Improving soil health and weed control through dhaincha (*Sesbania aculeata*) green manuring under semi-arid conditions

ABSTRACT

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| --- |
| **Aims:** Green manuring is a sustainable agricultural practice that enhances soil fertility and aids in weed management, particularly in organic farming systems. The study aimed to assess the effect of green manure incorporation on soil physicochemical properties and weed density. The experimental soil, classified as sandy clay loam, showed significant improvement in fertility parameters after the incorporation of dhaincha biomass.**Methodology**: This study was conducted at the Agricultural College and Research Institute, Madurai, to evaluate the impact of dhaincha (*Sesbania aculeata*) green manuring on soil physicochemical properties and weed dynamics. The experimental soil, classified as sandy clay loam (Typic Udic Hapludalf), was assessed before and after the incorporation of green manure**.****Results:** The results revealed that green manuring significantly improved key soil parameters. The soil pH decreased from 7.8 to 7.5, indicating a favourable shift toward neutral conditions, while electrical conductivity increased from 0.33 to 0.47 dS/m, suggesting enhanced nutrient availability. Organic carbon content rose slightly from 1.26% to 1.29%, highlighting improved microbial activity and organic matter status. Available nitrogen increased from 225.79 to 235.00 kg/ha, phosphorus from 31.36 to 33.60 kg/ha, and potassium from 251.00 to 256.12 kg/ha due to the nutrient-rich biomass and nitrogen-fixing ability of dhaincha. Additionally, green manuring exerted a suppressive effect on weed populations, especially broadleaf species, due to allelopathic interactions and shading. Weed density for broadleaf weeds decreased markedly from 56 to 8 plants/m² after dhaincha incorporation.**Conclusion:** The findings support the value of green manuring in improving soil fertility, enhancing nutrient cycling, and managing weed infestations sustainably. Incorporating dhaincha as a green manure crop can thus serve as an effective strategy for maintaining soil health and supporting organic crop production. |

*Keywords: Green manuring, Soil fertility, Dhaincha (Sesbania aculeata), Weed management and Organic farming*

**1. INTRODUCTION**

Green manuring is a vital practice in organic farming that enhances soil fertility by incorporating fresh plant biomass into the soil (Dalei *et al*., 2025). Green manures, defined as crops grown specifically to be integrated into the soil, have numerous advantages for agricultural systems (Rani *et al*., 2021; Gerke, *2022*; Iderawumi and Kamal, *2022*; Prajapati *et al*., 2023). India’s net sown area is approximately 141 million hectares in 2025, covering about 43% of the country’s total geographical are by Kumar *et al*. (2025). This method is most common in rice-growing states like Andhra Pradesh, Uttar Pradesh, Karnataka, Punjab, and Odisha. Green manure crops, especially legumes, are grown and ploughed under the soil while green or just after flowering, to enrich soil organic matter and nitrogen. These crops can supply 80–100 kg N/ha within 40–50 days, significantly reducing the need for synthetic fertilizers by Das *et al*. (2020). Green manuring is practiced in two major forms: green leaf manuring, using tree and shrub leaves from field bunds or forests, and in situ manuring, where legume crops are grown and incorporated directly into the same field Jhosna *et al*., 2024). The effectiveness of green manures depends on species selection, soil conditions, climate, and crop age. Legumes like dhaincha, sunhemp, mungbean, and cowpea are highly preferred for their nitrogen-fixing ability and biomass production. Weeds such as water hyacinth and Parthenium also offer high biomass and nutrient value and can be used for ex-situ manuring (Maitra *et al*., 2018).

Among green manure crops, Dhaincha (*Sesbania aculeata*) is one of the most effective. It thrives in loamy and clayey soils and is tolerant to both drought and water stagnation. It performs well even in alkaline soils and can help correct soil alkalinity when grown repeatedly Singh *et al.* (1992). Dhaincha yields about 10 –15 tonnes of green biomass per hectare and fixes nitrogen at the rate of 1 kg/day when inoculated with efficient Rhizobium strains. For best results, green manure crops should be sown just after the monsoon or during April–May with irrigation, and buried before seed setting. Proper decomposition (typically 4–6 weeks) before the next crop ensures the release of nutrients and improved soil health. Green manuring, especially with crops like dhaincha, offers a sustainable solution for boosting crop productivity and maintaining soil fertility under organic farming systems. The study aimed to assess the effect of green manure incorporation on soil physicochemical properties and weed density. The experimental soil, classified as sandy clay loam, showed significant improvement in fertility parameters after the incorporation of dhaincha biomass.

2. material and methods

**2.1 Location of the experimental site**

The experiment was conducted in Field No. 32 at the Department of Fruit Science, Horticultural College & Research Institute, Periyakulam. It comes under the southern agroclimatic zone of Tamil Nadu, India.

**2.2 Soil Characteristics**

The soil of the experimental field was sandy clay loam in texture classified as Typic Udic Hapludalf. The mechanical composition and physio chemical properties of the experimental fields are presented in table 1.

**Table: 1 Soil properties of the experimental field**

|  |  |
| --- | --- |
| **S.No** |  **Parameters** |
|  **I Mechanical Properties** |
|  1. | Clay (%) |  20.90 |
|  2. | Silt (%) |  7.50 |
|  3. | Coarse sand (%) |  20.40 |
|  4. | Find sand (%) |  48.30 |
|  5. | Textural class |  Sandy clay loam |
|  6. | Bulk density |  1.38 |

* 1. **Estimation of pH**

Weigh 20g of air-dry soil passed through 2mm sieve and transfer to a clean 100 ml beaker. Add 50 ml of distilled water. Using glass rod, stir the contents intermediately and allow it to stand for half an hour. Wash the electrode carefully with a jet of distilled water and wipe with a piece of filter paper. Stir the soil suspension again just before taking the reading. Immerse the electrode into the beaker containing soil water suspension and change the function switch the particular pH range. Record the meter reading both in supernatant solution and suspension by Jackson (1973)

LIST 1: pH range

|  |  |
| --- | --- |
| Extremely acidic  | <4.5 |
| Very strongly acidic  | 4.5-5.0 |
| Strongly acidic | 5.1-5.5 |
| Moderately acidic | 5.6-6.0 |
| Slightly acidic | 6.1-6.5 |
| Neutral | 6.6-7.3 |
| Mildely alkaline | 7.4-7.8 |
| Moderately alkaline | 7.9-8.4 |
| Strongly alkaline | 8.5-9.0 |
| Very strongly alkaline | >9.0 |

* 1. **Determination of soil electrical conductivity:**

Electrical conductivity (EC) gives the total amount of soluble salts present in the soil and is expressed as dSm-1 by Jackson (1973). Switch on the electrical conductivity bridge and wait for 10minutes. Check the instrument with saturated CaSO4 and with 0.01N KCl solution. EC should be 2.2 and 1.41 dSm-1. Use the same soil water suspension used for measuring pH for the estimation of EC. Stir the content and allow the soil to settle for 10 minutes. Adjust the temperature condition meter knob until the magic eye of the null indicator is at its widest width. The readings on the scale at this position indicate the electrical conductivity. Multiply this by the cell constant (noted on the cell itself) to get specific conductivity.

* 1. **Estimation of available nitrogen**

A known amount of soil is mixed with an excess of alkaline permanganate and distilled. Organic matter present in soil is oxidised by the nascent oxygen liberated by KMnO4 in the presence of NaOH, thus ammonia is released. This ammonia is absorbed in boric acid (2%) containing double indicator and forms ammonium borate. This ammonium borate is titrated against standard H2SO4 with 0.32%KMnO4, 2.5% NaOH, 2% Boric acid, 0.02N H2SO4 and Double indicator. Weigh 5 g of soil sample and wet the soil sample by distilled water fed in kelplus. Recover the sample in KELPLIS. Titrate against 0.02 N H2SO4

* 1. **Estimation of available phosphorous (Olsen’s method)**

This method of extraction of available soil phosphorus is suited for calcareous and alkaline soil. The Co32-irons from NaHCo3 will react with ca2+& CaCo3 is precipitated thus allowing some into the solution. The amount of P extracted is determined colorimetrically. 0.5 M NaHCO3, Darco G 60, Reagent A, Reagent B and ascorbic acid.Weigh 5g of soil in 200ml of shaking bottle. Add 50ml of 0.5 M NaHCO3 and a pinch of Darco G 60. Shake it for 30 minutes. Filter in Whatman No.40 filter paper. Collect the filtrate in a beaker and make up the volume to 25 ml. Pipette out 5 ml of filtrate in 25 ml volumetric flask. Add 4 ml of Reagent B (dissolved 1.056 g of ascorbic acid in 200 ml of Reagent A) and make up the volume to 25 ml used distilled water. Measure the intensity at 660 nm in spectrophotometer. Rating of soil for available P

List 2: Value Rating of soil for available P

|  |  |
| --- | --- |
| **Status of soil available P** | **Value (Kgha-1)** |
| Low | Less than 11 |
| Medium | 11-22 |
| High | >22 |

* 1. **Estimation of available potassium**

The k+ irons in the exchange sites are replaced by NH4+ irons and leached from the soil. The k+ irons in solution are then determined with the Flame photometer. 1N Ammonium acetate. Weigh 5g of soil in 200ml of shaking bottle. Add 25m of Neutral normal ammonium acetate into the shaking bottle. Shake in a reciprocating mechanical shaker for 5 minutes. Filter the sample through whatman No.42 dry filter paper and collect the filtrate in a dry test tube or beaker or injection vial. Measure the amount of K in the filtrate by using flame photometer.

List 3: Value Rating of soil for available k

|  |  |
| --- | --- |
| **Status of soil available K** | **Value (Kgha-1)** |
| Low | <118 |
| Medium | 118-280 |
| High | >280 |

3. results and discussion

**3.1 Effect of green manure on soil properties**

**3.1.1 pH (Potential of Hydrogen)**

The pH of the pre-harvest soil in the experimental field was 7.8. Hence, the soil had a slightly alkaline nature shown in Table 2.

 The pH of the post-harvest soil after the incorporation of green manure (45 DAS of daincha followed by 30 days after incorporation) was 7.5. After the incorporation of green manure in the experimental field, the pH of the soil was decreased because the green manures release organic acids and also involves the chelation process. So, the pH of the soil was decreased.

 The incorporation of green manure changes the pH of the soil. Improve the soil health and plant health. This statement was also proved by Ambrosano *et al*. (2013) they reported that the biomass of sunhemp induced a complete N substitution in sugarcane and could positively affect yield and increase Ca and Mg contents, sum of bases, pH, and base saturation, and decrease potential acidity and increase profit.

**3.1.2 EC (Electrical Conductivity)**

 The EC of the pre-harvest soil in the experimental field was 0.33 dSm-1. Hence, the soil was suitable for agriculture shown in Table 2.

 The EC of the post-harvest soil after the incorporation of green manure (45 DAS of daincha) was 0.47 dSm-1. The EC of the soil was increased after the incorporation of green manure

**3.1.3 Organic Carbon**

 The Organic Carbon content of the pre-harvest soil in the experimental field was 1.26%. The Organic Carbon of the soil is greater than 0.75%, so the organic carbon status of this soil is high shown in Table 2.

 Then, after the incorporation of green manure, the Organic Carbon of the post-harvest soil was increased up to 1.29%. The green manure provides nutrient-rich food to microorganisms, which increases the organic carbon content of the soil.

 This result was confirmed by Chaphale *et al*. (2000) noted that green manuring has been reported to increase the organic carbon status of soil in highly sodic soils. Bokhtiar *et al*. (2002) also recorded significant build-up of organic carbon, available N, P and K in soil under graded levels of fertilizers and also with green manure and green gram crop incorporation after the picking of pods. Singh and Chauhan (2002) reported that organic carbon and available N, P and K contents in soil were also improved with the application of FYM and Kudzu (*Pureriathum bergiana*) compost in wheat-ragi sequence under Almora conditions.

**3.1.4 Available Nitrogen**

 The pre-harvest soil in the experimental field has 225.79 Kg ha-1 available nitrogen. The available nitrogen of the soil is less than 280 Kg ha-1. The available nitrogen status of this soil is low shown in Table 2.

 The available nitrogen of the post-harvest soil after the incorporating of green manure (45 DAS of daincha) was 235 Kg ha-1. The incorporation of green manure increases the available nitrogen of the soil because green manure has some percentage of N content. For our analysis of the plant sample, they have 4.55% nitrogen content. The green manure root nodules fix the atmospheric nitrogen. This nitrogen is added to the soil and the available nitrogen of the soil increases after the incorporation of green manure.

 Incorporation of green manure has increased the available nitrogen of the soil and improved the chemical properties of the soil. This result was also confirmed by Sinha *et al*. (2009) studied the release of Nitrogen bound in the litter of decomposing green manure crop *Crotolaria juncea* about different climatic factors. Soil temperature has an effect on the pattern of nitrogen release during decomposition of added green manure residue in soil (Brar and Sidhu, 1997). Abeysekerra *et al*., (2001) noted that organic manures enhanced the mineral nitrogen contents in the soil irrespective of the source of green manure. Chaphale *et al*. (2000) noted that green manuring has been reported to increase the available nitrogen status of soil in highly sodic soils. Lokesh Dubey *et al*., (2005) reported that Leguminous green manure crop in soil increases nitrogen level by fixation.

**3.1.5 Available Phosphorus:**

 The available phosphorus of the pre-harvest soil in the experimental field was 31.36 Kg ha-1. The available phosphorus of the soil is greater than 22 Kg ha-1. The experimental field had high available phosphorus content shown in Table 2.

 Then, after the incorporation of green manure available phosphorus of the post-harvest soil was 33.6 Kg ha-1. Compared to the pre- and post-harvested soil, the available P of the soil is increased. The incorporation of green manure increases the available phosphorus of the soil because green manure has some percentage of P content. For our analysis of the plant sample, it has 0.88% phosphorus content. The phosphorus content of the plant was added to the soil. The P content of the soil was increased. The above result, as confirmed by Chaphale *et al*. (2001), noted that green manuring has been reported to increase the phosphorus status of soil in highly sodic soils. Green manure crops during decomposition release nutrients and are involved in recycling the nitrogen, phosphorus and potassium in the integrated plant nutrients system (IPNS) (Palaniappan, 1994; Goyal *et al*., 1999; Sharma and Ghosh, 2000; Yadav *et al*., 2000; Singh *et al*., 2007; Selvi and Kalpana, 2009, Sinha *et al*., 2009). Sinha *et al*., (2009) studied the release of Phosphorus bound in litter of decomposing green manure crop Crotolaria juncea concerning different climatic factors.

**3.1.6 Available Potassium**

 The available potassium of the pre-harvest soil in the experimental field was 251 Kg ha-1. The available potassium of the soil is between 118-280 Kg ha-1. The available potassium of this soil is medium shown in Table 2.

 The available potassium of the post-harvest soil after the incorporating of green manure (45 DAS of daincha) in main plots was 256.12 Kg ha-1. As available potassium of the soil slightly increased after the incorporation of green manures. Incorporation of green manure had changed the available potassium of the soil and improved the chemical properties of the soil. This result was also confirmed by Chaphale *et al*. (2001) noted that green manuring has been reported to increase potassium status of soil in highly sodic soils. Green manure crops during decomposition release nutrients and are involved in recycling the nitrogen, phosphorus and potassium in the integrated plant nutrients system (IPNS) (Palaniappan, 1994; Goyal *et al*., 1999; Sharma and Ghosh, 2000; Yadav *et al*., 2000; Singh *et al*., 2007; Selvi and Kalpana, 2009). Sinha *et al*. (2009) studied the release of Potassium bound in the litter of decomposing green manure crop Crotolaria juncea about different climatic factors. Chettri *et al*. (2003) noted that green manuring increased total available potassium.

**Table 2: Effect of dhaincha green manuring on soil properties**

|  |  |  |
| --- | --- | --- |
| **Soil properties** | **Before raising of dhaincha** | **After raising of dhaincha** |
| Bulk density (mg/m3) | 1.39 | 1.38 |
| pH | 7.80 | 7.50 |
| EC (dsm-1) | 0.33 | 0.47 |
| Organic carbon (%) | 1.26 | 1.29 |
| Available N (kg ha-1) | 225.80 | 235.00 |
| Available P (kg ha-1) | 31.40 | 33.60 |
| Available K (kg ha-1) | 251.00 | 256.12 |

**3.1.7 Effect on weed**

 The common weeds infesting the experimental field include grasses like *Echinochloa crusgalli*, *Digitaria sanguinalis*, *Brachiaria ramosa*, sedges like *Cyperus rotundas*, *Cyperus iria* and broad-leaved weeds like *Boerhaavia erecta*, *Amaranthus viridis*, *Cleome viscose*, *Digera arvensis*, *Eclipta prosterata*, *Trianthema portulacastrum*, *Portulaca oleraceae*, *Convolvulus arvensis*, *Phyllanthus niruri*, *Phyllanthus maderaspatensis*, *Tridax procumbens*, *Parthenium hysterophorus*, *Ipomoea purpurea* and *Commelina benghalensis*. Emergence of these weeds was observed during 20 to 30 DAS and thereafter, it continuously emerged throughout the crop growth stages in the control plot in Table 3. In the treatment plot (daincha green manuring), there was no effect on sedges, little effect on grasses and most of the broadleaf weeds were controlled. This is due to the allelopathic effect of green manures, some of the phytotoxic chemicals and secondary metabolites were released.

**Table 3: Effect of dhaincha green manuring on weed density**

|  |  |  |
| --- | --- | --- |
| **S. No** | **Type of weeds** | **Weed density (No./m2)** |
| **Without green manure** | **With green manure** | **After incorporation of dhaincha** |
| 1 | Grasses | 12.00 | 10.00 | 8.00 |
| 2 | Sedges | 8.00 | 6.00 | 6.00 |
| 3 | Broad leaf weeds | 56.00 | 12.00 | 8.00 |

4. Conclusion

The incorporation of dhaincha (*Sesbania aculeata*) green manure significantly improved the soil's physical and chemical properties in the experimental field. Post-harvest observations revealed a slight reduction in soil pH (from 7.8 to 7.5), indicating a shift toward neutral pH due to the release of organic acids and chelation by green manure. Electrical conductivity (EC) increased from 0.33 to 0.47 dS m⁻¹, remaining within the safe range for agricultural use. Organic carbon content showed a minor yet positive increase (from 1.26% to 1.29%), reflecting enhanced microbial activity and biomass decomposition. Nutrient availability also improved: available nitrogen rose from 225.8 to 235 kg ha⁻¹, phosphorus from 31.4 to 33.6 kg ha⁻¹, and potassium from 251 to 256.12 kg ha⁻¹. These enhancements affirm the role of green manure in enriching soil fertility and sustaining soil health. Furthermore, green manuring displayed an effective weed-suppressive effect, particularly against broadleaf weeds, due to its allelopathic properties and phytotoxic compound release. Overall, dhaincha green manuring not only enriched the soil with essential nutrients but also helped in managing weeds, making it a sustainable and eco-friendly practice for improving soil productivity and crop performance.

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Competing interests

The authors confirm that they have no conflicts of interest related to this work.

Authors’ Contributions

This study was a collaborative effort by all authors. All authors have read and approved the final manuscript.

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