Artículo de investigación

Sustainability of Soil Moisture and Reduce Fertilizer Soaking Using Nature-Friendly Hydrogels to Improve and Promote Cultivating

Sostenibilidad de la humedad del suelo y reducción del empapado de fertilizante con hidrogeles amigables con la naturaleza para mejorar y promover el cultivo

Sustentabilidade da Umidade do Solo e Redução da Absorção de Fertilizantes Utilizando Hidrogéis Amigáveis à Natureza para Melhorar e Promover o Cultivo

Recibido: 10 de mayo de 2018. Aceptado: 11 de junio de 2018

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Abstract

In order to investigate the water requirement of plants, especially in arid and desert areas and the poverty of most soils in these areas, we conducted a pot experiment to study the effect of the absorbance hydrophilic polymer on Panicum antidotale Retz. with its effect on nitrogen leaching in three types of light, medium and heavy soils in irrigation intervals of 4, 8 and 12 days. Comparison of results with control treatment showed that application of polymer that was carried out at 0.3% has the highest effect on the growth and dry matter production of Panicum antidotale Retz.The simple effect of polymer treatments, the irrigation interval and the soil texture on dry matter production, plant height, and nitrogen leaching from the soil were significant in this study. Also, the interaction effects of irrigation × soil texture on dry matter production, and nitrogen leaching showed a significant difference. So that the highest amount of dry matter of plant with 7.2 g was obtained from medium treatment with polymer in irrigation interval of 4 days. In the control treatment without the polymer, the plants were destroyed before harvest in the irrigation interval of 12 days. The effect of treatments on Panicum height indicated that the addition of polymer to the soil would increase the height of the Panicum besides increasing dry matter production. Also, the effect of simple polymer in irrigation water drain indicated that the nitrogen leaching rate from the average of 880 mg N/l of in the control decreases to about 550 mg N/l by the polymer.

Resumen

Para investigar el requerimiento de agua de las plantas, especialmente en áreas áridas y desérticas debido a la pobreza de la mayoría de los suelos en estas áreas, llevamos a cabo un experimento para estudiar el efecto del polímero hidrofílico de absorbancia en Panicum antidotale Retz. Con su efecto sobre la lixiviación con nitrógeno en tres tipos de suelos ligeros, medios y pesados en intervalos de riego de 4, 8 y 12 días. La comparación de los resultados con el tratamiento de control mostró que la aplicación de polímero que se llevó a cabo al 0,3% tiene el mayor efecto sobre el crecimiento y la producción de materia seca de Panicum antidotale Retz. El efecto simple de los tratamientos con polímeros, el intervalo de riego y la textura del suelo en seco La producción de materia, la altura de la planta y la lixiviación de nitrógeno del suelo fueron importantes en este estudio. Además, los efectos de interacción del riego por la textura del suelo en la producción de materia seca y la lixiviación con nitrógeno mostraron una diferencia significativa. De modo que la mayor cantidad de materia seca de la planta con 7,2 g se obtuvo a partir de un tratamiento medio con polímero en un intervalo de riego de 4 días. En el tratamiento de control sin el polímero, las plantas se destruyeron antes de la cosecha en el intervalo de riego de 12 días. El efecto de los tratamientos en la altura de Panicum indicó que la adición de polímero al suelo aumentaría la altura del Panicum además de aumentar la producción de materia seca.

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Therefore, it can be concluded that application of polymer not only influences soil moisture but also affects soil strengthening and decreasing nitrogen leaching, especially in desert poor soils.

Keywords: Hydrophilic polymer; Irrigation interval; Soil texture; Nitrogen leaching, Panicum

Además, el efecto del polímero simple en el drenaje de agua de riego indicó que la tasa de lixiviación de nitrógeno de la media de 880 mg N / l de en el control disminuye a aproximadamente 550 mg N / l por el polímero. Por lo tanto, se puede concluir que la aplicación de polímeros no solo influye en la humedad del suelo, sino que también afecta el fortalecimiento del suelo y la disminución de la lixiviación de nitrógeno, especialmente en suelos pobres del desierto.

Palabras claves: polímero hidrófilo; Intervalo de riego; Textura de la tierra; Lixiviación De Nitrógeno, Panicum.

Resumo

Para investigar o requerimento de água das plantas, especialmente em áreas áridas e desérmicas debilitadas à pobreza da maioria dos campos nestas áreas, será realizado um processo experimental para o estudo do efeito do polímero hidrófilo de absorventes no Panicum antidotale Retz. Com efeito sobre a lixiviación con nitrógeno en tres tipos de suelos ligeros, medios e pesados em intervalos de riego de 4, 8 y 12 días. A comparação dos resultados com o tratamento de controle é aquela que a aplicação de polímeros que determinam o desempenho de 0,3% do efeito potencial sobre a produção e a produção de matéria seca de Panicum antidotale Retz. O simples efeito dos tratamientos com polímeros, o intervalo de riego e a textura do suelo em seco A produção de materiais, a altura da planta e a lixiviação do nitrogênio do solo são importantes neste estudio. Además, os efeitos de interacção do riego pela textura do suelo na produção de materia seca e a lixiviación com nitrogénio mostram uma forma significativa. De modo que o maior município de materia seca da planta com 7,2 g se obtém a partir de um tratamento médio com polímero num intervalo de tempo de 4 dias. No tratamento do controle do polímero, as plantas se destroem antes da cura no intervalo de idade de 12 dias. O efeito dos tratamiento na altura de Panicum indicou que a adición de um polímero ao crescimento aumentou a altura do crescimento e aumentou a produção de materia seca. Además, o efeito do polímero simples na drenaje de água de riego indicou que a lixiviación de nitrogênio dos media de 880 mg N / l no controle disminuye aproximadamente 550 mg N / l por o polímero. Por isso, pode-se até agora que a aplicação de polímeros não influencie o solo na humildade do crescimento, mas também tenha o poder do crescimento e a eliminação da lixiviação do nitrogênio, especialmente nos males do prazer.

Palavras-chave: polímero hidrófilo; Intervalo de Riego; Textura da Terra; Lixiviación De Nitrógeno, Panicum.

Introduction

Increasing drought or water scarcity conditions has led to the use of soil moisture supply methods to increase soil moisture sustainability in plant production, especially in arid and desert areas.In these soils – especially in light soils due to the texture characteristics and potential weakness of water storage capacity on the one hand and, and the enhancement of soil fertility on the other hand -,in order to prevent water and nutrient losses, the use of natural or artificial absorbent materials is very important. Green manure, planting soil (mulch), perlite, straw, and litter are common natural absorbent materials. Also, Plant Bac is very useful to supply and store moisture in the soil. Of synthetic materials, super absorbent polymers can be mentioned here. Superabsorbent polymers according to the introduction of the manufacturing company, have the capacity to store as much as 100 to 1000 times the weight of the water and supply it to the plant when it is needed; and also prevent leaching of soil nutrients during irrigation. The use of superabsorbent polymers has been studied in many research projects in arid regions (Robiul Islam 2011), but the history of research in relation to polymers dates back to the 1960s (Yousefian et al., 2018). Since 2000, countries in the arid regions, such as the Middle East, South

America and African countries have been trying to find out more about this matter. In Iran, the use of gravitational materials does not have a long history, but recently, more attention has been paid to the use of these materials. The plant is still able to survive after 30 days, if we use 400 ml polymer in the last irrigation. However, in the control treatment, wilting symptoms in the same amount of water appear only after 15 days in the plant (Tongo et al., 2014). Polymer treatment, without irrigation, was again able to supply water for one month and if the amount of irrigation is upgraded to 800 milliliters, the polymer will provide water storage for plant consumption for 40 days. It recommends the use of a polymer in desert and dry areas to provide water for plant. Mignon et al., (2016) recommends the use of superabsorbent polymers for poor soils in dry areas. Adding the polymer to light soils increases the water holding capacity of these soils and subsequently increases the amount of water available in the soil for the plants (Rahbarand Banedjschafie, 2009). Addition of polymer in the ratio of 0.03% and 0.07% in addition to increasing the water efficiency will increase the production of soybean (Narjary andAggarwal, 2014). Performance and plant growth indices are affected by the use of hydrogel for the cucumber.

METHOD

This pot experiment conducted during the growing season in 2017 for one year at the Institute of Forest and Rangeland Research. Three main control treatments including:

-Three main irrigation treatments (A) including a_1(4-days irrigation), a_2(8-days irrigation), and a_3(12-day irrigation)
-Three sub-soil texture treatments (B): b_1 (light soils), b_2 (medium soils), and b_3 (heavy soils)
-Two subordinate sub-treatments (C): c_0 (soil without polymer or control), c_1 (soil mixed with polymer)

According to the above structure, this experiment was conducted in 72 pots in a completely randomized way in the form of a split plot design. The polymer was made by the Iranian Polymer Institute, and the polymer was mixed with in the treatments with 0.3% percent of its weight. The seeds of Panicum were provided by the Gene Bank of the Institute. After determining the viability, four seeds were cultivated in each 4.0 liter pot. After sufficient assurance of seed germination, only one seedling was kept and the rest was removed. The amount of water given to the pots at each irrigation interval was as much as the capacity of the soil. Ammonium nitrate fertilizer was used to investigate the role of polymer in preserving and preventing leaching of nitrogen fertilizer. In each pot, ammonium nitrate fertilizer was soluble in irrigation water in two stages with 0.3 g N / L concentration at the beginning of plant growth, and 0.9 g N / L in the critical stage of plant growth. To determine the amount of nitrogen produced by leaching in each pot, it was necessary that irrigation during drainage was sufficient to provide about 80-50 ml of drainage. After fertilization, the sampling was done from the drainage of pots which was 4 times more than collecting drainage. In order to ensure that other nutrients were sufficient, at the beginning of the experiment and at the time of preparation, phosphorus and potassium were added to the test soil. Finck (1992) advices were used to determine the amount of fertilizer. Table 1 indicates the characteristics of the soils.

Adding the stacosorb hydrogel to the soil can improve the capability of soils and other growing media to retain water and plant nutrients. ZangoeiNasab (2012) indicated that the maximum effect of polymer was obtained from 0.4% polymer content and most of the indices did not have a significant difference with the consumption level of 0.3% of the polymer. In addition to its effect on plant growth, the polymer also increased some of the soil physical properties such as soil saturation and moisture content of the plant. Kabiri et al., (2011) indicated that the use of superabsorbent polymers and bio fertilizer increased the yield of corn under two irrigation conditions, when the soil moisture was 75% and 40%. Benettet al., (2015) studied the effect of polymer mixing on soil and its effect on nitrogen leaching from soil. Results indicated that the potassium polymer in addition to growth of seedlings and increasing the water inside the plant, will improve the nitrogen uptake from 11% to 45%. Also, the use of the potassium polymer can reduces the nitrogen concentration in the drainage by half the amount of nitrogen in the control treatment.

Due to the preservation of moisture and soil nutrients, especially in arid and semi-arid regions, the aim of this paper is to determine the effect of polymer application on soil moisture storage and soil enhancement in order to reduce nutrient exhaust (nitrogen) and finally its effect on growth and production of dry matter of the plant.

Soil Type	pH	EC (dS/m)	SP	N	OC	CaCO3	Clay	Silt	Sand
Light	7.4	1.6	26.7	0.03	0.2	5.3	2.0	2.0	96.0
Medium	7.7	3.5	35.9	0.04	0.4	6.6	20.0	50.0	30.0
Heavy	7.3	2.2	40.4	0.06	0.5	9.3	30.0	38.0	32.0

Table 1 characteristic of the soils

To determine the dry weight of the plants, each pot was first cut at the end of the growing season at a distance of 2 cm from the top of the collar, and then weighed in the oven at 105 ° C and weighed afterwards.

Types and methods of measurement

Total, Nitrogen: by Kjeldahl method; Organic Carbon: by Walmik and Blak method; Soil texture:

Hydrometric method

Soil carbonate: by adding chloride acid to soil and then reading CO2 in a caliber calibrator
Measurement of available nitrogen in the drainage: after converting nitrate to ammonia nitrogen with powder and then measuring the existing ammonium nitrogen, such as the Kjeldahl method
The statistical operation was performed on the results obtained in this project using mstatc and means were compared by Duncan method.

RESULTS

The results showed that, with increasing irrigation interval, dry matter production also increased. In soil mixing with polymer, growth and dry matter production were more than control. By decreasing the irrigation interval, the amount of dry matter decreased, so that in 12-day irrigation interval, the plant stomata were washed before harvest. Table 2 indicates the results of analysis of variance of the effects of test treatments on dry matter and other measurements.

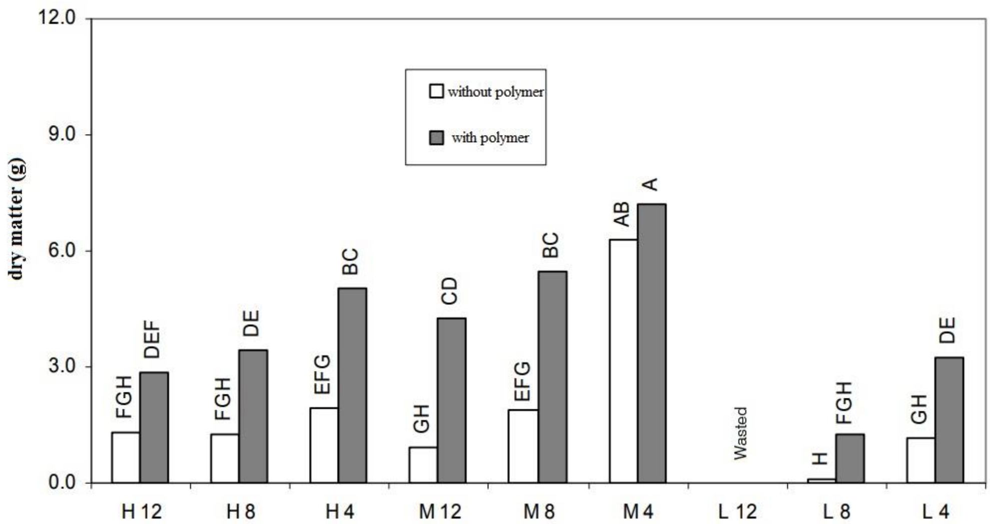

Figure 1 the effect of adding the polymer to light (L), medium (M) and heavy (H) soils in irrigation periods of 4, 8 and 12 days in the average dry matter production (non-metric letters mean the difference in the level of 5%)

Table 2 Analysis of variance related to irrigation (A), soil (B) and polymer (C) and their interactions on measured traits

	Treatments	Height	Dry matter	Nitrogen (N) in the drainage
A	2	13.8**	47.6**	32.8**
B	2	37.1**	75.1**	14.3**
AB	4	4.4 NS	4.9**	5.9*
Error	27	-	-	-
C	1	13.1**	67.3**	10.2*
AC	2	0.01 NS	0.5 NS	0.6 NS
BC	2	1.0 NS	3.5*	0.9 NS
ABC	4	3.6*	3.3*	0.1 NS
Error	27	-	-	-
Total	71	-	-	-

*.**Significant at 5% or 1% probability level; NS: non-significant

Table 2 indicates that the simple effect of experimental treatments on dry matter production was significant. Accordingly, the average soil with 4.34 g dry matter showed the highest effect on plant growth. In addition, from the simple effect of irrigation in Table 3, it can be seen that decreasing the irrigation rate decreases plant production and growth. In addition, from the simple effect of irrigation in Table 3, it can be seen that decreasing the irrigation rate decreases plant production and growth. The result of the effect of irrigation was 4 days long with production of 4.14 g dry matter more than other irrigation treatments.

Table 3 Effect of main treatments including irrigation treatment (A) and soil treatments (B) with their interactions on measured traits

Traits	Soil treatments	Irrigation intervals			Soil (B)
		4-days	8-days	12-days	
Dry matter in each plant [g]	Light	2.20d	0.68e	0.0e	0.96γ
	Medium	6.75a	3.74b	2.53cd	4.34α
	Heavy	3.48bc	2.35d	d	2.64β
	Irrigation (A)	4.14α	2.25β	1.54γ	-
Height [cm]	Light	Without observing the interaction effects (ns) between $A \times B$			17.2β
	Medium				46.6α
	Heavy				54.3α
	Irrigation (A)	52.5α	36.7β	29.0β	-

Non-consecutive letters indicate the significant difference between the main treatments A and B (α,,γ) and their interactions $A \times B$ (a-e)

In relation to the interactions of irrigation treatments (A) and soil treatments (B) on dry matter production, we can say that the 4-day irrigation interval in the middle soil with the production of 6.75 g per each plant had the highest effect and light soil in the 8-day irrigation interval with 0.68 g had the least effect on dry matter. As mentioned before, in the 12-day irrigation interval, the plants were perished down before harvest. The interactions of polymer and soil also showed that the polymer in the medium had the highest average dry matter production (ie, 5.64g). In nonpolymeric soil, the average dry matter was at the lowest level (Table 4).

Table 4 the effect of soil (B) and polymer (C) interactions on average dry matter production (g per plant)

Type of soil	Soil Treatment	
	With Polymer	Without Polymer
Light	0.42d	1.51c
Medium	3.03b	5.64a
Heavy	1.51c	3.77b

Unclassified varieties indicate a significant difference.

The results of variance analysis in Table 2 indicated that simple effects of irrigation, soil and polymer are effective on height. In the 4-day irrigation interval, the average height was 52.5 cm and in the 12-day irrigation interval, it reached the lowest elevation of 29 cm (Table 3). So, the highest soil effect was obtained on height with 54.3 cm from heavy soil. No significant effects were observed in relation to the interactions between irrigation and soil treatments (B × A), (Table 3). But the effect of interaction was significant among irrigation treatments, soil and polymer (C × B × A), (Table 2). Regarding the interaction effects of the test factors, it can be concluded that the polymeric soils were more effective than the control plants in increasing the plant height. However, in the medium-sized soils in the lower periods of irrigation, the plant height was more than that of the polymeric soils, but this increase was not significant.

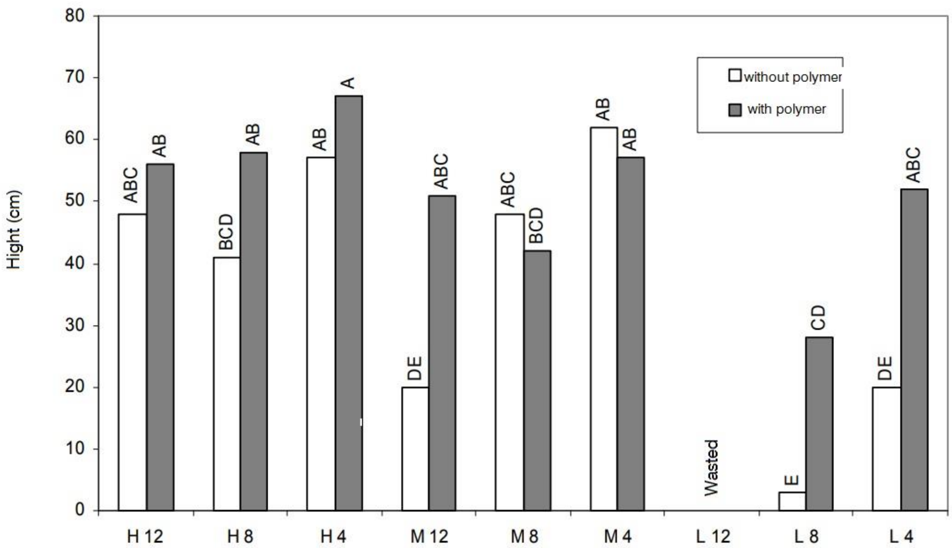

Figure 2 the effect of adding the polymer to light (L), medium (M) and heavy (H) soils in irrigation periods of 4, 8 and 12 days of the average height in the Panicum (Non-correspondence letters mean the difference in the level of 5%)

The results of analysis of variance related to the effect of nitrogen leaching experiments in Table 2 show that there is a significant difference between the simple effects of treatments.The maximum effect of irrigation with nitrogen was more than 900 mg N/l in 8-day drainage irrigation (see Table 5).Since the plants were wasted in the 12-day irrigation in the main growth stage before fertilization, there was no possibility for comparing all irrigation periods.Therefore, only 4 and 8-day irrigation periods were investigated for nitrogen leaching. The heavy soil with the 990 mg N/l have the highest amount of nitrogen in the drainage; and light soil with 531 mg N/l showed the lowest amount of nitrogen in the drainage.The effect of polymer on nitrogen with 542 mg N/l were significantly better than control.The effect of interactions between irrigation and soil was concluded that the total amount of leachate N in a 4-day irrigation interval was less than the 8-day irrigation interval. Heavy soil in the 8-day irrigation showed the highest amount of nitrogen in the drainage. However, in light soil in 4-day irrigation, nitrogen content was at the lowest level with 295 mg N/l.Also, there was no interaction between soil and polymer (see Table 5).

Table 5 the effects of main treatments including irrigation (A), soil treatment (B) and polymer treatment (C) and their interactions on the average nitrogen in the drainage after fertilizing (mg N/l), regardless of the 12-day irrigation (due to the plant's loss)

Soil (B)	Irrigation (A)		Polymer (C)		Mean (B)
	8-days	4-days	with polymer	control	
	766b	295c	Without observing the		531β
	664b	572bc	interaction effects between		618β
	1348a	631b	$B \times C$		990α
Mean C/A	926b	500a	884α	542β	

Non-consecutive letters indicate the significant difference between the main treatments A and B (α,,γ) and their interactions A×B (a-e)

The effect of the polymer on the soil showed that the amount of water absorption was increasedby adding the polymer to the soil. The polymer increased the average water absorption by 15% compared with the control (Table 6).The effect on soils in heavy soil was 50.5% higher than the average soil and light soil. Although, no interaction between soil and polymer ($B \times C$) treatments was observed.

Table 6 the effect of main treatments including polymer (C) and soil treatments (B) on soil moisture content as a percentage of weight

Polymer (C)		Soil (B)		
control	With polymer	light	medium	heavy
34.3α	49.1β	30.5α	44.3β	50.5γ

Non-common letters (α, β, γ) indicate the significance of the difference between the mean of numbers.

DISCUSSION

The results of this study showed that adding a polymer to the soil increases the dry matter and increases the height of the Panicum.Due to increased water holding capacity, adding polymer to soil improves plant growth (Li, S. et al., 2015). Adding the polymer to the soil resulted in the optimal use of water and subsequently increased dry matter in the plant (Zohuriaan-Mehr et al., 2010).The effect of the use of polymer on vegetative characters of

Chrysanthemums indicated thatvegetative traits such as dry and wet weight of flowers, dry and wet weight of stems and roots, plant height and number of flowers in comparison with control were affected by the polymer.The best result in his research was the use of 0.8% polymer mixing with soil (Ghasemi and Khoushkhouy, 2007). The addition of hydrogel stacosorb to soil increases the seedlings' height, increases the production of dry matter of the limbs and root. The highest effect of polymer on these indexes was obtained from 0.4% polymer content, which most of the indices did not show a significant difference with the consumption level of 0.3% of the polymer.Therefore, the use of 0.3% polymer is recommended for its use(Zangooei-Nasab et al., 2012).In addition to its effect on plant growth, the polymer also increased some of the soil physical properties such as the soil saturation moisture content and the applicable moisture for the plant. In another study, adding polymer to light soilat mixing levels of 0.2, 0.6 and 1percent in order to investigate its effect on the production of dry Panicum matter indicated that the highest amount of dry matter in polymeric soils is from 0.6% polymer treatment (Rahbar and Banedjschafie, 2009). Adding the polymer to the soil treated with the polymer increases the moisture content of the soil saturation. The effect of time elapsed on the rate of water absorption of soils treated with polymer in saturated moisture state is not significantly different. The saturation percentage or amount of water absorption due to the addition of polymer to soil is significantly affected by the addition of the polymer in comparison with the control.

Polymer treatment in all soils improves the amount of water stored in the soil than the control, but this increase in heavy soil is more than other soils. Also, the amount of N in the drainage is reduced by the polymer (Abedi and Mesforoush 2009). Super absorbent has the most effect on storage of nitrogen and phosphorus and has the least effect on manganese storage (Shi X et al., 2016). The effect of hydrogel on tomato crop cultivation been studied byBres and Weston (1993). They indicated that hydrogel improves water and ammonium nitrate conservation in plant growth medium than hydrogel and control.

Interaction effects of irrigation and soil showed that nitrogen content in the drainage for 8 days irrigation was more than 4 days irrigation.Increasing the yield of drought caused by 4-day irrigation in comparison with the 8-day period (see Table 3), resulting in higher nitrogen uptake in the plant, cannot have any effect on reducing nitrogen drainage below the irrigation interval.Also, in heavy soil, nitrogen content of drainage was higher than other soils (see Table 5). In this regard, we should mention the intrinsic nitrogen content of the heavy soil with 0.06 percent, which was higher than the other soils. Obviously, mineralization of total nitrogen in the soil was not affected by the amount of soil nitrogen and drainage. According to Hanschmann (1983), mineral nitrogen release from organic matter can be done at + 1 ° C, and with increasing temperatures up to more than 10 ° C, this dischargewill increase more. In a temperature of 10-30 ° C, the mineralization process increases 2.5 to 3 times. The results of this study showed that the application of the polymer increases plant growth (dry matter production) and prevents the outflow of nutrients in the soil.

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