RESEARCH PAPER | Agriculture | Volume : 5 | Issue : 9 | September 2015 | ISSN - 2249-555X

Agronomic Effectiveness of Jatropha Seedcake as an Organic Fertilizer

KEYWORDS: Organic fertilizer, Jatropha curcas, Jatropha seedcake.

Miyanda Moombe
Department of Soil Science, School of Agricultural Sciences, University of Zambia, P.O Box 32379, Lusaka, Zambia.

Obed I. Lungu
Department of Soil Science, School of Agricultural Sciences, University of Zambia, P.O Box 32379, Lusaka, Zambia.

ABSTRACT *Zambia has embraced bio-diesel processing from jatropha (Jatropha curcas) and, therefore, disposal of de-oiled residue of jatropha seeds (Jatropha seedcake) from the growing bio-diesel industry is likely to present challenges because it cannot be utilized as livestock feed. In this study, we explored the agronomic effectiveness of the seedcake as an organic fertilizer. We evaluated the rate of nitrogen release from the seedcake and maize crop performance in soils fertilized with the seedcake. The seedcake had a nitrogen mineralization rate of 0.14 wk^{-1} and its improvement to plant soil nutrient supply was evident in the vigorous growth and higher maize grain yields observed in plants grown in soils where seedcake was applied. Maize grain yields of 2.29, 2.32 and 2.75 ton ha^{-1} were obtained from plots treated with 2, 4 and 6 ton ha^{-1} of seedcake, respectively, compared to a yield of 1.4 ton ha^{-1} where no seedcake was applied. We, therefore, concluded that jatropha seedcake from bio-diesel processing could be safely disposed on land and be a valuable organic fertilizer. Nevertheless, further study needs to be done to ascertain possibilities of utilizing seedcake from processes where solvents are used for extracting oil from the seeds.*

Introduction
Growing of jatropha (*Jatropha curcas*) for processing into bio-diesel has been embraced in Zambia. Large quantities of de-oiled residue of jatropha seeds (jatropha seedcake) would be produced once production of bio-diesel starts and a challenge to safe disposal of the seedcake is eminent. Unlike seedcakes from other crops such as soybean and sunflower, jatropha seedcake is poisonous and not suitable for use as a livestock feed (Martinez-Herrera et al., 2005; Li et al., 2010). Therefore, there is need to consider other means of disposal. We investigated the disposal of the seedcake on land as an organic fertilizer.

The fertilizer value of an organic residue is determined by its rate of decomposition and subsequent mineralization and composition (Gosz et al., 1973; Douglas and Magdoff, 1991). Rates of decomposition and mineralization for various organic materials that are potential sources of nutrients for plant growth are seldom known (Palm and Sanchez, 1990; Cabrera et al., 2005). It is reported that jatropha seedcake contains about 4.5 % total organic N which is a slow-release source of nitrogen that can agronomically benefit crops. However, composition of the seedcake varies depending on the extraction process and whether or not solvents are employed in the oil extraction process (Achten et al., 2008; Berchmans and Hirata, 2008; Montes et al., 2011). In this study, we investigated disposal of seedcake obtained from mechanically de-oiled jatropha seeds on land as an organic fertilizer. The objectives were to determine the rate of release of nitrogen (mineralization) and to evaluate crop performance when supplied with nitrogen from the jatropha seedcake.

Materials and Methods
Jatropha seedcake from a pilot bio-diesel processing plant in Zambia was obtained for this study. The seedcake was characterized with respect to total organic nitrogen (N) and phosphorus (P) content, and total organic matter. Nitrogen mineralization rates were determined in the laboratory by mixing 5 g of seedcake with 100 g of top soil and 100 g washed sand in plastic bows, to mimic a field application rate of 6 ton ha^{-1}. As a control, 100 g of top soil were mixed 100 g of washed sand into separate bows. The mixtures were moistened and afterwards bows were air-tightly sealed and incubated away from light at room temperature for up to 12 weeks. Each treatment was analyzed for released mineral nitrogen (ammonium and nitrate) every week. The time series and the cumulative mineral nitrogen were regressed to calculate nitrogen mineralization rate constant and half-life (Stanford and Smith, 1972).

A complementary statistical field trial was conducted at the University of Zambia, School of Agricultural Sciences Field Station (15° 23′ 41″ S and 28° 20′ 14″ E) to evaluate the performance of maize on soils fertilized with jatropha seedcake as a source of nitrogen. Different rates of seedcake (0, 2, 4 and 6 ton ha^{-1}) were applied to an open pollinated variety of maize (Pool 16, Zamseed, Zambia) that was grown to maturity and the grain yield recorded. Four replications were made for the field trial.

Results and Discussion
Laboratory analysis showed that jatropha seedcake contained 47.9 % carbon, 4.2 % total organic N (giving a C: N ratio of 11.4: 1), 0.6 % P, 1.9 % K, 13.9 % Ca and 11.8 % Mg. At the maximum rate of seedcake application of 6 ton ha^{-1}, there would potentially be 250 kg N ha^{-1} available to the crop, sufficient for a good crop of maize. This amount was more than what would be supplied from the recommended application of 200 kg ha^{-1} of D compound fertilizer (10:20:10) basal dressing plus 200 kg ha^{-1} urea as topdressing.

This organic source of N is slow-release and depends on favourable soil conditions for microbial activities for mineralization. Nitrogen mineralization rate and half-life of Jatropha seedcake were determined as 0.14 week^{-1} (Fig.1) and 5 weeks, respectively. The rate of 0.14 wk^{-1} indicates a reasonable rate of N release (Agehara and Warncke, 2005). The result further implies that potentially 126 kg N ha^{-1} of mineral N could be released in 5 weeks from an application of 6 ton of the seedcake ha^{-1}.

Volume : 5 | Issue : 9 | September 2015 | ISSN - 2249-555X

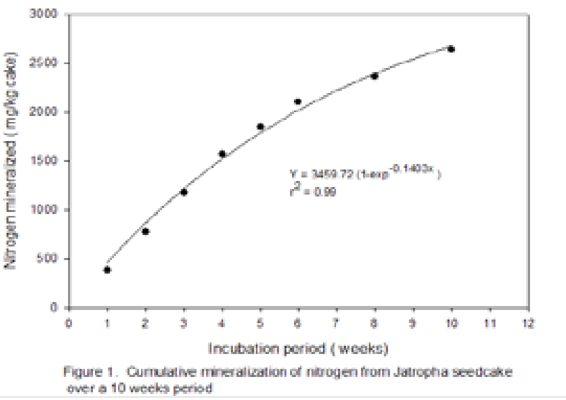

Fig.1: Mineralization of nitrogen from jatropha seedcake over a period of ten weeks.

The field trial confirmed the results from the incubation experiment, showing that jatropha seedcake supplied adequate plant available N to the maize crop. Vigorous growth of plants grown in soils fertilized with jatropha seedcake was evident five weeks after emergence (Fig. 2). The trend continued to harvest where maize grain yield of 2.29, 2.32 and 2.75 ton ha^{-1} were obtained from plots treated with 2, 4 and 6 ton ha^{-1} of seedcake respectively, compared to a yield of only 1.4 ton ha^{-1} from the control (Fig. 3). This implies that residue from mechanically de-oiled jatropha seedcake could be disposed on land as a valuable organic fertilizer.

Fig.2: Performance of maize at five weeks after emergence: control plot in the foreground (chlorotic) and nutrient adequately supplied crop (background).

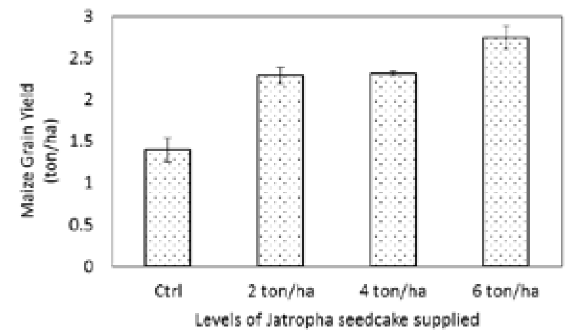

Fig.3: Effect of jatropha seedcake on maize yield.

Nevertheless, there are potential challenges to using Jatropha seedcake as an organic fertilizer in cases where industrial solvents are used to extract the bio-diesel (Achten et al., 2008). In such instances, disposal of the seedcake on land may not be an option until the environmental impacts of the solvents are ascertained.

Conclusion

Results from laboratory analysis and field trial showed that jatropha seedcake has potential as an organic fertilizer. A mineralization rate of 0.14 wk^{-1} was determined and a field trial confirmed that sufficient mineral N was released to support vigorous plant growth and a higher yield of maize. However, further studies need to be carried out to ascertain possibilities and environmental impacts of utilizing seedcake where solvents are used for extracting oil from the seeds.

REFERENCE Achten, W.M.J., Verchot, L., Franken, Y.J., Mathijs, E., Singh, V.P., Aerts, R. and Muys, B. (2008), Jatropha biodiesel production and use, Biomass and Bioenergy, 32:1063-1084. | Agehara, S. and Warncke, D.D. (2005), Soil moisture and temperature effects on Nitrogen release from organic Nitrogen sources, Soil Science Society of American Journal, 69:1844-1855. | Berchmans, H.J. and Hirata, S. (2008), Biodiesel production from crude Jatropha curcas L. seed oil with high content of free fatty acids, Bioresource Technology, 99:1716-1721. | Cabrera, M.L., Kissel, D.E. and Vigil, M.F. (2005), Nitrogen mineralization from organic residues: research opportunities, Journal of Environmental Quality, 34:75-79. | Douglas, B.F. and Magdoff, F.R. (1991), An evaluation of nitrogen mineralization indices for organic residues, Journal of Environmental Quality, 20:368-372. | Gosz, J.R., Likens, G.E. and Bormann, F.H. (1973), Nutrient release from decomposing leaf and branch litter in the Hubbard Brook forest, New Hampshire, Ecological Monographs, 43:173-191. | Li, C.Y., Devappa, R.K., Liu, J.X., Lv, J.M., Makkar, H.P.S. and Becker, K. (2010), Toxicity of Jatropha curcas phorbol esters in mice, Food and Chemical Toxicology, 48:620-625. | Martinez-Herrera, J., Siddhuraju, P., Francis, G., Davila-Ortiz, G. and Becker, K. (2006), Chemical composition, toxic/ antimetabolic constituents, and effects of different treatments on their levels, in four provenances of Jatropha curcas L. from Mexico, Food Chemistry, 96:80-89. | Montes, J.M., Aliciardi, M.R., Chavez, J.V., Guzman, C. and Calandri, E. (2011), Characterization of Jatropha curcas L. seed and its oil from Argentina and Paraguay, The Journal of the Argentine Chemical Society, 98:1-9. | Palm, C.A. and Sanchez, P.A. (1990), Decomposition and nutrient release patterns of the leaves of three tropical legumes, Biotropica, 22:330-338. | Stanford, G. and Smith, S.J. (1972), Nitrogen mineralization potentials of soils, Soil Science Society of America Proceedings, 36:465-472.