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Allelopathic Effects of Jatropha (*Jatropha curcas* Linn.) on Agricultural Crops

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ABSTRACT

Jatropha (*Jatropha curcas* Linn.) fascinated the cultivators owing to its biofuel potential. It possesses well known medicinal properties valuable in pharmaceutical and cosmetic industries. Most of the researchers have considered its phytochemical properties from medicinal point of view but its plant-plant interactions in crop association have received only secondary attention. Present article compiles the studies which throw light on the presence of different phytoactive compounds with allelopathic potential. The use of Jatropha in agroforestry systems requires an understandingt of its long term impact on companions. The present report assesses its particular effects under laboratory and nursery trials. Field trials with distinct patterns of intercropping have to made on large scale to find suitable crop combinations for the growers.

Key Words: Agroforestry; Biofuel; Food Crops; Intercropping; Phytochemicals.

INTRODUCTION

Jatropha (*Jatropha curcas* Linn.) is multipurpose shrub belonging to family Euphorbiaceae. It is believed to have originated from South America and Africa (Gubitz et al. 1999). Short gestation period (30-40 yr) and wide climatic adaptability acclaim its suitability in sustained cropping systems (Abugre et al. 2011). Apart from its biofuel potential, it has medicinal properties valuable in pharmaceutical and cosmetic industries (Akinpelu et al. 2009, Nazeema and Girija 2012). It has been cultivated in Andhra Pradesh, Karnataka, Tamilnadu, Chhattisgarh, Maharashtra, Orissa, Gujarat and in some parts of North India (http:// www.dolr.nic.in/wasteland_atlas.htm).

Presently domestication of Jatropha in agroforstry practices is ongoing at full swing. Intercropping would aid in maximizing the returns and better utilization of land resources. Allelopathy in Jatropha and its particular effects on companions remain obscure but now it is receiving attention of researchers. Generally, Jatropha releases various phytotoxins from living and dead plant parts. Their exudation influences the growth and metabolism of neighboring crops in vicinity (Alamari and Deokule 2013, Dayan et al. 2000,; Singh et al. 2006 and Todaria et al. 2005). Due to its interference with companion crops, the standardization for selection and performance of individual intercrop is prerequisite. It seems necessary to explore the allelochemicals' quantity and quality, their site of action and influence on the companions. We review the available studies on some aspects of allelopathy in Jatropha.

Allelopathic Stress in Relation to Plant Growth

Plant domination hinders the productivity because of the release of secondary metabolites through various plant parts (Bais et al. 2003, Quasam 2002). Phytoactive compounds may influence the plant from which these are released (auto-allelopathy) as well as the adjacent plants (allelo-allelopathy; Alagesaboopathi 2011, Dayan et al. 2000 and Murawat and Khan 2006). This might be beneficial or detrimental to the germination, growth and development of receptors (Basavaraju and Gururaju 2000, Nazir et al. 2007 and Thapaliyal et al. 2007). It appears that leaching from the litter, belowground residues and dead material which are added continuously to the soil and often remain there for a long period, probably acts as a major source of phytotoxins (Ashrafy et al. 2008 and Kaushal et al. 2006). Perhaps the responses depend upon the combinations and concentrations of the phytoactive compounds (Chowdhury et al. 2001 and Kumar et al. 2006).

Phytochemicals in *Jatropha curcas*

One or several combinations of phytochemicals in different proportions have been reported from different plant parts of *Jatropha curcas* (Amit et al. 2002 and Ashrafi et al. 2008). Majority of them are secondary metabolities like alkaloids, phenolics, flavonoids, glycosides, coumarins which are involved in various physiological and biochemical processes of plants (Abugre and Sam 2010, Kaushal et al. 2006 and Tomar and Agarwal 2013). Most of the bioactive compounds obtained from Jatropha were examined from the viewpoint of their pharmacological value whereas their phytotoxic effects on companion plants has received only secondary importance. Their role in allelopathic effects on the growth, quality and yield would provide the growers of Jatropha an opportunity to grow it with other crops. Usually Jatropha is cultivated as a monocrop. Thus, an integrated strategy is desirable to maximize the income and compensate the loss during crop failure and environmental threats. This review focuses on screening of various phytochemicals present in the plant parts of Jatropha (Table 1) and their potential effects.

Effect of Jatropha Leaf and Root Extract on Crops

Plant residues, including leaves and roots, had powerful allelopathic influence than any other vegetative part. Their preliminary screenings have shown the potential to affect germination and seedling growth of test crops (Alloli and Narayanareddy 2000). Ma et al. (2011) reported that the germination and initial growth of corn and tobacco are inhibited at increasing concentration of aqueous extracts of Jatropha due to the presence of azelaic acid in leaves and roots, identified by gas chromatographic-mass spectrometric analysis. This compound is responsible for suppressing germination at > 500 µg mL^{-1} concentration but aerial and radicular development were inhibited at concentations above 100 µg mL^{-1}. Similarly, strong inhibitory response of leaf (2% > 4% > 6% > 8%) and root (2% > 4% > 6% > 8%) extracts of Jatropha was found more pronounced in *Hibiscus esculentus* compared with *Phaselous vulgaries, Zea mays* and *Lycopersicon lycopersicum.* The aqueous leaf extract had greater inhibitory effect than root extract on germination, plumule and radicle length of tested crops. (Abugre and Sam 2010). Sanderson et al. (2013) reported that aqueous leaf

Table 1. Phytochemicals reported from various part of *Jatropha curcas*

Plant Prt	Chemical constituents	Contributors
Aerial parts	Kemeferol, coumariens and quercetin	Rejilia et al. (2012)
	Coumaric acid and Resosilic acid	Kamal et al. (2011)
	Saponins and tannins	Balaji et al., (2009)
Kernel	Phylates and saponins	Kamal et al. (2011)
	Trypsin inhibitor	Mujumdar and Misar (2004)
Latex	Curcacycline A, and cyclic octapeptide curcain [protease]	Mishra et al. (20 10)
	Jatrophine and jatropham	Kam and Liew (2002)
Roots	Sitosterol and its d-glycoside, marmesin, propacin, curculathyranes A and B, curcusones A-D, diterpenoides jatrophol, jatropholone A and B	Kamal et al. (2011)
	Coumarin, tomentin, coumarino-lignan and jatrophin taraxerol	Kannappan et al. (2008), Goonasekera and Gunawardana (1995)
Seeds	Curcin, lectin pharbolesters esterases (JEA), lipase (JEB)	Kamal et al. (2011)
	Crude protein, lipids, trypsin inhibitor, lectin, saponins and phylates	Makkar et al. (1997)
Stem bark	Amyrin, sitosterol and taraxerol	Shetty et al . (2006)
	Saponins, steroids, tannins, glycosides, alkaloids and phenols	Nazeema and Girija (2012)
	Flavanoids	Igbinosa et al. (2009) and Hodek et al . (2002)
	Deoxypreussomerins [CPI, JC1, JC2]	Ravindranath et al. (2004)

extract of Jatropha (1%, 5%, 10% and 15%) has no adverse effect on germination of lettuce var. Grand Rapids. After germination, increase in concentration inhibited its seedling growth appreciably. Another bio-assay carried out by Rejilia and Vijaykumar (2011) indicated suppressing behavior of leaf extract on germination and seedling development of green chilli and sesame. Similarly, 100% inhibition of the rootlets of wheat was observed at 10% concentration of *Jatropha macarantha* (Mongelli et al. 1997). Another experiment conducted on wheat (cultivar: MP-4010), showed the inhibition of seedling growth and biomass when it was grown with sun-dried leaf leachates and ovary walls of *Jatropha curcas.* The leaf leachate treatment had detrimental effects on plant height, leaf area, biomass and spike length of *Triticum aestivum* (Tomar and Agarwal 2013). They also recorded higher concentration of phenols, phytic acid and free amino acids from the leaf leachates than in ovary extracts that could be a cause of major interference. Similarly, Reichel et al. (2013) also reported the interference by dry leaf extract of Jatropha on initial growth of *Triticum aestivum*. These studies on Jatropha leaf and root extracts show that it suppresses germination and seedling growth in various test crops, and that the magnitude of their effect varies with the test crop and concentration of Jatropha extracts. More studies are required for testing its long-term effects on the growth of various crops. The metabolic and physiological responses of test crops also need to be investigated.

Leaf extract of different accessions exerts specific allelopathic effects on different species and their toxicity depends on the concentration. The tolerance to leaf extracts by some crops was found in the order: *Vigna munga* > *Triticum aestivum* > *Brassica juncea* > *Sorghum orientale* (Venkatesh et al. 2011). Likewise, eight days seedling extract of *Jatropha curcas* suppressed germination as well as radicular growth of *Helianthus annus* than *Zea mays* (Silva et al. 2012). Contrary to these studies, Abugre et al. (2011) reported beneficial effects of aqueous leaf and root extracts. They recommended *Hibiscus esculentus, Zea mays, Lycopersicon esculantum* and *Terminalia superba* for intercropping in *Jatropha curcas* alleys. This aspect also requires detailed field studies.

Effect of Jatropha Residues Incorporated Into Soil

Environmental factors influence plant-plant interactions in different ways at many developmental phases from germination to completion of their life cycle. During this period, numerous chemical substances leached out from plants come into contact with rainwater, dew, mist, etc.and become active to affect other plants.

Leaf leachates of Jatropha incorporated into soil significantly inhibit the plumule, radicle growth and antioxidative enzymes in *Tagetes erecta*. Phytotoxins released into soil had negative impact on physiological process of test crop (Zhang et al. 2011). Wang et al. (2009) reported that phytochemicals obtained from soil beyond certain concentration (20%) exert allelopathy. Leaf leachates and residues mixed into soil at higher concentration (75% and 100 %) suppress germination and seedling growth (shoot and root length) of marigold. At the same time these residues afford comparative increment in RPM (relative permeable membrane) and proline content but the degree of increment decreases over time. In a greenhouse experiment, brown flax sown in polystyrene trays irrigated with 0 %, 5%, 10%, 20%, 40% and 80% aqueous leaf and root extracts showed varying degree of inhibition at different concentration. The lower concentrations of both extracts (5 %, 10 % and 20 %) promoted the growth of linseed and suppressed it at higher (40 % and 80 %) concentration (Santos et al. 2013).

Abugre et al. (2011) concluded from a nursery trial that certain phytochemicals accumulated in soil because of rapid decomposition of *Jatropha curcas* leaf litter, and served as important source of nutrients improving the growth of companions. A pot culture study showed promotion of seedling growth of crops such as maize, mung and mustard when grown in media combination of 50% field soil and 50% *Jatropha curcas* rhizosphere (10-50 cm deep) soil. Among the three test crops, *Zea mays* showed better seedling establishment under nursery condition At the same time, 100 % *Jatropha* rhizosphere soil suppressed seedling growth of each of the test crops (Dhakane et al. 2014). Thus, it suggests the presence of some phytoactive compounds which promote growth in specific soil combinations.

Phytochemical Activity of *Jatropha* Seed Cake

Jatropha has been shown to hold promise as organic manure (Balasubramaniyan and Palaniappan 2003). Mavankeni (2007) observed improvement in growth and yield of maize (*Zea mays* L.) comparable with inorganic fertilizers when it was supplemented with Jatropha seed cake at the rate of 767 to 2301 kg ha^{-1} under Zimbabwean soil conditions. Its press cake serves as nitrogen rich source of fertilizer (Gubitz et al. 1999). However, seed cake of Jatropha used as biofertilizer has also been reported to cause phytotoxicity in terms of suppression of seedling growth in tomatoes (Heller et al. 1996). The allelopathic activity of Jatropha seed cake is not yet clear and the prospects for the use of Jatropha as a biofertilizer needs further research.

Intercropping with Jatropha

Multipurpose tree species integrated as a perennial component in agroforestry system are considered as endowed remunerative enterprise. Several combinations of annuals raised in interspaces of perennial plants probably support the useful response on the same land management unit (Nazir et al. 2007 and Todaria et al. 2005). Usually, it is assumed that this practice affords recognizable change in the structure of associated components with respect to growth and metabolism (Fitter 2003 and Indrajit and Duke 2003). Hence, attempts have been made to study the efficacy of test crops either in Jatropha alleys or in block plantations. This information helps us to screen out the allelopathic tolerance of companions.

Synergistic behaviour of Jatropha (widely spaced at 3m apart) and summer groundnut in Uttar Pradesh was observed by Singh et al. (2007). They observed an increment of total plant height, girth and branches per plant of *Arachis hypogea* over that in the sole cropping of groundnut. Parallel to this, successful intercropping of groundnut during dry period when Jatropha sheds its leaves was reported by Brittaine and Lutaladia (2010). Sahoo et al. (2009) found beneficial association of wheat grown in Jatropha alleys on field boundaries. Also, luxuriant growth of *Ocimum santum* and *Aloe vera* within the block plantation of *Jatropha curcas* has been reported. *Nyctanthes arbortristis*, *Asparagus racemosus* and *Commiphora mukul* were successfully intercropped in Jatropha plantation with no adverse effects (Bhattacharya and Bhagat 2002). Obiero et al. (2013) noted that most of the farmers preferred intercropping of maize, cowpea, common beans and green grams in *Jatropha curcas* alleys. Hedgerows of Jatropha at closer (1m) spacing caused no allelopathic effects in the first year but from 2nd year, they reduced the growth and yield of *Zea mays* in interspaces. Prominent differences were realized in plant height, diameter, stover weight, grain weight, weight of cob and weight of seed/cob of maize grown in 2 m spacing of hedgerows. Therefore, Abugre et al. (2011) recommended that a minimum distance of 2 m should be maintained in between the hedgerows in order to reduce competition for resources.

Based on these observations, it appears that Jatropha would form a valid option of filler cropping in interspaces. It could reverse the current trend of monoculture and help cope up with the energy needs along with food shortage.

CONCLUSION

Jatropha contains numerous phytochemicals and exerts allelopathic effects on various companion crops. However, field trials carried out in *Jatropha curcas* alleys support synergistic approach whereas laboratory and nursery level studies show negative impacts on the survival and establishment of intercrops. Bioassay experiments were restricted to test germination and seedling growth of companions. The nursery, greenhouse and field trials on large scale are necessary to identify particular crop combination with beneficial results. Through, identifying varying aspects of allelochemicals, economically viable and acceptable Jatropha based sustained cropping may be possible.

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