WATER HOLDING POLYMERS OF THEIR USE IN AGRICULTURAL IRRIGATION

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Abstract
World population is increasing at an alarming rate and expected to the major challenges of the near future. Population growth and the water demand is expected to be 50% higher than today. Using of Water Holding Polymers in agriculture has provided solutions to the problems of the present day agriculture increasing of the soils capacity to store water. Water holding polymers potentially influence soil evaporation and infiltration rates of water through the soils. Particularly, the polymers reduce irrigation frequency and compaction tendency, stop erosion and water run off. This study has been put together the possible effecs water holding polymers in water scarcity on yield and water using of the crops during critical periods of water. Polimers store rainwater in the soil in dry conditions. As a result, this review aimed to given information about the benefits of water holding polymers in the arid and semi-arid regions of the world.

Keywords: Agricultural irrigation, water holding polymers, water scarcity.

Introduction

The optimization of the use of water resources is strategic for the long-term competitiveness of the agricultural industry. As we know, the population of the world and our country is rapidly increasing day by day, while the water resources are seriously decreasing, which makes effective use of water compulsory. Water management is considered one of the major challenges of the near future (Saguy et al, 2013); At this point, all sectors and areas related to water develop new and effective water management strategies. As can be guessed, agriculture is at the forefront of the most used areas of water. Almost 70% of the world's available water is spent for agriculture. In such a context, it is apparent the importance to develop innovative agricultural systems and to promote technologies that could optimize the exploitation of water resources; nonetheless, it is crucial to guarantee that the appropriate amount of water is timely and efficiently delivered to the plants. Water holding polymers associated quickly with irrigation water to form gels resulting in an increase of the soils capacity to store water. The water stored in this way is available to plants for some considerable time. The polymers are present in the soil together with the water they receive in their constructions; fertilizers, nutrients and mineral salts.In this way, irrigated water is efficiently supplied to the plant roots when needed. The pores in the ground are filled with water after rain or full watering and become available for plants. The filled water in the pores is drawn by gravity. Therefore, plant roots can't benefit from the whole of this water and nutrients and lose a significant part. . SAPs can absorb and retain extremely large amounts of a liquid (water or an organic liquid) relative to their own mass (Horie et al, 2004) In agricultural applications, SAP granules are mixed with the soil in given amounts. After watering, the granules absorb the water by swelling, and then release it slowly through a diffusive mechanism, as the soil gets dry. Water absorbant polymers reduce the evapotranspiration and protect the plants from problems related to the lack of water and plant nutrients. Furthermore, SAP granules increase their size upon swelling, thus enhacing soil porosity and providing a better oxygenation to the roots. Since water absorbant polymers provide excellent moisture to the root zone,the chance of survival of newly planted plants increases significantly. As SAP increases the soil water storage capacity, irrigation applications should be made at times when the moisture content of the soil falls to a minimum level (Fonteno ve Bilderback, 1993). SAP enhance the development of root and stem. Moreover, the germination process, the plant growth, the nutrients uptake, the yield and both the water and fertilizer use efficiency were beneficially increased by mixing the plant pits in sandy soil with SAP (Ouchi et al. 1990; El-Hady et al. 2002). They are also responsible for the reduction of root fungi. This effect is associated with the crystallizing high pH value. (Johnson ve Hummel, 1985). It has been reported that when SAP are added in very dry soil, water conductivity is increased and channels are formed that allow the saline to drain through the soil. Hydrophilic polymers can also reduce salinity, especially in highly dry and swollen sodic soils. (Malik et al., 1991). Several researchers in this area have stated that certain SAP in the soil can absorb water 200-300 times their own weight. They also said that since SAP give the absorbed water to the soil in a controlled manner, so the loss of water from the root region is prevented. It is known that SAP, which can be used in many areas, are used in agriculture more than 40 years around the world. The SAP in the market have less than one hour of water absorption with 100% capacity. At least 99% of the absorbed water can be used by plants. SAP provide effective irrigation support by showing swelling and recrystallization periods in the soil and by repeatedly performing this property. It is claimed that this situation lasts 3-5 years and it is saved from water at least 30-60% depending on soil and climatic conditions. SAP have different efficiencies according to the place of use and their chemical structures. Today, there are three types of water-holding polymers that are widely used; natural polymers, semi-synthetic polymers and synthetic polymers. Natural polymers are based on starch and derived from grains such as corn and wheat. Natural polymers have a common usage as a thickener in the food industry. Firstly, semi-synthetic polymers are obtained from cellulose and then mixed with petrochemicals. These polymers differ in cation or anion. Synthetic polymers are mainly used in agriculture. Synthetic hydrophilic polymers generally come from polyvinylalcohol and polyacrylamides (Mikkelsen, 1994). The chemical structure of polymers acting as a kind of microsponge in the soil is potassium based water absorbers consisting of cross-linked acrylamide, acrylic acid, potassium salt and ammonium salt. The cross-linking molecules in the structure of SAP form a three-dimensional network and render the materials insoluble in water. When these materials interact with water, they swell rapidly, and form a gel structure by absorbing water and water-soluble nutrients. Acrylamide increases long-run stability and maintains this property for about 4-5 years. According to the researches, these materials have been disintegrated into soil by microorganisms in the soil. However, the rate of disintegration in the soil is between 10-15% per year on average and it takes a long period about 5-7 years, which means pollution of the environment by SAP and it is considered as a disadvantage. Ben-Hur-M (1994) reported that in a study with 20 kg polyacrylamide (PAM) and 40 kg polysaccharide (PS) application to the soil surface before the irrigation resulted in significant decreases in surface flux and erosion as well as potato and cotton yield increases. The same researcher stated that the PS application is more suitable than PAM because of its low viscosity and high water solubility. Wallace (1987) obtained high output and development in tomato and lettuce in thin textured soil with PAM. In studies with applied PAM on lettuce, radish and wheat, the plants have benefited more effectively the water absorbed in gel form compared to normal water. Furthermore, during the temporary drought period, gel water is used as a buffer and reduces the risk of product destruction at the germination period (Jhonson, 1990).

Impact of SAP's on the environment

According to recent ecotoxicological researches it has not been found that water-absorbant polymers have adverse effects on existing organisms in water or soil (Ohkawa ve ark., 1999). According to research results on acute toxicity, it is harmless after oral ingestion. It has also shown that transient intense skin contact has no irritating effect on the skin or eyes and has no potential for allergies. Mutagenic properties that could cause genetic alterations have not been observed (Madakbas et al, 2014). It is known that the roots of the plants are able to absorb acrylamide from the soil and carry it to other parts of the plants. Various investigations have been carried out to determine the level of pollution of the plants with acrylamide. In a study conducted in greenhouse conditions, 1% SAP application was made at seed stage in lettuce and carrot cultivation. These seeds are planted in sandy soil.Vegetables were harvested at different intervals and tried to determine the amount of polymer. The amount detected in the lettuce was only 0.12% of the maximum amount of applied polymer. The polymer value found for carrots is much lower than the lettuce. Free acrylamide was not detected in both types of vegetables (Madakbas et al, 2014). The consumption of cultivated plants using SAP has no risk for humans in terms of toxicology (Sojka et al., 2007; Viero and Little, 2006).

Benefits

Studies (Flannery and Busscher, 1982; Johnson, 1984) have shown that hydrogel application to soil does not affect the amount of water used by the plant. The applications show that the beneficial water in the plant root zone has increased and that the plants have less damage than water stress by extending the time between irrigations. El-Sayed and Kirkwood (1992) reported that addition of soil hydrogel leads to a decrease in salt ions in stationary corn pollen. According to this, it can be estimated that the hydrogels changes the level of salt ions in the plant tissues and decrease the negative effects of saltiness (Chen et al., 2004).

Hydrophilic polymers potentially influence infiltration rates, density, soil structure, compaction, soil texture, aggregate stability, crust hardness (Helalia and Letey, 1989), and evaporation rates (Teyel and El-Hady, 1981).

- Water loss due to evaporation or infiltration to the soil is prevented, thereby the water holding capacity of the soil increases and the irrigation range is extended.
- Decreases plant nutrient loss due to washing, increases plant growth.
- Water is used more efficiently, excessive and unnecessary consumption of water is avoided
- It provides durability against drought and water stress.
- Provides easier and faster germination
- Because the seed is wrapped with moisture layers, it increases the germination rate and gives uniform germination.
- It improves the physical properties of impermeable soils by correcting the aeration capacity and drainage of the soil.
- Prevents soil erosion.
- Protect the environment against underground water pollution.
- It provides economical benefit by reducing the cost of irrigation.
- Reduce production costs without reducing product yield.
- Activity to fight against root nematodes and fungi (Madakbas et al, 2014).
- It is ensured that the soil which is not suitable for harvesting.

Areas Used In Agriculture

- Plant growing pots

Water and plant nutrients are taken directly into the gelatin by thin fibrous roots, or they are slowly released by the osmotic process to the surrounding soil. Regular moisture supply leads to improved plant growth. Due to rapid and intensive root growth, the chance of survival of newly planted plants is significantly increased.

- Heather and tree planting

SAP is applied in the solid form with fertilizers or liquid form into soil depth of 20-120 cm via injectors. Injection is more advantageous than other application methods. In this method, the injector is applied very easily in hard soil without damaging the roots. Air, food and water are infiltrated by bringing a network between the gaps in the soil. In addition to increased plant yield, the quality also increases at a high rate. The application of SAP in the soil via injector is a low cost and very useful method

- Grass and grass areas

The use of water absorbant polymers in grass areas meets the general water requirements of plant species and affects plant performance. It allows for the necessary work to restore a green appearance of arid areas.

- Extensive spreading and surface application

It is applied hand application or with the fertilizer to the soil before the planting. After spreading, the soil is mixed about 15-25 cm. In this application form, 3-5 kg SAP is used per decare.

- Layerig and planting

This method is used to prevent root dryness during planting and to transport bare roots to long distances without being damaged. It is possible to add nematicides and fungicides to this mixture to protect the roots against nematode and fungi. The density of the SAP mixture is adjusted to best adhere to the roots (1 kg SAP to 100 - 300 lt water). SAP is slowly poured and mixed into water. By waiting for a while (15 minutes) the viscosity of the gel increases and the roots become better attached.

- Soilless cultivations

In soilless cultivations, plants are grown using mineral nutrient solutions in water, without soil (Di Lorenzo et al, 2013). In open soilless systems, there is a massive waste of water and nutrients, which is responsible for an increase in running costs and in contamination of ground and surface water (Vox, 2010). The adoption of the SAP to ration the delivery of nutrients to the plants would improve the overall environmental sustainability of these systems. Also for closed systems (in which water recirculates), the use of SAP may help hindering water retention of the plants;

- Semination with water

For coating with water, 1-2 kg of SAP is added per m3 of water. In addition to the seed, cellulose and fertilizer can be added to this mixture. Depending on the field moister capacity, type of soil and salt in the water, 10 to 20 kg of polymer per hectare are needed for SAP that covered water.

- Seed coating

In this method, the SAP is homogeneously mixed with the seeds. The SAP in the form of dust is attached to the surface of the seeds with a static charge. Better germination occurs in the soil because the seed will be covered with SAP. After the crop is harvested, the frozen SAP is a suitable regulator for storing cold air. This basic feature is valid as long as the SAP crystals remain solid. However when the crystals are soft, this basic feature disappears. SAP is placed in hermetic containers made of various materials according to the intended purpose. The polymers contained in these containers are frozen. It is placed in the middle of the harvested crop to be cooled. Frozen SAPs, which are active for 72 hours, are the most economical application method in terms of ease of use, reliability, no chemical contamination and friendliness to nature. It is also a great advantage to use again.

Results and discussion

This review was prepared considering the possible effecs water holding polyacrylamide (PAM) polymers in dry agriculture on yield and water use of the crops during critical periods of water. Water holding polymers were described in terms of their positive impacts on the soil and plants. We aimed to given information about the benefits of water holding PAMs in areas where there was not sufficient rainwater and irrigation water. SAP, which provide optimum conditions for plant growth, provide crop production profitability related to yield, yield and quality of the crop. They increase the living rate of the plants. They enable the sale of products with higher quality plant production and a higher market price. They allow plants to grow more comfortably in very hot and dry climatic conditions. We do not have the chance to increase water resources today, so we must protect what is available. We must use SAP to prevent evaporation and infiltration of the water which is insufficient in arid regions. The results suggest that hydrogels can improve sandy soil properties for plant growth by absorbing and keeping water longer in the soil matrix thus re-ducing watering frequency. The results show that hydrogels can be better utilized than sandy soils for plant growth with longer water holding in the soil matrix. The intelligent, economical and efficient use of water has also become a necessity in our country. In order to reduce irrigation and fertilization costs, SAP that can hold water with different properties are used as alternatives to excess water consumption. Because SAP polymers can also hold fertilizer, and mineral salts available in the soil. Thus, plants are protected from problems related to water stress and lack of nutrients.

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