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AGROMANAGEMENT TECHNIQUES TO MITIGATE DROUGHT IN YOUNG RUBBER PLANTATIONS

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In India, attempts are being made to expand rubber cultivation to agro-climatically less favourable regions also, where drought is the major constraint. Climate uncertainty and increasing drought are adversely affecting the establishment and growth of plants even in traditional regions. Objective of the present study was to develop a viable technology for mitigating adverse effects of drought in young rubber plants in dry areas. The effectiveness of super absorbent polymer, tillage and potassium (K) supplement was tested in a field experiment conducted at Puthukkad Estate, Trichur, which is a drought prone area during 2010-12. Three types of planting materials *viz*. polybag plants raised from green budded stumps, polybag plants raised through direct seeding and root trainer plants were evaluated. Observations on chlorophyll content index (CCI), soil moisture and plant growth were recorded. Plants which received super absorbent polymer, tillage and K supplement retained significantly higher CCI compared to control during dry period in January. Soil moisture status during dry period in January was significantly higher in the treatments with super absorbent polymer and tillage. Tillage and super absorbent polymer improved growth of plants during 2012. Polybag plants raised through direct seeding were significantly superior to polybag plants raised from budded stumps with respect to CCI and growth during both years and were superior to root trainer plants after two years. The results showed that tillage and super absorbent polymer are effective in mitigating adverse effects of drought in young rubber plants and polybag plants raised through direct seeding have a better performance in dry areas compared to the other two planting materials.

Keywords: Drought, Planting material, Potassium, Super absorbent polymer, Tillage

INTRODUCTION

In India, scarcity of land for further expansion of rubber cultivation in traditional rubber growing regions coupled with the comparatively stable and attractive income from rubber plantations in recent years has lead to expansion of rubber cultivation in agro-climatically less favourable regions. Area under rubber is fast expanding in Karnataka and Goa region, and many farmers are venturing to rubber cultivation in Maharashtra and Orissa also. Prolonged dry season is the main climatic constraint in these regions and its impact will be more pronounced during establishment and early growth of plants. Appropriate farm technologies to mitigate

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drought are needed for successful cultivation of rubber in these regions.

In traditional regions, rubber was historically cultivated as a rain fed crop, with planting during the usually assured rainy period in June-July and drought mitigation measures like mulching and shading adopted to tide over the drought during the following dry season. Severe drought mediated symptoms in leaves have been reported only in non-traditional areas of rubber cultivation in Central India (Devakumar *et al*., 1998; Jacob *et al*., 1999), but in recent years symptoms of drought like leaf scorching and chlorophyll bleaching are observed in traditional regions also (Jessy *et al*., 2011). The authors also observed that climate uncertainty is adversely affecting the establishment of plants in these regions and additional drought mitigation measures improve growth of plants and reduce casualty and that many farmers are resorting to life saving irrigation to tide over the dry season, a hitherto unusual practice in the traditional rubber growing regions.

Hydrophilic polymers (high molecular weight, cross linked polyacrylamide) are used in many studies to improve establishment and growth of plants. Huttermann (1999) reported that survival of *Pinus* seedlings subjected to drought could be prolonged by addition of hydrogel to soil Switelik (1989) also observed initial positive effect when hydrogel was applied, but later no effect was observed. Shooshtarian *et al*. (2011) reviewed and reported the various merits of super absorbent polymers on improving establishment as well as and growth of plants and prolonging the wilting under drought conditions in arid and semiarid regions. Sijacic-Nikolic *et al*. (2011) reported that super absorbent polymers were useful in the reforestation of difficult and degraded terrains with adverse climatic conditions such as lower precipitation and higher average temperatures. Negative or lack of effect was also reported in some studies based on soil conditions (Bhardwaj *et al*., 2007).

Surface tillage has been reported to enhance soil moisture storage considerably (Payne, 1999). Jessy *et al*. (2011) also observed the positive effect of tillage of plant basins, in conserving residual soil moisture and improving the establishment and early growth of rubber plants. Role of potassium in mitigating drought effects is well documented in literature. Positive effect of high levels of K in overcoming moisture stress effects in rubber plants raised in polybags was reported by Samarappuli *et al*. (1993) and Prasannakumari *et al*. (2011).

Polybag plants are widely used as planting materials and they are raised either from budded stumps or by direct seeding in polybags. When budgrafted seedlings are uprooted from the nursery for planting in polybags, some damage to the root system occurs. However, the practice has advantages such as better budding success and possibility of selection from the seedling nursery. When polybag plants are raised through direct seeding, the root system is intact without any damage. Root trainer plants are fast gaining acceptance due to several advantages like less man power requirement for transportation and planting, good root system *etc*.

The objective of the study was to develop a viable technology for mitigating adverse effects of drought in young rubber plants in dry areas. We also evaluated the performance of different planting materials during establishment and early growth period in a drought prone area.

MATERIALS AND METHODS

The experiment was conducted at Puthukad Estate, Trichur, which is a comparatively drought prone area in Kerala. The treatments comprised of control, life saving irrigation from the beginning of the dry season, K supplement, tillage of plant basin, super absorbent polymer applied in planting pit, K supplement and tillage, and an integration of K supplement, tillage and super absorbent polymer in planting pit. Soil of the experiment area was high in organic carbon content (1.62 %), medium in available P (22 mg kg^{-1} soil) and K (96.75 mg kg^{-1} soil). The soil was acidic with a pH of 4.91. The monthly rainfall received in the experiment area is shown in Figure 1. Two whorl uniform polyag plants raised from budded stumps were planted during June 2010. The design of the experiment was RBD with three replications. Gross plot size was 28 and net plot size was 10 plants. Additional dose of K was supplied so that N: K was 1:1 (45 and 90 g KCl during first and second year, respectively). Super absorbent polymer (20 g) was mixed with 6 L of water, stirred properly and the gel was applied in the planting pit around the polybag plants and the pit was filled with soil. At the end of the rainy season (October) the base (radius 1.0 m) of rubber plants was tilled to a depth of 10 cm. Life saving irrigation was given at five days interval (2 L /irrigation) with a water injector from December onwards. In the control, plants showed symptoms of drought by the end of January and life saving irrigation was given from February onwards.

Composite soil samples (0-30) were collected before the commencement of experiment for chemical analyses. Observation on growth was recorded after the dry season. During June 2011, diameter of plants was recorded at 20 cm from bud union and during June 2012, girth was recorded at 150 cm from bud union. Soil moisture was recorded gravimetrically during January 2011 and 2012 and chlorophyll content index was recorded during January 2011 with a chlorophyll content meter (CCM 200, Opti-Science, USA).

For evaluating planting materials, 90 plants each of polybag plants raised from green budded stumps, polybag plants raised through direct seeding and root trainer plants were planted during June 2010. Uniform two whorl plants were used for planting. Life saving irrigation was given to all plants after February. Observations on CCI and soil moisture were recorded during dry season. Growth of the plants was recorded at six months interval.

All the data were compared statistically by ANOVA or t test.

RESULTS AND DISCUSSION

Effectiveness of super absorbent polymer, tillage and K supplement in mitigating drought

During January 2011, chlorophyll content index was lowest in the control and it was comparable with that of treatment which received life saving irrigation (Table 1). It appears that the limited quantity of water given through life saving irrigation was not sufficient to prevent chlorophyll bleaching. Plants which received super absorbent polymer at planting had the highest CCI and it was comparable with treatments which received K supplement and an integration of K supplement, super absorbent polymer and tillage. Plants which received tillage also had significantly higher CCI than control. The significantly higher CCI indicate the effectiveness of these techniques to reduce chlorophyll bleaching.

Soil moisture status was significantly higher in the treatments with super absorbent polymer and tillage compared to control during both years (Table 1) indicating that these techniques are effective

Table 1. **Chlorophyll content index (CCI) and soil moisture status during dry period in January**

Treatment	CCI (Jan 2011)	Soil moisture status (%) Jan 2011	Soil moisture status (%) Jan 2012
T1- Polybag plants raised from green budded stumps (control)*	18.0	9.00	12.16
T2- T1+ Life saving irrigation**	20.60	15.68	11.30
T3 – T1+ tillage	56.77	11.21	14.86
T4- T1+ K supplement	61.78	8.66	11.67
T5- T1 + super absorbent polymer	67.72	12.64	15.57
T6- T1+ K + tillage	53.37	12.48	14.49
T7- T1 + K+ tillage + super absorbent polymer	64.87	14.09	16.01
SE	2.79	0.57	0.39
CD (P =0.05)	8.38	1.77	1.21

* During first year from February onwards

** During first year from December onwards

for conservation of residual moisture, which is very vital for survival of plants during dry season. Surface tillage has been reported to enhance soil moisture storage considerably (Payne, 1999). Conservation of soil moisture in young rubber plantation by tillage of the plant basin at the end of the rainy season was reported earlier by Jessy *et al*. (2011). Soil moisture status in the plots which received life saving irrigation was comparable with the treatment with the integration of tillage, K supplement and super absorbent polymer. Shooshtarian *et al*. (2011) also reported the effectiveness of super absorbent polymers for soil moisture conservation in arid and semiarid regions of Iran. In Karnataka, India, Patil *et al*. (2011) observed that super absorbent polymers when applied to soil store extra water and enable the plants to utilize this water for a longer period of time and improve growth of plants.

Table 2. **Growth of plants after dry season (June)**

Treatment	Diameter (mm) at 20 cm 2011	Girth (cm) at 150 cm 2012
T1-Polybag plants raised from green budded stumps (control)*	21.41	9.74
T2- T1+Life saving irrigation**	22-00	10.47
T3 – T1+ tillage	24.09	11.54
T4- T1+ K supplement	22.37	9.57
T5- T1 + super absorbent polymer	22.69	10.79
T6- T1+K+ tillage	23.99	10.08
T7- T1 + K+ tillage + super absorbent polymer	25.41	11.58
SE	0.94	0.29
CD (P =0.05)	2.81	0.90

* During first year from February onwards

** During first year from December onwards

Table 3. **Leaf nutrient status of two year old plants (%)**

Treatment	N	P	K
T1- Polybag plants raised from green budded stumps (control)*	3.60	0.19	1.07
T2- T1 + Life saving irrigation**	3.88	0.19	1.16
T3- T1+ tillage	3.56	0.17	1.08
T4- T1+ K supplement	3.61	0.18	1.13
T5- T1 + super absorbent polymer	3.59	0.17	1.08
T6- T1 + K + tillage	3.29	0.15	1.12
T7- T1 + K + tillage+ super absorbent polymer	3.39	0.17	1.17
SE	0.19	0.01	0.13
CD (P =0.05)	NS	NS	NS

* During first year from February onwards

** During first year from December onwards

During 2011 (one year after planting), growth was highest in the treatment which received combination of all drought mitigation measures, and it was comparable with the treatments with tillage and tillage with K supplement (Table 2). These treatments were superior to control. The growth of plants in the treatment which received combination of all drought mitigation measures was significantly superior to life saving irrigation. Super absorbent polymer and tillage significantly improved growth of plants compared to control during 2012 (two years after planting) also. Studies conducted by Sijacic-Nikolic *et al*. (2011) in Scots Pine showed that application of super absorbent polymers to soil resulted in higher seedling survival and better growth during the first year. The positive effect of tillage on improving the growth of young rubber plants was reported by Jessy *et al*. (2011). Leaf nutrient status was not significantly influenced by different treatments (Table 3).

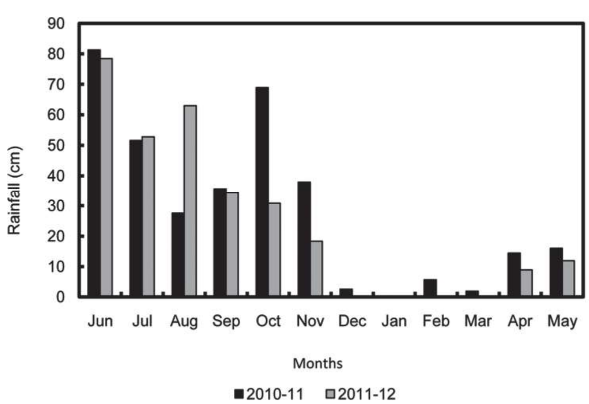

Fig. 1. Monthly rainfall in the area during the experiment period

Evaluation of planting materials in drought prone area

Root trainer plants and plants raised by direct seeding had a significantly higher CCI than polybag plants raised from budded stumps (Fig. 2). This might be due to the better root system of direct seeded polybag plants and root trainer plants compared to polybag plants raised from budded stumps, which facilitate better water uptake and better ability to tide over drought. There was no significant difference between direct seeded polybag plants and root trainer plants.

There was no significant difference between the planting materials six months after planting (December 2010). After one

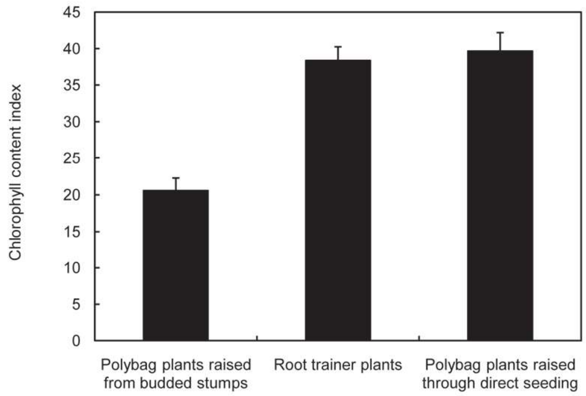

Fig. 2. Chlorophyll content index (CCI) of different planting materials during January

year (June 2011), direct seeded polybag plants were significantly superior to polybag plants raised from budded stumps. Direct seeded polybag plants continued to be significantly superior during the subsequent recordings also. Direct seeded polybag plants were significantly superior to root trainer plants also after two years (Table 4&5). There was no significant difference between polybag plants raised from budded stumps and root trainer plants. The in tact root system of direct seeded plants might have facilitated better water and nutrient uptake leading to better growth of plants.

CONCLUSION

The results showed that both tillage and super absorbent polymer were effective in improving establishment and early growth of rubber plants in dry areas. Scarcity of water and increasing labour wages are constraints to the large scale adoption of life saving irrigation and tillage and super absorbent polymer are alternative techniques to life saving irrigation. Among the different planting materials, polybag plants raised through direct seeding was the best followed by root trainer plants for drought prone areas.

Table 4. **Growth of different planting materials**

Treatment	Dec 2010	June 2011	Dec 2011	June 2012
	Diameter (mm) at 20 cm		Girth at 20 cm	Girth at 150 cm
Polybag plants raised from green budded stumps	15.22	21.40	11.21	9.76
Polybag plants raised through direct seeding	16.53	23.58	11.85	10.90
Root trainer plants	16.42	22.54	11.58	10.14

Table 5. **Statistical comparison of growth of different planting materials**

Treatment	Dec 2010	June 2011	Dec 2011	June 2012
Polybag plants raised from green budded stumps *vs* Polybag plants raised through direct seeding	NS	*		
Polybag plants raised from green budded stumps *vs* Root trainer plants	NS	NS	NS	NS
Polybag plants raised through direct seeding *vs* Root trainer plants	NS	NS	NS	*

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REFERENCES

Bhardwaj, A.K., Stainberg, I., Goldstein, D., Warrington, D.N. and Levy, G.J. (2007). Water retention and hydraulic conductivity of cross linked polyacrlamide in sandy soil. *Soil Science Society of America Journal,* **71**: 406-412.

Devakumar, A.S, Sathik, M.B.M., Jacob, J., Annamalainathan, K., Prakash, G.P andVijayakumar, K.R. (1998). Effects of atmospheric drought on growth and development of *Hevea brasiliensis*. *Journal of Rubber Research,* **1**(3): 190-198.

Huttermann,A., Zommorodi, M. and Leise, K. (1999). Addition of hydrogels to soil forprolonging the survivl of *Pinus halepensis* seedlings subjected to drought. *Soil and Tillage Research,* **59**: 295-304.

Jacob, J., Annamalainathan K., Alam, B., Sathik, M.B.M., Thapliyal, A.P. and Devakumar, A.S. (1999). Physiological constraints for cultivation of *Hevea* in certain unfavourable agroclimatic regions of India. *Indian Journal of Natural Rubber Research,* **12**: 1-16.

Jessy, M.D., Krishnakumar, R., Annamalainathan, K. and Jacob, J. (2011). Climate uncertainties and early establishment of young rubber plants in traditional rubber growing regions of India. *Natural Rubber Research,* **24**: 145-147.

Patil, A.A., Meena, M.K., Chetti, M.B. and Kumar, B.N.A. (2011). Influence of super absorbent polymer on various crop growth parameters. *Research Journal of Agricultural Sciences,* ISSN: 0976-1675.

Payne, W.A. (1999). Shallow tillage with a traditional West African hoe to conserve soil water. *Soil Science Society of America Journal,* **63**: 972-976.

Prasannakumari, P., Jessy, M.D. and Annamalainathan, K. (2011). Potassium and silicon help young rubber plants tide over drought. *Natural Rubber Research*, **24**: 150-154.

Samarappuli, L., Yogaratnam, N., Karunadasa, P. and Mitrasena, U. (1993). Role of potassium on growth and water relations of rubber plants. *Journal of Rubber Research Institute of Sri Lanka,* **73** : 37-57.

Shooshtarian, S., Abedi-Kupai, J. and TehraniFar, A. (2011). Evaluation of application of super absorbent polymers in green space of arid and semi-arid regios with emphasis on Iran. *Journal of Biodiversity and Ecological Sciences,* ISSN 2008-9287: 258-269.

Sijacic-Nikolic, M. Vilotic, D. and Milovanovic, J. (2011). Effect of polymers on scots pine (*Pinus silvestris* L.) and Austrian Pine (*Pinus Nigra* Arn.) seedling development in afforestration. *Global Journal of Biodiversity Science and Management,* **1**: 11-18.

Swietlik, D. (1989). Effect of soil amendment with Viterra hydrogel on establishment of newly planted grapefruit tree cv. Ruby red. *Communications in Soil Science and Plant Analysis,* **20**: 15-16.