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Comparative Evaluation of Selected Botanical Extracts in Enhancing Growth Parameters and Yield of Chilli Plants (*Capsicum annuum L*)

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Abstract: ***Chilli (Capsicum annuum L.) is one of the most widely cultivated and economically significant crops in many regions of the world. Chilli cultivation faces challenges such as poor soil conditions, pests, diseases, and environmental stresses that can hinder growth and reduce yield. In recent years, botanical extracts have been explored as potential alternatives to synthetic fertilizers and pesticides, offering natural, eco-friendly solutions to enhance plant health, growth, and productivity. Botanical extracts were evaluated for their effects on growth and yield of chilli under pot conditions. Six plant leaf extracts were applied at defined intervals and compared with untreated control. Growth parameters including plant height, dry matter, fruit number, and fruit weight were recorded. Neem and Polyalthia extracts significantly improved plant height and yield traits, with maximum fruit weight recorded under Polyalthia treatment. The findings demonstrate the potential of selected botanical extracts as sustainable alternatives for enhancing chilli productivity. These results support integration of plant based biostimulants in eco-friendly crop management strategies.***

Keywords: Botanical extracts; Capsicum annuum; Plant biostimulants; Sustainable agriculture; Yield enhancement; Organic crop management

1. Introduction

The global demand for chilli peppers (*Capsicum spp*.) continues to grow due to their diverse culinary, medicinal, and industrial applications. As an essential crop in many regions, chilli cultivation faces numerous challenges, including soil degradation, pest infestations, and climate variability, all of which can significantly impact growth and yield. In response to these challenges, sustainable agricultural practices that reduce dependence on chemical inputs are becoming increasingly vital.
One such innovative approach is the use of botanical extracts in enhancing the growth parameters and yield of chilli plants. Botanical extracts, derived from various plant species, have long been utilized in traditional agriculture for their natural pest control, growth-promoting, and disease-resistant properties. These extracts are rich in bioactive compounds such as plant hormones, antioxidants, and antimicrobial agents, which contribute to the overall health of the plants.

This study aims to explore the potential of botanical extracts as an alternative or complementary solution to synthetic fertilizers and pesticides in chilli farming. This research will investigate how specific botanical extracts can influence key growth parameters such as root development, shoot growth, flowering, and fruiting, as well as their effectiveness in enhancing overall yield and plant resilience to environmental stress. Additionally, the project will evaluate the feasibility of applying botanical extracts through various methods such as foliar sprays, soil amendments, and seed priming. Our main goal is to provide evidence-based recommendations for integrating botanical extracts into chilli farming practices.

ORIGIN
The chilli pepper (*Capsicum annuum*) is native to the Americas, specifically to regions ranging from southern North America to South America including regions extending to India. It belongs to the Solanaceae family, which also includes tomatoes, eggplants, and potatoes. It is commonly called as Chilli, Red pepper, bell pepper. Chilli peppers have a rich history, both culturally and agriculturally, dating back thousands of years. Archeological evidence suggests that chilli peppers were first cultivated in Mexico over 6,000 years ago. It has been a staple food in the indigenous diet where they were not only used in food but also in medicine. These plants were cultivated for fruits, earlier they were small and with vibrant colors over time they diversified extensively. The use of chilli spread over different regions worldwide including Europe, Asia and Africa. It became the integral ingredient in cuisines for distinct flavor and heat.

There are five main domesticated species of chilli peppers:
1) *Capsicum annuum* (the most common variety, including bell peppers, jalapeños, and cayennes)
2) *Capsicum frutescens* (e.g., Tabasco peppers)
3) *Capsicum chinense* (e.g., habanero, Scotch bonnet)
4) *Capsicum baccatum* (e.g., Aji peppers)
5) *Capsicum pubescens* (e.g., rocoto peppers)

Today, chilli peppers are grown all over the world, with major producers including China, India, Mexico, Indonesia, and Turkey. The chilli pepper industry is of great economic importance, with millions of tons of peppers being cultivated annually for fresh consumption, dried spices, and processing into sauces, powders, and other products.

In India, the area, production, and productivity of chilli are 1,660,000 hectares, 2.2 million tons, and 13-15 tons/ha respectively. Hence, India is one of the major producers of chilli in the world, contributing around 20% share of world chilli production.

These statistics illustrate that Andhra Pradesh and Tamil Nadu are the leading producers of chilli in India, accounting for a significant portion of the country's total chilli

production. The data emphasizes the regional concentration of chilli cultivation in India during the 2018-2019 period.

Nutritional and Medicinal Value of Chilli:

Capsaicin is the bioactive compound responsible for the spicy heat in chilli peppers. It has numerous health benefits, like Anti-inflammatory, Anti-oxidant, Pain Relief properties and also boosts metabolism. Amino acids like tryptophan, threonine, isoleucine, methionine, valine, lysine, alanine are present. Majority in vitamins goes to Vitamin C that give extensive immune support to the body, other vitamins like vitamin A, E, K and B are present that improves eye health, red blood cell formation, nerve function.

Objectives:

1) Effect of botanicals on growth of chilli plants
2) Expected mechanism of botanical action
3) Botanicals usage for improvement of yield attributes in chilli plants

2. Review of Literature

The use of botanical extracts to enhance the growth parameters and yield of chilli plants (Capsicum species) has gained considerable attention in recent years due to the increasing interest in sustainable agricultural practices and the limitations associated with synthetic chemical fertilizers and pesticides. This review discusses the current literature on the role of botanical extracts in improving the growth, yield, and disease resistance of chilli plants.

- Impact of botanical extracts on growth parameters show rapid change in the height of the plant some extracts like neem (*Azadirachta indica*), garlic (*Allium sativum*), ginger (*Zingiber officinale*), and turmeric (*Curcuma longa*), have been shown to enhance key growth parameters in chilli plants, including height, number of leaves, branching, and root development. For instance, neem extract is known to improve the root biomass and overall growth of chilli plants by enhancing nutrient uptake and reducing the effects of soil-borne pathogens (Kumar et al., 2017). These extracts basically act as phytoregulators enhancing photosynthesis, nutrient assimilation and hormone regulation. For example, **turmeric extract** has been reported to increase **chlorophyll content** in chilli plants, which directly contributes to enhanced photosynthetic efficiency (Sharma et al., 2018).
- Impact of extracts on yield increase due to improved flowering and fruit set will be better are the application of botanical extracts. The use of neem oil improves nutrient intake thereby contributing to better flowering and fruiting (Bhagat et al., 2019) and application of garlic extract reduces the disease incidence (Rao et al. 2025). The ginger extract helps to withstand high temperature stress in chilli plants (Singh et al., 2020).
- Botanical extracts also help in pest and disease management, Neem extract have been shown to exhibit effective repellent action against a wide range of chilli pests, such as aphids, whiteflies, and thrips. These extracts disrupt the life cycle of pests, reducing their damage to the plant and improving plant health (Lal et al., 2016). Fungal diseases such as Fusarium wilt and Alternaria blight are common in chilli cultivation. Garlic extract, with its potent antimicrobial properties, has been shown to reduce the incidence of these diseases by inhibiting the growth of fungal pathogens in the soil (Rahman et al., 2017).

The use of botanical extracts in enhancing the growth and yield of chilli plants offers a sustainable, eco-friendly alternative to chemical fertilizers and pesticides. The literature suggests that extracts from plants like **neem**, **garlic**, **ginger**, and **turmeric** have the potential to improve growth parameters, increase yield, and protect plants from diseases and pests.

3. Materials and Methods

Selection of botanicals

The following commonly available plant extracts were selected and used.

Name of the botanical	Plant part used
Azadirachta indica	Leaves
Parthenium hysterophorus	Leaves
Bougainvillea	Leaves
Polyalthia longifolia	Leaves
Calotropis gigantea	Leaves
Lantana camara	Leaves
Control	Without any plant extracts

Nursery

The nursery bed was prepared to which tomato seeds were sown (as shown in the figure 4) and watered regularly on alternate days. The vermiwash was sprayed on the young seedlings to enhance the growth. The earthen pots of 15cm diameter were filled with black clayey soil at 10 kg per pot. Four weeks old seedlings were transplanted @ two seedlings per earthen pot containing soil as shown in fig 4.

Treatment details

The experiment consisted of seven treatments containing six botanicals and a control, the botanicals extracted are shown in the figure 5. The botanical extract was obtained from plant leaves. Fresh green leaves were collected and washed thoroughly with clean water to remove dust and other impurities. The leaves were then dried under shade for several days until all the moisture was removed. After drying, the leaves were ground into a fine powder using a grinder to increase the surface area for extraction. Then the leaf powder was then soaked in a solvent such as ethanol and kept for about 24–72 hours with occasional shaking to ensure proper extraction of the bioactive compounds. After the extraction period, the mixture was filtered using filter paper to separate the liquid extract from the leaf residue. The filtrate obtained was then concentrated by evaporating the solvent using a water bath. Finally, the concentrated leaf extract was collected and stored in airtight containers in a cool and dry place and this is used for spraying on the different treatments.

Imposition of treatments

The recommended dose of fertilizers (150:100:50 N: P2O5:K2O kg per ha) and FYM (25 t per ha) were mixed with soil. The nitrogen was applied in two splits i.e., 50 per cent as basal dose and remaining 50 per cent as top dressing four weeks after transplantation. The botanicals were sprayed

as per the treatment schedule at 45, 60, 75 and 90 days after transplanting of chilli plantlets. A total of four sprays were given at an interval of 15 days.

Step 1: Calculate fertilizer amounts (kg/ha)

1) Nitrogen (N): 150 kg/ ha
Using Urea (46% N)

$$Urea\ Required = \frac{N\ requires}{\%\ N\ in\ urea} = \frac{150}{0.46} \approx 326.1 kg/ha$$

2) Phosphorus (P_2O_5): 100 kg/ha
Using SSP (16% P_2O_5)

$$SSP\ Required = \frac{100}{0.16} \approx 625 kg/ha$$

3) Potassium (K_2O): 50 kg/ha
Using MOP (60% K_2O)

$$MOP\ Required = \frac{50}{0.60} \approx 83.3 kg/ha$$

SSP – Single Super Phosphate
MOP – Muriate of Potash

Step 2: Convert to grams per m²
1 hectare = 10,000 m², so divide by 10,000:

- Urea: 326.1 kg ÷ 10,000 ≈ 32.6 g/m²
- SSP: 625 kg ÷ 10,000 ≈ 62.5 g/m²
- MOP: 83.3 kg ÷ 10,000 ≈ 8.33 g/m²

Step 3: Split application of nitrogen
Nitrogen is applied in two splits (50: 50)
32.6g/m² (Urea)÷2≈ 16.3 g/m² basal 16.3 g/m² top dressing after 4 weeks

Phosphorus (62.5 g/m² SSP) and potassium (8.33 g/m² MOP) are applied entirely as basal

Step 4: Application procedure

1) Mix FYM (if used, e.g., 25 t/ha → 2.5 kg/m²) with soil during land preparation.
2) Apply basal fertilizers: SSP, MOP, and half of urea uniformly in the soil at the time of transplanting.
3) Apply remaining urea as top dressing 4 weeks after transplanting.
4) Water the field lightly after fertilizer application to help nutrient absorption.

Harvesting
The fully mature fruits were harvested and stored separately as per the treatments in polythene bags

Collection of experimental data Growth characters
The different biometric observations were recorded at 45, 60, 75 and 90 DAT (days after transplantation) from two plants in each pot. The mean of two plants were used for analysis.

1) The plant height was measured from ground level to the tip of the main shoot. The mean of two plants were recorded as plant height in centimeters. It was recorded 45, 60, 75, 90 and 105 DAT.
2) Two plants from each pot were harvested and kept in brown paper bags having holes to enable air drying or simply sun dried and then oven dried at 70°C, sundry in figure 10 to achieve constant weight. Afterwards, the plant dry weight was recorded and expressed as total dry matter per plant, photographically shown in fig 10.
3) The matured fruits in each plant were collected at Ist, IInd pickings in two plants of each replicate pot. The mean of replications represented the number of fruits per plant.
4) The fruit weight per plant at harvest (2 pickings) was recorded and the mean fruit weight per plant was expressed in grams per plant.

4. Results and Discussion

- The height of the plant showed the highest values at all the observed stages (45, 60, 75 and 90 DAT) in T1 (*Azadirachta indica*) and T4 (*Polyalthia longifolia*), T2 (*Parthenium hysterophorus*) and T5 (*Calotropis gigantea*) showed moderate improvements in height, which could indicate a lesser but still positive impact on plant growth. T3 (*Bougainvillea*) and T6 **(***Lantana camara***)** had comparatively lower and statistically insignificant effects. The *control* (no treatment) plants showed the least growth at all stages, confirming that the treatments had a noticeable impact on improving chilli plant height compared to non-treatment. As shown in Table 1 and graphically represented in fig 1, photographs depicted in fig 6,7, 8, 9.
- Plant dry matter in T1 - *Azadirachta indica,* showed improving weight showing healthier growth when compared to all other treatments. As shown in Table 2 and graphically represented in fig 2, photographs depicted in fig 11.
- The number of fruits per plant increased to 35.5 in T1 - *Azadirachta indica* and fruit weight was highest in T4 - *Polyalthia longifolia* with 95.7 gms per plant. As shown in Table 3 and graphically represented in fig 3a, 3b, photographs depicted in fig 12,13.

Table 1: Plant height (cm) in Chilli influenced by different treatments

Treatments	45 DAT	60 DAT	75 DAT	90 DAT
T1=*Azadirachta indica*	30	60	78	127
T2=*Parthenium hysterophorus*	21	54	72	110
T3=*Bougainvillea*	22	53	70	120
T4=*Polyalthia longifolia*	24	56	74	125
T5=*Calotropis gigantea*	20	54	71	105
T6=*Lantana camara*	19	58	65	100
Control	17	45	62	90

DAT- Days After Transplanting

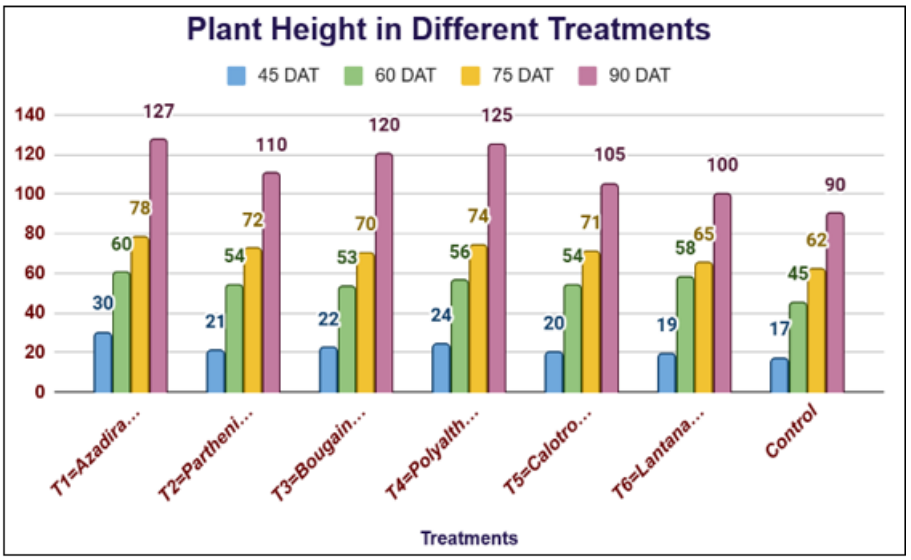

Figure 1: Displaying the effect of botanicals on plant height

Table 2: Effect of botanicals on dry matter of plant (at harvesting stage)

Treatments	Dry matter (g/plant)
T1=*Azadirachta indica*	35.5
T2=*Parthenium hysterophorus*	28.2
T3= *Bougainvillea*	30.1
T4=*Polyalthia longifolia*	32.0
T5= *Calotropis giganta*	27.8
T6=*Lantana camera*	29.4
Control	33.0

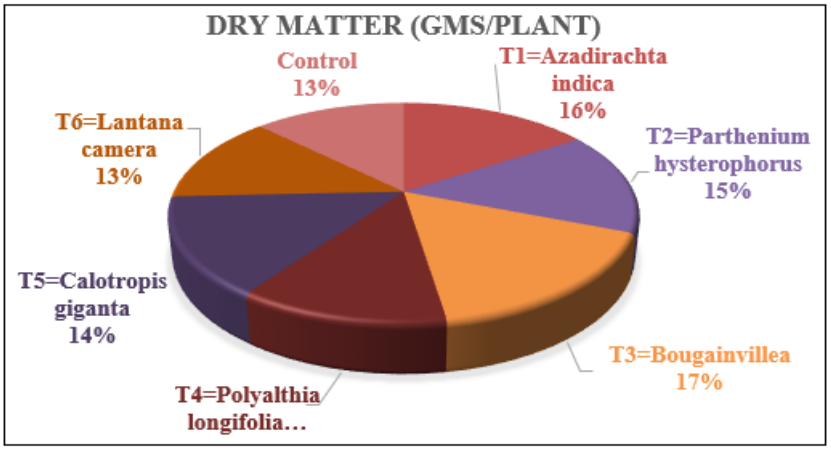

Figure 2: Display of Effect of botanicals on dry matter of plant (at harvesting stage)

Table 3: Effect of botanicals on the yield parameters of Chilli

Treatments	No. of fruits/ plant	Fruit weight (g/plant)
T1=*Azadirachta indica*	35.5	90.3gms
T2=*Parthenium hysterophorus*	32.7	84.5gms
T3=*Bougainvillea*	28.3	75.2gms
T4=*Polyalthia longifolia*	38.5	95.7gms
T5=*Calotropis giganta*	30.6	82.9gms
T6=*Lantana camera*	29.8	78.3gms
Control	25.1	68.4gms

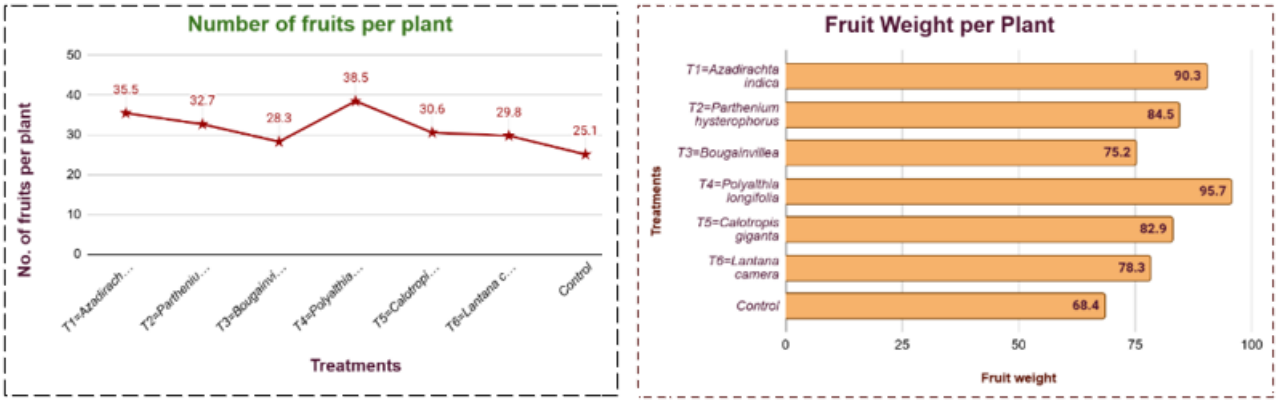

Figure 3 (a) and 3 (b): Display of effect of botanicals on yield attributes

5. Conclusion

The application of selected botanical extracts significantly influenced growth and yield attributes of chilli plants under controlled pot conditions. Neem and Polyalthia treatments demonstrated superior performance in plant height, dry matter accumulation, and fruit yield. These findings indicate that botanical extracts can function as effective eco-friendly biostimulants in chilli cultivation. Further research under field conditions and with optimized extract concentrations is recommended to validate large scale applicability.

Photographs

Figure 4: Sowing of Chilli Seeds and Replanting Seedlings

Figure 5: Preparation of leaf extracts for different treatments

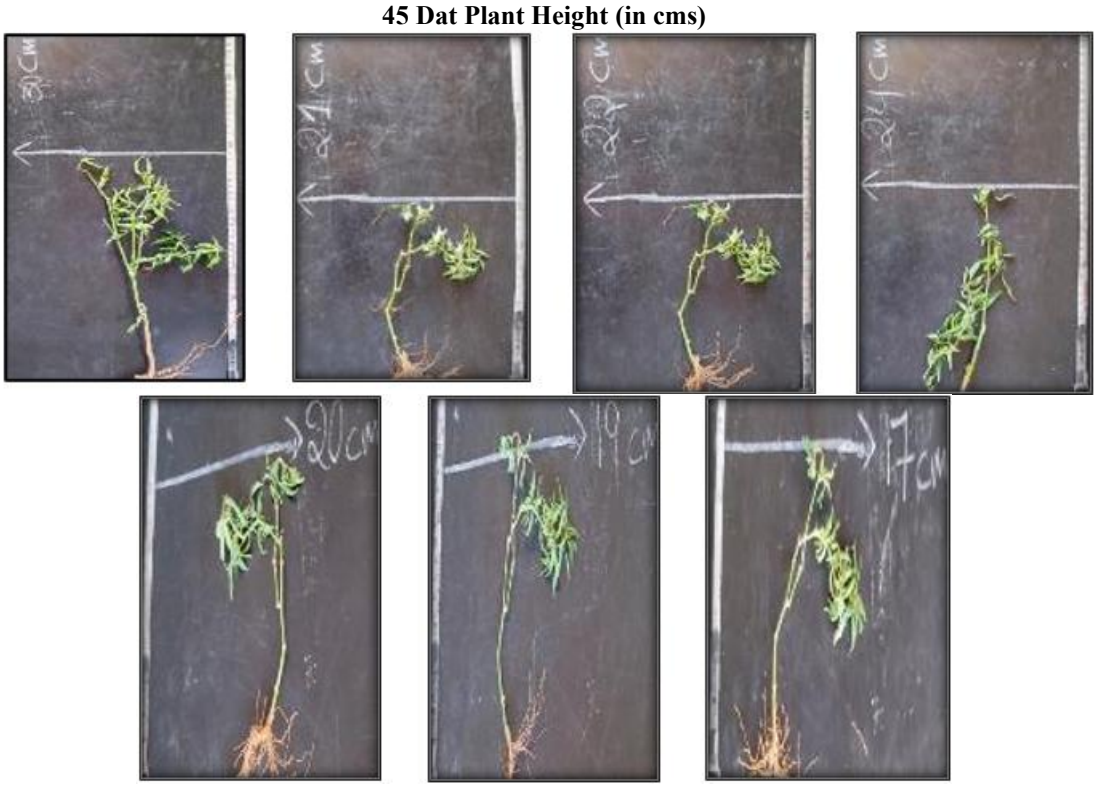

Figure 6: T1-30, T2-21, T3-22, T4-24, T5-20, T6-19, T7-17.

60 Dat Plant Height (in cms)

Figure 7: T1-60, T2-54, T3-53, T4-56, T5-54, T6-58, T7-45

75 Dat Plant Height (in cms)

Figure 8: T1-78, T2-72, T3-70, T4-74, T5-71, T6-65, T7-62.

90 Dat Plant Height (in cms)

Figure 9: T1-127, T2-110, T3-120, T4-125, T5-105, T6-100, T7-90

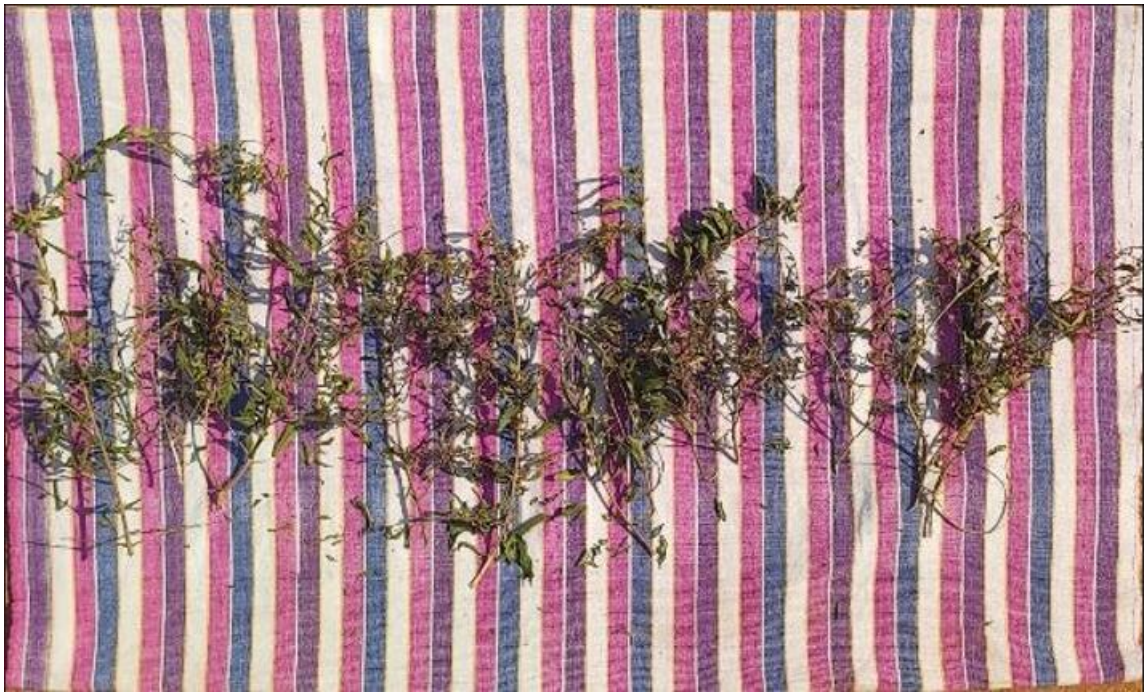

Figure 10: Sun Dry of Chilli Plants

Dry Matter of Chilli Plant (in gms)

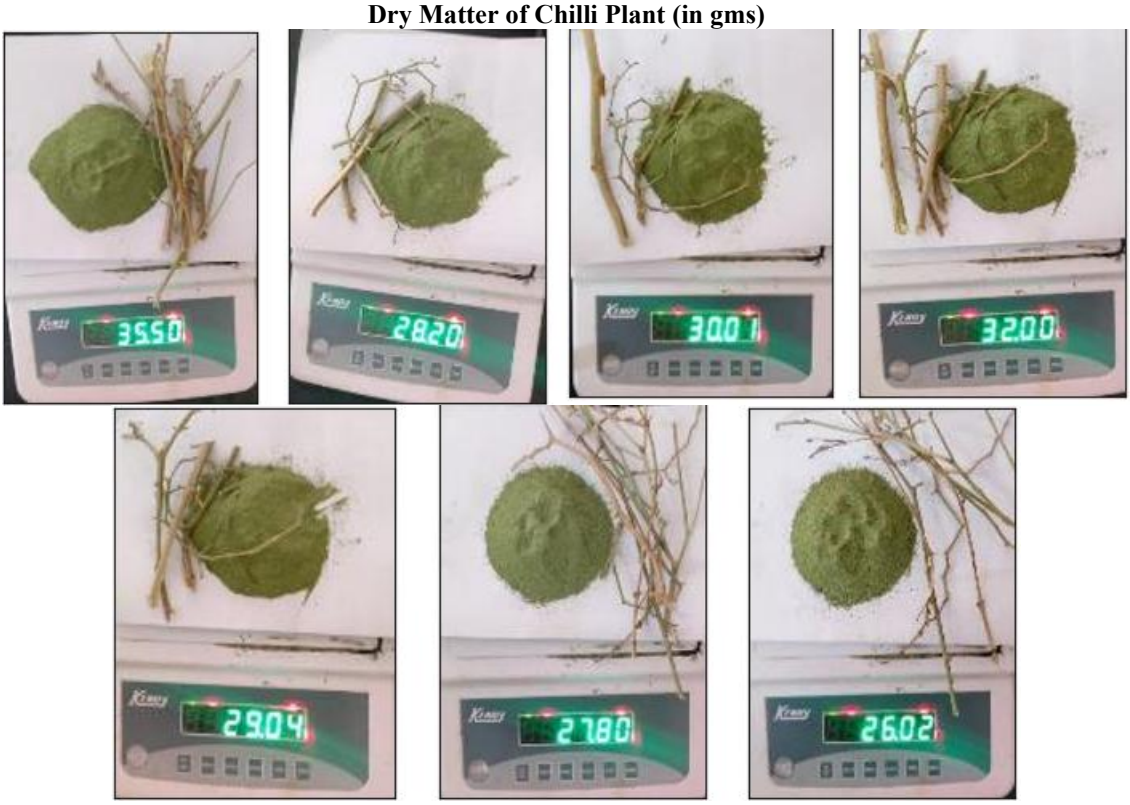

Figure 11: T1-35.50, T2-28.20, T3-30.01, T4-32.00, T5-29.04, T6-27.80, T7-26.02.

Yield Parameters of Chilli

T1 1st Picking **T1 2nd Picking**

T2 1st Picking **T2 2nd Picking**

T3 1st Picking T3 2nd Picking

T4 1st Picking T4 2nd Picking

T5 1st Picking T5 2nd Picking

T6 1st Picking T6 2nd Picking

T7 1st Picking T7 2nd Picking

Figure 12: Number of Fruits Per Plant

Fruit Weight Per Plant (in gms)

Figure 13: Mean values of the weight of fruit - T1- (89.46 & 91.20)- 90.3, T2- (83.77 &85.37) - 84.5, T3- (74.20 & 76.20) - 75.2, T4- (94.80 & 96.65) - 95.7, T5- (82.40 & 83.42) - 82.9, T6- (77.40 & 79.20) - 78.3, T7- (69.60 & 67.20) - 68.4

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