Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 19, Issue 3, 2019
PRINT ISSN 2284-7995, E-ISSN 2285-3952

THE DRY MATTER ACCUMULATION IN THE WINTER WHEAT ONTOGENESIS ON THE CALCAREOUS CHERNOZEM UNDER MINERAL FERTILIZERS ACTION

Vitalie CIOCHINA, Vasile LUNGU

Institute of Soil Science, Agrochemistry and Soil Protection "Nicolae Dimo", 100 Ialoveni str., Chisinau-2070, Republic of Moldova, Email: vitalie_ciochina@mail.ru

Corresponding author: vitalie_ciochina@mail.ru

Abstract

The weather conditions of the agricultural years 2015-2016 and 2016-2017 according to the rainwater regime were characterized as wet and very humid years. The administration of mineral fertilizers on the calcareous (carbonatic) chernozem showed the dependence of the dry substance accumulation on the winter wheat ontogenesis with the weather conditions. In the beginning of the straw stretch development phase of the winter wheat the most intense process of dry matter accumulation was determined. The dry matter accumulation was 3-4 times higher than in other plant development phases or 65% on average. The development phase of winter wheat with maximum organic mass accumulation was flowering, both for the control and fertilized variants. In the years with insufficient precipitation on the variant with dose rate $N_{60-120}P_{3.5}K_{60}$ were occurred the delay of the maximum phase of organic substance synthesis until the milk-wax phase of wheat plants. The experimental data showed that the optimal variant with dry accumulation matter in the wheat plants was the dose $N_{60}P_{3.5}K_{60}$. In the control variant, the dry matter content of the plant in the twinning phase consisted of 6.5 g on the 100 plants and increased by 73 times in the flowering phase with maximum nutrient consumption.

Key words: *dry substance, phenological phases, harvest, mineral fertilizers*

INTRODUCTION

Green plants consist from 75-96% of water and 4-25% of organic dry matter that consisting of 70 chemical elements [1]. Water is the basic component of all living organisms, being the medium of chemical, biological and physical reactions. It fulfills the role of transporting nutrients and synthesized substances, regulates the temperature of vegetal tissues in the plant body and osmotic pressure at the cellular level. Concurrently, it serves the enzyme reaction medium [2].

Dry matter accumulation is one of the best estimates for crop reaction to the effect of fertilizes or environmental factors [7].

The dry matter in the winter wheat consists of 9-26% protein in grains decomposing in albumins, globulins, prolamins and glutelines, essential aminoacids in the protein complex, wet gluten in the amount of 16-52% and crude gluten - 5-20% in the form of lipoproteids, nitrogen-free substances, vitamins, etc. [4].

The formation and accumulation of dry matter during the cycle of vegetation is the result of all physiological and biochemical processes taking place in the plant under concrete pedoclimatic conditions. In the literature we find a large amount of experimental material indicating the accumulation of dry matter in the process of growth, development and maturity of winter wheat grains [3, 10].

The process of dry matter accumulation takes place in the in the twining and straw beginning phases very slowly. At the milk phases, sometimes wax phases, an increase in growth intensity of grains development with maximum accumulation of dry matter are observed. At the full maturity of plants, the amount of dry matter is reduced.

The intensity and continuity of the green vegetation biomass accumulation is dependent on the environment conditions and the soil nutritional regime. Ensuring plants during active vegetation with nutrients of ternary or binary nutrients in the soil contributes to the development of foliar system of plants [4, 5].

As a result, the intensity of the photosynthetic process increases, resulting in the increase of the dry matter in the wheat plants and the harvest quality improvement [6].

MATERIALS AND METHODS

A field study was conducted for two years at the at the Experimental Station for Pedology and Agrochemistry of the Institute "N. Dimo", in Grigorievca village, Causeni district.
Phenological observations and research was carried out on winter wheat culture on the calcareous (carbonatic) chernozem.
The field experience has been assembled according to the randomized blocking method, consisting of 16 variants, in 4 repetitions, on a single field. The recent 2-year agricultural studies 2015-2016 and 2016-2017 have contributed to determine the accumulation of green vegetable biomass and dry matter in winter wheat. The mass of the dry matter was monitored on six phenological phases of wheat: twinning, straw output, spice, flowering, waxy- milk and full maturity. Samples of wheat plants were harvested manually by the random method and the bundle on 1 m^2 in 4 repetitions for each variant, mixed sample was obtained.
Thus, new data has been obtained on the dry matter accumulation process at different levels of nutrition with mineral fertilizers on the carbonatic chernozem. Laboratory analyzes were performed in the Agro-chemistry Laboratory within 3 hours of plant harvesting. In the samples of plants, the metric measurements were carried out and their division into organs, from which the straw is a mixture of stem leaves, spruces and grains, were researched separately.
The winter wheat plants were comminuted, weighed and dried at t = 105^0C for 6 hours. The data obtained were statistically systematized and displayed in tabular and graphical form.

RESULTS AND DISCUSSIONS

In order to obtain a high level of quality harvest, the main determinants are the climatic conditions and the soil type with the fertilization during the critical periods of the winter wheat nutrition. The increase in harvest quality is also dependent on the organic-mineral fertilization system characteristic for soils with percolative water regime or irrigation. Providing sufficient water to soils contributes to increasing the vegetable mass and decreasing the amount of protein in the case of non-application or insufficiency of fertilizers [8].
In the Republic of Moldova, an average of 250-300 thousand hectares of winter wheat is grown annually. The share of nitrogen and phosphorus comes from mineral fertilizers - about 90%. The most common fertilizers are ammonium nitrate - 65%, amorphous - 37%, less potassium chloride - 11% [1]. These fertilizers were studied in the variants at the experimental station.
The purpose of the research was to determine the mass of dry matter obtained as a result of winter wheat fertilization with the mentioned fertilizers under semiarid conditions in the southern area of the country.
According to the criterion of ensuring crops with temperature and humidity, the southern area of Moldova is characterized as the warm pedoclimatic area. The southern area occupies the Prenestrian Steppe and the Tighecian Heights with the formation of ordinary and carbonatic chernozems at altitudes 50-300 m above sea level.
The thermal regime of multiannual temperatures is $9.5\text{-}10.0^0$C, the sum of the active temperatures ≥100C make up 3,100-$3{,}350^0$C. The sum of the multi-annual rainfall is 450-550 mm, and the total evaporation - 850-900 mm, and the drought frequency - 3-4 dry years from 10 years [11].
The agrometeorological conditions of the agricultural year 2015 - 2016 influenced favorably the growth and development of the winter wheat manifested by obtaining a high level of harvest. During the agricultural year, rainfall amounted 434 mm, 65 mm more than the multiannual average. Precipitation has fallen irregular during both inactive vegetative and active vegetation periods.
The precipitation during the rest of the year was 262 mm, 46 mm more than the multiannual average, and in the active period -

172 mm, representing a deviation from an average of 108% over the multiannual average. The annual thermal regime - 11.7^{0}C, with 1.9^{0}C more than the multiannual average. Air humidity was relatively high - 70%.

In the agricultural year 2016-2017, the total amount of precipitation exceeded the previous years by 94 - 102 mm or 143% of the norm, with a multi-annual average deviation of 130%. The annual thermal regime maintained relative to 9.2^{0}C, with -1.5^{0}C less than the multiannual average. The relative humidity of the air was 68% annually.

The agricultural year 2015-2016 was wet and 2016-2017 - very wet according to the annual rainfall recorded at the experimental station.

Fertilization of winter wheat with mineral fertilizers indicates an accumulation of organic mass in the twinning phase. In the 2016 at the control consists 4.1 g per 100 dried plants, on the fertilized variants increased to 7.2-9.3 g/100 plants. In the 2017 year, on the control variant the dry matter consist 4.0 g/100 plants and 6.3-6.7 g on the fertilized variants (Figure 1).

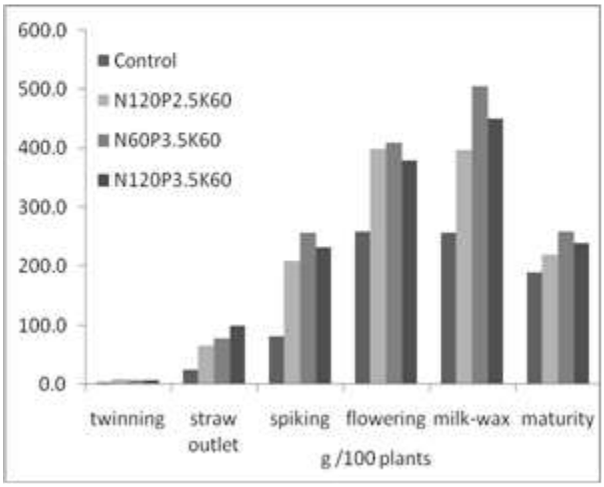

Fig. 1. The mineral fertilizers action on the dry organic mass of winter wheat, 2015-2016.
Source: Own determination.

In the beginning of straw phase the intensive growth and development of winter wheat on fertilizer variants were accumulated on average for 2 years - 2.6-4.3 times more organic mass than at the control variants. At the other development phases of winter wheat plants the difference in the accumulation of biomass quantity was maintained.

During the period with the maximum accumulation, the quantity of dry matter in plants on the control variant was 258.3-397.6 g/100 plants and on the variants N_{60-120} $P_{3.5}K_{60}$ - 408.5-608.6 g/100 plants: 1.5 times more than control variant, 2016-2017 (Figure 2).

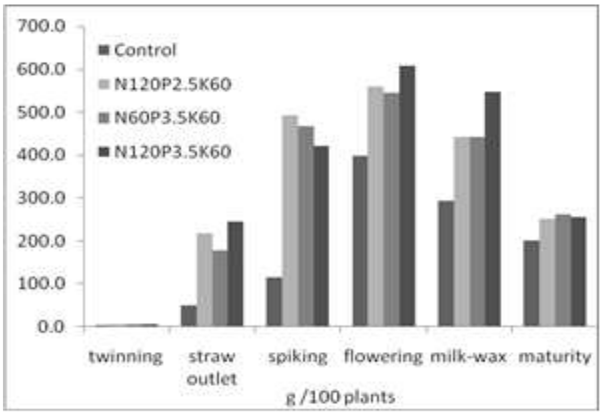

Fig. 2. The mineral fertilizers action on the dry organic mass of winter wheat, 2016-2017.
Source: Own determination.

Recent studies show that the accumulation of dry matter in winter wheat on the control and fertilized variants is analogous to the difference. Mineral fertilizers contribute to increasing the formation and growth of organic matter in plants at the same time [9].

The dynamics of dry matter accumulation in plant organs differ, being closely related to their biology and physiology (Figure 3, 4).

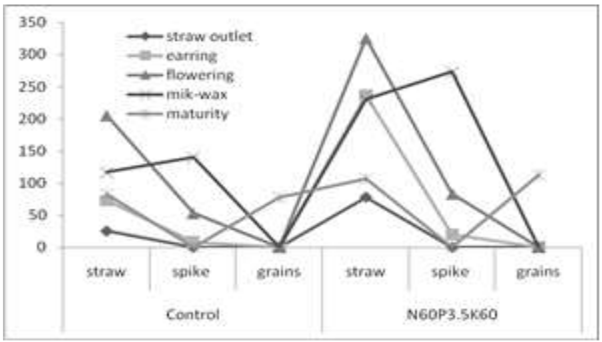

Fig. 3. Dry matter accumulation in the wheat, 2016.
Source: Own determination.

Correlative law in the action of mineral fertilizers on plant organs remains the same. Application of fertilizer in doses of $N_{60}P_{3.5}K_{60}$ has led to an increase in dry matter from 50.5 g to 178.5 g/100 plants in the vegetation period - increased 3.5 times. And when doubling the dose of 120 kg N/ha on the same background, straw weight increased 4.8 times as compared to the control variant.

In the maturity phase of the wheat grains, the total weight of the plants has decreased considerably. The part of the vegetative organs decreased due to the loss of organic bonds to the grains from total dry matter.

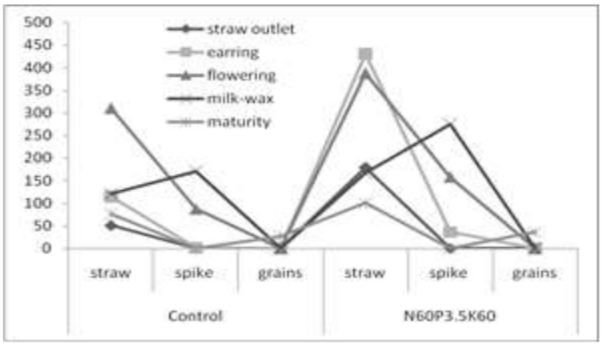

Fig. 4. Dry matter accumulation in the wheat, 2017.
Source: Own determination.

The increase of dry matter mass in the grains is rectilinear, which initially rises very suddenly then insignificantly decreased. At the flowering stage the dry mass accumulates on average was 84-100% of the total mass.

The dry matter mass in the winter wheat grains, from the straw beginning to the flowering phase increases by 2.3-5.2 times. The obtained research data shows that the synthesis process of organic mass during the vegetation period was uneven. From seeding to twining period the wheat plants was developed very poorly.

Table 1. Accumulation of dry matter in winter wheat, % of total, 2016 and 2017

Variant	Twin-ning	Straw out-let	Spi-king	Flower-ing	Waxy-milk	Matu-rity
2016						
Control	1.6	9.8	31.4	100	99.1	73.4
$N_{120}P_{2.5}K_{60}$	2.3	16.6	52.5	100	99.3	54.9
$N_{60}P_{3.5}K_{60}$	1.4	15.5	50.9	81.1	100	51.3
$N_{120}P_{3.5}K_{60}$	1.6	22.0	51.4	84.2	100	53.1
2017						
Control	1.0	12.7	29.0	100	73.6	50.4
$N_{120}P_{2.5}K_{60}$	1.2	39.1	88.3	100	79.2	45.0
$N_{60}P_{3.5}K_{60}$	1.2	32.7	85.5	100	81.1	47.9
$N_{120}P_{3.5}K_{60}$	1.0	40.4	69.1	100	90.0	41.9

Source: Own calculation.

During the twinning phase of plants at different fertilized variants, 1-2% of the dry matter was accumulated (Table 1).

After the twinning phase, when the foliar plant surface was increased, the photo-synthesis process intensified, and the organic mass began to increase. From the straw beginning stage in different variants, the plants synthesized about 22-52% in the year 2016 and 40-88% of organic matter in 2017.

From spiking to flowering phase, the mass of the dry matter continues to grow more intensely with a total maximum in 2017. It should be noted that according to the accumulation of dry matter mass, during the vegetation period the unfertilized plants were very small compared to the fertilized variants with mineral fertilizers.

In particular, in 2017, when the straw step was intensive, the quantity of dry matter in the variant $N_{120}P_{3.5}K_{60}$ was 40%, and in the control variant - 13%, with the maximum accumulation in the flowering phase of plants.

Although the synthesis of organic mass is related to plant genetics [6], winter wheat records indicate an increase in different levels.

The increase of biomass in the ontogenetic stages of root nutrition indicates that with the increase of the fertilizers doses the synthesis of the organic matter takes place faster. That is why mineral fertilizers have influenced the beginning of plant development.

Percentage systematized data allows us to notice that dependence on water supplies in the soil at a 15-25% deficiency below the norm established with the increase in nitrogen doses of 60-120 kg of N/ha on the optimal background of mobile phosphorus - 3.5 mg P_2O_5/100 g of soil, the process of organic mass synthesis continues to the wax-milk phase by accumulating dry matter in grains averaging 16-19%.

Ensuring the soil with sufficient reserves of useful water contributes to a significant increase in the mass of the dry matter. In this way the biomass accumulation process is very dynamic and depends on the plant's genetic potential, ontogenetic changes and growth conditions. The intensive accumulation of dry matter in fertilized plants with mineral fertilizers is determined by their degree of nutrient assurance.

CONCLUSIONS

Research on the accumulation of dry matter reveals the action of mineral fertilizers on six phenological phases. The data presented show that the period from earring phases to flowering, together with increasing nitrogen and phosphorus doses, accumulates 4-5 times more dry matter, than control variant.

Dynamics of dry matter accumulation indicate a sharp increase of 2-5 times the application of 60-120 kg N/ha on $P_{3.5}K_{60}$ background.

At the milk-wax phase and full maturity phase, organic mass losses occur, the accumulation of dry matter over 80% occurs in the wheat grains.

REFERENCES

[1]Andrieș S., 2011. Agrochimia elementelor nutritive, fertilitatea şi ecologia solurilor (Agrochemistry of nutritive elements, soil fertility and ecology) Pontos. Publishing House, Chișinău, 232 pp..

[2]Andrieș S., Rusu Al., *et al*, 2005. Managementul deșeurilor organice, nutrienților și protecția solului. Tipografia centrală. (Management of organic wastes, nutrients and soil protection. Central Publishing House). Chișinău, 6-112.

[3]Ceapoiu, N., 1984, Grâul. Ed. Academiei RSR. (Wheat. The Romania's Academy Publishing House), București, pp. 289.

[4]Lăcătușu, R., 2006, Agrochimie (Agrochemistry). Terra Nostra Publisging House, Iași, 32-385.

[5]Lixandru, G., Caramete, C., 1990, Agrochimie (Agrochemistry). Junimea Publishing House. București, 18-390.

[6]Petniov, G.A., 1959, Physiology of irrigated wheat. Publishing House Kolos. Moscow, 307. (Петниов Г.А., 1959. Физиология орошаемой пшеницы. Изд-во. Колос. Москва, 307).

[7]Pleshkov B.I., 1969, Biochemistry of agricultural plants. Publishing House Kolos. Moscow, 225. (Плешков Б. И., 1969, Биохимия сельско-хозяйственных растений. Изд-во. Колос. Москва, 225).

[8]Robert, P., 1990, Fertile Soil. A Grower's Guide to Organic and Inorganic Fertilizers, agAccess, Davis, California, 191.

[9]Roman, G.V., Ion V., et al, 2006. Fitotehnie – Cereale şi leguminoase pentru boabe (Phytotechnics-Cereals and leguminous plants for grains). Ceres Publishing House, Bucureşti, 300.

[10]Sabinin D. A., 1955, Physiological basis of plant nutrition. Publishing by Academy of Sciences of the USSR. Moscow, 280. (Сабинин Д. А., 1955. Физиологические основы питания растений. Изд-во. АН СССР. Москва, 280).

[11]Vronskikh, M.D., 2016, Reaction of agricultural crops to changes in environmental factors (climate parameters), Publishing House. Notograf Prim, Chisinau, 7-236. (Вронских М.Д., 2016. Реакция селъскохозяйственных културтур на изменения факторов внешней среды (параметры климата), Изд-во. Notograf Prim, Кишинев, 7-236. 554 с.)