WHEAT RESPONSE TO MICROBIAL IMPROVEMENT OF SOIL

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Abstract

Integrated farming systems have microbiological bases in soil, microorganisms having the ability to govern nutrient flows to and from plants. Improvement of production is based on calibration and balancing of circuits driven by rhizosphere microorganisms. Bioproducts have the role of supplementing microbial groups with a role in promoting plant growth. The purpose of the paper is to determine the global reaction of two wheat varieties to the application of bioproducts based on active microorganisms. The over- and underground growth of plants and the synthetic indices resulted from them were followed. Development parameters are significantly influenced by the application of bioproducts. In general, autumn wheat variety has a higher developmental balance than the spring one. For autumn wheat the presence of the microbial consortium caused the plant to transfer significant amounts of resources to the stem. The biological bases of spring wheat give it an oversize increase much higher than the winter wheat. A possible explanation for the growth and gradual development of plants is the provision of organic substances in a constant flow from both sides. For microorganisms, this situation has led to their proliferation irrespective of the presence of other organisms, and for the plant has ensured normal growth and development. Also in the case of spring wheat, the correlation between the stem and the root is lower than in the autumn one. The autumn variety has a clustered development, with an evolution in favor of the stem in the early stages of vegetation, and then leads to a stronger development of the root.

Key words: microbial bioproduct, starter effect, wheat, plant development.

Integrated farming systems have microbiological bases in soil, microorganisms having the ability to govern nutrient flows to and from plants. Improvement of production is based on calibration and balancing of circuits driven by rhizosphere microorganisms. Bioproducts have the role of supplementing microbial groups with a role in promoting plant growth. The purpose of the paper is to determine the global reaction of two wheat varieties to the application of bioproducts based on active microorganisms. The over- and underground growth of plants and the synthetic indices resulted from them were followed. Development parameters are significantly influenced by the application of bioproducts. In general, autumn wheat variety has a higher developmental balance than the spring one. For autumn wheat the presence of the microbial consortium caused the plant to transfer significant amounts of resources to the stem. The biological bases of spring wheat give it an oversize increase much higher than the winter wheat. A possible explanation for the growth and gradual development of plants is the provision of organic substances in a constant flow from both sides. For microorganisms, this situation has led to their proliferation irrespective of the presence of other organisms, and for the plant has ensured normal growth and development. Also in the case of spring wheat, the correlation between the stem and the root is lower than in the autumn one. The autumn variety has a clustered development, with an evolution in favor of the stem in the early stages of vegetation, and then leads to a stronger development of the root.

Biological interactions present in agroecosystems positively or negatively influence the quality of crops and production (Shennan C., 2008). Current trends in the agricultural field call for a holistic approach to the factors involved in plant growth and development (du Jardin P., 2015). Therefore, in the perspective of the integrated farming system, stimulating the integration of active biological systems leads to the sustainability of production and the stability of ecosystems. The study of biological interactions especially of the microorganism-plant type is important for understanding the reaction of crops to the application of inputs and for identifying biological improvement technologies (Altieri M.A., 2018).

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Current trends in agriculture are to improve production, both quantitative and qualitative (Walters J.P. *et al*, 2016). Part of this process is based on the study of microorganisms and their interactions with plants. Recent studies focus either on the mechanisms of a single microbial species as a partner of a plant species or on the activity of microbial consortia in relation to one or more species (Souza T., 2015).

The biological features of microorganisms offer them various development niches. The discovery of the microbial circuit of nutrients needed to grow and develop plants has raised questions about how it occurs (Jacoby R. *et al*, 2017). Microorganisms such as nitrogen fixing bacteria, phosphorus or potassium solubilizers play a specific role in the cultivated plant rhizosphere. These microorganisms are applied as a measure to improve soil fertility in the integrated farming system. The duration of plant-microorganism relationships ranges from short-term associations to particularly complex long-term associations. (Bertrand J.C., *et al*, 2011). The number and diversity of microbial is influenced by aspects such as plant age, crop technology, input type applied (Castro-Sowinski S. *et al*, 2007; Souza R.D. *et al*, 2015). In the case of wheat, even different varieties influence differently the presence of microorganisms.

Of the microorganisms, the symbiotic partners present in almost all crop plants are mycorrhizal fungi (Rouphael, Y. *et al*, 2005; Van Der Heijden M.G. *et al*, 2015), both in root extension and biofertilizers. Along with these root-system systems, a number of microbial communities are dependent on the symbiosis mode (Bever J.D. *et al*, 2012; Hardarson G.G., Broughton W.J., 2003; Nihorimbere V. *et al*, 2011). For this reason, in sustainable agriculture systems, the use of synergistic microbial consortia with a role in increasing and diversifying nutrients in the rhizosphere is preferred.

The aim of this study is to evaluate the overall reaction of two wheat varieties to the application of biofertilizers based on microbial consortia. Growth and development were analyzed over the first two months after plant emergence.

MATERIAL AND METHOD

The experiment was located in the vegetation house of the USAMV Cluj-Napoca, the biological material being represented by two wheat varieties: Wintergold (durum, autumn wheat) of the German origin and Pădureni (spring wheat), created at SCDA Turda. The experimental protocol follows whether the two wheat varieties react differently to the application of similar doses of MicrocatAg bioproduct (www.bioscienceinc.com, www.microcat.ro). Organisms with a role in restoring fertility of agricultural soils are present in the biopreparation formula. The doses applied were gradually increased to evaluate the minimum and maximum level of bioproduct that has a beneficial effect on plant growth and development. The producer recommends doses between 11.5 and 22.5 kg / ha. The 6 variants tested are V0 – control (unfertilized), V1 – ½ of the minimum dose (5.75 kg/ha), V2 – 11.5 kg/ha (minimum recommended), V3 – 17 kg/ha (intermediate dose), V4 – 22.5 kg/ha (maximum recommended) și V5 – 45 kg/ha (double of maximum recommended). The development of the roots and strains of the two wheat varieties were analyzed once every two weeks, starting with the second week after emergence. Recorded parameters were root (R), stem (S) and total length (RS). Also, we analyzed the R/S, S/R, R/RS and S/RS ratio, as indices of resources allocation from plant.

The soil used in the vegetation pots was a preluvosol, with a pH of 6.81 and 2.94% humus. Other parameters were: 2.88% IN, 0.145% Nt, 33.52% U, 400 ppm P-AL, 462 ppm K-AL, 7.4 ppm $N\text{-}NO_3$, 2.1 ppm $N\text{-}NH_4$, 9.5 ppm N-min, 12 Ca^{2+} me / 100g sol, 3.4 Mg2+ me / 100g sol. The plants were kept at a constant temperature of 20°C.

Data analysis was performed with the Statsoft Statistica software.

RESULTS AND DISCUSSIONS

The presence of microorganisms and biological processes they perform with the Wintergold variety is directly influenced by vegetative growth and development (Table 1). These are influenced by the variety studied and by the experimental variables. Development parameters of the Padureni variety (S, R, RS) show significant variations ($p<0.05$) due to differential application of bioproduct. The highest recorded values of the F test were in the case of stem (S) and total length (RS).

The correlations between the parameters indicate a more balanced development of the Wintergold variety than in the case of the Pădureni variety (*table 2*). This is due to the plant's investment both in the root and in the stem. In Pădureni, given that it is a spring, the plant quickly invests in foliage and over-the-earth development. Between the root and the stem, in Wintergold we see a significant correlation, while in Padureni this value is not significant.

Table 1

Descriptive statistics of plant growth parameters

Variety	Parameter	Mean	Minimum	Maximum	Std. dev.	F	*p*
Vintergold	R(cm)	7.36	3.00	13.00	2.50	4.82	*0.006*
	S (cm)	20.11	5.00	28.00	6.45	66.71	*0.000*
	RS(cm)	27.46	8.00	40.00	8.03	35.83	*0.000*
	R/S	0.40	0.22	0.70	0.15	16.91	*0.000*
	S/R	2.86	1.43	4.60	1.03	7.05	*0.001*
	R/RS	0.28	0.18	0.41	0.07	13.29	*0.000*
	S/RS	0.72	0.59	0.82	0.07	13.29	*0.000*
Pădureni	R(cm)	7.97	5.00	15.00	2.81	*4.29*	*0.009*
	S (cm)	24.43	9.00	34.00	7.39	*58.64*	*0.000*
	RS(cm)	32.40	14.00	45.00	8.57	*48.14*	*0.000*
	R/S	0.36	0.16	1.10	0.19	*6.96*	*0.001*
	S/R	3.33	0.91	6.20	1.37	*8.48*	*0.000*
	R/RS	0.26	0.14	0.52	0.09	*8.59*	*0.000*
	S/RS	0.74	0.48	0.86	0.09	*8.59*	*0.000*

p<0.05 / p<0.01** / p<0.001****

Table 2

Descriptive statistics of plant growth parameters

	Wintergold							Pădureni						
	R	S	RS	R/S	S/R	R/RS	S/RS	R	S	RS	R/S	S/R	R/RS	S/RS
R		*0.52*	*0.73*	0.19	-0.37	0.25	-0.25		0.26	*0.55*	*0.44*	*-0.57*	*0.49*	*-0.49*
S	*0.52*		*0.96*	*-0.73*	*0.58*	*-0.69*	*0.69*	0.26		*0.95*	*-0.69*	*0.59*	*-0.69*	*0.69*
RS	*0.73*	*0.96*		*-0.52*	0.35	*-0.48*	*0.48*	*0.55*	*0.95*		*-0.45*	0.32	*-0.43*	*0.43*
R/S	0.19	*-0.73*	*-0.52*		*-0.95*	*1.00*	*-1.00*	*0.44*	*-0.69*	*-0.45*		*-0.84*	*0.98*	*-0.98*
S/R	-0.37	*0.58*	0.35	*-0.95*		*-0.97*	*0.97*	*-0.57*	*0.59*	0.32	*-0.84*		*-0.93*	*0.93*
R/RS	0.25	*-0.69*	*-0.48*	*1.00*	*-0.97*			*0.49*	*-0.69*	*-0.43*	*0.98*	*-0.93*		
S/RS	-0.25	*0.69*	*0.48*	*-1.00*	*0.97*			*-0.49*	*0.69*	*0.43*	*-0.98*	*0.93*		

Values with red in table are significant at p<0.05

For Wintergold variety. analysis of regression equations indicates a high potential for influence of root length on stem growth (1.34 cm / cm of root), which is not found in the reverse, the stem stimulating root growth with only 0.20 / cm of stem (*table 3*). The reports indicate an increase in favor of the above ground development, which is considered to be directed by the ameliorative selection. By interpreting the regression equations of the Pădureni variety, a strain growth of 0.70 cm per root centimeter was observed, compared to root values where, at each extra cm of the stem, its growth was only 0.10 cm.

The way the root has developed in the Wintergold variety can support the idea of a lack of competition in the microbial ecosystem in the early stages of development. Root values (R) exceed the statistical estimate and coincide with high frequency and intensity values that in turn exceed the level curve (*figure 1*). The discrepancy in S/R and R/S results reveals the development of the root system and the strain according to microbial phenomena in the rhizosphere. In the early stages of growth, the necessary resources for development were directed to the root system and then to the stem. The presence of the microbial consortium caused the plant to transfer significant amounts of resources to the stem and implicitly resulted in significant differences in the root during the experiment. The growth of the root system in the Wintergold wheat variety was relatively normal, the total plant length being slightly above the statistically estimated values.

Table 3

Regressions of plant development

Wintergold	Pădureni
S= 10.282+1.3355 * R	S= 18.921 + 0.69195 * R
S= -1.152 + 0.77406 * RS	S= -2.072 + 0.81805 * RS
R= 1.1518 +0.22594 * RS	R= 2.0716 + 0.18195 * RS
R= 3.3287 + 0.20035 * S	R= 5.5218 + 0.10006 * S
RS= 3.3287 + 1.2003 * S	RS= 5.5218 + 1.1001 * S
RS= 10.282 + 2.3355 * R	RS= 18.921 + 1.6919 * R

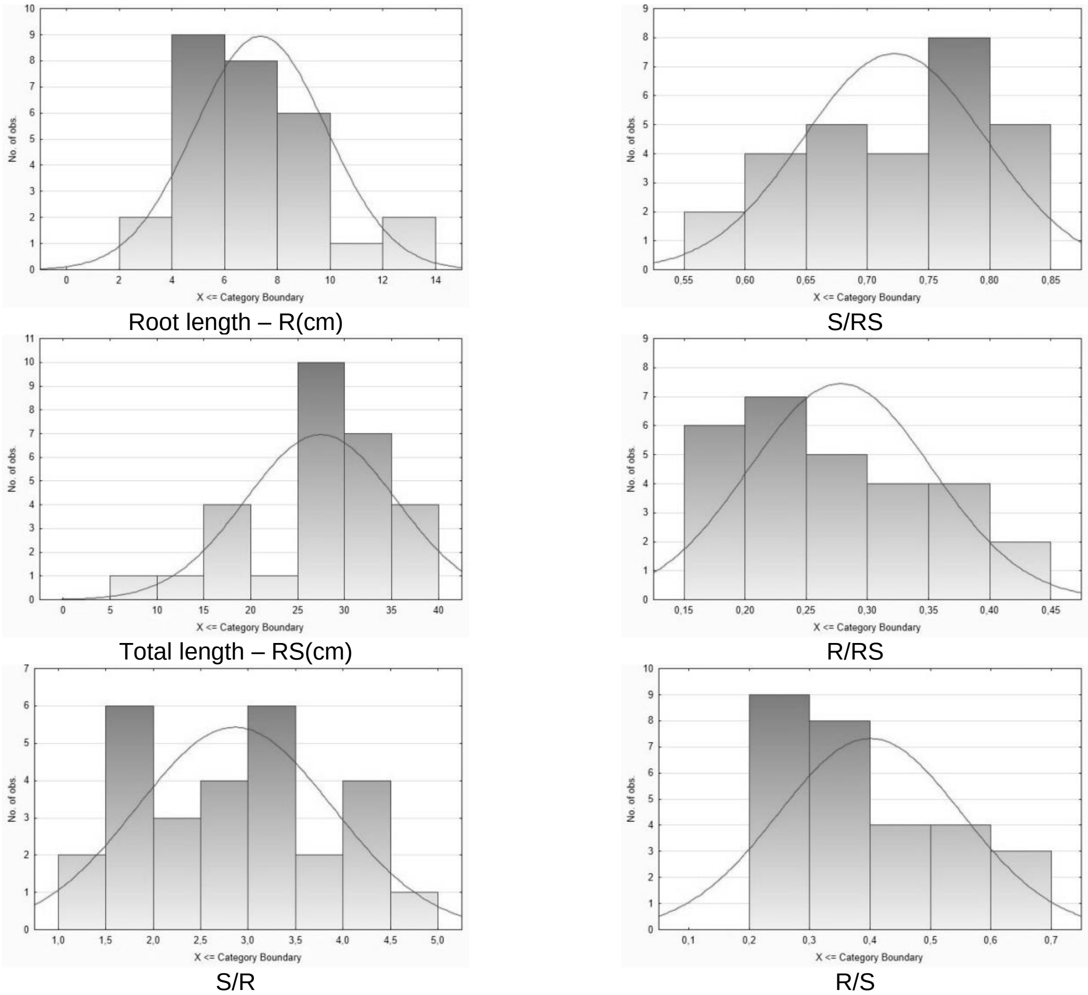
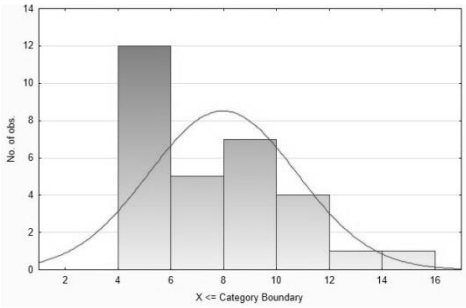
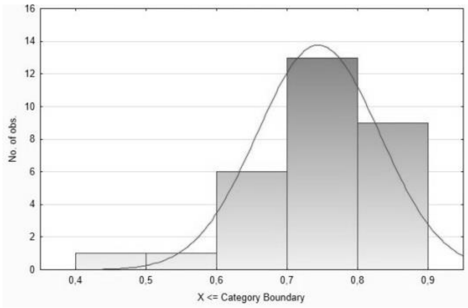


Figure 1 **Frequency histogram of parameters –Wintergold variety**

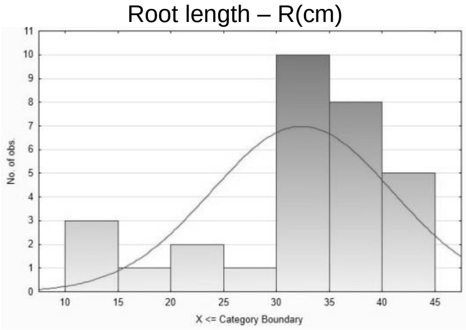
The dimensions of the radicular system in the Padureni variety and the size of the stems in relation to the total length were similar to the statistically estimated values (*figure 2*). The physiology of the spring variety may explain to some extent the more positive response of the variety to the presence of mycorrhizae, and how the root system and strain have developed. A possible explanation for the growth and gradual development of plants is the provision of organic substances in a constant flow from both sides. For microorganisms, this situation has led to their proliferation irrespective of the presence of other organisms, and for the plant has ensured normal growth and development. The values obtained within the parameters can be explained by the starter effect of the bioproduct.



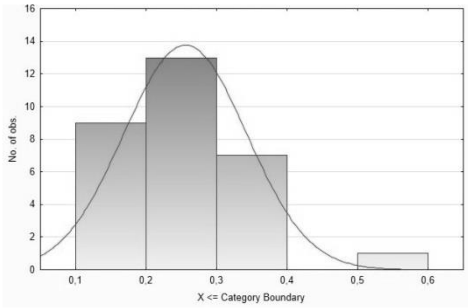
Root length – R(cm)



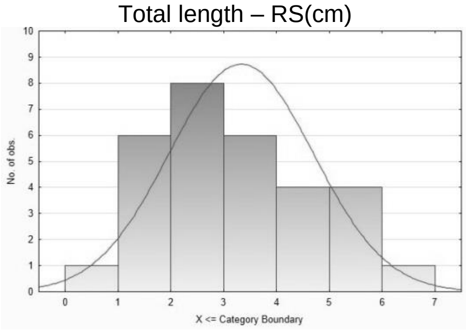
S/RS



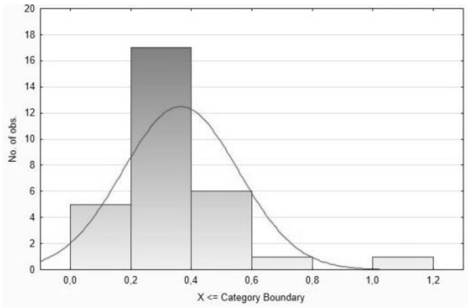
Total length – RS(cm)



R/RS



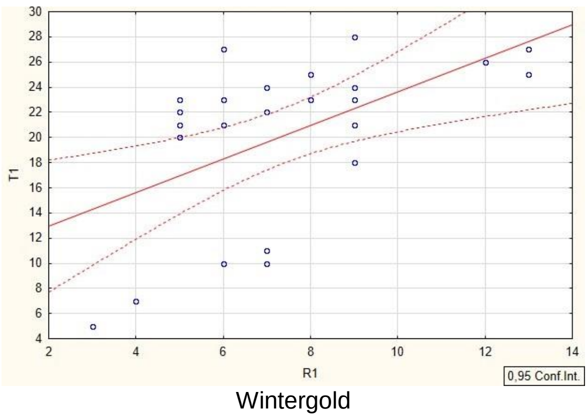
S/R



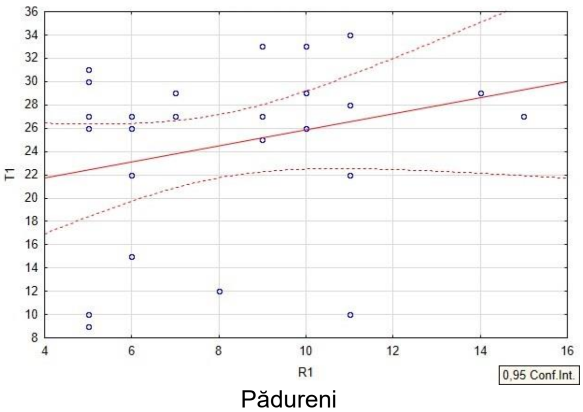
R/S

Figure 2 **Frequency histogram of parameters – Pădureni variety**

The interaction between R and S at Wintergold indicates a root length about 2-3 times smaller than the length of the stem (*figure 3*). In Pădureni, the application of bioproducts produces strong increases in the roots but poorly correlated with the stems or a strong development of the aerial part over the roots. The autumn variety has a clustered development, with an evolution in favor of the stem in the early stages of vegetation, and then leads to a stronger development of the root.



Wintergold



Pădureni

Figure 3 **Interaction S (cm) to R (cm)**

CONCLUSIONS

The reaction of wheat plants to application of bioproducts is closely related to their genetic background. For spring wheat, above-ground investment is usually detrimental to the root. In autumn wheat, the way of development is more balanced, both the above and the below-ground parts growing steadily.

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