Agriculture and Natural Resources 50 (2016) 454–459

Contents lists available at ScienceDirect

Agriculture and Natural Resources

journal homepage: http://www.journals.elsevier.com/agriculture-and-natural-resources/

Original Article

Effects of soil moisture conservation practice, irrigation and fertilization on *Jatropha curcas*

Aran Phiwngam, Somchai Anusontpornperm,* Suphicha Thanachit, Worachart Wisawapipat

Department of Soil Science, Faculty of Agriculture, Kasetsart University, Bangkok 10900, Thailand

ARTICLE INFO

Article history:
Received 23 March 2016
Accepted 13 October 2016
Available online 3 January 2017

Keywords:
Fertilization
Irrigation
Jatropha curcas
Soil moisture conservation practice
Ultic Haplustalf

ABSTRACT

A field experiment was conducted on an Ultic Haplustalf at the Kanchanaburi Research Station, Muang district, Kanchanaburi province, western Thailand between July 2011 and June 2012. Split plots in a randomized complete block design with four replications were employed, having eight main plots (soil moisture conservation practice and irrigation, W1–W8) and 2 sub plots (fertilization, F1 and F2). *Jatropha curcas* (KUBP 78-9 Var.), having been planted at 2 × 2 m spacing, was aged 2 yr when the experiment was commenced. The highly significantly heaviest 100-seed weight of 42 g was obtained 1 mth after water irrigation which had been applied at the rate of 16 L/plant, particularly in the treatment with crop residue mulching (W8) but there were no significant differences among the other treatments where irrigation had been applied (W5–W7). Fertilization and a combination between different fertilizers and soil moisture conservation schemes plus irrigation showed no different effect on the weight of 100 seeds throughout the year of measurement. Growing *J. curcas* with drip-irrigated water at the rate of 16 L/plant applied every 2 d and crop residue mulching (W8) significantly gave the highest seed yield of 1301.3 kg/ha at 15% moisture content. There were no significant differences among the seed yields from the plots applied with the same amount of irrigated water but with no mulching (W7) and half that amount of irrigated water with crop residue mulching (W6), producing yields of 1112.0 kg/ha and 1236.3 kg/ha, respectively. Three-year-old *J. curcas* gave inferior seed yield when grown with no irrigated water supply (W1–W4). The application of 50–150–150 kg/ha of N–P_2O_5–K_2O significantly induced a higher amount of seed yield (933.9 kg/ha) than did the addition of 93.75–93.75–93.75 kg/ha of N–P_2O_5–K_2O (786.3 kg/ha). The interaction between soil moisture conservation plus irrigation and fertilizer was clear. Applying 50–150–150 kg/ha of N–P_2O_5–K_2O together with water irrigation at the rate of 16 L/plant (W7F2) significantly promoted the greatest seed yield of 1415.2 kg/ha. However, irrigated water can be reduced to 8 L/plant in combination with crop residue mulching and the addition of 50–150–150 kg/ha of N–P_2O_5–K_2O (W6F2) and the plants still performed well, producing a seed yield of 1356.4 kg/ha. In addition, with no irrigation, none of the moisture conservation practices (W2–W4) showed any significant effects regardless of the different fertilizers applied.

Introduction

Jatropha curcas L. (Jatropha or Physic nut) is a wild plant that has been cultivated as a result of variety research and belongs to the family Euphorbiaceae being classified as having plant oil similar to palm oil (Anderson and Ingram, 1993; Sricharoenchaikul et al., 2008). What distinguishes *J. curcas* from many other bio fuel crops are the benefits it can offer to relatively small rural areas in less developed countries. In recent years, *J. curcas* has been planted widely, using artificial management (Openshaw, 2000). However, soil water and plant nutrients are the most important factors affecting the growth and water use of this plant (Heller, 1996). The plant is commercially rather new to Thailand so that there is scarce information about fertilization to improve the yield of *J. curcas* grown in the Kingdom. General recommendations for fertilizer use when growing *J. curcas* are based on those used in other plants such as cassava, where a ratio of 1:1:1 for the plant major nutrients is broadly recommended (Chinawong, 2006). Recent study has indicated that the application of nitrogen and phosphorus

* Corresponding author.
E-mail address: somchai.a@ku.ac.th (S. Anusontpornperm).

http://dx.doi.org/10.1016/j.anres.2016.10.006

increased the growth, seed yield and oil yield of *J. curcas* (Patolia et al., 2007; Yin et al., 2010). These results also conformed with the findings of Yong et al. (2010) and Kalannvar (2008). A pot experiment was conducted in the greenhouse and the result showed that the optimal nitrogen supply was 288 kg/ha, which can increase the photosynthetic rate and growth of *J. curcas* under mild drought conditions (Yin et al., 2011). Nitrogen addition significantly promotes the growth of the main stem, and added P or K fertilizer can clearly increase the yield of *J. curcas* (Liu et al., 2009; Gu et al., 2011). Previous study also showed that to optimize the yield for degraded soils in India, the recommended regime was an irrigation frequency at 30 d as water is required, 2 kg of farmyard manure and N, P and K at 10 g, 20 g and 10 g per plant, respectively (Singh et al., 2013). In addition, nitrogen fertilization improved photosynthesis at 80% of water holding capacity (Yin et al., 2010). Nitrogen addition also increased the total dry mass, whole plant water storage capacity, total evapotranspiration and water use efficiency (Yang et al., 2013). A study in the coarse-textured soils of northwest India (Tikkoo et al., 2013) showed that *J. curcas* seed yield increased significantly at 60 kg/ha N with no irrigation whereas seed yield increased significantly up to 90 kg/ha N with one and two irrigation events. A significant effect of potassium application on seed yield was found up to 45 kg/ha K_2O in the absence of irrigation but its effect was significant up to 60 kg/ha K_2O with one and two irrigation events. As mentioned earlier, additional information on fertilization for growing *J. curcas* is essential, particularly in tropical regions where this plant has the potential to be grown for use as a source of energy. Thus, the current study was undertaken as a preliminary investigation into the yield response of *Jatropha* grown on an Ultic Haplustalf soil in western Thailand to different types of soil moisture conservation practice, irrigation and fertilization.

Materials and methods

Experimental site description

The experiment was conducted at the Kanchanaburi Research Station, Muang district Kanchanaburi province in western Thailand (47 535142° E, 1561440° N). The area has a tropical climate with an average annual rainfall of 1114.3 mm (2012–2014), having a bimodal pattern and a mean annual temperature of 27.7 °C (National Statistical Office, 2014). The average rainfall is slightly lower than normal for the area because the station is located on the lee side of a mountainous area (away from the wind). The mountains block the passage of rain-producing weather systems and cast a "rain shadow" behind them. Soil at the experimental site is an Ultic Haplustalf, having been formed on a nearly flat surface on the dissected footslope of a limestone mountain. The soil has loam and clay loam textures in the topsoil and subsoil, respectively, with clay particle increasing with increasing depth. Table 1 summarizes the properties of soil prior to conducting the experiment. The soil pH values varied slightly within 60 cm from the mineral soil surface, in the range 5.1–5.4. Soil organic matter had clearly accumulated in the topsoil layers (10.5 g/kg) and decreased in the layers below (6.81 and 2.72 g/kg). The total nitrogen content of the soil was very low (0.63–0.84 g/kg), while available phosphorus was very low to low (2.54–4.52 mg/kg). The range of available potassium content in the top 60 cm of the soil was low (41.2–54.1 mg/kg).

Experimental trial design and crop management

J. curcas (KUBP 78-9 Var.) was planted in June 2009, using direct seeding at a spacing of 2 × 2 m, giving a total population of 2500 plants/ha. Basal dressing fertilization was applied using 56.25 g/plant consisting of equal amounts of N, P and K chemical fertilizer with 2.5 kg compost per hole; the compost properties are presented in Table 2. Then, three *J. curcas* seeds per hole were sown. The growing plant was tipped at 50 cm height to allow the plant to branch laterally at the beginning of its growth in the first year. Drip irrigation at the rate of 2 L/plant every 2 d was performed throughout the whole period of growth in the first year. In the second year, the plants were irrigated in accordance with the treatments described below. The same amount of fertilizer (93.75–93.75–93.75 kg/ha of $N–P_2O_5–K_2O$) was applied to all plots in both years.

The current study utilized data gathered from the same experiment but was commenced when the plants were fully two years old. It began with hard pruning being done for all plants in July 2010. A split plot in a randomized complete block design with four replications was employed for the experiment. The main plots consisted of: W1 = control, W2 = crop residue mulching (mainly local weeds), W3 = vetiver grass grown between rows of *J. curcas* and the vetiver leaves were slashed twice a year and then mulched around the *J curcas* plants, W4 = jack bean grown as ground cover, W5 = drip irrigation applied at the rate of 8 L/plant every 2 d, W6 = drip irrigation applied at the rate of 8 L/plant every 2 d with crop residue mulching as in W2, W7 = drip irrigation applied at the rate of 16 L/plant every 2 d and W8 = drip irrigation applied at the rate of 16 L/plant every 2 d with crop residue mulching as in W2. Crop residue mulch was composed mainly of rice straw and a layer approximately 2.5 cm thick of the residue was placed to wholly cover all designed plots at the beginning of the rainy season in each year. Vetiver grass was grown using a spacing between tillers of 30 cm in the first year at the time when the *J. curcas* plants were aged 2 mth and their leaves were slashed at a height of 20 cm twice a year during the rainy season for mulching purposes. Jack bean was grown using direct seeding at a rate of 62.5 kg/ha at the same time as the vetiver grass and it was re-sown each year at the beginning of the rainy season. Irrigation was performed during the drought period, starting from October 2011 until the end of April 2012. Subplots comprised two rates of chemical fertilizer: F1 = 93.75–93.75–93.75 kg/ha of $N–P_2O_5–K_2O$ and F2 = 50–150–150 kg/ha of $N–P_2O_5–K_2O$. These fertilizer rates were based on the result of the response of *J. curcas* grown on an Ultic Paleustalf to chemical fertilizers and compost previously studied nearby (Saikaew et al., 2014) where the characteristics of the soil and its fertility level were rather similar to those in this experiment. Split applications of equal amounts of these

Table 1
Properties of soil prior to conducting the experiment (before placing seedbed).

Depth (cm)	Textural class	pH 1:1 (H_2O)	OM (g/kg)	Total N (g/kg)	Avail. P (mg/kg)	Avail. K (mg/kg)
0–20	Silt loam	5.1	10.52	0.84	4.52	54.1
20–40	Clay loam	5.2	6.81	0.70	3.52	49.9
40–60	Clay loam	5.4	2.72	0.63	2.54	41.2

Note: Avail. P = available P, Avail. K = available K.

Table 2
Properties of compost used in the experiment.

Parameter	Analysis	Unit	Parameter	Analysis	Unit
pH (H_2O 1:2)	6.20	–	Total Mg	0.29	g/kg
Organic matter	24.59	g/kg	Total Na	0.08	g/kg
Total N	5.12	g/kg	Total Fe	1.03	mg/kg
Total P_2O_5	4.72	g/kg	Total Zn	0.84	mg/kg
Total K_2O	0.93	g/kg	Total Cu	0.21	mg/kg
Total Ca	0.52	g/kg	Total Mn	0.11	mg/kg