CONTROL OF WIREWORMS BY SEED TREATMENT IN ROMANIA

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ABSTRACT

In Romania, the main species of *Elateridae* are: *Agriotes ustulatus* (40.1%), *A. obscurus* (17.3%), *A. sputator* (11.3%), *A. flavicornis* (10.9%), *A. pilosus* (6.9%), *A. lineatus* (3.8%), *Limonius pilosus* (1.8%), *Synaptus filiformis* (1.6%), *Selatosomus latus* (1.5%). Annually, the wireworms attack 800,000 ha aproximately. The recorded densities in field crops vary from 5-10 larvae/sq. m up to 70-100 larvae/sq. m which determine attack levels up to 25-30% in wheat and barley crops and up to 40-65% in maize and sunflower crops. At present, the seed chemical treatment method is the most important, efficient, economic and little polutant measure for the control of wireworms in field crops. At the winter spiked cereals, the seed treatment was made with products based on lindan and one or more fungicides (carbendazim, carboxine, diniconazol, miclobuthanil, prochloraz, tebuconazol, tiophanat methyl, thiram, triadimenol). In this case, a good simultaneous protection to both wireworms and some specific pathogens (*Tilletia* spp. and *Fusarium* spp. in wheat crops or *Ustilago nuda* and *Pyrenophora graminea* in barley crops) was assured. At the spring row-crops (maize and sunflower), different products based on the folowing active ingredients: acetamiprid, bifentrin, carbofuran, fipronyl, furatiocarb, imidachlopride, thiamethoxam, have been used. The efficacy, up to 80% permitted their registration and promoting in production in Romania.

Key words: wireworms, field crops, insecticides, insectofungicides, seed treatment

INTRODUCTION

Wireworms (*Elateridae, Coleoptera*) present a high harmful effect for many field crops. In Romania, the wireworms are spread in all the agricultural areas, especially in hilly regions where their densities are high (Bărbulescu and Popov, 1995, 1999; Paulian et al., 1974; Perju et al., 1971; Popov, 1996). The heavy and excessively moist soils (podzols, river meadows, Danube meadow), as well as strong fodder grasslands, encourage this pest (Bărbulescu and Popov, 2000; Manole et al., 1998, 1999; Popov et al., 1996 a, 1998; Trotuº et al., 1994 a).

Because of its specific mode of life, in which the harmful stage, larva respectively, live and eat exclussively into soil, on germinated grains or on seedlings, the possibilities of the attack prevention are limited enough.

The wireworms, especially in spring crops, are able to induce significant yield losses, even to compromise the crops (Manole et al., 1993; Mărgărit et al., 1990).

The crop protection, both maize and sunflower, with reduced number of plants/sq. m and spiked cereals, represents an important technological priority (Bărbulescu and Popov, 1999, 2000; Popov et al., 1996 b; Trotuº et al., 1994 b).

At present, the best results for the control of these pests, are obtained by seed treatment before sowing, with an insecticid or insectofungicid, differentiated as active ingredient or rate, from a crop to another.

The seed chemical treatment is the most important, efficient, economic and little polutant measure for field crop protection against both seed or soil born phatogens as well as soil pests including wireworms.

The paper presents the obtained data regarding the control of wireworms in wheat, barley, maize and sunflower crops by seed treatment.

MATERIALS AND METHODS

The researches were performed in different localities during 1994-1999, under experimental conditions and in large production plots. For larvae collecting, the soil sampling (25/25 cm area up to 30 cm depth) were used. The insect adults were collected using the net method.

For seed treatment, experiments with different products in each crop (wheat,barley, maize and sunflower), the most cultivated hybrids and cultivars in the area, were used.

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At wheat and barley crops, the following insecticides were tested: lindan – based products (Lindan 400 C: lindan 40%; Lindan HC SC: lindan 666 g/l) or mixture of lindan with different fungicides (Gammavit 85 PSU: lindan 35% + carboxine 25% + thiram 35%; Masterlin: lindan 50% + tebuconazol 1.5%; Miclodan Extra 45 PUS: lindan 40% + miclobuthanil 5%; Procarb L PUS: lindan 33% + carbendazim 26% + prochloraz 7%; Protilin Al 81 PUS: lindan 35% + thiram 40% + prochloraz 6%; Sumidan: lindan 500g/l + diniconazol 10g/l; Supercarb T 80: lindan 35% + carbendazim 15% + thiram 30%; Supercarb T 585 SC: lindan 250 g/l + carbendazim 11 g/l + thiram 225 g/l; Tirametox 90 PTS: lindan 35% + tiophanat methyl 20% + thiram 35%; Tirametox 625 SC: lindan 250 g/l + tiophanat methyl 150 g/l + thiram 225 g/l; Trialin MT PTS: lindan 40% + tiophanat methyl 10% + triadimenol 10%; Vitalin 85 [illegible] thiram 2

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Mãrgãrit et al., 1988; Popov et al., 1999; Trotuº et all., 1994 a). Usually, in field crops, the larvae density of different *Elateridae* species varies form 5-10 larvae/m^2 up to 25-40 larvae/m^2, and seedom, can exceeds 100 larvae/m^2 (Table 1).

As the recent research data show, 60 species of *Elateridae* which belong to 12 subfamilies and 20 genera, have been identified (Manole et al., 1999). The most important species from the viewpoint of both infested area and larvae density/sq. m are: *Agriotes* species, such as *Agriotes ustulatus, Agriotes obscurus, Agriotes ustulatus* var. *flavicornis, Agriotes sputator, Agriotes pilosus, Agriotes lineatus* and *Agriotes gurgistanus* and other species as *Synaptus filiformis, Selatosomus latus, Melanotus crassicollis* and *Athous hirtus.*

In the field crops (Table 2), *Agriotes ustulatus* species is the most spread one (40.09%), [illegible]

Table 2. Percentage of the main *Elateridae* species, in field crops, in Romania

Species	%	Agro-ecosistem of field crops						
		Winter spiked cereals (wheat, barley)	Row-crops (maize, sunflower)	Leguminous for grains (soybean, pea, bean, chick-pea)	Sugar beet	Potato	Forage crops (alfalfa, clover)	Vegetable fields
Agriotes ustulator	40,09	++++	++++	++	+++	++++	++++	+
Agriotes obscurus	17,30	+++	++++	+++	++	+++	++	+
Agriotes sputator	11,26	+++	+++	+	++	++	+++	-
Agriotes flavicornis	10,87	++	+++	+	++	++	+++	+
Agriotes pilosus	6,90	++	+++	+	++	++	+++	-
Agriotes lineatus	3,85	++	++++	-	++	+	+	-
Limonius pilosus	1,80	+	++	+	+	+	+	-
Synaptus filiformis	1,55	+	++	-	+	+	+	-
Selatosomus latus	1,46	++	+	+	++	+	+	-
Agriotes gurgistanus	1,38	++	+++	-	+	+	+	-
Other species	3,54	+	+	-	+	+	+	-

Note: (-) no presence; (+) accidental presence; (++) moderate presence; (+++) high presence; (++++) significant pre sence

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Table 3. Evolution of the chemical methods for prevention and control of wireworms, in field crops, in Romania

Variants	Commercial product (composition)	Rate	Crops
Powder*)	DUPLITOX 5 +3 (DDT +HCH)	25 – 30 kg/ha	different field crops
	HECLOTOX 3 (HCH)	40 – 50 kg/ha	
	PEB + LINDAN 5+3 (Metil-chlor+Lindan)	25 – 30 kg/ha	
	LINDATOX 3 PP (Lindan)	25 – 30 kg/ha	
Granules	SINORATOX 5 G (lindan)	20 – 30 kg/ha	different field crops
	SINOLINTOX 10 G (dimetoat+lindan)	15 – 20 kg/ha	
Seed treatment **)	*Lindan* – based products	900 g a.i./t	wheat, barley
	INSECTOFUNGICIDES	900 – 1000 g a.i./t	
	Carbofuran – based products	25 – 28 l/t	maize, sunflower
	CRUISER 350 FS	9 – 10 l/t	
	GAUCHO 600 FS	6 – 10 l/t	
	COSMOS 250 and 500	5,0 and 2.5 l/t	
	SEMAFOR 20 ST	2 – 3,5 l/t	

Notã: *) Products forbidden before 1992
**) Products presented in the table with the results, which are being used presently

because they provided only a low extent of outbreak limitation, at a high cost.

On the basis of numerous studies, the prevention of wireworm attack from the main field crops, wheat, barley, maize, sunflower, is exclusively realized by seed treatment before sowing, with specially conditioned specific products.

At winter spiked cereals, the seed treatment was made with various insecto-fungicides which contain *lindan* and different fungicides, their efficacy to control the wireworms being about 85%.

inclusively wireworms, and specific pathogens, as common bunt or scab has been assured. Data from table 4 show that, in different experimental stations, during 1994-1998, the attack frequency of wireworms varied from 9.0% (Secuieni, 1994) up to 31.6% (Oradea, 1998). The average of the attack frequency per year and stations, was 10.7% in 1994-1995, 20.6% in 1995-1996, 12.1% in 1996-1997 and 20.0% in 1997-1998. Under these conditions, the mean values of efficacy ranged between 79.1% and 83.7% in 1994-1995; 83.6% and 89.5%

Table 4. Efficacy of some insecticides and insecto-fungicides applied as seed treatment against wireworms in winter wheat crops

Experimental years	Variants	Rate kg,l/t	Efficacy, %			
			Secuieni	Pitesti	Oradea	Average
1994-95	**Untreated** (% attack)		**9.0**	**12.4**	**10.7**	**10.7**
	Tirametox 90 PTS	3.0 kg	77.4	83.3	89.0	83.2
	Gammavit 85 PSU	3.0 kg	77.8	81.5	88.6	82.6
	Miclodan 50 PTS	3.0 kg	67.9	86.8	82.7	79.1
	Supercarb T 80	3.0 kg	77.3	84.7	89.2	83.7
	Vitalin 85 PTS	3.0 kg	67.7	83.0	89.5	79.7
	Lindan 400 SC	2.5 l	78.6	80.6	81.4	80.2
1995-96	**Untreated** (% attack)		**26.0**	**11.5**	**24.3**	**20.6**
	Tirametox 90 PTS	3.0 kg	73.5	92.0	91.1	85.5
	Gammavit 85 PSU	3.0 kg	85.8	91.5	91.1	89.5
	Procarb L	3.0 kg	74.9	91.8	90.9	85.8
	Supercarb T 80	3.0 kg	70.8	91.5	93.3	85.2
	Vitalin 85 PTS	3.0 kg	70.4	92.5	91.1	84.7
	Lindan 400 SC	2.25 l	72.5	90.3	88.1	83.6
	Lindan HC SC	1.35 l	73.9	92.0	93.5	86.6
1996-97	**Untreated** (% attack)		**10.2**	**14.5**	**11.6**	**12.1**
	Procarb L	3.0 kg	88.0	86.3	89.4	87.9
	Tirametox 625 SC	3.75 l	78.9	87.6	83.7	83.4
	Lindan HC SC	1.35 l	74.3	90.3	89.3	84.6
	Miclodan Extra 45	2.5 kg	83.7	89.1	90.3	87.7
	Protilin Al 81 PUS	3.0 kg	85.0	88.4	91.3	88.2
	Trialin MT	2.5 kg	85.3	88.5	85.9	86.6
	Trialin 50	2.5 kg	86.7	87.2	87.6	87.2
1997-98	**Untreated** (% ttack)		**12.6**	**16.0**	**31.6**	**20.0**
	Masterlin PTS	2.0 kg	81.0	84.0	84.0	83.0
	Tirametox 625 SC	3.75 l	80.0	87.0	83.0	83.3
	Supercarb 585 SC	3.75 l	84.0	87.0	87.0	86.3
	Lindan HC SC	1.35 l	87.4	89.0	89.1	88.5
	Trialin MT	2.5 kg	83.0	85.0	85.0	84.3
	Trialin 50	2.5 kg	85.0	87.0	86.0	85.0
	Protilin Al 81 PUS	3.0 kg	86.4	86.9	88.3	86.7
	Sumidan	1.8 l	87.0	90.0	86.4	87.8

In the case of winter wheat, a good simultaneous protection against both harmful insects,

in 1995-1996; 83.4% and 88.2% in 1996-1997;

83.0% and 88.5% in 1997-1998, the differencies between the tested products being insignificant.

In order to control the wireworms from wheat crops, the following products were registred and promoted in production in Romania: Gammavit 85 PSU - 3.0 kg/t; Masterlin - 2.0 kg/t; Miclodan Extra 45 PUS - 2.5 kg/t; Procarb L PUS - 3.0 kg/t; Protilin Al 81 PUS - 3.0 kg/t; Sumidan - 1.8 kg/t; Supercarb T 80 PTS - 3.0 kg/t; Supercarb T 585 SC - 3.75 kg/t; Tirametox 90 PTS - 3.0 kg/t; Tirametox 625 SC - 3.75 kg/t; Trialin MT - 2.5 kg/t; Trialin 50 - 2.5 kg/t; Vitalin 85 PTS - 3.0 kg/t.

1995-1996; 86.9 - 89.4% in 1996-1997 and 84.0 - 90.0% in 1997-1998.

On the basis of the good results in controling the wireworms from barley crops, the following products: Gammavit 85 PSU - 3.0 kg/t; Masterlin - 2.0 kg/t; Miclodan Extra 45 PUS - 2.5 kg/t; Protilin Al 81 PUS - 3.0 kg/t; Sumidan - 1.8 kg/t; Vitalin 85 PTS - 3.0 kg/t, were registered and promoted in production in Romania.

Additionally, for treatment of wheat and barley seeds, lindan–base products formulated as con-

Table 5. Efficacy of some insecticides and insecto-fungicides applied as seed treatment against wireworms in winter barley crops

Experimental year	Variant	Rate kg,l/t	Efficiacy, %			
			Secuieni	Pitesti	Oradea	Average
1994-95	**Untreated** (% attack)		**10.5**	**14.5**	**6.5**	**10.5**
	Gammavit 85 PSU	3.0 kg	88.4	87.1	81.3	85.6
	Miclodan 50 PTS	3.0 kg	70.8	86.4	75.6	77.6
	Vitalin 85 PTS	3.0 kg	87.2	86.4	91.3	88.3
1995-96	**Untreated** (% attack)		**9.3**	**12.8**	**22.5**	**14.9**
	Gammavit 85 PSU	3.0 kg	89.2	91.3	92.5	91.0
	Vitalin 85 PTS	3.0 kg	90.5	91.3	92.5	91.4
	Lindan 400 SC	2.25 l	89.2	90.4	88.9	89.5
	Lindan HC SC	1.35 l	90.5	90.0	91.5	90.7
1996-97	**Untreated** (% attack)		**15.0**	**9.2**	**21.2**	**15.1**
	Miclodan Extra 45	2.5 kg	87.0	84.9	89.0	86.9
	Protilin Al 81 PUS	3.0 kg	88.5	88.0	91.7	89.4
	Lindan HC SC	1.35 l	87.0	89.1	87.8	87.9
	Lindan 400 SC	2.25 l	86.5	87.4	90.0	88.0
1997-98	**Untreated** (% attack)		**16.2**	**11.7**	**13.3**	**13.7**
	Masterlin PTS	2.0 kg	86.6	83.4	81.9	84.0
	Protilin Al 81 PUS	3.0 kg	88.6	89.5	92.1	90.0
	Sumidan	1.8 l	83.7	89.0	84.7	85.8
	Lindan HC SC	1.35 l	87.2	87.9	87.9	87.7

For winter barley, the tested insecto-fungicides showed the same good simultaneous protection against both the soil pests, as wireworms, and the specific pathogens which cause loose smut or barley leaf stripe (Table 5). In the experimental period the attack frequency of wireworms varied from 6.5% (Oradea 1994) up to 22.5% (Oradea 1995). The yearly means of the attack frequency were 10.5% in 1994-1995; 14.9% in 1995-1996; 15.1% in 1996-1997 and 13.7% in 1997-1998. Under these conditions, the mean values of efficacy varied between 77.5 and 88.3% in 1994-1995; 89.5 - 91.4% in

centrated suspension, Lindan 400 SC at the rate of 2.25 l/t and Lindan HC SC-1.35 l/t gave good results against wireworms. These products can be applied, as the second treatment, on seeds already treated with a specific fungicide for wheat or barley.

At spring crops, the attack of wireworms can be extremely dangereous, especially for maize and sunflower, in the first vegetation stages. Wireworm attack is typical in moist and cold springs,

with deep sowing which delays the germination and plant growing.

Under these conditions, even one larva/sq. m can be harmful. From this viewpoint, the crop protection by both cultural and chemical methods (seed treatment) can be assured.

In table 6, the results obtained in maize seed treatment are presented. During the experimental period, the maize crops from the above mentioned experimental stations presented an attack frequency level of 15.0% at seeds, and 12.2% at root neck, in 1995; 22.4% / 16.9% in 1996; 17.3% / 16.6% in 1997 and 29.8% / 28.2% in 1998. Although at the average level (years and stations), the attack values at both seed and root neck are closely, with the remark that the seed attack was higher, however at the individual level, the seed attack as compared with that of collum was greater differentiated. Thus, cases when seed attack was higher in comparison with collum attack (Secuieni 1995; 1998) or, on the contrary, seed attack was more reduced (Pite°ti 1995, Suceava 1998) are stand out. Very high levels for both attack stages (Suceava 1996; Pite°ti 1998) are mentioned, too. Under these conditions, the tested insecticides for wireworm control assured a partial protection of the plant. On this basis, in order to control wireworms in maize crops, the following products gave satisfactory results and were registered and promoted in Romania: Carbodan 35 ST - 28 l/t; Carbofuran 350 - 28 l/t; Cosmos 250 FS - 5.0 l/t; Cosmos 500 FS - 2.5 l/t; Cruiser 350 FS - 9.0 l/t; Diafuran 35 ST - 28 l/t; Furadan 35 ST - 28 l/t; Semafor 20 ST – 2.0 l/t; Gaucho 600 FS - 7.0 l/t; Promet 400 CS - 25.0 l/t,.

Table 6. Efficacy of various insecticides applied as seed treatment against wireworms in maize crops

Experimental year	Variants	Rate l/t	Attack frequency, %							
			Suceava		Pite°ti		Secuieni		Average	
			seed	Root neck	seed	Root neck	seed	Root neck	seed	Root neck
1995	**Untreated**		**10.7**	**3.9**	**9.6**	**29.4**	**24.6**	**3.4**	**15.0**	**12.2**
	Furadan 35 ST	28.0	2.1	0.5	2.1	10.7	10.3	0.3	4.9	3.8
	Carbofuran 350	28.0	2.3	0.6	2.3	11.3	11.2	0.3	5.3	4.1
	Cosmos 500 FS	2.5	1.3	0.4	2.6	10.0	12.2	0.3	5.4	3.6
1996	**Untreated**		**42.8**	**31.2**	**9.3**	**13.0**	**15.0**	**6.5**	**22.4**	**16.9**
	Carbodan 35 ST	28.0	21.6	11.1	3.7	1.3	7.6	1.3	10.9	4.6
	Promet 400 CS	25.0	17.3	7.9	2.1	1.4	7.3	1.4	9.0	3.6
	Cosmos 250 FS	5.0	8.0	3.6	4.7	1.3	5.0	1.0	9.7	3.9
	Diafuran 35 ST	28.0	20.2	10.7	3.3	1.2	6.4	1.3	9.9	4.4
1997	**Untreated**		**4.6**	**23.8**	**25.2**	**12.0**	**22.0**	**14.0**	**17.3**	**16.6**
	Semafor 20 ST	2.0	2.2	3.6	13.4	3.2	10.3	3.7	8.6	3.5
	Carbofuran 350	28.0	1.8	3.7	10.6	4.0	8.5	3.9	7.0	3.9
	Gaucho 600 FS	6.0	2.9	2.2	5.6	3.8	10.5	5.0	6.3	3.6
	Cruiser 350 FS	9.0	2.1	1.9	3.1	2.7	6.0	3.0	3.7	3.2
1998	**Untreated**		**9.3**	**22.7**	**42.0**	**54.0**	**36.0**	**8.0**	**29.8**	**28.2**
	Furadan 35 ST	28.0	5.5	2.2	2.4	4.3	26.0	3.1	10.6	3.2
	Cruiser 350 FS	9.0	2.5	2.0	6.0	4.0	20.0	5.0	9.5	3.6
	Gaucho 600 FS	6.0	4.3	2.7	6.8	5.4	12.7	3.0	7.9	3.7

Tabel 7. Efficacy of some insecticides applied as seed treatment against wireworms in sunflower crops

Experimental year	Variant	Rate l/t	Attack frequency, %							
			Oradea		Pite°ti		Secuieni		Average	
			seed	root neck	seed	root neck	seed	root neck	seed	root neck
1995	**Untreated**		**7.9**	**23.1**	**8.0**	**13.7**	**48.0**	**5.5**	**23.2**	**14.1**
	Furadan 35 ST	28.0	2.0	3.2	1.8	5.2	16.5	1.2	6.8	3.2
	Carbofuran 350	28.0	2.3	2.8	2.0	4.7	20.3	1.7	8.2	3.1
	Cosmos 500 FS	2.5	0.8	1.8	1.7	2.7	22.0	2.1	8.2	1.4
	Semafor 20 ST	3.5	1.7	1.4	3.0	6.0	20.1	1.7	8.3	3.0
	Mospilan 70	12.5	1.9	1.1	1.7	4.3	3.0	2.5	2.2	2.6
1996	**Untreated**		**64.0**	**31.7**	**55.0**	**53.0**	**27.0**	**9.2**	**48.7**	**31.3**
	Carbodan 35 S T	28.0	21.6	5.2	3.7	1.3	7.6	1.3	10.9	2.6
	Diafuran 35 ST	28.0	23.9	6.0	15.0	4.5	9.0	3.1	15.9	3.2
	Cosmos 250 FS	5.0	26.4	2.0	17.0	5.2	8.7	2.8	17.3	3.3
1997	**Untreated**		**25.7**	**20.7**	**12.6**	**17.0**	**35.0**	**16.0**	**24.4**	**17.9**
	Furadan 35 ST	28.0	5.2	3.9	2.5	1.5	12.0	4.2	6.6	3.2
	Carbofuran 350	28.0	4.8	3.7	3.6	2.0	8.5	3.9	5.6	3.2
	Gaucho 600 FS	10.0	5.0	2.5	2.5	7.2	14.0	4.3	7.2	4.6
	Cruiser 350 FS	10.0	2.5	1.2	2.2	1.1	15.2	4.1	6.6	2.1
1998	**Untreated**		**26.7**	**20.4**	**25.1**	**35.3**	**21.0**	**13.2**	**24.3**	**23.0**
	Furadan 35 ST	28.0	6.0	3.7	8.0	10.2	3.8	3.7	5.9	5.8
	Carbodan 35 ST	28.0	4.8	4.0	6.5	9.3	4.2	4.0	5.2	5.7
	Cruiser 350 FS	10.0	7.2	4.8	11.6	9.3	9.4	4.2	9.1	6.1
	Gaucho 600 FS	10.0	6.2	3.2	7.1	9.2	9.0	1.7	7.4	4.7

CONCLUSIONS

In Romania, the main *Elateridae species* are: *Agriotes ustulator* (40.1%), *A. obscurus* (17.3%), *A. flavicornis* (10.9%), *A. pilosus* (6.9%), *A. lineatus* (3.8%), *Limonius pilosus* (1.8%), *Synaptus filiformis* (1.6%), *Selatosomus latus* (1.5%).

The registered densities of the wireworms in field crops vary from 5 -10 larvae/sq m up to 70-100 larvae/sq m, which determine an attack level up to 31.6% in wheat; 22.5% in barley; 42.8% at seed and 54.0% at root neck, in maize and 64.0% at seed and 53.0% at root neck, in sunflower.

On the basis of the good results obtained in controling wireworms the following pro-ducts are registered in Romania:

For wheat: Gammavit 85 PSU - 3.0 kg/t; Lindan 400 SC - 2.25 l/t; Lindan HC SC - 1.35 l/t; Masterlin - 2.0 kg/t; Miclodan Extra 45 PUS - 2.5 kg/t; Procarb L. PUS - 3.0 kg/t; Protilin Al 81 PUS - 3.0 kg/t; Sumidan - 1.8 l/t; Supercarb T 80 PTS - 3.0 kg/t; Supercarb T 585 SC - 3.75 l/t; Tirametox 90 PTS - 3.0 kg/t; Tirametox 625 SC - 3.75 l/t; Trialin MT - 2.5 kg/t; Trialin 50 - 2.5 kg/t; Vitalin 85 PTS - 3.0 kg/t.

For barley: Gammavit 85 PSU - 3.0 kg/t; Lindan 400 SC - 2.25 l/t; Lindan HC SC - 1.35 l/t; Masterlin - 2.0 kg/t; Miclodan Extra 45 PUS - 2.5 kg/t; Protilin Al 81 PUS - 3.0 kg/t; Sumidan - 1.8 l/t; Vitalin 85 PTS - 3.0 kg/t.

For maize: Carbodan 35 ST - 28.0 l/t; Carbofuran 350 - 28 .0 l/t; Cosmos 500 FS - 2.5 l/t; Cosmos 250 FS - 5.0 l/t; Cruiser 350 FS - 9.0 l/t; Diafuran 35 ST - 28.0 l/t; Furadan 35 ST - 28.0 l/t; Gaucho 600 FS - 6.0 l/t; Promet 400 CS - 25.0 l/t; Semafor 20 ST - 2.0 l/t.

For sunflower: Carbodan 35 ST - 28.0 l/t; Carbofuran 350 - 28.0 l/t; Cosmos 500 FS - 2.5 l/t; Cosmos 250 FS - 5.0 l/t; Cruiser 350 FS - 10.0 l/t; Diafuran 35 ST - 28.0 l/t; Furadan 35 ST - 28.0 l/t; Gaucho 600 FS - 10.0 l/t; Semafor 20 ST - 3.5 l/t.

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Table 1. Soil manifests some physiological and enzymic potentials and chemical contents necessary for determining the soil fertility

Main physiological potentials:	Main enzymic potentials:	Main chemical contents:
1. Respiration	1. Catalase	1. Humus (Ct%)
2. Biomass	2. Saccharase	2. Extractable carbon (Ce%)
3. Cellulolyse	3. Urease	3. Humic acids (Cah%)
4. Di-nitrogen fixation	4. Total phosphatases	4. Fulvic acids (Caf%)
5. Proteolise		5. Total nitrogen – Kjeldahlization – (Nt%)
6. Ammonification		6. Organical phosphorus (PO%)
7. Nitrification		7. Acidity
		8. Base saturation

Table 2. Absolute and relative values for respiration potential (mg CO2/100 g soil d.w./24 h), cellulolytic potential (g decayed cellulose / 100 g cotton tissue d.w. / 18 days) and Indicator of Vital Activity Potential (IVAP %) from different soil types

Soil type	Absolute values				
	Respiration (R)	Cellulosolyse (C)	R%	C%	IVAP%
Vermic – typical chernozem	b 33.45	b 40.0	22.30	40.00	c 31.15
Cambic chernozem	a 40.70	a 47.3	27.13	47.30	b 3721
Argiloilluvial chernozem	a 45.30	a 59.4	30.20	59.40	a 44.80
Brown – reddish soil	b 33.50	b 39.7	22.33	39.70	c 31.01
Albic luvisol	c 13.90	c 15.3	9.27	15.30	e 12.28
Albic luvisol	a 39.80	c 13.9	26.53	13.90	d 20.22
Maximum Empiric Value (MEV)	150	100			
LD 5%	3.2	7.4			3.33
1%	4.2	9.8			4.43
	5.5*	12.7*			5.76*
*) utilized LD for comparison					

Table 3. Absolute and relative values for following potentials: catalase (cm^3 O_2/minute), saccharase (mg monoses / 24 h), urease (mg NH_4+ / 24 h) and total phosphatase (mg P / 24 h), all values are reported to 100 g soil d.w. and the Indicator of Enzymic Activity Potential (IEAP %) from different soil types

Soil type	Absolute values	Relative values

	Catalase (K)	Sac-charase (Z)	Urease (U)	Phos-phatase (F)	K%	Z%	U%	F%	IEAP%
Vermic – typical chernozem	a 1607	b 2744	c 35.8	b 2.81	80.35	78.40	23.87	11.24	a 48.46
Cambic chernozem	b 737	b 2320	a 81.1	a 5.60	36.85	66.29	54.07	22.40	a 44.90
Argiloilluvial cher-nozem	b 870	d 945	c 32.4	b 2.39	43.50	27.00	21.60	9.56	b 25.41
Brown – reddish soil	c 313	e 699	e 18.2	b 2.36	15.65	19.97	12.13	9.44	d 14.30
Albic luvisol	c 364	d 967	d 30.3	b 3.14	18.20	27.63	20.20	12.56	c 19.65
Albic luvisol	d 71	c 1882	b 43.3	b 2.64	3.55	53.77	28.87	10.56	b 24.19
Maximum Empiric Value (MEV)	2000	3500	150	25					
LD 5%	85	71	2	0.71					2.32
1%	113	94	3	0.95					3.08
0.1%	147*	122*	4*	1.23*					4.01*
* utilized LD for comparison									

Table 4. Absolute and relative values from the soil chemical analyses: humus (Ct%), extractable carbon (Ce%), humic acids (Cah%), total nitrogen (Nt%), organical phosphorus (P mg/100 g soil d.w.) and pH-H_2O and the Chemical Synthetic Indicator (CSI %)

Soil type	Absolute values						Relative values						
	Ct	Ce	Cah	Nt	PO	pH	Ct	Ce	Cah	Nt	PO	pH	CSI%
Vermic-typical chernozem	1.56	0.56	0.41	0.19	6.56	7.97	36.71	40.00	51.25	76.00	25.23	96.02	a 70.93
Cambic cher-nozem	1.55	0,74	0.59	0.14	7.46	7.29	36.47	52.86	73.75	56.00	28.69	87.83	b 66.69
Argiloilluvial chernozem	1.27	0.61	0.43	0.15	13.97	6.74	29.88	43.57	53.75	60.00	53.73	81.20	b 64.69
Brown-reddish soil	0.76	0.38	0.26	0.11	3.56	4.68	17.88	27.14	32.50	44.00	13.69	56.39	d 41.72
Albic luvisol	1.32	0.80	0.28	0.11	4.79	4.89	31.06	57.14	35.00	44.00	18.42	58.92	c 48.02
Albic luvisol	0.81	0.36	0.09	0.08	8.45	4.62	19.06	25.71	11.25	32.00	32.50	55.66	d 39.88
Maximum Em-piric Value (MEV)	4.25	1.40	0.80	0.25	26	8.30							
LD 5% 1% 0.15													1.91 2.55 3.32*

* utilized LD for comparison

Table 5. Conversion of the Note of Humic Class (NHC) of humus horizons from the soil colour of qualitative description (Chiriþã, 1955), to the Interval of Soil Humus Content (ISHC)

Note of	Soil colour description referring to the	Interval of Soil Humus

Humic class (NHC)	humus content of horisons in soil profile	Content (ISHC) Ct%
1.	Soil without humus; very light colour in superior horizon; yellowish, whitish, whitish - grey	< 1
2.	Soil meagre in humus; brown – yellow-ish; yellowish – brown; brown - grey	1 – 1.49
3.	Soil with moderate content in humus; chestnut, brown, reddish-brown, grey - brown	1.5 – 1.99
4.	Soil rich in humus, black colour	2 – 3
5.	Peaty soil, peat, swamp. Hardly one sees the minerals in organical matter	It is not used. They are not agricultural soil

Example of calculation for Humic Global Index (HG) for a Vermi-typical chernozem:

HGI = 4 (2.5) + (0.5) + 2 (1.8) + 2 (2.2) = 19.5
Note: - figures in front of the parentheses = not of humic class horizons in soil profile
- figures into the parantheses = dimension in decimeters of horison
Transformation of Humic Global Index in Pedo-Genetical Indicator (PGI%):

$$PGI\% = \frac{HGIx100}{MEV}$$

MEV = 20 (a very fertile soil from Mileanca, Boto°ani (county)

$$\text{Consequently, } PGI\% = \frac{19.5x100}{20} = 97.5$$

Table 6. Calculation made for determining Humic Global Index (HGI) and Pedo-Genetical Indicator (PGI%) for analysed soils

Station and soil type	Horizon	Thickness dm	Humus Ct%	Humic group	HGI ?(2 x 4)	PGI%

					colons	$\frac{HGIx100}{MEV}$
Colons	1	2	3	4	5	6
Valul lui Traian	Ap1	2.5	2.01	4		
Constanþa County	Ap 2 h	0.5	1.55	3	19.5	97.5
Vermic-typical cher-nozem	Am k	1.8	1.49	2		
	Ac k	2.2	1.09	2		
Fundulea	Ap	1.8	1.72	3		
Cãlãraºi County	Ap h	1.2	1.72	3	15.4	77.0
Cambic cher-nozem	Am	1.5	1.38	2		
	AB	1.7	1.21	2		
Caracal	Ap 1	1.8	1.77	3		
Olt County	Ap 2	1.4	1.68	3	17.8	89.0
Argiloilluvial chernozem	Am	1.8	1.40	2		
	AB	2.3	1.31	2		
ªimnic	Ap	2.0	0.87	1		
Dolj County	Ao	1.2	0.62	1	8.1	40.5
Brown-reddish soil	AB	1.7	0.39	1		
Albota						
Argeº County	Ap + Er	2.7	0.96	1	2.7	13.5
Albic luvisol						
Livada						
Satu-Mare County	Ap + Er	2.7	0.92	1	2.7	13.5
Albic luvisol						

Table 7. Modular and synthetic indicators of fertility level of different soil types

Soil type	IVAP (%)	IEAP (%)	BSI(%) = $\frac{IVAP + IEAP}{2}$ (Biological Synthetic Indicator)	CSI (%)	VETL(%) = $\frac{BSI + CSI}{2}$ (Vital, Energetic and Trophic Level)	PGI(%) (Pedo-Genetical Indicator)	SISF(%) = $\frac{VETL + PGI}{2}$
Vermic-	c	a	a 38.17	a	a 54.55	97.5	a 76.02

typical chernozem	31.15	48.46		70.93			
Cambic chernozem	b 37.21	a 44.90	a 41.05	b 66.69	a 53.87	77.0	c 65.43
Argiloilluvial chernozem	a 44.80	b 25.41	b 35.10	b 64.69	b 49.89	89.0	b 69.44
Brown-reddish soil	c 31.01	d 14.30	c 22.65	d 41.72	c 32.18	40.5	d 36.34
Albic luvisol	e 12.28	c 19.65	d 15.96	c 48.02	c 31.88	13.5	e 22.74
Albic luvisol	d 20.22	b 24.19	c 22.20	d 39.88	c 31.04	13.5	e 22.27
LD 5%	3.33	2.32	1.86	1.91	1.35		1.35
1%	4.43	3.08	2.47	2.55	1.81		1.81
0.1%	5.76*	4.01*	3.32	3.32*	2.35*		2.35*

*) utilized LD for comparison