Agriculture, Ecosystems and Environment 231 (2016) 240–245

Contents lists available at ScienceDirect

Agriculture, Ecosystems and Environment

journal homepage: www.elsevier.com/locate/agee

Allelopathy in jatropha plantation: Effects on seed germination, growth and yield of wheat in north-west India

A. Mahmoud, S.D. Singh*, K.S. Muralikrishna

Centre for Environment Science and Climate Resilient Agriculture, ICAR-Indian Agricultural Research Institute, New Delhi, 110 012, India

ARTICLE INFO

Article history:
Received 21 August 2014
Received in revised form 30 October 2014
Accepted 1 November 2014
Available online 16 July 2016

Keywords:
Allelopathy
Bioassay
ex-situ approach
in-situ approach
Agroforestry

ABSTRACT

In-situ and *ex-situ* allelopathic effects of jatropha *(Jatropha curcas* L.) were analyzed by studying growth and yield of wheat (*Triticum aestivum* L.). *Ex-situ* approach included studying laboratory bioassay of leaf aqueous extract effects on seed germination and seedling growth; and pot experimentation with different jatropha plant parts as soil amendments. Wheat was grown under the jatropha plantation in *in-situ* approach. To eliminate the shade effects of jatropha, a treatment plot was prepared by cutting jatropha trees to 0.5 m above ground level. Bioassay indicated the inhibitory effects of leaf extracts, particularly at high concentrations on seed germination and seedling growth of wheat. In *ex-situ* pot experiment, soil amendments with different plant parts enhanced biomasses and grain yields of wheat. Increase in yield and biomass was higher in pots amended with jatropha fruit, followed by leaf and stem. When wheat crop was grown with jatropha in *in-situ* approach, results were more conclusive as the ill effects of jatropha were not seen in pruned plants plots. Grain yield and biomass declined under the standing jatropha cultivation, with lowest reduction in low plant population density plots. Thus, an inhibitory effect of jatropha on wheat was limited to *ex-situ* bioassay only. Winter shedding of leaves in jatropha could be a boon for the *Rabi* (winter season) intercrops, and wheat could be an option for its cultivation under low plant population densities of jatropha with limited irrigation in north-west India.

1. Introduction

Jatropha is a multipurpose plant with potential carbon sequestration ability and is known to rehabilitate degraded lands through enhancing soil organic matter (Francis et al., 2005; Achten et al., 2008; Kabir et al., 2009; Abhilash et al., 2010; Achten et al., 2010a; Wani et al., 2012). But, we understand that in most situations, jatropha is an exotic species. Some reports conclude that jatropha shows invasive characteristics. However, it is considered as a potential candidate for biofuels (daSchio, 2010). Policymakers consider biofuel for carbon replacement in fossil fuels as a strategy to address energy security and climate change related issues (GOI, 2009; Phalan, 2009; Achten et al., 2010b). Much to its importance, the Government of India in 2009 has approved a 'National Policy on Biofuels' targeting a 20% blend of biofuels with gasoline and diesel by 2017 (Achten et al., 2010b).

Apart from energy security, food security is one of the important issues, which leads to development of agroforestry systems. Growing crops with perennial trees will give sustenance to the farmer. However, several factors such as light, nutrient and water availability play significant roles in productivity of complex agroforestry systems. The situation is aggravated due to inhibitory effects of some of the perennial plant species on the growth and development of intercrops (Todaria et al., 2005; Singh et al., 2006). Focused research on the ecosystem level effects of jatropha is required in order to clarify these issues. Several studies indicate allelopathic effects of jatropha leaf extracts on various field crops. Jatropha leaf has high phenol content and its extract inhibited the germination of wheat, mustard, sesame and black gram and other crops (Abugre and Sam, 2010; Ma et al., 2011; Rejila and Vijayakumar, 2011; Venkatesh et al., 2011; Tomar and Agarwal, 2013). Studies also revealed the inhibitory effect of jatropha root extract on maize and tobacco (Ma et al., 2011). Most of these studies were, however, carried out in laboratory conditions. Allelopathic effect was not observed in crops such as greengram (*Vigna radiate* L.), clusterbean (*Cyamopsis tetragonoloba* L.), mothbean (*Vigna aconitifolia*), pearl millet (*Pennisetum glaucum*), mustard (*Brassica juncea* L.), taramira (*Eruca Sativa* L.), chickpea (*Cicer arietinum* L.) and barley (*Hordeum vulgare* L.) when amended with dry jatropha leaf tissues (Singh et al., 2010; Singh et al., 2012). Winter shedding of leaves in jatropha will help the growth and

* Corresponding author.
E-mail address: sdsingh16b@yahoo.in (S.D. Singh).

http://dx.doi.org/10.1016/j.agee.2016.06.042
0167-8809/

development of *Rabi* (winter season) intercrops, as the shading effects will be reduced. The literature review on the production and use of jatropha in a system of agroforestry identifies several knowledge gaps, which need to be bridged before large scale cultivation of both jatropha and intercrops. A holistic approach directed towards evaluating the ill effects, if any, of the jatropha cultivation is very much essential.

Hence, the present study was conducted to assess; i) the effects of different concentrations of jatropha leaf extract on wheat seed germination (*ex-situ* bioassay), ii) impact of soil amendment with different plant parts of jatropha on growth and yield of wheat (*ex-situ* pot experiment) and effects of jatropha plantation on growth and yield of wheat in agroforestry system *(in-situ* experiment) (Plate 1).

2. Materials and methods

The experiments were conducted at ICAR-Indian Agricultural Research Institute, New Delhi, India (28°35′N and 77°12′E) during *Rabi* 2011–12. The allelopathic potentials of jatropha were analyzed through *ex-situ* and *in-situ* approaches. The general weather parameters like mean maximum and minimum temperatures, humidity and rainfall during the experimental period are presented in Fig. 1.

2.1. Ex-situ approach

2.1.1. Bioassay

A bioassay of jatropha leaf aqueous extract on germination of wheat seeds was tested in the laboratory. For this, green leaves were collected from jatropha field, dried in sunlight and ground to fine powder. Different quantities of dry leaf powder *i.e.* 0.5, 1.0, 5.0, 10.0 and 20 g were soaked in 100 ml distilled water at room temperature for two days to obtain varying concentrations of leaf extracts (0.5, 1, 5, 10, 15 and 20%). The leaf extracts were filtered through four layered cheesecloth to remove fibre fragment and the resulting solutions were filtered through Whatman No. 1 filter paper. A treatment of distilled water was set as the control. 5 ml leaf extract of each concentration was added to different petri-dishes containing two layers of germination paper. Twenty seeds of wheat (cv. Kundan) were placed in each prepared petri-dish. Four dishes of each treatment (overall, 28 petri-dishes) were arranged in a completely randomized design and kept in a chamber at room temperature for 12 days. Each petri-plate was replenished with 2 ml extracts in subsequent days. Number of seeds germinated in each petri-dish was counted from third day onwards. Ten seedlings from each petri-dish were sampled on the 10th day and root lengths, shoot lengths and total seedling dry weights were measured.

2.1.2. Ex-situ pot experiment

Allelopathic effects of different parts of jatropha *viz.,* leaf, stem and fruits (after shedding) were tested on growth and yield of wheat plants. Wheat seeds were sown in earthen pots (35 cm diameter & 30 cm height) filled with normal soils that were amended with 100 g each of dry powder form of jatropha stem, leaf and fruit separately, along with control (without organic amendment). The experimental unit was fertilized with adequate dose of NPK nutrients prior to sowing. The overall experiment had four treatments: control, stem amended soils, leaf amended soils and fruit amended soils. Pots were irrigated to the field capacity and wheat plants were raised under normal (open) conditions throughout the growth period (germination to maturity). At maturity, plants were harvested and biomass, grain yield and yield attributes *viz.,* number of spikes, number of grains/spike, grain size were quantified. Finally, the relative treatment effect/response was calculated by dividing the difference between treatment and control means with control mean and multiplied by hundred and expressed as percent increase or decrease over control.

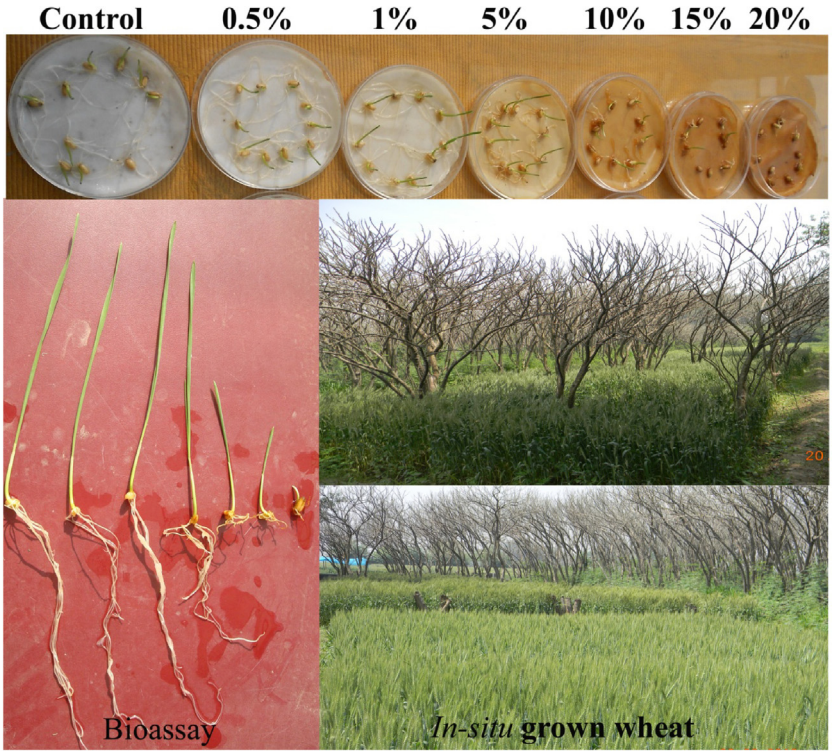

Plate 1. *Ex-situ* bioassay of different concentrations of jatropha leaf extracts on seed germination and seedling growth in wheat; wheat grown *in-situ* under jatropha plantations during *Rabi* (winter season) 2011–12.