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Effect of Hydrogel on Water and Nutrient Management of *Citrus limon*

S. K. Pattanaaik*, Barun Singh, L. Wangchu, P. Debnath, B. N. Hazarika and A. K. Pandey
College of Horticulture and Forestry (Central Agricultural University),
Pasighat, Arunachal Pradesh-791102
*Corresponding Author's Email: saroj_swce@rediffmail.com

Abstract – **The hydrogel is a soil conditioner able to retain water and plant nutrients. Hydrogel is commercially available as Stockosorb/Raindrop/Agrosorb. Stockosorb releases water and nutrient to the plants, when surrounding soil near root zone of plants starts to dry up. Soils of Arunachal Pradesh are eroded, well drained and gravely in nature. The soils vary from sandy loam to loamy sand with acidic in reaction with varying N: P: K status. The cultivated lands of state occur mostly in the hill slopes which are less water retentive. Horticulture is usually practiced as a remunerative profession in the state. Citrus is the most important crop among the horticultural crops grown in the state. Planting of citrus on steep hill slopes and lack of supplementary irrigation and application of nutrients, cause gradual decrease in their productivity. A study was carried out at the research farm of the College of Horticulture and Forestry located at Pasighat, Arunachal Pradesh to evaluate the effect of stockosorb on the growth and yield of Assam lemon (*Citrus limon*). The experiment was laid out in randomised block design with six treatments and five replications. The treatments were T_1= 25gms of stockosorb, T_2=50gms of stockosorb, T_3=75gms of stockosorb, T_4=100gms of stockosorb, T_5=120gms of stockosorb and T_6=Control i.e. zero amount of stockosorb applied during December, 2012 along with application of recommended doses of N: P: K i.e. 900gm, 250gm and 500gm, respectively to each plant after the application of stockosorb. Among all the treatments, T_4 was found to be the best with respect to yield which was significantly higher than other treatments. The application of stockosorb under treatment T_4 increased the water holding capacity of the soil from 28.74 per cent to 34.63 per cent. The increasing yield may be due to the fact that the soil was wet for a longer time increasing the microbial activity as well as reducing the fruit drop due to water stress. With respect to growth of the tree, an appreciable increase in the growth of the tree in all the treatments was observed as compared to control. It was also observed that stockosorb was able to retain available water for the plant up to fifteen days after irrigation.**

Keywords – **Stockosorb, Citrus, Water Management, Nutrient Management.**

I. INTRODUCTION

The ever-expanding global demand for water, combined with the impacts of climate change, is already making water scarcity a reality in many parts of the world. While we are approaching the limit of the available clean water supply, there will be an increasing competition for water. Irrigation water stress is one of the major limiting factors that affect crop and fruit growth and productivity. Plant productivity is often also limited by adverse physical and chemical soil properties such as low infiltration rates as well as low water retention and low cation exchange capacity. The water and nutrient holding capacity of sandy and permeable soils, in particular, are extremely limited. These soil types are characterized by excessive drainage of rain and irrigation water, as well as plant nutrients leaching below the root zone (Kazanskii and Dubrovskii, 1992; Al-Omran and Al-Harbi, 1998). This leads to inefficient water and fertilizer use by crops. These conditions are intensified in shallow-rooted crops or when irrigation water or irrigation systems are missing. Stockosorb is a hydrogel which is an organic cross linked copolymer with water binding groups. It is marketed in India as raindrop. In the dry form, the stockosorb polymer is a white crystalline granule, specially formulated for safe use in the production of food crops (Austin and Bondari, 1992; Green et al., 2004). This soil conditioner is specially designed and developed for water and nutrient retention and release in substrates and soils upon contact with water. Stockosorb swells quickly, creating a hydrogel by absorbing and retaining large quantities of plant available water. It has the ability to retain water (Alessandro Sannino, 2008). Fertilizer leaching can thus be reduced (Buchholz, 1998; Kazanskii and Dubrovskii, 1992). During the soil drying process, both water and water-soluble nutrients are released to the plant in a uniform manner. The higher water availability helps to avoid water stress during longer periods of water scarcity. During the water release phase of the hydrogel, free pore volume will be created within the soil, offering additional space for root growth and air and water infiltration and storage. Stockosorb also strongly resists soil pressure at high soil depth without losing its swelling capacity. Consequently, water is stored in the root zone so that water and plant nutrient losses due to deep percolation and nutrient leaching can be avoided. In this way water and nutrients are available to the plant over a longer period of time (Buchholz, 1998). According to Taylor and Halfacre (1986), this allows stronger and healthier plant growth also under hot and dry climate conditions and therefore increases the safety margin and yield potential in plant production. This is a technology which helps for lasting improvement in the efficiency of water and soil management in agriculture and horticulture. Field trials have been widespread in the United States, Chile and Australia where the objectives of the applications were to reduce water usage by 30% and increase yields. The crop responses observed have shown the elimination of plant growth cessation due to drought stress, increased nutrient uptake, increased plant emergence and increased crop yield.

The soils of East Siang district of Arunachal Pradesh is highly porous, gravely and sandy in nature. Well drained,

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gravely and sandy soil are characterized by low water-holding capacity and excessive drainage of rain and irrigation water below the root zone, leading to poor water and fertilizer use efficiency by the crops. The high rainfall (average annual rainfall of 4500mm) cannot cater to the need of the crops, because of gravely and porous nature of soils. The crops here suffer from acute water stress during the period from October to March, causing considerable loss in productivity. Taking this into account a study was carried out at the research farm of the College of Horticulture and Forestry located at Pasighat, Arunachal Pradesh to evaluate the effect of stockosorb on the growth and yield of Assam lemon (*Citrus limon)* and to standardize the amount of stockosorb required by the plant based on the specific agro-climatic condition.

II. Material and Methods

Experimental site

The research farm is situated in the foot hills of Eastern Himalayan range at an altitude of 169m above mean sea level with 28^0 04' 43"N latitude & 95^0 19' 26" E longitude. The climate of this area is hot and humid in summer and moderate winter. The experimental plot has size 45m×18m. The soil of experimental site is sandy loam with acidic in reaction, which is highly drained and gravely in nature. The nutrient status of the soil indicates available N=301kg/ha, P_2O_5 = 25.3 kg/ha, K_2O = 107.52 kg/ha. However, the soil has high organic carbon content 2.43%. The topography of the area is plane having average slope of less than 1 per cent.

Design and layout

The experimental material of investigation comprised of four year old Assam lemon (*Citrus limon*) plants. The experiment was laid out in randomized block design with five replications and six treatments. The treatments were T_1= 25gms of stockosorb, T_2=50gms of stockosorb, T_3=75gms of stockosorb, T_4=100gms of stockosorb, T_5=120gms of stockosorb and T_6=Control i.e. zero amount of stockosorb. The form of the stockosorb used was 600µ granule. The stockosorb along with recommended dose of NPK was applied in the trench along the drip line of the plant canopy of each plant. The size of the trench was 20cm × 20cm. After the application of stockosorb and fertilizer, the excavated soil was filled back into the trench. N: P: K was applied @ 900gms, 250gms and 500gms, respectively to each plant. Then irrigation was applied in the basin.

Data taken and analysed

The data on the number of mature fruits harvested and height of the lemon plants were recorded. The moisture content of the soil added with different quantities of stockosorb was measured gravimetrically and as well as by soil moisture meter. The soil sample was collected at 15cm depth at the midpoint between the drip line of the plant canopy and the plant base. Then the data was analysed statistically by using the MS Excel 2007 and WASP 1.0.

III. Results And Discussion

Rainfall-evaporation pattern of Pasighat

The rainfall-evaporation analysis of Pasighat, East Siang district of Arunachal Pradesh indicates that the months starting from October to March are the water scarce months, where the evaporation is more than the rainfall received as given in the figure 1. The crops are water stressed during this period and need frequent irrigation for their growth. But, application of basin irrigation in the porous and gravely soils is a difficult task. The source of the water for irrigation here is from water harvesting tank. The water has to be utilised from the water harvesting tank with proper water management technology. Hence, the stockosorb technology i.e. the application of hydrogel was applied to evaluate its effect with its subsequent standardisation in this location for Assam lemon crop.

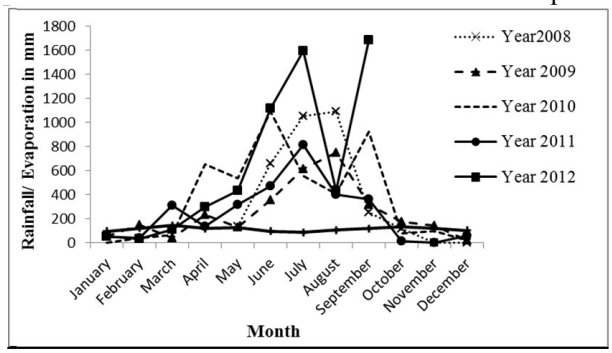

Fig.1. Monthly variation of rainfall vs evaporation showing the dry months at Pasighat, Arunachal Pradesh.

Effect of hydrogel in retaining the water

The moisture content of the soil was plotted versus days after watering the basin. The graph shows gradual decrease of soil moisture with advance of days with respect to the day of watering. This is shown in the figure 2. The decreasing trend is observed for all the treatments including the control. The treatment T_5 has highest moisture retention in comparison to all other treatments. However, the treatment T_4 has moisture retention near to the treatment T_5. The treatments T_1, T_2 has a equal trend of decreasing soil moisture. The control loses soil moisture at fast rate and needs irrigation at an interval of five days. It is observed that stockosorb retains water considerably for a longer time than control. The present finding corroborates with the finding of Alessandro Sannino in the year 2008.

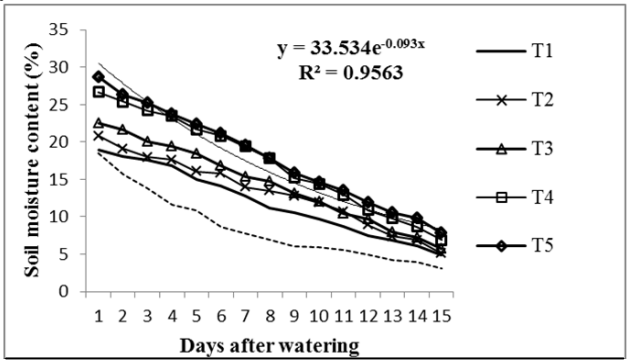

Fig.2. Treatment wise variation of soil moisture w.r.t. days after irrigation

Effect of hydrogel on growth of Citrus limon

The stockosorb technology was applied in the Assam lemon block of the research farm of college of Horticulture and Forestry, Pasighat during December, 2012 with application of recommended doses of N: P: K i.e. 900gm, 250gm and 500gm, respectively to each plant. Irrigation was applied equally to all the plants. The mean fruit yield and increase in height of the plants are given in table 1. Among all the treatments, T_4 was found to be the best with respect to yield (130.20 fruits/plant) which was significantly higher than other treatments. The application of stockosorb under treatment T_4 increases the water holding capacity of the soil from 28.74 per cent to 34.63 per cent. This corroborates with the study by Pattanaaik, *et al.*, 2015 for the increased yield of *citrus reticulata* by the application of hydrogel. This may be due to the fact that the soil was wet for a longer time increasing the microbial activity and availability of nutrients. This also helps in reducing the fruit drop due to water stress. Moreover, with respect to growth of the plant, it has been found that there is appreciable increase in the growth of the tree in all the treatments where stockosorb was used as compared to control. Physico-chemical parameters of lemon fruit (Table 2) reveals that treatment T_4 had the highest fruit weight (262.5 gm), followed by T_5 (201.8 gm) and T_3 (180.3 gm) and least in T_6 (93.69 gm). With regard to total thickness of the peel as well as thickness of the alvido, treatment T_4 had the highest width i.e. 9 mm and 6 mm, respectively and treatment T_6 has least width i.e. 5 mm and 3 mm. The thickness of flavido was highest in T_2, followed by T_4, and T_5 with 3 mm and lowest in T_1, T_3 and T_6 with 2 mm. The juice content was recorded highest in T_4 (77 cc) and these parameters were lowest in T_6 with 26 cc, but the total acidity was found highest in T_1 (5.95 %) followed by T_2 (5.203 %) and lowest in T_5 with 4.8 %. Hence, the overall performance of the treatment T_4 was found to be best.

Table 1: Treatments mean yield of fruits and plant height of lemon plants

Treatments	Mean yield of fruits in numbers	Mean increase in height in per cent
T_1	83.600	20.000
T_2	61.400	20.700
T_3	102.600	14.100
T_4	130.200	16.900
T_5	87.400	15.200
Control	90.800	13.700
Coefficient of variation	**30.318**	**19.308**
CD at 5% level	**37.065**	**4.271**

Table 2. Physico-chemical parameters of lemon fruits

Treatment	Weight (gm)	Total thickness of skin (mm)	Alvido thickness (mm)	Flavido thickness (mm)	Volume (cc)	Total acidity (%)
T_1	164	6	4	2	43	5.97
T_2	163.2	8	5	3	40	5.203
T_3	180.3	6	4	2	53	5.3
T_4	262.5	9	6	3	77	5.15
T_5	201.8	6	3	3	52	4.8
T_6	93.6	5	3	2	26	5.18

IV. Conclusion

The Stockosorb/ Raindrop/ Agrosorb is a soil conditioner able to retain water and plant nutrients. Stockosorb releases water and nutrient to the plants when surrounding soil near root zone of plants starts to dry up. Planting on well drained, gravely and sandy soils of Pasighat and lack of supplementary irrigation and application of nutrients causes gradual decrease in productivity of crops. These soils when added with 100 gms of stockosorb granule per plant increase the irrigation interval considerably for Assam lemon (*Citrus limon*). The productivity of the crop can be increased by 43 per cent by application of 100gm of stockosorb per plant in comparison to the control. The application of stockosorb also produced lemon fruits having high juice content. This also increases the nutrient use efficiency of soil treated with stockosorb. Hence, the application of stockosorb in the well drained, gravely and sandy soil of Pasighat was found to be effective in increasing the yield of Assam lemon. It also increases the WHC of the soil, which provides a conducive atmosphere for better growth of roots in well drained and gravely and sandy soils and ultimately increases yield.

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