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MANAGEMENT OF FERTILIZATION WITH NON-POLLUTING PRODUCTS IN THE CULTURE OF COWPEA (*VIGNA UNGUICULATA* L. WALP) IN THE SANDY SOILS CONDITIONS

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Abstract

*The researches were carried out in the period 2020-2021 on the cowpea crop, located in irrigated conditions, on a sandy soil with low natural fertility, in the southern area of Oltenia, and aimed at reducing the effects of abiotic stress and increasing production, through management fertilizing the crop with environmentally friendly products. Five variants of foliar fertilization were experimented (non-fertilized foliar, Basfoliar 36 Extra, in a dose of 3 l / ha; Maturevo 3.35.35 + ME, in a dose of 3 kg/ha; liquid Biohumussol in a concentration of 1 %; Polyactiv Mn, at a dose of 1.5 l/ha), on two agrofunds of root fertilization (N30P30K30; N60P60K60). The obtained results showed that ensuring a rational fertilization of cowpea, in relation to the requirements of the plant and the state of soil fertility can regulate the mechanisms of plant protection against stressors on sandy soils. The foliar fertilization with environmentally friendly products has positively influenced the percentage of dry matter, bound water and the concentration of vacuolar juice in cowpea leaves, increasing the plant's resistance to thermohydric stress. Through the foliar fertilization of the cowpea crop, there were increases of production between 30-47.5%, on the agrofound of N30P30K30 and of 15.8-22.1% on the agrofund of N60P60K60. The cowpea registered a maximum production (2,983.4 kg/ha), at the fertilization with Maturevo 3.35.35 + ME, in a dose of 3 kg/ha, on the agrofund of N60P60K60, with the significant difference ($p>0.05$), compared to unfertilized foliar. There was a positive correlation, distinctly significant, between between the leaf area index and cowpea grain production ($r = 0.882$ **).*

Key words: *thermohydric stress, physiological indices, leaf area, biometrics, productivity*

INTRODUCTION

Originally from Central Africa, the cowpea (*Vigna unguiculata* L. Walp) is a leguminous plant that, due to its special biological and morphological peculiarities (very strong root system, with a high absorption power, waxy layer on the leaves), can make very good use of the sandy soils from Romania and has a high tolerance to thermohydric stress conditions [6], [25]. Stomatous closure is the common strategy used by different cowpea genotypes to avoid dehydration of the foliar apparatus, and the genotypic variance in stomatal conductance increases considerably in drought conditions [1], [11]. Having the possibility of biological fixation of atmospheric nitrogen, with the help of symbiotic bacteria of the genus Rhizobium), cowpea are successfully grown in crops in areas with sandy soils [10], [16], [23]. The process of biological nitrogen fixation has great significance, given the prospect of population growth, which requires increased production of cereals and legumes, which are achieved with very large amounts of chemical fertilizers with nitrogen [12] [2]. Due to the low organic matter content of sandy soils in Romania, which is closely dependent on the amount of organic residues and the activity of soil organisms, for the success of most crops, large amounts of chemical fertilizers are needed, which can often lead to groundwater pollution with nitrates taking into account the deficient hydro-physical properties in terms of chemical retention [5], [19]. From the point of view of ensuring the nutrients necessary for the nutrition of cowpea plants, sands and sandy soils are characterized by low natural fertility, determined by the low content of organic matter and fertilizing elements. Often on these lands there is a lack of microelements, especially zinc and magnesium [3], [8], [20]. Research results have shown that when a single nutrient is deficient in the plant, or one of the technological factors is not optimally ensured, the yields obtained on sandy soils can be significantly reduced [14], [4], [18]. In intensive agriculture, which requires high yields, in order to maintain the health of the soil, the yields obtained and finally the consumer, the importance of using inputs (pesticides, fertilizers) is undeniable [17]. In this sense, research has been initiated on the cowpea crop, which aimed to reduce the effects of abiotic stress and increase production, by managing the fertilization of the crop with environmentally friendly products.

MATERIALS AND METHODS

The researches were carried out in the period 2020-2021 on the cowpea crop located in irrigation conditions, on a sandy soil with low natural fertility in the southern area of Oltenia. Organic carbon showed values in the range of 0.20% - 0.63%, indicating a reduced state of soil supply of organic matter, and soil pH ranged between 4.53 and 6.08, values that show a reaction moderately acidic to slightly acidic.

The experiment was placed in field conditions, according to the method of plots subdivided with 2 factors:

Factor A - Root fertilization;

a_1- 1/2 of the technological dose of nitrogen, phosphorus and potassium, respectively: N30P30K30

a_2 - technological dose of nitrogen, phosphorus and potassium, respectively: N60P60K60.

Factor B - Foliar fertilization:

b_1 - unfertilized foliar

b_2 - Basfoliar 36 Extra, in a dose of 3 l/ha

b_3 - Maturevo 3.35.35 + ME, in a dose of 3 kg/ha

b_4 - Liquid Biohumussol, in a concentration of 1%

b_5 - Polyactiv Mn, at a dose of 1.5 l/ha

Fertilization with N30P30K30 (a_1) was performed in the preparation of the germination bed, and the dose of N60P60K60 (a_2) was applied in two fractions (1/2 in the preparation of the germination bed and ½ in the phase of 4-5 true leaves). Foliar fertilization was carried out in the phase of 6-8 leaves of the plant, by applying doses of foliar fertilizers, calculated for 250-300 l water/ha (Photo 1). During the vegetation period, determinations of physiology, biometrics were made (Photo 2, Photo 3) and grain production was determined at harvest.

Physiological determinations of water forms and dry matter in the leaves were performed gravimetrically by oven drying. The leaf area was determined in the laboratory using the Area Metter AM 300 device. The vacuolar juice concentration was read with a Pocket Refractometer. The results obtained from cowpea were calculated and analyzed by the method of analysis of variance (ANOVA) and using mathematical functions.

RESULTS AND DISCUSSIONS

The impact of fertilization on some physiological aspects of the cowpea plant

The results on the influence of fertilization on physiological indices in beans highlighted the fact that, in addition to the direct influence of environmental factors, special importance should be given to the type and dose of fertilizers used in the crop. Table 1 shows the results obtained in the period 2020-2021 in terms of dry matter, bound water content and vacuolar juice concentration in the leaves. The dry matter registered values between 13.4% for the variant fertilized with N30P30K30, foliar non-fertilized and 16.5%, for root fertilization with N60P60K60 + foliar fertilization with the product Maturevo 3.35.35 + ME, in a dose of 3 kg/ha, in the phase of 6-8 leaves of the plant. Ensuring a rational fertilization of cowpea, in relation to the requirements of the plant and the state of soil fertility, can regulate the mechanisms of plant protection against stressors on sandy soils. Thus, it was noticed the increase of the percentage of bound water from 2.4-2.9%, values registered in foliar non-fertilized variants, to 3.2-3.6%, by foliar fertilization with Maturevo 3.35.35 + ME, in a dose of 3 kg / ha, in the phase of 6-8 leaves of the plant. The concentration of vacuolar juice was differentiated depending on the root and foliar fertilization, registering values in the range of 7.7-9.9%.

Photo 1. Application of foliar fertilization with Vermorel
Source: Original.

Table 1. Value of physiological indices in cowpea according to fertilization

The experimental variant: Root fertilization (agrofond)	The experimental variant: Foliar fertilization	Dry matter (%)	Bound water (%)	Vacuolar juice concentration (%)
N30P30K30	Unfertilized foliar	13.4	2.4	7.7
	Basfoliar 36 Extra	15.5	2.9	8.3
	Maturevo 3.35.35 + ME	16.1	3.2	9.3
	Biohumussol Liquid	16.1	2.9	8.7
	Polyactiv Mn	15.9	3.0	8.3
Average		15,4	2.9	8.4
N60P60K60	Unfertilized foliar	15.2	2.9	8.1
	Basfoliar 36 Extra	15.6	3.5	9.6
	Maturevo 3.35.35 + ME	16.4	3.6	9.9
	Biohumussol Liquid	16.2	3.6	9.6
	Polyactiv Mn	16.4	3.1	9,5
Average		16	3.3	9.3

Source: Own research.

Foliar fertilization with Maturevo 3.35.35 + ME, at a dose of 3 kg/ha increased the stress resistance of the cowpea, by recording the highest values of physiological indices in the flowering phase of the plant, namely dry matter, bound water and juice concentration vacuolar (Figure 1). Compared to unfertilized foliar fertilizer, Maturevo 3.35.35 + ME increased the dry matter by 13.6%, the bound water by 28.3% and the vacuolar juice concentration by 21.5%. In addition to the plant's nutrient regime, the variety is an essential factor in the stress behavior of cowpea. Research in South Africa has highlighted the stress resistance of cowpea and their ability to rehydrate, depending on the variety [13], [21]. The results show that a tolerant variety can recover all photosynthetic parameters after 60 hours of rehydration, being able to maintain a higher photochemical activity and a gas exchange of leaves during water deficit for a longer period compared to a sensitive variety.

The impact of fertilization on some morphological properties of the cowpea plant

The results presented in Table 2 highlight the role of fertilization on the growth and development of cowpea plants, in sandy soil conditions, characterized by low macro and microelement content**.** Thus, the nutrition of the plant with N60P60K60 led to a better development of the plants and to the increase of the number of pods with 2 pods / plant, compared to the application of ½ from the dose of NPK. Also, the foliar fertilization was highlighted, on the two agrofunds of NPK. When fertilizing the cowpea crop with 1/2 of the technological dose, respectively N30P30K30, the plants reacted by intensifying the fruiting process of the plant to the foliar fertilization with Maturevo 3.35.35 + ME, applied in a dose of 3 kg/ha. Maximum results were observed on the agrofund N60P60K60, for foliar fertilization with Maturevo 3.35.35 + ME, applied in a dose of 3 kg/ha and with Biohumussol Liquid, in a concentration of 1%. In these variants, the bean yielded 17 pods / plant with a number of 11-12 seeds in the pod, registering high values of the foliar index (8-8.5). Research conducted in Brazil has highlighted the major role of phosphorus fertilization and irrigation on cowpea pod formation [24].

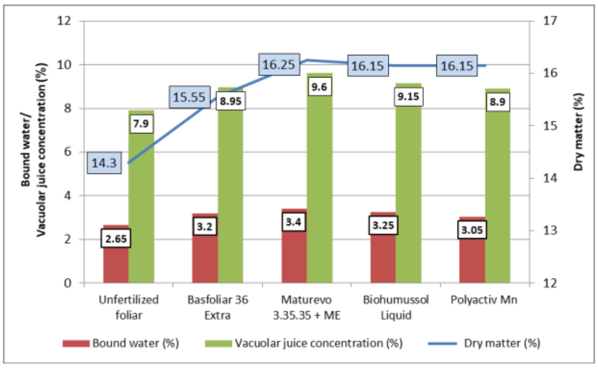

Fig. 1. The influence of foliar fertilization on some physiological indices in cowpea
Source: Own research.

Photo 2. Observations in the experimental field with cowpea
Source: Original.

Table 2. Value of biometric and productivity traits in cowpea in different fertilization variants

The experimental variant		Plant height (cm)	Nr. pods/ plant	Nr. grains/ pods	pod length (cm)	Leaf area index (LAI)
Root fertilization (agrofond)	Foliar fertilization					
N30P30K30	Unfertilized foliar	83.7	9	8	11.6	5.9
	Basfoliar 36 Extra	90.7	13	10	13.2	6.5
	Maturevo 3.35.35 + ME	92.0	15	11	14.0	6.9
	Biohumussol Liquid	89.5	12	10	13.2	6.4
	Polyactiv Mn	89.5	14	10	12.3	6.2
Average		89.08	13	10	12.86	6.38
N60P60K60	Unfertilized foliar	89.1	12	10	12.9	6.4
	Basfoliar 36 Extra	87.3	13	10	13.5	6.8
	Maturevo 3.35.35 + ME	96.3	17	11	14.1	8.5
	Biohumussol Liquid	93.5	17	12	14.2	8.0
	Polyactiv Mn	94.0	16	12	12.5	7.4
Average		92.04	15	11	13.44	7.42

Source: Own research.

The impact of fertilization on cowpea production results

Leguminous plant that symbiotically synthesizes 80.6% of the nitrogen needed for nutrition, cowpea need this element, at the beginning of vegetation until the installation of microbial activity in the soil in order to carry out the normal metabolism of the plant [15], [7], [9]. The results obtained when fertilizing the cowpea crop with N60P60K60 and presented in Table 3, showed an increase in grain production by 453.8 kg/ha, compared to the use of the dose of N30P30K30, an increase that is within the limits of the experimental error ($p < 0.05$).

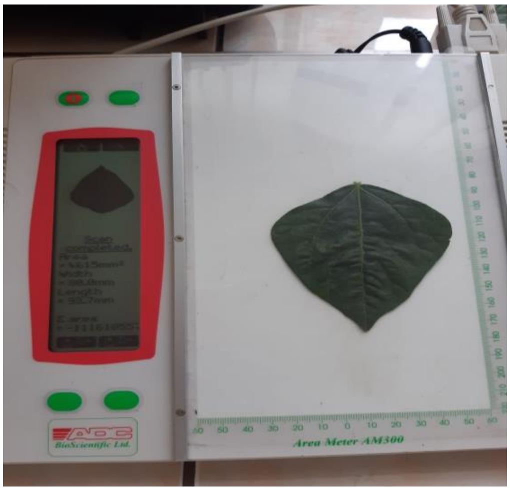

Photo 3. Measured the area of a cowpea leaf with the Area Metter AM 300
Source: Original.

Table 3. Significance of cowpea production obtained from basic NPK fertilization

Root fertilization	Grain yield kg/ha	Grain yield %	The difference compared to the control kg/ha	Significance
N30P30K30	2,343.4	100.0	Control	Control
N60P60K60	2,797.3	119.4	453.8	-

LSD 5%=565.2
LSD 1%=1,305.3
LSD 0.1%=4,153.8

Source: Own research.

The analysis of the influence of foliar fertilization on cowpea production, compared to the non-fertilized foliar variant, shows a distinctly significant differentiation of grain production (p> 0.01), obtained by fertilizing the crop in the 6-8 leaf phase, with one of Basfoliar 36 Extra products, at a dose of 3 l/ ha, or Maturevo 3.35.35 + ME, at a dose of 3 kg/ha, variants in which 2,746.2-2,782.3 kg/ha were registered (Table 4).

The effect of the application of the product Basfoliar 36 Extra is due, in particular, to the high content of magnesium and trace elements that are chelated by biodegradable compounds, being very quickly absorbed by the leaves and do not turn into compounds inaccessible to plants.

Table 4. Significance of cowpea production obtained in terms of foliar fertilization

Foliar fertilization	Grain yield kg/ha	Grain yield %	The difference compared to the control kg/ha	Significance
Unfertilized foliar	2,126.6	100	Control	Control
Basfoliar 36 Extra	2,782.3	130.8	655.7	**
Maturevo 3.35.35 + ME	2,746.2	129.1	619.6	**
Biohumussol Liquid	2,604.6	122.5	478.0	*
Polyactiv Mn	2,592.0	121.9	465.4	*

LSD 5%=360.27
LSD 1%=496.22
LSD 0.1%=683.15

Source: Own research.

Also, the very high content of microelements of the product Maturevo 3.35.35 + ME, especially magnesium, as the main component of chlorophyll, ensured the maintenance of the foliar apparatus for a longer period of time and therefore a prolonged development of the process of photosynthesis. Fertilization with the product Maturevo 3.35.35 + ME acts on the metabolism of the cowpea plant, increasing the selective absorption from the soil of nutrients, especially phosphorus and potassium, which play an essential role in fruiting and increase resistance to stress.

Due to the low content of humus and microelements of sandy soils, in the crops located on these lands, there are often disorders of metabolism in the plant [5]. Research in Spain has highlighted the positive response of the cowpea plant to mineral and organic fertilization, as the differences between the two methods are not significant, so that fertilization with organic products can be successfully applied to this crop [22]. The results on the influence of foliar fertilization on grain production, obtained from cowpea, highlight statistically assured differences depending on root fertilization (Table 5). Thus, by foliar fertilization with one of the four tested products, production increases between 30-47.5% were obtained, on the N30P30K30 agrofund and by 15.8-22.1% on the N60P60K60 agrofund. The maximum production, of 2,983.4 kg / ha, was achieved at the fertilization with Maturevo 3.35.35 + ME, in a dose of 3 kg / ha, on the agrofund of N60P60K60, the difference of production compared to non-fertilized foliar being significant (p> 0.05).

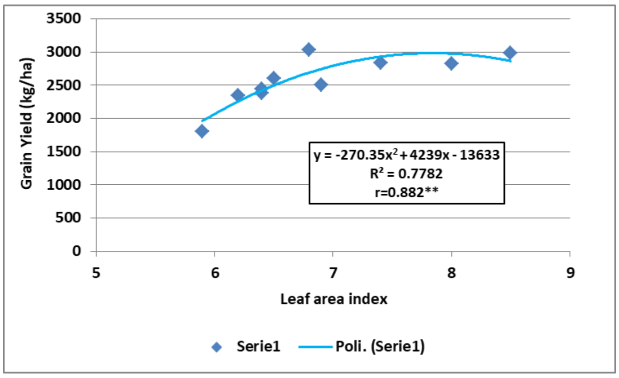

Fig. 2. The correlation between the leaf area index and the grain production obtained from cowpea
Source: Own research.

Intraspecific competition between plants takes place during the development of the root and leaf system, and the results obtained show that higher increases in production are achieved as the plant is grown in an area as similar as possible to the origin, and develops an area larger foliar [14], [4]. The analysis of the functional link between the leaf area and the cowpea production, obtained in the 10 fertilization variants, showed a positive correlation, a phenomenon highlighted very well by the polynomial function of degree 2, whose coefficient r = 0.882 ** underlines a correlation distinctly significant between cause and effect (Figure 2).

Table 5. Significance of grain production obtained from cowpea under the influence of root and leaf fertilization

The experimental variant		Grain yield		The difference compared to the control kg/ha	Significance
Root fertilization (agrofond)	Foliar fertilization	kg/ha	%		
N30P30K30	Unfertilized foliar	1,809.2	100.0	Control	
	Basfoliar 36 Extra	2,667.7	147.5	858.5	**
	Maturevo 3.35.35 + ME	2,509.0	138.7	699.8	*
	Biohumussol Liquid	2,379.1	131.5	569.9	*
	Polyactiv Mn	2,352.1	130.0	542.9	*
N60P60K60	Unfertilized foliar	2,444.1	100.0	Control	
	Basfoliar 36 Extra	2,896.8	118.5	452.7	
	Maturevo 3.35.35 + ME	2,983.4	122.1	539.3	*
	Biohumussol Liquid	2,830.1	115.8	386.0	
	Polyactiv Mn	2,831.9	115.9	387.8	
			LSD 5%	509.5	
			LSD 1%	701.7	
			LSD 0.1%	966.1	

Source: Own research.

CONCLUSIONS

Ensuring a rational fertilization of cowpea, in relation to the requirements of the plant and the state of soil fertility can regulate the defense mechanisms of the plant against stressors.

Foliar fertilization with the product Maturevo 3.35.35 + ME, in a dose of 3 kg/ha, applied in the phase of 6-8 leaves of the cowpea plant determined the increase by 13.6% of the dry matter, by 28.3% of the water related and 21.5% of the vacuolar juice concentration, compared to the unfertilized foliar control.

The results regarding the influence of foliar fertilization on grain production, obtained from cowpea, underline differentiations statistically ensured according to root fertilization, registering increases between 30-47.5%, on the agrofund of N30P30K30 and 15.8-22.1 % on the agrofund of N60P60K60.

The cowpea registered a maximum production (2,983.4 kg/ha), at the fertilization with Maturevo 3.35.35 + ME, in a dose of 3 kg/ha, on the agrofund of N60P60K60, the difference compared to non-fertilized foliar being significant ($p > 0.05$).

There was a positive correlation, distinctly significant, between the leaf area and cowpea production (r = 0.882 **).

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