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# The effect of refugia flowers (*Cosmos sulphureus* Cav.) on pest and natural enemy population dynamics of soybean (*Glycine max* (L.) Merr.) in Panaikang, Maros District, South Sulawesi

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**Abstract** Improving domestic soybean production remains constrained by persistent pest infestations that reduce both yield and quality. The effect of refugia flowers (*Cosmos sulphureus* Cav.) on pest and natural enemy population dynamics in soybean fields in Panaikang, South Sulawesi was investigated. The presence of yellow kenikir significantly altered arthropod community structure by increasing the abundance of key natural enemies, including *Coccinella* sp., *Oxyopes* sp., and Odonata, compared with insecticide-treated and artificial flower plots. Plots with *C. sulphureus* (P3) showed higher arthropod abundance, including both pests and natural enemies. Despite increased pest presence, pod damage intensity was lower, indicating enhanced biological control. Major pests such as *Lamprosema indicata*, *Spodoptera litura*, *Melanagromyza sojae*, and *Valanga nigricornis* were observed across treatments. However, damage caused by *Etiella zinckenella* was consistently lower in P3 plots, with a reduction of 5–11% during the pof filling stage. These findings indicated that *C. sulphureus* refugia enhanced ecosystem-based pest regulation by strengthening natural enemy activity rather than reducing pest visitation. This approach is represented a sustainable strategy for integrated pest management in soybean cultivation.

**Keywords:** Food crop, Soybean, Yellow kenikir, Pests control, *Etiella zinckenella*

## Introduction

The soybean (*Glycine max* (L.) Merr.) is an East Asian crop that has been extensively cultivated at high altitudes, both traditionally and in modern times. Soybean is capable of thriving in a range of soil types and under diverse climatic conditions (Chanthy *et al.*, 2010; Nget *et al.*, 2021). In Indonesia, soybean is an important food commodity, ranking alongside rice and corn as a source of food,

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protein, and oil (Harsono *et al.*, 2022). Soybeans have become a significant commodity for Indonesians, particularly those residing in South Sulawesi, which is regarded as one of the most prominent soybean production regions in Indonesia. The consumption of products derived from soybeans continues to increase on an annual basis. However, the cultivation of soybeans in this region frequently encounters significant obstacles due to the prevalence of pests that can diminish both productivity and yield quality. As stated by Norris *et al.* (2003), infestations of pests have a detrimental impact on crop yields. This is due to a number of factors, including physical damage, chemical contamination, disease transmission, increased production costs, social and environmental costs, and consumer disapproval. The cultivation of soybeans in the Panaikang Subdistrict of Maros Regency, South Sulawesi, is vulnerable to a range of pests, including those that are destructive and leaf-eating, such as *Spodoptera litura* (F), *Plusia chalcites* L., *Lamprosema indicata* F., *Stomopterix subcesivella* Zell., *Melanagromyza sojae, Tetranychus bimaculatus* Harv., *Herse convonvuli* L., *Empoasca* sp., *Valanga* sp., and *Liriomyza* sp. (Inayati and Marwoto, 2012; Biswas, 2013). In addition, there are several species of pod-sucking pests found on soybean plants, such as *Riptortus linearis* F., *Nezara viridula* L., *and Piezodorus hybneri* (Talekar, 1997; Suharsono and Sulistyowati, 2012), and pod-boring pests such as *Etiella zinckenella* and *Helicoverpa armigera* Hubner (Melo and Silveira, 1998; Apriyanto *et al.*, 2009). The consequences of uncontrolled pest attacks can have direct and indirect impacts, affecting the quantity and quality of crop yields, disrupting local food security, and threatening the sustainability of soybean farming (Rahayu *et al.*, 2018).

The primary challenge confronting soybean farmers in Panaikang Subdistrict is the prevalence of pests that cannot be effectively managed through conventional methods, such as the extensive use of chemical insecticides, which have demonstrated limited efficacy in addressing the issue. Nevertheless, the population of the pest in question continues to grow. This is largely attributed to the development of insect resistance to commonly used insecticides (Kontsedalov *et al.*, 2012). This is often associated with improper application and limited understanding of pest bioecology, leading to ineffective control (Tabasian *et al.*, 2014). Furthermore, the use of chemical insecticides at elevated concentrations has the capacity to alter the configuration of insect communities, precipitate the emergence of secondary pests, and directly impair or even annihilate natural enemies (Ndakidemi *et al.*, 2016; Fernandez *et al.*, 2021). The principal aim of this study was to ascertain the influence of planting refugia flowers (*Cosmos sulphureus*) on pest populations and natural enemies in soybean crops. This was achieved by managing the habitat of natural enemies in a manner that was conducive to the natural enemies in question, thereby exerting greater pressure on pest populations. It is anticipated that the findings of this research will contribute to increased soybean yields in terms of both productivity and quality while reducing reliance on chemical pesticides. This, in turn, will facilitate the advancement of more sustainable and environmentally conscious agricultural practices.

The effective and sustainable control of pests represents a significant challenge in the cultivation of soybeans, particularly in the Panaikang subdistrict of Maros District, South Sulawesi. Previous research has demonstrated the efficacy of a range of methodologies for the mitigation of pest infestations. Nevertheless, a considerable number of these techniques continue to depend on chemical pesticides that have a detrimental impact on the environment and human health. The use of refugia as a natural pest control strategy has demonstrated considerable potential; however, the precise impact of *Cosmos sulphureus* refugia flowers on soybean plants remains under-researched. A number of studies have investigated the use of different types of refugia plants as a means of controlling pest populations and favoring the proliferation of natural enemies. In their study, Barros *et al.* (2022) reported that *C. sulphureus* Cav. plants have the ability to attract and retain natural enemies, particularly spiders, Chrysopidae, and Coccinellidae, in rice and soybean intercropping systems. Furthermore, Allifah *et al.* (2019) proposed that the yellow kenikir flower (*C. sulphureus* Cav.) is one of the flowering plants that serves as a refuge and alternative food source for natural enemies. However, the outcomes of these studies frequently vary depending on the specific plant species and the prevailing local environmental conditions.

The objective of this study was to evaluate the effects of yellow kenikir (*Cosmos sulphureus* Cav.) refugia on pest populations, the abundance of natural enemies, and the intensity of *Etiella zinckenella* infestation in soybean (*Glycine max* (L.) Merr.) fields in Panaikang, Maros District, South Sulawesi.

## Materials and methods

### *Study area and research period*

The research was conducted throughout 2021 in a farmer-owned soybean field located in Panaikang Hamlet, Leang-leang Village (latitude: 4°57′24.86″S, longitude: 119°40′13.47″E), Maros Regency, South Sulawesi, Indonesia.

### *Experimental treatments*

This study was conducted as a field experiment and comprised of four treatments and five replications. The treatments were arranged using a randomized block design (RBD). The treatments were chlorpyrifos and cypermethrin insecticide combination (P0), yellow kenikir flower syrup (P1), artificial flowers (P2), and live yellow cosmos flower plants (P3).

The soybean plants implemented in this trial were sowed in an area of 28 m x 26 m, with a spacing of 20 cm x 50 cm. The experimental site comprised four treatment plots of 8m x 6m each. To act as an appropriate control, insecticides comprising chlorpyrifos + cypermethrin were used that were adjusted to match the local farming practices in pest control on soybean plants. While the kenikir flower plants were cultivated in polybags measuring 35 cm x 30 cm, flower extracts were prepared using sterile water. The resulting extract was mixed with natural and artificial sweeteners and other additives to create a new flower syrup formula, which was then stored in glass bottles as stock for field experimentation.

### *Field application*

Each replicate plot contained five treated soybean plants, resulting in a total of 80 sample plants. The control treatment (P0) was administered solely at the onset of planting, prior to flowering, and during harvesting. Meanwhile, the kenikir flower extract syrup treatment (P1) was applied weekly during the experiment. The syrup was evenly sprayed onto the soybean plants at a rate of 100 mL per plant. The artificial flowers (P2) received 5 mL of kenikir flower syrup by spray application until fully absorbed. Afterward, they were hung on a rope that circled both the perimeter and center of the experimental plot. A total of 37 imitation flowers were used for the field experiment, while 48 kenikir plants (P3) were placed around the perimeter and centre of the experimental plots.

### *Direct observation*

The observed variables included pests that destroy leaves and eat pods, along with arthropods that may function as natural enemies of soybean pests. The observations of pests that leaf-feeding and pod-feeding pests commenced at 40 days after planting. Observations of pests on soybean plant leaves and pods were visually conducted by counting their population and damage intensity to the pods. Pest identification was conducted through photographic documentation and laboratory analysis of samples chosen. Observations were carried out twice daily at 06:00-09:00 and 15:30-17:30, with 8 observations in a week with an interval of 7 days.

***The pitfall trap***

A pitfall trap sampling technique was used by creating trap holes on the ground to sample arthropods. Two pitfall traps were set up in each replicate plot. The pitfall trap method employs a plastic cup with a 15 cm diameter and a 20 cm height, of which 1/3 is filled with 70% alcohol to cause trapped arthropods to sink and die. The pitfall traps were positioned in the ground with the plastic surface parallel to the ground surface for 24 hours. To prevent rainwater or other disruptions from entering, the pitfall trap was topped with a zinc cover designed like a roof (Prihatin *et al.,* 2023). The trap's cover was designed to allow arthropods to continue to enter, through two open sides. Arthropods collected at a single sampling location were placed in a sample bottle with an alcohol solution.

***Sweep net***

Sweep netting is an active sampling technique for collecting insects by swinging an organdy cloth net over plants. The net had a diameter of 0.4 m and a 1.5 m long stalk. Sampling was conducted twice for each replicate plot by swinging the net three times in a zigzag pattern starting at 7 am. The arthropods were captured and placed into a sample bottle containing 70% alcohol to maintain the sample's condition until identification in the laboratory as part of the arthropod identification process.

***Arthropod identification***

Insects are morphologoical identified in the field using photographs, whereas unfamiliar insects are identified under laboratory conditions using an insect identification book referred to by Levi *et al.* (1968) and CSIRO (2000), as well as a stereo microscope. The majority of arthropod specimens were identified as wet preparations.

***Data analysis***

The obtained data were classified with Microsoft Excel 2016 spreadsheet software and analysed using dynamic cross tabulation to produce histograms. The observational data for each treatment was subjected to analysis of variance (ANOVA), and in cases of significant differences between treatments, further tests were done with the Tukey test at the 0.05 level.

The formula for calculating the intensity of pod borer attacks, whether absolute or not, is as follows (Directorate General of Food Crops, 2018):

$$I = \frac{n}{N} x100\%$$

I = Intensity of the attack (%)
n = The number of pods that have suffered absolute damage
N = total number of pods under observation.

## Results

### *Soybean plant pests*

Field observations revealed several key pest species, including *Lamprosema indicata* (Lepidoptera: Noctuidae), *Spodoptera litura* (Lepidoptera: Noctuidae), *Melanagromyza sojae* (Diptera: Agromyzidae), and *Valanga nigricornis* (Orthoptera: Acrididae) on soybean plants. Pest populations differed significantly among treatments (Table 1). The P3 treatment in soybean fields consistently yielded higher numbers of pests, including *L. indicata*, and *S. litura*, and *M. sojae* compared to the other treatments. This increase may be attributed to the attractiveness of refugia plants, which provide floral resources and habitat that attract various arthropods. The yellow kenikir flower treatment produced an average of 2.61 *L. indicata* and 2.71 *S. litura* per plant, which were significantly different from each other. However, there was no significant difference in the population of *M. sojae* and *V. nigricornis* in all treatments.

### *Population of natural enemy arthropods*

Based on observations and identification, several predatory arthropods were recorded using pitfall traps and sweep nets, including *Coccinella* sp. (Coleoptera: Coccinellidae), *Oxyopes* sp. (Araneae: Oxyopidae), and members of Odonata. The P3 treatment exhibited the highest average population of natural enemies, with mean values of 1.70 for *Coccinella* sp., 2.05 for *Oxyopes* sp., and 0.35 for Odonata. This indicates that refugia plants not only attract pests but also enhance the abundance of natural enemies within the ecosystem. In contrast, the P0 treatment (chlorpyrifos + cypermethrin) showed lower populations of natural enemies, with mean values of 0.25 for *Coccinella* sp. and 0.85 for *Oxyopes* sp. (Table 2).

**Table 1.** Populations of pests found damaging soybean plants

| Treatments | Number of pest population per plant (Mean±SD) | | | |
|---|---|---|---|---|
| | ***Lamprosema indicata*** | ***Spodoptera litura*** | ***Melanagromyza sojae*** | ***Valanga nigricornis*** |
| P0 | 1,21±0,96[b] | 0,43±0,19[b] | 0,32±0,12[a] | 0,64±0,32[a] |
| P1 | 2,04±0,86[ab] | 0,64±0,28[b] | 0,29±0,09[a] | 0,50±0,29[a] |
| P2 | 1,71±1,08[ab] | 1,18±0,83[b] | 0,54±0,47[a] | 0,61±0,28[a] |
| P3 | 2,61±0,32[a] | 2,71±0,51[a] | 0,61±0,32[a] | 0,46±0,17[a] |

Numbers in a column, followed by the same letter, are not significantly different by Tukey's multiple range test (P≤0.05)

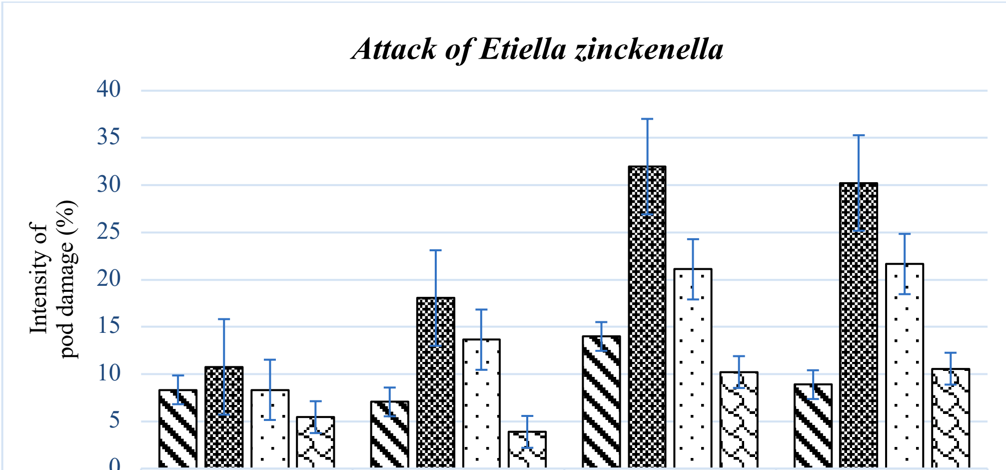
**Table 2**. Population of natural enemy arthropods found in soybean fields

| Treatments | Number of natural enemies in soybean plants (Mean±SD) | | |
|---|---|---|---|
| | ***Coccinella* sp.** | ***Oxyopes* sp.** | ***Odonata*** |
| P0 | 0,25±0,22[b] | 0,85±0,76[a] | 0,00±0,00[b] |
| P1 | 0,55±0,21[b] | 1,30±0,59[a] | 0,25±0,18[a] |
| P2 | 0,35±0,13[b] | 1,35±0,99[a] | 0,15±0,14[ab] |
| P3 | 1,70±0,72[a] | 2,05±1,01[a] | 0,35±0,14[a] |

Numbers in a column, followed by the same letter, are not significantly different by Tukey's multiple range test (P≤0.05)

### *Intensity of Etiella zinckenella attack*

According to observations, *E. zinckenella* initiated attacks on soybean pods when the plants were 54 days post-planting. The level of pod damage caused by *E. zinckenella* between 54 to 75 DAP in each treatment exhibited marked differences. The P1 treatment had the highest percentage of soybean pod damage, recording 10.76% at 54 DAP, 18.05% at 61 DAP, 31.96% at 68 DAP, and 30.23% at 75 DAP. The P2 treatment witnessed 8.33% at 54 DAP, 13.64% at 61 DAP, 21.09% at 68 DAP, and 21.65% at 75 DAP. In contrast, the P3 treatment endured the lowest soybean pod damage percentage, at 5.44% at 54 DAP, 3.88% at 61 DAP, 10.21% at 68 DAP, and 10.57% at 75 DAP. Meanwhile, a low percentage of soybean pod damage also occurred in the P0 treatment using chlorpyrifos and cypermethrin insecticides (Figure 1).




| | 54 DAP | 61 DAP | 68 DAP | 75 DAP |
|---|---|---|---|---|
| P0 | 8.33 | 7.05 | 13.98 | 8.88 |
| P1 | 10.76 | 18.05 | 31.96 | 30.23 |
| P2 | 8.33 | 13.64 | 21.09 | 21.65 |
| P3 | 5.44 | 3.88 | 10.21 | 10.57 |

**Figure 1.** *E. zinckenella* infestation on soybean pods at 54 to 75 DAP

## Discussion

During this study, arthropods classified as both pests and natural enemies were predominantly attracted to and found in the yellow kenikir flower treatment (P3). This may be explained by the presence of refugia plants that provide alternative food sources and shelter for arthropods. This finding is consistent with Landis *et al*. (2000), who reported that the connection between plants and insects can arise from a number of factors, including acting as a food source for insect pests and serving as a refuge for natural enemies.

Arthropods are drawn to plants due to the unique odour they emit. According to Rowan (2011), insects are drawn to plants due to the odours they emit in the form of volatile compounds, which are derived from low molecular organic compounds and can stimulate insects to visit plants. Furthermore, arthropods are also drawn to the colours of plants. This is evident in the arthropod population under the P3 treatment, where the yellow kenikir flower treatment possesses a flower colour that can quickly attract arthropods through visual response compared to other treatments. According to Sunarno (2011), most insects have two types of pigments in their vision; pigments that absorb bright yellow and green, and pigments that absorb pink and ultraviolet light.

The arthropods attracted to the kenikir flower suggest it may be the ideal plant choice. Specifically, the abundance of arthropods in the P3 treatment indicates its potential to serve as a microhabitat for natural enemies and draw plant pests. This indirect plant treatment can control pests naturally, thus promoting environmental balance in soybean plantations. This is supported by observations of the intensity of *Etiella zinckenella* attacks on soybean pods. The yellow kenikir flower treatment exhibits significantly lower attack intensity ($p<0.05$) than other treatments. Furthermore, the kenikir flower treatment appears to be highly attractive to natural enemies such as *Coccinella* sp., *Oxyopes* sp., and *Odonata*, which benefit from the protective conditions provided by the dense and branched plant structure. Another characteristic of the P3 treatment connected with natural predators is that the fully-developed pollen serves as a food source. In a study conducted in Indonesia, Aldini *et al.* (2019) identified thirty families of predators drawn to these plants. Notably, these include Lycosidae, Linyphiidae, Syrphidae, and Coccinellidae.

In conclusion, this study demonstrated that incorporating yellow kenikir flowers (*Cosmos sulphureus* Cav.) in soybean fields led to a substantial decrease in pest populations and an increase in natural enemies in soybean fields. The findings indicate that implementing protective flowers can serve as an effective supplementary tactic for integrated pest management in soybean cultivation.

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## Conflicts of interest

The authors declare no conflict of interest.

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