Influence of carboxy methyl cellulose (CMC) colloid on irrigation frequency of planting material with a closed root system

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Abstract. This article discusses the impact of different amounts of carboxymethyl cellulose (CMC) colloid on the frequency of watering seedlings with a closed root system in containers. The study found that increasing the CMC dose from 0.05% to 2.0% of the dry soil mass resulted in a decrease in the number of irrigations per month during summer from 5-6 to 2-3, an increase in the frequency from 5-6 to 11-16 days, and a reduction in the volume of irrigation water per container from 3700 cm^3 to 2250 cm^3 during the growing season. However, it should be noted that doses higher than 0.4% resulted in the formation of a thick soil crust in the containers, which negatively affected seed germination and plant growth.

1. Introduction

The mountainous regions of the Republic of Uzbekistan currently require an increase in forested areas on the slopes to improve the environmental condition. Over the past few decades, there has been excessive exploitation of woods and surrounding open areas, which has resulted in abnormal grazing, tree and shrub cutting for firewood and fencing plots, and a mass collection of fruits, medicinal and ornamental herbs, and hay. This has led to a significant reduction in already small forest areas, exposing the soil cover to vegetation and causing an increase in water erosion of soils. Consequently, the natural regeneration of the forest has been disturbed or stopped [1, 2]. For this reason, it became necessary to artificially restore forests on mountain slopes and expand forest areas on currently unforested slopes to enhance the environmental condition. However, in the conditions of the Central Asian region, the creation of artificial forests is challenging due to the peculiarities of the climate.

The region has a sharply continental Mediterranean climate, characterized by significant variations in temperature between summer and winter. However, the precipitation regime is unfavorable for vegetation since most of it occurs during the winter-spring period [1, 2]. During the summer, there is hardly any rainfall, which, combined with high air temperatures, makes it challenging for trees to survive and grow on the slopes.

Each year, there is a significant loss of planted trees, resulting in additional planting and higher costs for forest plantations. In this regard, the urgent task is to develop new ways to create forest plantations on mountain slopes, which can increase the survival rate and improve the growth of planted trees [3].

A promising solution to this issue is the use of artificial preparations. These can be added to the soil when planting seedlings and help to retain moisture that has accumulated during the winter, reducing its physical evaporation. This moisture can then be used by the plants for their nutrition during dry periods [3-8].

One such chemical is carboxymethyl cellulose (CMC), which, when water is added, forms a colloid that retains moisture well. There is already experience described in the literature of using this colloid in agriculture by adding it to the soil when growing field crops, where it showed a positive effect [3, 9, 10, 11]. However, in forestry in the conditions of Central Asia, this drug was not used when planting forest crops and needed preliminary testing. It was important to determine the appropriate dosage of hydrogel that would provide optimal results while being cost-

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effective [1]. To achieve this, an experiment was conducted to gauge the water absorption capacity of CMC in polyethylene containers when growing forest crop seedlings.

2. Methods

The research methodology was based on the principle of studying the rate of physical evaporation of soil moisture at different doses of CMC colloid, which helps to bind and retain moisture in the soil. The experiment took place in a greenhouse with equal air conditions for all options. The soil substrate used in the experiment followed the recommendations for growing planting material for woody plants [1]. For this, 70% of ordinary gray earth soil was mixed with 30% of completely rotted sheep manure. The prepared soil substrate, after preliminary mixing with different doses of the colloid planned for the study, was placed in the recommended polyethylene containers 15x20 cm in size and compacted. The experiment was carried out in the autumn-winter period. Woody plant seedlings were cultivated in containers.

The rate of soil moisture consumption was studied by determining the number of days between irrigations, which was determined by the interval between the mass of soil in containers with plantings after irrigation at the lowest moisture capacity, optimal for plant growth, which is 70% of the field moisture capacity (FMC) and its mass at a moisture content that reached 15 % of FMC, exceeding the wilting moisture by 6-7%, previously determined empirically for the soil with which the containers were filled. After that, another watering was carried out. The mass of containers at 70% and 15% humidity from the FMC was determined before the experiment [12].

There has been no experience using CMC colloid in growing planting material in containers, and its recommended use for growing field crops is from 0.02 to 0.7% of the soil mass [3]. Therefore, to determine the optimal dose of colloid application, we included various doses in the experiment - 0.05; 0.1; 0.2; 0.4; 0.8; 1.0, and 2.0% of the dry weight of the soil, which filled the containers, which was 2000 g. In the experiment as a control, the variant without applying colloid was included. Irrigation of seedlings was carried out by sprinkling. Each variant of the experiment was carried out in ten repetitions. Weighing was carried out daily. At the same time, all the dates of irrigation were recorded for each variant of the experiment, according to which the rate of moisture consumption was determined. The results of the experiment are presented in the table.

3. Results and Discussion

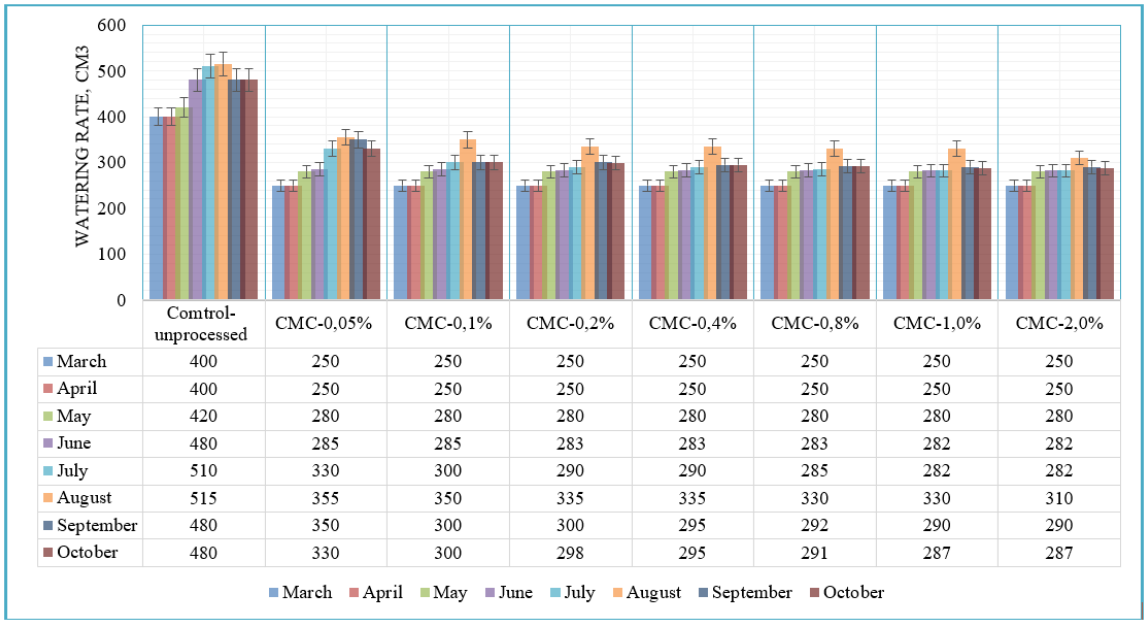
According to the experiment's findings, when the doses of CMC application are increased, the time for watering the soil decreases from 11-16 days and the watering rate reduces from 1255-1392 cm3 in comparison to the control. The highest watering frequency for seedlings was observed during the summer months (July-August) in the control group. In March and April, the number of waterings was 2-4 times, which then increased to 6-7 times per month by the end of the growing season (as shown in Table 1).

Table 1. Frequency of soil irrigation in containers at different doses of CMC in 2012-2015

Options	March	April	May	June	July	August	September	October
	Watering period							
Control - unprocessed	2 times a month (15 and 24 dates)	4 times a month (01, 06, 13, 19, 25 dates)	5 times a month (03,08,13,19, 26, dates)	5 times a month (01, 08, 15, 22, 29, dates)	6 times a month (01,06,11,17, 21,27 dates)	6 times a month (01,06,11, 17,21, 27 dates)	5 times a month (03,10,16,23, 29 dates)	5 times a month (01,09, 16,23,28 dates)
0,05% dose of CMC	2 times a month (15,24 dates)	3 times a month (05, 15,26 dates)	4 times a month (02 10,18,29 dates)	4 times a month (01, 08, 18, 29 dates)	4 times a month (03,12,20,28 dates)	5 times a month (02, 10, 17, 24, 29 dates)	4 times a month (05, 13,21, 27 dates)	4 times a month (04, 13,21,29 dates)
0,1% dose of CMC	2 times a month (15, 24 dates)	3 times a month (07, 18, 28 dates)	4 times a month (04,12, 21, 29 dates)	4 times a month (03, 12,21, 30 dates)	4 times a month (01, 10, 19, 28 dates)	5 times a month (02, 08, 13,, 20, 28, dates)	4 times a month (06, 15, 23, 29 dates)	4 times a month (02, 11, 21,28 dates)
0,2% dose of CMC	2 times a month (15,24 dates)	3 times a month (08, 21, 29 dates)	3 times a month (03, 18, 28 dates)	3 times a month (03, 14,25 dates)	3 times a month (02, 13, 24, dates)	4 times a month (03, 14,23,29 dates)	3 times a month (03, 14,25)	3 times a month (03, 14, 26 dates)
0,4% dose of CMC	2 times a month (15,24 dates)	3 times a month (08, 22, 28 dates)	3 times a month (06, 20, 30 dates)	3 times a month (04, 16, 28 dates)	3 times a month (03, 15,27 dates)	4 times a month (05, 12, 21, 28 dates)	3 times a month (04, 17, 29 dates)	3 times a month (04, 17, 28 dates),
0,8% dose of CMC	2 times a month (15, 24 dates)	3 times a month (09,21, 29, dates)	3 times a month (09, 22, 30, dates)	3 times a month (05, 18, 29, dates)	3 times a month (04, 17,30 dates)	3 times a month (04,16,26,28 dates)	3 times a month (05, 19, 30 dates)	3 times a month (06, 18, 29 dates)
1,0% dose of CMC	2 times a month (15,24 dates)	3 times a month (09, 21, 29 dates)	3 times a month (08, 21,29, dates)	2 times a month (07, 25, dates)	2 times a month (09,25, dates)	2 times a month (07, 23, dates)	2 times a month (09, 24, dates)	2 раза в месяц (10, 26 dates)
2,0% dose of CMC	2 times a month (15, 24 dates)	3 times a month (09, 21,29 dates)	3 times a month (08, 21,29, dates)	2 times a month (07, 25, dates)	2 times a month (05, 23, dates)	2 times a month 08,25, dates)	2 times a month (10, 27 dates)	2 times a month (06,24, dates)

When the CMC dose was increased from 0.8% to 2.0%, the number of irrigations decreased by 2-3 times compared to other experiment variants (according to Table 1). However, it was observed that even at a low dose of 0.4%, applying CMC resulted in the formation of a thick soil crust, which negatively impacted both seed germination and plant growth. The rate of each watering per container increased on the control variant from 400 cm^3 in April to 515 cm3 in August, while when CMC was applied, it was from 250 cm^3 to 300 cm^3 over the same period. The total water consumption for irrigation during the growing season decreased from 3685 cm^3 in the control to 2231 cm3 with the introduction of 2.0% CMC (Figures 1 and 2).

According to the experiment, the optimal amount to apply is 0.2% of the dry soil's mass. This amount helps to keep the soil moist enough to provide plants with the necessary nutrients. In the summer, this amount allows containers to go without watering for 11-12 days. In comparison, without CMC, the containers needed to be watered every 6-7 days.



	Comtrol-unprocessed	CMC-0,05%	CMC-0,1%	CMC-0,2%	CMC-0,4%	CMC-0,8%	CMC-1,0%	CMC-2,0%
March	400	250	250	250	250	250	250	250
April	400	250	250	250	250	250	250	250
May	420	280	280	280	280	280	280	280
June	480	285	285	283	283	283	282	282
July	510	330	300	290	290	285	282	282
August	515	355	350	335	335	330	330	310
September	480	350	300	300	295	292	290	290
October	480	330	300	298	295	291	287	287

March April May June July August September October

Fig. 1. Dynamics of the irrigation rate of forest seedlings with a closed root system in containers during the growing season, cm ^{3}

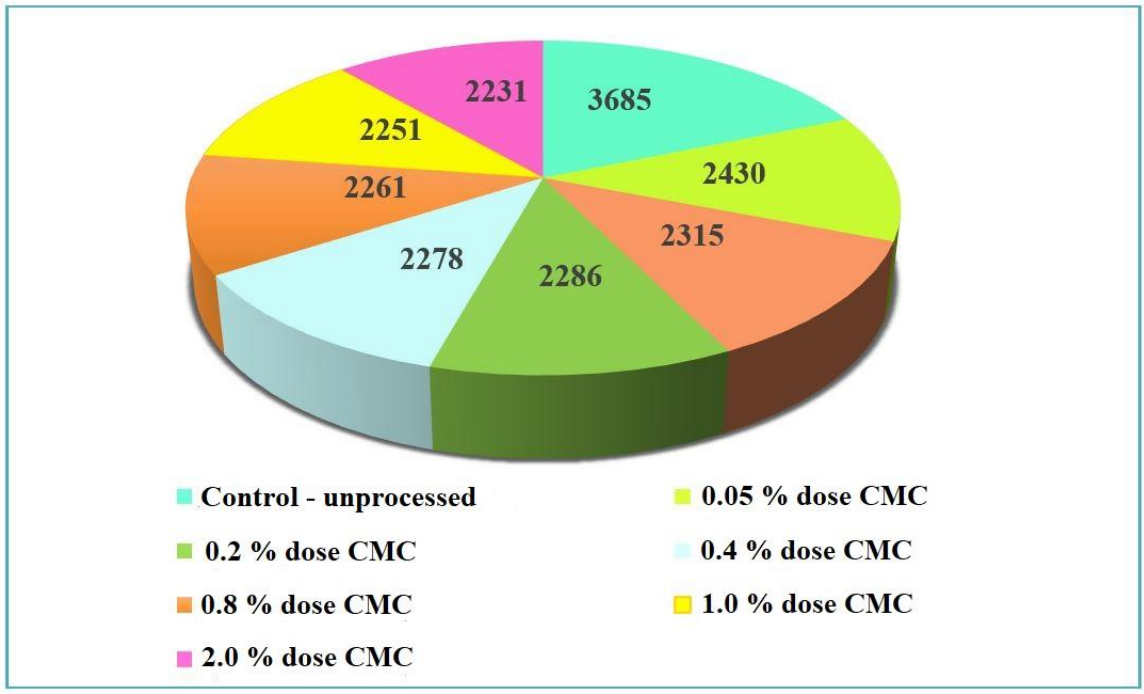


Fig. 2. The general rate of irrigation in the growing season, cm^3

4. Conclusion

From the results of the studies, it can be concluded that with an increase in the dose of CMC hydrogel from 0.05; 0.1; 0.2; 0.4; 0.8; 1.0, and 2.0% of the norm of the dry weight of the soil can reduce the amount of watering the soil

in containers in each month up to 2-3 times compared to the control without soil additives, where the frequency of watering is 6-7 once.

The most frequent watering is observed in the summer period (July-August) when the timing is 1.2-3.0 times more often than the initial growing season (March, April, May).

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