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RESEARCH ARTICLE

Assimilation apparatus indices of maize plants under conditions of the right bank forest steppe of Ukraine

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Abstract

The influence of different methods of basic tillage and post-harvest sowing of oil radish and winter oil rape seeds on maize productivity has been studied. Improving the photosynthetic properties of crops, including corn for grain, is one way to increase their productivity, as today in production are widespread varieties and hybrids that use to form their harvest is not a significant part of its potential (about 6% of possible (Nychyporovych 1955, 1961). Therefore, optimizing the conditions of their growth and development for positive changes in this direction is important.

Keywords: Maize, chlorophyll, productivity, oil radish, winter rape, postharvest sowing, green manure.

Introduction

In the conditions of high culture of farming among the complex of measures the main role belongs to agrotechnical measures aimed at improving the conditions of plant development in order to increase their productivity. Nychyporovych A.A. (Nychyporovych A.A. 1955; 1961) indicates that normal course of photosynthesis depends on the nutrition of plants with nitrogen, ash elements and water. The most important means of regulating these conditions are rational mechanical tillage, as well as destruction of competitors for cultivated plants-weeds (Kravchenko 2020; Pochinok 1976; Filev et al. 1980; Karbivska et al. 2020; Litvinov et al. 2019).

The volume and quality of the crop is the result of its formation conditions. In its turn, according to the author, the latter is a complex set of such processes as nutrition, growth, development, metabolism and conversion of substances and energy of plants in crops and plantations (Karpenko et al. 2019; Litvinov et al. 2020; Hryhoriv et al. 2020). Since the process of photosynthesis significantly depends on plant nutrition conditions, water and air regimes, the study of the use of postharvest crops against the background of various measures of basic tillage is relevant, as these measures make it possible to actively regulate the above soil parameters.

Materials and Methods

Our research included the study of the impact of post-harvest crops and measures of main tillage on maize productivity, which were carried out at PS NULES of Ukraine "Agronomic Research Station" in stationary field crop rotation. There, are studied agronomic, chemical, biological and complex weed control measures followed by crop rotation: 1-clover; 2-winter wheat + post-harvest crops; 3-corn for grain; 4- peas; 5-winter wheat + post-harvest crops; 6-sugar beets; 7-corn for silage; 8- winter wheat; 9-barley with additional clover sowing.

The soil of experimental plot is typical low-humus black soil, the humus content in the arable layer is 4.2-4.5%, pH is 6.8-7.3, amount of general nitrogen is 0.27-0.31, phosphorus is 0.14-0.25 and potassium is 2.3-2.5%.

The scheme of the experiment provides for the study

of the following variants: 1) control (root and post-harvest residues of winter wheat); 2) manure, 40 t/ha; 3) winter rape for green manure; 4) winter rape for green fodder; 5) oil radish for green manure; 6) oil radish for fodder. Ploughing and chisel measures of basic tillage to a depth of 28-30 cm were used in the experiment for corn.

Phenological observations of the growth and development of corn were carried out according to current methodical guidelines (Manko et al. 2019; Tester and Langridge 2010). The content of chlorophyll "a" and "b" and carotenoids were determined in the plants 2 times during the growing season: in the phase of 6 leaves and in the phase of corn flowering. The method of analysis of variance (Dospekhov 1985) was used to process yield data.

Results

One of important morphological indices is the height of plants. Plant growth tempo is correlated with thermal and nutrient regime of soil (Tanchyk et al. 2019; Karpenko and Rozhko 2015; Karbivska et al. 2019). Conducted studies have shown (Tab. l) that the growth processes took place differently at vegetation period and depended on systems of soil tillage. During ploughing tillage in the phase of 6-8 leaves, the height of maize plants was lower than during chisel tillage. In the flowering phase, corn plants were higher in the variant with ploughing. This trend remained until the phase of milk-wax ripeness.

Obviously, chisel cultivation creates better conditions for seed germination and plant growth in the first periods of vegetation (Karpenko et al. 2020; Shiferaw et al. 2011; Scherner et al. 2016). Significant impact on the growth of corn was noticed under conditions of infusion of the oil radish green mass into the soil in post-harvest sowing.

The conducted studies show that the systems of main tillage influenced changes in plant living conditions, and thus the overall development of plants and the leaf apparatus in particular (Tab. 2). The usage of ploughing tillage stipulated for the formation of a smaller area of leaf surface of maize during all phases of development compared to chisel tillage. At the time of corn flowering, the index of leaf surface area in the control variant was at ploughing-2.33, and at chisel tillage-2.69. These and other data indicate that the use of chisel tillage contributed to a more intensive formation of the leaf apparatus, which had a positive effect on the overall productivity of maize.

A noticeable effect of post-harvest crops on the growth dynamics of maize leaves was registered. The best living conditions for plants were created by the predecessor-oil radish for green manure, especially under conditions of chisel tillage, where the leaf index was 3.47, while in the control version 2.33. Thus, it can be concluded that the green mass of oil radish increases biological activity of the soil, enriches the soil with nutrients, reduces weeds and thus supports the increase in leaf surface area.

The high area of maize leaf surface grown by chisel cultivation can be explained by better nutrient regime

Table 1. The influence of main tillage systems and postharvest sowing of various usage on height of corn, cm.

Experiment variants	Ploughing 28-30 cm			Chisel tillage 28-30 cm		
	Phases of maize development					
	6-8 leaves	flowering	milk-wax ripeness	6-8 leaves	flowering	milk-wax ripeness
1. Control (root and stubble residues of winter wheat)	73	184	199	81	169	190
2. Manure, 40 t/ha	74	208	252	86	196	242
3. Winter rape for green manure	73	195	232	82	186	221
4. Winter rape for green fodder	75	196	213	73	180	210
5. Oil radish for green manure	82	202	263	84	198	250
6. Oil radish for green fodder	81	199	229	77	189	236

Table 2. Index of maize leaf surface for grain depending on the system of main soil tillage and post-harvest sowing of various usage.

Variants of the experiment	Ploughing 28-30 cm		Chisel tillage 28-30 cm	
	Phases of maize development			
	6-8 leaves maize	maize flowering	6-8 leaves maize	maize flowering
1. Control (root and stubble residues of winter wheat)	1.20	2.23	1.22	2.33
2. Manure, 40 t/ha	1.27	2.66	2.04	3.00
3. Winter rape for green manure	1.29	2.42	1.71	2.84
4. Winter rape for green fodder	1.14	2.27	1.27	2.56
5. Oil radish for green manure	1.50	2.75	1.74	3.47
6. Oil radish for green fodder	1.46	2.53	1.35	3.18

of the soil and increased content of amino acids in the soil. The obtained data on the growth and development of maize after different predecessors stipulated necessity of the study of physiological and biochemical characteristics of plants.

An important biochemical indicator of assimilation apparatus of plants is the amount of pigments, especially chlorophyll. Organic compounds are formed in the process of photosynthesis, which determine the growth and development of plants. Taking into consideration participation of leaf pigments in the synthesis of plastic substances, we conducted research on accumulation of green and yellow pigments in maize leaves.

In a result of conducted analysis, it was found that the content of chlorophyll "a" and "b" was higher in plants under conditions of chisel tillage. It should be noted that during the flowering period of maize, its maximum amount is observed in the variant with oil radish for green manure (Tab. 3). In the variants where post-harvest crops were used for green fodder amount of chlorophyll "a" was lower comparing to the control.

Different systems of main tillage and post-harvest crops affected the ratio of chlorophyll "a" and "b". Ploughing tillage stimulated more even ratio of chlorophyll "ä to "b". The highest ratio at this tillage is observed in the variants with winter rape for green manure and green fodder and oil radish for green manure and is equal to 2.6. It indicates that ploughing creates more equal conditions for plant growth and development.

Under conditions of chisel tillage higher ratios of chlorophyll "a" to "b" were established. Post-harvest crops especially affected the ratio under this kind of cultivation. Carotenoids play an important role in the process of photosynthesis. They belong to accompanying pigments that complement the function of chlorophyll, without which the process of photosynthesis cannot fully take place.

Carotenoids are involved in oxide-restoration processes and plant growth. It is also known that increased synthesis of carotenoids in plants is a protective response to the action of one or another factor.

The main evaluation criterion of any measures for growing crops is productivity. Different organic fertilizers affect the growth and development of plants differently and it can significantly affect the formation of maize (Tab. 4). As our research showed, the best conditions for the development of maize was with chisel cultivation on the background of green manure of oil radish and winter rape. Thus, the usage of oil radish for green manure provided the highest yield of maize grain-90.6 kg/ha, which is 10.4 kg/ha more than in the control variant. The application of manure and winter rape for green manure provided a slightly smaller, but also significant yield increase, respectively 7.1-10 c/ha and 7.6-9.9 c/ha.

Usage of post-harvest crops for green fodder gave a slight increase in yield. A larger increase in maize yield was in the variant with oil radish for green fodder. Different systems of main soil tillage and post-harvest sowings of different forms of usage provide different conditions for plant growth and development, and that is why different yields of maize plants are observed.

The highest yield of maize grain for both chisel tillage and ploughing was in the variant with oil radish for green manure-8.1-8.2 t/ha.

Therefore, as follows from the data presented in Tab. 3, earning crops on green manure has a positive effect on the accumulation of chlorophyll in the corn leaf. Among the measures of tillage is more promising chisel, as in the options with its use against the background of the use of oilseed radish on green manure higher rates

Table 3. Influence of post-harvest crops and soil tillage on the content of pigments in maize leaves (flowering phase).

Experiment variants	Ploughing 28-30 cm						Chisel tillage 28-30 cm					
	chlorophyll «a», мг/%	chlorophyll «b», мг/%	«a» «b»	carotenoids, mg /%	«a» + «b»	«a» + «b» carotenoids	chlorophyll «a», mg/%	chlorophyll «b», m/%	«a» «b»	carotenoids, мг/%	«a» + «b»	«a» + «b» carotenoids
1. Control	177.2	72.0	2.5	44.9	249.2	5.6	180.5	73.9	2.4	51.95	254.4	4.9
2. Manure, 40 t/ha	190.9	75.9	2.5	49.25	266.8	5.4	198.8	77.2	2.6	54.75	276.0	5.0
3. Winter rape for green manure	175.8	69.8	2.6	49.23	243.8	4.9	170.9	66.5	2.5	58.24	237.4	4.1
4. Winter rape for green fodder	199.7	77.5	2.6	47.6	277.2	5.8	184.5	74.8	2.5	56.33	259.3	4.6
5. Oil raddish for green manure	196.8	76.7	2.6	49.4	273.5	5.5	216.3	79.5	2.7	55.7	295.8	5.3
6. Oil raddish for green fodder	165.8	68.8	2.4	41.3	234.6	5.7	179.8	73.9	2.4	57.5	253.7	4.4

Table 4. Influence of post-harvest sowings and measures of main tillage on maize productivity, t/ha.

Experiment variants	Soil tillage	
	Ploughing 28-30cm	Chisel tillage 28-30 cm
1. Control (root and stubble residues of winter wheat)	7.1	7.0
2. Manure, 40 t/ha	8.1	7.9
3. Winter rape for green manure	7.4	7.7
4. Winter rape for green fodder	7.0	7.5
5. Oil radish for green manure	8.1	8.2
6. Oil radish for green fodder	7.9	8.0

HIP05 factor A-soil tillage-0.10 t/ha; Factor B-post-harvest sowings-0.16 t/ha.

are formed.

As can be seen from the data presented in table 4, the yield of corn for grain was directly proportional to the nature of the manifestation of the studied indicators. Thus, the use of oilseed radish on green manure on the background of chisel cultivation provides an increase in the yield of corn for grain due to the accumulation of pigments and carotenoids in the leaves. The increase in yield in comparison with the control was 0.53-0.88 t/ha with ploughing, and 1.0-1.1 t/ha with chisel cultivation. Variants with winter rape for green manure provided a slightly smaller yield increase and respectively amounted to 0.3-0.7 t/ha, 7.6-9.9 c/ha. The usage of post-harvest crops for green fodder gave a slight yield increase. Maize yield increase in the variant with oil radish for green fodder with chisel tillage was 0.2-0.4 t/ha, and with ploughing-0.8 t/ha. In the variant with winter rape for green fodder with chisel tillage the yield increase was within 0.5 t/ha.

Conclusion

Positive effect of post-harvest sowing usage can be explained by creation of close to optimal conditions for water-physical properties and nutrient regime of the soil, which affected the growth and development of maize plants. Usage of green manure also had a significant effect on reducing weeds (Karpenko et al. 2020; Van Der Heijden et al. 2008). Taken together, all created conditions had a positive effect on photosynthetic activity and productivity of photosynthesis. We also found that oil radish and winter rape emit free organic substances, which create positive allelopathic potential of root environment which stimulates the growth and development of maize plants (Karpenko and Rozhko 2015; Kolisnyk et al. 2019). As more and more attention is paid today to the use of additional or alternative sources of organic fertilizers, the use of green manure crops is becoming quite important. Our research proves the prospects for the use of oilseed radish on the background of chisel cultivation.

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