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Full Length Research Paper

Comparative Study of Seedlings Growth Performance in the Nursery with and Without Hydrogels

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Tree planting in many ASAL areas in Kenya is hampered by poor water supply. Many small scale tree nursery owners in these areas cannot afford the cost of providing adequate water for their seedlings. Given that 80% of Kenya is Arid or Semi-arid, there is great potential for afforestation if the water problem can be solved. In this paper we report the benefits of using hydrogels in nursery pots soil mixtures in comparison to watering directly into the pots. Hydro gels are super absorbent polymers, capable of absorbing large quantities of water into their structure and then slowly dispensed the water to the seedling roots as needed by the plant, thereby reducing the frequency of watering, leaching of nutrients and wastage of water and significantly reducing nursery costs. A comparative study of seedling height and root collar diameter growth with and without hydrogels was used for 5 months. Two soil treatments were used; a) normal pot mix of the University of Eldoret tree nursery, and b) normal pot mix (as in (a) above) plus hydrogels. Two species were used in the study i.e. *Cupressus lusitanica* and *Eucalyptus grandis*. Three watering sub-treatments were used; i) normal watering twice daily as normally done by the nursery attendants; ii) watering directly into the potted seedlings with 10 ml of water twice daily (early morning and late evening) ; and iii) watering twice in a week, every Monday and Thursday, early morning and late evening with 10 ml of water throughout the duration of experiment. The results showed that seedlings in pots with hydrogels grew significantly better (α = 0.05) than those without. Mode of watering and watering-by-soil mix interaction had also a significant effect. This study showed that there is great potential to raise seedlings in water scarce areas using hydrogels.

Keywords: Nursery, Hydrogels, ASALs

INTRODUCTION

Tree planting in many arid and semi-arid (ASAL) areas in Kenya is hampered by poor water supply and even in areas with adequate water, high evapotranspiration rates mean that most of the water is lost into the atmosphere. This can create reverse osmosis and exacerbate the growth conditions further. Many small scale tree nursery owners in these areas cannot afford the cost of providing adequate water for their seedlings. Given that 80% of

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Kenya is arid or Semi-arid, there is great potential for afforestation if the water problem can be solved. Water management forms the most critical process in the dry areas, as it impacts livelihoods, food security, land conservation and productivity and the society as a whole. These areas (arid and semi arid) are normally characterized by less trees and other vegetation. These lands can be restored by planting trees. Tree nurseries are good business in the dry lands for the improvement of both the local environment and the peoples' livelihood. Small scale nurseries are owned by individuals, families, groups of people, schools and small organizations. In the dry areas nursery activities and plantation establishment are to a great extent limited by water shortages (www.people.com). The importance of water is underscored by the fact that many deserts and grasslands could support luxuriant plant growth if only adequate supply of water was available (Kramer, 1987).

Hydrogels are super absorbent polymers, capable of absorbing large quantities of water into their structure through the process of osmosis (Bouranis *et al*. 1995). Hydrogels absorb water up to 500 times their weight, and when their surrounding begins to dry out, they gradually release up to 95% of the stored water to the surrounding. When they are exposed to water again, they rehydrate and repeat the process of storing, and releasing water. This process can last up to 7 years, when the biodegradable hydrogels decompose (Bouranis *et al*. 1995). Hydro gels are advantageous in that they not only release the stored water to plant roots as needed, but also drastically reduce evaporation rates. The rate of water loss through infiltration beyond the seedling`s rooting zone is also reduced. This helps to; i) improve the efficiency of water use by the seedlings, ii) improve the water holding capacity of the soil, and iii) reduce rates of runoff/spill over during watering. The reduced levels of water loss through drainage have the advantage of reducing leaching of nutrients (www.greensgrow.org/../faqhp). Forestry activities in the ASALs are normally limited by water shortage. Hydrogels can thus be used to raise seedlings and later in field planting as they are water stores for the seedlings. The hydrogels can store large amounts of water and make available to tree seedlings so that they have time to establish (www.greensgrow.org/.../faqphp). Hydrogels have many advantages including i) increasing their capacity to hold water, ii) increase the efficiency of the water being used, iii) reduce erosion and run off, iv) reduce frequency of watering, v) increase soil permeability and infiltration, vi) reduce the tendency of the soil to get compacted, vii) help improve plant performance and viii) improve use of nutrients by reducing losses from leaching.

Kenya's constitution calls for a 10% forest cover. 80% of Kenya's land is arid or semi-arid. Given the highly competitive use of the 20% arable land, it is prudent that the potential to increase forest and tree cover in Kenya lies in using the ASALs. But the ASALs are faced with water shortages and thus raising seedlings using conventional nursery procedures e.g. normal soil pot mixes is not viable. Good plantation forestry practice starts with an effective and efficient tree nursery. Small scale nurseries are a potential commercial enterprise in rural areas, both as a source of income and local planting for wood fuel provision. Use of Hydrogel can help meet the challenge by enabling tree seedlings to be raised efficiently and with minimal water. This will also contribute to conservation of the dwindling water resources. This study investigated the potential of hydrogel as a water retainer in soil pot mix in raising seedlings compared to use of conventional soil pot mix without hydrogel.

This study had three main objectives, thus; i) to find out the potential to use of Hydrogels in tree nurseries to improve seedling growth, ii) to examine the efficiency of water use in tree seedlings using different watering levels, and iii) to determine if hydrogels could be used to reduce the amount of water used to raise tree seedlings (conserve water) in small scale nurseries.

In this paper we report only on one of these objectives: comparative growth of seedlings raised with soil pot mix with and without hydrogel. The study null hypothesis was; **H_o: t**here is no significant difference in the growth (height and root collar diameter) of seedlings raised with and without hydrogels.

MATERIAL AND METHODS

The study was conducted in the University of Eldoret forest tree nursery. The area is within the Uasin Gishu plateau, which is in the lower highlands (LH3) agro ecological zone (Jaetzold and Schmidt,1999). The University is located 11 Km from Eldoret town; 3 km off the Eldoret-Iten road. It is in Uasin Gishu County. The site lies at a latitude of $00^{0}30$`N, longitude $35^{0}15$`E and an altitude of 2180 meters above sea level. The mean annual rainfall ranges between 1000-1800mm per annum. Rains start at the end of March to October. Maximum rainfall is observed during the month of August. Temperatures average 17.5^{0}C during the wet, cold season with a maximum of 25^{0}C during the dry season. The relative humidity of the area ranges between 45% and 55%. (According to the data from Kapsoya meteorological station 2011). Geology of the study area is dominated by tertiary volcanic, consisting mainly of alkaline basalt and phenolites soils which are generally deep, well drained, red to brown, friable clay, loam derived from basic volcanic rock especially basalts and may be classified as typical hapludox.

Experimental Design and Layout

A factorial experimental design was used for this study. Normal pot mixture of soil as used in the nursery was used in 4" by 6" polythene tubes. Two main treatments; Soil **(S0)**

i) **Height**

Table 7: ANOVAs table for height of *Cupressus lusitanica* seedlings at 5 months

Source of Variation	df (n-1)	Sum of squares (ss)	mean of squares (ms)	F Value	Pr.>F
Soil	1	5153.317028	5153.317028	167.04	<0.0001
Watering	2	8926.171989	4463.085995	144.67	<0.0001
Soil * Watering	2	2944.003585	1472.001793	47.71	<0.0001
Error	443	13666.53192	30.84996		
Total	448	30656.23608			

i) **RCD**

Table 8: ANOVAs table for RCD of *Cupressus lusitanica* seedlings at 5 months

Source of Variation	df (n-1)	Sum of squares (ss)	mean of squares (ms)	F value	Pr. >F
Soil	1	0.18718688	0.18718688	104.38	<0.0001
Watering	2	0.36384257	0.181921285	101.44	<0.0001
Soil * Watering	2	0.03906481	0.019532405	10.89	<0.0001
Error	443	0.79445029	0.001793342		
Total	448	1.38326238			

without hydrogel and Soil with Hydrogels **(S1)**. Two tree species were used, *Cupressus lusitanica* **(C)** and *Eucalyptus grandis* **(E)** and for each of these species three watering levels were used; i) watering normally as done by the Chepkoilel department of forestry tree nursery attendants **(W1)**, ii) watering directly into the pot with 10ml of water twice in a day **(W2)** and iii) watering with 20ml (10 in the morning and 10ml in the evening) of water twice in a week **(W3)**.

The experiment was replicated thrice and randomization was enhanced in the experiment in the arrangement of seedlings as shown in the following table of lay out.

Seedlings were transferred from growing beds to treated pots and nurtured to remove transfer shock. Each plot had 25 seedlings and height and root collar diameter were assessed every 2 weeks for 6 months. Collected data was analyzed using ANOVA to test effect of soil treatments (with and without hydrogels) on seedlings' height and Rcd growth. Means separation was carried out where treatments were significant (α = 0.05).

RESULTS

The statistical output of the means showed that there were significant differences between the growth both in height and root collar diameter between the two soil treatments (with and without hydrogel) in both species.

Mean Height and Red Growth

There were statistically significant differences in height and root collar diameter growth for seedlings grown in soil with hydrogel compared to those in soil without hydrogel.

Figure 1; showing the mean height and root collar diameter of *Cupressus lusitanica* among different watering levels and soil treatments.

Figure 5 and 6 are graphs of the mean height and RCD at the end of 5 months for *Eucalyptus grandis* and their respective error bars.

Analysis of Variance (ANOVA)

There were significant differences (α = 0.05) in height and Rcd growth of *Cupressus lusitanica* seedlings at 5 months for soil, watering and the interaction as shown in tables 1 and 2.

There were significant differences (α = 0.05) in height and Rcd growth of *Eucalyptus grandis* seedlings at 5

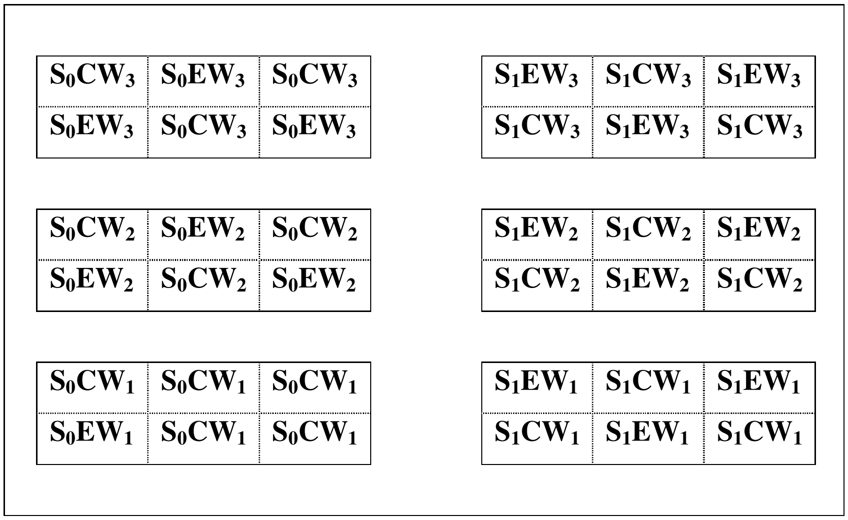

Figure 1: shows the experiment layout

KEY:

For example;

S_0EW_1- Eucalyptus under soil without hydrogel in watering one (W_1)

S_1CW_1- Cypress under soil with hydrogel in watering one (W_1)

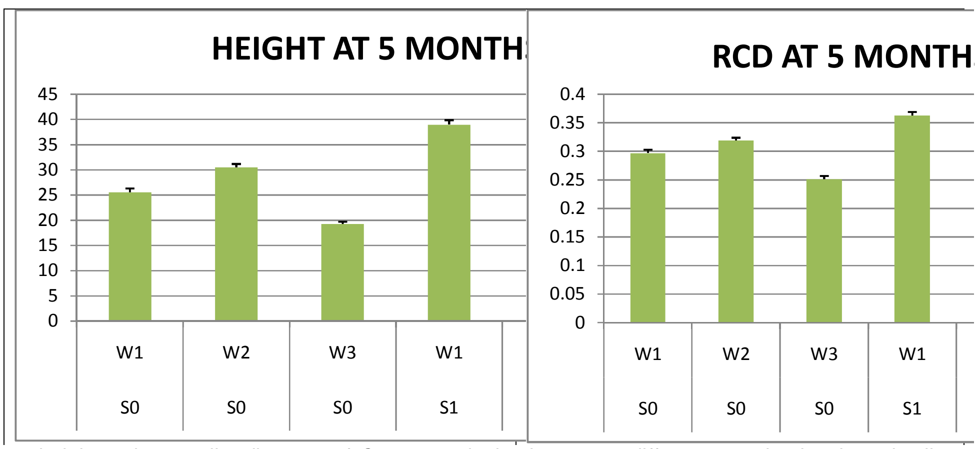

Figure 1; showing the mean height and root collar diameter of *Cupressus lusitanica* among different watering levels and soil treatments
Figure 2; showing the mean RCD of *Cupressus lusitanica among* different watering levels and soil treatments

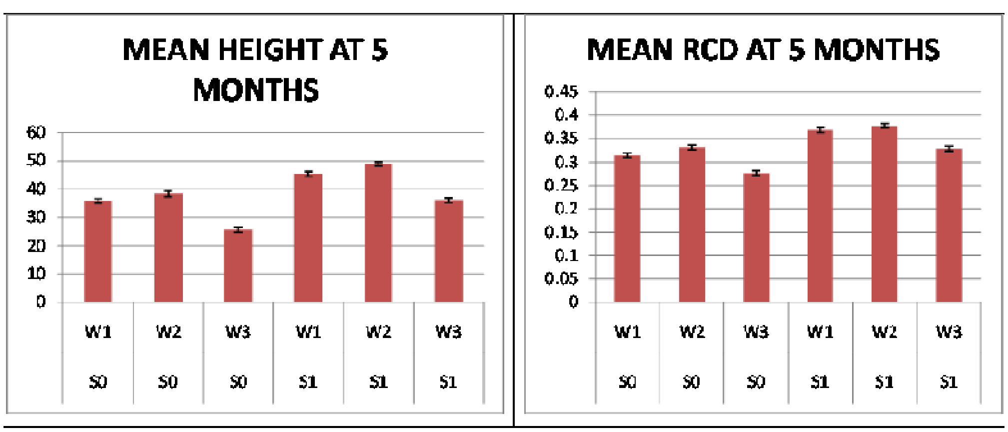

Figure 5: showing the mean Height of *Eucalyptus grandis* among the different watering levels

i) Height

Table 9: ANOVA table for Height of *E. grandis* seedlings at 5 months

Source of Variation	df (n-1)	Sum of squares (ss)	mean of squares (ms)	F value	Pr. >F
Soil	1	11748.48766	11748.48766	320.91	<0.0001
Watering	2	13326.45202	6663.22601	182	<0.0001
Soil * Watering	2	29.94501	14.972505	0.41	<0.0001
Error	442	16181.72321	36.61023		
Total	447	41337.88069			

i) RCD

Table 10: ANOVA table for RCD of *E. grandis* seedlings at 5 months

Source of Variation	df (n-1)	Sum of squares (ss)	mean of squares (ms)	F value	Pr.>F
Soil	1	0.29111903	0.29111903	211.77	<0.0001
Watering	2	0.21680578	0.10840289	78.85	<0.0001
Soil * Watering	2	0.00128248	0.00064124	0.47	0.6275
Error	442	0.60762312	0.001374713		
Total	447	1.11759196			

i) Soil

Table 11: means separation of *C. lusitanica* for height and RCD, there were significant differences in the growth of the seedlings between the two soil treatment

***Cupressus lusitanica* for Height**			***Cupressus lusitanica for RCD***		
Tukey Grouping	**Mean**	**Soil**	**Tukey Grouping**	**Mean**	**Soil**
A	31.8728	S1	**A**	0.33	S1
B	25.1232	S0	**B**	0.28933	S0

(Means with same letter are not significantly different)

Table 13: means separation of *E. grandis* for height and RCD, there were significant differences in the growth of the seedlings between the two soil treatments

Height			***RCD***		
***Tuk*ey Grouping**	**Mean**	**Soil**	**Tukey Grouping**	**Mean**	**Soil**
A	43.6204	S1	**A**	0.3584	S1
B	33.3547	S0	**B**	0.307354	S0

Means with same letter are not significantly different.

months for soil, watering and the interaction as shown in tables 9 and 10.

Separation of means was done to determine which of the means shown had significant difference from which other one. Tukey test was used as it the strongest test for this purpose. Means with the same letters have no significant difference and vice versa. Growth in height and RCD for those seedlings in soil with hydrogels (S1) differed significantly from those in soil without hydrogels (S0). There was no significant difference in the growth of seedlings between watering normally with unquantified amount of water (W1) and watering regularly with 20ml of water (W2).

DISCUSSION

Hydrogel

After water was added into the hydrogel during the pre test, it was absorbed into its structure and swollen thus when added to the soil ¼ of the pot size should be left free to give space for hydrogel swelling when the seedlings are watered. When watering in the different watering levels was done, it was found out that the 20 ml of water in W2 and W3 was just enough to soak the soil and thus no 'run-through' was observed. For W1, water was observed pouring during the watering process and collected in the sheet under the seedlings. This amount of water was comparable for both S0 and S1. This water formed the first water measurements. This was interpreted as water running between the pots for both S0 and S1. After watering was done, S1 had just a few drops dripping from the soil while S0 had a lot of water dripping even after a few minutes of watering, this water made the second water measurement. This was interpreted as; in S1 the water was immediately absorbed by the hydrogel and so very little run-through was observed while for S1, after the soil was wet enough the excess dripped as the soil water holding capacity could not accommodate the excess water.

Seedling Growth

Different watering levels under the same soil treatments showed differing responses with watering normally (W1) and watering with 20ml of water twice daily (W2) reflecting insignificant differences in growth as shown in the results section. This means that in our daily watering in the nursery a lot of water is wasted as it runs between the pots and also the excess water running through the soil after the soil is wet enough. This water does not benefit the seedlings and the run through causes leaching of nutrients. The act of hydrogels absorbing the water and releasing it to the seedling's rooting structure as needed by the seedlings improve the efficiency of water use. This was reflected in the differing performance (growth) of seedlings with those seedlings under S1 (soil with hydrogel) having higher means than those in S0 (soil without hydrogel) under the same water levels, as shown in the graphs 5, 6, 7, and 8. Watering with 20ml of water twice per week showed significantly lower means meaning that this water was too little and hence the seedlings were stressed.

CONCLUSION

- Hydrogels improved the efficiency of water use in raising tree seedlings as those seedlings S1 (soil with hydrogels) doing better than those in S0 (soil without hydrogel) for all watering levels.

RECOMMENDATIONS

- Investment should be made into ways of feeding seedlings with quantified amounts of water to reduce unnecessary wastage of water in our nurseries.
- The individual farmers, companies and the government at large should invest in the use of hydrogels in the nurseries to improve the efficiency of water use.

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