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Usage of *Jatropha curcas* as Botanical Insecticide in Controlling Insect Pest

Penggunaan Jatropha curcas sebagai Insektisida Botani dalam Pengendalian Serangga Hama

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ABSTRACT

Insect pests can cause damage to plants and cause losses. Insect pests on plants need to be controlled both preventively and curatively. Integrated control is an integration of several control methods that can be implemented in a compatible and comprehensive. Insect pest control using bio-active plant materials as an alternative to synthetic chemicals. Plants produce secondary metabolite compounds that can affect insects, including Jatropha curcas (Euphorbiaceae). Studies on several insect pests both in the laboratory and in the field against insect pests that attack the field and agricultural product storage warehouses have been carried out to determine their effectiveness. Jatropha curcas plants/parts of plant were applied after extraction treatment with various solvents (water, ethanol, methanol, acetone, petroleum ether, n-hexane and chloroform) or direct use. The results showed that J. curcas exhibited control effects against several types of insect pests from various insect pest. Laboratory study showed the insecticidal effect of J. curcas against Helicoverpa armigera, Spodoptera frugiperda, Plutella xylostella, Earias insulata, Spilarctia oblicua, Tuta absulata, Nezara viridula, Corcyra cephalonica, Maruca vitrata. Field study showed population reduction of Putella xylostella and Aphis craccivora. Whilst, on stored product study showed mortality of insect pest (Sitophilus zeamais, Rhyzopertha dominica, Callosobruchus chinensis and C. maculatus) and reduction of weight loss of stored products. Jatropha curcas has the potential as a pest insect control to be integrated into the IPM component.

Keywords: Jatropha curcas, Botanical insecticide, Insect pest

ABSTRAK

Serangga sebagai hama dapat menimbulkan kerusakan pada tanaman dan menimbulkan kerugian. Serangan serangga hama pada tanaman perlu dikendalikan baik secara preventif maupun kuratif. Pengendalian secara terpadu merupakan integrasi beberapa metode pengendalian yang dapat dilaksanakan secara kompatibel dan komprehensif. Pengendalian hama serangga termasuk menggunakan bahan bio-aktif yang berasal dari tumbuhan merupakan alternatif penggunaan bahan kimia sintetik. Tumbuhan menghasilkan senyawa metabolit sekunder yang dapat mempengaruhi serangga termasuk Jatropha curcas (Euphorbiaceae). Pengujian pada beberapa serangga hama baik di laboratorium maupun di lapangan terhadap serangga hama yang menyerang di lapangan maupun gudang penyimpanan hasil pertanian telah dilakukan untuk mengetahui efektivitasnya. Tumbuhan/bagian tumbuhan J. curcas diaplikasikan setelah perlakuan ekstraksi dengan berbagai pelarut (air, etanol, metanol, aseton, petroleum eter, n-heksan dan kloroform) ataupun penggunaan langsung. Hasil pengujian menunjukkan bahwa J. curcas menunjukkan efek pengendalian terhadap beberapa jenis serangga hama. Pengujian di laboratorium menunjukkan efek insektisidal terhadap Helicoverpa armigera, Spodoptera frugiperda, Plutella xylostella, Earias insulata, Spilarctia oblicua, Tuta absulata, Nezara viridula, Corcyra cephalonica, dan Maruca vitrata. Studi di lapangan menunjukkan penurunan populasi Putella xylostella and Aphis craccivora. Sedangkan pada bahan simpan menunjukkan mortalitas serangga Sitophilus zeamais, Rhyzopertha dominica, Callosobruchus chinensis dan C. maculatus serta penurunan kehilangan berat bahan simpan. Jatropha curcas mempunyai potensi sebagai pengendalian serangga hama untuk dipadukan ke dalam komponen PHT.

Kata kunci: *Jatropha curcas, Insektisida botani, Serangga hama*

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INTRODUCTION

Insect pests are estimated to cause yield losses in agriculture. In many important commodities, insect infestation is a constraining or limiting factor for production improvement programs. Crop damage due to pest infestation is enormous. Several cases have shown harvest failure due to pest infestation. Insects feed on the leaves, fruits, stems, twigs and roots of plants causing crop damage. Insects can also cause damage to plants due to their biological activities such as laying eggs or pupating. Some insects can transmit disease-causing microorganisms to plants. The presence and interaction of insects as pests in crop cultivation will be a problem if their activities cause losses to crop cultivation (Cook *et al*., 2007; Poppy *et al*., 2014).

In managing insect pests, farmers have always relied on the use of synthetic chemicals. Several negative effects occur due to the use of chemicals to control insect pests. Synthetic chemicals can kill useful insects in agroecosystems, such as parasitoids, predators, and pollinating insects. Another impact is that insect pests develop resistance to these chemicals. Hazards to humans such as farmers or agricultural workers are also a serious problem (Dodia *et al*., 2008; Tudi *et al*. 2021).

Precautionary considerations in the use of chemical pesticides are also related to the global demand for synthetic chemical-free food, so sustainable agriculture, and environmentally friendly, organic products, are a necessity. Precise control strategies are needed to achieve this expectation, searching for chemical compounds that can be combined with other methods integrated into the IPM component, have short persistence and are environmentally safe. An effort to find alternative chemicals for insect pest control is by utilizing materials derived from plants. Plant extracts have various effects on insects. Plant chemical compounds may have effects of toxic, repellent, anti-feedant, repelling egg laying and inhibiting reproduction. It is easily degradable in the environment, cheap, and non-toxic to natural enemies, and selective, reducing the possibility of resistance. Plant extracts are alternative materials for insect pest control, suitable for sustainable agriculture compared to synthetic chemical insecticides (Isman, 2006).

Plants contain secondary metabolite compounds that are useful as self-defense mechanisms from various factors that suppress their lives. These secondary metabolite compounds can cause biological effects on insects. These effects can kill, repel, lure, and disrupt the metamorphosis process of insects. Currently, a large number of botanical insecticides are commercially traded whose active ingredients are obtained from plant extractions such as neem, tobacco, chrysanthemum, and garlic. In addition, synthetic imitations of natural active ingredients such as imidacloprid are neuro-active insecticides that are chemically similar to nicotine. Many researchers have tested the efficacy of secondary metabolites in various plants (Isman, 2006; Dodia *et al*., 2008). Therefore, in this paper, the potential of *Jatropha curcas* as a botanical insecticide will be reviewed.

CHARACTERISTICS AND UTILIZATION OF *JATROPHA CURCAS*

Jatropha curcas (Euphorbiaceae) is an annual plant. This plant originates from Latin America and spreads in the tropics in both arid and semi-arid climates. *Jatropha curcas* grows well in dry lowland climate with an altitude of 0-500 meters above sea level, with rainfall of 300-1000 mm per year. It is also found in lowland drylands with wet climates. *Jatropha curcas* is a small tree or large shrub that reaches five meters in height. The trunk has protrusions of fallen leaves, slightly cloudy white gummy, and is single-leafed with a pale abaxial surface and ovate. The leaf blade is 5-15 cm long. The width of the leaf is 6-16 cm, angular or notched 3-5, the base of the leaf is heart-shaped, the tip is tapered, the main leaf blade is fingered with 5-7 lines, the length of the petiole is 3-15 cm. The flowers are yellowish green, unisexual, monoecious, male and female flowers are each arranged in a saucer-shaped arrangement. The fruit is round with a diameter of 3-4 cm, when ripe it is yellow which is divided into 3 rooms, when dry it will crack (Supriadi, 2001).

All parts of *J. curcas* have been used for a long time in traditional medicine in various parts of the world. Its oil is used as a laxative, treating skin diseases and rheumatism. The liquid extract of the leaf decoction is used as a cough remedy and post-natal antiseptic. Ingredients that act to relieve wounds and inflammation have also been isolated from *J. curcas* plant parts. This plant has many advantages, besides being a producer of non-food vegetable oil, it is also useful as a traditional medicine, botanical insecticide, shading plant and erosion prevention and land conservation. Another advantage is it can be processed into animal feed, organic fertilizer and surfactant products. The results of seed pressing can also be used as organic fertilizer. The oil content in the seeds can be used as an alternative fuel source to biodiesel oil. This biodiesel is more environmentally friendly, renewable, and biodegradable (Sherchan *et al*., 1989; Gubitz *et al*., 1999; Adebowale and Adedire, 2006; Muniz *et al*., 2020).

In Indonesia, *J. curcas* is known as jarak pagar. In some regions, it has local names such as baklawah (Aceh); jarak kosta (Sunda); jarak pager (Bali); jarak budeg, jarak gundul, jarak cina (Java); jarak pageh (Nusa Tenggara). *Jatropha curcas* plants can be found thriving in various places in Indonesia. This plant has many benefits, especially its use as a traditional medicine. It is commonly found in the fences of houses and gardens or along the roadside. This plant is also a producer of non-food vegetable oil, botanical insecticides, protective plants and erosion prevention/conservation and can be processed into animal feed, organic fertilizer and surfactant products. The seeds contain a high oil content of 30-50% and have potential as an alternative fuel (biodiesel). The development of jatropha commodities is most suitable on marginal or critical land in Indonesia (Septyadi *et al*., 2007). The use of *J. curcas* plants as botanical insecticides has the opportunity to be utilized as a chemical control which is compatible with IPM. Soetopo (2007) reported that leaves, stems and seed cakes of *J. curcas* have a high crude protein of 58-60%, and also contain a strong poison. Tukimin *et al*. (2010) stated that *J. curcas* seeds can also be utilized as raw materials for botanical insecticides, fungicides and molluscicides.

CHEMICAL CONTENT OF *J. CURCAS* AND POTENCY IN CONTROLLING INSECT PEST

Chemical content

Phytochemical examinations of jatropha leaves, roots, bark and seeds showed the presence of alkaloids, flavonoids, saponins, phenols, and tannins. Several studies have been conducted to see the effects of *J. curcas* plants on insects. The studies were carried out by extracting plants/plant parts as well as direct use. There was also the isolation of bioactive compounds such as phorbol ester, curcin, saponins, curcalonic acid, phytates, lectins, and protease inhibitors. (Kumar *et al*., 2014). Jatropha leaves contain active compounds such as saponins (4.89%), tannins (7.43%), and flavonoids (7.35%). There are the main biological effects of phorbol ester (tetracyclic diterpenoid) fraction in *J. curcas* seed oil extracts. Six phorbol esters have been characterized from *J. curcas* seed oil with the molecular formula C44H54O8Na, as intra-molecular diesters of the same diterpene, 12-deoxy-16-hydroxyphenol. Biocidal, including the insecticidal activity of phorbol esters is due to stimulation of the cellular target protein kinase C (PKC) (Uche and Aprioku, 2008; Devappa *et al*., 2011).

According to Harimurti and Sumangat (2011), the oil content in *J. curcas* seeds is about 30-40%, whilst that of the kernel is 40-50%. Jatropha oil is a triglyceride which is composed of palmitic (14.1%), stearic (6.8%), oleic (38.6%), linoleic (36%) and other fatty acids (4.5%). *Jatropha curcas* seeds contain unsaponifiable oils, hydrocarbons/stereo esters, tryacycerol, free fatty acids, diacylglycerols, sterols, monoacylglycerols, and polar fats. Unsaponifiable properties contain sterols and triterpene alcohols that react as insecticides. The predominant sterols are 24-ethylcholesterol and β-sitosterol. Pentacyclic triterpenoids have insect growth-inhibiting effects disrupting insect growth and chemo-sterilant effects. Fatty acid composition showed dominant linoleic acid (47.3%). The high molecular weight of fatty acids gives the effect of repellent activity on insects. *Jatropha curcas* seed oil can reduce the number of *Callosobruchus maculatus* eggs laid and prevent adult emergence (Adebowale and Adedire, 2006; Babarinde *et al*., 2019). Chemical content of *J. curcas* is given in Table 1.

Table 1. Chemical content of *J. curcas*

Various parts	Chemical Composisition	References
Stem bark	β-amyrin, β-sitosterol, taraxerol	Kumar and Sharma (2008)
Seed	Curcin, tryacycerol, linolenic acid, sterols, triterpene alcohol lectin	Adebowale and Adedire (2006) Makkar *et al.* (1997)
Press cakes	Phytates, saponins and trypsine inhibitor	Makkar *et al.* (1997)

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and kernel		
Leaves	alkaloids, flavonoids, terpenoids, saponins, tannins, steroids	Uche and Aprioku (2008)
Seed oil	Triglyceride composed of palmitic, stearic, oleic, linoleic, phorbol ester	Devappa *et al*. (2011)

Potency *Jatropa curcas* against insect pest

Many studies have been conducted on the effectiveness of *J. curcas* plants from the fruit, seeds, leaves, stems and roots against insect pests. Studies were carried out directly from these plant parts as well as the results of extractions and isolated chemical compounds. Some studies of insecticidal effects and biological effects on insects were carried out in laboratories and glass houses, and some have also been carried out in the field to control pests which attack plants. Studies of the effects of pests which attack agricultural products stored in the form of grains have also carried out by several researchers. The demand for food free of pesticide residues makes the use of insecticides derived from plants very attractive (Ugwu, 2021; Holtz *et al*., 2021;

Laboratory study

A study on *J. curcas* seed waste of residue processing seeds to make oil in several accessions was reported by Tukimin and Karmawati (2012). *Jatropha curcas* seed waste in the form of cake macerated with methanol and sprayed to *Helicoverpa armigera* larvae instar 2 showed the sequences of effectiveness of mortality are accessions of South Sulawesi, Lampung and East Java at a concentration of 10 ml /solution with mortality respectively 61, 27.67 and 24.33% and LC_{50} is 20.81, 60.87 and 40 ml / l at 120 hours after application. This is in accordance with the results of the analysis of the chemical content of phorbol ester seed cake which is 9.34, 6.64, and 4.39 µg/ml respectively.

Devappa *et al*. (2012) reported that phorbol ester from *J. curcas* seed oil was tested as contact and stomach poison on instar 3 larvae of *Spodoptera frugiperda*, a corn pest. The results showed that toxicity as a contact poison (topical application) with an LC_{50} value of 0.83 mg/ml, and treatment on corn leaves at 0.25 mg/ml showed a reduction in feed consumption by 33%, and reduced growth by 42%. Ingle (2017) evaluated that *J. curcas* seed, bark, shell, leaf and root extracts have insecticidal activity against *Plutella xylostella* applied at 5% concentration and causing 80, 40, 100, 80 and 80% larval mortality, respectively. Meanwhile, 15% concentration of shell, caused 60% mortality of *H. armigera*, and 5% concentration of leaf and root extracts caused 41.55 and 43.20% mortality of *H. armigera* and reduction of larval weight. When sprayed on spiny bollworm *Erias insulana* eggs, aqueous extracts of powdered *J. curcas* seeds at concentrations of 5, 10, 15, and 20% (w/v) caused egg hatchability to be 30.5, 23.5, 28.6, and 36.4%, respectively. While reductions in egg hatchability at 5, 10, and 15% concentrations were 28.9, 18.9, and 23.3%, respectively (Ishag and Osman, 2020).

Sharma (2012) evaluated the acetone extract of *J. curcas* leaves on the growth and development of *Spilarctia oblicua* larvae at concentrations of 0.625, 1.25, 2.5, 5 and 10 v/v. The highest mortality was obtained at 5% extract application with mortality of 33.3% and the largest reduction in pupal percentage was 36.6%. Research on the effects of *J. curcas* petroleum ether extract on eggs and larvae of *Tuta absulata* as a contact poison showed that egg mortality was highest at 125 mg/l extract concentration while larval mortality was at 4000 and 8000 mg/l concentrations of 85 and 100%, respectively (Koona *et al*., 2014). *Jatropha curcas* seed oil at a concentration of 3% affected the egg hatching of *Diatraea saccharalis* as a contact poison method with results showing only 60% eggs hatched (De Oliveira, 2013). The effect of acetone extract of *J. curcas* seeds on green stink bug *Nezara viridula* (Hemiptera; Pentatomidae) at concentrations of 0.5 and 0.25% as contact poison test showed mortality of 97.5 and 90% respectively with the toxicity of LC_{50} = 0.026% (Asmanizar *et al*., 2019). Whilst, the study by dipping soybean pods into the extract solution with a concentration of 0.5 and 0.25% and fed to the *N. viridula* showed 100% mortality at both concentrations tested with LC_{50}=0.005% (Asmanizar *et al.*, 2020). Acetone extract from *J. curcas* seeds showed more toxic effects as stomach poison than as contact poison.

Khani *et al*. (2013) conducted study effect of petroleum ether *J. curcas* seeds extract on larvae and eggs of *Corcyra cephalonica*. The concentration extracts tested were 2, 4, 6, 8 and 10% (w/v) as the contact method. The result

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showed that the LC_{50} was 13.22 ul/ml. Application extract at 12 and 20 ul/ml of concentrations showed mortality of 66.5 and 98%, respectively. Concentration of 10 ul/ml can reduce egg hatching by 92% and inhibit adult formation. Ugwu (2020) also conducted a study on the extract of *J. curcas* seed on pod borer *Maruca vitrata*. Extract application of the extract to *Vigna unguilata* seedbeds reduced the larval population by 59.12%.

Field Study

Application on cabbage crops in the field with botanical insecticides from *J. curcas* leaves extracted with water solvent at a concentration of 3% (w/v) showed a 66% reduction in the population of *Plutella xylostella* larvae (Amoabeng *et al*., 2013). Another study showed that the latex from *J. curcas* stems at concentrations of 25 and 50% (v/v) applied to cabbage plants showed decreasing of *P. xylostella* larvae 7 and 45%, respectively (Mwine *et al*., 2013).

Jatropha curcas seed oil formulations (50% oil, 30% ethanol, 20% Arabic gum as adjuvant) applied to *Aphis craccivora* infested *Vigna unguilata* plants in the field showed that concentrations of 5 and 7% could reduce *A. craccivora* infestation by 10 and 50% compared to the control. Concentrations of 5-15% caused 80-100% aphid mortality (Habou *et al*., 2011).

Stored product study

The use of botanical insecticides also occurs in warehouses where agricultural products are stored. Damage caused by warehouse pests will cause significant losses if not controlled properly. The use of synthetic chemicals is a method that has many negative effects, especially since stored materials can be contaminated with chemical residues that can interfere with the health of humans who consume the product. Risks to applicators can also occur, especially gaseous chemicals. Some studies on the use of botanical insecticides from the *J. curcas* plant are described here (Isman, 2006).

Application of aqueous extracts and powder of seeds and pericarp of *J. curcas* against insect pests *S. zeamais* (Coleoptera: Curculionidae) and *Rhyzopertha dominica* (Coleoptera: Bostrychidae) at concentrations of 5 and 10% (w/v). At high concentrations, it caused 75 and 100% mortality of *S. zeamais* and *R. dominica*, respectively (Silva *et al*., 2012). The study on the effect of *J. curcas* seed extract against *Sitophilus zeamais* applied as seed protection on rice grain with a concentration of 0.1% (v/w) showed 100% mortality of *S. zeamais*, whilst a concentration of 0.01% showed weight loss and seed damage of 6.27 and 10.82%, respectively (Asmanizar *et al*., 2012[a]). Application in the form of *J. curcas* seed powder showed mortality of *S. zeamais* 98.85% at a concentration of 2% (w/w) and 93.45% at a concentration of 0.5%. Application at a concentration of 1% had no weight loss and rice damage (Asmanizar *et al*., 2012[b]).

Jide-Ojo (2013) evaluated *J. curcas* leaf extract and seed oil as grain protection against *S. zeamais*. The results showed that concentration of 100 ppm, both extracts showed a >90% prevention of *S. zeamais* emergence. At a concentration of 50 ppm, the leaf extract showed 26.7% egg laying prevention, while the seed oil showed no significant egg laying prevention up to a concentration of 10 ppm. *Jatropha curcas* leaf extract and seed oil at 100 ppm caused a decrease in the percentage of hatched eggs to 92.3 and 64.3%, respectively, and *S. zeamais* adult mortality to 100 and 58.9%, respectively. Ukpai (2017), studied the effect of *J. curcas* seed powder at 2.5, 5, 7.5 and 10 g/50 g maize grain. The results showed that 10 g of seed powder had a good effect on *S. zeamais* mortality.

Jatropha curcas leaf powder was also tested on *Callosobruchus chinensis* a pest on mung beans by mixing leaf powder with mung bean seeds at 1, 2 and 3 g to 20 g of mung bean seeds. Results showed that concentrations of 1, 2 and 3 g showed significantly different mortality of *C. maculatus* at 72 hours after application with mortality occurring 86-90%. The effect of leaf powder also showed anti ovipositional activity at all concentrations tested. The concentration of 1 g/ 20 g seeds showed a decrease in oviposition up to 81.04%. The response of insect pests to *J. curcas* leaf powder is attributed to the chemical content of saponins, tannins, alkaloids, flavonoids and cyanogenic glycosides (Opuba *et al*., 2018).

Several solvents were tested to know their ability to affect insects. Habib-ur-Rehman *et al*. (2018) conducted methanol, chloroform, petroleum ether, and n-hexane for the extraction of *J. curcas* leaves and assessing their toxicity on *Tribolium. castaneum* and *Ryzopertha dominica*.

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Table 2. The potency of *J. curcas* in controlling insect pests

Botanical insecticides	Bioactivity	References
Cake macerated with methanol	Extracts sprayed to *Helicoverpa armigera* larvae instar 2 showed of mortality accessions of South Sulawesi, Lampung and East Java at a concentration of 10 ml/solution with mortality respectively 61, 27.67 and 24.33% and LC_{50} is 20.81, 60.87 and 40 ml / l at 120 hours after application.	Tukimin and Karmawati (2012)
Phorbol ester from seed oil	Phorbol ester was tested as contact and stomach poison on instar 3 larvae of *Spodoptera frugiperda* showed the toxicity as a contact poison with an LC_{50} value of 0.83 mg/ml, and treatment on corn leaves at 0.25 mg/ml showed a reduction in feed consumption (33%), and reduced growth (42%).	Devappa *et al.* (2012)
Seed, bark, shell, leaf and root extracts	Insecticidal activity against *Plutella xylostella* applied at 5% concentration and causing 80, 40, 100, 80 and 80% larval mortality, respectively.	Ingle (2017)
Extracts of powdered *J. curcas* seeds	Aqueous extracts at concentrations of 5, 10, 15, and 20% (w/v) caused egg hatchability to be 30.5, 23.5, 28.6, and 36.4%, respectively. While reductions in egg hatchability at 5, 10, and 15% concentrations were 28.9, 18.9, and 23.3%, respectively.	Ishag and Osman (2020)
Leaf extract	Application on of *Spilarctia oblicua* larvae at concentrations of 0.625, 1.25, 2.5, 5 and 10 v/v showed the highest mortality was obtained at 5% extract (33.3%) and the largest reduction in pupal (36.6%).	Sharma (2012)
Seed extract	Application petroleum ether extract on eggs and larvae of *Tuta absulata* as a contact poison showed that egg mortality was highest at 125 mg/l extract concentration while larval mortality was at 4000 and 8000 mg/l concentrations of 85 and 100%, respectively	Koona *et al.* (2014)
Seed oil	*Jatropha curcas* seed oil at a concentration of 3% affected the egg hatching of *Diatraea saccharalis* as a contact poison method with results showing only 60% eggs hatched	De Oliveira (2013)
Seed	Application extracts on *Nezara viridula* at concentrations of 0.5 and 0.25% as contact poison test showed mortality of 97.5 and 90% respectively with the toxicity of $LC_{50} = 0.026\%$	Asmanizar *et al.* (2019)
Seed	Dipping soybean pods into the extract solution with a concentration of 0.5 and 0.25% and fed to the *N. viridula* showed 100% mortality at both concentrations tested with LC_{50}=0.005%	Asmanizar *et al. (*2020)
Seed extract	Treatment of petroleum ether extract on larvae and eggs of *Corcyra cephalonica* at the concentration extracts tested were 2, 4, 6, 8 and 10% (w/v) as the contact method caused the LC_{50} was 13.22 ul/ml. Application extract at 12 and 20 ul/ml showed mortality of 66.5 and 98%, respectively. Concentration of 10 ul/ml can reduce egg hatching (92%) and inhibit adult formation	Khani *et al.* (2013)
Seed extracts	Extract application to *Vigna unguilata* seedbeds reduced the *Maruca vitrata* larval population (59.12%).	Ugwu (2020)
Leaves extract	Application on cabbage crops in the field with water solvent at 3% (w/v) showed a 66% reduction in the population of *Plutella xylostella* larvae.	Amoabeng *et al.* (2013)
Stem latex	Application at 25 and 50% (v/v) to cabbage plants showed decreasing of *P. xylostella* larvae 7 and 45%, respectively.	Mwine *et al.* (2013)

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Seed oil	Application of 50% oil, 30% ethanol, 20% Arabic gum as adjuvant to *Aphis craccivora*-infested *Vigna unguilata* plants in the field showed that concentrations of 5 and 7% could reduce *A. craccivora* infestation by 10 and 50% compared to the control. Concentrations of 5-15% caused 80-100% aphid mortality.	Habou *et al.* (2011)
Seed, pericarp powder extract	Application on *S. zeamais* and *Rhyzopertha dominica* at concentrations 10% (w/v) caused 75 and 100% mortality of *S. zeamais* and *R. dominica*, respectively.	Silva *et al.* (2012)
Seed extract	Extract applied as seed protection on rice grain with a concentration of 0.1% (v/w) showed 100% mortality of *S. zeamais*, whilst a concentration of 0.01% showed weight loss and seed damage of 6.27 and 10.82%, respectively.	Asmanizar *et al.* (2012[a])
Seed powder	Mixing of powder on rice grain showed mortality of *S. zeamais* was 98.85% at a concentration of 2% (w/w) and 93.45% at 0.5%. Application at a concentration of 1% had no weight loss and rice damage.	Asmanizar *et al.* (2012[b]).
Leaf extract and seed oil	Grain protectant at 100 ppm leaf extract and seed oil caused a>90%prevention *S. zeamais* adult emerge, decreased eggs hatched (92.3 and 64.3%). At a concentration of 50 ppm, the leaf extract showed 26.7% egg laying prevention, while the seed oil showed no significant egg laying prevention up to a concentration of 10 ppm.	Jide-Ojo (2013)
Seed powder	Application at 2.5, 5, 7.5 and 10 g/50 g maize grain showed that 10 g of seed powder had a good effect on *S. zeamais* mortality.	Ukpai (2017)
Leaf powder	Mixing leaf powder with mung bean seeds at 1, 2 and 3 g/20 g showed that concentrations of 1, 2 and 3 g showed significantly different mortality of *C. mculatus* at 72 hours after application with mortality occurring 86-90%. There was also anti ovipositional activity at all concentrations tested. The concentration of 1 g/ 20 g seeds showed a decrease in oviposition up to 81.04%.	Opuba *et al.* (2018).
Leaf extracts	The results showed that 15% concentration of methanol extract caused the highest mortality 37.32 and 49.17% of *T. castaneum* and *R. dominica*.	Habib-ur-Rehman *et al.* (2018)

Effect on natural enemies

There was a field study conducted to know the effect of *J. curcas* plant extracts on predators (coccinellids, syrphids, and chrysophids) *Aphis gossypii* infesting *Plantago* sp. The result showed that the population of predators in various treated plots with *J. curcas* leaf extract at 10% concentration caused a non-significant difference with the number of predators in the control plot. It suggested that this extract was safe for natural enemies (Dodia *et al.*, 2008).

CONCLUSIONS

Jatropha curcas plants are found in many regions in Indonesia. In villages, this plant is easily found because of its utilization as a traditional medicine. In addition, this plant is easy to grow and develop even on marginal soils that are less fertile. The chemical content of this plant has been widely studied and has an effect on insect pest. The results of research in laboratories, fields, and agricultural product storage warehouses show that *J. curcas* plants, both direct use, extraction, and isolation of chemical compounds, generally have a control effect on insect pests in agriculture. However, studies to know the effectiveness of the field in real conditions need to be carried out to increase the information effect in the field. Likewise, the effect on non-target organisms such as pollinating insects and natural enemies needs to be increased.

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