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Research Article

Oviposition of *Spodoptera exigua* on Shallot in Monoculture and Polyculture System with Groundnuts and Cowpeas

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ABSTRACT

Spodoptera exigua is the main pest of shallot (*Allium cepa*) that cause significant damage on leaves and reduce yield. Polyculture is a potential management strategy against *S. exigua* by deterring their oviposition behavior. This study aims to evaluate *S. exigua* oviposition preference on shallots grown in monoculture or polyculture system. In the no-choice assay, shallots, groundnuts (*Arachis hypogaea*), and cowpeas (*Vigna unguiculata*) were planted alone while shallots were planted with either groundnuts or cowpeas plant in the choice assays. Observed parameters were the number of eggs laid by female *S. exigua* on shallot plants on each day and the total after the oviposition periods. Results showed that the number of eggs laid on shallots were significantly lower in polyculture systems (161.67 ± 96.02) compared to ones planted in monoculture systems (309.67 ± 39.70). This implies that polyculture systems between shallots with groundnuts or cowpeas can potentially reduce *S. exigua* oviposition on shallots.

Keywords: cowpeas; groundnuts; oviposition; shallot; *Spodoptera exigua*

INTRODUCTION

Shallot (*Allium cepa*) is an economically valuable and major crop in Indonesian cuisines with a stable increase of annual demand. In 2020−2024, shallot supply averagely increased by 2.51% each year or 3.83 kg/capita/year (Anna & Supriyatna, 2020). However, shallot production in Indonesia are challenged by insect pest damage, such as *Spodoptera exigua*. This pest can cause significant leaf damage that lead to yield decrease. This pest is nocturnal and can spread quickly making it a major pest in shallot productions (Dwiyanti & Salbiah, 2022).

S. exigua damage on shallot show specific symptoms and can lead to significant loss of yield quality and quantity. After being laid, eggs hatch after several days and develop into nocturnal larvae. These larvae damage leaf tips and enter shallot leaves. Larvae will feed on the internal side of leaves and leave thin epidermis layer which latter dry (Triwidodo & Tanjung, 2020). In high populations, larva can also damage bulbs by creating holes and causing bulbs to be susceptible to rot. Larva will pupate in soil and develop into adults (Zhou *et al*., 2023). *S. exigua* management still rely on intensive use of chemical insecticides at high dossage. This practice decreases natural enemies and raises the chances of insecticide resistance within *S. exigua* populations. This intensive insecticide use demonstrates the need of alternative sustainable management strategies that are effective.

Polyculture is a potential strategy to manage *S. exigua* in shallot production. Polyculture is a cultivation system that plants two or more different plant species in one area (Telleng *et al*., 2016). Polyculture can help manage pest by creating barriers that prevent pest from locating their preferred host crops (Sitorus & Wilyus, 2023). According to Ngawit *et al*., (2023), shallot grown with legum plants can potentially reduce *S. exigua* damage on shallot. This research aimed to determine the effects of polyculture between shallots with either groundnuts (*Arachis hypogaea*) and cowpeas (*Vigna unguiculata*) on *S. exigua* oviposition compared to monoculture shallot productions.

MATERIALS AND METHODS

Research Location and Preparation

Research was conducted in the greenhouse and laboratory of the Faculty of Agriculture, Universitas Gadjah Mada, Yogyakarta, between July 2024 to January 2025. Initial *S. exigua* population was collected from a shallot field in Panjatan, Regency of Kulon Progo, Special Regency of Yogyakarta, and reared under laboratory condition at 26 °C. Larva were fed with fresh shallot leaves. Each 50 mL vial were populated with fifteen 1st and 2nd instar larvae. When larva reached 3rd to 5th instar, they were seperated to one larva per vial to prevent cannibalism. Vials were sealed using perforated cloths to ensure airflow. After pupating, pupae were moved to ±1 liter plastic containers (diameter ±12 cm, height ±15 cm). This containers serves as mating and ovipositing containers. A piece of 10 × 20 cm paper was placed inside the container as a oviposition media while a 10% sugar solution insisde a plastic cup was placed as a food source for imagoes. To create suitable environments for *S. exigua* development, containers were covered with black cloth to reduce light intensity and ensure air circulation.

Shallot, groudnut, and cowpea plants were planted in 14 oz plastic containers that were filled with sterile soil. Each container contained one plant that were planted 2−3 cm deep. Bulbs and seeds used were screened to ensure uniformity. Bulbs used were undamage and disease-free with diameter of 3 cm. Meanwhile groundnut and cowpea seeds used were also undamage and disease-free. Germination rates of seeds were tested by applying water on 20 seeds. Seeds that grew roots and shoots with lengths 3 cm were categorized as germinated. The seed batches used in this study were required to reach a minimum of 80% germination rate. Plants were placed in 50 × 50 × 65 cm cages with 40 mesh insect nets.

This study was set as a Complete Randomized Block Design (CRBD) with 6 treatments, namely: M0 (shallot monoculture), M1 (cowpeas monoculture), M2 (groundnut monoculture), M3 (polyculture of shallots with groundnuts), M4 (polyculture of shallots with cowpeas), and M5 (polyculture of shallots with both groundnuts and cowpeas). Each treatment were replicated 3 times totalling in 18 experimental units. To resemble field conditions, twenty plants were placed in each cage. In monoculture settings, only one plant species was place in cages while shallot plants was placed in between groundnut or cowpea plants accordingly to the designated treatment in polyculture treatments. In M3 and M4, 12 shallot plants were placed in between 8 groundnut or cowpeas plants while 12 shallots plants were placed with 4 groundnut and 4 cowpea plants in M5. Shallot plants used were 21 days after planting (DAP) and 30 DAP for groundnut and cowpea plants. In each experimental unit, a pair of male and female imago were placed in the cage.

Observed Parameters and Data Analysis

Parameters observed were daily eggs laid by *S. exigua* females laid on each plant. Collected eggs was then calculated to obtain total eggs laid. Each egg in egg mass were counted by carefully removing protective cotton-like structures under a stereo microscope. Total collected eggs was analyzed using ANOVA and when significant difference were detected, a post-hoc test using Tukey HSD was done. All test were done at = 5%.

RESULTS AND DISCUSSION

During their life cycles, *S. exigua* will reproduce to maintain its population and ovipositing is an essential part of this process. Females will prefer oviposition sites that ensure the highest survival of their offsprings. The ovipostion ability of *S. exigua* differed between treatments (Table 1). Low oviposition was shown in M5 where shallot plants were planted with groundnuts and cowpeas (161.67 ± 96.02) while the highest oviposition was from the monoculture shallot (309.67 ± 39.70). This is due to shallot being *S. exigua* main host and monoculture system ease females in locating suitable oviposition sites (Tooker & Frank, 2012). Snyder *et al.* (2020) stated that monoculture system increases risk of pest damage and number of egg oviposited in the field due to the continuous availabily of resources.

Oviposition decrease in polyculture system using

Table 1. Average individual eggs laid by female *Spodoptera exigua*

Treatment	Total eggs (mean ± SE)	*P*-value
Shallot monoculture	309.67 ± 39.70	
Cowpea monoculture	183.67 ± 110.43	
Groundnut monoculture	164.33 ± 107.48	4.98×10^{-6}*
Polyculture shallot with groundnut	218.67 ± 98.62	
Polyculture shallot with cowpea	261.0 ± 138.73	
Polyculture shallot with groundnut and cowpea	161.67 ± 96.02	

Notes: Data was transformed using a log (x + 1) while data shown are untransformed value; asterix (*) indicate significant different between treatments at *a* = 0.05.

three different plant species maybe caused by inhibition effects from groundnuts and cowpeas. Polycutlure system affect resource availability and quality for *S. exigua*. Crop diversity can produce allelopathic and volatiles compounds that prevent pest access to their host (Mayer-Pinto *et al.*, 2024). In addition, a study by Geuss *et al.* (2018) showed that interaction between pest and their host can affect plant composition in ecoystem that latter affect where insect oviposit.

Groudnuts and cowpeas are not *S. exigua* main host. According to Ekholm *et al.* (2020), herbivors are more attracted to their main host than other plants. In these ecosystems, alternative host provide less resources for larval development. Leaf textures may also be a factor that prevent *S. exigua* oviposition. Groudnuts and cowpeas have coarser leaf textures compared to shallot leaves. This was consistent with the findings from Zheng *et al.* (2011) that demonstrated that female *S. exigua* prefer to oviposit on leaf dari are soft, thin, and smooth in crop of such as onion, cauliflower, mustard green, carrot and celery. This is due their easiness to digest compared to graminae and legum plants.

Polyculture systems using three plant species create more complex ecosystems that prevent pest from finding their optimum host. Groudnuts and cowpeas may divert *S. exigua* and indirectly reduce shallot damage. Martinez *et al.* (2024) stated that complex agricultural system reduce pest infestation by preventing them to locate their host. Refugia plants, such as legum plants, reduce damage intensity of armyworm on shallots. Research by Ngawit *et al.* (2023) showed that density of groudnut refugia affected *S. exigua* damage intensity in shallots. This implies that groudnut and cowpeas can be used in polyculture systems with shallot as refugia plants to reduce pest damage.

Shallot also contain several chemical compounds, such as amino acid, simple sugars (glucose and fructose) (Machado *et al.*, 2021), allyl sulfide and organic sulphuric compounds that attract pest for oviposition. These compounds do not only signal females but is a signal of suitable host plant for their offspring to develop (Marcinkowska & Jele, 2022). Meanwhile, groundnuts and cowpeas have compounds that are less prefered by *S. exigua* due to their allelopathic and secondary metabolites, such as flavonoid, terpenoid, tannin, phenol, and alkaloid that prevent pest oviposition (War *et al.*, 2011).

Undernourish crops can hinder larval growth; thus, preventing females from ovipositng on them. Female moths can detect suitable ovipoistion sites through habitat, microhabitat, chemical visual, and thermal signal (Eilers *et al.*, 2013). The most common strategy is to oviposit directly on their food sources to ease larval devleopment. Therefore, female moths avoid ovipoisiting on plants that are deemed undernourish (Simons *et al.*, 2023).

Highest *S. exigua* oviposition events was shown in M0 that solely contained shallot with 4 events while only 2 events where shown in M1, M2, M3, M4 (Figure 1). The lowest oviposition events was shown in M5. Shallot monoculture provide optimal conditions for females to oviposit as it saves their energy to locate suitable host (Table 2) (Awmack & Leather, 2002). Meanwhile, non-host plant may emitt additional chemical signals that hinder females from ovipositing on host plants in polyculture system. This will then reduce the number eggs found in these treatments. Reddy and Guerrero (2004) stated that competing semiochemical signals between plants

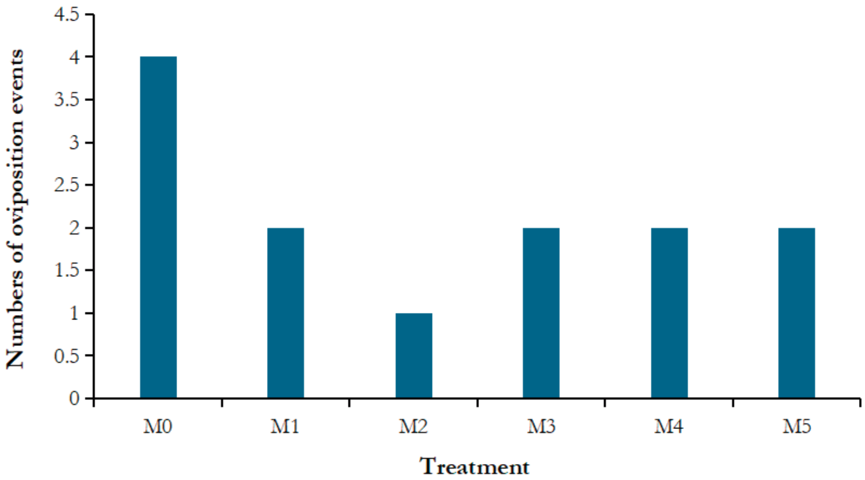

Figure 1. Average oviposition events by female *Spodoptera exigua* during the experiment. M0 (shallot monoculture), M1 (cowpeas monoculture), M2 (groundnut monoculture), M3 (polyculture of shallots with groundnuts), M4 (polyculture of shallots with cowpeas), and M5 (polyculture of shallots with both groundnuts and cowpeas).

in polyculture systems may extend the time insect need to find suitable host and oviposit. Host plant chemical compounds stimulate pheromone release and mating behavior.

Host preference due to chemical compounds can affect mating and induce premating isolation between species. This might latter contribute to sympatric speciation. Volatile compounds produced by host plant have significant roles in oviposition by stimulating pheromone and mating behavior. This implies that stimulli from plants do not only function as ecological guidance but sensoric promoter that induce female ovarium development (Witzgall *et al.*, 2005).

These conditions correlate with female *Spodoptera exigua* lifespans (Table 2). Shorter female lifespan can reduce total eggs oviposited by females. In polycutlure systems, minor crops, such as groundnuts and cowpeas produce many chemical signal resulting in non-suitable environment that can increase *S. exigua* stress. High stress can affect insect immune levels, slow physiological processes, and increase the time required to oviposit. These coniditons increase energy usage and shorten lifespans (Ma *et al.*, 2023).

Table 2. *Spodoptera exigua* female imago performance

Treatment	Average (day)	
	Started oviposition	Female death
Shallot monoculture	2	8
Cowpea monoculture	3	5
Groundnut monoculture	1	3
Polyculture shallot with groundnut	3	4
Polyculture shallot with cowpea	2	5
Polyculture shallot with groundnut and cowpea	2	4

CONCLUSION

Our work demonstrated that shallot farming systems affected *S. exigua* oviposition. Shallot polyculture with groundnut and cowpea reduced total eggs laid on shallot plants compared to monoculture systems. This decrease may be due to the mixture of volatile compounds and secondary metabolites produced within these planting system. These findings support the use of groundnut and cowpea in polyculture systems in shallot production as a sustainable management strategy against *S. exigua*.

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