Tephrosia candida (Roxb.) DC., (White hoary pea or Himalayan hoary pea): A review on its potential as a bio mulch

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Abstract: *Tephrosia candida*, commonly known as the white hoary pea, is a perennial green manure crop native to India, belonging to the Leguminosae family. *Tephrosia candida* is widely distributed across numerous tropical and subtropical countries worldwide. It hosts rhizobia, a gram-negative nitrogen-fixing bacterium that converts atmospheric nitrogen into ammonia (NH_3) through a process known as nitrogen fixation. This species is renowned for its insecticidal properties because of a compound called rotenoids, which is responsible for effectively eliminating predatory fish and insects. The leaf biomass of *Tephrosia candida* contains significantly higher levels of essential nutrients, including nitrogen (N), phosphorus (P), potassium (K), calcium (Ca^{2+}), and major micronutrients. This paper reviewed *Tephrosia candidas* properties as an effective bio-mulch for improving soil physical, biological and chemical properties ultimately leading to improvements in crop yield and quality.

Keywords: soil organic carbon, nutrients, microbes, biomass, litter decomposition, green manuring.

Received: May 19, 2022. Revised: October 2, 2023. Accepted: November 13, 2023. Published: December 29, 2023.

1. Introduction

Biomass mulching refers to the practice of applying organic materials, such as plant residues, crop byproducts, or other biodegradable materials, to the soil surface. It improves soil health, conserve moisture, suppress weed growth, and enhance nutrient cycling in agricultural or horticultural systems. Green manuring incorporates all the essential plant nutrients required for the complete life cycle of any plant. When compared to food legumes, which are considered inferior due to their poor nutritional content and limited production of dry matter, green manure crops can provide up to 80-100 kg of nitrogen per hectare. This is due to their higher biomass output and superior nutrient composition (Dubey *et al.,* 2015). Perennial green manuring crops such as Red clover (*Trifolium pratense*), Alfalfa (*Medicago sativa*), Comfrey (*Symphytum* spp.), White clover (*Trifolium repens*), Winter rye (*Secale cereale*), Sweet clover (*Melilotus* spp.), Subabul (*Leucaena leucocephala*), White hoary pea (*Tephrosia candida*), etc, solve the problem of annual resowing.*Tephrosia candida* (Roxb.) DC., commonly known as white hoary pea or himalayan hoary pea, is a perennial shrub native to the Himalayan tropical foothills of India, is well-adapted to withstand drought conditions and has the unique ability to fix atmospheric nitrogen through synergistic association with Rhizobium (Oyen, 1997). This genus belongs to the Leguminosae or Fabaceae family and the Papilionoidea sub-family (Kusumaningtyas *et al.,* 2021). It has more than 400 species, among that India is native to 35 species (Zhang *et al.,* 2020). A few species in the genus are known for their insecticidal properties because of rotenoids including *Tephrosia candida*. *Tephrosia candida* has a global distribution in the Indo-Malesia region. In India, it is primarily found in Assam, Meghalaya, and the Idukki district of Kerala. *Tephrosia candida* is known to enhance soil fertility, making it highly valuable for soil improvement and erosion control purposes. Besides this its roots play a vital role in enhancing soil drainage by loosening compacted soil and creating pathways for water flow. This effective process aids in minimizing waterlogging issues and contributes to the overall improvement of soil health. Numerous studies, including those by Fagerström *et al*. (2001), Mamuye *et al.* (2020), and Das *et al.* (2021), have demonstrated the positive effects of Tephrosia species on soil organic matter and the rehabilitation of degraded land. For instance, Fagerström *et al*. (2001) successfully utilized *Tephrosia candida* to reclaim shifting cultivation areas in Indonesia. It can tolerate wide range of soils but intolerant to water logged soils (Nguyen *et al.,* 1993). The reduction in soil acidity may be due to higher amount of calcium, magnesium, and other alkaline elements present in their leaves. These components have the ability to neutralize acidic conditions in the soil, helping to create a more balanced and favorable pH level for plant growth. It thrives well in acidic soils and can tolerate pH levels as low as 3.5, with greater suitability observed in more acidic soils (Orwa *et al*., 2009). Due to its odour, it is less likely to be consumed by foraging animals (Nguyen *et al.,* 1993). It is a drought-tolerant and fast-growing crop, thrives in arid regions and requires minimal maintenance, making it an ideal and sustainable choice for biomass mulching.

Kingdom	Plantae
Phylum	Tracheophyta
Class	Equisetopsida C. Agardh
Order	Fabales
Family	Fabaceae (Leguminosae)
Genus	Tephrosia
Species	*Tephrosia candida* (Roxb.) DC.

Table1: Taxonomical details of plant *Tephrosia candida* (Roxb.) DC

2. Biomass production

Biomass production and leaf litter composition are important factors when assessing the suitability of a species for use as biomass mulch. One of the unique physical features of *Tephrosia candida* is its ability to generate a higher amount of biomass compared to *Tephrosia vogelii* (Zhang *et al.,* 2020). Research in different regions has shown substantial biomass yields for Tephrosia species, in a humid tropical environment in Kpite, southeastern Nigeria, Ikpe *et al.* (2003) recorded a complete biomass yield, including wood and stems of *Tephrosia candida*, amounting to 21.5 t/ha^{-1} after a 2-year natural fallow. In southwestern Ethiopia, Mamuye *et al.* (2020) observed a total foliar biomass production of 6.5 ± 0.5 t/ha^{-1} in *Tephrosia vogelii* during a 2-year natural fallow. Meanwhile, at ICAR RCER, FSRCHPR, Ranchi, Das *et al.* (2019) reported a dry biomass yield of 12.8 t/ha, involving two loppings per year. In western Kenya, Jama *et al.* (2008) reported that *Tephrosia candida* has a dry matter content of approximately 10.5 tons per hectare when grown as a fallow crop. Meelu and Morris (1986) found that *Tephrosia candida*, when used as a green manuring crop, had the highest biomass yield of 20 t/ha, surpassing mung bean, native bean, cowpea, and peanut. Tephrosia used as mulch has shown significant effectiveness during the initial three years after planting (Fagerström *et al.,* 2001). However, as the plant matures, it tends to become woody, which may affect its mulching properties. Additionally, Tephrosia plants displayed higher shoot biomass, reaching 40 grams per plant within the first six months of planting (Kadiata *et al.,* 1996).

3. Effect of biomass mulching of *Tephrosia* on soil fertility

The practice of biomass mulching with Tephrosia has been shown to have a significant positive impact on soil fertility. In a study on Tephrosia species and provenance trials at Zambia, Mafongoya *et al.* (2003) discovered that *Tephrosia candida* provenance 02972 had significantly higher total inorganic nitogen (12.5 mg kg^{-1}) compared to *Tephrosia vogelii* (5 mg kg^{-1}). According to Bucagu *et al.* (2013), using Tephrosia mulch led to a significant variation of 60-82% in soil nitrogen and phosphorus concentrations, as well as 54-65% variation in potassium and calcium concentrations. Mamuye *et al.* (2020) recorded improvements in various soil chemical parameters, including increased pH from 5.2 to 6.3, organic carbon from 0.5 to 3.4%, and nitrogen from 0.6 to 6.8 mg/kg with the use of Tephrosia under natural fallow for maize. *Tephrosia candida* as a solo crop improved the soil enzymatic activities like urease, phosphatase and catalase along with total nitrogen, total phosphorus, total potassium, effective nitrogen, effective phosphorus, and effective potassium in Sothern China (Lie *et al.,* 2016). In Vietnam, Rani *et al.* (2021) reported an increase in soil green matter content from 1.7% to 4%. In relation to the nutrient composition of the biomass, Ikpe *et al.* (2003) found that *Tephrosia candida* leaves contained two to three times more nutrients (nitrogen, phosphorus, calcium, magnesium, and potassium) compared to leaves of other species during a two-year study. The species also exhibits interesting root exudates, which significantly improve soil nutrients through enhanced microbial growth (Manpoong *et al.,* 2020). Moreover, its leaf litter has a high-quality composition, leading to faster decomposition (Ghosh and Tripathi, 2021). Das *et al.* (2021) reported that

Tephrosia candida biomass fulfils 100% of the nitrogen and potassium requirements and 23% of the phosphorus requirements for the bael trees. Furthermore, the leaves of *Tephrosia candida* contain approximately 2.94% nitrogen, 0.16% phosphorus, 1.06% potassium, 35.35±5.46 ppm zinc, and 19.18±3.14 ppm copper. Kadiata *et al*. (1996) found that after six months of planting, *Tephrosia candida* exhibited a higher number of root nodules, with 13 nodules in ultisols and 6 nodules in alfisols. Tephrosia fallow reduced fertilizer purchase needs by 50%. (Mafongoya *et al.,* 2003). In Indonesia, Tephrosia has been recognized as one of best green manuring species for reclaiming poor soil conditions following shifting cultivation practices (Fagerström *et al.,* 2001). When interplanting *Tephrosia candida* and *Sesbania cannabina* with eucalyptus, it has been observed that *Tephrosia candida* exhibits a higher abundance of rhizobia, indicating a significant difference in nitrogen fixation compared to *Sesbania cannabina*. Additionally, *Tephrosia candida* activates higher levels of soil phosphorus in the soil layer 10 to 20 cm and enhances soil organic carbon (OC) levels by over 17 g/kg of soil in the lower depth of 20-40 cm (Zhu *et al.,* 2021). These findings suggest that *Tephrosia candida* has significant long-term carbon sequestration potential. According to Sakala and Mhango (2003), *Tephrosia vogelii* exhibited 2.88% nitrogen and 0.25% phosphorus. Additionally, the nodule dry weight remained higher in the initial days after planting for *Tephrosia candida* and *Mucuna aterrima*. The study in southeastern Nigeria on *Tephrosia candida* as a natural fallow crop on acid soil revealed that soil organic carbon content was 2.07% and total nitrogen content was 0.18% at 0-5 cm depth, while at 5-15 cm depth, soil organic carbon content was 1.23% and total nitrogen content was 0.11%, indicating that *Tephrosia candida* can effectively enhance the accumulation of organic carbon and nitrogen in the upper soil layers (Gichuru, 1991). The application of *Tephrosia candida* as green manure significantly increased the contents of microbial biomass carbon (326.98 mg/kg) and microbial biomass nitrogen (71.15 mg/kg) compared to gramineous green manures and the control, leading to an increase in bacterial communities and changes in bacterial community compositions associated with plant residue decomposition; additionally, there was an overall improvement in soil pH (5.46), total nitrogen (1 g/kg), ammonium nitrogen ($NH4^+$-N) (249.85 mg/kg), nitrate nitrogen ($NO3^-$-N) (105.5 mg/kg), available phosphorus (1.4 mg/kg), and C:N ratio (22.67) (Qian *et al.,* 2022). In their study, Ghosh and Tripathi (2021) discovered that *Tephrosia candida* leaf litter had a low initial carbon/nitrogen ratio (8.77) and lignin/nitrogen ratio (2.29), indicating it is a high-quality resource with a faster decomposition rate. The initial carbon, nitrogen, lignin, C:N ratio, and lignin:N ratio of *Tephrosia candida* leaf litter were measured as 36.69±0.01%, 4.14±0.01%, 9.63±0.02%, 8.84, and 2.32, respectively. Manpoong *et al*. (2020) studied *Tephrosia candida* root exudates, finding an annual carbon exudation rate of 157 mg C g^{-1} yr^{-1}, which notably enhanced soil nutrients by promoting microbial growth. According to Munthali *et al*. (2014), *Tephrosia candida* leaves contain a substantial nitrogen content of 5.2%, whereas the twigs exhibit a lower nitrogen content of 2.2%. Additionally, Wapongnungsang and Tripathi (2017) reported that the initial carbon composition of *Tephrosia candida* leaves varied with different fallow durations, with percentages of 30±2.28%, 31±2.25%, and 37±2.53% for fallows lasting 3 years, 5 years, and 10 years, respectively. However, it is important to note that the use of *Tephrosia candida* as a fallow species may potentially exacerbated the problem of soil acidification, in acid

Ultisols, by the increasing aluminium and lowering Ca content in fallowed plots as reported by Ikpe *et al*., 2003.

4. Effect of biomass mulching of *Tephrosia* on crop growth and yield

Mulching with Tephrosia presents a multifaceted approach to improving soil health and fostering optimal tree growth. In regions facing water scarcity, the mulch proves invaluable by preserving precious moisture, safeguarding against evaporation. It offers the advantage of suppressing weed growth (Figure 1 and 2), which competes with plant for essential resources like water, nutrients, and light. The allelopathic compounds released by the mulch make it difficult for weeds to germinate, ensuring a thriving habitat for tree development. Remarkably, studies have revealed that Tephrosia mulching can lead to a promising 20% increase in tree growth and yield, thanks to its transformative impact on soil moisture, weed suppression, and soil fertility enhancement. The effect of biomass mulching of Tephrosia on crop growth and yield has been studied extensively, and it has shown positive outcomes in various agricultural systems. In Nigeria, Gichuru, (1991) have reported increase in maize yield with *Tephrosia candida* fallow, attributed to enhanced soil nitrogen. Fagerström *et al*. (2001) observed an increased maize yield through mulching with a mixture of *C. grahamiana* and Tephrosia. In their research on Tephrosia species and provenance in Zambia, Mafongoya *et al*. (2003) found that maize (*Zea mays* L.) had a higher yield after *Tephrosia candida* provenances compared to *T. vogelii* provenances. Wang *et al*. (2011) reported a 15.8% increase in corn biomass with the application of fresh *Tephrosia vogelii* leaves @ 200g/m2. Mamuye *et al*. (2020) recorded an 80% increase in maize yield with Tephrosia under natural fallow. Mng'omba *et al*. (2020) also observed an increase in maize yield with Gliricidia or Tephrosia biomass. Compared to conventional fallow, Mamuye *et al*. (2020) reported an 80% higher maize yield and 41% higher Cajanus yield with the use of Tephrosia. In a farmer's participatory study on the evaluation of agroforestry species, farmers screened *Tephrosia candida* over other species simply because of their indigenous knowledge, even though the agronomic trial showed comparable yield with *Tephrosia vogelii* and *T. candida* (Mafongoya and Kuntashula, 2005). Bucagu *et al*. (2013) observed a significant increase in coffee plantation yield with Tephrosia mulch compared to the farmer's mulch, and both Tephrosia fallow and Tephrosia mulch transfer systems showed the potential to enhance crop yield per hectare, supported by positive economic net present values for natural fallow and Tephrosia mulch. Mulching with Tephrosia biomass as a mulch increased growth parameters and yield of five-year-old bael plants (Das *et al*., 2019). The maize yield was higher in the Tephrosia-maize system due to rapid establishment and faster biomass accumulation of Tephrosia plants (Akinnifesi *et al*., 2009). According to Das *et al*. (2021), *Tephrosia candida* in a three-year alley-cropping system has been reported to recycle approximately 1,031.94 kg/ha of nitrogen (N), 56.16 kg/ha of phosphorus (P), and 372.06 kg/ha of potassium (K). Tephrosia and Stylosanthes plants have been found to extract only minimal amounts of water below a depth of 90 cm (Burle *et al*., 1992), indicating that they will not interfere with the yield of the main tree crop when grown as an alley crop. The implementation of residue mulching, particularly Maize + white hoary pea (*Tephrosia candida*), had a positive impact on soil available N, P, and K, and improved soil moisture, ultimately leading to enhanced crop and water productivity (Ngangom *et al*., 2020). When *Andropogon gayanus* was cultivated as a single crop, it yielded 451 kg/ha of dry matter (DM). However, when intercropped with *Tephrosia candida*, the yield increased to 587 kg/ha DM, and when intercropped with *Leucaena leucocephala*, the yield was 539 kg/ha DM (Odedire and Babayemi, 2008). This result indicate that *Tephrosia candida* demonstrated greater effectiveness compared to the widely accepted *Leucaena leucocephala*.

5. Effect of biomass mulching of *Tephrosia* on weed growth and pest and disease incidence

Tephrosia candida possesses the remarkable ability to produce allelopathic compounds that act as natural inhibitors, hindering the growth of neighbouring plants. These compounds are released from various parts of the plant, including the roots, leaves, and flowers. It is recognized for its beneficial properties attributed to the production of flavonoids, rotenoids, and sterol compounds (Zhang *et al*., 2020). Dihydrocodeinone found in the stems and leaves acts as a stomach and contact poison toxic to insects, while tephrosin from the roots interferes with insect growth and development, and deguelin primarily found in the roots has antifeedant and growth inhibition properties, making it effective against insects and nematodes (Andrei, *et al*., 1997; Hegazy *et al*., 2011; Matsumura, 2012; Touqeer *et al*., 2013; Kayange, *et al*., 2019). The research by USDA has during 1960s to 1970s has found that the rotenoid compound in the genus varied from 0.65% to 4.25% (Zhang *et al*., 2020). Moreover, it harbours beneficial insects like ladybirds and lacewings, which play a vital role in pest control, thus reducing the risk of pest damage. Studies have revealed that this extraordinary plant can effectively minimize the incidence of pests such as stem borers, leafhoppers, and aphids, showcasing its potential as a valuable and eco-friendly component of pest management strategies. Research in Malawi indicated that *Tephrosia candida* extracts were less effective against aphids in common bean compared to *T. vogelii*, mainly due to the lower concentration of active compounds in *Tephrosia candida* (Zhang *et al*., 2020). Nevertheless, *Tephrosia candida* remains valuable as a cover crop for repelling the diaprepes root weevil, a significant threat to citrus production in Florida and the Caribbean. The leaves of T. ca *Tephrosia candida* ndida contain antifeedants that deter adult weevils from feeding and laying eggs, and larvae that fed on the roots experienced reduced weight gain and survival, suggesting the presence of toxic compounds. These properties highlight *Tephrosia candida* 's potential as a cover crop for controlling diaprepes root weevil in citrus fields (Zhang *et al*., 2020). *Tephrosia candida* finds widespread use in mixed cropping systems and as a fallow crop in tropical production regions like Vietnam and India, prized for its positive impact on soil fertility and ability to repel insect pests (Zhang *et al*., 2020). According to Desaeger and Rao (2001), Tephrosia is not a suitable option for restoring soil fertility in nematode-susceptible crops. However, Tephrosia was less susceptible than Sesbania spp. On the other hand, Ikpe *et al*. (2003) reported that *Tephrosia candida* has weed smothering capabilities. In Zambia, Mafongoya *et al*. (2003) found more weed growth and less pest infestation in T. vogelii provenances compared to T. candida. They also discovered that Tephrosia vogelii provenance 98/02 from Zambia and *Tephrosia candida* 02972 are resistant to Meloidogyne incognita nematodes. Wang *et al*. (2011) reported that aqueous leachates from fresh T. vogelii leaves, at a concentration of >= 0.05 g/ml, inhibited weed seed germination and increased corn biomass by 15.8% at 200 g/m2. The reduced weed growth under mulched plots may be attributed to decreased solar radiation passage, temperature change, and allelochemicals released by the mulch (Oliveira *et al*., 2014). Mamuye *et al*. (2020) have suggested that T. vogelii not only provides organic fertilizer but also exhibits potential pest management abilities. *Tephrosia candida* DC possesses a toxic compound in its seeds, stems, roots, and leaves, serving as a potent antifeedant and repellent against Diaprepes Root Weevil, a pest that primarily targets citrus roots, making it a natural defense mechanism for managing Diaprepes Root Weevil infestations in citrus orchards (Lapointe *et al*., 2003). Tephrosia helps control termites, does not harbor pests and diseases during its growth stages, and proves advantageous for farmers who use it as an ally crop or mulch (Akinnifesi *et al*., 2009). Tephrosia has shown to improve the overall yield of upland rice when used as mulch by suppressing weeds, insects, and erosion while maintaining soil fertility, and it exhibits very low light compensation when used as hedgerow (Fagerström *et al*., 2001). However, Tephrosia spp. is highly associated with cucumber mosaic virus (Kumar *et al*., 2020).

Figure 1, Tephrosia candida mulched plot

Figure 2, Control plot without mulching

6. Litter decomposition pattern of *Tephrosia*

The litter decomposition pattern of *Tephrosia candida*, a nitrogen-fixing plant species, has been studied extensively. Litter decomposition is a fundamental ecological process that drives the recycling of essential nutrients and carbon in terrestrial ecosystems. It involves the breakdown of dead plant material, such as leaves, roots, and stems, into simpler compounds, which are then assimilated back into the soil. Plant litter decomposition plays a dominant role in transferring carbon and nutrients, as it supplies essential elements to plants and serves as a primary source of soil organic matter; fresh litter and root remnants are the main contributors to soil organic carbon (Ramesh *et al*., 2015; Naik *et al.,* 2017), and as leaf litter undergoes decomposition, it transforms into humus, which positively influences various soil characteristics (Murthy *et al*., 2013). Further degradation releases tannins and lignin compounds that hinder rapid carbon decomposition, thereby facilitating its retention within aggregates (Kalambukattu *et al*., 2013).

The litter decomposition rates of *Tephrosia candida* are affected by several factors, including litter age, environmental conditions, and the presence of other organisms. Typically, younger litter and warm, moist conditions lead to faster decomposition. Additionally, the involvement of bacteria and fungi can accelerate the decomposition process. Several works have shown that the decomposition process of *Tephrosia candida* litter follows a particular pattern over time. Initially, there is a rapid loss of mass and decomposition of the litter, with significant carbon and nitrogen release into the surrounding environment. This initial stage is marked by dynamic microbial activity, breaking down the organic matter relatively quickly. As the decomposition progresses, the rate of mass loss and nutrient release gradually slows down, leading to a stabilization of the process. During this later stage, the remaining litter undergoes a more gradual breakdown, and the release of carbon and nitrogen becomes less pronounced. The litter decomposition pattern of *Tephrosia candida* was found to vary based on initial litter quality, abiotic factors, and site fertility levels, primarily influenced by changes in litter microorganisms (Wapongnungsang and Tripathi, 2017). The nutrient release from decomposing *Tephrosia candida* litter is influenced by various factors. Generally, nitrogen is predominantly released during the early stages of decomposition, while carbon release occurs mainly in the later stages. Conversely, the release of other nutrients like phosphorus and potassium is more evenly distributed throughout the entire decomposition process. The carbon/nitrogen release patterns were notably higher in the leaf and fine root components compared to other parts plant (Wapongnungsang and Tripathi, 2017). Lalramliani *et al*. (2016) observed that *Tephrosia candida* showed the highest decomposition rates during the rainy season and the lowest rates during the summer season.

According to Rutunga *et al*. (2001), the decay rate of Tephrosia roots and leaves was approximately two months. Additionally, Wapongnungsang and Tripathi (2017) reported the initial carbon composition of *Tephrosia candida* leaves grown in different fallows, showing percentages of 30±2.28%, 31±2.25%, and 37±2.53% for 3 years, 5 years, and 10 years fallows, respectively. Ghosh and

Tripathi (2021) provided data on the initial carbon, nitrogen, lignin, C:N ratio, and lignin N ratio of *Tephrosia candida* leaf litters as 36.69±0.01%, 4.14±0.01%, 9.63±0.02%, 8.84, and 2.32, respectively. They also observed that the carbon and nitrogen released from Tephrosia leaf litter followed a pattern similar to mass loss, with rapid mass loss at the beginning and a slowdown in the later stages of decomposition. Das *et al*. (2021) found that *Tephrosia candida*, when used as biomass mulch, took approximately 1.82 months for 50% decomposition and 13.16 months for 99% decomposition. Additionally, they observed that the nutrient release from Tephrosia was gradual, leading to an enhancement in overall soil fertility. In contrast, Munthali *et al*. (2013) found a rapid decomposition rate for Tephrosia fallow biomass, with a half-life of 2-3 weeks and over 95 percent decomposition achieved within 8-25 weeks, while noting no nitrogen or phosphorous immobilization during the decomposition process; although increased CO2 concentrations had no significant impact on litter chemistry or decomposition rates, they did affect the C:N ratio of the litter. An increased nitrogen content in leaf litter results in accelerated decomposition rates (Tang *et al*., 2004).

7. Conclusion

Tephrosia candida is a promising green manuring crop, it is widely recognised for its higher biomass production and insecticidal properties. It is particularly effective in accumulating and retaining high amount essential nutrients in its foliage. *Tephrosia candida* as a biomass mulch is effective in improving soil microclimate by improving soil moisture content, soil bulk density, soil acidity, soil enzymatic activities, soil organic carbon, soil biomass carbon, soil biomass nitrogen etc. The short life span of tephrosia (up to 7 years), medium shallow root system, and slower seed dispersal rate help in the easier eradication of the crop make this pant stand out from the existing widely recognised green manuring crops like subabul. Moreover, the higher biomass content, slow decomposition rate of its leaf litter, and higher carbon content of up to 40% make *Tephrosia candida* a compelling choice for sustainable agriculture, offering a viable solution to enhance soil quality, mitigate pest pressures, and boost crop yields in farming systems. The genus tephrosia is widely studied for their larvicidal and anti-cancerous properties because of the compounds like rotenoids and flavonoids. The studies with respect to its mulching properties is very merger.

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