JOURNAL OF ENGINEERING annals OF FACULTY OF ENGINEERING HUNEDOARA
Tome V (year 2007), Fascicole 1, (ISSN 1584 – 2665)

FIELD MANAGEMENT METHODS AND TECHNIQUES FOR SOIL WATER EROSION CONTROL AT GROWING WHEAT ON SLOPES

Peter DIMITROV

INSTITUTE OF SOIL SCIENCE-SOFIA, BULGARIA

ABSTRACT:
1.0 to 1.2 million hectares of wheat are being grown in the Republic of Bulgaria annually and a considerable part of them are on slope areas due to the terrain conditions of the country which is conducive to the water erosion in this crops. Therefore it is necessary to apply some additional erosion control field management methods and techniques beside the conventional widely-used practices in order to resolve this problem at growing this crop on slopes and they are as follows: contour tillage, vertical mulching, breaking and dead-furrowing which includes vertical mulching and breaking with dead-furrowing in a particular sequence as an erosion control technique. This report presents some results from research and experiments with these methods and techniques, which prove their field management and erosion control efficiency. The erosion control technique which includes the field management soil conservation methods of vertical mulching and the subsequent breaking with dead furrowing in winter have been found as the most appropriate ones with a view to the field management and erosion control.
KEY WORDS:
soil water erosion, contour tillage, vertical mulching, breaking with dead furrowing, a technique including vertical mulching and breaking with dead furrowing.

1. INTRODUCTION

Wheat is the main grain crop grown in the Republic of Bulgaria. According to Ivanov P. (2005), 1.0 to 1.2 million hectares of wheat is being grown in the Republic of Bulgaria annually and a considerable part of them are on slope areas due to the terrain conditions of the country.

Although wheat is considered to have a good potential as an erosion control agricultural broadcast crop, this creates conditions for occurrence of moderate to high water erosion in the crops. Therefore it is necessary to apply some additional erosion control field management methods and even entire techniques for controlling or completely eliminating water erosion processes and conserving soil fertility. Among the most widely-used practices are: contour tillage, vertical mulching, breaking and dead-furrowing with erosion control technique incorporating vertical mulching and breaking with dead-furrowing in a particular sequence. The techniques were developed and tested at Nickola Pushkarov Institute on Soil Science, Sofia in our country.

The goal of this report is to present some results from the research and experiments carried out with these methods and techniques as well as to specify the most appropriate agricultural practice with a view to erosion control at growing wheat on slopes in Bulgaria.

2. MATERIALS AND METHODS

The research was carried out within the period of 2004 -2005 in the experimental field at Nickola Pushkarov Institute on Soil Science, Sofia in the area of the village of Trastenik, the district of Rousse, at growing wheat in non-irrigated conditions in carbonate humus soil of medium erosion and average slope gradient of 5°.

In order to achieve this purpose we carried out field experiments in accordance with the methods of the field tests, which were performed in five versions with four repetitions as follows:

- B_0 - wheat crops grown through a traditional technology in the direction of the slope – check test;
- B_1 - wheat crops grown through a traditional technology transversely to the slope;
- B_2 - wheat crops grown via applying the erosion control method of vertical mulching;
- B_3 - wheat crops grown via applying the erosion control method of breaking with dead furrowing;
- B_4 - wheat crops grown via applying the erosion control technique incorporating the soil conservation method of vertical mulching and breaking with dead furrowing.

The separate erosion control field management methods were carried out in particular sequence in accordance with the manner specified by the methods of experimenting. The vertical mulching with versions B_2 and B_4 took place in the fall before sowing the wheat and comprised of breaking cuts transversely to the slope at the depth of 0.40 m of width 0.10 to 0.12 m and 0.06 to 0.08 m at the bottom of the cut. They were performed in parallel couples in a strip scheme with 1.4-metre interspacing between them within the strip and 9-metre interspacing between the separate strips in the field. The cuts thus formed were filled with plant residue of chopped corn stalks or wheat straw and afterwards through the subsequent tillage – disking, covered with a thin layer of soil. The vertical mulching was performed by a converted breaker and dead furrower SHTN-2-140 equipped with a hopper for crop residue and coupled to DT-75M tractor of 66.2 kW capacity.

Breaking and dead furrowing with versions B_3 and B_4 took place in the winter, in February, transversely to the slope, at the depth of 0.40 m in superficial frozen soil (0.05-0.08 m) in a strip scheme and was carried out by a breaker and dead furrower. With the first version B_3, the spacing between the separate strips within the crops was 9 m, while with the second B_4 we kept to the requirement of about 4-metre interspacing between the cut strips and the strips filled with vertical mulch.

All other tillage procedures with versions B_1, B_2, B_3 and B_4 were carried out transversely to the slope in the conventional pattern.

The field management and erosion control tests were performed in accordance with the requirements of the methods during the test period. The field management experiments included soil tests and biometrical monitoring while the erosion control tests were carried out in a stationary method with draining sites of sizing 13 m x 5 m, total area of 65 m^2 provided for each version. The latter were used for determining the quantity of the water runoff and washed-out and dislodged soil after each erosion rainfall.

3. RESULTS AND DISCUSSIONS

The results from the soil tests carried out within a two-year period show that utilizing different erosion control methods at growing wheat on slopes contribute to the reduction in the soil bulk density and hardness and increase in the soil porosity. Besides, applying these methods results in increase in moisture-holding ability and water permeability. The best values of these indices at growing wheat through applying erosion control technique incorporating the soil conservation method of vertical mulching and breaking with dead furrowing, followed by those in versions B_2, B_3 and B_1. The most unfavorable data are the ones about the soil indices in version B_0 in which wheat is grown according to the conventional technique in the direction of the slope.

The results from some of the biometric monitoring which show the developmental stages of the plants during the reported period are presented in Tables 1 and 2. As it is seen, the best ones are from the crops subjected to vertical mulching in the fall before sowing and breaking with dead furrowing in the winter.

TABLE 1. PLANT HEIGHT AT DEVELOPMENTAL PHASES (CM) Test in Wheat 2004 – 2005

Version	2004			2005			2004 – 2005		
	Developmental Stage			Developmental Stage			Developmental Stage		
	Shooting	Ear formation	Flowering	Shooting	Ear formation	Flowering	Shooting	Ear formation	Flowering
B_0	29,1	63,7	71,3	39,5	50,3	65,7	34,3	57,0	68,5
B_1	30,9	65,2	72,8	40,4	51,2	66,6	35,7	58,2	69,7
B_2	34,1	69,5	80,6	45,7	62,5	78,3	39,9	66,0	79,5
B_3	32,3	67,3	75,4	43,8	60,1	75,3	38,1	63,7	75,4
B_4	38,5	73,1	86,0	48,6	68,0	87,8	43,6	70,6	86,9

TABLE 2. FOLIAR SURFACE IN DEVELOPMENTAL STAGES OF THE PLANT (M^3/HA),

Version	2004			2005			2004 – 2005		
	Developmental Stage			Developmental Stage			Developmental Stage		
	Shooting	Ear formation	Flowering	Shooting	Ear formation	Flowering	Shooting	Ear formation	Flowering
B_0	6384	9956	19872	6627	10822	20352	6505,5	10389	20112,0
B_1	7053	10234	20777	7450	11384	21268	7251,5	10809	21022,5
B_2	15257	22783	31151	17016	25542	32688	16136,5	24162,5	31919,5
B_3	11483	14955	29325	12033	16347	30044	11758,0	15651	29684,5
B_4	20159	29899	35589	21652	31819	38116	20905,5	30859,0	36852,5

The values of the wheat height and foliar surface with the other version, in which erosion control has also been carried out, have also been good, predominantly those from B_2 - the version with mulching, followed by the ones of the crops broken and dead furrowed in the winter – versions B_3 as well as version B_1 with the tillage carried out transversely to the slope.

The poorest plant development in wheat growing has been observed in the version of growing wheat via the conventional practice in the direction of the slope. The above results have also been confirmed by the yields obtained during the experimental years – the grain and the non-grain part - the straw, which can be seen in Tables 3 and 4. Within the period of 2004-2005 the average wheat grain yield for version B_4 has been 33% higher (by1027 kg/ha) than the one from the check test with tillage in the direction of the slope, while for version B_2, B_3 and B_1 the increase has

been respectively by 28.9% (by 900 kg/ha), by 21.65 (672 kg/ha) and by 4.6% (by 144.5 kg/ha).

TABLE 3. AVERAGE YIELD IN WHEAT GRAIN AT 14 % MOISTURE Test 2004 – 2005

Version	2004		2005		2004 – 2005	
	kg/ha	%	kg/ha	%	kg/ha	%
B_0	2983,0	100	3238,0	100	31110,0	100
B_1	3116,0	104,5	3395,0	104,8	3255,5	104,6
B_2	3846,0	128,9	4176,0	128,9	4011,0	128,9
B_3	3628,0	121,6	39,38,0	121,6	3783,0	121,6
B_4	3964,0	132,9	4312,0	133,2	4138,0	133,0
GD 5 %	41,5	1,4	75,5	2,3		
GD 1 %	58,3	2,0	106,0	3,3		
GD 0,1 %	82,3	2,8	149,6	4,6		

The results from the average yield in wheat straw have been similar for the experimental period. As it is seen from Table 4 once again, with version B_4, which incorporates the erosion control method of vertical mulching in the fall and breaking with dead furrowing in the winter, the average yield has increased by 30.5% (by 690 kg/ha) compared to that from the check test B_0 with tillage carried out in the direction of the slope. With the other versions for which different erosion control methods of tillage have been utilized the average yield has increased respectively by 26.6% (by 601 kg/ha) for version B_2 with vertical mulching, by 17.2% (by 390 kg/ha) for version B_3 with breaking and dead furrowing in the winter and by 5% (by 113.5 kg/ha) for version B_1 with tillage transversely to the slope.

TABLE 4. AVERAGE YIELD IN WHEAT STRAW Test in Wheat 2004 – 2005

Version	2004		2005		2004 – 2005	
	kg/ha	%	kg/ha	%	kg/ha	%
B_0	2179,0	100	2348,0	100	2263,5	100
B_1	2284,0	104,8	2470,0	105,2	2377,0	105,0
B_2	2754,0	126,4	2975,0	126,7	2864,5	126,6
B_3	2537,0	116,4	2770,0	118,0	2653,5	117,2
B_4	2826,0	129,7	3081,0	131,2	2953,5	130,5
GD 5 %	27,7	1,3	37,0	1,6		
GD 1 %	38,9	1,8	51,9	2,2		
GD 0,1 %	54,9	2,5	73,2	3,1		

All data concerning yields in wheat grain and straw have been processed according to the methods of the mathematical statistics and the differences have been well proven statistically.

Water runoff from the soil surface as well as the washed out and dislodged soil have been accounted for after each rainfall via the specially created draining sites during the experimental period. It is evident from the results presented in Table 5 that the lowest values of the surface water runoff and the eroded soil are with version B_4 at which the wheat crop was grown with the help of the erosion control technique incorporating the soil conserving tillage with vertical mulching and breaking with dead furrowing. This method has decreased the surface water runoff by 4.8 to 6.7 times and the eroded soil by 20.0 to 27.9 times compared to the check test which incorporated tillage in the direction of the slope and this effect had been maintained for the whole period of the production cycle. Also, a significant erosion control effect has been observed with version B_2 in which the field management method of vertical mulching has been utilized for soil conservation. This method has decreased the surface water runoff by 2.5 to 4.5 times and the quantity of the

dislodged soil by 5.8 to 10.7 times compared to the check test. The results which come close to the above ones are obtained from version B_3, with crops broken and dead furrowed in the winter. In this version the surface water runoff has been reduced by 2.1 to 3.1 and the quantity of the dislodged soil has decreased by 4.5 to 6.9 times compared to version B_0 check test in which the tillage was carried out in the direction of the slope. The erosion control efficiency of version B_1 in which the wheat was grown in the conventional method carried out transversely to the slope has been poorer. It shows decrease in the surface water runoff by 1.2 to 1.6 times and in the quantity of the dislodged soil by 1.6 to 2.1 times compared to the check test.

TABLE 5. TOTAL AMOUNT OF SURFACE WATER RUNOFF AND ERODED SOIL IN TEST WITH WHEAT, 2004 – 2005

Date	Rainfall Quantity l/m^2	Surface Runoff, m^3/ha					Eroded Soil, kg/ha				
		Version					Version				
		B_0	B_1	B_2	B_3	B_4	B_0	B_1	B_2	B_3	B_4
April 23, 2004	11,0	58,716	36,258	17,541	20,143	8,852	396	198	56	68	15
May 6, 2004	22,0	81,126	57,947	33,115	38,631	16,845	842	443	146	189	42
June 19, 2004	14,0	59,021	38,576	19,836	22,170	9,841	448	232	72	83	18
June 22, 2004	12,0	57,597	36,921	18,361	20,512	9,344	416	210	60	73	16
Total Annual:	59,0	256,46	169,70	88,853	101,45	44,882	2102	1083	334	413	91
Average Annual:	14,8	64,115	42,426	22,213	25,364	11,221	526	271	84	103	23
May 11, 2005	19,0	76,296	54,752	22,524	26,224	12,983	1832	874	172	255	72
May 22, 2005	9,0	64,609	39,897	14,448	20,862	9,576	949	463	93	138	34
May 27, 2005	20,0	85,461	71,203	30,259	35,433	16,525	1910	1169	253	366	81
June 1, 2005	10,0	65,800	41,179	17,155	21,086	10,246	967	481	105	157	35
June 7, 2005	20,0	79,356	60,838	26,052	28,685	13,220	1161	651	135	183	45
July 4, 2005	66,0	116,66	101,33	41,009	56,332	20,483	2189	1363	272	387	89
July 11, 2005	27,0	115,30	95,991	38,668	51,453	18,678	2128	1247	243	344	81
Total Annual:	171,0	603,48	465,19	190,11	240,07	101,71	1113	6248	1273	1830	437
Average Annual:	24,4	86,212	66,456	27,159	34,296	14,530	1591	893	182	261	62

4. CONCLUSION

Taking into consideration all results obtained from the carried out research we can conclude the following:

- Erosion control field management methods of vertical mulching and breaking with dead furrowing as well as contour tillage transversely to the slope combined with erosion control technique incorporating vertical mulching before sowing and breaking with dead furrowing in the winter can be utilized as a means of soil conservation from water erosion at growing wheat on slopes in the conditions of carbonate humus soil in the Republic of Bulgaria.
- Utilizing these soil conservation methods and techniques at growing wheat on slopes contribute to maintaining the soil indices for bulk density, hardness and porosity with values close to the most favorable ones for this agricultural crop, facilitate the improvement of the soil water-and-air regime and create better conditions for growth and development of plants as well as increase the yields.

- The erosion control technique incorporating vertical mulching before sowing and breaking with dead furrowing in the winter has the best field management effect at growing wheat on slopes as through utilizing it the grain yield increases by 33% (by 1027 kg/ha) and the wheat straw by 30.5% (by 690 kg/ha).
- The technique for soil conservation from water erosion, which incorporated the field management methods of vertical mulching and breaking with dead furrowing, is once again the most efficient one with a view to the erosion control. Utilizing it in growing wheat on slopes of 5° gradient reduces the surface water runoff by 4.8 to 6.7 times and the quantity of the eroded soil by 20.0 to 27.9 times.
- With a view to the field management and erosion control this technique is the most appropriate one to be applied at growing wheat on slopes of 5° gradient in the conditions of carbonate humus soil.

BIBLIOGRAPHY

[1.] IVANOV, P. Main Agricultural Crop Production in Bulgaria. Agrobusinesat, Vol.8, Sofia, pp. 24-25, 2005.

[2.] ONCHEV, N.G. Erosion Intensity and Optimization of Erosion Control Activities. Zemedelie Plus No.9, Sofia, pp. 21-24. 2001.

[3.] RUSSEVA, S.S., Information Basis for Developing Geographic Data Base for Estimating Erosion Risks. Research Work Qualifying for an Academic Degree of Senior Research Associate I Degree, Nikola Pushkarov Institute on Soil, Sofia, 2002.