

JASMONIC ACID INDUCED DEFENSE MECHANISMS AGAINST INSECT PESTS IN CHICKPEA

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Abstract

Chickpea (*Cicer arietinum* L.) is one of the most important and nutritious legume crops. It is often severely affected by insect pests, particularly the gram pod borer (*Helicoverpa armigera*), leading to significant yield losses. Jasmonic acid plays a central role in regulating plant defense responses against insect herbivory. Upon insect attack, JA biosynthesis and signaling are rapidly activated, resulting in the induction of direct defenses such as proteinase inhibitors, secondary metabolites, oxidative burst and strengthening of physical barriers. JA also mediates indirect defenses through the emission of herbivore-induced plant volatiles that attract natural enemies. Understanding JA-induced defense mechanisms provides opportunities for developing sustainable pest management strategies in chickpea.

Keywords: Chickpea, Jasmonic acid, induced defense, *Helicoverpa armigera*

Introduction

Chickpea is an important legume crop grown around the world and serves as a key protein source, especially for people in South Asia, Africa, and Mediterranean countries. Unfortunately, chickpea cultivation faces major challenges from insect pests, especially the gram pod borer (*Helicoverpa armigera*, Hübner), which can cause substantial yield losses if not managed effectively. In response to insect herbivory, plants activate a suite of defense mechanisms regulated by phytohormones. One particularly important hormone in this defense system is Jasmonic acid (JA), which helps plants fight back against insects that chew on them. JA is part of the octadecanoid pathway and functions both as a local defender and a systemic signaler, prompting biochemical and molecular changes that enhance resistance to insect attack (Sane *et al.*, 2025).

Jasmonic acid biosynthesis and signaling

The plant produces Jasmonic acid starting from α -linolenic acid through enzymes like LOX, AOS, and AOC, creating JA and its stronger form JA-Ile. When insects damage the plant, JA and JA-Ile levels quickly rise at the injured area, starting a chain reaction inside cells. JA-Ile attaches to COI1-JAZ receptors, which breaks down JAZ proteins and releases transcription factors such as MYC. These factors then switch on defense genes that change how the plant functions and protects itself against attacking insects. This cascade effectively amplifies the defense response to herbivore attack.

Chickpea plants demonstrate rapid defense responses when exposed to simulated insect damage through oral secretions and physical injury. This triggers immediate activation of JA-related genes within minutes. The resulting JA production serves as a critical defense signal that diminishes

herbivore attraction, survival, and reproductive success. Plant defenses operate through two mechanisms: direct and indirect response. Direct responses create deterrent compounds and protective proteins at injury sites that discourage feeding and egg-laying while impairing insect development; indirect responses emit specific volatile compounds that recruit herbivore predators (Karban, 2011) (Fig 1). Together, these complementary strategies form an integrated defense network protecting plants from continued herbivore damage.

Direct Defense Mechanisms Activated by JA

Induction of Defensive Proteins: One of the primary outcomes of JA signaling in plants is the induction of defensive proteins, such as proteinase inhibitors (PIs), which inhibit insect digestive enzymes. PIs reduce the ability of insect pests to process plant proteins, thus slowing larval growth and reducing survival.

Secondary Metabolite Accumulation: JA triggers the accumulation of secondary metabolites, including phenolics, flavonoids, tannins, and phytoalexins, which can act as antifeedants or toxins to insect herbivores. In chickpea, herbivory has been associated with an up-regulation of genes in the phenylpropanoid pathway and increased synthesis of flavonoids compounds known to negatively affect insect digestive physiology and deter feeding.

Oxidative Burst and Detoxification Enzymes: Chickpea shows rapid up-regulation of reactive oxygen species, ROS-related genes, along with defensive enzymes that manage oxidative stress, such as peroxidases and superoxide dismutase, which help balance signaling and cellular protection.

Indirect Defense Mechanisms Activated by JA

Volatile Organic Compounds (VOCs): Beyond direct defenses, JA plays a key role in indirect plant defense by stimulating the emission of herbivore-induced plant volatiles (HIPVs). These VOCs can attract natural enemies of herbivorous pests, such as parasitoids and predatory insects, enhancing tritrophic interactions that suppress pest populations.

Systemic Signaling: JA not only acts locally at the wound site but also contributes to systemic signaling, leading to induced resistance in undamaged parts of the plant. The long-distance transport and signaling functions of JA enhance overall plant defense plasticity.

Crosstalk with Other Hormonal Pathways

Plant defense signaling is a network of interacting hormones. In chickpea, ethylene (ET) often works synergistically with JA to amplify defense responses, while salicylic acid (SA) can act antagonistically in some contexts (Zhang *et al.*, 2025). Studies indicate simultaneous up-regulation of JA and ET pathways shortly after wounding, enabling integrated defense responses. JA-ET crosstalk enhances expression of defense genes and might reduce SA-mediated suppression of JA responses, providing stronger protection against chewing pests (Pandey *et al.*, 2017).

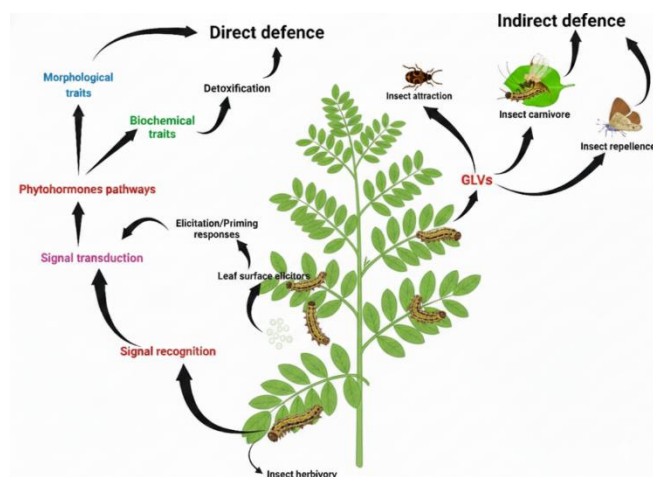


Fig 1: JA mediated defense responses against *H. armigera* in chickpea

JA and Chickpea Pest Management

Given the central role of JA in plant defense, exogenous application of JA or its derivatives has been explored as a strategy to enhance resistance in crops. While most evidence comes from model plants and cereals, analogous approaches in chickpea could potentially boost defensive enzyme activities and metabolic defenses, reducing reliance on chemical insecticides. Exogenous JA application has been shown in other crops to enhance resistance against herbivores and can improve yield under pest pressure by pre-activating defense pathways. Developing JA-based treatments or breeding chickpea cultivars with enhanced JA responsiveness could be integrated with other pest management strategies (El Wakeil *et al.*, 2010). However, the growth defense trade-off should be considered; over-activation of defense responses can divert energy away from growth and yield.

Conclusions and Future Perspectives

Jasmonic acid is a pivotal regulator of defense mechanisms in chickpea, activating a broad range of direct defenses (secondary metabolites, defensive proteins, oxidative responses) and indirect defenses (VOC emission, systemic signaling) that collectively reduce insect damage. JA interacts with other hormonal pathways to orchestrate a balanced and effective response to herbivory. While much of the mechanistic understanding comes from broader plant biology studies, emerging transcriptomic and physiological research in chickpea reinforces the importance of JA-mediated responses during insect attack.

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