FRUIT TREE ALLELOPATHY AND ITS INTERACTION WITH INTERCROP IN AGRI-HORTICULTURAL SYSTEMS

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Shrinking of the agricultural land together with population growth has created significant pressure on the agriculture-based food production system. If this trend continues, to ensure food and nutritional security of future generations, most of the farmlands under monocropping need to be converted as multiple cropping systems. This is one of the reasons why agri-horti systems where crops, fruit trees and vegetables are grown together on the same piece of land at a same time (Figure 1 & 2) are widely being promoted in Indian farmlands nowadays. Agri-horti systems not only famous for profitability but also for the allelopathic effects, a phenomenon where plants release special types of chemicals called "allelochemical" which affect the growth and development of nearby plants or succeeding crops grown in the same field. Trees in orchards, such as fruit trees, often produce allelochemicals in various parts of their plant tissue, including leaves, bark, and roots. These allelochemicals can inhibit the germination of seeds of the intercrop by affecting seed coat permeability, seedling growth, and nutrient uptake.

Figure 1. Aonla Based Agri-Horti Systems

Figure 2. Mango Based Agri-Horti Systems

Common allelochemicals found in trees are phenolic compounds, flavonoids, terpenoids and alkaloids. Sensitivity of intercrop seeds to tree allelochemicals vary depending on the species and genetic makeup of both trees and the intercrops. Some intercrops species exhibit greater tolerance to allelochemicals and which help their seeds germinate and establish despite the presence of allelopathic compounds. Understanding the species-specific responses to allelochemicals is essential for the selection of appropriate intercrops and optimizing crop performance in orchard systems.

Tree allelochemicals can persist in the soil and plant residues for varying time periods, depending on their chemical stability, soil properties, and microbial activity. Persistent allelochemicals exhibit continuous inhibitory effects on intercrops for multiple crop seasons. In agri-horticultural systems, allelopathy can have both positive and negative effects (Lal et al., 2020; Lal and Biswas, 2023). Some compounds suppress the weeds growth in agri-horticulture systems, reducing the need of herbicides and manual weeding; whereas, some other allelochemicals deter pests or inhibit the growth of plant pathogens, resulting natural pest control.

Allelopathic plants release compounds that improve soil structure, increase nutrient availability, or enhance soil microbial activity, benefiting the overall health of agri-horticultural systems. Allelopathic compounds that can suppress the growth of nearby plants, reduces competition for resources such as water, nutrients, and light. This can inhibit the growth of desired crops. These allelochemical may accumulate in soil for several years leading to soil sickness (Narwal et al., 2004).

EFFECT OF TREE ALLELOCHEMICALS ON SEED GERMINATION OF INTERCROPS IN ORCHARDS

In orchards, negative effect of tree allelochemicals on seed germination of intercrops can significantly impact the overall productivity and sustainability of the system. Tree allelochemicals inhibit the seed germination by interfering with the critical physiological processes. For example, allelochemicals may inhibit water uptake by seeds, disrupt cell division and elongation, or interfere with hormone signaling pathways involved in the seed germination. This kind of inhibition can delay or reduce the seed germination rates, leading to poor crop stand and reduced crop yields. In our field experiment where intercrops viz., wheat, chick pea, mustard, cow pea and soybean were grown in mango, citrus, aonla and guava orchards, showed that germination of soybean was significantly affected in all the orchards whereas wheat was least affected.

EFFECT OF TREE ALLELOCHEMICALS ON GROWTH OF INTERCROPS IN ORCHARDS

Allelochemicals releases by trees can significantly impact the growth and development of intercrops in orchards in the following ways.

Inhibition of Growth: Tree allelochemicals can inhibit the growth of intercrops by interfering with various physiological processes, including seed germination, root development, nutrient uptake, and photosynthesis. These allelochemicals may be released through leaching from tree leaves, bark, or root exudates, creating an allelopathic environment that suppresses the growth of neighboring plants.

Reduced Biomass Production: Intercrops exposed to tree allelochemicals may exhibit reduced biomass production, leading to lower yields and economic losses for farmers. Allelopathic inhibition can result in stunted plant growth, decreased leaf area, and diminished reproductive capacity, ultimately impacting the overall productivity of intercropping systems in orchards.

Altered Morphology: Exposure to tree allelochemicals make changes in the morphology and architecture of intercrops in some cases and the affected plants may display abnormal growth patterns such as distorted leaves, shortened roots, or reduced branching due to allelopathic stress. These morphological alterations can reduce the ability of intercrops to compete for resources and withstand biotic and abiotic stresses in orchards.

Species Specificity: Effects of tree allelochemicals on growth of intercrops can vary depending on the sensitivity and tolerance of plant species to allelopathic inhibition. While some express high susceptibility to allelochemicals released by certain tree species, some other crops exhibit more resistance even allelopathy themselves.

Long-Term Impact: Prolonged exposure to tree allelochemicals can have long-term consequences for intercrop growth and ecosystem dynamics in orchards. Chronic allelopathic stress may lead to shifts in species composition, reduced biodiversity, and altered nutrient cycling within the agroecosystem over time. These changes can affect the resilience and sustainability of orchard-based cropping systems, requiring careful management and mitigation strategies to minimize negative impacts on intercrop growth and productivity.

EFFECT OF TREE ALLELOCHEMICAL ON YIELD OF INTERCROPS IN ORCHARDS

Effect of tree allelochemicals on the yield of intercrops in orchards depend upon several factors like specific allelochemical involved, its concentration, sensitivity of intercrop species, and management practices. Here are some key points to consider:

Yield Reduction: Tree allelochemicals can inhibit the growth and development of intercrops. Allelopathic inhibition may affect various physiological processes in intercrop plants, including seed germination, root elongation, nutrient uptake, and photosynthesis, which can all contribute to decreased crop productivity.

Species Interaction: Allelochemicals can influence species interactions within intercropping systems, affecting competition for resources such as water, nutrients, and sunlight. In some cases, allelopathic inhibition may give certain intercrop species a competitive advantage over others, leading to shifts in species composition and yield dynamics. Managing species interactions and optimizing crop combinations can help maximize overall yield in orchard-based intercropping systems.

Crop Sensitivity: Different intercrop species vary in their degrees of sensitivity to allelochemicals released by trees. When highly tolerant crops maintain relatively high yields despite the presence of allelochemicals, susceptible intercrop species may exhibit substantial yield losses.

Temporal Dynamics: Effects of tree allelochemicals on intercrop may vary over time as a result of changes in allelochemical concentration, development stages of crop, and environmental conditions. Monitoring of yield responses throughout the growing season can provide insights into the temporal dynamics of allelopathic interactions and take adaptive management strategies to mitigate yield losses and optimize crop performance.

EFFECT OF TREE ALLELOCHEMICAL ON QUALITY OF INTERCROPS IN ORCHARDS

Effects of tree allelochemicals on the quality of intercrops in orchards can be significant and multifaceted. Here are some key points to consider:

Nutritional quality: Tree allelochemicals can influence the nutritional composition of intercrops by affecting nutrient uptake, metabolism, and allocation within plants. Allelopathic inhibition may lead to nutrient deficiencies or imbalances in intercrop plants, resulting in reduced nutritional quality. This can impact the concentration of essential nutrients, such as vitamins, minerals, and antioxidants, in harvested produce.

Phytochemical Composition: Allelochemicals can alter the phytochemical composition of intercrops, including concentration of secondary metabolites like phenolics, flavonoids, alkaloids, and terpenoids. These compounds play important roles in plant defence against pests and diseases, as well as in human health and nutrition. Changes in the composition of phytochemical due to allelopathic stress may affect the flavor, aroma, color, and bioactive properties of intercrop produce.

Pesticide Residues: In orchards where plant protection chemicals are used to manage pests and diseases, tree allelochemicals may interact with pesticide residues in soil or plant tissues, potentially affecting the quality and safety of intercrop produce. Allelopathic stress can alter pesticide metabolism, degradation, and translocation within intercrop plants, leading to variations in pesticide residues levels and potential health risks for consumers.

Physical Characteristics: Allelochemicals released by trees can influence the physical characteristics of intercrop produce, such as size, shape, texture, and shelf life. Allelopathic inhibition may affect plant growth and development, leading to changes in fruit morphology, ripening patterns, and post-harvest physiology. These changes can impact the marketability, storage stability, and processing suitability of intercrop produce in orchard-based agroecosystems.

Consumer Preferences: Changes in the quality of intercrop produce due to tree allelochemicals may influence consumer preferences and market demand. Consumers may prioritize produce that meets specific quality standards, including taste, appearance, nutritional value, and safety. Understanding the effects of allelopathic stress on intercrop quality is essential for meeting consumer expectations and maintaining market competitiveness in the orchard industry.

MANAGEMENT STRATEGIES

Farmers can employ various management strategies to mitigate the allelopathic effects of trees on intercrop seed germination, crop growth, yield. This includes selection of allelopathy-tolerant species as intercrops, adjusting the planting distances between trees and intercrops, incorporating organic amendments into the soil to improve soil structure and microbial diversity, and practicing crop rotation to minimize allelochemical buildup in the soil. Additionally, practices like mulching and cover cropping help to suppress weed growth and enhance soil health, further supporting the growth of intercrops in allelopathic environments. Integration of multiple management strategies such as use of diverse crops for rotations and agroecological approaches, can help to build resilience against allelopathic stress and optimize intercrop yields in orchards. By promoting soil health, biodiversity, and ecosystem resilience, these strategies help to enhance the quality and sustainability of intercrop production in orchard systems.

CONCLUSION

Understanding the effects of tree allelochemicals on intercrop growth is essential for sustainable orchard management and maximizing the productivity and resilience of agroecosystems. Ongoing research and monitoring efforts can provide valuable insights into the mechanisms underlying allelopathic interactions and inform the development of effective management strategies to mitigate their negative impacts on intercrop growth and performance in orchards.

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