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EFFECTS OF AGROTECHNICAL MEASURES ON WEED DYNAMICS AND WATER BALANCE IN SOIL FOR DIFFERENT CROPS

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Abstract

In conditions of the modernization of agriculture, knowledge about the weeds can influence the production are required. The researches were performed during the 2018-2021, in the experimental field of NARDI Fundulea and aimed to study the influence of agrotechnical practices on the weeds and water balance in soil. The paper presents the results obtained in long term experiences with fertilizers, soil tillages and crop rotations. The crops showed an infestation with monocotyledonous and dicotyledonous weeds, represented as follows: weed wheat crop 27%, weed maize crop 80%. Weeding sources and the number of weeds are higher in the soils where the manure is administered, it is not herbicided and for the seed in uncultivated land. The dynamics of the soil moisture reserve was correlated with the precipitation regime and the water consumption of the plants. The reporting values for determining the soil moisture were as follows: Field capacity - 4,391 m.c./ha; Withering coefficient - 2,132 m.c./ha. Monthly determinations of soil moisture revealed atypical values of humidity at a depth of 0-75 cm, finding a variable amount of water.

Key words*: wheat, maize, weed dynamics, water balance, soil.*

INTRODUCTION

Romania has agricultural areas facing increasingly severe drought, with insufficient water resources for crops and the restoration of groundwater reserves, which threatens food security, economic development and local quality of life.

Water stress has a significant effect on water consumption and corn and wheat yields. A positive linear relationship between water production and use has been established in many studies (Fatih et al., 2008; Istanbulluoglu et al., 2002; Bouazzama et al., 2012).

Soil water conservation is directly related to all the phenomena of penetration, circulation, retention, use and loss. By agrotechnical methods can be directly or indirectly influenced, one or more components of the water regime, so as to bring it as close as possible to the requirements of plants for water. Soil water dynamics is influenced by climatic conditions, applied technological links and the consumption of the crop plant (Popescu and Bucur, 1999; Sin and Ionita, 1997). The study of weeding of agricultural crops is a means of knowing the structure of the plant flora, in order to establish measures to control weeds and prevent the increase in the number of weeds that may appear on agricultural land. The causes of weeding, its seasonal, annual and multiannual dynamics are a matter of interest in agriculture.

The sources of weeding of agricultural crops are given by the existing weed seed reserve in the arable soil layer, by the uncultivated areas, by the heads of the unsown plots and by the unconditioned seed used for sowing the agricultural crops. Thus, the total elimination of weeds from agricultural lands is impossible and, for ecological reasons, it is not desirable. Because of this, “thresholds” of damage have been established, up to which the number of weeds in a species does not cause damage that would justify the control (Zanin et al., 1994; Ionescu, 2010).

The reduced competition of crop plants in the fight against weeds, especially in the first phenophases of growth (Wilson, 1988), requires specific research on the causes of weeds, weed species and the possibilities to control them (Berca, 2008; Maxwell et al.,

2007; Partal et al., 2017; Serban and Maturaru, 2019).
Climate change can have various effects on agricultural production, depending on the type of soil and the technological measures applied in agricultural crops (Moss et al., 2010; Paraschivu et al., 2017).

MATERIALS AND METHODS

The tests were performed between 2019 and 2021, on a chernozem cambic soil specific for southern Romania, in a long-term experience at NARDI Fundulea.
Regarding the physical characteristics of the soil, the humus content is higher in the first 15 cm due to the former bedding and gradually decreases to depth. The soil consists of several horizons:
- Ap+Aph - 0-30 cm, clay-clay-dust with 36.5% clay and permeability 492, pH 5.9.
- Am - 30-45 cm, clay-clay with 37.3% clay, compacted, DA 1.41g / cm³, pH 5.9.
- A/B (45-62 cm), Bv1 (62-80 cm), Bv2 (82-112 cm), Cnk1 (149-170 cm), Cnk2 (170-200 cm).

Depending on the agricultural year, the water supply of the soil is favorable for field crops, groundwater at 10-12 meters.
Experimental factors included A- crop rotation with 4 graduations: monoculture, rotation of 2, rotation of 3 and rotation of 4 years; B - soil work with 3 graduates: no-tillage, disk tillage and autumn plowing; C - fertilization with 3 graduates: unfertilized, $N_{90}P_{75}$, manure 20 t/ha applied at 4 years.
The size of the plot was 56.0 m^2 (4 rows x 20 m long x 70 cm distance between rows).
Regarding the weed dynamics, counts and determinations were performed in different vegetation phases of the crop plants.
Regarding the dynamics of the soil moisture reserve, it was correlated with the precipitation regime and with the water consumption of the plants. During the vegetation, from sowing to harvesting, soil samples were collected at a depth of 1.25 m to determine the state of humidity. The values taken into account when determining the soil moisture were the following: Field capacity - 4391 m.c./ha; Withering coefficient - 2132 m.c./ha; Minimum ceiling - 3264 m.c./ha.
The principle of the method of determining the soil moisture: the soil is dried at a temperature of 105^{0}C to a constant weight and then weighed. The difference in weight obtained before and after drying, represents the humidity that is expressed as a percentage (%).
Materials used: termoadjustable drying oven; analytical balance; weighing ampoules; dryer.
The experimental data obtained were presented in the form of tables and graphs.
In order to reduce the weeding of crops and the best possible conservation of water in the soil, it is necessary to apply differentiated agrotechnical practices throughout the vegetation period in correlation with technological inputs.

RESULTS AND DISCUSSIONS

Climatic aspects
In 2019, the precipitations recorded the lowest values, of 6.2 mm in September, compared to the multiannual average of 48.5 mm and in August by 12.6 mm compared to the multiannual average of 49.7 mm. The greatest amount of precipitation occurred in July, with 87.4 mm, about 16.3 mm above the multiannual average. Regarding the thermal regime, in the period June-September, the recorded values show that the average monthly temperatures were higher than the multiannual average, in June by 2.8ºC above the multiannual average.
The year 2020 was an extremely dry one, with an accentuated water deficit and high temperatures, compared to the multiannual average. The months with the lowest rainfall were 5.4 mm compared to 49.7 mm on average and July with 34.2 mm compared to 71.1 mm on average. The deficit of precipitation influenced the weeding of crops and the dynamics of water in the soil. The average temperatures recorded in the agricultural year 2020 were 13.5ºC, compared to the multiannual average of 10.9ºC, with an increase of 2.6ºC.
The 2021 was a normal year in terms of water levels, but with an uneven distribution of rainfall, especially in July, August and September. Temperatures recorded an annual average of 12.1ºC and a difference of 1.2ºC from the multiannual average. The rainfall here averages 584.3 mm. In 2019, the amount of

precipitation was 42.9 mm lower than the multiannual average, in 2020 by 161.1 mm and in 2021 by 31.1 mm. The climatic data obtained were corroborated with the elements followed during the vegetation period of the crops (Table 1).

Table 1. The meteorological parameters in the experimental period (Fundulea, 2019-2021)

Years/Months		Jan	Febr	Mar	Apr	May	Jun	July	Aug	Sept	Oct	Nov	Dec	Total/ Average
Precipitations (mm)	2019	53.8	21.4	22.4	51.4	124	74.6	87.4	12.6	6.2	38.2	33.2	16.2	541.4
	2020	2.0	16.6	29.8	14.0	57.8	68.4	34.2	5.4	68.6	24.0	20.0	77.6	423.2
	2021	77.0	16.2	59.0	31.0	57.6	135	21.2	24.2	4.0	56.4	33.8	37.6	553.2
50 years average		**35.1**	**32.0**	**37.4**	**45.1**	**62.5**	**74.9**	**71.1**	**49.7**	**48.5**	**42.3**	**42.0**	**43.7**	**584.3**
Temperatures (°C)	2019	-1.1	3.8	9.3	11.2	17.2	23.6	22.9	24.7	19.3	12.0	11.0	4.0	13.2
	2020	0.9	5.2	8.3	12.4	16.8	21.8	25.1	25.5	20.8	12.8	6.2	4.0	13.5
	2021	1.6	3.2	5.1	9.7	17.2	21.1	25.3	24.2	17.3	10.2	7.7	2.6	12.1
50 years average		**-2.4**	**-0.4**	**4.9**	**11.3**	**17.0**	**20.8**	**22.7**	**22.3**	**17.3**	**11.3**	**5.4**	**0.1**	**10.9**

Weed dynamics

The maize crop was infested with weeds in a proportion of approximately 90%, represented as follows: annual and perennial monocotyledons - 46%; dicotyledonous - 42%; other insignificant weeds - 2% (Figure 1).

Of the total of 46% of the annual and perennial monocotyledonous weeds, the following species are part of the component:

Setaria spp. - 25%;

Echinochloa crus-galli - 12%;

Shorghum halepense - 9%;

Of the total of 42% of the dicotyledonous weeds, the following weeds are part:

Amaranthus retroflexus - 19%;

Chenopodium album - 15%;

Xanthium strumarium - 8%.

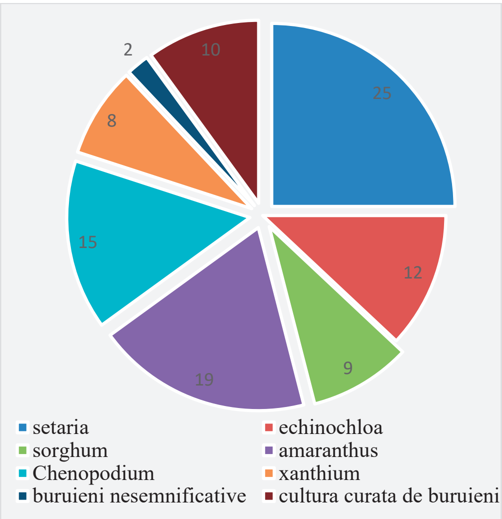

Figure 1. The presence of weeds in maize crop - expressed as a percentage in 2020

For maize, one of the advantages of combining crop rotation and tillage is to control most weed species and significantly reduce the supply of weed seeds in the soil.

In 2020, the associated variant A4B3 - 4 year rotation + autumn plowing led to the appearance of a number of 52 weeds/m^2 for the non-fertilized and fertilized version with $N_{90}P_{75}$ and for 53 weeds/m^2 for the version with manure application 20 t/ha (Table 2).

The application of the basic works of the soil with the disc achieves a more efficient control of the weeds in comparison with the no-tillage one, regardless of the technological combinations made, but less efficient compared to the variant of the autumn plowing of the soil. Thus, the association with fertilization with manure 20 t/ha, led to the appearance of a number of weeds between 56-118 weeds/m^2 depending on the crop rotation applied. The lowest number of weeds was recorded in the A4B2C3 variant with 56 weeds/m^2.

Crop rotation has fluctuated depending on the technological combination applied. Thus, the monoculture variant achieved the lowest weed control rate, with 170 weeds/m^2 in the variant associated with no-tillage and unfertilized.

The 3-year crop rotation registered the lowest number of weeds when associated with the basic work of plowing through autumn plowing and the application of manure 20 t/ha, with 77 weeds/m^2.

The appearance of such a large number of weeds in the variants where fertilization with manure was applied 20 t/ha, regardless of the associations with crop rotation or soil work, is due to the very high content of viable seeds present in the manure.

Thus, in the experience was recorded a number between 118-162 weeds/m^2 for the monoculture variant, between 78-100 weeds/m^2 for the 2-year rotation variant, between 77 - 102 weeds/m^2 for the 3-year rotation variant and between 53-63 4-year rotation weeds.

Table 2. The number of weeds depending on the technological combination applied to the maize crop - 2020

Variants		C1		C2		C3	
		Weeds*	%	Weeds*	%	Weeds *	%
A1	B1	170	100	170	100	162	100
	B2	127	74.7	127	74.1	118	73
	B3	146	85.9	146	85.2	130	80
A2	B1	80	100.0	80	100	100	100
	B2	65	81.2	65	73.0	78	78
	B3	75	93.7	75	85.7	86	86
A3	B1	110	100	108	100	102	100
	B2	80	72.7	80	74.0	88	86
	B3	110	100	72	66.6	77	75
A4	B1	59	100	59	100	63	100
	B2	54	91.5	54	84.8	56	88
	B3	52	88.1	52	93.5	53	84

*number of weeds/m^2 - average

In the agricultural year 2021, for maize cultivation, the number of weeds/m^2 registered significant variations depending on the applied technological variant. Thus, the highest number of weeds/m3 was registered in the technological variant A1B1C1 - monoculture + no-tillage + unfertilized with 181 weeds/m^2. The technological variant with the lowest number of weeds was the associated A4B3C2 - 4 years rotation + autumn plowing + $N_{90}P_{75}$ fertilization, with 40 weeds/m^2 (Table 3).
Manure application 20 t/ha recorded the lowest number of weeds in association with 4 years crop rotation + autumn plowing, with 65 weeds/m^2, followed by association of 4 years rotation + disc, with 67 weeds/m^2. The application of fertilization has registered notable variations depending on the technological associations.
Thus, compared to manure fertilization 20 t/ha, the variant fertilized with $N_{90}P_{75}$ registered a smaller number of weeds, regardless of the technological variant or the grading of factors such as crop rotation and tillage, with values between 44-126 weeds/m^2 as an average of the associated variants.

Table 3. The number of weeds depending on the technological combination applied to the maize crop - 2021

Variant		C1		C2		C3	
		Weeds*	%	Weeds*	%	Weeds *	%
A1	B1	181	100	150	100	170	100
	B2	135	75	110	73	135	79
	B3	150	83	120	80	125	73
A2	B1	90	100	70	100	110	100
	B2	77	85	50	71	92	84
	B3	85	94	58	83	85	77
A3	B1	110	100	90	101	109	100
	B2	109	99	70	78	95	87
	B3	90	82	70	78	85	78
A4	B1	70	100	48	100	73	100
	B2	65	93	45	93	67	91
	B3	62	88	40	83	65	89

*number of weeds/m^2 – average

The sunflower crop showed an infestation with weed species in the proportion of about 80%, and these were represented as follows: annual and perennial monocotyledonous weeds - 36%; dicotyledonous weeds - 42%; other insignificant weeds - 2%.
Of the total percentage of 36% of annual and perennial monocotyledonous weeds, the most

representative are the following weeds: *Setaria spp*. - 13%; *Echinochloa crus-galli* - 8%; *Shorghum halepense* - 15%, and of the total of 42% of dicotyledonous weeds the following representative weeds are part: *Amaranthus retroflexus* - 19%; *Cirsium arvense* - 15%; *Xanthium strumarium* - 8% (Figure 2).

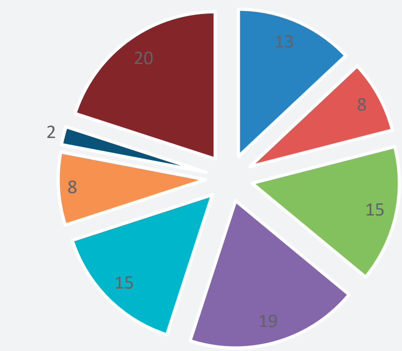

Figure 2. The presence of weeds in sunflower crop - expressed as a percentage - 2020

The weeds that recorded the largest presence in the culture were: Shorghum halepense and Amaranthus retroflexus.

In the sunflower crop, in 2019, the association of the 4-year rotation + tillage by autumn plowing led to the appearance of a number of 61 weeds/m^2 for the non-fertilized version, for 31 weeds/m^2 for the version fertilized with $N_{90}P_{75}$ and for 40 weeds/m^2 for the fertilized version with manure 20 t/ha. The application of the basic works of the soil with the disc achieves a more efficient control of the weeds in comparison with no-tillage one, regardless of the technological combinations made, but less efficient compared to the variant of the autumn plowing of the soil. Thus, the association with manure fertilization led to a number of 41 weeds/m^2 at 4-year rotation and 52 weeds/m^2 at 2-year rotation (Table 4).

The uncultivated variant registers a high number of weed species and implicitly a large number of weeds of each species, compared to the other tillage variants. Thus, associated with non-fertilization and monoculture, a number of 150 weeds/m^2 was registered, as an average of the experiments. In the variant associated with $N_{90}P_{75}$ fertilization, the number of weeds dropped to 125/m^2.

Table 4. The number of weeds depending on the technological combination applied to sunflower crop - 2019

Variant		C1		C2		C3	
		Weeds*	%	Weeds*	%	Weeds*	%
A1	B1	150	100	125	100	155	100
	B2	120	80.0	101	80.8	118	76.0
	B3	102	68.0	88	70.4	105	68.0
A2	B1	70	100	52	100	61	100
	B2	61	87.1	43	82.7	52	85.0
	B3	52	74.3	35	67.3	44	72.0
A3	B1	100	100	74	100	80	100
	B2	91	91.0	66	89.2	73	91.0
	B3	70	70.0	56	75.6	59	73.0
A4	B1	66	100	40	100	56	100
	B2	61	92.4	38	95.0	41	73.0
	B3	58	63.7	31	77.5	40	71.0

*number of weeds/m^2 – average

In 2020, in the sunflower crop there were variations in the number of weeds depending on the graduations of the experimental factors, of 68.0-102.0%. Thus, the lowest number of weeds was registered in the variant associated with the 4-years rotation + autumn plowing + fertilization with $N_{90}P_{75}$, with 42 weeds/m^2, followed by the variant with 2-years rotation + autumn plowing + fertilization with $N_{90}P_{75}$, with 46 weeds/m^2 (Table 5). The no-tillage variant registered values of the number of weeds very high, regardless of the association with other factors, between 135-165 weeds/m^2. The application of manure 20 t/ha led to the appearance of a number of 51 weeds/m^2 at the association with the rotation of 4 years +

autumn plowing and of 59 weeds/m^2 at the variant with the rotation of 2 years + autumn plowing. The variation of weeds is high due to the low competition capacity of the crop plants and due to the monocotyledons which have a high capacity for twinning and growth.

Table 5. The number of weeds depending on the technological combination applied to the sunflower crop - 2020

Varianta		C1		C2		C3	
		Weeds*	%	Weeds*	%	Weeds*	%
A1	**B1**	165	100	135	100	142	100
	B2	117	71.0	115	85.2	115	81.0
	B3	117	71.0	100	74.0	96	68.0
A2	**B1**	80	100	63	100	71	100
	B2	71	88.7	54	85.7	62	87.0
	B3	62	77.5	46	73.0	59	83.0
A3	**B1**	109	100	85	100	89	100
	B2	102	93.5	88	103	80	89.0
	B3	80	73.4	68	80.0	73	82.0
A4	**B1**	76	100	51	100	78	100
	B2	70	92.1	49	96.1	60	76.0
	B3	68	89.5	42	82.4	51	70.0

* number of weeds / m2 – average

Water balance in soil

The soil samples taken in order to determine the soil moisture highlight the climatic character of the agricultural year and establish the influence on field crops.

Soil moisture indicates the reserve with respect to the wilting coefficient, the deficit with respect to the field capacity and the water reserve with respect to the minimum ceiling.

Soil water, between the withering coefficient (CW) and the water capacity of the soil in the field (FC), is the water accessible to plants. The field capacity is the water content of the soil at the maximum saturation point and the cessation of the downward movement of the water; the wilting coefficient (wilting point) is the minimum humidity that the plant needs in order not to wither.

The humidity determinations performed as an average in 2019, showed normal values of humidity in the case of all variants, on the depth of 0-75 cm, finding a satisfactory amount of water, which is made available to the plants. These humidity values are lower in the 75-125 cm layer, but remain constant. The soil samples taken show us a reserve compared to the wilting coefficient of 1367.2 m^3/ha, a deficit compared to the field capacity of 891.8 m^3/ha and a water reserve compared to the minimum ceiling of 235.2 m^3/ha (Table 6).

Table 6. Determination of soil moisture in spring crops - average in 2019

Depth (cm)	Bulk density (g/cm³)	Momentary water reserve		Coefficient withering CW (m³/ha)	Field capacity FC (m³/ha)	Reserve by CW (m³/ha)	Deficit from FC (m³/ha)	Minimum ceiling MC (m³/ha)	Reserve by MC (m³/ha)
		%	m³/ha						
0 - 25	1.33	21	698.3	405	884	293.3	-185.8	645	53.3
25 -50	1.38	20.9	721.1	464	929	257.1	-208.0	697	24.0
50 -75	1.43	20.5	732.9	469	928	263.9	-195.1	699	33.9
75 -100	1.36	20.4	693.6	426	837	267.6	-143.4	632	61.6
100 -125	1.32	19.8	653.4	368	813	285.4	-159.6	591	62.4
TOTAL	-	-	**3499.2**	2132	4391	**1367.2**	**-891.8**	3264	**235.2**

Humidity determinations calculated as an average of 2020, showed low values of humidity in all variants, on the whole depth of 0-125 cm.

The soil samples taken do not show a reserve of the wilting coefficient of 965.2 m^3/ha, a deficit compared to the field capacity of -1293.8 m^3/ha and a negative water reserve compared to the minimum ceiling of -166.8 m^3/ha. The water reserve compared to the minimum ceiling registered negative values and made the vegetation of the plants difficult in March, April, August, September and October. The deficit in field capacity registered negative values in each month of 2020, thus showing the non-uniformity of the quantities of water accumulated in the soil. The determination of soil moisture highlighted the unfavorable nature of the agricultural year 2020 for field crops (Table 7).

Table 7. Determination of soil moisture in spring crops - average in 2020

Depth (cm)	Bulk density (g/cm³)	Momentary water reserve		Coefficient withering CW (m³/ha)	Field capacity FC (m³/ha)	Reserve by CW (m³/ha)	Deficit from FC (m³/ha)	Minimum ceiling MC (m³/ha)	Reserve by MC (m³/ha)
		%	m³/ha						
0 - 25	1.33	16.2	538.7	405	884	133.7	-345.4	645	-106.4
25 -50	1.38	22.0	759.0	464	929	295.0	-170.0	697	62.0
50 -75	1.43	19.4	693.6	469	928	224.6	-234.5	699	-5.5
75 -100	1.36	17.0	578.0	426	837	152.0	-259.0	632	-54.0
100 -125	1.32	16.0	528.0	368	813	160.0	-285.0	591	-63.0
TOTAL	-	-	**3097.2**	2132	4391	**965.2**	**-1293.8**	3264	**-166.8**

The humidity determinations performed on average in 2021, showed satisfactory values of humidity in all variants, on a depth of 0-75 cm, finding a larger amount of water, which is made available to plants. These humidity values are lower in the 75-125 cm layer, but remain constant. The soil samples taken show a reserve with respect to the wilting coefficient of 1389.1 m3/ha, a deficit with respect to the field capacity of 869.9 m^3/ha and a water reserve with respect to the total minimum ceiling of 257.1 m^3/ha (Table 8).

Table 8. Determination of soil moisture in spring crops - average in 2021

Depth (cm)	Bulk density (g/cm³)	Momentary water reserve		Coefficient withering CW (m³/ha)	Field capacity FC (m³/ha)	Reserve by CW (m³/ha)	Deficit from FC (m³/ha)	Minimum ceiling MC (m³/ha)	Reserve by MC (m³/ha)
		%	m³/ha						
0 - 25	1.33	19.9	661.7	405	884	256.7	-222.3	645	16.7
25 -50	1.38	20.8	717.6	464	929	253.6	-211.4	697	20.6
50 -75	1.43	21.2	757.9	469	928	288.9	-170.1	699	58.9
75 -100	1.36	21.0	714.0	426	837	288.0	-123.0	632	82.0
100 -125	1.32	20.3	669.9	368	813	301.9	-143.1	591	78.9
TOTAL	-	-	**3521.1**	2132	4391	**1389.1**	**-869.9**	3264	**257.1**

The determinations regarding the soil moisture, carried out on an annual average, showed different values depending on the studied variants, on the depth of 0-75 cm, finding a higher amount of water, which is made available to the plants, and in the layer 75-125 cm, the values are lower but remain constant. From the analysis of the soil moisture values it was found that the water reserves from the spring are a decisive indicator in the adaptation of the agrotechnical measures to the annual particularities of the climatic conditions.

CONCLUSIONS

The reduction of the total weeding up to the limit of excluding the competition for the crop plants can be achieved by observing the 3-4 years crop rotation associated with the execution of the basic soil works by autumn plowing and fertilization with $N_{90}P_{75}$ or the application of manure 20 t/ha to 4 years. Crop rotation contributes to a decrease in the number of weeds/m^2 by up to 25-30%.

For the efficient conservation of the water from the soil, it is necessary to apply differentiated agrotechnical practices throughout the vegetation period in correlation with the technological contributions. Among the agrotechnical methods of water conservation in the soil we mention: the practice of crop rotation for 3-4 years, the execution of soil tillages in the optimal working interval, avoiding the mobilization of the soil at greater depths than necessary, both for basic tillages and preparation of germination bed.

The dynamics of water in the soil is directly proportional to the amount of precipitation and the vegetation phase of the crop plant, which specifies the level of consumption of the plant. The basic tillages of the soil by autumn plowing will be carried out by alternation, at 3-4 years with the disk tillage, taking into account the advantages it brings to the soil, and last but not least to the productivity of crops in the two systems of tillages.

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