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INCREASE OF SOIL MOISTURE CONTENT BY APPLYING POLYMER-MINERAL MATERIAL

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The paper presents the results of using polymer-mineral material (PMM) to retain water in the soil (substrate) in order to increase its moisture content. The substrate, presented by Timiryazev Academy, is a mixture of soil with additives of manure and peat for growing fruit tree seedlings. Various experiments were carried out to determine the moisture content in such a substrate both without additives of PMM and with its addition in various proportions and in different ways. The dynamics of decreasing the moisture content in containers due to filtration and evaporation was measured. Containers with such mixtures were filled with water until the substrate reached its maximum amount then it was analyzed how much water flows from the holes at the bottom of the container and how much evaporates from the surface of this substrate over time. As a result of the experiments, the possibility of obtaining an additional amount of water in the substrate surpassing its moisture content was revealed and it is also shown how this additional amount of water is stored for a long time in comparison with the substrate without PMM which allows not only to accumulate additional moisture but also to reduce the coefficients of filtration and evaporation of the soil.

Key words: water, irrigation, plant, ground, filtration, polymer, additive.

Introduction

Plants will be grown for quite a long time under natural conditions in agriculture often without additional irrigation, so the efficient use of solar energy and moisture from rainfall and groundwater are the most important tasks in many arid regions of the Earth, particularly in Armenia. For normal growth the plants also need water, nutrients, air in addition to light and heat which they receive from the soil and the environment. In particular, solar energy and nutrients in the soil are quite enough for the regions of Armenia, but water problems often arise here. Additional water for plants is necessary not only for more growth and high yield but also just for survival.

High yield of cultivated crops is the most important characteristic of agriculture which influences on their cost price and increases the competitiveness of agricultural production. Water and air in cultivated structural soil provide all the vital processes in plants and the vital activity of great number of microorganisms as well which are in the plants and provide the necessary technological processes for their growing. Therefore, due to lack of water, the productivity of many plant species under rain fed conditions is significantly lower than that in irrigated soils of the same region.

Rain fed lands (rain fed fields, rain fed agriculture) – are lands in the zone of irrigated agriculture on which crops are cultivated without artificial irrigation, i.e. they mainly use moisture which the soil gets in spring. Mostly these lands are located in foothill plains and margins of oases where drought-resistant corn, food and garden plants are grown.

Therefore, in the territories of land where crops are cultivated without artificial irrigation, the use of polymer-mineral material (PMM) will improve the water regime which may lead to increased yields by reducing the root system of grown plants and reducing the coefficients of filtration and soil evaporation. In particular, the use of polymer-mineral material in soil under rainfed conditions will ensure the rapid growth of trees and increase their viability.

Thus, when growing plants are in rainfed conditions, the main reason of the low yield is water shortage, therefore, in the regions of Armenia, where annual rainfall is 250-450 mm, agriculture is carried out by using artificial irrigation. In foothill and mid-mountain zones where the average annual precipitation is 450-650 mm, agriculture is carried out mainly without artificial irrigation. However, often recurring natural disasters such as drought, hail and others, cause serious damage to agriculture, creating the danger of desertification of lands.

The reason for the decrease of moisture in soil in natural conditions is not only the high temperature of the environment and small amount of precipitation, but also human anthropogenic impact. The increase in the capacity of agricultural machinery, the intensity of agriculture, the depth of cultivation and intensified loosening and traditional furrow turning create conditions for soil degradation and thereby difficult conditions for the survival and growth of plants. In this regard, minimal and zero tillage is of great importance using effective agro technical activities such as scientifically based crop rotation, the use of organic fertilizers and ameliorants which not only allow the plant to survive but also produce high yields. At different times, specialists of agriculture often made attempts to quickly improve the physical properties of the soil with the help of various ameliorants in addition to traditional methods [1-6]. The authors of this study consider purposeful to use polymer-mineral material (PMM) as ameliorant which is created by Research Institute of Mechanics of Moscow State University after M.V. Lomonosov.

Conflict settings

The aim of the study is to increase the moisture content of the soil and the possibility of retaining sufficient amount of additional water collected from precipitation and groundwater long before for the purpose of irrigation or sharply reduced irrigation regime of plant growth. The effects obtained from PMM can be used in the cultivation of various plants and will help to increase the productivity, to reduce production costs and to regulate the regime of water in the soil under rain-fed conditions.

Research results

The fertility of the soil depends on its structure, porosity, moisture content and absorption capacity which in its turn depends on the presence of colloidal particles (size 0,0001 mm or less) of organic and mineral origin. The more such particles, the greater the absorption capacity of the soil. Consequently, water and dissolved salts and gases are retained in the soil until the plant picks them up as its nutrition through its root system. A plant inevitably gradually dies in the soil in conditions of water and air deficit despite having a sufficient amount of nutrients. Therefore, it is necessary to provide a sufficient amount of water and air to the pores, which, depending on the type of soil, occupy about half of its volume determined by its moisture content (moisture content is the ability of the soil to accept and retain a certain amount of precipitation water in its fiber holes not allowing the latter to drain).

Moisture content determines the amount of water in substrate at the moment of measuring.

For effective farming medium sized pores (less than 3-5 mm) are desirable in the soil. Then in moist soil water will be stored in small pores and the air which is necessary for respiration of the root system of plants and microorganisms will be kept in large ones. The type of vegetation growing in the soil, relief, the processing system, the presence of winds, surrounding temperature etc. affect the level of soil moisture.

The rate of soil filtration which is characterized by a parameter - the filtration coefficient, also has a significant effect on the level of soil fertility.

Filtration coefficient is a characteristic of soil permeability in relation to certain filtered water; in case of the linear law of filtration it is equal to the rate of water filtration with a unit pressure gradient.

Precipitation fallen to the surface of the earth is absorbed into the soil through large pores and then it is filtered inland through small pores and capillaries surrounding the particles of the earth. In sandy soils the filtration rate is much higher than in alumina. If the soil is rich in calcic compounds, then small particles, especially colloidal ones, stick together with each other forming sufficiently strong porous grains that resist water erosion processes longer. Under natural conditions, medium-sized pores are formed between the grains and such alumina acquire good filtration characteristics. The greater the porosity of the soil is, the more water is placed in it. This amount of water meets the criterion of soil moisture content which should be distinguished from the concept of water-holding ability of soil determined by the content of moisture remaining in the soil after complete water saturation until the final free squeeze.

The property of the soil to retain water by absorption and capillary forces is called water retention capacity. The quantitative characteristics of water holding capacity are the moisture content and potential of soil moisture. The formation of productive moisture content in the soil is associated with water-holding ability. There is always moisture storage in the soil but not all of it is available for plants.

Such important indicators as evaporation, buoyancy force of the soil etc. are also important for cultivated plants.

So, all the physicochemical and biological properties of the soil are important for the growth of various plants which acquire their best indicators in structural soils where there is a sufficient amount of water and air at the same time.

Restoration and preservation of the soil structure is carried out by agro - technical methods and by introducing artificial structure-forming agents into the soil. Agro - technical methods for improving soil structure include: sowing perennial grass, cultivation of ripening soil, liming acidic soils, gypsum treatment of saline soils and applying mineral and especially organic fertilizers.

Traditional methods of preserving soil structure are based on deep tillage using intensive loosening, furrow turning and applying crop rotation and also using fertilizers, treating acid soils with calcic and gypsum treatment of saline soils. However, deep tillage of the soil with the use of intensive loosening and furrow turning leads to its rapid degradation. Nowadays the best conditions for both maintaining and improving soil structure and increasing fertility are created with minimal and zero tillage using scientifically based crop rotation and ameliorants and fertilizers as well.

Therefore, in order to improve the physical properties of the soil for increasing yield and reducing cost price and improving the characteristics of cultivated plants in rainfed conditions as well, the task is set to regulate the water regime in the soil using ameliorants, particularly PMM material. The obtained results can be guaranteed.

Taking into account that it is difficult to ensure equal conditions for experiments in the field conditions, therefore, for obtaining reliable results the studies were carried out indoors at room temperature and humidity (wind, sun and temperature changes can significantly affect the speed of evaporation under natural conditions).

Depending on the method and amount of the ameliorant, the following were determined: soil moisture content and the amount of accumulated water in the substrate over time. The experiments were conducted with soil without vegetation in order to exclude flow of one of the components of the fluid, namely, the moisture consumption by plants for their growth and surviving. In this case only two components were analyzed that affect the dynamics of the accumulated water in the substrate, associated with evaporation and leakage from the bottom of the container with many holes into which the substrate with PMM was placed.

To determine the moisture content of the substrate a container with a mixture of PMM was placed in a bath tube of water to be filled to the maximum limit. The “dry substrate” was weighed in advance. The time for filling fluctuated from 15 minutes to a day. Further the container was placed on a solid surface with holes for out flowing of additional water after which it was weighed according to the difference between the results of measuring the mass of the dry mixture and thus the quantity of maximum (additionally) collected water was determined by soaked mixture.

For example, if a container with a “dry” substrate weighed 315 g in which 15 g is the weight of the container and 300 g is the weight of either a pure substrate or a mixture of a substrate with PMM, then after soaking in a bath tube the container could weigh 450 g. So, the additionally collected water in this case will be 450 - 315 = 135 g. Next, daily measurements of the mass of such substrate in the container were carried out and observations were made until the indicator on the scales again showed a mass approaching the dimension corresponding to the mass of the container with the mixture before the experiment began. The experiments were repeated several times. Below we bring the average measurement indicators that demonstrate the effect of the use of PMM in the substrate.

Let us enumerate the basic variants of mixing the substrate with PMM.

1. Pure substrate without PMM for controlling the measurement of various variants of mixture.
2. Definite amount of PMM equally mixed with substrate by the proportion of 1 to 4 (75 g PMM and 225 g substrate summing up the total weight of 300 g).
3. On the bottom of the container 0,5 or 1 cm layer of PMM was put for reducing the water filtration (the layer of PMM thicker than 2 cm is a good isolator and practically doesn't let water out).
4. Two layered amount: on the bottom of the container we put the layer of substrate mixed with PMM and on the top we put pure substrate without PMM.
5. Multi layered (three layered) packing: on the bottom and top we put the substrate mixed with PMM and between them the pure substrate which provides reduced filtration and evaporation (fluid is poorly evaporated when soaked in PMM).
6. «Slices» (rods made of PMM) with diameter of 0,5 - 1 cm and depth up to 10 cm into the substrate filled with PMM. The amount and sizes of rods are determined by the amount of PMM which is necessary to insert into the substrate for collecting additional badly evaporated water (particularly, 1 g. PMM absorbs up to 1,5 liter water). Diameter of the rod is limited such a way the bigger it is the slower the absorption of moisture is into PMM. Increasing the amount of rods in their optimal fixed diameter leads to the increase of the surface for water absorption. On the top the rods are covered by the layer of substrate.

Let us note that the mixture of the substrate with PMM has the property of multiple use and is not washed out with water (repeatedly watering or growing of new plants is possible in this mixture), a small concentration of PMM in the substrate should not lead to fading of the plant due to extra moisture, pores must be left in the substrate for air (minimum watering).

Results of experiments

Amount of water accumulated by the substrate in the container is determined as difference between the mass of the container with substrate at the time of measuring and the mass of the container before starting its soaking into the water in bath tube.

Relative moisture content in the container is calculated as the relation of water amount to initial "dry" mass of substrate before it is wetted in the bath tube which is shown in percents.

1 experiment

300 g pure substrate is wetted at room temperature in the bath tube during 10-15 min. Total weight of accumulated water with soil comprised 430 g i.e. we additionally have 130 g of water. The results of the experiment are shown in Table 1.

Table 1

Days	0	1	2	3	4	5	6	14	17	18	20
Water amount, g	130	100	90	85	80	75	70	40	30	25	0
Relative moisture content, %	43,33	33,33	30,00	28,33	26,67	25,00	23,33	13,33	10,00	8,33	0,00

Conclusion 1: The substrate absorbed an additional 130 g. water to the one that was before the experiment. The water completely evaporated and flowed out of the container in about 20 days (measurement accuracy of 1 gram, measurements were rounded to 5 grams). Obviously, in a container with a seedling, the amount of water would have decreased faster due to consumption for its life.

2 experiment

A container weighing 20 g filled with a mixture of a total mass of 300 g, containing a substrate of 225 g mixed with 75 g PMM, after wetting in a bath tube with water for 15 minutes weighed 470 g, hence, the mass of additionally collected water is: 470 - 300 - 20 = 150 g. Thus, compared with experiment 1, 75 g PMM replacing 75 g substrate absorbed 20 g more water. The results of experiment are shown in Table 2.

Table 2

Days	0	1	2	3	4	5	6	14	17	18	20
Water amount, g	150	135	130	125	120	115	110	65	50	45	40
Relative moisture content, %	50,00	45,00	43,33	41,67	40,00	38,33	36,67	21,67	16,67	15,00	13,33

Conclusion 2: Mixture of substrate with PMM collected 20 g water more than without PMM and then after 20 days it kept 40 g more water which is badly evaporated and may be used for nourishing the plants.

3 experiment

We take two containers, put 25 g PMM on the bottom of the first container (approximately 0,5 cm thick layer) and a substrate of 275 g was poured on top (total weight is 300 g.), weight of container is 15 g (total weight is 315 g. before watering) and put 50 g PMM on the bottom of the second container (layer is about 1 cm thick). Then both containers were placed in a bath tube with water. The results of the experiment are shown in Tables 3 and 4.

Table 3

Days	0	1	2	3	4	5	6	14	17	18	20
Water amount, g	130	115	110	108	105	100	95	70	60	55	50
Relative moisture content, %	43,33	38,33	36,67	36,00	35,00	33,33	31,67	23,33	20,00	18,33	16,67

Table 4

Days	0	1	2	3	4	5	6	14	17	18	20
Water amount, g	145	125	120	115	110	105	100	70	60	55	50
Relative moisture content, %	48,33	41,67	40,00	38,33	36,67	35,00	33,33	23,33	20,00	18,33	16,67

Conclusion 3: The size of the PMM layer of 0,5 cm or 1 cm practically does not affect the amount of stored water at the end (50 g.) and in order to save PMM it can be put even less. Besides, at the beginning more water was collected where there was a layer of 1 cm. This is due to a decrease in filtration. The evaporation process prevailed over the process of filtration and water changes in the first and second cases over time mainly depended on evaporation and they turned out to be equal. Comparing these results with the first and second experiments, we can conclude that a relatively small amount of PMM laid on the bottom (25 and 50 g) allows us to save more water for longer time (50 g) than 75 g PMM mixed with a substrate (40 gr. water). For saving in the costs for PMM, we can put its even thinner layer with thickness of 1 to 3 mm. (for example, in the form of a cartridge of PMM between two layers of paper laid on the bottom of the container).

4 experiment

40 g PMM mixed with 120 g substrate (total 160 g.) was put on the bottom of the container and 150 g substrate was poured on top (weight of the mass is 310 g, weight of container is 20 g), total weight is 330 g which is the weight of the container with the mixture before irrigation. The container

was placed in a bath tube filled with water for 15 minutes. The weight of the container was 465 g from which 135 g is the amount of additional water. The results of the experiment are shown in Table 5.

Table 5

Days	0	1	2	3	4	5	6	14	17	18	20
Water amount, g	135	120	115	110	105	100	95	70	60	55	50
Relative moisture content, %	45,00	40,00	38,33	36,67	35,00	33,33	31,67	23,33	20,00	18,33	16,67

Conclusion 4: Two-layer substrate (bottom layer of a mixture of PMM and substrate in a ratio of 1: 4 and top layer of a substrate of 150 g) allows us to collect additional water on one hand and reduces the filtration coefficient on the other hand compared to options 2 and 4 and allows us to save the amount of PMM and save an additional 50 g water even after 20 days.

5 experiment

Three-layer substrate: 40 g PMM is mixed with 120 g substrate and the resulting mixture is laid at the bottom and on the top inside the container for 80 g each layer and between them there is a layer of 150 g substrate. Before watering the weight of the container is 330 g 20 g of which is the weight of the container and 310 g mass of the mixture. After soaking, the weight of the container was 480 g 150 g of which is added water. The results of the experiment are shown in Table 6.

Table 6

Days	0	1	2	3	4	5	6	14	17	18	20
Water amount, g	150	125	120	115	110	105	100	75	65	65	60
Relative moisture content, %	50,00	41,67	40,00	38,33	36,67	35,00	33,33	25,00	21,67	21,67	20,00

Conclusion 5: Three-layer mixture is obtained where the bottom and top layer of the mixture with PMM allows us to collect more water, to reduce evaporation and filtration and after 20 days save an additional 60 g water at the same waste of PMM (40 g).

6 experiment

520 g substrate is put in the container weighing 45 g where PMM is put in four slices of 80 g with 0,5 cm diameter (20 g each). Total weight of the container is 645 g. After filling it with water during 15 minutes the weight becomes 980 g from which the weight of added water is 335 g. The results of the experiment is shown in Table 7.

Table 7

Days	0	1	2	3	4	5	6	14	17	18	20
Water amount, g	335	290	275	260	245	225	215	120	90	70	65
Relative moisture content, %	55,83	48,33	45,83	43,33	40,83	37,5	35,83	20	15	11,67	10,83

Conclusion 6: The version of the container with 80 g PMM with four holes after 20 days retained an additional 65 g. water and around the holes the substrate is almost dry as before the experiment. This option can be used for already planted trees or perennials by making holes in the ground or in a container with PMM holes.

Conclusion

Mixing PMM with the substrate and laying it on the bottom of the container and in the holes inside the substrate as well allows us to save more water thereby increasing moisture content, to reduce evaporation from the surface of the substrate and filtration through the bottom of the container.

These experiments must be carried out together with various plants which will allow to determine the optimal amount of PMM for a particular plant taking into account the possibility of irrigation or rainfall and other climatic conditions for its growth both indoors and in natural conditions.

References

1. Качинский Н.А. О влажности почвы и методах её изучения /М:, «Новая деревня», 1923, 40с.
2. Tokmajyan V.H., Markosyan A.Kh., Khalatyan A.A., Khachatryan N.B. The Perspectives Of Providing The Storage Of Irrigation Water In The Case Of Using Water Collecting Additives In The Ground // Bulletin of high technology, Shushi , N 2 (6) /2018, p. 9-14.
3. Danilova T.N., Regulation of the water regime of grainy sandy loam soils and moisture supply of plants with the help of water-absorbing polymers. Agro physics, 2016, № 1, p. 8-16.
4. Hydrogel and plants //floweryvale.ru/houseplants/hydrogel-and-plants.html
5. Forms of water in the soil //http://mse-online.ru/pochva/formy-vody-v-pochve.html
6. Terleev V.V., Topaj A.G., Mirshel V., Gourin P.D., Modeling of water-retaining capacity of soil on the basis of concepts of capillary hysteresis and lognormal pore size distribution //theory of Agro physics, S.P. (b), 2014, N1(13), p. 9-18.

References

1. Kachinskiy N.A., About the humidity of the soil and the methods of its study /M:, «New village», 1923, 40 p.
2. Tokmajyan V.H., Markosyan A.Kh., Khalatyan A.A., Khachatryan N.B. The perspectives of providing the storage of irrigation water in the case of using water collecting additives in the ground // Bulletin of high technology, Shushi , N 2 (6) /2018, p. 9-14.
3. Danilova T.N., Regulation of the water regime of grainy sandy loam soils and moisture supply of plants with the help of water-absorbing polymers. Agro physics, 2016, № 1, p. 8-16.
4. Hydrogel and plants //floweryvale.ru/houseplants/hydrogel-and-plants.html
5. Forms of water in the soil //http://mse-online.ru/pochva/formy-vody-v-pochve.html
6. Terleev V.V., Topaj A.G., Mirshel V., Gourin P.D., Modeling of water-retaining capacity of soil on the basis of concepts of capillary hysteresis and lognormal pore size distribution //theory of Agro physics, S.P. (b), 2014, N1(13), p. 9-18.

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ՀՈՂԻ ՋՐԱՏԱՐՈՂԱԿԱՆՈՒԹՅԱՆ ԱՎԵԼԱՑՈՒՄԸ ՊՈԼԻՄԵՐԱՀԱՆՔԱՅԻՆ ՆՅՈՒԹԻ ՕԳՆՈՒԹՅԱՄԲ

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[1]Լոմոնոսովի անվան Մոսկվայի պետական համալսարան
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[3]Ճարտարապետության և շինարարության Հայաստանի ազգային համալսարան

Հոդվածում բերվում են հողի ջրատարողունակության բարձրացման նպատակով, պոլիմերահանքային նյութի օգտագործման միջոցով ջուրը այնտեղ պահելուն ուղղված հետազոտությունների արդյունքները: Տիմիրյազևյան ակադեմիայի կողմից ներկայացված, մրգատու ծառերի տնկիների աճեցման սուբստրատը՝ հողի, օրգանական պարարտանյութի (գոմաղբ) և տորֆի խառնուրդ է: Իրականացվել են բազմաթիվ փորձեր, այդպիսի սուբստրատի ջրատարողունակության որոշման ուղղությամբ, ինչպես պոլիմերահանքային նյութի, տարբեր չափերով և եղանակներով, օգտագործմամբ, այնպես էլ՝ առանց դրա: Բեռնարկղերում չափվել է սուստրատում ջրի քանակի վրա, ֆիլտրացիայի և գոլորշիացման ազդեցության դինամիկան: Բեռնարկղերը հագեցվում էին ջրով, մինչև սուբստրատի առավելագույն ծավալի ստացումը, այնուհետև վերլուծվում էր, թե ինչքան ջուր է հոսել բեռնարկղի հատակի անցքերից և ժամանակի ընթացքում, ինչքան է կազմում գոլորշիացումը: Կատարված հետազոտությունների արդյունքում, բացահայտվել է, սուբստրատում, պոլիմերահանքային նյութի օգտագործման դեպքում, ջրի լրացուցիչ ծավալ կուտակելու և ըստ ժամանակի, դրա պահպանման հնարավորությունը: Պոլիմերահանքային նյութի օգտագործման հետևանքով, նաև փոքրանում է հողի ֆիլտրացիայի գործակիցը և գոլորշիացման ծավալը:

Բանալի բառեր. ջուր, ոռոգում, բույս, հող, ֆիլտրացիա, պոլիմեր, լցանյութ:

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УВЕЛИЧЕНИЕ ВЛАГОЕМКОСТИ ПОЧВЫ С ПОМОЩЬЮ ПОЛИМЕРНО-МИНЕРАЛЬНОГО МАТЕРИАЛА

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В работе приведены результаты использования полимерно-минерального материала (ПММ) для удержания воды в почве (субстрате) с целью повышения его влагоемкости. Субстрат для выращивания саженцев фруктовых деревьев, предоставленный Тимирязевской академией, представляет собой смесь из почвы с добавками навоза и торфа. Проводились различные эксперименты по определению влагоемкости воды в таком субстрате, как без добавок ПММ, так и с его добавлением в различных пропорциях и разными способами. Измерялась динамика уменьшения влагосодержания в контейнерах за счет фильтрации и испарения. Контейнеры с такими смесями наполнялись водой, до достижения субстратом максимального объема, далее анализировалось сколько воды вытекает из отверстий на дне контейнера и сколько испаряется с поверхности этого субстрата во времени. В результате проведенных экспериментов выявлена возможность получения дополнительного объема воды в субстрате сверх его влагоемкости, а также показано как этот дополнительный объем воды сохраняется продолжительное время, по сравнения с субстратом без ПММ, который позволяет не только аккумулировать дополнительную влагу, но и понизить коэффициенты фильтрации и испарения почвы.

Ключевые слова: вода, орошение, растение, грунт, фильтрация, полимер, добавка.

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