Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 22, Issue 1, 2022
PRINT ISSN 2284-7995, E-ISSN 2285-3952

BIODYNAMIC PREPARATIONS FOR ALTERNATIVE PLANT CULTIVATION SYSTEMS; CASE STUDY IN WHEAT

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Abstract

The study evaluated the variation of some physiological indices and productivity elements in wheat, in response to treatments with biodynamic preparations. Two preparations were used, applied singly and in combination, at the recommended dose (P500 and P501) or at half the dose (P500/2; P501/2), in five experimental variants (V1 – P5001; V2 – P500/2; V3 – P500; V4 – P500+P501; V5 – P500+P501/2). A control variant with untreated plants V6(Ct) was used for comparison. Plant height (PH, cm), biomass weight (BW, g) and grain number on ear (GNE, No) were evaluated. Plant height (PH) values ranged from 49 to 69 ±1.66 cm, biomass weight (BW) relative to one plant (mean values) ranged from 3.36 to 7.50 ±0.38 g, and grains number in ear (GNE) ranged from 20 - 38 ± 1.58. The GNE variation according to BW was described by a spline model, in conditions of $\overline{\varepsilon} = 0.00162$ *. The regression analysis facilitated the obtaining of an equation that described the variation of GNE as a function of PH and BW in statistical safety conditions,* $R^2 = 0.998$, $p < 0.001$. *According to PCA, PC1 explained 97.486% of the variance, and PC1 explained 2.0343% of the variance. It was found that in the case of variant V1 (product P501) there were negative increases, which shows that administered alone the product did not have a favourable effect on wheat plants, under the study conditions. The highest values of the increase in indices and the elements taken into account were recorded in the V4 variant, which was a combination of products (P500+P501).*

Key words: *biodynamic agriculture, cultivation systems, GNE, model, PCA, wheat*

INTRODUCTION

The foundations of biodynamic agriculture were laid by the philosopher Rudolf Steiner in 1924, through the philosophical theses presented and promoted [16].
Worldwide, biodynamic agriculture is quantified as being practiced in 55 countries and occupies, according to a recent study [17] an area of 251,842 ha. On the first places are Germany (84,426 ha), Australia (49,797 ha), France (14,629 ha), Italy (10,781 ha) and India (9,303 ha), USA (9,001 ha), Netherlands (8,681 ha). According to the same study, Romania has an area of 200 ha cultivated in a biodynamic system.
The principles of dynamic agriculture have been taken over and promoted in different parts of the world, biodynamic agriculture being promoted as an (advanced) variant of organic agriculture [2], as an alternative agriculture [18].
Certification of biodynamic agriculture, in relation to organic agriculture (or other ecological, biological, forestry farming systems) involves the use of biopreparations with the role of improving the soil and ensuring crop yields [2].
The cultivation of plants in a biodynamic system has been studied in different species of interest, such as vegetables, cereals, potatoes, medicinal plants, vines, fruit trees [11], [15], [12], [20].
Some studies have performed comparative analysis of biodynamic systems with conventional systems [11]. Soil quality in biodynamic culture systems was also evaluated [12], [13].
Biodynamic management has positive ecological, economic and social effects over time. Thus, positive effects on agro ecosystems, plant production and food quality have been reported [1], to which can be added beneficial effects on the human life (growers and consumers of biodynamic products).
Various studies have reported the quality of

plant food resources from biodynamic cultivation systems, or integrated management (organic, biodynamic), with different examples of lettuce [9], garden watercress [14], giant pumpkin [10], viticultural products [7].

The present study evaluated the influence of treatments with biodynamic preparations on some physiological indices and elements of wheat productivity.

MATERIALS AND METHODS

The study analyzed the influence of two biodynamic preparations on wheat culture, in terms of physiological indices and productivity elements.

Two products were used, applied singly and in combination, at the recommended dose (P500 and P501) or at half the dose (P500/2; P501/2). P500 was applied to the soil and P501 was applied to plants in two treatments. Five treated variants resulted (V1 - P5001; V2 - P500/2; V3 - P500; V4 - P500 + P501; V5 - P500 + P501/2). A control variant, V6 (Ct), was used to compare the results.

Plant height (PH, cm), biomass weight relative to plant (BW, g) and grains number in ear (GNE, No) were determined.

The experiment was organized under controlled conditions, Belinț locality, Timiș County, Romania. Aspects from the experiment are presented in Photo 1.

a B c

Photo 1. Wheat plants under biodynamic cultivation conditions; a - plants in growing boxes; b - details on plants; c - detail on the root of the plants

Source: Original images, photos of the authors.

The experimental data obtained were analyzed by usual statistical analyzes in order to evaluate the statistical safety, the presence of the variance, the level of correlation, and the GNE variation depending on the physiological index of the plants, the degree of similarity of the variants in relation to the evaluated index. For this, EXCEL, PAST software [8] and Wolfram Alpha software (2020) [21] were used.

RESULTS AND DISCUSSIONS

The treatments applied with the biodynamic products, led to a specific variation of the wheat plants. Plant height (PH) values ranged from 49 to 69 ±1.66 cm, biomass weight (BW) relative to one plant (mean values) ranged from 3.36 to 7.50 ±0.38 g, and grains number in ear (GNE) ranged from 20 - 38 ±1.58. The complete set of recorded values is presented in Table 1. The graphical distribution, average values, of GNE in relation to PH and BW is shown in Fig. 1.

Table 1. Values of physiological indices and elements of wheat productivity, in conditions of biodynamic culture

Treatment	Trial	Plant height (PH)	Biomass weight (BW)	Grains number in ear (GNE)
		(cm)	(g)	(No)
P501	V1	49	3.36	20
P500/2	V2	55	3.75	24
P500	V3	64	6.47	32
P500+P501	V4	69	7.50	38
P500+P5001/2	V5	61	5.25	34
Control	V6(Ct)	53	3.50	23
Standard Error (SE)		±1.66	±0.38	±1.58

Source: Original data from the experiment.

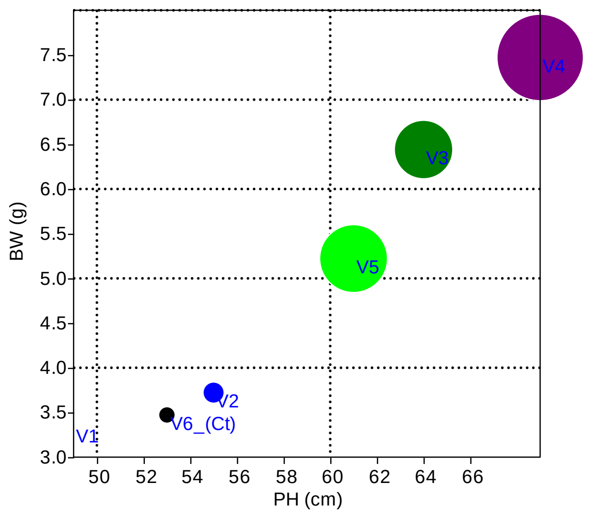

Fig. 1. Average grain number in ear (GNE), depending on plant height (PH, x-axis) and biomass weight (BW, y-axis) in wheat, under biodynamic treatment
Source: Original figure, generated based on data.

The ANOVA test highlighted the presence of the variance in the set of experimental values obtained, and confirmed the statistical certainty of the recorded results (F> Fcrit, p <0.001), Table 2.

Table 2. ANOVA Test, Single Factor

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	25,913.19	2	12,956.59	400.497	6.56E-32	7.93391
Within Groups	1,649.912	51	32.35122			
Total	27,563.1	53				

Alpha = 0.001
Source: Original data, obtained by calculation.

The GNE variation (No) was analyzed in relation to each of the two physiological indices, based on the applied treatments. The variation according to BW was described by a spline model, and the calculated values, according to equation (1), are presented in Table 3. The GNE variation in relation to BW, given by the spline model, is shown graphically in Figure 2.

$$\bar{\varepsilon} = \left(\sum_{i=1}^{n} \varepsilon_i\right) / n = \left(\sum_{i=1}^{n} \left| \frac{ys_i - y_i}{y_i} \right| \right) / n \qquad (1)$$

Table 3. Statistical values related to GNE in relation to BW (g) in wheat plants, under the study conditions, obtained from the spline model

Trial	GNE				
No	x_i	y_i	ys_i	e_i	$I_{i/1}$
V1	3.36	20	20.758	0.03790	1.000
V2	3.75	24	24.346	0.01442	1.173
V3	6.47	32	32.925	0.02891	1.586
V4	7.5	38	37.651	-0.00918	1.814
V5	5.25	34	33.239	-0.02238	1.601
V6(Ct)	3.5	23	22.082	-0.03991	1.064

$\bar{\varepsilon} = 0.00162$

Source: Original data, obtained by calculation.

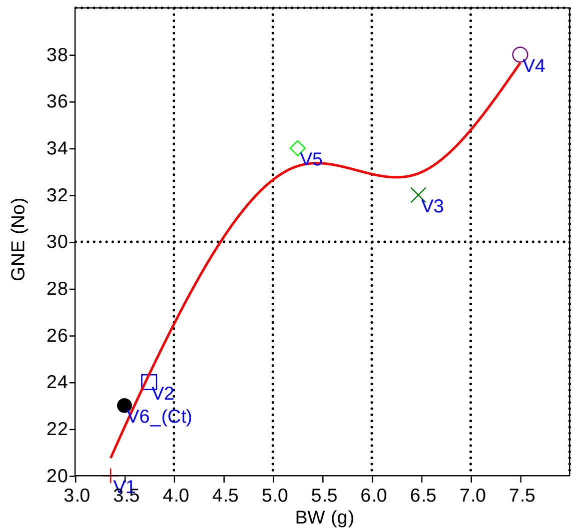

Fig. 2. GNE in relation to BW in wheat plants, under the influence of treatments with biodynamic products
Source: Original graph, generated based on calculated data.

Regression analysis was used to evaluate the variation of GNE (No) in relation to both studied physiological indices, PH (cm) and BW (g) of wheat plants, under the influence of treatments with biodynamic products. A mathematical model, equation (2) and graphical models, a 3D model (Figure 3) and an isoquant model (Figure 4) were obtained, which represented the GNE variation in relation the two physiological indices considered, as direct action and interaction.

$$\text{GNE} = a\,x^2 + b\,y^2 + c\,x + d\,y + e\,xy + f \qquad (2)$$

where: GNE – Grains number in ear (GNE, No);
x – plant height (PH, cm);
y – biomass weight (BW) (g/plt);
a, b, c, d, e, f – coefficients of the equation (2);
a = -0.1093913; b = -7.6251822
c = 4.1200014; d = -58.3407161
e = 2.2049040; f = 0

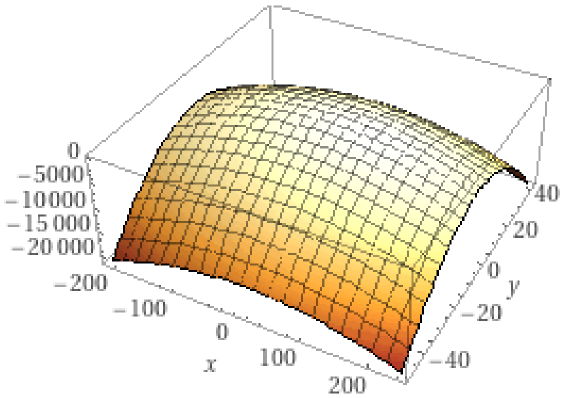

Fig. 3. 3D graphical representation of GNE variation according to plant height, PH (cm) (x-axis) and biomass weight, BW (g) (y-axis), wheat crop, under the influence of biodynamic preparations
Source: Original graph, obtained based on data.

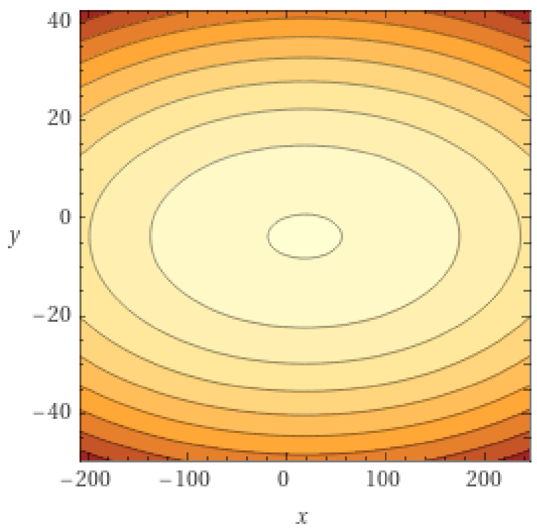

Fig. 4. Graphic representation in isoquants form of GNE variation depending on plant height, pH (cm) (x-axis) and biomass weight, BW (g) (y-axis), wheat culture, under the influence of biodynamic preparations

Source: Original graph, obtained based on data.

According to PCA (correlation) was generated the diagram from Figure 5, which represents the distribution of experimental variants (given by biodynamic preparations) and considered indices and elements (PH, BW and GNE). PC1 explained 97.486% of variance, and PC1 explained 2.0343% of variance.

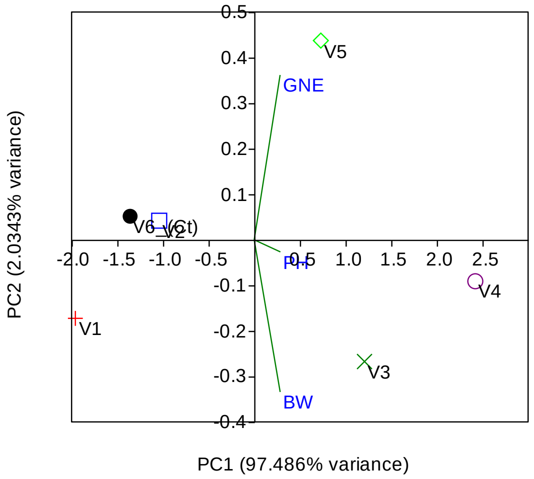

Fig. 5. PCA diagram, for the distribution of experimental variants
Source: Original diagram, obtained based on data

The cluster analysis facilitated the obtaining of the dendrogram from Figure 6, in conditions of statistical safety (Coph.corr = 0.846), in which the variants were associated on the basis of similarity in generating the results of the evaluated indices and parameters.

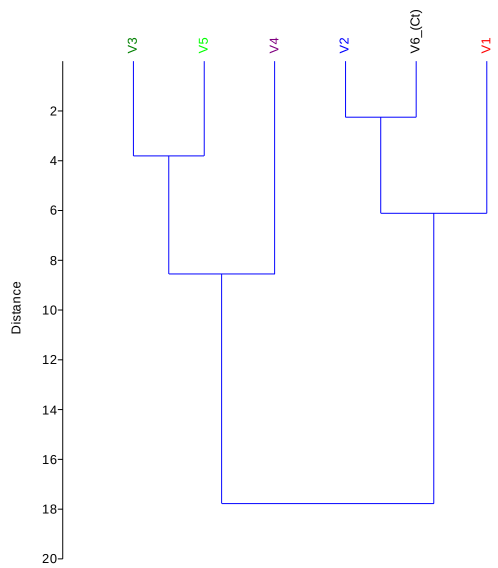

Fig. 6. Grouping dendrogram of experimental variants, based on Euclidean distances, wheat plants, under the influence of biodynamic preparations

Source: Original diagram, generated based on data.

Two clusters were formed, C1 and C2. Within the C1 cluster, the V3, V4 and V5 variants were associated with the best values recorded for PH, BW and GNE. The highest level of SDI values was recorded in variants V2 and V6 (SDI = 2.2500), followed by variants V3 and V5 (SDI = 3.8064). The complete set of SDI values is presented in Table 4.

Table 4. SDI values, wheat culture, under the influence of biodynamic preparations

	V1	V2	V3	V4	V5	V6_(Ct)
V1		7.2216	19.4590	27.2240	18.5360	5.0020
V2	7.2216		12.3450	20.1510	11.7580	2.2500
V3	19.4590	12.3450		7.8779	3.8064	14.5200
V4	27.2240	20.1510	7.8779		9.2229	22.2930
V5	18.5360	11.7580	3.8064	9.2229		13.7140
V6_(Ct)	5.0020	2.2500	14.5200	22.2930	13.7140	

Source: Original data, results from the analysis of experimental data.

In relation to the control variant (V6), the increase (expression in %) was calculated, given by the treatments applied with biodynamic preparations, at the indices and parameters taken into account (PH, BW and GNE). The values obtained are represented graphically in Figure 7.

It was found that in the case of variant V1 (product P501) there were negative increases, which show that the single product P501 did not have a favourable effect on wheat plants, under the study conditions. The highest values of the increase, at the indices and elements taken into account, were recorded in the V4 variant, which was a combination of products (P500 + P501).

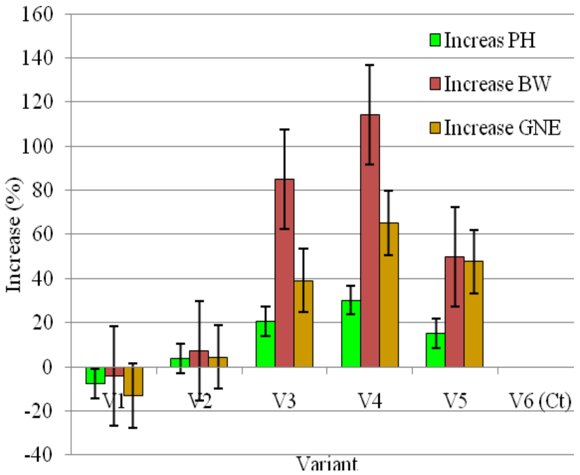

Fig. 7. Variation of increase (%) of physiological indices and productivity elements (PH, BW, GNE) in wheat, under the influence of biodynamic preparations
Source: Original graph, generated based on experimental data.

As an alternative plant cultivation system, biodynamic agriculture aims to produce quality food, in the context of protecting the soil and the environment, with benefits for growers and consumers.

Regulated agricultural practices, specific to this biodynamic culture system, ensure a balanced growth of quality plants and production. The increase in production must be understood both in terms of quantity, but especially in terms of quality.

In the context of the present study, the favourable influence of the products used was quantified at the level of biomass production as well as grain production (evaluated by the number of grains in the ear).

With the exception of variant V1 (P501) in which the differences were negative compared to the control variant, in all the other variants treated, positive increases of the indices and elements considered were registered. The increase in biomass production (BW, g), as an average value per plant, was in descending order of 4.00 g (V4), 2.97 g (V3) and 1.75 g (V5). Spike grain growth (GNE, no) was 15 grains (V4), 11 grains (V5) and 9 grains (V3).

In the case of variant 2, although growth increases were recorded, they were insignificant.

The biodynamic preparations used (P500, P501) were more effective for combined application, which has been reported in other plant species [10].

According to specific of plant nutrition [19], and interest in quality agricultural and horticultural products, various studies have evaluated local germplasm resources, with high ecological plasticity and sustainable technologies [3], [4]. Also, non-invasive methods for assessing vegetation status and plant health have been used [5], [6], and can be promoted in sustainable plant culture systems, such as biodynamic systems.

CONCLUSIONS

P500 and P501 preparations, recommended for biodynamic agriculture, had a specific influence on wheat plants, in relation to the singular or associated application and the evaluated indices. The associated application has been shown to have better effects than the single application.
The favourable effects of the two products in six experimental variants (control variant V6) were quantified at the level of plant size (PH), biomass production (BW) and grain number in ear (GNE). The results obtained showed increases of up to 30.19% for PH, 114.28% for BW, and 65.22% for GNE, compared to the control variant (V6).

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