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Allelopathic effects of leaf extracts of three agroforestry trees on germination and early seedling growth of wheat (*Triticum aestivum* L.)

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ABSTRACT

Understanding of the growth promotory or inhibitory allelopathic effects of agroforestry trees on other plants is necessary for selection of suitable crops to be cultivated in their vicinity. In this experiment, aqueous leaf extracts of three agroforestry trees (*Populus deltoides*, *Melia azedarach* and *Morus alba*) were evaluated on germination and seedling growth of wheat applied at concentration 1, 1.5, 2.0 and 2.5 g L^{-1} while distilled water was used as control treatment. Lower concentration of extracts (1 and 1.5 g L^{-1}) of *P. deltoides* stimulated percent germination, root and stem height and dry biomass while higher concentration (2 and 2.5 g L^{-1}) had no effect on these parameters. Mean germination time (MGT) was not affected by the extract and its concentration. Aqueous extracts of *M. azedarach* and *M. alba* at concentration > 1 g L^{-1} significantly lowered the studied parameters except MGT which was significantly prolonged. Negative allelopathy was more evident at the highest aqueous extract concentration (2.5 g L^{-1}) of the two trees. Extracts of *M. alba* were found more growth inhibitory than those of *M. azedarach*. The study suggests that lower concentration of leaf extracts of *P. deltoides* imparts stimulatory while *M. azedarch* and *M. alba* have negative allelopathic effects on wheat germination.

INTRODUCTION

Wheat (*Triticum aestivum* L.) is one of the most important major field crops cultivated throughout the world for grains and several other popular food products. After rice, wheat is ranked the second most grown and traded commodity which has significant impact on human food requirements, accounting for more than 20% of global caloric supply (Trnka et al. 2014; Prins et al. 2016). Owing to high consumption, demand and global food reliance on this crop, increases in wheat production is crucial which can be attained by employing proper agricultural practices. In Pakistan and many agricultural countries, agroforestry trees are cultivated either as shelter belts or intercrops with economically important crops (Singh et al. 1993; Chaudhry 2003) which periodically improves soil's properties physically and chemically and contributes to its organic matter contents by littering (Singh and Sharma 2007). Physiological and mechanical leaf fall from these trees, however, may pose allelopathic stress upon crops growing in their vicinity. The allelopathic stress may trigger growth suppression or promotion of the interacting crops by direct phytotoxic effects or phytostimulation or indirectly by modifying the rhizospheric microbial community, strengthening competitor plants and to a limited extent altering soil physico-chemical properties (Ambika 2013).

Plants are known to possess secondary metabolic compounds (alkaloids, flavonoids, phenolic and terpenoids) which have no known direct role in the growth and development but can act as stress mediators during environmental challenges and when plants are confronted by pathogens, insects, pests and herbivores (Crozier et al. 2006; Bartwal et al. 2013; Majeed et al. 2014). These compounds can make their way to soil from parent plants via leach out from roots, littering and decomposition of fallen parts and correspond to

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allelopathic interactions with other plants; the allelopathic interactions among donor and receiving plants can be growth inhibitory to suppress the competitors or stimulatory to co-benefit from the available resources which generally depend on the interacting species, nature and concentration of allelochemicals (secondary metabolites) and the soil biota (Saraf et al. 2014; Cheng and Cheng 2015; Fernandez et al. 2016; Majeed et al. 2017).

Melia azedarach, *Morus alba* and *Populus deltoides* are important trees cultivated for timber and protection of fields as shelter belts. *P. deltoides* is widely grown with wheat and other crops for gaining benefits utilizing the same piece of land (Rizvi et al. 1999). Nakafeero et al. (2007) highlighted the significance of agroforestry trees in soil building and crop improvement. Jose (2009) described that agroforestry improves soil, provides ecosystem services, give benefits to environment and improves livelihood. Mbow et al. (2014) correlated agroforestry management system to soil fertility, crop production and ensuring food security. Whether grown as shelter belts or intercrops, understanding of the allelopathic activities of these trees on crops which are cultivated in their vicinity is crucial for potential allelopathic impacts on their yields. The aim of this study was to assess the allelopathic effects of aqueous leaf extracts of *M. alba, M. azedarach* and *P. deltoides* at four different concentrations on germination and early growth of wheat.

MATERIALS AND METHODS

Leaves of three agroforestry trees (*Melia azedarch, Morus alba* and *Populus deltoides*) were collected from different fields in district Peshawar during April-September 2016. Levees of each tree were first dried in shady conditions and then in oven at 62°C for 72 h until constant dry weight was attained. Dried leaves were made powder with the help of an electric grinder. Aqueous extracts were prepared by soaking leaf powder of each tree at 1, 1.5, 2.0 and 2.5 g in 1L distilled water respectively. Aqueous extracts preparation were done during the month of November when seed bioassay were ready. Extracts were stored at 4°C at Botany Department, Government Degree College Naguman, Peshawar for further studies.

Seed germination and growth test was performed in November 2016 at room temperature and under natural photoperiod. Seeds of wheat cv Atahbib-2010, obtained from Pir Sabaq Research Station, were placed on two layer filter paper (Whatmann 1) in petridishes (15 × 100 mm). 10 seeds were placed in a single petri dish, each petri dish was repeated five times in a completely randomized design. Aqueous leaf extracts of three trees at different concentrations were provided to petridishes at 08 ml. The same volume of distilled water was applied to control seeds. Data for percent germination, mean germination time, $MGT = \sum(nt)/\sum n$;where n is the number seeds germinated in time t (Soltani et al. 2016) (d), stem and root length (cm) were determined for 12 days. Dry biomass of seedlings (g) were measured at the 12th day of experiment. For each parameter under respective treatments, data were averaged for ten seedlings.

Petridihes were established in completely randomized design with each petri dish further repeated five times. Analysis of variance was applied to the data on germination and growth using computer software MSTAT. Least significant test (LSD) at $p \leq 0.05$ was used to calculate significant difference between the parameters in response to different extracts.

RESULTS AND DISCUSSION

Germination percentage of wheat was not influenced by higher concentration (2 and 2.5 g L^{-1}) of leaf extracts of *P. deltoides* but was significantly increased over control at lower concentration (Figure 1). Thus, lower extract concentration promoted germination. The effect of *M. azedarach* were phytotoxic in a concentration dependent way except for 1g L^{-1} extract which had no effect on germination. Concentration increasing 1 g L^{-1} significantly reduced the percent germination reaching to the lowest (90.12%) at 2.5 g L^{-1} when compared to control (98%). In case of *M. alba*, 1 and 1.5 g L^{-1} concentration of leaf extract did not influence germination but significantly reduced germination 95.64 and 95.47% were observed at 2 and 2.5 g L^{-1} concentration, respectively.

Data presented in Figure 2 revealed that leaf extract of *P. deltoides* did not alter MGT and almost consistent values were recorded for different concentrations and control which ranged between 4.13 and 4.75 day. Prolonged MGT was observed at all the applied concentration of *M. azedarach*. Control petridishes revealed that average MGT was 4.57 days which elevated to significant extent 5.81 d at 1 g L^{-1} followed by a further increase (5.91 d) at 1.5, 7.1 and 7.0 d at 2 and 2.5 g L^{-1} extract concentration. Extracts of *M. alba* had no effect on MGT at concentration 1 and 1.5 g L^{-1} but higher concentration 2 and 2.5 g L^{-1} significantly delayed germination time corresponding to 6.17 and 6.53 days respectively.

The effect of aqueous extracts of *P. deltoides* at 1.0 and 1.5 g L^{-1} was significant on root length of seedlings but not significant at higher

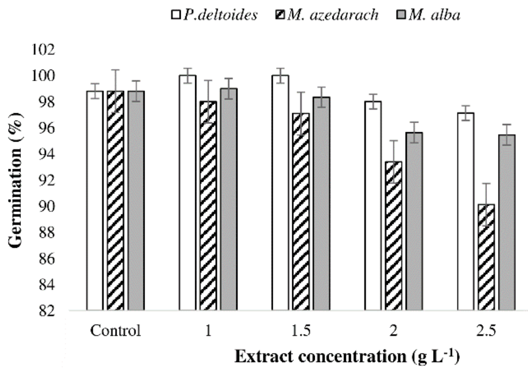

Figure 1. Effect of different concentrations of aqueous leaf extracts of *P. deltoides, M. azedarach* and *M. alba* on germination of wheat

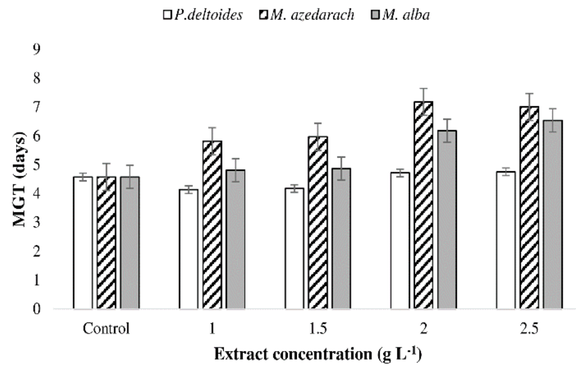

Figure 2. Effect of different concentrations of aqueous leaf extracts of *P. deltoides, M. azedarach* and *M. alba* on mean germination time (MGT) of wheat

concentration. Seeds treated with distilled water produced 13.26 cm long roots which were promoted to 15.67 and 18.49 cm at extract concentration 1.0 and 1.5 g L^{-1} respectively (Figure 3). Generally all the extract concentration of *M. azedarach* were inhibitory in effects on root length; however, maximum retardation was observed at 2.0 and 2.5 g L^{-1} which resulted in 9 and 8.46 cm seedling root length respectively. Extract concentration of *M. alba* up to 1.5 g L^{-1} had no effect on root length where root lengths were consistent with control ranging between 12.91 and 13.26 cm; however, significant decrease in root lengths were found at 2.0 and 2.5 g L^{-1} extract concentration resulting in 11.37 and 11.22 cm long seedling roots.

Variable results were obtained for stem length of seedling in response to different extracts concentrations and trees used. Lower extract concentrations (1 and 1.5 g L^{-1}) of *P. deltoides* significantly increased stem length 12 and 12.36 cm respectively over control (9.22 cm) while higher concentration had no effect on the studied parameter (Figure 4). Seeds treated with extracts of *M. azedarach* revealed variable results however, lower concentration of extract were ineffective to induce stimulatory or inhibitory changes in stem length. Reduced stem length were observed at concentration 2 and 2.5 g L^{-1} where seedlings attained 8 cm stem length. The effect of extracts of *M. alba* were comparatively stable on stem length up to concentration 1.5 g L^{-1} which produced similar results to control (9-9.22 cm); however, 2 and 2.5 g L^{-1} extracts reduced seedling stem length to 8.4 and 8.6 cm respectively.

Among the extract concentrations of *P. deltoides*, only 1 and 1.5 g L^{-1} stimulated dry biomass while higher concentration had no effect on the parameter. Compared to control (0.23 g), dry biomass of seedling was recorded as 0.37 and .4 g at 1.0 and 1.5 g L^{-1} extract concentration respectively (Figure 5). Conversely, extracts of *M. azedarach* at all concentration levels were inhibitory. Significant decline in dry biomass occurred at 1 g L^{-1} (0.21 g) followed by further decrease reaching to minimum 0.16 g at the highest concentration 2.5 g. In case of *M. alba*, extract at concentration 1.0 g had no effect on dry biomass but exceeding concentration resulted in decreased biomass.

Agroforestry trees have sufficient amount of secondary metabolic compounds which can modify the composition and growth processes of adjacent plants through allelopathic interactions in addition to their role in soil enrichment (Paramathma et al. 2000). Although, secondary metabolic compounds are distributed throughout the plant parts, their concentration seems to be elevated in leaves because of extraordinary metabolic reactions occurring in those organs. Response of plants to allelopathy is generally dependent on the types of allelochemicals (secondary metabolic compounds) and their concentration and may impart negative or stimulatory effects on the germination, growth and biomass of the responding flora (Muhammad and Majeed 2014). Both stimulatory and growth inhibitory effects of *P. deltoides*, *M. alba* and M. *azedarach* on wheat, bermudagrass, radish, lactuca and wild oat have been documented (Shafique et al. 2007; Haq et al. 2010; Singh et al. 2010; Lungu et al. 2011: Phuwiwat et al. 2012). In laboratory and field experiments, reduced germination of wheat was recorded in response to allelopathy of *P. deltoides* (Sharma et al. 2000; Singh et al. 2000) which does not support our studies. The differences in results may be due to different experimental conditions and type of extracts as partially decomposed leaves and surface soil from fields of *P. deltoides* were used as extracts in the reported studies. Nandal and Dhillon (2005), on the other hand, reported similar results which demonstrated that lower concentration of *P. deltoides* had stimulatory but higher concentration had no effect on the germination of some wheat cultivars. Shafique et al. (2007) observed enhanced

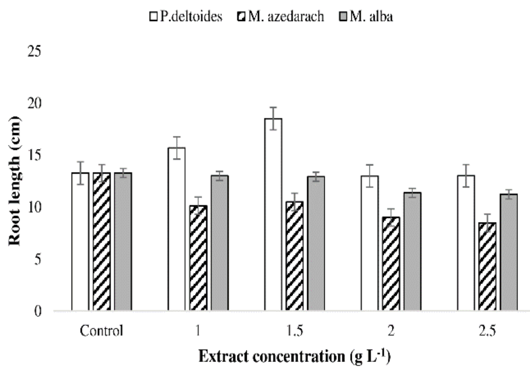

Figure 3. Effect of different concentrations of aqueous leaf extracts of *P. deltoides, M. azedarach* and *M. alba* on root length of wheat

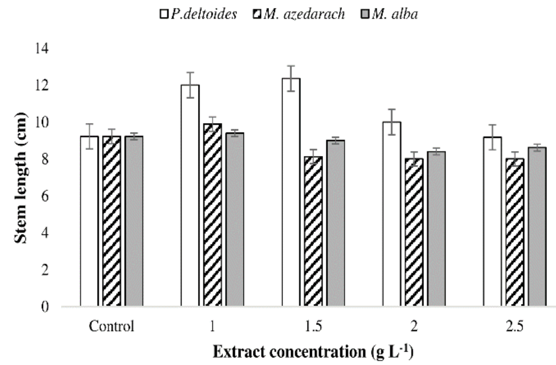

Figure 4. Effect of different concentrations of aqueous leaf extracts of *P. deltoides, M. azedarach* and *M. alba* on stem length of wheat

germination of wheat seeds treated with 20% aqueous extracts of *M. azedarach* for ten minutes; however, Khan et al. (2016) documented negative effects on germination parameters. Our results were also in contradiction with Haq et al. (2010) who asserted that germination wheat significantly increased at lower concentration but declined at 100% extract concentration of *M. alba*.

Germination and growth response of the target plants to the allelochemicals may be due to several reasons. Higher concentration of extract pose stressed environment for the test crop which results in failure of metabolic machinery to activate embryo to germinate. Lower concentration may possibly stimulate efficient enzyme and hormonal coordination for successful germination. It may be asserted that plants growing in allelochemically induced environment may experience changes in enzymes functionality, water and mineral uptake, permeability of cell membrane and photosynthetic activity corresponding to either reduced germination, seedling growth and dry matter accumulation or stimulation in these parameters (Rizvi and Rizvi 1992; Majeed et al. 2012; Muhammad and Majeed 2014). Moreover,

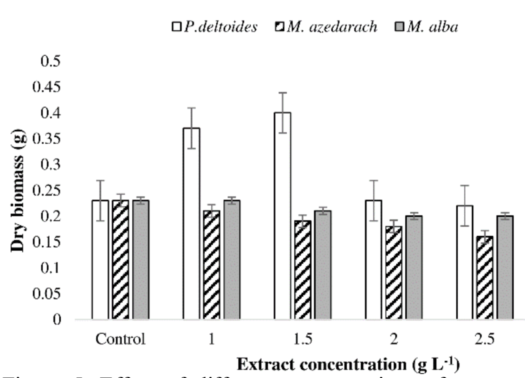

Figure 5. Effect of different concentrations of aqueous leaf extracts of *P. deltoides, M. azedarach* and *M. alba* on dry biomass of wheat

stimulatory and inhibitory effect of the allelopathic plants on target plants is strongly correlated with the concentration and types of allelochemicals. In our study, lower extracts concentration of *P. deltoides* stimulated germination and growth of wheat while extracts of *M. alba* and *M. azedarach* had negative influence on the studied parameters which suggests that there are different secondary metabolites in the three trees which exhibit different allelopathic potentials.

CONCLUSION

The present study concludes that aqueous leaf extracts of *P. deltoides* promoted germination, seedling growth and biomass of wheat at concentration 1 and 1.5 g L^{-1} while extracts of *M. alba* and *M. azedarach* had strong inhibitory allelopathy. *M. azedarach* was found more phytotoxic than M. *alba.*

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