomass (table 2), the formation of 3.97 t/ha and 8.17 t/ha in the case of the dolomite + $N_{40}P_{40}$ combination is found in the control. If we take into account the influences of the 2 factors on the formation of the maximum increase in biomass, it is found that it was 5.36 t/ha (100%). The 4 types of $CaCO_3$ used contributed 3.86 t/ha (72%), and the NP type fertilizers brought an additional 4.52 t/ha (84%). If we analyze the interaction between the 2 factors, we find a negative increase of -3.02 t/ha (56%). It is possible that this negative interval is caused by a relative antagonism between calcium and phosphorus (Dodd at al., 2010).

Regarding the formation of pod biomass, the extreme value obtained was 5.58 t/ha (table 3). In the case of biomass at the same gradation of Doloflor with $N_{40}P_{40}$ the maximum increase was 4.29 t/ha (100%). The amendments contributed to these with 2.33 t/ha (54%) and the NP dose with 3.30 t/ha (77%). And in the case of pod biomass, the interaction between the two factors was negative, namely at the level of -1.34 t/ha (31%).

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Table 2. Total biomass formation (t/ha) of soybean plants, Cristina TD variety

Ca/NP	N_0 P_0	N_{40} P_{40}	N_{80} P_{80}	Factors influence
Check	3.97	2.85	7.37	Maximum yields 5.36 t/ha, 100%
A-Ca pw 2.5 t/ha	6.78	7.70	8.21	
D-Ca pw 2.5 t/ha	7.83	7.75	7.86	Ca 3.86 t/ha, 72%
D-Ca gr 2.5 t/ha	5.41	8.17	7.09	
N-Ca pw 2.5 t/ha	4.92	4.22	6.72	NP 4.52 t/ha, 84%
	Ca	*NP*	*Ca x NP*	
DL 5 % = *DL 1 % =* *DL 0.1 %=*	*1.099* *1.598* *2.402*	*0.896* *1.222* *1.653*	*1.899* *2.682* *3.849*	Ca x NP -3.02 t/ha, -56%

Table 3. Pods biomass formation (t/ha), Cristina TD variety

Ca/NP	N_0 P_0	N_{40} P_{40}	N_{80} P_{80}	Factors influence
Check	2.61	1.29	4.59	Maximum yields 4.29 t/ha, 100%
A-Ca pw2.5 t/ha	4.04	4.95	5.31	
D-Ca pw 2.5 t/ha	4.94	5.40	5.08	Ca 2.33 t/ha, 54%
D-Ca gr 2.5 t/ha	3.35	5.58	5.40	
N-Ca pw 2.5 t/ha	3.09	2.51	4.21	NP 3.30 t/ha, 77%
	Ca	*NP*	*Ca x NP*	
DL 5 % = *DL 1 % =* *DL 0,1 %=*	*0.905* *1.317* *1.979*	*0.552* *0.753* *1.019*	*1.404* *2.000* *2.911*	Ca x NP -1.34 t/ha, -31%

The total grain biomass was included under the same conditions between 1.22-3.37 t/ha, resulting in a maximum increase of 2.81 t/ha (table 4). To this maximum increase in production, the amendments contributed 1.57 t/ha (56%) and the interaction with NP 1.54 t/ha (55%). And in the case of grains, the interaction of the two factors was negative, respectively -0.30 t/ha (11%), for the same antagonistic reasons.

Table 4. Grains biomass formation, (t/ha) Cristina TD variety

Ca/NP	N_0 P_0	N_{40} P_{40}	N_{80} P_{80}	Factors Influence
Mt	1.22	0.56	2.10	Maximum yields 2.81 t/ha, 100%
A-Ca pw 2.5 t/ha	1.58	3.12	2.74	
D-Ca pw2.5 t/ha	2.79	2.82	2.22	Ca 1.57 t/ha, 56%
D-Ca gr 2.5 t/ha	1.89	3.37	3.27	
N-Ca pw 2.5 t/ha	1.49	1.05	2.38	NP 1.54 t/ha, 55%
	Ca	*NP*	*Ca x NP*	
DL 5 % = *DL 1 % =* *DL 0,1 %=*	*0.692* *1.007* *1.512*	*0.392* *0.535* *0.724*	*0.886* *1.256* *1.812*	Ca x NP - 0.30 t/ha, -11%

In the case of the 4th element, the determination of the mass of a thousand grains, the value obtained demonstrated a maximum increase of 47 gr (100%) (table 5). The amendments contributed to this increase with 10 gr (21%) and the NP doses with 47 gr (100%). The interaction between $CaCO_3$ and NP was negative, namely -10 gr (21%).

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Table 5. Mass of thousand grands formation (MTG) g Cristina TD variety

Ca/NP	N_0 P_0	N_{40} P_{40}	N_{80} P_{80}	Factors influnece
Check	222	179	226	Maximum yields 47 g, 100%
A-Ca pw 2.5 t/ha	218	221	220	
D-Ca pw2.5 t/ha	212	210	211	Ca 10 g, 21%
D-Ca gr 2.5 t/ha	222	217	214	
N-Ca pw 2.5 t/ha	220	213	221	NP 47 g, 100%
	Ca	*NP*	*Ca x NP*	
DL 5 % = *DL 1 % =* *DL 0.1 %=*	*15* *22* *24*	*16* *22* *30*	*28* *39* *54*	Ca x NP -10 g, -21%

Dispersion analysis of soybean production formation in the Cristina TD variety. From the data obtained in table 6, the analysis of the F test shows that absolutely all determinations, namely: total biomass, pod biomass, grain biomass, the differences were significant, distinctly significant and very significant.

Table 6. Dispersions analysis of soybean yields formation Cristina TD variety

Cause of variability	Sq.m				GL	Variance, S^2				F Test			
	Total d.w.	Pods	grains	MTG		Total d.w.	Pods	grains	MTG	Total d.w.	pods	grains	MTG
Rep.	5.03	1.76	0.82	794	2								
A FACT	68.42	38.46	16.14	910	4	17.11	9.62	4.03	227	10.1**	8.3**	9.9**	1.13
Er.A	13.62	9.25	3.25	1609	8	1.70	1.16	0.41	201				
Big P	87.08	49.46	20.20	3313	12								
B Fact.	23.14	13.92	4.19	1096	2	11.57	6.96	2.10	548	12***	22***	13***	1.97
A x B	34.79	19.20	10.78	3027	8	4.35	2.40	1.35	378	4.4**	7.62***	9***	1.36
Er.B	16.60	6.30	3.19	5559	20	0.83	0.32	0.16	278				
Small P	74.50	39.40	18.16	9682	30								
Total	161.6	88.87	38.37	12995	44								

Figure 1. Cristina TD flowering period

Figure 2. Pod formation period

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Figure 3. Cristina TD at maturity

Figure 4. Cristina TD grains aspect

Figures 1-4 show images of the soybean culture, in the interaction of the 2 factors, both in full vegetation and as an aspect of the grains.
The correlations obtained between the main determinations of the soybean plant, the Cristina TD variety.

Table 7. Corelations between the main determination of soybean plants Cristina TD variety

Indices	DW.	No pods	DW pods	No grains	DW grains	MTG
DW.	1	95.7* **.978****	95.2 **.976**	79.2 **.890**	78.4 **.885**	19.2 **.438**
No pods		1	92.9 **.964**	77.1 **.878**	75.0 **.866**	18.3 **.428**
DW pods			1	90.5 **.952**	88.0 **.938**	19.6 **.443**
No grains				1	93.4 **.967**	11.5 **.338**
DW grains					1	15.0 **.387**
MTG						1
	LSD5% = .190, LSD 1% = .250, LSD 0.1% = .320					

**Correlation coefficient of determination (D%), **correlation coefficient (r)*

Two important ideas emerge from the data obtained, namely the level of correlations is in totality very significantly positive (table 7). And of the two types of correlations, the determination values were between 75% and 96% regarding plant biomass and between 11-20% in the case of the mass of one thousand grains (MTG).

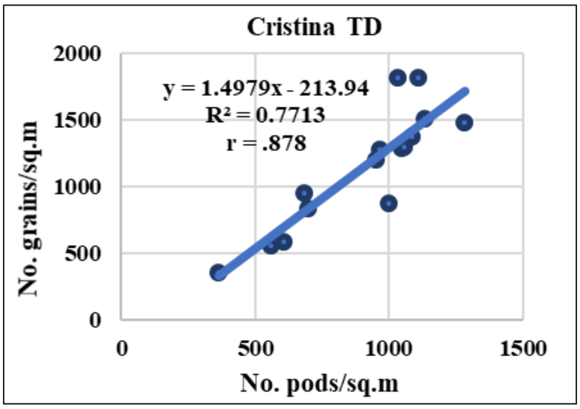

Figure 5. Corelation between pods no x sq.m grains no/sq.m

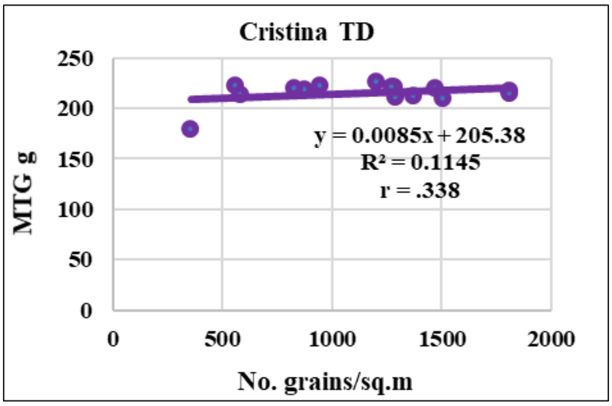

Figure 6. Corelation between grains no /sq.m

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Next, two of these correlations are presented with some differentiation of the formation of the respective characters. Thus, figure 5 shows correlations between the number of pods per square meter and the number of grains per square meter. The correlation is highly significantly positive with a determination of 77%. Next, the correlation between the number of grains and MTG, the correlation is with a determination of 11% (relatively low), positive and statistically well assured.

The biomass structure of soybean plants obtained in the two experimental factors. If we analyze the absolute data and the ratios between the 4 biomasses, we find special aspects (Cosgrove, 2005) of the Cristina TD variety (table 8). Thus, of the total biomass formed by the interaction of the two factors, the pods represented 63.4% at the level of the entire experiment, and that of the grains 32.54%. In the case of MTG, the statistical difference was insignificant.

Table 8.Soybean biomass structure, Cristina TD variety, by experimental factors

$CaCO_3$ 2.5 t/ha	NP	DW. plant t/ha,	DW. plant %	DW. Pods t/ha	DW. Pods %	DW grains t/ha	DW grains %	MTG g
0	$N_0 P_0$	3.97	100	2.61	65.7	1.22	30.7	222
	$N_{40} P_{40}$	2.85	100	1.29	45.3	0.56	19.6	**179**
	$N_{80} P_{80}$	**7.37**	100	**4.59**	62.3	2.10	28.5	226
A-Ca pw	$N_0 P_0$	**6.78**	100	**4.04**	59.6	1.58	23.3	218
	$N_{40} P_{40}$	**7.70**	100	**4.95**	64.3	**3.12**	40.5	221
	$N_{80} P_{80}$	**8.21**	100	**5.31**	64.7	**2.74**	33.4	220
D-Ca pw	$N_0 P_0$	**7.83**	100	**4.94**	63.1	**2.79**	35.6	212
	$N_{40} P_{40}$	**7.75**	100	**5.40**	69.7	**2.82**	36.4	210
	$N_{80} P_{80}$	**7.86**	100	**5.08**	64.8	**2.22**	28.2	211
D-Ca gr	$N_0 P_0$	5.41	100	3.35	61.9	1.89	34.9	222
	$N_{40} P_{40}$	**8.17**	100	**5.58**	68.3	**3.37**	41.2	217
	$N_{80} P_{80}$	**7.09**	100	**5.40**	76.2	**3.27**	46.1	214
N-Ca pw	$N_0 P_0$	4.92	100	3.09	62.8	1,49	30,3	220
	$N_{40} P_{40}$	4.22	100	2.51	59.5	1,05	24,0	213
	$N_{80} P_{80}$	**6.72**	100	**4.21**	62.6	**2,38**	35,4	221
	Mean	6.457	100.0	4.157	63.4	2.173	32.54	215
DL 5 % *DL 1 %* *DL 0.1%*		*1.899* *2.622* *3.849*		*1.404* *2.000* *2.911*		*0.886* *1.256* *1.812*		*28* *38* *54*

4. CONCLUSIONS

1. Within the experiment, it was sought to obtain new results by promoting both formulations. The aim was to ascertain the complex efficiency in the case of the new Cristina TD soybean variety, of the influences between the two factors.
2. The total biomass of the soybean plant shows a gain of 5.36 t/ha to which calcium contributed with 72% and NP with 84%. In the case of pods, the maximum increase was 4.29 t/ha, of which the amendments had an influence of 54% and those of the NP type 77%. Grain biomass had a maximum increase of 2.81 t/ha in which Ca and Mg combinations contributed 56% and NP 55%, respectively. The interactions of the two factors in all three determinations were negative, the explanation would be the existence of an antagonistic interaction between the cations.

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3. The dispersion analysis demonstrated in all cases significant aspects that invite the promotion of new soybean varieties under the amendment conditions. And in the case of correlations obtained between characters, the values obtained show very close positive links.
4. In the specific crop conditions of 2022, of the total biomass formed in the experiment, the pods represented 63% and the grains 33%. The mass of one thousand grains was at an average level of 215 gr, without significant deviations, due to the fact that this character is genetically controlled and fluctuates less.
5. The positive results obtained in the research indicate the cultivation of new soybean varieties, ecologically adapted in the station. Within the technology, there should be no lack of application of amendments of any kind.

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