EFFECT OF SOIL MOISTURE CONTENT ON *Jatropha curcas* L. DURING EARLY GROWTH STAGE

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ABSTRACT

Jatropha curcas L. commonly known as Physic nut belonging to family Euphorbiaceae, has recently evoked much interest worldwide as a potential alternative source of renewable energy with an oil content of 37 %. It is a plant that could be able to gain a recovered production from marginal lands in Sri Lanka since it is suggested as an adaptable and drought resistant, perennial medium size tree. *Jatropha curcas* grows best in well drained soils having pH around 6-9, and is well adapted to marginal soils with low nutrient contents. However, it needs more than 600 mm rainfall per year for better growth and it can withstand long periods of drought. The present study is based on estimation of the effect of soil moisture content in *J. curcas* in early crop growing stages. For this propose, the variation of soil moisture suction against volumetric soil moisture content (VSMC) relationship and SPAW (Soil-Plant-Air-Water) modeling results were used. Soil particle size distribution analysis in lysimeter study identified that soil type is 'sandy clay loam' according to the SPAW model. The same model identified the following physical and hydraulic parameters: bulk density 1.58g/cm^3, saturated moisture content 40.4%, field capacity 23.0%, permanent wilting point 15.2%, and saturated hydraulic conductivity 12.32 mm/h. At the 60% and 50% management allowable soil moisture depletion levels, plants showed wilting symptoms and leaves felled in five and half month and six month old *J. curcas* plants. Such a moisture depletion level at very early plant growth stage will drastically reduce the vegetative plant growth as well as reproductive plant growth and directly affecting the economic yield component of the plant.

Keywords: *Jatropha curcas* L., renewable energy, volumetric soil moisture content, SPAW modeling.

1. INTRODUCTION

The demand for plant-based feedstock for biodiesel production has received much attention in recent years. At present, the majority of the world's energy needs are supplied through non-renewable sources of energy such as petrochemical sources, coal and natural gases. These resources are considered as rapidly declining as well as one of the major sources of Green House Gasses leading to global warming. Unlike sugar cane, wheat, corn and other biofuel sources mainly produced from food crops, *Jatropha curcas* L. gives remarkable output to commercial growers. *Jatropha* can be used to make a wide range of products including high quality paper, energy pellets, soap, cosmetics, toothpaste, embalming fluid, pipe joint cement, cough medicine, and as a moistening agent in tobacco. In addition, it has been considered as highly potential plant for biodiesel production (Kumar and Sharma, 2008).

In the situation where water supply is limited and rainfall is inadequate, the irrigation demand of early crop growing season is decisive for rapid growth and giving the potential economic yield. Selection of suitable plants to tolerate such conditions is more beneficial.

Jatropha curcas is a plant that could be able to gain a recovered production from marginal lands in Sri Lanka since it is an adaptable, drought resistant, perennial plant belonging to the family

Euphorbiaceae (Niu *et al.,* 2012). It grows best in well drained soils having pH around 6-9, and is well adapted to marginal soils with low nutrient contents. *Jatropha curcas* grows well with more than 600 mm rainfall per year and it can withstand long periods of drought (Pushpakumara *et al*., 2008). It is a tropical plant that can be grown either in farms as a commercial crop or on the farm boundaries as a hedge to protect fields from grazing animals and to prevent erosion in marginal lands. The plant sheds its leaves during a prolonged dry season (Kheira and Atta, 2009).

The drought is considered as a period without precipitation, with consequent decrease in water content in soil, leading to drought stress of plants. Though the situation is similar to that, *Jatropha curcas* has a higher potential to well adapt to uncultivable lands in Sri Lanka as a solution to fuel deficit.

The present study is based on estimation of crop water requirement in *Jatropha curcas* within early crop growing stage in comparing soil moisture suction against volumetric soil moisture content (VSMC) relationship and SPAW modeling results. The objectives of this study is to estimate the temporal variability of soil moisture content within the root zone after irrigation and compare with soil moisture characteristic curve of the field soil. Plants' responses for the different moisture contents were analyzed accordingly.

2. MATERIALS AND METHODS

Department of Agricultural Engineering premise was selected to conduct the experiment to determine the crop water requirement using a lysimeter study using the weight balance method. Five buckets were selected as lysimeter containers/pots and, cuttings were planted in four containers while the other container was kept as the control without a plant. Daily weight balances were measured at uniform time intervals with intermittent irrigation. These data were used to calculate the daily water losses from each lysimeter.

Metric potential of soil was also measured by using a tensiometer, within each 24 h time interval at the time of water loss measurements were taken. When the metric potential reached 55 milibars, the first irrigation was done to bring the VSMC in all pots back to the field capacity. The crop water requirement at the initial growth stage of *Jatropha curcas* was estimated by using weight balance method (Igbadun, 2012) in pot lysimeters data.

Pot numbers one and two were maintained at 50% management allowable moisture depletion and pot numbers three and four were maintained at 60% management allowable moisture depletion levels. Plant growth data were analyzed at each and every stage of moisture content in soil, while all the other conditions were constant. Soil particle size analysis was done using wet sieving, electrical sieving and hydrometer method. Soil hydraulic parameters were predicted using the SPAW model (Saxton and Rawls, 2006) according to the particle size distribution in the sample soil.

3. RESULTS AND DISCUSSION

3.1. Analysis of lysimeter data in progressing irrigation:

Figure 1 shows temporal variation of VSMC for five lysimeters with nine irrigation events. Result show that almost similar moisture loss pattern from pots having plants (Pot numbers 1, 2, 3 and 4) while the control (Pot number 5) show a slightly different depletion pattern (Figure 1). This higher water loss in pots 1, 2, 3 and 4 is obvious since water loss is accounted to evapotranspiration whereas water loss from pot number 5 is only due to evaporation.

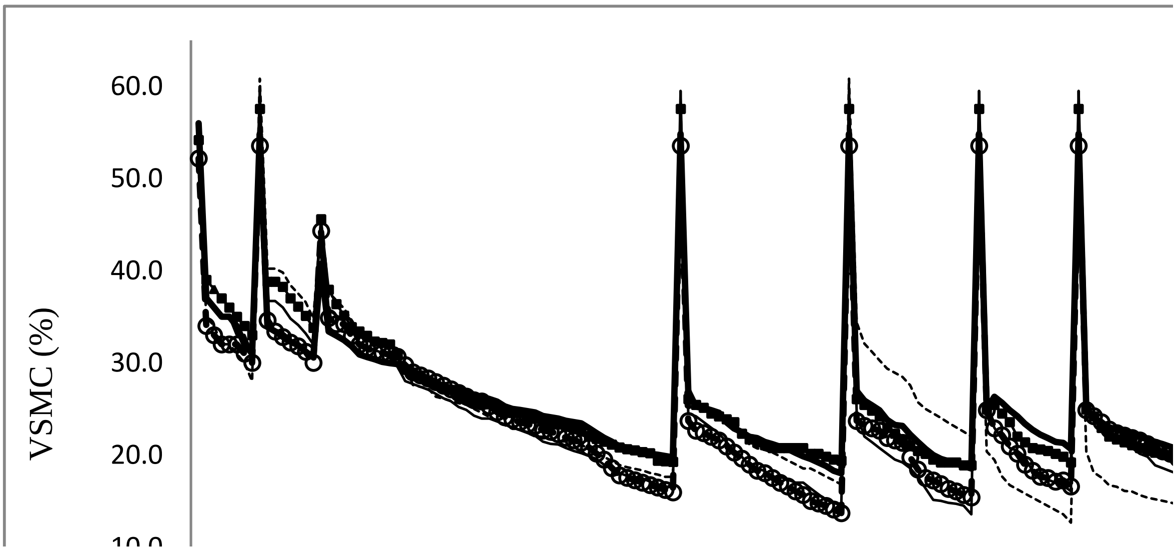

Figure 1: Temporal variation of VSMC for all five lysimeters with nine irrigation events

The objective of the SPAW model was to understand and predict agricultural hydrology and its interactions with soils and crop production without unnecessary affliction of computation time or input details (Saxton and Ralws, 2006). According to the particle size distribution, the soil moisture characteristic curve was developed for the sample field soil which was used in the lysimeter study. The SPAW model provided the following physical and hydraulic parameters of the soil: bulk density 1.58g/cm^3, saturated moisture content 40.4%, field capacity 23.0%, permanent wilting point 15.2%, and saturated hydraulic conductivity 12.32 mm/h.

According to the soil particle size distribution the soil was identified as a 'sandy clay loam' soil (Table 1) and the developed soil moisture characteristic curve based on lysimeter study and SPAW model is given in Figure 2.

Table 1: Soil particle size distribution according to the hydrometer method

Type of particle	Amount (%)
Sand content	71.0
Silt content	03.7
Clay content	24.0
Organic matter	01.3

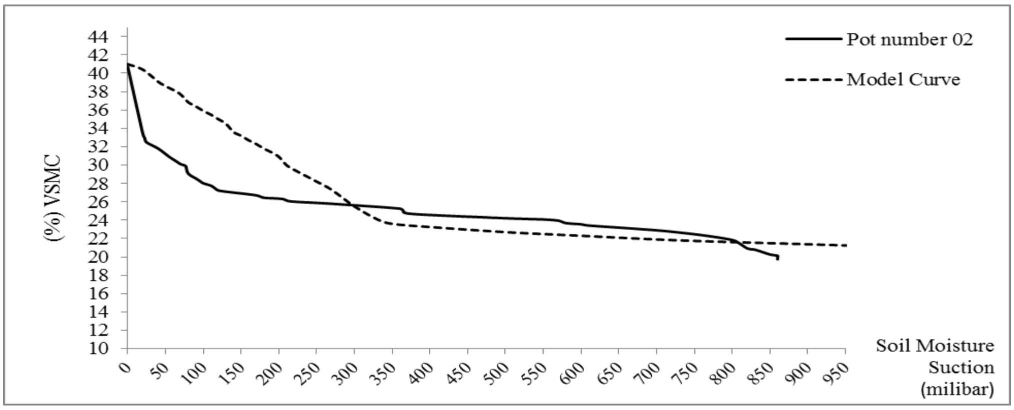

Figure 2: Soil moisture characteristic curve developed from lysimeter data and SPAW model

The above curve was developed by using tensiometer data obtaining from pot number 2 and compared with model data. According to Figure 2, the measured water losses from the soil is higher than that of model predicted water losses until the soil reach around 300 mbar tension. This soil moisture suction is within the Field Capacity (FC) level which is found to be around 24% according to measured data. However, according to predictions, the SPAW model gave a FC of 23%. Further, beyond 300 mbar soil moisture suction level, both model predicted and measured data are closely matched (Figure 2). The difference in the measured curve and the predicted curve from saturation to FC could be due to (i) inaccuracy of tensiometer readings and (ii) over estimation of clay content in textural analysis of which could have affected on higher moisture retention at lower suctions in predicted data. More intensive sampling with replicates and development of soil moisture characteristic curve in laboratory are needed in confirming the accuracy of SPAW model for local soil conditions.

When maintaining a 60% management allowable soil moisture depletion, wilting characters were appeared in pot numbers 3 and 4, and all the leaves felled within one week in five and half month old plants. It might be the deciduous nature of the *J. curcas* plant. At the 50% management allowable soil moisture depletion, all the leaves felled within three weeks in six month old plants in pot numbers 1 and 2.

4. CONCLUSIONS

Soil particle size distribution analysis in lysimeter study gave that soil type is ‘sandy clay loam’ according to the SPAW model. At the 60% and 50% management allowable soil moisture depletion levels, plants showed wilting symptoms and leaves felled in five and half month and six month old *Jatropha* plants. Such a moisture depletion level at very early plant growth stage will drastically reduce the vegetative plant growth as well as reproductive plant growth and directly affecting the economic yield component of the plant.

5. REFERENCES

[1] Pushpakumara D.K.N.G., H.P.M. Gunasena, V.P. Singh, “Jatropha (*Jatropha curcas* L.): A potential biodiesel crop for Sri Lanka,” ICRAF South Asia Program, New Delhi, India, pp 20–39, 2008.

[2] Saxton K.E. and W.J. Rawls, “Soil water characteristic estimates by texture and organic

matter for hydrologic solutions," Soil Science Society Journal, Volume 70, pp 1569–1577, 2006.

[3] Niu G., D. Rodriguez, M. Mendoza, J. Jifon, G. Ganjegunte, "Responses of *Jatropha curcas* to salt and drought stresses," International Journal of Agronomy, Volume 2012, pp 02–06, 2012.

[4] Igbadun H.E., "Estimation of crop water use of rain-fed maize and groundnut using mini-lysimeters," The Pacific Journal of Science and Technology, Volume 13, pp 527–535, 2012.

[5] Kheira A.A.A. and N.M.M. Atta, "Response of *Jatropha curcas* L. to water deficits: yield, water use efficiency and oilseed characteristics," Journal of Biomass and Bioenergy ELSEVER, Volume 33, pp 1343–1350, 2009.

[6] Kumar N. and P.B. Sharma, "*Jatropha curcus* – A sustainable source for production of biodiesel," Journal of Scientific and Industrial research, Volume 64, pp 883–889, 2005.