Chapter

Soybean Cultivation Technology Innovation and Environmentally Friendly Pest Control in Paddy Fields in South Sulawesi, Indonesia

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Abstract

South Sulawesi is one of the centers for soybean development in Indonesia and farmers generally plant it on paddy fields. Soybean cultivation technology innovation in paddy fields in general, farmers use a cropping system without tillage, rice fields after planting rice are directly sprayed with herbicides 3 times and then planted with soybeans. The varieties that are favored and widely planted by farmers in South Sulawesi have large seeds (weighing 100 seeds around 15.0–19.5 g) such as Detap-1, Devon-2, Derap-1, Dega-1, and Dena-2. The spacing used by farmers is 20 × 40 cm with double rows and single-row models. Types of pests that mostly damage soybean plants in South Sulawesi include *Spodoptera litura*, pod borer *Etiella zinckenella*, whitefly *Bemisia tabaci*, aphid *Aphis glycines*, leaf-rolling caterpillar *Lamprosema indicata* Fabricius, caterpillar Helicoverpa *Heliothis armigera*, pod ladybug *Riptortus linearis* F. green *Nezara viridula* L., soybean beetle *Phaedonia inclusa* and grasshopper *Locust migratoria*. To control these pests, farmers combine the use of vegetable insecticides and chemical insecticides.

Keywords: soybean, paddy field, technology, cultivar, variety, pests control, farmer

1. Introduction

South Sulawesi is one of the soybean development centers with a land potential of around 586,492 ha. The average soybean production achieved in South Sulawesi ranges from 1.10 to 1.50 t/ha [1]. This production is still much lower than the potential that is often achieved from research results of 2.0–3.0 t/ha [2]. The low production was due, among other things, to high pest attacks and the use of fertilizers that had not been optimal.

In the cultivation of soybeans in paddy fields after rice, the timeliness of planting greatly determines the success of farming because of the limited time for land preparation. Soybean planting is immediately carried out 2–4 days after rice harvesting with a no-tillage system (zero tillage) because it is associated with soil moisture conditions, in addition to saving energy and production costs. To produce well, soybean crops need to be irrigated 3–4 times, water can come from irrigation networks and groundwater with a pumping system.

According to the Report of the Indonesian Horticultural and Food Crop Protection Agency [3], the area of attack by pod borers, pod suckers, and armyworms for 5 years ranging from 7182 ha. The main pest attack rate on soybeans in 2008 was around 15–35% [4]. Furthermore, the results of research by Fattah and Hamka [5], conducted in Panincong Village (soybean development center in South Sulawesi), the intensity of pod borer attacks (9.59–13.16%), the intensity of pod suckers (6.17–22.55%), and armyworm intensity (8.61–17.26%). Control efforts carried out by farmers generally use insecticides with high doses and a spraying frequency of 1–2 per week. The use of these chemical pesticides has impacts including (1) polluting the environment including pesticide residues, (2) poisoning humans and animals, (3) killing natural enemies and other useful organisms such as bees which are plant pollinators, (4) creating new pests strains that are resistant to pesticides, (5) causing pest resurgence or an increase in pest populations after excessive application of pesticides. To avoid the negative effects of the use of chemical pesticides, the main soybean pest control is directed to the use of bio-pesticides or insecticides.

Biopesticides or insecticides from plant materials are not something new but have been used by farmers for a long time, even at the same time as agriculture itself was born. Farmers in Indonesia are already using vegetable materials as pesticides, including using soursop leaves to control locust pests and rice stem borers. Meanwhile, farmers in India use neem seeds as an insecticide to control insect pests. In addition to vegetable materials which are widely used by farmers as vegetable insecticides, the use of biopesticides is also used, such as the use of NVP from armyworms.

This book is structured to provide information on environmentally friendly soybean cultivation technologies including the use of crop residues such as straw as organic fertilizers and also to provide information about the importance of using natural ingredients in pest control and the use of biopesticides in soybean farming systems carried out by farmers in South Sulawesi.

2. Technology of soybean cultivation at the farmer level

2.1 How to process land

Farmers in South Sulawesi generally plant soybeans in rainfed lowland areas with no-tillage systems. Planting soybeans after rice in rainfed lowlands with a no-tillage system (TOT) has several advantages such as; saving costs, energy, and time. Conversely, if the rainfed lowland paddy field is perfectly processed (OTS), it will be less profitable due to a delay in planting time, in addition to the land losing water because the soil surface is open. Other benefits obtained from soybean planting with a non-tillage system in paddy fields can break the pest cycle, use the remaining fertilizer that is still left in the soil, and make the remaining soybean plants green fertilizers [6].

Rice field preparation is crucial so that soybeans grow and produce well. There are two kinds of rice harvesting models, namely those that harvest rice manually (human labor) and those using a Combine Harvester. The two methods of harvesting cause differences in straw residue in paddy fields.

2.1.1 Land preparation in paddy fields whose solids are harvested manually, using human power

Planting soybeans in paddy fields harvested by paddy using a manual scythe, the rice stems are cut off at the base of the rice stems so that they do not separate the rice stalks that stand on the paddy fields making it easier to grow soybeans (**Figure 1a**). In a non-tillage system to kill grass in paddy fields, farmers use herbicides both contact and systemic. Contact herbicides that are widely used by farmers are herbicides with active ingredients of paraquat dichloride. This herbicide is a full-grown herbicide to control weeds in rainfed lowland fields, while a systemic herbicide that is widely used by farmers is an active ingredient of isopropyl amine glyphosate (Roundup Max 660 SL). Herbicide spraying was carried out on paddy fields.

Rice that has been harvested and straw stumps are cut about 20–30 cm from the ground which aims to prevent the growth of new shoots and facilitate the planting of soybeans. In addition, it also functions to block the seeds of pea fly pests from laying eggs on pieces of seeds so that the dead and attacked plants become reduced. Because soybeans are not resistant to drought and waterlogging, a drainage canal is needed before planting with a distance of 3–5 m and a depth of 20–30 cm. This channel beside flowing water so that it is not flooded also functions for irrigation if the plants experience drought, especially if irrigation water is available. The straw which is still present in paddy fields should be spread over the surface of the land (**Figure 1b**). The results of research in Indonesia show that soybean yields that are planted after paddy fields without tillage are better than those with perfectly cultivated soil because perfectly treated soils can cause evaporation so groundwater supplies are not sufficient for plant growth. In addition, perfect soil processing can cause delays in planting time so that the plants will experience drought in the stage of development and filling of seeds, especially in the dry season. Planting soybeans immediately after harvesting rice, at which time the rainfall has been reduced but still enough for soybean growth [6].

The harvesting system uses Combine Harvester to separate pieces of straw which are about 50–75 cm high so that when planted directly soybeans will be disrupted. In rice fields that are still high in the hay, farmers use two ways to prepare soybeans, namely, some farmers cut back the straw to the base of the stem and some farmers

Figure 1.
Rice field that has been cut with straw: (a) spraying herbicides, (b) making canals with a hoe, and (c) making canals using a hand tractor.

Figure 2.
Former rice plantations were then planted with soybeans: (a) straw stalks, (b) soybean plants mixed with rice stalks, and (c) soybean growth after the rice stalks were removed.

do not cut the straw again but immediately sprayed the herbicide 2–3 times until the straws die and dry like **Figure 2a**. The advantages of soybean plants that are planted between rice stalks are not attacked by peanut fly pests. This is probably caused by the imago of the bean fly being blocked by rice stems when they want to lay their eggs on soybean cotyledons. Another advantage of soybean plants planted between rice straws is straw stems that have been extracted and then immersed in the soil so that the soil becomes fertile and the soybean grows fertile as shown in **Figure 2b** and **c**.

The way farmers grow soybeans in paddy fields with this system can create an environmentally friendly organic farming system because all the remaining rice straw stems are immersed in organic fertilizer. This makes farmers not use chemical fertilizers in their farming systems, moreover, the land used for planting is still fertile because it contains a lot of fertilizer from residues during fertilization in the rice planting period.

Soybean cultivation techniques that are appropriate after paddy is without tillage (TOT), also known as "zero tillage". This technology is appropriately developed in anticipation of the limited workforce in South Sulawesi and at the same time utilizes the remaining availability of groundwater at the time of rice harvesting, especially in areas with simple irrigation or rainfed rice fields. Components of growth and seed yield in soybeans grown with a system without tillage are better than those with perfect tillage systems (**Table 1**). Components of growth such as plant height, number of branches, number of pods, and seed yields were significantly different between systems without tillage with tillage systems. Weaknesses in a perfect tillage system will result in a delay in planting time, so that in areas with a short period of rain it will cause plants to lack water, the plants will experience drought, and seed yield will decrease.

Parameter	Complete tillage	No tillage	t-Hitung
Plant height (cm)	79.80	86.30	*
Number of branches (branches)	3.30	4.00	*
Number of pods	205.00	235.00	*
Weight of 100 seeds (g)	28.80	29.10	Ns
Seed yield (t/ha)	1.90	2.40	*

Explanation = significant at 5% level.
Ns = no significant at 5% level.
Source: Idaryani and Yusmasari [7].

Table 1.
Growth and yield of soybean seeds in the complete tillage and zero tillage systems in South Sulawesi. Indonesia. 2015.

2.1.2 Land preparation using perfect tillage carried out by farmers

The process of harvesting rice in paddy fields using combine generally compacts the soil, making it difficult to plant soybeans using the zero tillage method. To fertilize their land, some farmers use tractors. The use of 4-wheel tractors for tillage is only carried out by farmers who have a lot of farming costs. This is because the cost of cultivating the land using a 4-wheel tractor costs Rp. 1,350,000 per hectare. Meanwhile, planting soybeans using the zero tillage method only costs around IDR 450,000–600,000 per hectare.

2.2 How farmers plant soybeans in paddy fields

The remaining straw in paddy fields is spread over the soil surface (**Figure 3b**). This method can inhibit the growth of weeds and reduce the evaporation of groundwater and prevent the attack of fly pests on peanut seeds (**Figure 4**).

2.3 Ways for farmers to control weeds and soil loosening of soybean plants

The way farmers control weeds in soybean cultivation generally uses traditional tools such as hoe. Farmers do not use herbicides in controlling weeds in soybean plantations because they can cause soybean death or leaf. In controlling weeds in soybean cultivation in paddy fields, farmers usually also loosen the soil. Weeds that have been honed are collected and then processed into organic fertilizer (fermentation). The fermented weeds after they become weathered are used for organic fertilizer on soybean plantations (**Figure 5**).

Figure 3.
How to cultivate the land using a tractor (a) and cultivated land (b) in paddy fields where the rice is harvested using a combine.

Figure 4.
How farmers plant soybeans on uncultivated land (a), how farmers grow soybeans on cultivated land (b), and how farmers grow soybeans using soybean planting tools (c), and Soybean planting tool (d).

(a) (b) (c)

Figure 5.
The way farmers control weeds manually and the application of organic fertilizers on soybeans (a), growth of soybeans that had been given organic straw fertilizer at the age of 25 days after planting (b), and growth of soybeans that had been given organic straw fertilizer at the age of 35 days after planting (c).

2.4 Application of organic fertilizer

2.4.1 Application of organic fertilizer from straw fermentation

Composting straw increases the levels of macro and micronutrients, especially Phosphorus (P2O5) and Potassium (K2O), as well as Magnesium (Mg) and Potassium (K) (**Table 1**). The main nutrient elements that need to be added to fertilizing cocoa plants include Nitrogen, Phosphorus, Potassium, and Magnesium [8] (**Figure 6**).

The results of soil analysis after immersion of rice straw into the soil and fertilization showed an increase in the percentage of clay mass in the soil. After most of the material has decomposed in the composting process, the temperature will gradually decrease, and at this time advanced compost maturation occurs, namely the formation of a humus clay complex [9].

2.4.2 Application of liquid organic fertilizer from cow urine (Biourin)

This ceremony uses the means of plant destruction as a vegetable pesticide. However, this is forgotten by subak member farmers in Bali [10]. Biourine is a liquid organic fertilizer derived from the urine of fermented livestock. Fermentation technology is used in processing cow urine into bio urine. This process can cause changes in the properties of materials into simpler molecules so that they are easily absorbed by plants. Based on research conducted by Sutari [11], there was an increase

(a) (b)

Figure 6.
How farmers make fermented straw for organic fertilizer (a) and how farmers apply organic fertilizer from fermented straw (b).

(a) (b) (c)

Figure 7.
Liquid organic fertilizer from cow urine (Biourine) (a), liquid organic fertilizer application on soybean (b), and growth of soybeans that have been given biourine liquid fertilizer (c).

in macronutrient content, micronutrients, and pH in the urine of cattle that had been fermented into bio urine. Cow bio urine can improve plant growth because, cow urine contains elements of N (0.36%), P2O5 (5.589 mg/l), K2O (975.0 mg/l), Ca (25.5 mg/l). and C-organic (0.706%) [12]. Besides that, cow bio urine can improve the physical properties of the soil because beef bio urine is fermented using Azotobacter and Bacillus sp. Biourine contains the hormone Indo Acetate Acid (IAA) of 1197.6 mg/l, while the urine of fresh cattle containing IAA is only 704.26 mg/l. IAA hormone functions as the main auxin in plants [11].

MOL (local micro-organisms) can function as decomposers and also as liquid organic fertilizer. According to Septiana et al. [13], plant residues such as kale, spinach, mustard greens, cabbage, and bamboo shoots can be made into liquid organic fertilizer by adding a biocatalyst. The addition of 60 ml of the biocatalyst is very good for increasing the phosphorus content to 79.26 ppm in the manufacture of liquid organic fertilizer from mustard greens and spinach waste. Baharuddin [14], agricultural waste such as municipal waste, straw, corn waste, sugarcane waste, and livestock manure can be processed using biotechnology to produce liquid organic fertilizer/MOL and biopesticides. The results of research by Suhera et al. [15], microbes as a type of MOL are quite effective for increasing the weathering process in plant residues. Giving Microbat 20% can inhibit *Phytophthora palmivora* by about 50%. Furthermore, it was said that giving Microbat 10% could accelerate weathering (92%) compared to using EM-4 10% (75%). Giving 10 cc/l of Microbat water can increase potato production 30–45% (**Figure 7**).

According to Widhiastuti et al. [16], some other agricultural wastes are good enough to make liquid organic fertilizers such as palm oil mill waste as soil biodiversity fertilizer. The waste can function as organic fertilizer by increasing the physical, chemical, and biodiversity properties of the soil, and increasing the total soil bacteria.

2.5 Types of caterpillars found in soybean planting and how to control them at the farmer level

2.5.1 Spodoptera litura armyworm pest

The pests that attack soybeans in the districts of Maros, Pangkep, Wajo, and Soppeng are armyworms with varying intensities. The intensity of each variety is different. The highest attack intensity of armyworm attacks was found in Detam-2 (16.24%) and Gema (16.29%) varieties in Wajo District and the lowest in Grobogan (10.38%) and Argomulyo (11.25%) varieties, while in The highest attack rate of

(a) (b) (c) (d)

Figure 8.
Armyworm larvae (Spodoptera litura on soybeans) (a) and S.litura pests and symptoms of damage to soybean leaves (b).

armyworm pests in Maros was the Burangrang variety (15.26%) and the lowest was the Grobogan variety (9.87%) (**Figure 8**) [17].

Spodoptera litura is an important pest that damages soybean leaves compared to other leaf-damaging pests [18]. Yield losses due to *Spodoptera litura* pest attacks can reach 80%, even puso if not controlled [19]. The rate of yield loss depends on the variety used, the growth phase, and the time of attack [18]. *Spodoptera litura* is known as a polyphagous pest and migratory insect which causes serious damage to soybean crops (**Table 2**) [20].

2.6 How to control soybean pests at the farmer

2.6.1 Use of botanical insecticides

Botanical pesticides are pesticides that are produced from plant parts. Several types of plants can be used as vegetable pesticides: Srikaya seeds (annonacin) which are stomach poison and contact to control aphids, jicama (pchyrrhizid) to control (*Plutella zinckenella*), tuba roots (Derris), *Lantana cedar* (salira), *Fragrant Lemongrass* (Andopogon), Patchouli (*Pogostemon cabilin*), Clove (*Euginia sygium*),

Variety	The intensity of S.litura attack on soybean leaves (%)				Seed yield(t/ha)
	Wajo regency	Maros regency	Pangkep regency	Soppeng regency	
Anjasmoro	14.36	11.24	12.30	10.94	2.71
Detam-2	16.24	12.32	17.01	15.54	2.21
Detam-1	13.24	12.11	16.20	12.53	1.90
Kaba	17.36	11.37	15.43	13.50	1.97
Gepak Kuning	13.29	10.39	10.40	12.30	2.00
Grobogan	10.38	9.87	12.32	8.83	2.10
Argomulyo	11.25	11.95	13.84	10.36	2.10
Gema	16.29	11.32	14.49	14.10	2.18
Burangrang	14.36	15.26	13.85	12.12	2.08

Source: Abdul Fattah et al. [21].

Table 2.
Average intensity of soybean leaf damage due to S.litura pest attack.

Neem (*Azadirachta indica*), tobacco leaves and pork nuts (Kphrosia candida). Of all these vegetable ingredients, pork and neem nuts have the highest ability and are almost comparable to carbaryl insecticides in controlling weevil pests [22].

Neem extract should be sprayed at an early stage of insect development, sprayed on the leaves, and sprinkled on the roots so that it can be absorbed by plants and control insects in the soil [23]. Furthermore, it was said that 50 g of neem seed extract was dissolved in 1 liter of water and added 0.5 ml/l grading agent effectively suppressed mite populations on sweet potatoes with a mortality of 70%. neem 50 g/l water can reduce yield loss of *Maruca testulalis* by 13–45%. The results of research by Sukorini [24], the application of vegetable pesticides from amethyst leaves gives the lowest attack intensity (0.53–0.89%) and the highest on butrowali plants (1.02–1.94%) in cabbage plants clove leaves contain eugenol between 70 and 95% which can kill microorganisms such as *Bacillus subtillis*, *Staphylococcus aureus*, and *Escherichia coli*. In addition, eugenol can also kill or suppress the development of plant pathogens such as *Fusarium oxyspora, Phytopthora capsici, Rhizoctonia solani*, and *Sclerotium rolfii* [25].

Based on their origin, biopesticides are divided into two: Botanical pesticides, which are extracts from certain parts of plants, including leaves, fruit, seeds, and roots, which have toxic properties against certain pests and diseases. Botanical pesticides are generally used to control pests (insecticides) and diseases (bactericidal or fungicide). Several types of plants are capable of controlling pests such as the Meliaceae family (Neem) and the Anonaeceae family (Srikaya seeds and Soursop seeds). The results Indiati, S.W. dan Marwoto [26] that the use of castor seed extract (*Ricinus communis*) as a vegetable antifertility ingredient in field rats with 2 ml/100 g of rat body weight/day given for 5 days, causes infertility in female field rats and has the effect of reducing 64.2–90.70% active sperm temperature in male rats compared to controls. The results of Balitsa Lembang research [27], several types of plants that can be used as vegetable pesticides: sugar apple seeds (annonain) which are stomach and contact poisons for controlling aphis, yam seeds (pchyrrhizid) for controlling (*P. zinckenella*), tuba roots (Derris), *Cypress lantana* (salira), *Fragrant citronella* (Andopogon), patchouli (*Pogostemon cabilin*), cloves (*Euginia sygium*), neem (*Azadirachta indica*), tobacco leaves and pork nuts (*Kphrosia candida*). Of all these vegetable ingredients, pig beans and neem have the highest ability and are almost comparable to carbaryl insecticides in controlling weevils [27].

According to Thamrin et al. [28], extract from the bark of kapayang (*Pangium edule*) can kill the puith stem borer (*Scipopaga innotata*) around 80% after application, while controls using synthetic insecticides (BPMC) have a mortality of around 100%. Furthermore, it is said that rose, papaya, jengkol, lemongrass, noni, pepper, and gadung plants can kill caterpillars (*Plutella xylostella*) around 65–100%. The use of kedondong leaf extract can kill Plusia sp. larvae around 26.7% at 36 hours after infestation (jsi), 66.7% at 48 hrs, and 77.0% at 72 hrs, while the control (chlorpyrifos (control) kills 83, 3% at 36 jsi, 100% at 48 isi. Similarly, Luwa leaf extract (*Ficus glomerata*) can kill plutella caterpillar plants (*Plutella sp*) by about 70%, parang red beans, green severe beans, and soursop are quite effective in killing pariah fruit caterpillars by about 75–80%. Betel leaf contains saponins, flavonoids, and polyphenols, while galangal rhizome contains benzyl benzoate, −methoxycinamal and xanthorhizal which can be used to control neck disease in rice (*Pyricularia oryzae*), and leaf spot disease in peanuts.

Neem (*Azadirachta indica*) contains the active compounds azadirachtin, meliantriol, and salanin. It is in the form of powder from leaves or liquid oil from seeds/fruit. Effectively prevents eating (antifeedant) for insects and prevents insects from approaching plants (repellent) and is systemic. Neem can make insects sterile because it can interfere with hormone production and insect growth. Neem has a spectrum effective for controlling soft-bodied insects (200 species), including grasshoppers, thrips, caterpillars, white butterflies, etc. Besides that, it can also be used to control fungi (fungicides) at a preventive stage, causing fungal spores to fail to germinate. Controlled fungi include powdery mildew, rot, leaf smallpox/scab, leaf rust, and leaf spot. And prevent bacteria in powdery mildew (powdery mildew). Neem extract should be sprayed at an early stage of insect development, sprayed on the leaves, and sprinkled on the roots so that it can be absorbed by plants and control insects in the soil.

Tuba root (*Deris eliptica*) is a compound that has been found, including rotenon. Rotenone can be extracted using ether/acetone to produce 2–4% rotenone resin, made into water concentrate. Rotenon works as a very strong cell poison (insecticide) and as an antifeedant that causes insects to stop eating. Insect death occurs several hours to several days after rotenone exposure. Rotenone can be mixed with pyrethrin/sulfur. Rotenone is a broad-spectrum (non-systemic) contact poison and a stomach poison. Rotenone can be used as a molluscicide (for mollusks), insecticide (for insects), and acaricide (for mites).

Rotenone can be used as a molluscicide (for mollusks), insecticide (for insects), and acaricide (for mites).

The compound tobacco contains is nicotine. It turns out that nicotine is not only toxic to humans but can also be used to poison insects. Dry tobacco leaves contain 2–8% nicotine. Nicotine is a fast-acting nerve poison. Nicotine acts as a contact poison for insects such as caterpillars that destroy leaves, aphids, triphs, and control fungi (fungicides).

In addition to being able to kill plant-disturbing insects, vegetable insecticides can also function as (1) Reference, which repels the presence of insects mainly due to their smell or the substances they contain, (2) Antifidants, causing insects to dislike plants, for example, because they taste bad, (3) Preventing insects from laying eggs and inhibiting the process of hatching eggs, (4) Poisons that can interfere with the nervous system and insect hormones, and (5) Attractants, as attractants for the presence of insects that can be used as a trap plant. Natural ingredients that contain bioactive compounds can be classified into three, namely (1) natural ingredients containing anti-phytopathogenic compounds (agricultural antibiotics), (2) natural ingredients containing compounds that are phytotoxins and plant growth regulators (phytotoxins, plant hormones, and the like) and natural ingredients containing compounds that are active against insects (insect hormones, pheromones, anti-oxidants, repellents, attractants, and insecticides that poison plants) (**Figure 9**).

(a) (b) (c) (d) (e)

Figure 9.
The process of making vegetable insecticides by farmers (a-c) and the extract results for vegetable insecticides (d).

2.6.2 Use of pathogens

SlNPV propagation was carried out by taking several armyworms instars 4 and 5 which died naturally due to virus infection in soybean plantations with the characteristics of the caterpillars being elongated/expanding, not shrinking when massaged emitting a foul-smelling liquid, and sometimes hanging on the lower surface of the leaves.. The armyworm then made an emulsion using sterile aqua dest. The armyworm NPV emulsion was then diluted with sterile aqua dest and rubbed on the surface of the mulberry leaves. The caterpillars were kept until they died. After death, the armyworms were collected, extracted, mixed with distilled water, and then filtered using nylon gauze to obtain a pure coarse polyhedra suspension. According to Bedjo [29], the use of SLNPV (*Spodoptera liture* Nuclear Polyhedrosis Virus) 150–200 g/ha can kill around 80–100% of the *S liture* armyworm. S LNPV multiplies in its host's cells, so the transmission is through food. Symptoms of SLNPV transmission in armyworms appear 1–3 days after application. Instar-1 caterpillars infected with SLNPV will look milky white. Symptoms in instar caterpillars 3 and 4 will appear brownish white on the abdomen (abdomen), while on the back it is blackish milk brown. If the 5th and 6th instar caterpillars are infected with SLNPV, then at the pupal stage they will rot. In caterpillars that are infected with the SLNPV virus, their feeding activity is reduced, movement is slow, and the body swells due to the replication or multiplication of SLNPV virus particles. The caterpillar's integument usually becomes soft and brittle and easily torn. If the body of the caterpillar is broken, it will emit a very pungent odor. The death of caterpillars infected with this virus in the field is characterized by symptoms of the bodies of the larvae hanging or clinging to leaves or twigs of plants. Armyworm death usually occurs 3–7 days after contracting the virus. Furthermore, Sanjaya et al. [30], stated that a dose of 438 PIB/ml SINPV is sufficient. Effective for killing Instar-5 larvae in armyworms.

Biological pesticides are formulations that contain certain microbes in the form of bacteria, fungi, or viruses that are antagonistic to other microbes (causing plant diseases) or produce certain compounds that are toxic to both insects and nematodes. Some examples of biological insecticides include: (1) Nuclear polyhedrosis virus (NPV), (2) *Beuveria bassiana* (sunflower isolate) which is capable of controlling noncong beetles, the main pest of orchids and ticks on chrysanthemum plants, (3) Bio-PF contains Pf to control wilt, (4) Bio-GL contains (Gliodadium spp) to control soil-borne diseases, and (5) Prima—BAPF contains Bacillus spp. to control root swelling, wilt disease and root rot [31]. To distinguish between armyworms that die due to virus infection and pesticide poisoning in the field, it can be seen the characteristics and differences that arise, namely the death of caterpillars affected by the virus, they tend to elongate or not shrink, whereas if they die from pesticides, they tend to shrink. Larvae that die from the virus, when they are massaged or pricked, tear easily and secrete mucus like pus which smells bad, while caterpillars that are exposed to pesticides do not smell bad [32].

The results of laboratory experiments show that NPV has a high biotic potential, indicated by its level of pathogenicity which is expressed by the LC50 value (the concentration that kills 50% of the population). The LC50SlNPV for the armyworm was 5.4 × 103 polyhedra inclusion bodies (PIBs)/ml [33], while for the pod-eating caterpillar, it was 6 × 103 PIBs/ml [34]. The NPV infection process begins with the ingestion of the polyhedra by the caterpillar with the feed. In the digestive tract, which is alkaline (pH 9.0–10.5), the polyhedra coat dissolves,

Figure 10.
Ulat yang terinfeksi virus NPV (a), making process and biological insecticides and their application at the farm level (b).

freeing the virions. Virions penetrate the wall of the digestive tract to enter the body cavity, then infect susceptible cells. Virion replication occurs in the cell nucleus. Within 1–2 days after the polyhedra are ingested, the hemolymph which was originally clear turns cloudy. The caterpillar looks greasy, accompanied by swollen integumentary membranes and changes in body color to pale-reddish, especially on the stomach. Its ability to eat decreases, so its growth is slow. The caterpillar tends to crawl to the top of the plant and then dies hanging upside down with the pseudo limbs at the end of the plant. The integument of the dead caterpillar undergoes lysis and disintegration, making it very fragile. Polyhedra. Young caterpillars (instars l-lll) die within 2 days, while old caterpillars (instars IV-VI) in 4–9 days after the polyhedra are ingested [35].

Considering that it is susceptible to sun exposure, especially ultra-violet rays, and the behavior of caterpillars that are active in the evening and at night [36].

The Nuclear Polyhedrosis Virus (NPV) bioinsecticide is one type of pathogenic virus that has the potential as a biological agent in controlling armyworms because it is specific, selective, effective for pests that are resistant to insecticides, and safe for the environment. NPV has been developed in vivo in the Balitkabi laboratory, for biological control of Lepidoptera pests. As a bioinsecticide, the virus can control target insect pests precisely because it is specific, has a fairly high killing ability, is relatively inexpensive, and does not pollute the environment. The results of NPV engineering with carrier materials can maintain NPV virulence so that it can suppress armyworm populations on soybean plants in the field by up to 90% [29] (**Figure 10**).

To distinguish between armyworms that die due to virus infection and pesticide poisoning in the field, it can be seen the characteristics and differences that arise, namely the death of caterpillars affected by the virus, they tend to elongate or not shrink, whereas if they die from pesticides, they tend to shrink. Larvae that die from the virus, when they are massaged or pricked, tear easily and secrete mucus like pus which smells really bad, while caterpillars that are exposed to pesticides do not smell bad [32]. NPV application should be done in the afternoon or evening under favorable weather conditions, considering that it is susceptible to sun exposure, especially ultra-violet rays, and the behavior of caterpillars that are active in the evening and at night [36]. The results of other studies regarding the use of NPV to control armyworms in rice can cause 53% mortality at 3 days after inoculation and 95% at 9 days after inoculation [37].

3. Types of soybean varieties in Indonesia according to the description of new superior varieties of soybeans in Indonesia

Several high-yielding soybean varieties that have been produced by researchers in Indonesia are according to the Description of Soybean Varieties [38].

3.1 Derap-1

Growth type: Determine Flowering age: ± 34 days Ripening age: ± 76 days Hypocotyl color: Purple Epicotyl color: Green Leaf color: Green Flower Color: Purple Hair color: White Pod skin color: Yellow Seed coat color: Yellow Cotyledon color: White Hilum color: Light brown Leaf shape: Round Leaf size: Medium Branching: 2–4 branches/plant number of pods per plant: ±45 podsPlant height: ±59 mourning: Moderate lodging resistantPod break: Slightly resistant to splitting pods Seed size: Large100 seed weight: ±17.62 gramSeed shape: RoundBrightness of seed coat: ShinyYield potential: 3.16 tons/ha of dry beans (at 12% KA) Average yield: ±2.82 tons/ha of dry beans (at 12% KA) Protein content: ±39.17% BKFat content: ±18.10% BKPest resistance: and disease (*Phakopsora pachirhyzi* Syd), sensitive to SMV virus disease, resistant to pod sucking pest (*Riptortus linearis*), resistant to pod borer (*Etiella zinckenella*), and moderately resistant to armyworm (*Spodoptera litura* F.) Breeder: Ayda Kri snawati, M. Muchlish Adie, Apri Sulistyo Researchers: Marida Santi Yudha Ika Bayu, Kurnia Paramita Sari, Erliana Ginting, Joko Susilo Utomo, Eriyanto Yusnawan Technician: Arifin Proposer: Research Institute for Various Beans and Tubers.

3.2 Detap-1

Growth type: Determine Flowering age: ± 35 days Ripe age: ± 78 days Hypocotyl color: Purple Epicotyl color: Green Leaf color: Green Flower Color: Purple Feather color: White Pod skin color: Yellow Seed skin color: Yellow Cotyledon color: White Hilum color: Yellow Leaf shape: Slightly round Leaf size: Medium Branching: 3–6 branches/plant Number of pods per plant: ±51 pods Plant height: ±68.70 cm Bedding: Slightly resistant to lodging Split pods: Resistant to the splitting of pods Seed size: Large 100 seed weight: ±15.37 great shape: Round Yield potential: 3.58 ton/ha Average yield: ±2.70 ton/ha Protein content: ±40.11% PCFat content: ±16.16% PCPest resistance: Resistant to leaf rust disease, sensitive to SMV virus disease, resistant to pod-sucking pests, moderately resistant to pod borers, and sensitive to armyworm pest Breeders: M. Muchlish Adie, Ayda Krisnawati, Gatut Wahyu AS. Researchers: Erliana Ginting, Eryanto Yusnawan, Marida Santi YIB, Kurnia Paramita Sari, Didik Hanowo Technician: Arifin Proposer: Research Institute for Various Nuts and Tubers, Agency for Agricultural Research and Development.

3.3 Deja-1

Growth type: Determinite Flowering age: ±39 days Ripe age: ± 79 days Hypocotyl color: Purple Epicotyl color: Purple Leaf color: Green Flower color: Purple Fur color: Brown Pod skin color: Dark brown Seed coat color: Yellow Cotyledon color: Yellow Hilum color: Light brown Leaf shape: Oval Leaf size: Medium Branching: 3 branch/plant Number of pods per plant: ±36 pods Plant height: ±52.7 cm Creeping: lodging resistant Split pods: Not easily broken Seed size: Medium 100 seed weight: ±12.9 gram Seed shape: Oval Yield potential: 2.87 tons/ha Average yield: ±2 .39 ton/ha Protein content: ±39.6% PCFat content: ±17.3% PCPest resistance: Moderately resistant to armyworm pests, resistant to pod borers, resistant to pod suckers and moderately resistant to leaf rust disease.Remarks: Very tolerant to water stress from 14 days to maturity. Breeders: Purwantoro, Suhartina, Gatut Wahyu A.S., Novita Nugrahaeni and Titik Sundari. Researchers: Abdullah Taufiq, Suh arsono, A. Ghozi Manshuri, Eriyanto Yusnawan, and Kurnia Paramita. Proposers: Research Institute for Various Nuts and Tubers, Agency for Agricultural Research and Development.

3.4 Deja-2

Growth type: Determine Flowering age: ± 37 days Ripe age: ± 80 days Hypocotyl color: Purple Epicotyl color: Purple Leaf color: Green Flower Color: Purple Fur color: Brown Pod skin color: Light Brown Seed coat color: Yellow Cotyledon color: Yellow Hilum color: Brown Leaf shape: Oval Leaf size: Medium Branching: 3 branches/ plant Number of pods per plant: ± 38 pods Plant height: ± 52.3 cm Mortality: lodging resistant Split pods: Pods do not break easily Seed size: Large 100 seed weight: ± 14.8 gram Seed shape: Oval Yield potential: 2.75 ton/ha Average—average yield: ±2.38 ton/ha Protein content: ±37.9% PCFat content: ±17.2% PCPest resistance: Susceptible to armyworm pest, moderately resistant to pod borer, moderately resistant to pod sucker, and slightly resistant to leaf rust disease. Description: Tolerant of water saturation stress from 14 days old until the cooking phase. Breeders: Suhartina, Purwantoro, Gatut Wahyu AS, Novita Nugrahaeni and Titik Sundari. Researcher: Abdullah T aufiq, Suharsono, A. Ghozi Manshuri, Eriyanto Yusnawan, and Kurnia Paramita. Proposers: Agency for Agricultural Research and Development (**Figure 11**).

3.5 Gamasugeng-2

This variety has a determinate growth type, which means that the plant is upright and flowers in unison. Some varieties have an indeterminate growing type, meaning that the plant spreads and the flowers appear gradually. While the semi-determinate type of growth is a plant that has an upright growth type the flowering is not simultaneous or the flowers appear gradually.

The Gamasugeng-2 variety has a flowering age of about 30 days and a ripening age of about 68 days. Hypocotyl purple, epicotyl green, flowers purple, fur brownish white, pod skin brown, seeds yellow, cotyledons green, plant height about 45 cm, number of branches 4–5 stems per plant, yield potential 2.6 t/ha, average seed yield 2.4 t/ha, medium seed size (11.5 g seed weight), 37.4% protein content and 13.2% fat content.

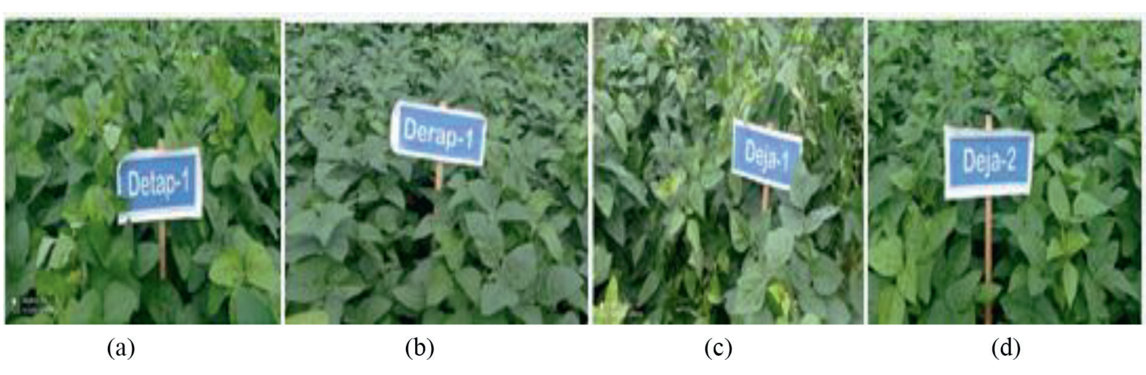

Figure 11.
Appearance of several Indonesian soybean varieties.

Gamasugeng-2 variety, resistant to lodging, and resistant to leaf rust disease (*Phakospscora pachithyzi* Syd), resistant to brown leaf spot/blight (Cercospora), resistant to shoot borer (*Malanagromyza sojae*).

3.6 Gamasugeng-1

The Gamasugeng-1 variety is almost the same as the Gamasugeng-2 variety which were both released in 2013. and is the result of radiation of the Tidar variety at a dose of 200 gray. Determinate growth type with a flowering age of 30 days and maturity of 66 days. The hypocotyl is purple, the epicotyl is green, the flower is purple, the pod skin is brownish white, the seed coat is bright yellow, the cotyledons are green, and the helium is green. The number of branches is 4–5 branches per plant, the number of pods per plant is 52 pods, the plant height is 45 cm, it is resistant to lodging, and the seeds contain 37.6 and 13.2% fat content.

Gamasugeng-1 variety has medium seed size (11.5 g in 100 seed weight), 2.60 t/ha seed yield potential, round seeds, resistant to leaf rust disease (*Phakospscora pachithyzi* Syd), resistant to brown leaf spot/blight (Cercospora), resistant to shoot borer (*Malanagromyza sojae*).

3.7 Detam 4 prida

Determinate growth type, flowering age 36 days, harvest age 76 days, hypocotyl purple color, epicotyl green color, flower purple color, fur color brown, pod skin color brown, seed skin color black, cotyledon color white, helium color white, leaf shape oval (triangular), oval seed shape, plant height 53.2 cm, number of pods per plant 55 pods, moderately tolerant to lodging and moderately tolerant to breaking of pods.

This variety has a medium seed size (11.0 g in 100 seeds), a potential seed yield of 2.90 t, an average seed yield of 2.50 t, the seeds have a protein content of 40.3%, and a fat content of 19.2%.. Moderately resistant to pod-sucking pests, moderately resistant to rust, early maturing and drought tolerant.

3.8 Detam 3 prida

The Detam 3 Prida variety was released in 2013 which was the result of cross-selection between the W9837 and Cikuray lines. Determinate growth type, flowering age 34 days, ripening age 75 days, hypocotyl purple color, epicotyl green color, flower purple color, fur color brown, pod skin color brown, seed skin color black, cotyledon color white, leaf shape oval (triangular), plant height 56.9 cm, somewhat tolerant of lodging, moderately tolerant of pod splitting, oval seed shape and number of pods per plant 51 pods. The potential seed yield per hectare is 3.20 t, while the average seed yield per hectare is 2.90 t, has a medium seed size (100 seeds weigh 11.8 g), the seeds have a protein content of 36.4% and a fat content of 16.7%. This variety is sensitive to pod-sucking pests, sensitive to rust.

3.9 Dering-1

The variety was released in 2012 and is a single cross-product of the Davros x MLG 2984 superior variety. It has a determinate growth type. Flowering age 35 days after planting and harvest age 81 days after planting. Plant height 57 cm, brown fur color, oval leaf shape, purple hypocotyl color, purple epicuticle color, purple flower color, brown pod skin color, yellow seed skin color, helium seed color, dark cotyledon color, resistance to fall, number of branches 3–6 Batang per plant. Having a medium seed size (weight of 100 seeds 10.7 g), the potential yield of seeds is 2.80 t/ha, the average yield of seeds is 2.0 t/ha, and the seeds have a protein content of 34.2% and fat content of 17.1%.

These varieties are resistant to pod borer (*Etiella zinckenella*) and susceptible to armyworm (*Spodoptera litura*), resistant to leaf rust disease (*Phakospscora pachithyzi* Syd), and tolerant of dryness during the reproductive phase.

3.10 Gema

The Gema variety was released in 2011 which was the result of the crossing of Shirome's introduction with the Wilis variety. According to type, varieties have determinate growth types with light brown feathers, purple cotyledon colors, purple hypocotyl colors, green epicuticle colors, and white cotyledon colors. This echo variety has a plant height of 55 cm, a medium size (weighs 100 seeds 11.90 g), a flowering age of 35 days, harvests 73 days, a yield potential of 3.06 t/ha, and an average yield of 2.47 seeds t/ha. Brown pod color, purple flower color, round seed shape, light yellow seed skin color, and brown helium color. The seeds have a protein content of 39.07% and fat content of 19.11%.

The echo variety is sensitive to leaf viruses (CMMV) and moderate rust. Besides that, the variety is also rather sensitive to pod-sucking pests, rather resistant to pod borer, and moderate to armyworm pests.

3.11 Varietas gepak kuning

The variety was released in 2008 which is a selection of local varieties of Gepak Kuning. Determinant growth type, purple hypocotyl color, green epicuticle color, purple flower color, greenish young yellow seed color, old brown pod color, brown stem fur color, tagak branching, and oval leaf shape. Plant height of 55 cm, age of flowering 28 days, age of cooking 73 days, have small seed size (weight of 100 seeds 8.25 g), potential yield of 2.86 t/ha, and the average yield of seeds 2.22 t/ha. In this variety, the seeds have a protein content of 35.38% and fat content of 15.10%.

Gepak Kuning varieties are rather resistant to armyworms, Aphis sp., and leaf scavengers of Phaedonia sp. Adapt well to paddy fields and tegal land both in the rainy season and in the dry season.

3.12 Varietas grobogan

The Grobogan variety was released in 2008 which is a local population purification of Malabar Grobogan. It has a determinate growth type, purple hypocotyl color, purple epicuticle color, brown bark color, purple flower color, brown old pod color, lanceolate leaf shape, and helium brown cocoa color. Plant height 50–60 cm, flowering age 30–32 days, age of cooked pods 76 days, have large seed size (weight of 100 seeds, 18 g), seed yield potential of 3.40 t/ha, and an average yield of seeds 2, 77 t/ha. The seeds have a fat content of 18.4% and a protein content of 43.9%. Adapts well to several different growing environmental conditions. Having pods is not easily broken, and at harvest, the leaves are shed 95–100%.

3.13 Varietas Detam-2

The variety was released in 2008 which was a selection of intra-line crossings introduced 9837 with Wilis. Determinant type of growth, purple hypocotyl color, green epicuticle color, purple flower color, dark brown pod color, purple stem hair color, black seed skin color, helium cocoa color, oval leaf shape, oval shape, and brightness of dull seed skin. Age of flowering is 34 days, cooking age of pods 82 days, plant height is 57 cm, medium size (weight 100 seeds 13.54 g), potential yield of 2.96 t/ha, and yield of seeds 2.46 t/ha. The seeds have a protein content of 45.56% and fat content of 14.83%. The nature of resistance to pests, rather resistant to pod suckers, this variety is sensitive to armyworms. Other properties are rather resistant to drought.

3.14 Varietas Detam-1

Detam-1 variety was released in 2008, which was the result of the selection of crossing lines introduced in 9817 with Kawi. This variety has a determinant growing type, purple hypocotyl color, green epicuticle color, purple flower color, light brown stems, old pods of dark brown skin, black seed skin color, yellow cotyledon color, slightly round leaf shape, skin brightness shiny seeds.

This variety also has a plant height of 58 cm, a flowering age of 35 days, a ripe pod age of 84 days, a large seed size (weight of 100 seeds 14.84 g), a yield potential of 3.45 t/ha, and an average yield of 2 seeds, 51 t/ha, the seeds have a protein content of 45.36% and fat content of 33.06%. The nature of resistance to pests is sensitive to armyworms and somewhat resistant to pod suckers and other properties rather sensitive to drought.

3.15 Varietas anjasmoro

Anjasmoro variety was released in 2001 which was the result of mass selection from the population of the full-fledged Mansusia line. It has purple hypocotyl color, purple epicuticle color, white stem hair color, purple flower color, yellow seed skin color, light brown pod color, and helium color of brownish lining seeds.

This variety also has oval leaves, wide leaf size, determine the growing type, flowering age 35–39 days, aged pod pods 82–92 days, plant height 64–68 cm, number of branches 2–5 branches, has a large seed size (weight of 100 seeds 14.8–15.3 g). The seeds have a protein content of 41.8–42.1%, a content is 17.2–18.6%, and does not hold down. Anjasmoro varieties are moderate to leaf rust, and pods are not easily broken.

3.16 Varietas mahameru

This variety was released in 2001 which was the result of the mass selection of a population of pure Mansuria strains. It has purple hypocotyl color, purple epicuticle color, white stem hair color, purple color, yellow seed skin color, brown pod color, brownish yellow helium color, oval leaf shape, wide leaf size, and determine growth type. Flowering age 36–39 days, and the age of pod pods 83–94 days.

The Mahameru variety has a plant height of 62–64 cm, branches of 2–5 branches, several books 12–15 books, size of seeds (large seeds) with a weight of 100 seeds 16.5–17.0, pods are not easily broken, and resistant fall down The seeds have a protein content of 42.9–44.3%, and fat content of 17.3–18.2%. Another characteristic of this variety is that it is moderate to leaf rust.

3.17 Kaba

This variety was released in 2001 which was the result of a double crossing of 16 elders. It has purple hypocotyl, green epicotyls, yellow cotyledons, brown stems, purple flowers, yellow seed coat, brown pods, brown helium seeds, and oval-shaped seeds..

The Kaba variety has a determinant growing type, a plant height of 66 cm, a flowering age of 35 days, ages of mature pods of 88 days, medium-sized seeds (weight of 100 seeds 10.37 g), seed yields of 2.13 t per ha, have 44.0, 8.0% fat content, resistant to fall, rather resistant to leaf rust disease, has pods that are not easily broken and adaptive to paddy fields.

3.18 Burangrang

This variety released in 1999 originating from natural cross aggregates, taken from farmers' plants in Jember, is the result of pure line selection, three generations of segregation. Burangrang varieties have purple hypocotyls, yellowish brown feathers, purple flowers, yellow seeds, bright helium seeds, oblong-shaped leaves, and pointed edges.

Burangrang variety has determined growing type, the number of branches of 1–2 branches, age of 35 days of flowering, age of pods aged 80–82 days, plant height of 60–70 cm, large size seeds (weight of 100 seeds 16 g), seed yields ranging from 1.6–2.5 t/ha, has a 39% protein content, 20% fat content, not easy to fall, tolerant of leaf rust disease. This variety is suitable for raw materials for soy milk, tempeh, and tofu.

3.19 Argomulyo

This variety was released in 1998 from the introduction of Thailand by PT. Nstle Indonesia in 1998 by the name of Nakhon Sawan 1. Has purple hypocotyl, brown fur, purple flower color, yellow seed coat, bright white helium seed, determined growing type, 35-day flowering age, 80-age harvest 82 days, plant height 40 cm, number of branches per plant 3–4 stems from the main stem, having a large seed size (weight 100 seeds 16.0 g), having seed yield of 1.5–2.0 t/ha, has a protein content of 39.4%, has a fat content of 20.8%, has resistance to falling. In addition, the Argomulyo variety is tolerant of leaf rust and this variety is suitable for soy milk raw materials.

4. Conclusion

The soybean cultivation system carried out by farmers in paddy fields in South Sulawesi using environmentally friendly technology has a quite high potential. This is supported by the availability of organic materials which are quite widely available around farmers' fields such as straw, cow dung, and cow urine (bio urine). These raw materials are processed by farmers into organic fertilizers for use in soybean cultivation to reduce the use of chemical fertilizers. Similarly, in controlling pests and diseases, farmers use raw materials from extracted plants to become vegetable insecticides. This control technique has high potential because the raw materials are widely available in nature, such as areca nut, cashew skin, clove flower, mengkuduh fruit, betel leaf, srikaya leaf, neem seeds, yam seeds, saponins, pine lantana, and tobacco leaves. The advantages of the soybean cultivation technology developed by farmers in South Sulawesi include being more efficient because the raw materials are from nature and do not need to be purchased at high prices such as using chemicals.

Besides that, other advantages of the soybean cultivation technique used by farmers are that it is more environmentally friendly because the organic fertilizers used by farmers are the raw materials from plant residues and livestock manure such as straw and cow urine (bio urine). Likewise, the control of plant pests carried out by farmers in South Sulawesi uses raw materials from plants and biological microorganisms so it is more environmentally friendly than using chemicals. However, there are also drawbacks to the soybean cultivation technology used by farmers, including the time needed for the manufacturing process and the availability of some raw materials used by farmers in nature is limited, so they need to be developed through cultivation, such as neem seeds, areca nut, and sugar apple seeds. In general, the soybean cultivation technology used by farmers in South Sulawesi has greater prospects and opportunities to be developed as a whole in Indonesia, which has a tropical climate.

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