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Certificate

This is to certify that the work recorded in this thesis entitled "RHIZOSPHERIC STUDY IN BAEL (*Aegle marmelos* Correa) UNDER ALLEY CROPPING OF DIFFERENT BIOMASS YIELDING PLANTS" submitted in partial fulfillment of the requirements for the Degree of **Master of Science in Forestry (Silviculture and Agroforestry)** of the Faculty of Post-Graduate Studies, Birsa Agricultural University, Ranchi (Jharkhand) is the genuine record of the bonafide research work carried out by **Mr. Nandan Kumar Mishra** under my supervision and guidance.

The investigation results reported in this thesis have not so far been submitted for any other degree or diploma. It is further certified that such help or information received during the course of investigation and preparation of the thesis has been duly acknowledged.

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**RHIZOSPHERIC STUDY IN BAEL (*Aegle marmelos* Correa)
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YIELDING PLANTS**



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ABBREVIATIONS AND SYMBOLS USED

%	: Percentage
°C	: Degree centigrade
RBD	: Randomized Block Design
ICAR	: Indian Council of Agricultural Research
RCER	: Research Complex for Eastern Region
FSRCHPR	: Farming System Research Centre for Hill and Plateau Region
m	: Meter
cm	: Centimeter
mm	: Millimeter
e.g.	: Example
i.e.	: That is (Id est)
et al.	: and others
etc.	: And so forth
g	: Gram
kg	: Kilogram
ha	: hectare (10000 m ²)
Chl	: Chlorophyll
BD	: Bulk Density
pH	: Potential of hydrogen
EC	: Electrical Conductivity
SOC	: Soil Organic Carbon
N	: Nitrogen
P	: Phosphorus
K	: Potassium
Ca	: Calcium

Mg	: Magnesium
Zn	: Zinc
Fe	: Iron
Cu	: Copper
Mn	: Manganese
Fe	: Iron
(⁻¹)	: Per
No.	: Number
Max.	: Maximum
Min.	: Minimum
viz.	: namely (videlicet)
RH	: Relative humidity
ppm	: parts per million
BOD	: Bio Oxygen Demand
NS	: Non- significant
CD	: Critical Difference
CV	: Coefficient of Variation
SEm (±)	: Standard Error Mean

ABSTRACT

The roots are the parental part of the plant; the nature and the distribution of roots largely influence the plant growth and its productivity. But this half-hidden part, which is the root cause of all the problems and same is the solution to all the problems, are rarely touched. There are several studies relating to the above ground, but the below ground studies are rare or limited. Therefore, it becomes a great concern to work on this zone, particularly the rhizospheric ecosystem in an alley cropping system. Keeping all such perspectives and conditions of the present scenario, the research entitled "**RHIZOSPHERIC STUDY IN BAEL (*Aegle marmelos* Correa) UNDER ALLEY CROPPING OF DIFFERENT BIOMASS YIELDING PLANTS**" had been undertaken to develop a viable system which would be sustainable, an economically feasible and eco-friendly in nature. Two objectives were set for the successful conduct of this research; first, to study the effect of basin enrichment on plant growth, yield and root distribution of Bael plants, and second, to study the effect of basin enrichment on soil physical, chemical and biological properties in the plant basin.

A field experiment was conducted at ICAR- RCER, FSRCHPR, Plandu, Ranchi, Jharkhand during the period from June 2019 to December 2020. The field was laid out with Randomized Block Design (RBD) consisting of 4 replications and 11 treatments viz. Soil incorporation of vegetable soybean biomass (T₁), Mulching of vegetable soybean biomass (T₂), Soil incorporation of Tephrosia biomass (T₃), Mulching of Tephrosia biomass (T₄), Soil incorporation of rice bean biomass (T₅), Mulching of Rice bean biomass (T₆), Soil incorporation of Subabul biomass (T₇), Mulching of Subabul biomass (T₈), Soil incorporation of Weeds (T₉), Mulching of Weeds (T₁₀), and Control (T₁₁) under this research following parameters were studied such as plant height, trunk diameter, canopy

spread, fruit yield/plant, chlorophyll content of leaves, root weight, root volume, soil physical, chemical, and biological property. The data on various parameters were recorded under different treatments and analyzed statistically with the help of analysis of variance to draw a valid conclusion. The results revealed that the application of basin enrichment had no significant effect on the growth performance of Bael. The results also showed that the fruit yields were statistically *at par* in the treated and control plot. A significant difference was noticed in root weight and root volume relative to control and initial value. The maximum root weight and root volume were found under mulching of Subabul biomass (T₈), followed by Mulching of Tephrosia biomass (T₄), while the minimum was observed under Control (T₁₁).

A significant difference was also observed in soil physical, chemical and biological properties. The bulk density was highest in control compared to the other treatments in both the basin and alley areas. Soil moisture was also observed highest in all the treatments relative to control in both basin and alley area. The soil chemical properties like soil pH, soil organic C, available N, available P, exchangeable K, Ca, Mg and micronutrients were increased due to alley cropping practice respectively, compared to the control and the initial status of the experimental soil. Similarly, maximum (29.66×10^6 cfu g⁻¹ of soil) soil bacteria was noted under Mulching of Subabul biomass (T₈) in the month of September, 2020 and lowest (4×10^6 cfu g⁻¹ of soil) was with Control (T₁₁) in the month of July, 2019. Likewise, the fungal count was observed maximum (48.66×10^3 cfu g⁻¹ of soil) under Mulching of Vegetable Soyabean biomass (T₂) in month of September, 2020 while minimum (6.66×10^3 cfu g⁻¹ of soil) was observed in Control (T₁₁) in the month of July, 2019.

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Place: Ranchi

Date:

(Nandan Kumar Mishra)

Jharkhand, an eastern state of India, falls under the agro-climatic zone VII (Eastern Plateau and Hilly region), receiving annual rainfall of 1200 - 1600 mm. The climate ranges from dry semi humid to humid semiarid types. Despite adequate rainfall, cropped area and cropping intensity in the state are low due to undulating toposequences. The cultivable area is estimated at around 3.8 million ha, but the net sown area is 2.56 million ha, with irrigation covering just 12% of the cropped area. The total cultivable land in the State is 52% compared to 55% of the country, but only 43% of this is under net sown area compared to a national average of 76%. The soils of the region are low in organic carbon and available phosphorus content with a deficiency of micronutrients like Boron and Zinc. About 1.6 million ha (19% of total geographical area) is acidic. The region has a major problem of slight to moderate soil erosion as 74% of the areas are located on very gentle to gentle slopes.

Among various states of Eastern India (Eastern Uttar Pradesh, Bihar, Jharkhand, Odisha, Chhattisgarh, West Bengal, and Asam), Jharkhand has the highest area under wastelands/ degraded lands (14.84%), followed by Asam (11.20%) and Odisha (10.69%) (World Bank, 2007). The low lands and the medium uplands are used for rainfed rice production, whereas the uplands are rarely used for agronomical crop production. These uplands are either used as open pastures or for social forestry as per the conditions. Further, due to the lower productivity of rainfed crops, growing agricultural crops is unprofitable, particularly for upland, where water is one of the limiting factors. To ensure high returns from the underutilized and stressed lands and to improve the soil characteristics, alley cropping is one such possible alternative that can fulfill this need on a long-term basis. This system ensures increased and sustained crop production with minimum degradation of non-renewable soil resources base. This allows farmers to make

use of available land resources and yield varied products at different times with lower environmental costs

Alley cropping is a part of an agroforestry system in which trees are placed within agricultural cropland. In this system, arable crops are grown in between the hedges of woody shrubs and tree species, preferably legumes that are regularly cut back to minimize tree-crop competition for light, water, and nutrients (Tossah *et al.*, 1998). The pruned materials are incorporated into the soil at planting or during the cropping period so that pruned tree leaves add nutrients to the soil, improve the soil's physicochemical properties, and subsequently improve the growth and development of the allied crops (Miah, 1993). The choice of tree species for use in agroforestry is very important and to a large extent, determines the system's success or failure (Atta-Krah, 1983).

Species selected for alley cropping must be easy to establish, fast-growing, deep rooted, coppicious and have the ability to withstand frequent prunings and produce heavy foliage (Wilson *et al.*, 1986). Many trees and shrubs species have been evaluated for alley cropping in a different part of the world. Promising alley cropping leguminous or tree species being considered by IITA are *Lucaena leucocephala*, *Gliricidia sepium*, *Acioa barteri*, *Anthonatha macrophylla*, *Alchornea cordifolia*, *Cassia siamea*, *Sesbenia grandifolia* and *Flemingia congesta* (IITA Annual Report 1980). Among them *Gliricidia sepium*, *Indigofera tysmanii* and *Lucaena leucocephala* are the three most suitable species that can biologically fix N, can be established quickly by direct seeding, tolerate frequent pruning, produce huge amounts of biomass of high quality and under rapid decomposition release nutrients and are relatively long-lived (Ngambeki and Wilson, 1983).

The benefits of alley cropping in increasing crop productivity are well documented (Kang *et al.*, 1981; Atta-krah and Kolawole, 1987; Duguma *et al.*, 1988). Recycling of nutrients, erosion control, production of mulching material, green manure, staking material, fuelwood, and fodder are among the benefits of alley-cropping are also

cited (Yamoah *et al.*, 1986a; Yamoah *et al.*, 1986b; Lal, 1989; Budelman 1990; Fernandes *et al.*, 1993; Kang, 1993). However, farmers rarely use this practice because of the common concern of competition of these secondary crops with primary crops for water and nutrients (Hall *et al.*, 2006).

Many trials report low yields of crops grown adjacent to hedgerows that negate the benefits from yield increases in the centre of the alleys (Kang and Shannon, 2001). This reduction can be attributed to above-ground competition for light or below-ground competition for water and nutrients (Heinemann *et al.*, 1997). Most of the report shows above ground interaction, but the information on below ground interaction is rare or limited. Key issues of the below-ground environment and the level of competition that exists between different plant species grown together in an alley-cropping system need to be addressed before arriving at any conclusion about the benefits of the system. The management option that optimizes the efficient use of available resources should be evaluated and tested (Abdelkadir, 1997). A major production constraint in alley-cropping is the below-ground competition of trees with the companion food crops for available water and nutrients in the soil. Knowledge of root production and distribution, soil water, and nutrient availability in the alley cropping system, therefore, has significant practical relevance for matching suitable trees and crops so that they complement one another and share the available resources effectively for maximum productivity (Abdelkadir, 1997).

However, despite major efforts into tree root research in agroforestry in recent years (Ruhigwa *et al.*, 1992; Dhyani *et al.*, 1990; Jonsson *et al.*, 1988), the impact of tree roots on soils and associated crops in agroforestry associations are still poorly understood. Quantitative analysis of the positive and negative effects of tree roots and their changes in space and time is, therefore, necessary to optimize agroforestry associations (Das and Chaturvedi, 2008).

In order to assess the effect of below ground competition, it is essential to know the root distribution (Schroth, 1995), particularly the rhizospheric zone of an alley

cropping system. The rhizosphere is a dynamic region governed by complex interactions between plants and organisms in close association with the root (de la Fuente Cantó *et al.*, 2020). These interactions range from symbiotic relationships such as N₂ fixation and mycorrhizal associations to pathogenic interactions (Kennedy and de Luna, 2005). The microorganisms of the rhizosphere, directly and indirectly, influence the composition and productivity (i.e., biomass) of natural plant communities (van der Heijden, 1998; 2006; 2008, Schnitzer *et al.*, 2011). To maintain the ecology and biota of the rhizosphere a better understanding of the rhizosphere and its effects on organisms that inhabit this area will allow for manipulations that benefit plant production and the environment (Brahmaprakash *et al.*, 2017).

With this background, a project was initiated in 2014 in ICAR-RCER, Plandu, Ranchi (Capital districts of Jharkhand) to develop agroforestry technologies for the eastern plateau and hills region containing Bael (*Aegle marmelos*) as main crop with biomass yielding perennial crops like *Tephrosia candida*, *Leucaena leucocephala* and annual crops like rice bean, grain cowpea, vegetable Soybean. The study relating to the effect of basin enrichment in an alley cropping system has already been done. More information needs to be generated on the effect of biomass basin enrichment on biophysical dynamics around the rhizosphere. A better understanding of root distribution can help in the management strategies of crops in alleys.

Keeping the above facts in view, the present experiment "**RHIZOSPHERIC STUDY IN BAEL (*Aegle marmelos* Correa) UNDER ALLEY CROPPING OF DIFFERENT BIOMASS YIELDING PLANTS**" was carried out with the following **objectives**:

1. To study the effect of basin enrichment on plant growth, yield, and root distribution of Bael plants.
2. To study the effect of basin enrichment on soil physical, chemical, and biological properties in the plant basin.

The basin enrichment through alley cropping system in the form of soil incorporation and surface mulching is one of the effective tools by which plant growth, yield, soil physio-chemical and biological environment can be enhanced naturally in a sustainable manner and on a long-term basis. The available literature in relation to the experiment entitled "**RHIZOSPHERIC STUDY IN BAEL (*Aegle marmelos* Correa) UNDER ALLEY CROPPING OF DIFFERENT BIOMASS YIELDING PLANTS**" has been reviewed and presented in this chapter. The review related to this research are covered under the following heads.

2.1 Rhizosphere

2.2 Effect of basin enrichment on root distributions

2.3 Effect of basin enrichment on plant growth and yield

2.4 Effect of basin enrichment on soil physical property

2.5 Effect of basin enrichment on soil chemical property

2.6 Effect of basin enrichment on soil biological property

2.1 Rhizosphere

The growth and development of a plant are largely influenced by the soil environment, especially surrounding the roots. It is a microenvironment provided by the plant, where major contributors are the microbes. This region is specifically referred to as the 'rhizosphere,' representing a realm of greater nutritional activity, increased gas exchange, and enhanced release of root exudates, all of which collectively contribute to plant growth (Brahmaprakash *et al.*, 2017).

The term "rhizosphere" has been derived from the Greek word 'rhiza', meaning root, and 'sphere', meaning field of influence. It was first defined by German scientist Hiltner

(1904) as "the zone of soil immediately adjacent to legume roots that support high levels of bacterial activity". Organisms found in the rhizosphere include bacteria, fungi, oomycetes, nematodes, protozoa, algae, viruses, archaea and arthropods (Lynch, 1990; Raaijmakers *et al.*, 2009; Bonkowski *et al.*, 2009; Buée *et al.*, 2009).

The number and diversity of microorganisms are related to the quantity and quality of the exudates and the outcome of the microbial interactions that occur in the rhizosphere (Somers *et al.*, 2004). As the plant grows, they release various organic compounds in the form of the root exudates into the surrounding soil; it is a ubiquitous phenomenon (Jones and Darrah, 1995). Roots release compounds via at least two potential mechanisms, and the rates of exudation vary widely among species and environmental conditions (Kochian *et al.*, 2005).

Root exudates are mainly composed of water-soluble sugars, organic acids, and amino acids and contain hormones, vitamins, amino compounds, phenolics, and sugar phosphate esters (Uren, 2007). The qualitative and quantitative compositions of root exudates are affected by various environmental factors, including pH, soil type, oxygen status, light intensity, soil temperature, nutrient availability and the presence of microorganisms. These factors may have a greater impact on root exudation than differences due to the plant species (Singh and Mukerji, 2006).

The rhizosphere is a dynamic region governed by complex interactions between plants and organisms in close association with the root. These interactions range from symbiotic relationships such as N₂ fixation and mycorrhizal associations to pathogenic interactions (Kennedy and de Luna, 2005).

The microorganisms of the rhizosphere, directly and indirectly, influence the composition and productivity (i.e., biomass) of natural plant communities (van der Heijden, 1998; 2006; 2008, Schnitzer *et al.*, 2011). Hence, microbial species richness belowground has been proposed to predict above-ground plant diversity and productivity (De Deyn *et al.*,

2004; Hooper *et al.*, 2005; Van der Heijden *et al.*, 2008; Lau and Lennon, 2011; Wagg *et al.*, 2011). Wagg *et al.* (2011) further suggested that belowground diversity may act as insurance for maintaining plant productivity under different environmental conditions. Due to their sensitivity to small changes in abiotic conditions, including environmental stress and perturbation, soil and rhizosphere microbes are considered as bio-indicators of soil quality.

To maintain the ecology and biota of the rhizosphere, a better understanding of the rhizosphere and its effects on organisms that inhabit this area will allow for manipulations that benefit plant production and the environment (Brahmaprakash *et al.*, 2017). The numerous studies conducted over the past have clearly shown that the manipulation of rhizosphere interaction between different species intercropping has enhanced nutrient use efficiency and crop productivity. The facilitation in P and N nutrition under intercropping has been well documented, especially in intercropping systems between cereals and legumes (Ae *et al.*, 1990; Boucher and Espinosa, 1982; Horst and Waschkies, 1987; Li *et al.*, 2007; Midmore, 1993; Stern, 1993; Zhang and Li, 2003).

2.2 Effect of basin enrichment on root distribution

The root is the parental part of the plant; the nature and the distribution of the root largely influence plant growth and productivity. The root system is important for plant fitness because it provides anchorage, contributes to water use efficiency, and facilitates the acquisition of mineral nutrients from the soil (Lopez-Bucio *et al.*, 2005).

Chatterjee *et al.* (2017) reported that in sandy loam soil, application of wheat residue mulch resulted in a significant increase in root length density and root mass density of maize at 0–15 and 15–30 cm soil depth due to better availability of soil moisture and favourable soil temperature under mulching.

Li *et al.* (2006) conducted a field experiment to investigate the relationship between root distribution and interspecific interactions between intercropped plants. Roots were

sampled twice by auger and twice by the monolith method in wheat (*Triticum aestivum* L.)/maize (*Zea mays* L.) and faba bean (*Vicia faba* L.)/maize intercropping and in sole wheat, maize, and faba bean up to 100 cm depth in the soil profile. The results showed that the roots of intercropped wheat spread under maize plants and had much greater root length density (RLD) at all soil depths than sole wheat. The roots of maize intercropped with wheat were limited laterally but had a greater RLD than sole-cropped maize.

Acharya *et al.* (1998) reported that there was a significant increase in the root mass density of rainfed wheat under minimum tillage and lantana mulch that moderated the hydro-thermal regime compared to repeated conventional tillage in the maize-wheat cropping system.

Acharya and Bhagat (1984) reported that pine needle mulch applied on conventionally cultivated plots resulted in a much higher rooting density of maize in depths below 10 cm compared to that under no mulch.

Maurya *et al.* (1981) carried a field experiment to evaluate the effect of different mulch materials on soil properties and the root growth and yield of maize (*Zea mays*) and cowpea (*Vigna unguiculata*). The result showed that root density was generally high under straw mulch and low under unmulched flat and ridged treatments. The maximum shoot elongation rate was 5.5 cm/day with the straw mulch and 3.0 cm/day with the unmulched ridged treatment. In general, translucent polythene and straw mulch materials yielded more than unmulched ridges and transparent polythene treatments.

Lal (1978) conducted an experiment to check the Influence of within- and between-row mulching on soil temperature, soil moisture, root development and yield of maize (*Zea mays* L.) in tropical soil. He observed that the mean and maximum depth of root penetration were generally highest for treatments with mulched inter-row; however, root concentration was found to be significantly greater close to the mulched layer.

Chaudhry and Prihar (1974) worked on to determine the effect of mulching in root growth and rooting pattern in corn (*Zea mays* L.) and to relate these with changes in soil environment. Four cultural treatments, 1) control, 2) 5-cm deep post planting cultivation, 3) 2-cm thick straw mulch, and 4) interrow compaction, were established on sandy loam and loamy sand soils during 1970 and 1971. In the end, they found that straw mulch and cultivation enhanced root growth in the upper 15 cm of soil and increased the lateral spread of roots both years. They also found a high concentration of roots directly beneath the mulched layer.

2.3 Effect of basin enrichment on plant growth and yield

Da Costa Leite *et al.* (2019) studied to evaluate the growth, production, and leaf contents of macronutrients, as well as the yield of forage sorghum cultivated on the alleys of Gliricidia (*Gliricidia sepium* (Jacq.) Kunth ex Walp.) and Leucaena (*Leucaena leucocephala* (Lam.) de Wit) in the presence and absence of mineral fertilization. Cultivation in Leucaena alleys showed a higher leaf content of nitrogen (N) when compared to the single crop, both in the presence and absence of mineral fertilization. In the double crop, sorghum cultivated in Leucaena alleys without fertilization presented a higher forage yield (up to 67%) when compared to the single crop system. Overall, the alley crops improved the productivity of forage sorghum.

Xu *et al.* (2019) conducted an experiment including apple (*Malus pumila*)/peanut (*Arachis hypogaea*), apple/millet (*Setaria italica*) and apple/maize (*Zea mays*) alley cropping systems with conventional intercropping distance and corresponding monocultures. The results showed net present values of three alley cropping systems were on average 60.1% higher than the corresponding monocultures across the alley cropping period.

Deiss *et al.* (2017) worked to analyzed weed competition effects on soybean growth, grain yield, and yield components at different distances from 4- year-old eucalyptus

(*Eucalyptus benthamii*) in an alley cropping system, as well as in a sole-crop system. The result showed soybean yield components were mostly reduced between tree lines compared with sole-cropping without trees. Reduction in soybean yield in the agroforestry system was rather caused by competition from trees.

Bithi *et al.* (2014) performed a field experiment to check the effect on mustard under alley cropping systems developed with Subabul (*Leucaena leucocephala*). This experiment was carried out during the period from November 2013 to February 2014 in Randomized Complete Block Design (RCBD) with three replications. Different treatments of the experiment were T₀ = without fertilizer and manure, T₁ Subabul leaf biomass (ILB) as manure, T₂ = ILB + ½ RFD (Recommended Fertilizer Dose), T₃ = ILB + ¼ RFD recommended Fertilizer Dose) and T₄ (open field and without manure and fertilizer). They reported that the highest yield was 2.41 t/ha in ILB and ½ RFD treated plots and the lowest was 1.70 t/ha respectively in without fertilizer and manure treated plots. The yield of mustard was 5-7 % and 10-12 % lower in ILB + ¼ RFD treated condition and only ILB treated condition, respectively, compared to treatment T₂ (ILB and ½ RFD). The growth and yield of this crop were remarkably lower (40-50%) in control situation both inside and outside the alley cropping system, but in both control situation growth and yield of this crop was statistically similar.

Vekariya *et al.* (2014) experimented to find out suitable alley width and organic manure for groundnut crop. The interaction effect was found non-significant in respect of pod and haulm yield of groundnut and green biomass of gliricidia. Whereas, significantly higher soil moisture content was recorded under lopping of gliricidia applied as mulch with 9.6 m alley width. Growing groundnut with gliricidia at the alley width of 9.6 m gave the highest net returns of Rs. 15668 ha⁻¹ with the benefit: cost ratio of 1.12. While application of FYM @ 5 t ha⁻¹ gave the highest net returns of Rs.14230 ha⁻¹ as compared to control.

Basak *et al.* (2011) conducted a field experiment to evaluate the performance (growth and yield) of maize, soybean, and wheat during the hedge establishment period of alley cropping using three different treatment T₁ (with recommended fertilizer), T₂ (with manure) and T₃ (without fertilizer and manure). The result of the experiment was revealed that the yields in plots without manure and fertilizer application plots were very low and it reduced 40-45% compared to manure and fertilizer utilized plots. Thereby suggesting alley cropping system will be helpful for fertility development in an organic way.

Uwah and Iwo (2011) performed a field experiment to evaluate the effectiveness of organic mulch on maize productivity (*Zea mays*) for the period from 2007- 2009 by using the different rates of mulch (0, 2, 4, 6, and 8 t/ha). This experiment was done in a coastal plain of acidic soil in South East Nigeria. At the end of the experiment, they found that soil moisture reserves were highest at the 8 t/ha mulch rate, followed by the 6 t/ha rate. The unmulched control plots had the highest weed infestation, lowest soil moisture reserves, shortest plants and least number of leaves/plants. Plant height and number of leaves/plants were maximized at 8 t/ha rate, while dry stover yield, the weight of grains/cob and grain yield/ha peaked at 6 t/ha rate. The grain yield obtained at 6 or 8 t/ha rates was more than double that of the unmulched control plots.

Vanlalhluna *et al.* (2008) investigated the impact of mulches on tree growth and yield of ginger, turmeric and maize in a *Gmelina arborea* based agroforestry system studied during 2003-2005 in the humid tropic of India. They reported that the Mean Annual Increment (MAI) in height, collar diameter, crown diameter and biomass of the tree was higher in mulched treatments compared to control (without mulch). Amongst treatments, plots with subabul leaves mulch showed better growth of the tree (MAI) compared to other treatments (rice straw and weeds mulch). Plots having higher mulch doses (10 t/ha) also had more benefits to the growth compared to other treatments (8 and 6 t/ha). The crop yield from mulch application (ginger, turmeric and maize intercropping) was low in the first year,

which significantly ($P < 0.05$) increased after two years. The study depicts that mulching can be an effective tool to improve crop productivity under the *Gmelina arborea* based agroforestry system in the humid tropics of north east India.

Olasantan (2000) studied in an on-farm experiment to assess the effect of nitrogen rate with hedgerow prunings applied as mulch in *Gliricidia sepium* alley cropping system on weed control and growth and yields of okra and tomato. He examined that with total foliage from hedgerow pruning applied as a mulch, weed dry weight decreased significantly by 70-75% and 60-66% under okra and tomato, respectively, with and without fertilizer. It is concluded that application of a small amount (about 30 kg ha^{-1}) of nitrogen fertilizer with hedgerow prunings applied as mulch can suppress weed growth and increase fruit yield of okra and tomato under the *Gliricidia sepium* alley cropping system.

Ndiaye *et al.* (2000) performed a field experiment of a short-term maize variety and a tree legume (*Gliricidia sepium*) in an alley cropping system. The result showed equal cultivated areas; alley cropping provides a maize yield greater than that of maize grown in a pure stand without nitrogen fertilizer.

Mwangi *et al.* (1996) performed a field experiment to assess the use of leaf prunings of *Calliandra calothyrsus* and *Leucaena leucocephala* for soil fertility improvement in alley cropping and sole cropping systems. The result showed that alley cropped treatments yielded less maize and bean grain than sole cropped treatments during the 1993/94 short rainy season; thus, it was attributed to competition for growth resources.

Horst *et al.* (1995) studied maize and cassava alley yields with *Leucaena leucocephala* and *Cajanus cajan*. They found that the yields of maize crops were reduced mainly due to competition with the hedgerows for water and nutrients, as indicated by lower soil moisture and nitrogen concentrations in the soil solution and high root-length densities in plots with hedgerows.

Mureithi *et al.* (1995) conducted a field experiment of forage production based on Napier grass and *Leucaena* in an alley cropping system. After three years, results showed that compared with sole napier, the hedgerow treatment receiving slurry increased yield ha⁻¹ of Napier by 50%, total forage by 80%, and nitrogen (measured over two harvests) by 200%.

Tonye and Titi-Nwel (1995) performed a field experiment to assess the agronomic and economic evaluation of alley cropping under a maize/groundnut intercrop system. The result showed that in treeless (control) plots, maize grain yields decreased from 1.2 t ha⁻¹ in 1990 to 0.8 t ha⁻¹ in 1992, while groundnut yields declined from 1.1 to 0.5 t ha⁻¹ during the same period. With *Leucaena* pruning alone, groundnut yield was maintained around 1 t ha⁻¹ for three years while maize yields stabilized at 2.5 t ha⁻¹ in the second and the third year; the yields of both crops were greater over the three years than in control.

Korwar and Radder (1994) conducted an experiment to investigate the effect of root pruning and cutting interval of *Leucaena* hedgerows on alley cropped rabi sorghum. In their investigation, root pruning of *Leucaena* hedgerows increased sorghum yield and stover yield by 33% and 17 %, respectively, over the control (root not pruned). This increase can be attributed to a reduced competition of *Leucaena* hedgerows with sorghum crop for soil moisture as indicated by higher soil moisture in root pruned plots than control plots at sowing, flowering and harvest stages of sorghum crop.

Mathews *et al.* (1992) ran a study to evaluate the potential of alley cropping in maize production using *Leucaena leucocephala*, *Gliricidia sepium*, *Sesbania sesban*, *Albizia falcata*, *Flemingia congesta*, and *Cassia spectabilis* which were grown in alley crops with hybrid maize and soybean. The result showed that incorporating *Leucaena leucocephala* pruning resulted in an increase of up to 95% in yields. There was a significant correlation between the quantity of pruning biomass applied and the proportional increase in maize yields over the control treatment.

Rosecrance *et al.* (1992) conducted a field experiment to evaluate the effects of alley cropping on soil characteristics, weed populations, and taro. Taro yields were compared from *Calliandra calothyrsus* and *Gliricidia sepium* alleys, spaced at 4 m, 5 m, 6 m, and a no tree control. Measurements were made for soil moisture and temperature, weed growth, hedge biomass production, and taro growth and yield. Data was analyzed over 4 consecutive years, from 1988 to 1991. They found no improvement was in nitrogen, phosphorus, potassium, calcium, magnesium and organic carbon content in the alley plots compared to the controls. There was no positive yield effect of alley cropping on taro yield. Yields in the 5 m and 6 m alleys were not significantly different from the control, while the 4 m alleys produce significantly lower yields than the control. Thus, alley cropping did not prove a viable alternative to traditional shifting cultivation after four years of continuous cropping in this trial.

Onim *et al.* (1990) did an experiment using three multipurpose tree species, namely leucaena (*Leucaena leucocephala*), sesbania (*Sesbania sesban* var. *nubia*) and pigeonpea (*Cajanus cajan*). The following species were pruned at the height of 60 cm above the ground every two months, and the resulting plant biomass was incorporated into the soil as green manure. For comparison, maize (*Zea mays*) stover was also incorporated into some plots, while some other plots were left fallow. Varying quantities of plant biomass were incorporated into the soil over a period of 12 months, caused considerable changes in major soil plant nutrients, and it substantially improved soil fertility. To test for improved soil fertility, test crops of maize and beans (*Phaseolus vulgaris*) were grown on the test plots after six biomass incorporations of 4806, 13603, 16659 and 7793 kg ha⁻¹ for pigeonpea, sesbania leucaena and maize, respectively. Responses of the test crops indicated that sesbania and leucaena green manures improved maize stover, cobs and grain yields, and bean haulms and grain yields by 77.6% when compared to fallow plots.

Singh *et al.* (1989) performed a field experiment to examine below ground interaction in sorghum (*Sorghum bicolor* Moench)-leucaena (*Leucaena leucocephala* Lam. de Wit) alley cropping system. The result showed that the growth and yield of crops declined from 150 to 30% of the sole crop as the distance from the hedgerows decreased from 5 to 0.3 m. The presence of the root barrier had a marked effect on crop growth and completely eliminated any reduction in crop yield, although shading by the hedgerows reached 30 to 85% of full sunlight. From the above result, the author concluded that alley cropping in the semi-arid tropics induces competition for moisture between the trees and crops, which may severely reduce crop yield.

2.4 Effect of basin enrichment on soil physical property

Jeyamangalam *et al.* (2015) evaluated the effect of different organic amendments and their combination on various physical properties of soil and groundnut crop. They observed that the bulk and particle density of the soil has decreased as compared to control. The water holding capacity, pore space, saturated moisture, hydraulic conductivity and permeability were found to increase considerably.

Jordan *et al.* (2010) performed a field experiment to examine the effects of mulching on soil physical properties and runoff under semi-arid conditions in southern Spain. After a 3-years investigation, they reported mulching application significantly improved the physical and chemical properties of the studied soil with respect to control. Bulk density, porosity and aggregate stability were also improved with increasing mulching rates.

Surekha and Rao (2009) studied the influence of organic sources (paddy straw dhaincha) in combination with chemical fertilizers on soil quality in the irrigated rice-rice system at Hyderabad. They observed that the organic sources improved the soil bulk density, fertility (soil organic carbon and available N and K) and biological (soil respiration) parameters over inorganic fertilizers alone.

Dahiya *et al.* (2003) conducted a field experiment on ratoon sugarcane in fine loamy soil and observed that sugarcane trash and enriched sugarcane trashed and enriched sugarcane trashed mulch decreased soil bulk density, salt accumulation and increased *in-situ* saturated hydraulic conductivity.

Guled *et al.* (2002) studied the watershed on Typic Chromustert at Madabhavi. They found that green gram residue incorporation or sunhemp green manure integrated with chemical fertilizer improve physical properties such as infiltration rate, bulk density, particle density, pore space, water holding capacity, hydraulic conductivity, water stable aggregate.

Reddi *et al.* (2001) studied that incorporating 5 t ha⁻¹ organic residues in combination with fertilizer resulted in improvement in infiltration rate, hydraulic conductivity, stable water aggregate, and moisture retention.

2.5 Effect of basin enrichment on soil chemical property

Kumar *et al.* (2014) conducted the field experiment during the period 2010 and 2011 to study the effect of plant spacing (30 cm × 30 cm and 45 cm × 30 cm) and four mulches pine needles (*Pinus roxburghii*), poplar leaf (*Populus deltoides*), silver oak (*Grevillea robusta*) tree leaf mulch and unmulched control on growth, yield, quality of stevia and soil fertility. After the completion of the experiment, they found that mulched plots significantly increased organic carbon (OC), available nitrogen (N), phosphorus (P) and potassium (K), bacterial and fungal populations compared to unmulched plots. Tree leaf mulches also enhanced soil biological activities.

Rahman *et al.* (2010) conducted a field experiment to investigate the changes in maize production and soil properties in an Alley cropping system. The result showed an increased trend in soil properties in terms of organic C, total N and CEC in alley cropping treatments, especially in *G. sepium* and *L. leucocephala* alleys compared to the initial and control soils.

Youkhana and Idol (2009) investigated the effect of tree pruning mulch on soil C and N in a shaded coffee agroecosystem in Hawaii. Chipped tree pruning residues (mulch) were added to coffee plots shaded with the *Leucaena* hybrid KX2 over three years and reported that mulch additions significantly increased soil C and N in the top 20 cm by 10.8 and 2.12 Mg ha⁻¹, respectively. In the no-mulch treatment, there was no significant change in soil C or N concentration, but a decline in soil bulk density led to a significant decline in total soil C. *Leucaena* mulch can provide an important source of organic C and N to coffee agroecosystems and can help sequester C lost as plant biomass during shade tree management.

Okonkwo *et al.* (2009) carried out a field experiment to assess the changes in soil properties under existing alley cropping system with three leguminous crops (*Leucaena leucocephala*, *Gliricidia sepium*, and *Cajanus cajan*) with five treatments consisting of 10 t ha⁻¹ each of *L. leucocephala*, *G. sepium* and *C. cajan* prunings, 300 kg ha⁻¹ of 20:10:10 and a control. The result showed that the soil pH increased from pH 4.2 (strongly acid) in the pre-planting to pH 6.1 (slightly acid) in *C. cajan* alley plots. The organic matter increased from 1.01 g kg⁻¹ in the pre-planting to 5.98 g kg⁻¹ in the *C. cajan* alley plots in 2005. Total N increased in all the alley plots with the highest N content of 2.31 g kg⁻¹ in the *G. sepium* alley plots, which was 68% in 2003, 90% in 2004 and 95% in 2005 over the pre-planting. Available P and exchangeable Ca and Mg increased significantly in the alley plots over the pre-planting. The EC increased in line with exchangeable bases. Total acidity and Al³⁺ saturation were very low in the alley plots.

Issac *et al.* (2003) conducted field experiment to check the effect of pruning using *Leucaena leucocephala* (Lam.) De Wit on soil C and N dynamics in an alley cropping system. After 3.5 years, surface soil samples with pruning's applied as mulch or incorporated at planting had, respectively, 20 and 16% higher organic C, 34 and 18% higher organic N

concentrations, higher potential C and N mineralization and higher relative N mineralization than with prunings removed.

Kaur *et al.* (2000) performed a field experiment to analyze the role of agroforestry systems in improving soil organic matter status, microbial activity and nitrogen availability of soil. The result showed that microbial biomass was higher by 42% (microbial C) and 13% (microbial N) in tree-based systems than monocropping. Soil carbon increased by 11–52% due to the integration of trees along with the crops. Also, the soil inorganic N levels were higher by 8–74% and nitrogen mineralization by 12–37% compared to monocropping.

Kang *et al.* (1998) studied the long-term effects of woody species grown in hedgerows in alley cropping and soil tillage on soil properties, runoff and erosion, and crop performance. In this six land use systems were compared: *Leucaena leucocephala* and *Gliricidia sepium* hedgerows planted at 2 and 4 m interhedgerow spacings and tilled, no-till and tilled controls without hedgerows. After 5 years, results showed that hedgerows and no-till treatments maintained higher soil organic carbon (Org. C) and exchangeable cations contents. Highest Org. C and exchangeable cations were observed in plots with 4 m *Leucaena* hedgerows. Treatments with hedgerows also showed lower soil bulk density than the controls. Mean maize yields for the five years showed the following order: 4 m *Leucaena* > 4 m *Gliricidia* > 2 m *Leucaena* > 2 m *Gliricidia* > no-till control > tilled control plots.

Chander *et al.* (1998) The effects of growing trees in combination with field crops on soil organic matter, microbial biomass C, basal respiration and dehydrogenase and alkaline phosphatase activities were studied in soils under a 12-year-old *Dalbergia sissoo* (an N₂-fixing tree) plantation intercropped with a wheat (*Triticum aestivum*) – cowpea (*Vigna sinensis*) cropping sequence. The inputs of organic matter through *D. sissoo* leaf litter increased, and crop roots decreased with the increase in tree density. Higher organic C and total N, microbial biomass C, basal soil respiration, and dehydrogenase and alkaline

phosphatase activities were observed in treatments with tree-crop combination than in the treatment without trees. Soil organic matter, microbial biomass C and soil enzyme activities increased with the decrease in the spacing of the *D. sissoo* plantation. The results indicate that adoption of the agroforestry practices led to an improved organic matter status of the soil, which is also reflected in the increased nutrient pool and microbial activities necessary for long-term productivity of the soil. However, tree spacing should be properly maintained to minimize the effects of shading on the intercrops.

Larbi *et al.* (1993) studied the effect of managing hedgerow foliage for mulch and fodder in *Leucaena leucocephala* and *Gliricidia sepium* alley farming systems on maize grain yield and soil chemical characteristics. They found that yields increased as the proportion of mulch applied, also soil organic carbon, nitrogen and available phosphorus tended to increase with increasing proportion of prunings applied as mulch.

Brasil (1992) studied to evaluate the effect of legume mulches on the yield of maize and cowpeas and soil fertility. The result showed that applications of mulch to the soil increased the levels of OM in the soil, contributed to weed control and reduced labour costs. However, competition for light, water, and nutrients between the legumes and the annual crops negatively affected the yield of the crops.

Sangsinga *et al.* (1988) conducted a field experiment to evaluate the nitrogen contribution from the shoot and root system of symbiotically grown leucaena with maize in an alley cropping system. The result showed maize in plots that received prunings from inoculated leucaena contained more N, and grain yield was increased by 1.9 t ha⁻¹. Also, the application of prunings from inoculated leucaena resulted in higher soil organic C, total N, pH and available NO₃.

Yamoah *et al.* (1986) studied to evaluate the effects of pruning of leguminous shrubs on some soil properties in an alley cropping system. They found that soil chemical

properties were improved in alley cropped sites. Soils under Cassia had the highest N, P, K and organic carbon content with values of 0.344%, 45.6 ppm, 0.55 meq/100g and 2.32%, respectively, after the second maize crop. Bulk density, mean aggregate diameters, and water holding capacity were better in the alley cropped sites relative to control. Gravimetric moisture content was generally higher in the alley cropped sites and highest under Cassia.

Kang *et al.* (1981) conducted a field experiment to investigate the effect of Leucaena pruning on soil and maize in an alley cropping system. In this system, maize was grown in 4 m width alleys between Leucaena hedge rows. After the experiment, the result showed higher maize grain yields with the addition of pruning compared to control (without pruning). The addition of pruning also increased total soil N and organic C levels.

2.6 Effect of basin enrichment on soil biological property

Microorganisms are core drivers of soil nutrient cycling and soil quality improvement (Delgado-Baquerizo *et al.*, 2016; Jiao *et al.*, 2018). Several studies have revealed that soil microorganisms are sensitive to changes in soil attributes (e.g., organic matter content and soil moisture availability) arising from agricultural management practices (Drenovsky *et al.*, 2004; Buyer *et al.*, 2010). Therefore, mulching practices can alter the microbial community composition and diversity by improving the soil physicochemical environment (Buyer *et al.*, 2010; Chen *et al.*, 2014; Zheng *et al.*, 2018). Dutta and Majumder (2009) also stated that the mulches have a substantial impact on enhancing the sustainable yield and quality of fruit. It improves the physical and chemical attributes of the soil and the availability of the nutrient pool and biological qualities by increasing beneficial soil microbes.

Lalruatsangi *et al.* (2018) performed a field experiment to study the effects of paddy straw and rice husk mulching on acid lime during 2014-2015 in Randomized Block Design compared with control (without mulch). The study revealed that the microbial

population of the soil was found to be highly significant. The higher microbial population count for bacteria was observed in paddy straw mulch (83.45×10^5 cfu/g) as compared to rice husk mulch (74.88×10^5 cfu/g), while the minimum was found in control (14.06×10^5 cfu/g). Likewise, the highest microbial population count for fungi was observed in rice husk mulch (119.34×10^5 cfu/g) compared to paddy straw mulch (54.77×10^5 cfu/g). In contrast, no microbial growth of fungi was observed under control (no mulch).

According to Krishnakumar *et al.* (2005), the addition of organic matter results in an increase of secondary and micronutrients in the soil, which in turn helps increase the microbial population. Like this, many other studies have also reported the increased soil microbial population (Bhagat *et al.*, 2016) and augmented microbial activity under mulch-covered soil (Chen *et al.*, 2017).

Lee and Jose (2003) carried out the field experiment to assess the soil respiration rate and microbial biomass under two age classes (young and old) of pecan (*Carya illinoensis*) – cotton (*Gossypium hirsutum*) alley cropping system, two age classes of pecan orchards, and a cotton monoculture on a well-drained, Redbay sandy loam (a fine-loamy, siliceous, thermic Rhodic Paleudult) in the southern USA. From the following experiment, they concluded that trees in agroforestry systems have the potential to enhance soil fertility and sustainability of farmlands by improving soil microbial activity and accreting residual soil carbon.

Tiquia *et al.* (2002) reported that total microbial biomass after the application of fertilization and mulching was significantly higher than that in bare soil plots. Similarly (Treseder, 2008; Tu *et al.*, 2006) showed the impact of mulching and fertilization on microbial biomass and activity, likely by improving the carbon and water availability for soil microbes. Tu *et al.* (2006) further reported an increase of microbial biomass by 42% in straw mulching compared to non-mulching soil.

A field experiment entitled "RHIZOSPHERIC STUDY IN BAEI (*Aegle marmelos* Correa) UNDER ALLEY CROPPING OF DIFFERENT BIOMASS YIELDING PLANTS" was conducted during the period from July, 2019 to December, 2020 at ICAR- RCER, FSRCHPR, Plandu, Ranchi, Jharkhand. The details of the experimental site, materials used, the methodology adopted and the procedures followed for the experiment are outlined in this chapter.

3.1 Experimental Site

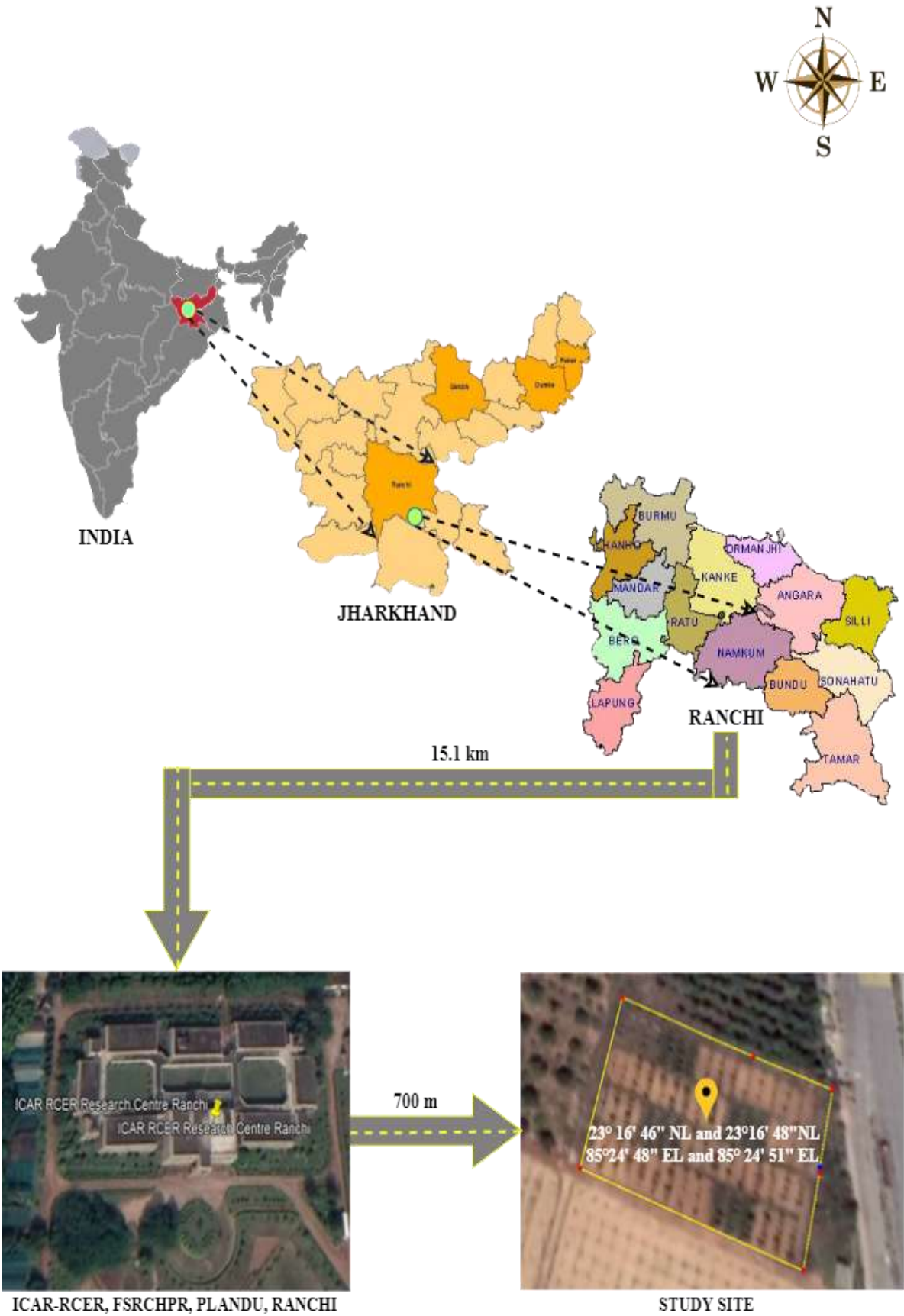
3.1.1 Location

Geographically location of the study site lies between 23° 16' 46" N and 23°16' 48" N latitude and 85° 24' 48" E and 85° 24' 51" E longitude with an average elevation 629m (2,064ft) above sea level. The topography of the region is generally undulating since it falls under the eastern plateau hill region. The research station of ICAR-RCER, FSRCHPR, is 15.1 km away from Ranchi and 26.2 km away from Birsa Agricultural University. The NH-33 and SH-01 pass through Namkum, connecting it to major cities such as Kolkata and Jamshedpur in the east of India.

3.1.2 Climate

This region has a subtropical climate characterized by hot summers from March to May and well-distributed rainfall during the southwest monsoon from June to October. The Winter season in the area is marked by dry and cold weather during the months of November to February.

Plate- 3.1: Map view of the study site



The details of monthly meteorological data obtained from the meteorological observatory during the experimental period from July, 2019 to December, 2020 are presented in the table.

Table- 3.1: Monthly Meteorological data of the study site (July, 2019 to December, 2020)

Months	No. of Rainy days	Rainfall(mm)	Temperature (°C)		Average Relative humidity (%)
			Average Maximum	Average Minimum	
2019					
July	14	243	30.5	25.95	90.33
August	20	387	29.78	25.39	91.52
September	15	267	30	24.39	91.43
October	6	217	29.04	20.13	90.54
November	0	0	28.2	15.08	90.64
December	3	24	22.91	9.82	89.13
2020					
January	3	23	23.38	10.04	88.27
February	2	7	26.06	10	89.32
March	9	91.2	28.03	13.25	75.41
April	7	106.8	32.94	17.14	69.23
May	5	17	34.51	22.77	90.41
June	12	254	31.05	25.1	92.21
July	19	304	32.12	26.08	91.18
August	19	541	30.72	25.43	90.17
September	15	177	31.88	24.93	89.21
October	4	11	30.82	20.74	88.82
November	0	0	27.98	13.18	81.98
December	1	4	25.40	8.85	87.14

(Source: Meteorological Department, ICAR- RCER, FSRCHPR, Plandu, Ranchi, Jharkhand.)

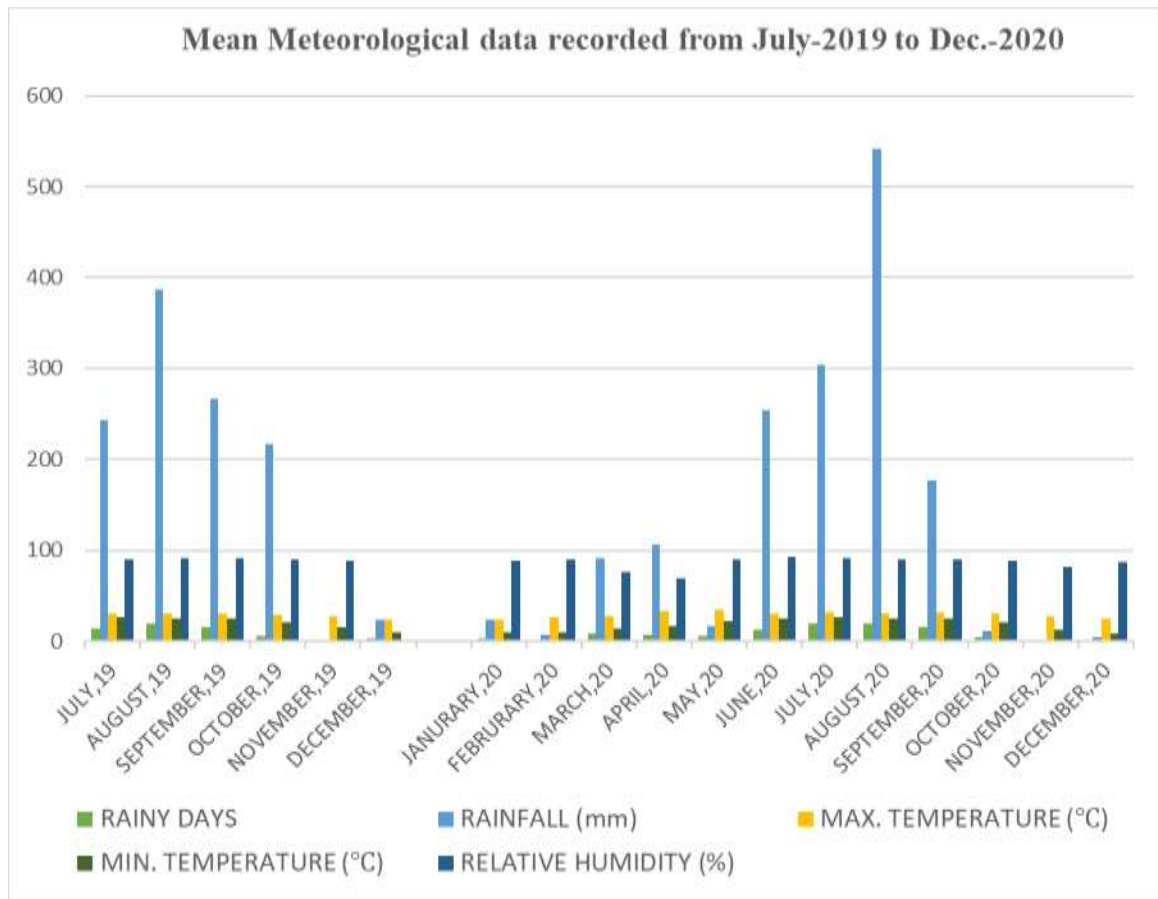


Figure-3.1: Graphical representation of meteorological data

3.1.3 Rainfall

The estimated average annual rainfall of this region ranges from 1400- 1430mm. About 82% of the annual precipitation comes from the southwest monsoon season, which lasts from mid-June to September. The number of rainy days in the region varies from a minimum of 90 days to a maximum of 100 days. The maximum amount of rainfall received during the year 2019 and 2020 was the month of August (387 mm, 541 mm).

3.1.4 Temperature

The mean monthly maximum temperature of the area ranges from 22.91°C to 34.51°C and the mean monthly minimum temperature of the area ranges from 8.85 °C to 26.08 °C. During the period from July, 2109 to December, 2020, the mean monthly

maximum temperature was recorded in May, 2020 (34.51°C) and the minimum was recorded in December, 2020 (8.85 °C).

3.1.5 Soil

The soil at the experimental location was sandy loam in texture, with low organic carbon and available nitrogen, medium available phosphorus, and high available potassium; nevertheless, to determine the actual nature of the soil due to the plantation, a detailed examination of the physiochemical character in the area was performed. The soil sample was collected one prior to the experiment and the other was taken at the end of the investigation, taking two different depths (0- 15 cm and 15- 30 cm) cm using a soil auger. The collected soil sample was air-dried in the shade, then oven-dried and made into powdered form and were subjected to physiochemical analysis.

3.2 Experimental details

The field experiment was conducted in a Randomized Block Design with eleven treatments, each of which was replicated four times. The details of the layout, treatments and experimental materials are presented in the table below:

Location	ICAR- RCER, FSRCHPR, PALANDU, RANCHI
Design	Randomized Block Design (RBD)
Treatments	11
Replications	4
Total no. of plot	44 (Each plot carries two treatments)
Total number of trees in one plot	5
Total number of trees in the experimental field	220
Area of a single plot	(15 m x 12.5 m) = 187.5 m ²
The total area of the research plot	(90m x 50 m) = 4500 m ²

Experimental materials:

Main Crop	Spacing	
Bael (<i>Aegle marmelos</i> Corr.) <ul style="list-style-type: none"> ▪ Variety: Pant Aparna ▪ Age: 6 Years 	Plant to plant 2.5 m	Row to row 5 m

Biomass Yielding Plants in Alleys	Spacing	
<ul style="list-style-type: none"> ▪ Vegetable soybean (<i>Glycine max</i>) * ▪ White tephrosia (<i>Tephrosia candida</i>) ** ▪ Rice Bean (<i>Vigna umbellata</i>) * ▪ Subabul (<i>Leucaena leucocephala</i>) ** ▪ Weed** ▪ Control 	Plant to plant 20 cm	Row to row 30 cm

* Annual crop (sown in May- June, 2019 and 2020 harvested in September, 2019 and 2020)

** Perennial crop (harvested three times in a year i.e May, September and December, 2019 and 2020)

Treatments Details: -

Treatments	
T ₁	Alley cropping of Vegetable soybean and soil incorporation of biomass in bael plant
T ₂	Alley cropping of Vegetable soybean and mulching of the biomass in bael plant basin
T ₃	Alley cropping of Tephrosia and soil incorporation of biomass in bael plant
T ₄	Alley cropping of Tephrosia and mulching of the biomass in bael plant basin
T ₅	Alley cropping of Rice bean and soil incorporation of biomass in bael plant
T ₆	Alley cropping of Rice bean and mulching of the biomass in bael plant basin
T ₇	Alley cropping of Leucaena and soil incorporation of biomass in bael plant
T ₈	Alley cropping of Leucaena and mulching of the biomass in bael plant basin
T ₉	Soil incorporation of weed obtained from alley area
T ₁₀	Mulching of weed obtained from alley area
T ₁₁	Control

Treatments Referred as	
T ₁	Soil incorporation of vegetable soybean biomass
T ₂	Mulching of vegetable soybean biomass
T ₃	Soil incorporation of Tephrosia biomass
T ₄	Mulching of Tephrosia biomass
T ₅	Soil incorporation of rice bean biomass
T ₆	Mulching of Rice bean biomass
T ₇	Soil incorporation of Subabul biomass
T ₈	Mulching of Subabul biomass
T ₉	Soil incorporation of Weeds
T ₁₀	Mulching of Weeds
T ₁₁	Control

Layout of the Experimental Field

Plate- 3.2: Layout of the Experimental Field

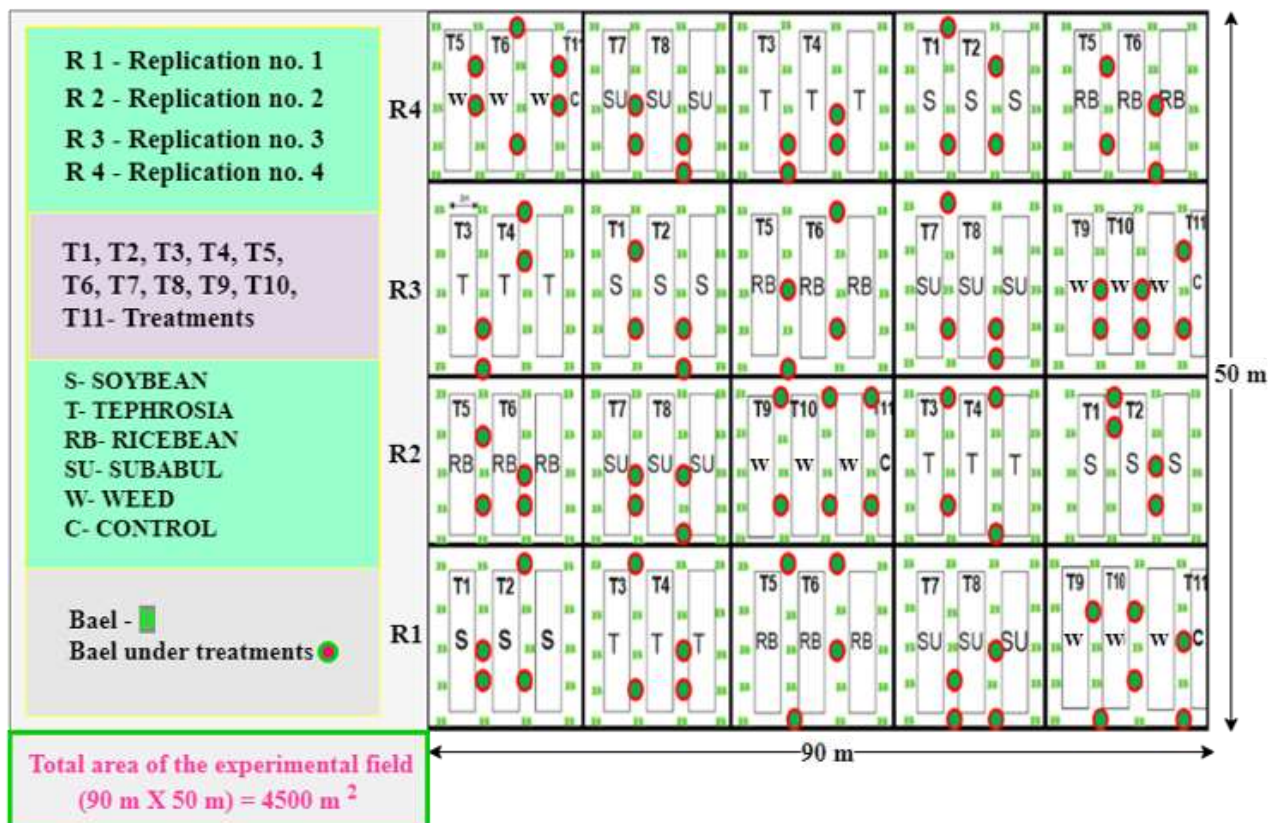
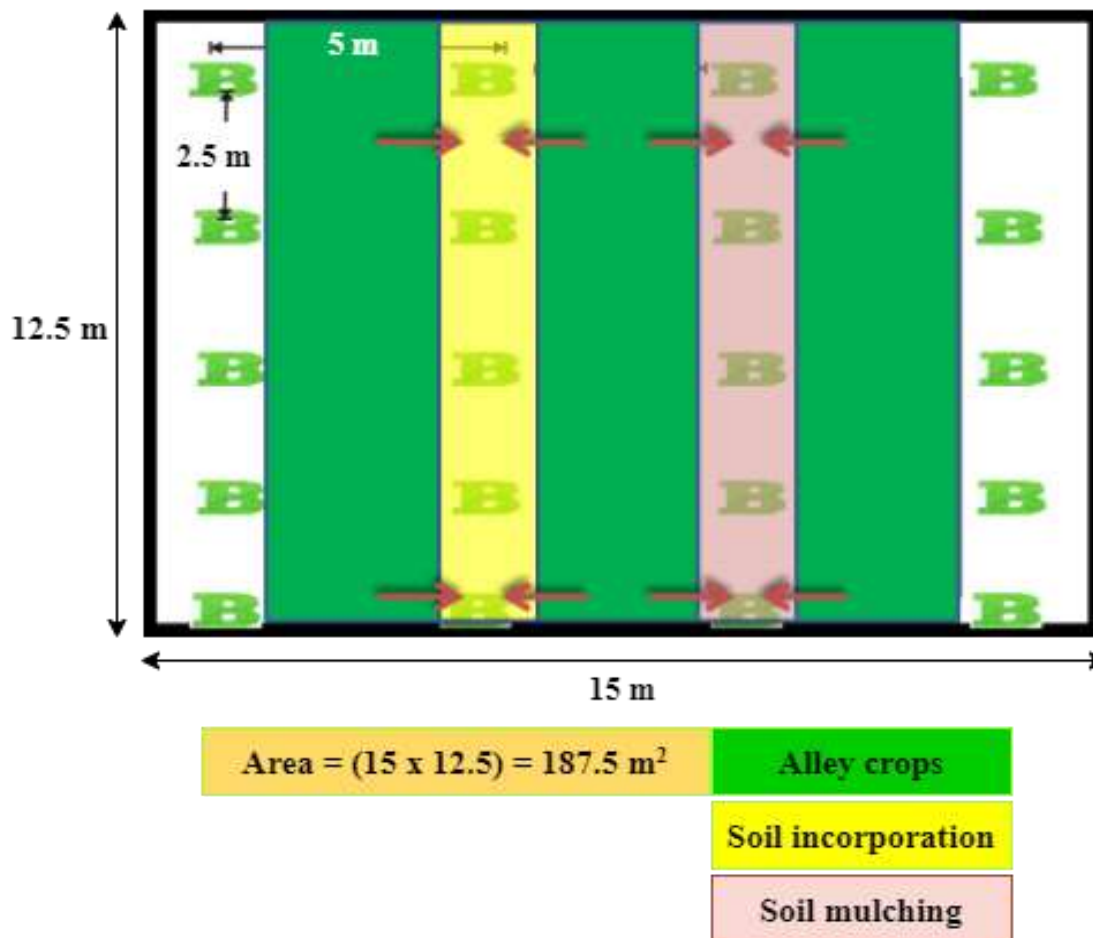


Plate 3.3: Layout of plot of a particular alley crop having two treatments



3.3 Details of the experimental materials

3.3.1 Bael (*Aegle marmelos* Correa):

The bael (*Aegle marmelos* Correa) is an important indigenous fruit of India. It belongs to the family Rutaceae, often termed as 'underutilized minor fruit'. It is also known as 'Bengal quince', 'Indian quince', 'Golden apple', 'Holy fruit', 'Stone apple', 'Bel', 'Bela', 'Sriphal', 'Belgeri', 'Baelpatra', 'Bilva', 'Maredoo' and finds mention in Ramayana, Yajurveda, Buddhist and Jain literature. According to Hindu custom, the trifoliate aromatic leaves of the tree traditionally used as a sacred offering to 'Lord Shiva'. It grows throughout India peninsular as well as in Srilanka, Pakistan, Bangladesh, Burma, Thailand and most of the South - East Asian countries.

The species is a medium-sized deciduous tree that grows slowly and can reach a height of 12 to 15 meters. Being hardy, it is ideal for dry land horticulture and an economical tree planting programme. It can grow on a wide range of soil with a pH of 5-10 and can tolerate temperatures as low as 7 °C and as high as 48 °C.

Bael has got multiple benefits; several parts of the tree such as leaves, fruits, stems and roots are used at all stages of maturity. Fresh half-ripe Bael fruit is mildly astringent and used to treat dysentery, diarrhea, hepatitis, tuberculosis, dyspepsia and is safe for the heart and brain. The mature fruits are used for the preparation of high-quality soft drinks and beverages. It has a very calming effect and protects the body system by maintaining body temperature during hot summer. The ripe fruit is used for the preparation of murrabba, candy, toffee and bael powder. The fruit is rich in Vitamin 'B' (Riboflavin) and has a decent proportion of Vitamin 'A', Vitamin 'C' and minerals such as calcium, phosphorus potassium and protein content in ripe fruit is very high.

According to Gopalan *et al.* (1971), Bael fruit contains 61.5 gm of water, 1.8 gm of protein, 0.39 gm of fat, 1.7 gm of minerals, 3.1 gm of carbohydrates, 55 mg. of carotene, 0.31 mg. of thiamine, 3.19 mg. of riboflavin, 1.1 mg. of niacin and 8 mg of vit. C per 100 g edible portion of the fruit. No other fruit has high riboflavin content of this nature. Mukherjee and Ahmad (1957) had also stated that the riboflavin content was very high for the mature Bael fruit. A chemical study of Bael seeds showed that the seed contained 62 percent protein (2% water soluble and 60% water insoluble), 30% oil, 3% carbohydrates and 3% ash (Banerjee and Maiti, 1980). Roots have antidiarrhoeic, antidote to snake venom, anti-inflammatory and wound healing properties. The leaves and seed oil have pesticidal properties.

Because of its productive potential and multiple benefits such as nutritional, medicinal, environmental as well as commercial importance makes it more demanding

from an agroforestry point of view. Also, it can easily grow in any soil, climate and does not require much management.

3.3.2 Soybean (*Glycine max* (L.) Merrill)

Glycine max is an annual herbaceous plant in the Fabaceae family, grown for its edible seeds. The soybean plant is usually an erect bush with woody stems and alternately arranged leaves. The leaves have three individual leaflets, which are oval or lance-like in shape, growing to a length of 3–10 cm (1.2–4.0 in). The soybean plant produces small white or purple flowers and curved seed pods with a long, hairy seed of length 3–15 cm (1.2–6 in) and can contain between 1 and 5 seeds. The colors of the seeds may be yellow, orange, black or molted. Soybean is an annual plant, surviving only one growing season and can reach heights of 0.2–1.5 m (0.7–1.4 ft) depending on the variety. Soybean may also be referred to as soybean or soya and originates from Northeast China.

Soybean is a short-day plant that can grow on a large variety of soils but grows best on a light, loose, well-draining loam with a pH of 6.5 and ambient temperatures between 15 °C and 27 °C. Plants are sensitive to waterlogging but are tolerant of drought conditions once established. Like several legumes, soybeans can fix atmospheric nitrogen due to the presence of symbiotic bacteria from the rhizobia group.

Soybean is primarily a pulse crop but in India mostly grown as an oilseed. In general, average yield of soybean ranges from 1.6 to 1.9 t/ha. Soybean seeds contain high protein, equivalent to milk and eggs, in the range of 35 - 40%. It is rich in oil (20%), vitamins and minerals. It one of the best and cheapest sources of protein and is a staple of human and animal diets. Soybeans and entire plants are also commonly used for animal fodder and pasture, hay, and silage and grown as a cover crop (green manure). Moreover, it is an ideal intercrop.

3.3.3 Rice Bean (*Vigna umbellata* (Thunb.) Ohwi and Ohashi)

Vigna umbellata (Thunb.) Ohwi and Ohashi, previously *Phaseolus calcaratus*, is a warm-season annual vine legume with yellow flowers and small edible beans. Generally known as ricebean or rice bean. To date, it is little known, little researched and little exploited. It is regarded as a minor food and fodder crop. It is often grown as an intercrop or mixed crop with maize (*Zea mays*), sorghum (*Sorghum bicolor*) or cowpea (*V. unguiculata*), as well as a sole crop in the uplands, on a minimal area. Like other Asiatic *Vigna* species, ricebean is a comparatively short-lived warm-season annual. Cultivated mainly as a dried pulse, it is also essential as fodder, green manure and vegetables. The variety matures within 125 days and gives 6 quintals/acre of average yield. Being leguminous it helps to fix nitrogen and increases soil fertility. Ricebean is the most widely grown as an intercrop, particularly with maize, throughout Indo-China and extending into southern China, India, Nepal and Bangladesh. In the past, it was widely grown as a lowland crop on residual soil water after harvesting long-season rice but has been increasingly displaced where shorter term rice varieties are grown. It is a short-lived perennial legume typically grown as an annual. It has a very variable habit: it may be erect, semi-erect or twining. It is normally 30-100 cm in height but may grow up to 200 cm. It has a comprehensive root system with a taproot that can be as deep as 100-150 cm. The stems are branched and finely haired. The leaves are trifoliate with entire 6-9 cm long leaflets. The flowers, born on 5-10 cm long axillary racemes, are papilionaceous and bright yellow. The fruits are cylindrical, 7.5-12.5 cm long pods containing 6-10 oblong, 6-8 mm seeds of concave hilum.

Because of its wider adaptability, ricebean can thrive on a wide range of soils, including shallow, infertile, or degraded soils. It does better in areas where annual rainfall ranging from 1000 to 1500 mm and average temperatures range from 18 to 30°C with a pH in the range 6 - 7.5.

3.3.4 Bhoomi Shudha (*Tephrosia candida*)

Tephrosia candida, a white hoary pea, is a perennial shrub native to India in the legume family. It has been introduced to Malaysia, South America, Africa, South East Asia and Australia. The natural habitat of *T. candida* is a mainly primary and secondary forest in seasonally dry tropical climates, along riverbanks and now also disturbed land, agricultural fields, roadsides, on sandy soils in coastal areas and even on steep slopes and very poor, eroded uplands.

T. candida is an erect herb, shrub or small tree, up to 3.5 m tall, with straggling branches from the base; it typically grows up to 3.5 meters tall, occasionally reaching 5 meters. Leaves are compound, with 13-27 leaflets. Leaflets are narrowly ovate, with a sharp or blunt tip, 2.5-7.5 cm long, 0.6-1.3 cm wide, smooth above, velvety below. White pea-like flowers appear in racemes on branches. The racemes are up to 25 cm long. Flowers are 2-2.5 cm long. Sepal cups are 5-8 mm long, densely hairy, with the sepals shorter than a tube. The seed pods are 6-10 cm long, 8-9 mm wide, densely covered with brown or grey hairs.

T. candida grows in the seasonally dry tropics up to 1600 m altitude, with average annual temperatures of 18-28°C and average annual rainfall of 700-2500 mm. It does not tolerate any frost or waterlogging. It prefers acid soils, tolerating a soil pH of as low as 3.5; the more acidic soils often appear more suitable. It also grows on coastal sands, degraded upland soils and mine spoils where few other plants grow.

At harvest, it produces about 25-30 tonnes of green leaves per hectare. With its ability to fix large amounts of atmospheric nitrogen and produce a good bulk of biomass, white tephrosia is commonly used in agroforestry as a green manure crop to regenerate the degraded land etc. Not only does it supply nitrogen, but the plant also increases soil phosphorus and potassium levels compared to the rise in organic matter. The Soil structure

improves, water retaining capacity and permeability increases, and the soil loss caused by water erosion decreases. It can yield well on acid soils; for example, in Vietnam, the green-matter content of the soil increased from 1.7 to 4%. It is widely used for hedgerows, providing mulch for various upland crops. The leaves of *T. candida* are high in protein (17%) and can be used as fodder for pigs and cattle. When the species become woody with age, it provides suitable fuel wood.

3.3.5 Subabul (*Leucaena leucocephala* (Lam.) de Wit)

Leucaena leucocephala is a medium-sized fast-growing tree with a large root system belonging to the Fabaceae family. It is native to Southern Mexico and Northern Central America, and now has been naturalized in several tropical and sub-tropical areas. It grows up to 20 m height. The Leaves look like tamarinds, with white flowers tinged with yellow, and long flattened capsules. The seeds are dark brown with a hard, glossy coat of seed.

L. leucocephala is a plant of the tropics; it succeeds at altitudes up to 1,500 meters, occasionally to as high as 2,100 meters. It grows well with an average annual temperature range of 25 – 30°C and an average yearly rainfall of 650 - 3,000 mm. It likes well-drained soil in full sun. Tolerant to a wide range of soils, including limestone, wet and dry soils, soils of volcanic origin, and those with moderate salt levels. It is found in the wild on shallow limestone soils and coastal sand. Prefers a pH in the range 6 - 7.7, tolerating 5 - 8.5. Plants are very tolerant of drought and salt-laden winds.

It has multipurpose uses; the various parts of this plant-like root, the leaves, stem bark, wood and seeds are highly useful to human beings and animals. The stem has a high timber value. The leaves are used as animal feed because of their high nutritional value. The leaves of leucocephala are also used as green manure in organic farming. On an average subabul produces about 5-10 tons/ha-year of dry edible biomass and 40-50 tons/ha-year of fresh woody biomass. Since it has a large number of roots with root

nodules aids to help fix the atmospheric nitrogen significantly. The hardwood is used to make major agricultural implements like a spade, pick-axe, ploughing tools, and shelves for rearing honey bees. *L. leucocephala* is an excellent firewood species with specific gravity and high calorific value. The oil extracted from the kernel is used as a bio-fuel. It is planted as a living fence around the garden as ornamental, firebreak and windbreak. The product obtained from the plant is natural and eco-friendly. So, it is very apt to call as the miracle tree.

3.4 Observations recorded for the Bael plant

3.4.1 Above ground parameters

Diameter (cm): The diameter of an individual plant in each replication was measured from 10 cm below the lowermost branch of the Bael tree using a vernier digital calliper.

Total height (m): The height of the individual plant in each replication was measured from ground level to the tip of the plant with the help of an altimeter.

Canopy spread (m): Canopy spread was measured in both the direction N-S and E-W by measuring the spread of canopy with the help of measuring tape, and then their mean value was taken using the formula:

Calculation,

$$\text{Canopy spread} = \frac{D1+D2}{2}$$

Where,

D1 = Canopy Spread in N-S

D2 = Canopy Spread in E-W

Fruit yield: Number fruit produced per plant was counted and fruit yield per plant in kg was recorded.

3.4.2 Biochemical properties of Bael leaves

Estimation of chlorophyll (mg g⁻¹f.w.)

The estimation of chlorophyll was done by the method as suggested by Hiscox and Israelstam, (1979) using the reagent Dimethyl sulphoxide (DMSO): (CH₃)₂SO. In this method, accurately weighed 100 mg of clean mature green leaf sample was taken and immersed in 10 ml of DMSO (AR-grade of SRL Chem. Co. Mumbai). The samples were incubated at 70°C for 4 hr in a hot air oven. Then, it was taken out, and 1 ml of the solution was diluted to 5 ml with pure DMSO, and the sample was read on a UV-VIS double beam spectrophotometer at 645 and 663 nm wavelengths. Pure DMSO was used as blank.

Calculation,

$$\text{Chlorophyll 'a' (mg g}^{-1}\text{f.w.)} = \frac{(12.7 \times \text{OD}_{663}) - (2.69 \times \text{OD}_{645}) \times \text{volume} \times \text{dilution}}{1000 \times \text{weight of the sample}}$$

$$\text{Chlorophyll 'b' (mg g}^{-1}\text{f.w.)} = \frac{(22.9 \times \text{OD}_{645}) - (4.68 \times \text{OD}_{663}) \times \text{volume} \times \text{dilution}}{1000 \times \text{weight of the sample}}$$

3.4.3 Below ground parameters

For the better record of the data, the belowground parameters such as root weight, root volume, microbial count and soil moisture were studied only under the mulch treatments, i.e., T₂, T₄, T₆, T₈, T₁₀, T₁₁, while the treatments under soil corporation, i.e., T₁, T₃, T₅, T₇, T₉ were not taken under study because the soil biota of this areas gets disturbed during incorporation of biomass.

Root weight & root volume: This was done using the Coring method. In the coring method, soil cores were obtained by driving hollow tubes into the soil, taking two different distances of 50 cm and 100 cm at two different depths 30 cm and 60 cm, from the basal region of Bael plant. From soil core, roots were separated from it by washing with water.

- The roots so collected were categorized as (thick size roots, $4\text{ mm} >$), (thin to medium size roots, $2\text{-}4\text{ mm}$) and (fibrous roots, $< 2\text{ mm}$).
- The root volume, their fresh weight was measured. These roots were then placed in the oven at 60°C for one week to find their dry weight.
- This was done twice, one before sowing of alley crops and others at the end of the experiment to find the extend of root distribution.

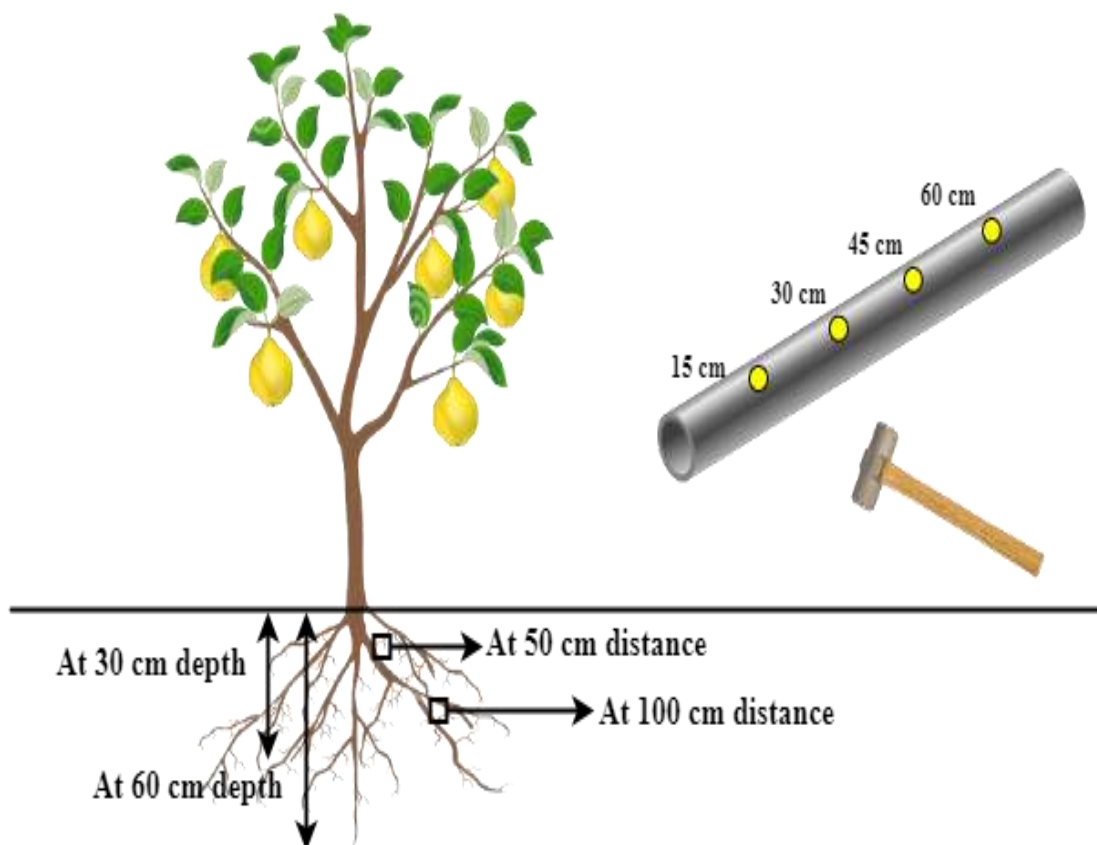


Plate-3.4: Core method of excavation for root studies at different radial distances and depths

3.5 Observations recorded for soil

3.5.1 Physical Properties of Soil

3.5.1.1 Bulk density

The Bulk density was done using the core method (Bodman, 1942). In this method, a metal core was pressed into the soil at different depths and was carefully removed to

preserve a known volume of samples as it existed. The samples were oven-dried to 105°C and weighed. The Bulk density (g cm^{-3}) was calculated using the following expression

$$\text{Bulk density (g cm}^{-3}\text{)} = \frac{\text{Oven dry weight of soil (g)}}{\text{Volume of the soil (cm}^3\text{)}}$$

3.5.1.2 Moisture content

The soil sample for moisture content was collected at 0-15 cm and 15-30 cm depth from the treatment of each replicate in a monthly interval. For the collection of soil samples, aluminium boxes were used. The weight of fresh soil samples was taken immediately on pan balance and oven-dried at 105 °C for dry weight. The soil moisture was calculated by the gravimetric method using the following formula:

$$\text{Soil moisture (\%)} = \frac{(\text{Fresh soil weight} - \text{Oven dry weight})}{\text{Oven dry weight}} \times 100$$

3.5.2 Chemical properties of Soil

The soil sample was collected from the experimental area from the depth of 0-15 cm and 15- 30 cm to estimate the soil's chemical properties. The samples were collected twice, one at the beginning of the experiments and the other at the end of the experiments. The collected soil sample was air-dried, powdered and sieved to a size of 2 mm prior to chemical analysis. The composited samples were used to analyze and determine the chemical properties like soil pH, EC, soil organic carbon, available N, P and exchangeable K, Ca, Mg, and micronutrients such as Zn, Cu, Fe and Mn. The different methods followed for the analysis of chemical properties of soil are as follows:

3.5.2.1 Soil pH

The pH of the soil was measured by potentiometry (pH meter). For this purpose, soil: water suspension was prepared in the ratio of 1: 2.5 (10 g soil and 25 ml distilled water). The suspension was shaken at regular intervals for half an hour. The pH meter was calibrated, and then the sample was analysed to know the pH value.

3.5.2.2 Electrical Conductivity

The electrical conductivity indicates the amount of soluble (salt) ions in the soil. The determination of electrical conductivity (EC) of soil was made with a conductivity cell by measuring the electrical resistance of a 1: 2.5 soil: water suspension. The unit of measurement for electrical conductivity is expressed in microSiemens per centimeter ($\mu\text{S cm}^{-1}$).

3.5.2.3 Estimation of Soil Organic Carbon

Estimation of soil organic carbon was done by the titration method as suggested by Walkley and Black (1934) using the following reagent 1 N $\text{K}_2\text{Cr}_2\text{O}_7$, Conc. H_2SO_4 , $(\text{NH}_4)_2\text{Fe}(\text{SO}_4)_2$, H_3PO_4 and Diphenylamine indicator. In this method, a 1 g soil sample was taken in a 500 mL conical flask. Then 10 mL of 1N $\text{K}_2\text{Cr}_2\text{O}_7$ was added to it, followed by the addition of 20 mL of concentrated H_2SO_4 . After swirling a little, the flask contents were placed on an asbestos sheet for half an hour. Then 200 mL of distilled water and 1ml of diphenylamine indicator was added in a 500 mL conical flask, a titration was done with $(\text{NH}_4)_2\text{Fe}(\text{SO}_4)_2$ until the colour changes from blue-violet to parrot green. A blank was operated simultaneously without soil. The percentage amount of OC existing in a unit mass of the soil sample was determined by the following expression.

Calculation,

$$\text{Organic Carbon \%} = \frac{10(B-S)}{B} \times 0.003 \times \frac{100}{\text{MASS OF SOIL TAKEN}}$$

Where,

B and S denote the titre values (mL) for the blank and sample, respectively.

3.5.2.4 Estimation of available Nitrogen

The estimation of available nitrogen was done by the Kjeldahl method as suggested by Subbiah and Asija, 1956 using the following reagents 2.5 % NaOH , 0.32% KMnO_4 , 2.5% H_3BO_3 , 0.02 N H_2SO_4 , Methyl red 40 mL and Bromo cresol green 60 mL. In this

method, firstly, the system was loaded with the above reagent and was set in process for 9 min. Then 5 g of air-dried soil was taken into the digestion tube and was loaded for distillation. After 9 min, the sample colour in a conical flask changed from pink to blue, which was the endpoint. The distillate solution was then titrated with 0.02 N H₂SO₄ until the blue colour change to pale pink. The blank sample without soil was also titrated in a similar manner simultaneously, and the value was noted down.

Calculation,

$$\text{Available N (Kg ha}^{-1}\text{)} = \frac{(S-B) \times N \text{ of H}_2\text{SO}_4 \times 14 \times 2.24 \times 10^6}{\text{Wt.of Soil Sample} \times 1000}$$

Where,

B and S denote the titre values (mL) for the blank and sample, respectively.

3.5.2.5 Estimation of Available Phosphorus

The estimation of available phosphorus was done by the method as suggested by Bray and Kurtz (1945) using the following reagents bray solution, molybdate-tartrate solution, Ascorbic acid solution, 7 N H₂SO₄ and 100 ppm KH₂PO₄. In this method, 5 gram of soil sample was taken in 250 mL of a conical flask, and then 50 mL of extractant bray solution (0.03 N NH₄F + 0.025 N HCl) with a pinch of charcoal was added to it. The suspension was shaken for about 5 min on a reciprocating shaker. The mixture was then filtered through a Whatman no. 1 filter paper. About 5 mL of filtrate was taken in 25 mL of the volumetric flask to which 4ml of ascorbic was added, and to make the solution of 25 mL, the rest distilled water was added to it. The solution was then kept for about 30 min to develop a blue colour, and after this sample was measured by spectrophotometer at 660 nm wavelength. The wavelength produced by the different standard solutions of KH₂PO₄ was plotted to prepare a graph.

Based on the graph obtained by plotting the value of the different standard solutions of KH₂PO₄, the linear equation (y = mx + c) was formed. The value of the sample was then calculated using this linear equation.

3.5.2.6 Estimation of Exchangeable Potassium

The estimation of exchangeable potassium was done by the method as described by Jackson (1973) using the following reagents 1 N Ammonium acetate ($C_2H_7NO_2$). In this method, 5 g of soil was taken in the conical flask. Then 1N of 25ml of ammonium acetate was added to it. The solution was shaken for about 15 min. The mixture was then filtered through a Whatman no. 1 filter paper, and the potassium concentration in the filtrate was determined by flame photometry.

Calculation,

$$\text{Available K (Kg ha}^{-1}\text{)} = C \times \frac{25}{5} \times 2.24$$

Here, C = Concentration of K (ppm) in the sample.

3.5.2.7 Estimation of calcium and magnesium

Estimation of exchangeable calcium and magnesium was done by EDTA method as suggested by Hesse (1971) using the following reagents 1N Ammonium acetate ($C_2H_7NO_2$), 0.01 N Triplic, Erichrome black T (EBT), $NH_4CL + NH_4OH$, Callon solution and 16% NaOH. In this method, 10 g soil was taken, a 25 mL sample extractant (1:2) (soil: water) was mixed with 10 drops of buffer solution and a pinch of Erichrome black T indicator. Titrated against EDTA solution and total hardness of soil samples were determined. Similarly, a 25mL sample was taken in 5-drops of NaOH solution was added together with a pinch of calcium indicator. It was further titrated again with EDTA, and the percentage of calcium was computed.

Calculation,

$$\begin{aligned} & \text{meq of Ca or } \frac{\text{Mg}}{100} \text{ g of soil} \\ & = \text{Titrate value} \times \text{Titriplex (0.01 N)} \times \frac{\text{Volume of extract (25ml)}}{\text{Volume of aliquot(1ml)}} \times \frac{100}{\text{wt. of soil}} \end{aligned}$$

3.5.2.8 Estimation of Available Iron, Manganese, Zinc and Copper

The estimation of available Iron, Manganese, Zinc and Copper was done by the method as suggested by Lindsay and Norvell (1978) using the following reagents Diethylene triamine penta acetic acid (DTPA), CaCl_2 and Triethanol amine (TEA). Diethylene triamine penta acetic acid (DTPA) acts as a chelating agent and bind with free metal ions in solution to form soluble complexes of Fe, Mn, Cu and Zn. In this method, 10g of soil sample was shaken with 20 mL of DTPA for two hours. The filtrate was collected in bottles. The element was detected by using Atomic Absorption Spectrophotometer. The instrument was calibrated each time with a standard solution of the element before analyzing the sample solution.

Calculation,

Micronutrients (ppm) = Conc. of micronutrients from curve (ppm) x dilution factor

Micronutrients (mg kg^{-1}) = 2 x Micronutrients (ppm)

3.6 Biological properties

3.6.1 Microbial activity (Fungi and Bacteria count)

The microbial activity was determined as suggested by Waksman, 1952. In this study, separate media was prepared for both bacteria and fungi. The media for the study of bacterial colony prepared was Thornton's media (Composition: 1g K_2HPO_4 , 0.2 g $\text{MgSO}_4 \cdot 7\text{H}_2\text{O}$, 0.1 g CaCl_2 , 0.1 g NaCl , FeCl_3 , KNO_3 , 1g Asparagine, 1g Mannitol, 15g Agar, 1000 mL distilled water) and media for the study of fungal colony was Martin's Agar media (composition: 10 g Glucose, 5 g Peptone, 1g K_2HPO_4 , 0.5 g $\text{MgSO}_4 \cdot 7\text{H}_2\text{O}$, 15 g Agar- agar, 1000 mL distilled water, 30 mg/ mL Streptomycin). Isolation of fungi and Bacteria populations was done by serial dilution plate method. In this method, 1g of soil sample was taken in the 250 mL conical flask containing 10 mL sterilized distilled water to

make 1: 10 dilutions. The flask was swirled for 15 min to prepared the homogenous solution. 1mL of this solution was transferred to another 2nd tube containing 9 mL of the sterilized solution to make 1: 100 dilutions. Thereafter, 1ml of this solution was transferred to the third test tube containing 9 mL of the sterilized solution to make 1: 1000 dilutions. This process of dilution was continued till the sixth test tube to make the dilution 1:1000000.

The fungal count was done selecting the third test tube of dilution 1: 1000 was taken from which 1ml was transferred into a Petri dish containing rose Bengal agar medium. The Petri dish was then gently rotated to disperse the suspension. Three replicates of each sample were maintained. The Petri dish was then placed in a BOD incubator $25 \pm 1^\circ\text{C}$ for three days. After three days, the number of colonies formed by the fungus was then counted.

To calculate the bacterial population, sixth test tube of dilution 1: 100000 was taken. 1 mL of this dilution was transferred into a Petri dish containing nutrient agar medium. The Petri dish was then gently rotated to disperse the suspension. Three replicates of each sample were maintained. The petri dish was then placed in a BOD incubator $30 \pm 1^\circ\text{C}$ for five days. After five days, a number of colonies formed by the bacteria were then counted.

3.7 Statistical Analysis

To determine the significant difference between the treatments and draw the valid conclusions, the data obtained were subjected to statistical analysis by ‘Analysis of Variance’ as described by Panse and Sukhatme (1954). The significance of the treatment difference was tested by “F” test (Variance ratio) at 5 percent level. Further, mean values for different parameters were calculated and presented along with Standard Deviation (SD), Standard Error (SE) and Critical Difference (CD) at 5%.

In this chapter, results obtained from an investigation entitled “**RHIZOSPHERIC STUDY IN BAEI (*Aegle marmelos* Correa) UNDER ALLEY CROPPING OF DIFFERENT BIOMASS YIELDING PLANTS**” are presented and discussed with past relevant literature and supportive data. The data on various parameters were recorded under different treatments and analyzed statistically with the help of analysis of variance to draw a valid conclusion. The results are shown in the form of tables and graphs as per the objective in the following manner.

4.1 To study the effect of basin enrichment on plant growth, yield and root distribution of Bael plants

4.1.1 Effect of treatments on the height of the Bael plant

The data relating to the effect of treatments on the height of the Bael plant were statistically analyzed and presented in table 4.1. The result clearly shows that the different treatments had a non-significant effect on the height of the Bael plant.

Table 4.1: Effect of treatments on the height of the Bael plant

Treatments	Bael plant: Height (m)		
	July- 2019	Dec- 2020	
T ₁ - Soil incorporation of Vegetable Soybean biomass	4.03 ± 0.24	4.61 ± 0.27	
T ₂ - Mulching of Vegetable Soybean biomass	4.10 ± 0.56	4.80 ± 0.52	
T ₃ - Soil incorporation of Tephrosia biomass	4.23 ± 0.15	4.95 ± 0.07	
T ₄ - Mulching of Tephrosia biomass	4.03 ± 0.35	4.77 ± 0.40	
T ₅ - Soil incorporation of Rice bean biomass	3.97 ± 0.13	4.62 ± 0.21	
T ₆ - Mulching of Rice bean biomass	4.23 ± 0.74	4.78 ± 0.71	
T ₇ - Soil incorporation of Subabul biomass	3.85 ± 0.55	4.65 ± 0.66	
T ₈ - Mulching of Subabul biomass	3.60 ± 0.40	4.43 ± 0.50	
T ₉ - Soil incorporation of weed	3.86 ± 0.74	4.50 ± 0.61	
T ₁₀ - Mulching of weed	3.55 ± 0.37	4.16 ± 0.06	
T ₁₁ - Control	3.59 ± 1.05	4.11 ± 0.81	
	<i>SE(m) ±</i>	<i>0.32</i>	<i>0.29</i>
	<i>C.D. (5%)</i>	<i>NS</i>	<i>NS</i>
	<i>C.V. (%)</i>	<i>14.23</i>	<i>11.31</i>

4.1.2 Effect of treatments on trunk diameter of the Bael plant

The data relating to the effect of treatments on the trunk diameter of the Bael plant were statistically analyzed and presented in table 4.2. The result clearly shows that the different treatments had a non-significant effect on the trunk diameter of the Bael plant.

Table 4.2: Effect of treatments on trunk diameter of the Bael plant

Treatments	Bael plant: Trunk diameter (cm)		
	July- 2019	Dec- 2020	
T ₁ - Soil incorporation of Vegetable Soybean biomass	7.65 ± 1.35	10.20 ± 1.67	
T ₂ - Mulching of Vegetable Soybean biomass	8.44 ± 2.08	10.33 ± 2.30	
T ₃ - Soil incorporation of Tephrosia biomass	8.27 ± 2.01	11.47 ± 2.36	
T ₄ - Mulching of Tephrosia biomass	9.98 ± 0.59	12.48 ± 0.96	
T ₅ - Soil incorporation of Rice bean biomass	8.50 ± 1.00	11.53 ± 0.90	
T ₆ - Mulching of Rice bean biomass	8.75 ± 0.76	11.79 ± 1.06	
T ₇ - Soil incorporation of Subabul biomass	7.56 ± 2.54	10.34 ± 3.83	
T ₈ - Mulching of Subabul biomass	7.40 ± 2.29	10.17 ± 2.50	
T ₉ - Soil incorporation of weed	8.83 ± 2.52	11.42 ± 2.13	
T ₁₀ - Mulching of weed	7.82 ± 2.15	10.16 ± 2.27	
T ₁₁ - Control	7.72 ± 3.39	9.55 ± 3.87	
	<i>SE(m) ±</i>	<i>0.88</i>	<i>1.09</i>
	<i>C.D. (5%)</i>	<i>NS</i>	<i>NS</i>
	<i>C.V. (%)</i>	<i>18.52</i>	<i>17.51</i>

4.1.3 Effect of treatments on Canopy spread of the Bael plant

The data relating to the effect of treatments on the trunk diameter of the Bael plant were statistically analyzed and presented in table 4.3. The result clearly shows that the different treatments had a non-significant effect on the Canopy spread (m) of the Bael plant.

Table 4.3: Effect of different treatments on Canopy spread of Bael plant

Treatments	Bael plant: Canopy spread (m)		
	July- 2019	Dec- 2020	
T ₁ - Soil incorporation of Vegetable Soybean biomass	2.86 ± 0.25	3.50 ± 0.19	
T ₂ - Mulching of Vegetable Soybean biomass	3.00 ± 0.26	3.55 ± 0.18	
T ₃ - Soil incorporation of Tephrosia biomass	3.02 ± 0.58	3.63 ± 0.56	
T ₄ - Mulching of Tephrosia biomass	3.17 ± 0.24	3.80 ± 0.20	
T ₅ - Soil incorporation of Rice bean biomass	3.27 ± 0.40	3.85 ± 0.40	
T ₆ - Mulching of Rice bean biomass	2.98 ± 0.40	3.54 ± 0.34	
T ₇ - Soil incorporation of Subabul biomass	2.40 ± 0.99	3.20 ± 0.80	
T ₈ - Mulching of Subabul biomass	2.38 ± 0.81	2.99 ± 0.76	
T ₉ - Soil incorporation of weed	2.94 ± 0.85	3.50 ± 0.87	
T ₁₀ - Mulching of weed	2.65 ± 0.44	3.34 ± 0.48	
T ₁₁ - Control	2.57 ± 0.72	3.04 ± 0.66	
	<i>SE(m) ±</i>	0.27	0.24
	<i>C.D. (5%)</i>	<i>NS</i>	<i>NS</i>
	<i>C.V. (%)</i>	16.82	12.37

4.1.4 Effect of treatments on fruit yield of the Bael plant

The data relating to the effect of treatments on the fruit yield (kg) of the Bael plant were statistically analyzed and presented in table 4.4. The data revealed a significant difference among all treatments. The both fruit yield and fruit number per Bael plant were found maximum in the treatment T₁- Soil incorporation of Vegetable Soybean biomass (9.82 kg and 9.11) respectively while no fruit yield and fruit number were found in the treatment T₁₁: Control.

The above results are in conformity with earlier studies done by Uwah and Iwo (2011) in their studies; they found that the Plant height and number of leaves/plants were maximized at 8 t/ha rate, while dry stover yield, the weight of grains/cob and grain yield/ha peaked at 6 t/ha rate. The grain yield obtained at 6 or 8 t/ha rates was more than double that of the unmulched control plots. Also, Onim *et al.* (1990) reported that application of sesbania and leucaena green manures improved maize stover, cobs and grain yield, and bean haulms and grain yield by 77.6% when compared to fallow plots.

Table 4.4: Effect of treatments on fruit yield of the Bael plant

Treatments	Bael plant: Fruit yield (kg)	
	Fruit yield (kg)	Fruit No.
T ₁ - Soil incorporation of Vegetable Soybean biomass	9.82 ^a ± 1.15	9.11 ^a ± 0.84
T ₂ - Mulching of Vegetable Soybean biomass	3.11 ^e ± 0.43	2.66 ^{ef} ± 0.58
T ₃ - Soil incorporation of Tephrosia biomass	4.96 ^{cd} ± 0.67	3.55 ^{de} ± 1.26
T ₄ - Mulching of Tephrosia biomass	4.52 ^d ± 0.87	3.50 ^{de} ± 1.32
T ₅ - Soil incorporation of Rice bean biomass	2.60 ^e ± 0.41	2.00 ^f ± 0.50
T ₆ - Mulching of Rice bean biomass	3.19 ^e ± 0.18	1.77 ^f ± 0.63
T ₇ - Soil incorporation of Subabul biomass	6.10 ^{bc} ± 0.35	5.16 ^{bc} ± 0.76
T ₈ - Mulching of Subabul biomass	2.70 ^e ± 0.44	2.77 ^{ef} ± 0.69
T ₉ - Soil incorporation of weed	6.28 ^b ± 0.96	6.00 ^b ± 0.87
T ₁₀ - Mulching of weed	5.63 ^{bcd} ± 1.56	4.33 ^{cd} ± 0.58
T ₁₁ - Control	0.00 ^f ± 0.00	0.00 ^g ± 0.00
	<i>SE(m) ±</i>	<i>0.39</i>
	<i>C.D. (5%)</i>	<i>1.17</i>
	<i>C.V. (%)</i>	<i>15.25</i>
		<i>0.41</i>
		<i>1.24</i>
		<i>19.47</i>

4.1.5 Effect of treatments on fresh weight of thick size root > 4 mm at a radial distance of 50 cm and depth 30 cm and 60 cm of the Bael plant

The data pertaining to the effect of basin enrichment through the application of biomass under different treatments on fresh weight of thick size root > 4 mm at a radial distance of 50 cm and depth 30 cm and 60 cm) of the Bael plant were statistically analyzed and presented in table 4.5. The result shows that all the treatments had a significant effect on root weight as compared to control. The fresh weight of thick size root at a radial distance of 50 cm and depth 30 cm was found maximum initially in treatment T₈: Mulching of Subabul biomass (3.65 g) and at final in the treatment T₄: Mulching of Tephrosia biomass (6.7 g) respectively, while the minimum was found both for initial and final in the treatment T₁₁: Control (1.76 g and 2.08 g) respectively.

Similarly, fresh weight of thick size root at a radial distance of 50 cm and depth 60 cm was found maximum both for initial and final in the treatment T₂: Mulching of Vegetable Soybean biomass (3.07 g and 3.86 g) respectively, while the minimum was

found both for initial and final in the treatment T₁₁: Control (1.33 g and 1.05 g) respectively

Table 4.5: Fresh weight of thick size root > 4mm at a radial distance of 50 cm and depth 30cm and 60cm of the Bael plant

Treatments	July- 2019	Dec.- 2020	July- 2019	Dec.- 2020
	50cm- 30cm	50cm- 30cm	50cm- 60cm	50cm- 60cm
T ₂ -Mulching of Vegetable Soybean biomass	2.83 ^b ± 0.50	6.05 ^a ± 0.81	3.07 ^a ± 0.26	3.86 ^a ± 1.00
T ₄ - Mulching of Tephrosia biomass	2.64 ^b ± 0.48	6.7 ^a ± 0.17	1.82 ^{bc} ± 0.29	1.92 ^b ± 0.19
T ₆ - Mulching of Rice bean biomass	2.48 ^{bc} ± 0.42	3.67 ^{bc} ± 0.10	1.61 ^c ± 0.16	3.35 ^a ± 0.23
T ₈ - Mulching of Subabul biomass	3.65 ^a ± 0.48	4.43 ^b ± 0.96	2.68 ^{ab} ± 0.72	3.51 ^a ± 0.30
T ₁₀ - Mulching of weed	2.45 ^{bc} ± 0.31	3.54 ^c ± 0.42	1.93 ^{bc} ± 0.87	1.29 ^b ± 0.07
T ₁₁ -Control	1.76 ^c ± 0.06	2.08 ^d ± 0.11	1.33 ^c ± 0.55	1.05 ^b ± 0.06
<i>SE(m) ±</i>	0.24	0.27	0.30	0.28
<i>C.D. (5%)</i>	0.79	0.86	0.95	0.89
<i>C.V. (%)</i>	16.24	10.79	25.04	19.50

4.1.6 Effect of treatments on dry weight of thick size root > 4 mm at a radial distance of 50 cm and depth 30 cm and 60 cm of the Bael plant

The data pertaining to the effect of basin enrichment through the application of biomass under different treatments on the dry weight of thick size root > 4 mm at a radial distance of 50 cm and depth 30 cm and 60 cm of the Bael plant were statistically analyzed and presented in table 4.6. The result shows that all the treatments had a significant effect on root weight as compared to control. The dry weight of thick size root at a radial distance of 50 cm and depth 30 cm was found maximum initially in treatment T₈: Mulching of Subabul biomass (2.05 g) and at final in the treatment T₄: Mulching of Tephrosia biomass (2.90 g) respectively, while the minimum was found both for initial and final in the treatment T₁₁: Control (0.96 g and 1.11g) respectively.

Similarly, dry weight of thick size root at a radial distance of 50 cm and depth 60 cm was found maximum both for initial and final in the treatment T₂: Mulching of Vegetable

Soyabean biomass (1.96 g and 2.47 g) respectively, while the minimum was found both for initial and final in the treatment T₁₁: Control (0.75 g and 0.80 g) respectively.

Table 4.6: Dry weight of thick size root > 4mm at a radial distance of 50 cm and depth 30cm and 60cm of the Bael plant

Treatments	July- 2019	Dec.- 2020	July- 2019	Dec.- 2020
	50cm- 30cm	50cm- 30cm	50cm- 60cm	50cm- 60cm
T ₂ -Mulching of Vegetable Soybean biomass	1.51 ^{ab} ± 0.38	2.72 ^{cd} ± 0.29	1.96 ^a ± 0.19	2.47 ^a ± 0.49
T ₄ - Mulching of Tephrosia biomass	1.45 ^b ± 0.35	2.90 ^a ± 0.12	1.12 ^{bc} ± 0.10	1.24 ^b ± 0.15
T ₆ - Mulching of Rice bean biomass	1.33 ^b ± 0.40	2.11 ^a ± 0.21	1.18 ^{bc} ± 0.19	2.23 ^a ± 0.15
T ₈ - Mulching of Subabul biomass	2.05 ^a ± 0.17	2.29 ^b ± 0.40	1.54 ^{ab} ± 0.24	2.30 ^a ± 0.11
T ₁₀ - Mulching of weed	1.26 ^b ± 0.17	1.58 ^c ± 0.07	1.09 ^{bc} ± 0.48	0.96 ^b ± 0.06
T ₁₁ -Control	0.96 ^b ± 0.20	1.11 ^d ± 0.03	0.75 ^c ± 0.30	0.80 ^b ± 0.10
<i>SE(m) ±</i>	0.18	0.12	0.16	0.14
<i>C.D. (5%)</i>	0.57	0.4	0.50	0.45
<i>C.V. (%)</i>	21.61	10.42	21.81	14.79

4.1.7 Effect of treatments on fresh weight of thick size root > 4 mm at radial distance of 100 cm and depth 30 cm and 60 cm of the Bael plant

The data pertaining to the effect of basin enrichment through the application of biomass under different treatments on fresh weight of thick size root > 4 mm at a radial distance of 100 cm and depth 30 cm and 60 cm of the Bael plant were statistically analyzed and presented in table 4.7. The result shows that all the treatments had a significant effect on root weight as compared to control. The fresh weight of thick size root at a radial distance of 100 cm and depth 30 cm was found maximum initially in treatment T₈: Mulching of Subabul biomass (2.41g) and at final in the treatment T₄: Mulching of Tephrosia biomass (3.20 g) respectively, while the minimum was found both for initial and final in the treatment T₁₁: Control (0.99 g and 1.59 g) respectively.

Similarly, fresh weight of thick size root at a radial distance of 100 cm and depth 60 cm was found maximum both for initial and final in the treatment T₈: Mulching of Subabul biomass (2.21 g and 3.09 g) respectively, while the minimum was found both for initial and final in the treatment T₁₁: Control (0.70 g and 1.58 g) respectively.

Table 4.7: Fresh weight of thick size root > 4 mm at a radial distance of 100 cm and depth 30 cm and 60 cm of the Bael plant

Treatments	July- 2019	Dec.- 2020	July- 2019	Dec.- 2020
	100cm- 30cm	100cm- 30cm	100cm- 60cm	100cm- 60cm
T ₂ -Mulching of Vegetable Soybean biomass	1.57 ^{cd} ± 0.33	2.57 ^{ab} ± 0.50	1.48 ^{ab} ± 0.08	2.60 ^a ± 0.62
T ₄ - Mulching of Tephrosia biomass	2.10 ^b ± 0.10	3.20 ^a ± 0.21	2.12 ^a ± 0.93	2.40 ^{ab} ± 0.43
T ₆ - Mulching of Rice bean biomass	1.65 ^c ± 0.15	2.75 ^{ab} ± 0.23	2.07 ^a ± 0.08	2.76 ^a ± 0.41
T ₈ - Mulching of Subabul biomass	2.41 ^a ± 0.12	2.99 ^a ± 0.54	2.21 ^a ± 0.32	3.09 ^a ± 0.32
T ₁₀ - Mulching of weed	1.33 ^d ± 0.08	2.18 ^{bc} ± 0.20	0.99 ^{bc} ± 0.22	2.83 ^a ± 0.35
T ₁₁ -Control	0.99 ^e ± 0.23	1.59 ^c ± 0.44	0.70 ^c ± 0.10	1.58 ^b ± 0.32
<i>SE(m) ±</i>	0.08	0.23	0.23	0.26
<i>C.D. (5%)</i>	0.26	0.75	0.74	0.85
<i>C.V. (%)</i>	8.35	15.95	25.24	18.24

4.1.8 Effect of treatments on dry weight of thick size root > 4 mm at a radial distance of 100 cm and depth 30 cm and 60 cm of the Bael plant

The data pertaining to the effect of basin enrichment through the application of biomass under different treatments on the dry weight of thick size root > 4 mm at a radial distance of 100 cm and depth 30 cm and 60 cm of the Bael plant were statistically analyzed and presented in table 4.8. The result shows that all the treatments had a significant effect on root weight as compared to control. The dry weight of thick size root at a radial distance of 100 cm and depth 30 cm was found maximum initially in treatment T₈: Mulching of Subabul biomass (1.32 g) and at final in the treatment T₄: Mulching of Tephrosia biomass (1.93 g) respectively while the minimum was found both for initial and final in the treatment T₁₁: Control (0.59 g and 0.89 g) respectively.

Similarly, dry weight of thick size root at a radial distance of 100 cm and depth 60 cm was found maximum both for initial and final in the treatment T₈: Mulching of Subabul biomass (1.27 g and 1.97 g) respectively while the minimum was found both for initial and final in the treatment T₁₁: Control (0.39 g and 0.83 g) respectively.

Table 4.8: Dry weight of thick size root > 4 mm at a radial distance of 100 cm and depth 30 cm and 60 cm of the Bael plant

Treatments	July- 2019	Dec.- 2020	July- 2019	Dec.- 2020
	100cm- 30cm	100cm- 30cm	100cm- 60cm	100cm- 60cm
T ₂ -Mulching of Vegetable Soybean biomass	0.84 ^c ± 0.11	1.35 ^{abc} ± 0.36	0.64 ^{bc} ± 0.05	1.52 ^{ab} ± 0.27
T ₄ - Mulching of Tephrosia biomass	1.27 ^a ± 0.08	1.93 ^a ± 0.37	1.10 ^a ± 0.47	1.26 ^{bc} ± 0.38
T ₆ - Mulching of Rice bean biomass	1.09 ^b ± 0.04	1.62 ^{ab} ± 0.24	1.05 ^{ab} ± 0.12	1.77 ^{ab} ± 0.23
T ₈ - Mulching of Subabul biomass	1.32 ^a ± 0.07	1.85 ^a ± 0.51	1.27 ^a ± 0.28	1.97 ^a ± 0.31
T ₁₀ - Mulching of weed	0.73 ^c ± 0.08	1.10 ^{bc} ± 0.10	0.62 ^c ± 0.14	1.88 ^a ± 0.27
T ₁₁ -Control	0.59 ^d ± 0.20	0.89 ^c ± 0.17	0.39 ^c ± 0.05	0.83 ^c ± 0.15
<i>SE(m) ±</i>	<i>0.03</i>	<i>0.19</i>	<i>0.13</i>	<i>0.21</i>
<i>C.D. (5%)</i>	<i>0.11</i>	<i>0.63</i>	<i>0.41</i>	<i>0.55</i>
<i>C.V. (%)</i>	<i>6.05</i>	<i>23.67</i>	<i>26.75</i>	<i>19.92</i>

4.1.9 Effect of treatments on fresh weight of medium size root 2 mm- 4 mm at radial distance of 50 cm and depth 30 cm and 60 cm of the Bael plant

The data pertaining to the effect of basin enrichment through the application of biomass under different treatments on fresh weight of medium size root 2 mm- 4 mm at a radial distance of 50 cm and depth 30 cm and 60 cm of the Bael plant were statistically analyzed and presented in table 4.9. The result shows that all the treatments had a significant effect on root weight as compared to control. The fresh weight of medium size root at a radial distance of 50 cm and depth 30 cm was found maximum initially in treatment T₈: Mulching of Subabul biomass (1.44 g) and at final in the treatment T₆: Mulching of Rice bean biomass (1.90 g) respectively, while the minimum was found both for initial and final in the treatment T₁₁: Control (0.49 g and 1.13 g) respectively.

Similarly, fresh weight of medium size root at a radial distance of 50 cm and depth 60 cm was found maximum both for initial and final in the treatment T₈: Mulching of Subabul biomass (1.21 g and 132 g) respectively, while the minimum was found both for initial and final in the treatment T₁₁: Control (0.22 g and 0.30 g) respectively.

Table 4.9: Fresh weight of medium size root 2 mm- 4 mm at a radial distance of 50 cm and depth 30 cm and 60 cm of the Bael plant

Treatments	July- 2019	Dec.- 2020	July- 2019	Dec.- 2020
	50cm- 30cm	50cm- 30cm	50cm- 60cm	50cm- 60cm
T ₂ -Mulching of Vegetable Soybean biomass	1.01 ^b ± 0.07	1.23 ^{bc} ± 0.13	0.43 ^{bc} ± 0.10	0.93 ^b ± 0.24
T ₄ - Mulching of Tephrosia biomass	0.86 ^{bc} ± 0.34	1.53 ^{ab} ± 0.22	0.53 ^a ± 0.02	1.17 ^a ± 0.10
T ₆ - Mulching of Rice bean biomass	0.62 ^{bc} ± 0.08	1.90 ^a ± 0.35	0.28 ^{cd} ± 0.05	0.59 ^c ± 0.19
T ₈ - Mulching of Subabul biomass	1.44 ^a ± 0.43	1.62 ^{ab} ± 0.26	1.21 ^a ± 0.07	1.32 ^a ± 0.13
T ₁₀ - Mulching of weed	0.96 ^b ± 0.24	1.27 ^{bc} ± 0.34	0.31 ^{cd} ± 0.13	0.55 ^c ± 0.19
T ₁₁ -Control	0.49 ^c ± 0.04	1.13 ^c ± 0.19	0.22 ^d ± 0.1	0.30 ^d ± 0.06
<i>SE(m) ±</i>	0.12	0.15	0.05	0.06
<i>C.D. (5%)</i>	0.40	0.46	0.17	0.22
<i>C.V. (%)</i>	24.12	17.41	18.62	14.76

4.1.10 Effect of treatments on dry weight of medium size root 2 mm- 4 mm at radial distance of 50 cm and depth 30 cm and 60 cm of the Bael plant

The data pertaining to the effect of basin enrichment through the application of biomass under different treatments on the dry weight of medium size root 2 mm- 4 mm at a radial distance of 50 cm and depth 30 cm and 60 cm of Bael plant were statistically analyzed and presented in the table 4.10. The result shows that all the treatments had a significant effect on root weight as compared to control. The dry weight of medium size root at a radial distance of 50 cm and depth 30 cm was found maximum initially in treatment T₈: Mulching of Subabul biomass (0.69 g) and at final in the treatment T₆: Mulching of Rice bean biomass (0.93 g) respectively, while the minimum was found both for initial and final in the treatment T₁₁: Control (0.23 g and 0.61g) respectively.

Similarly, dry weight of medium size root at radial distance of 50 cm and depth 60 cm was found maximum both for initial and final in the treatment T₈: Mulching of Subabul biomass (0.79 g and 0.82 g) respectively, while the minimum was found both for initial and final in the treatment T₁₁: Control (0.12 g and 0.16 g) respectively.

Table 4.10: Dry weight of medium size root 2 mm- 4 mm at a radial distance of 50 cm and depth 30 cm and 60 cm of the Bael plant

Treatments	July- 2019	Dec.- 2020	July- 2019	Dec.- 2020
	50cm- 30cm	50cm- 30cm	50cm- 60cm	50cm- 60cm
T ₂ -Mulching of Vegetable Soybean biomass	0.50 ^{ab} ± 0.08	0.66 ^{bc} ± 0.10	0.21 ^{bc} ± 0.03	0.53 ^b ± 0.11
T ₄ - Mulching of Tephrosia biomass	0.45 ^{bc} ± 0.20	0.85 ^{ab} ± 0.10	0.22 ^b ± 0.01	0.61 ^b ± 0.08
T ₆ - Mulching of Rice bean biomass	0.35 ^{bc} ± 0.04	0.93 ^a ± 0.17	0.14 ^{bc} ± 0.04	0.30 ^c ± 0.08
T ₈ - Mulching of Subabul biomass	0.69 ^a ± 0.20	0.82 ^{abc} ± 0.05	0.79 ^a ± 0.05	0.82 ^a ± 0.12
T ₁₀ - Mulching of weed	0.55 ^{ab} ± 0.18	0.65 ^{bc} ± 0.15	0.15 ^{bc} ± 0.06	0.30 ^c ± 0.02
T ₁₁ -Control	0.23 ^c ± 0.02	0.61 ^c ± 0.13	0.12 ^c ± 0.05	0.16 ^c ± 0.04
<i>SE(m) ±</i>	0.07	0.06	0.03	0.05
<i>C.D. (5%)</i>	0.22	0.21	0.09	0.15
<i>C.V. (%)</i>	26.05	15.49	17.77	17.83

4.1.11 Effect of treatments on fresh weight of medium size root 2 mm- 4 mm at a radial distance of 100 cm and depth 30 cm and 60 cm of the Bael plant

The data pertaining to the effect of basin enrichment through the application of biomass under different treatments on fresh weight of medium size root 2 mm- 4 mm at a radial distance of 100 cm and depth 30 cm and 60 cm of the Bael plant were statistically analyzed and presented in table 4.11. The result shows that all the treatments had a significant effect on root weight as compared to control. The fresh weight of medium size root at a radial distance of 100 cm and depth 30 cm was found maximum both for initial and final in treatment T₈: Mulching of Subabul biomass (0.84 g and 0.98 g) respectively, while the minimum was found both for initial and final in the treatment T₁₁: Control (0.28 g and 0.33 g) respectively.

Similarly, fresh weight of medium size root at a radial distance of 100 cm and depth 60 cm was found maximum initially in the treatment T₈: Mulching of Subabul biomass (0.70 g) and at final in the treatment T₄: Mulching of Tephrosia biomass (1.52 g) respectively, while the minimum was found both for initial and final in the treatment T₁₁: Control (0.22 g and 0.33 g) respectively.

Table 4.11: Fresh weight of medium size root 2 mm- 4 mm at a radial distance of 100 cm and depth 30 cm and 60 cm of the Bael plant.

Treatments	July- 2019	Dec.- 2020	July- 2019	Dec.- 2020
	100cm- 30cm	100cm- 30cm	100cm- 60cm	100cm- 60cm
T ₂ -Mulching of Vegetable Soybean biomass	0.75 ^{ab} ± 0.12	0.86 ^{ab} ± 0.20	0.64 ^{ab} ± 0.30	0.52 ^{cd} ± 0.11
T ₄ - Mulching of Tephrosia biomass	0.55 ^{cd} ± 0.10	0.80 ^{ab} ± 0.16	0.45 ^b ± 0.07	1.52 ^a ± 0.07
T ₆ - Mulching of Rice bean biomass	0.41 ^{de} ± 0.09	0.61 ^b ± 0.04	0.57 ^{ab} ± 0.06	0.61 ^{bc} ± 0.04
T ₈ - Mulching of Subabul biomass	0.84 ^a ± 0.06	0.98 ^a ± 0.23	0.70 ^a ± 0.04	0.77 ^b ± 0.20
T ₁₀ - Mulching of weed	0.63 ^{bc} ± 0.17	0.66 ^b ± 0.05	0.66 ^a ± 0.08	0.73 ^b ± 0.04
T ₁₁ -Control	0.28 ^e ± 0.63	0.33 ^c ± 0.16.	0.22 ^c ± 0.07	0.33 ^d ± 0.27
<i>SE(m) ±</i>	0.05	0.08	0.06	0.06
<i>C.D. (5%)</i>	0.18	0.25	0.21	0.20
<i>C.V. (%)</i>	17.33	20.04	21.11	14.90

4.1.12 Effect of treatments on dry weight of medium size root 2 mm- 4 mm at radial distance of 100 cm and depth 30 cm and 60 cm of the Bael plant

The data pertaining to the effect of basin enrichment through the application of biomass under different treatments on the dry weight of medium size root 2 mm- 4 mm at a radial distance of 100 cm and depth 30 cm and 60 cm of Bael plant were statistically analyzed and presented in the table 4.12. The result shows that all the treatments had a significant effect on root weight as compared to control. The dry weight of medium size root at a radial distance of 100 cm and depth 30 cm was found maximum both for initial and final in treatment T₈: Mulching of Subabul biomass (0.45 g and 0.51 g) respectively,

while the minimum was found both for initial and final in the treatment T₁₁: Control (0.14 g and 0.18 g) respectively.

Similarly, dry weight of medium size root at a radial distance of 100 cm and depth 60 cm was found maximum initially in the treatment T₁₀: Mulching of weed (0.36 g) and at final in the treatment T₄: Mulching of Tephrosia biomass (0.78 g) respectively, while the minimum was found both for initial and final in the treatment T₁₁: Control (0.11 g and 0.20 g) respectively.

Table 4.12: Dry weight of medium size root 2 mm- 4 mm at a radial distance of 100 cm and depth 30 cm and 60 cm of the Bael plant

Treatments	July- 2019	Dec.- 2020	July- 2019	Dec.- 2020
	100cm- 30cm	100cm- 30cm	100cm- 60cm	100cm- 60cm
T ₂ -Mulching of Vegetable Soybean biomass	0.40 ^{ab} ± 0.08	0.43 ^{ab} ± 0.15	0.29 ^{ab} ± 0.12	0.36 ^b ± 0.11
T ₄ - Mulching of Tephrosia biomass	0.29 ^{bc} ± 0.05	0.50 ^a ± 0.04	0.24 ^b ± 0.04	0.78 ^a ± 0.06
T ₆ - Mulching of Rice bean biomass	0.25 ^{cd} ± 0.06	0.31 ^{bc} ± 0.04	0.32 ^a ± 0.06	0.41 ^b ± 0.05
T ₈ - Mulching of Subabul biomass	0.45 ^a ± 0.07	0.51 ^a ± 0.14	0.33 ^a ± 0.02	0.43 ^b ± 0.07
T ₁₀ - Mulching of weed	0.35 ^{abc} ± 0.09	0.32 ^{bc} ± 0.05	0.36 ^a ± 0.07	0.43 ^b ± 0.49
T ₁₁ -Control	0.14 ^d ± 0.05	0.18 ^c ± 0.10	0.11 ^c ± 0.04	0.20 ^c ± 0.14
<i>SE(m) ±</i>	0.04	0.04	0.02	0.04
<i>C.D. (5%)</i>	0.13	0.14	0.08	0.12
<i>C.V. (%)</i>	22.68	20.94	16.39	14.68

4.1.13 Effect of treatments on fresh weight of fibrous size root < 2 mm at a radial distance of 50 cm and depth 30 cm and 60 cm of the Bael plant

The data pertaining to the effect of basin enrichment through the application of biomass under different treatments on fresh weight of fibrous size root < 2 mm at a radial distance of 50 cm and depth 30 cm and 60 cm of Bael plant were statistically analyzed and presented in table 4.13. The result shows that all the treatments had a significant effect on root weight as compared to control. The fresh weight of fibrous size root at a radial distance of 50 cm and depth 30 cm was found maximum initially in the treatment T₄: Mulching of Tephrosia biomass (0.71 g) and at final in treatment T₈: Mulching of Subabul

biomass (0.78 g) respectively, while the minimum was found both for initial and final in the treatment T₁₁: Control (0.37 g and 0.31g) respectively.

Similarly, fresh weight of fibrous size root at a radial distance of 50 cm and depth 60 cm was found maximum initially in the treatment T₈: Mulching of Subabul biomass (0.40 g) and at final in the treatment T₄: Mulching of Tephrosia biomass (0.48 g) respectively, while the minimum was found both for initial and final in the treatment T₁₁: Control (0.25 g and 0.27 g) respectively.

Table 4.13: Fresh weight of fibrous size root < 2 mm at a radial distance of 50 cm and depth 30 cm and 60 cm of the Bael plant

Treatments	July- 2019	Dec.- 2020	July- 2019	Dec.- 2020
	50cm- 30cm	50cm- 30cm	50cm- 60cm	50cm- 60cm
T ₂ -Mulching of Vegetable Soybean biomass	0.44 ^{bc} ± 0.09	0.52 ^b ± 0.10	0.30 ^{bc} ± 0.09	0.36 ^b ± 0.03
T ₄ - Mulching of Tephrosia biomass	0.71 ^a ± 0.14	0.73 ^a ± 0.13	0.39 ^{bc} ± 0.01	0.48 ^a ± 0.04
T ₆ - Mulching of Rice bean biomass	0.51 ^{abc} ± 0.09	0.57 ^b ± 0.05	0.33 ^{bc} ± 0.07	0.37 ^b ± 0.04
T ₈ - Mulching of Subabul biomass	0.62 ^{ab} ± 0.14	0.78 ^a ± 0.07	0.40 ^a ± 0.08	0.45 ^a ± 0.03
T ₁₀ - Mulching of weed	0.46 ^{bc} ± 0.11	0.48 ^b ± 0.02	0.29 ^{bc} ± 0.06	0.33 ^{bc} ± 0.06
T ₁₁ -Control	0.37 ^c ± 0.09	0.31 ^c ± 0.08	0.25 ^c ± 0.01	0.27 ^c ± 0.02
<i>SE(m) ±</i>	0.06	0.04	0.03	0.03
<i>C.D. (5%)</i>	0.06	0.12	0.11	0.08
<i>C.V. (%)</i>	21.72	12.23	17.66	11.53

4.1.14 Effect of treatments on dry weight fibrous size root < 2 mm at a radial distance of 50 cm and depth 30 cm and 60 cm of the Bael plant

The data pertaining to the effect of basin enrichment through the application of biomass under different treatments on fibrous size root < 2 mm at a radial distance of 50 cm and depth 30 cm and 60 cm of Bael plant were statistically analyzed and presented in table 4.14. The result shows that all the treatments had a significant effect on root weight as compared to control. The dry weight of fibrous size root at a radial distance of 50 cm

and depth 30 cm was found maximum initially in the treatment T₄: Mulching of Tephrosia biomass (0.39 g) and at final in treatment T₈: Mulching of Subabul biomass (0.49 g) respectively, while the minimum was found both for initial and final in the treatment T₁₁: Control (0.22 g and 0.18 g) respectively.

Table 4.14: Dry weight of fibrous size root < 2mm at a radial distance of 50 cm and depth 30cm and 60cm of the Bael plant

Treatments	July- 2019	Dec.- 2020	July- 2019	Dec.- 2020
	50cm- 30cm	50cm- 30cm	50cm- 60cm	50cm- 60cm
T ₂ -Mulching of Vegetable Soybean biomass	0.26 ± 0.04	0.30 ^b ± 0.05	0.17 ± 0.04	0.19 ^{bcd} ± 0.04
T ₄ - Mulching of Tephrosia biomass	0.39 ± 0.11	0.43 ^a ± 0.13	0.16 ± 0.01	0.18 ^{cd} ± 0.07
T ₆ - Mulching of Rice bean biomass	0.28 ± 0.08	0.31 ^b ± 0.02	0.19 ± 0.03	0.24 ^{abc} ± 0.05
T ₈ - Mulching of Subabul biomass	0.37 ± 0.07	0.49 ^a ± 0.04	0.23 ± 0.04	0.30 ^a ± 0.04
T ₁₀ - Mulching of weed	0.29 ± 0.09	0.29 ^{bc} ± 0.03	0.17 ± 0.03	0.25 ^{ab} ± 0.01
T ₁₁ -Control	0.22 ± 0.06	0.18 ^c ± 0.05	0.14 ± 0.01	0.14 ^d ± 0.03
<i>SE(m) ±</i>	<i>0.04</i>	<i>0.03</i>	<i>0.02</i>	<i>0.02</i>
<i>C.D. (5%)</i>	<i>NS</i>	<i>0.10</i>	<i>NS</i>	<i>0.07</i>
<i>C.V. (%)</i>	<i>24.27</i>	<i>17.45</i>	<i>18.03</i>	<i>18.05</i>

Similarly, dry weight of fibrous size root at a radial distance of 50 cm and depth 60 cm was found maximum both for initial and final in treatment T₈: Mulching of Subabul biomass (0.23 g and 0.30 g) respectively, while the minimum was found both for initial and final in the treatment T₁₁: Control (0.14 g and 0.14 g) respectively.

4.1.15 Effect of treatments on fresh weight of fibrous size root < 2 mm at a radial distance of 100 cm and depth 30 cm and 60 cm of the Bael plant

The data pertaining to the effect of basin enrichment through the application of biomass under different treatments on fibrous size root < 2 mm at a radial distance of 100 cm and depth 30 cm and 60 cm of Bael plant were statistically analyzed and presented in

table 4.15. The result shows that all the treatments had a significant effect on root weight as compared to control. The fresh weight of fibrous size root at a radial distance of 100 cm and depth 30 cm was found maximum both for initial and final in treatment T₄: Mulching of Tephrosia biomass (0.42 g and 0.45 g) respectively while the minimum was found both for initial and final in the treatment T₁₁: Control (0.21 g and 0.23 g) respectively.

Table 4.15: Fresh weight of Fibrous size root < 2 mm at a radial distance of 100 cm and depth 30 cm and 60 cm of the Bael plant

Treatments	July- 2019	Dec.- 2020	July- 2019	Dec.- 2020
	100cm- 30cm	100cm- 30cm	100cm- 60cm	100cm- 60cm
T ₂ -Mulching of Vegetable Soybean biomass	0.30 ± 0.05	0.33 ^b ± 0.02	0.22 ± 0.03	0.25 ^{ab} ± 0.02
T ₄ - Mulching of Tephrosia biomass	0.42 ± 0.09	0.45 ^a ± 0.02	0.17 ± 0.05	0.23 ^{ab} ± 0.03
T ₆ - Mulching of Rice bean biomass	0.22 ± 0.07	0.25 ^c ± 0.02	0.23 ± 0.05	0.26 ^a ± 0.03
T ₈ - Mulching of Subabul biomass	0.30 ± 0.03	0.32 ^b ± 0.03	0.24 ± 0.04	0.27 ^a ± 0.02
T ₁₀ - Mulching of weed	0.29 ± 0.09	0.33 ^b ± 0.06	0.18 ± 0.03	0.20 ^{bc} ± 0.01
T ₁₁ -Control	0.21 ± 0.03	0.22 ^c ± 0.03	0.15 ± 0.03	0.16 ^c ± 0.04
<i>SE(m) ±</i>	0.04	0.02	0.02	0.02
<i>C.D. (5%)</i>	NS	0.06	NS	0.06
<i>C.V. (%)</i>	24.77	10.52	19.99	13.70

Similarly, fresh weight of fibrous size root at a radial distance of 100 cm and depth 60 cm was found maximum both for initial and final in treatment T₈: Mulching of Subabul biomass (0.24 g and 0.27 g) respectively, while the minimum was found both for initial and final in the treatment T₁₁: Control (0.15 g and 0.16 g) respectively.

The above results are in conformity with earlier studies done by Li *et al.* (2006) in their studies; they found that the roots of intercropped wheat spread under maize plants had much greater root length density (RLD) at all soil depths than sole wheat. Also, Acharya *et al.* (1998); Acharya and Bhagat (1984); Maurya *et al.* (1981) reported that application of mulch resulted in a high concentration of root relative to that under no mulch.

4.1.16 Effect of treatments on dry weight fibrous size root < 2 mm at a radial distance of 100 cm and depth 30 cm and 60 cm of the Bael plant

The data pertaining to the effect of basin enrichment through the application of biomass under different treatments on fibrous size root < 2 mm at a radial distance of 100 cm and depth 30 cm and 60 cm of Bael plant were statistically analyzed and presented in table 4.16. The result shows that all the treatments had a significant effect on root weight as compared to control. The dry weight of fibrous size root at a radial distance of 100 cm and depth 30 cm was found maximum initially in the treatment T₄: Mulching of Tephrosia biomass (0.23 g) and at final in treatment T₈: Mulching of Subabul biomass (0.22 g) respectively, while the minimum was found both for initial and final in the treatment T₁₁: Control (0.12 g and 0.16 g) respectively.

Table 4.16: Dry weight of Fibrous size root < 2mm at a radial distance of 100 cm and depth 30cm and 60cm of the Bael plant

Treatments	July- 2019	Dec.- 2020	July- 2019	Dec.- 2020
	100cm- 30cm	100cm- 30cm	100cm- 60cm	100cm- 60cm
T ₂ -Mulching of Vegetable Soybean biomass	0.16 ^b ± 0.03	0.21 ^{abc} ± 0.03	0.12 ^{ab} ± 0.02	0.16 ^a ± 0.02
T ₄ - Mulching of Tephrosia biomass	0.23 ^a ± 0.06	0.25 ^a ± 0.03	0.11 ^{ab} ± 0.01	0.17 ^a ± 0.05
T ₆ - Mulching of Rice bean biomass	0.12 ^b ± 0.02	0.16 ^{bc} ± 0.02	0.13 ^a ± 0.02	0.16 ^a ± 0.02
T ₈ - Mulching of Subabul biomass	0.17 ^b ± 0.01	0.22 ^{ab} ± 0.03	0.14 ^a ± 0.02	0.16 ^a ± 0.01
T ₁₀ - Mulching of weed	0.16 ^b ± 0.02	0.21 ^{abc} ± 0.02	0.09 ^{bc} ± 0.02	0.11 ^b ± 0.01
T ₁₁ -Control	0.12 ^b ± 0.02	0.16 ^c ± 0.03	0.07 ^c ± 0.01	0.09 ^b ± 0.02
<i>SE(m) ±</i>	0.02	0.02	0.01	0.01
<i>C.D. (5%)</i>	0.06	0.05	0.03	0.04
<i>C.V. (%)</i>	20.58	17.05	16.66	15.45

Similarly, dry weight of fibrous size root at a radial distance of 100 cm and depth 60 cm was found maximum initially in the treatment T₈: Mulching of Subabul biomass (0.14 g) and at final in the treatment T₄: Mulching of Tephrosia biomass (0.17 g) respectively, while the minimum was found both for initial and final in the treatment T₁₁: Control (0.07 g and 0.09 g) respectively.

4.1.17 Effect of treatments on root volume of thick size root > 4 mm of the Bael plant

The data pertaining to the effect of basin enrichment through the application of biomass under different treatments on root volume (cm^3) thick size root > 4 mm of Bael plant are depicted in the figures. 4.1. The figure shows that root volume (cm^3) at a radial distance of 50 cm and depth 30 cm was observed maximum initially in the treatment T₈: Mulching of Subabul biomass (4 cm^3) and minimum in the treatment T₁₁: Control (2 cm^3) while at final maximum root volume (cm^3) was observed in the treatment T₄ - Mulching of Tephrosia biomass (7 cm^3) and minimum in the treatment T₁₁: Control (2.2 cm^3).

Likewise, root volume (cm^3) at a radial distance of 50 cm and depth 60 cm was observed maximum initially in the treatment T₈: Mulching of Subabul biomass (3.4 cm^3) and minimum in the treatment T₈: Mulching of Subabul biomass T₁₁: Control (1.5 cm^3) while at final maximum root volume (cm^3) was observed in the treatment T₈: Mulching of Subabul biomass (4 cm^3) and minimum in the treatment T₁₁: Control (1.2 cm^3).

Similarly, root volume (cm^3) at a radial distance of 100 cm and depth 30 cm was observed maximum initially in the treatment T₈: Mulching of Subabul biomass (2.6 cm^3) and minimum in the treatment T₁₁: Control (1.2 cm^3) while at final maximum root volume (cm^3) was observed in the treatment T₄ - Mulching of Tephrosia biomass (3.5 cm^3) and minimum in the treatment T₁₁: Control (1.8 cm^3).

In the same manner, root volume (cm^3) at a radial distance of 100 cm and depth 60 cm was observed maximum initially in the treatment T₈: Mulching of Subabul biomass (2.5 cm^3) and minimum in the treatment T₁₁: Control (1 m^3) while at final maximum root volume (cm^3) was observed in the treatment T₈: Mulching of Subabul biomass (3.4 cm^3) and minimum in the treatment T₁₁: Control (1.8 cm^3).

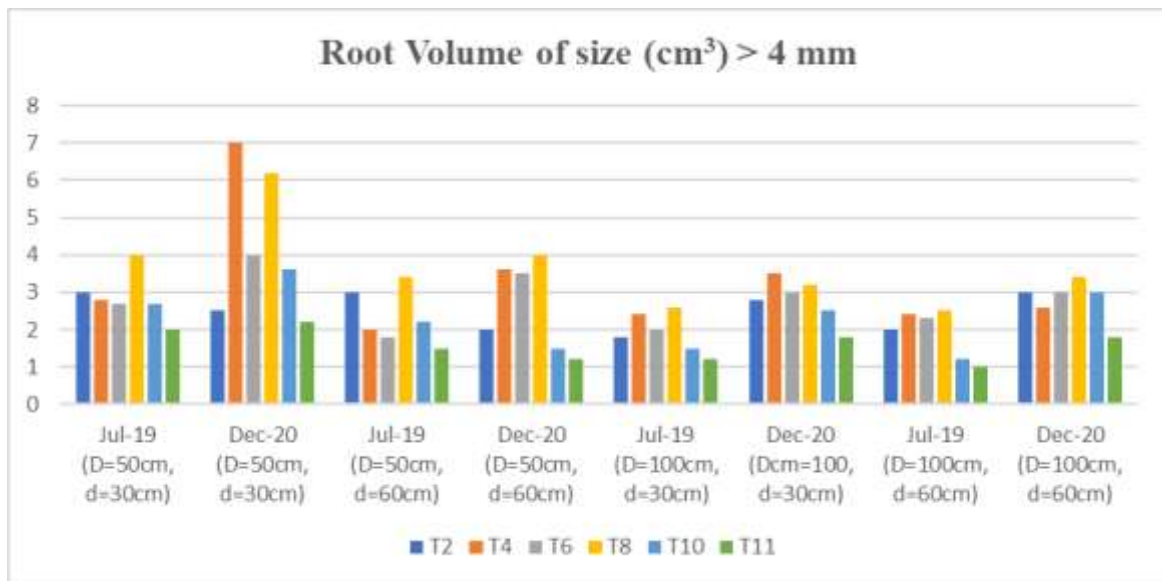


Figure 4.1: Root volume of thick size root > 4 mm

4.1.18 Effect of treatments on root volume of medium size root 2 mm- 4 mm of Bael plant

The data pertaining to the effect of basin enrichment through the application of biomass under different treatments on root volume (cm³) medium size root 2 mm- 4 mm of Bael plant are depicted in the figures. 4.2. The figure shows that root volume (cm³) at a radial distance of 50 cm and depth 30 cm was observed maximum initially in treatment T₈: Mulching of Subabul biomass (1.5 cm³) and minimum in treatment T₁₁: Control (0.7 cm³) while at final maximum root volume (cm³) was observed in the treatment T₆ - Mulching of Rice bean biomass (2.3 cm³) and minimum in treatment T₁₁: Control (1.2 cm³).

Likewise, root volume (cm³) at a radial distance of 50 cm and depth 60 cm was observed maximum initially in the treatment T₈: Mulching of Subabul biomass (1.5 cm³) and minimum in the treatment T₁₁: Control (0.4 cm³) while at final maximum root volume (cm³) was observed in the treatment T₄ - Mulching of Tephrosia biomass (1.5 cm³) and minimum in the treatment T₁₁: Control (0.4 cm³).

Similarly, root volume (cm³) at a radial distance of 100 cm and depth 30 cm was observed maximum initially in the treatment T₈: Mulching of Subabul biomass (1 cm³) which was at par with the treatment T₂- Mulching of Vegetable Soybean biomass (1 cm³)

and minimum in the treatment T₁₁: Control (0.5 cm³) while at final maximum root volume (cm³) was observed in the treatment T₈: Mulching of Subabul biomass (1.2 cm³) and minimum in the treatment T₁₁: Control (0.4 cm³).

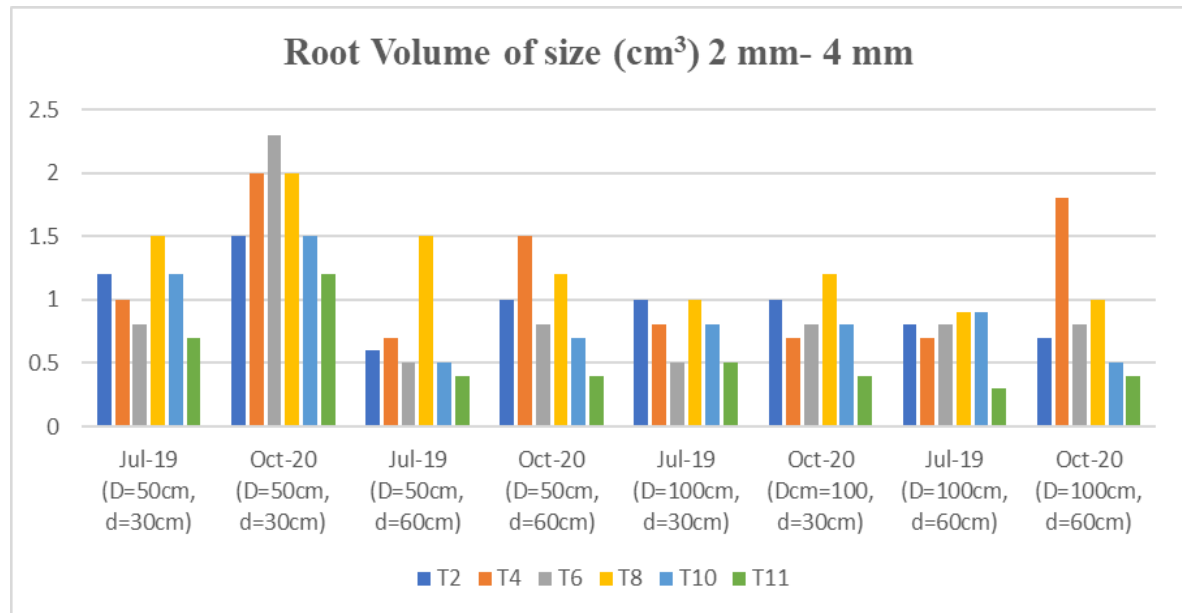


Figure 4.2: Root volume of medium size root 2 mm- 4 mm

In the same manner, root volume (cm³) at a radial distance of 100 cm and depth 60 cm was observed maximum initially in the treatment T₈: Mulching of Subabul biomass (0.9 cm³) which was at par with the treatment T₁₀- Mulching of weed and minimum in the treatment T₁₁: Control (0.9 cm³) while at final maximum root volume (cm³) was observed in the treatment, T₄ - Mulching of Tephrosia biomass (1.8 cm³) and minimum in the treatment T₁₁: Control (0.4 cm³).

4.1.19 Effect of treatments on root volume of fibrous size root < 2 mm of Bael plant

The data pertaining to the effect of basin enrichment through the application of biomass under different treatments on root volume (cm³) fibrous size root 2 mm- 4 mm of Bael plant are depicted in the figures. 4.3. The figure shows that root volume (cm³) at a radial distance of 50 cm and depth 30 cm was observed maximum initially in the treatment T₄ - Mulching of Tephrosia biomass (0.9 cm³) and minimum in the treatment T₁₁: Control (0.5 cm³) while at final maximum root volume (cm³) was observed in the treatment T₈: Mulching of Subabul biomass (1 cm³) and minimum in treatment T₁₁: Control (0.5 cm³).

Likewise, root volume (cm^3) at a radial distance of 50 cm and depth 60 cm was observed maximum initially in the treatment T₁₀- Mulching of weed (0.7 cm^3) and minimum in the treatment T₁₁: Control (0.5 cm^3) while at final maximum root volume (cm^3) was observed in the treatment T₈: Mulching of Subabul biomass (0.6 cm^3) and minimum in the treatment T₁₁: Control (0.4 cm^3).

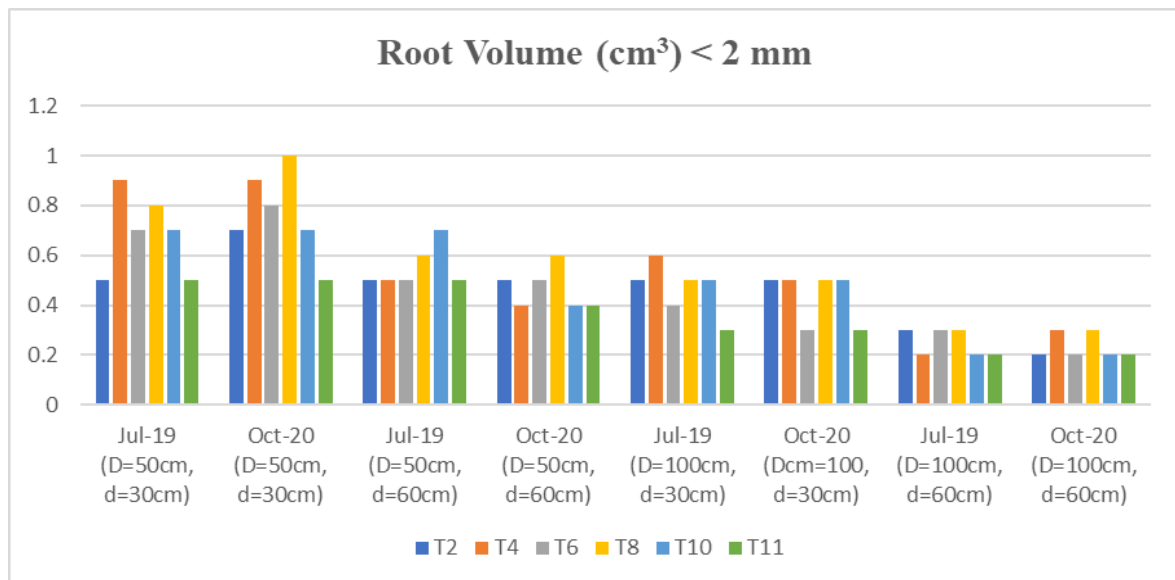


Figure 4.3: Root volume of fibrous size root < 2 mm

Similarly, root volume (cm^3) at a radial distance of 100 cm and depth 30 cm was observed maximum initially in the treatment T₄ - Mulching of Tephrosia biomass (0.6 cm^3) and minimum in the treatment T₁₁: Control (0.3 cm^3) while at final maximum root volume (cm^3) was observed in the treatment T₈: Mulching of Subabul biomass (0.5 cm^3) which was at par with the treatment T₂, T₄, T₁₀ respectively and minimum in the treatment T₁₁: Control (0.3 cm^3).

In the same manner, root volume (cm^3) at a radial distance of 100 cm and depth 60 cm was observed maximum initially in the treatment T₈: Mulching of Subabul biomass (0.3 cm^3) which was at par with the treatment T₄ - Mulching of Tephrosia respectively and minimum in the treatment T₁₁: Control (0.2 cm^3) while at final maximum root volume (cm^3) was observed in the treatment T₄ - Mulching of Tephrosia biomass (0.3 cm^3) which was at par with the treatment T₈: Mulching of Subabul biomass and minimum in the treatment T₁₁: Control (0.2 cm^3).

4.1.20 Effect of treatments on the chlorophyll content of Bael leaves

The data pertaining to the effect of basin enrichment through the application of biomass under different treatments on the chlorophyll content of Bael leaves were statistically analyzed and presented in table 4.20. The data revealed significant differences among all the treatments. The maximum chlorophyll 'a' was found under the treatment T₇- Soil incorporation of Subabul biomass (1.62 mg g⁻¹) and the minimum was found under treatment T₁₁: Control (1.17 mg g⁻¹). While chlorophyll 'b' was found maximum under the treatment T₃- Soil incorporation of Tephrosia biomass (1.07 mg g⁻¹) and the minimum was found under the treatment T₁₀- Mulching of weed (0.77 mg g⁻¹). The total chlorophyll content was observed in the treatment T₇- Soil incorporation of Subabul biomass (2.65 mg g⁻¹) and minimum in the treatment T₁₁: Control (1.88 mg g⁻¹).

Table 4.17: Chlorophyll content (mg g⁻¹) of the Bael leaves (July, 2019)

Treatments	Chl. a	Chl. b	Total Chl.
T ₁ - Soil incorporation of Vegetable Soybean biomass	1.46 ^{abc} ± 0.09	0.92 ^{abcd} ± 0.10	2.39 ^{bc} ± 0.16
T ₂ - Mulching of Vegetable Soybean biomass	1.41 ^{ab} ± 0.05	0.81 ^{cd} ± 0.05	2.22 ^{cd} ± 0.10
T ₃ - Soil incorporation of Tephrosia biomass	1.54 ^{ab} ± 0.07	1.07 ^a ± 0.20	2.61 ^{ab} ± 0.21
T ₄ - Mulching of Tephrosia biomass	1.43 ^{abc} ± 0.16	0.98 ^{abc} ± 0.28	2.41 ^{abc} ± 0.26
T ₅ - Soil incorporation of Rice bean biomass	1.27 ^{cd} ± 0.05	0.79 ^{cd} ± 0.18	2.06 ^{de} ± 0.17
T ₆ - Mulching of Rice bean biomass	1.43 ^{abc} ± 0.08	0.95 ^{abcd} ± 0.13	2.38 ^{bc} ± 0.07
T ₇ - Soil incorporation of Subabul biomass	1.62 ^a ± 0.14	1.02 ^{ab} ± 0.14	2.65 ^a ± 0.28
T ₈ - Mulching of Subabul biomass	1.45 ^{abc} ± 0.15	1.01 ^{ab} ± 0.18	2.46 ^{abc} ± 0.17
T ₉ - Soil incorporation of weed	1.37 ^{bcd} ± 0.07	0.84 ^{bcd} ± 0.08	2.22 ^{cd} ± 0.05
T ₁₀ - Mulching of weed	1.26 ^{cd} ± 0.09	0.77 ^d ± 0.10	2.03 ^{de} ± 0.06
T ₁₁ - Control	1.17 ^d ± 0.25	0.80 ^{cd} ± 0.11	1.88 ^e ± 0.08
<i>SE(m) ±</i>	0.07	0.06	0.08
<i>C.D. (5%)</i>	0.22	0.19	0.25
<i>C.V. (%)</i>	9.37	12.55	6.49

4.1.21 Effect of treatments on the chlorophyll content of the Bael leaves

The data pertaining to the effect of basin enrichment through the application of biomass under different treatments on chlorophyll content of the Bael leaves were statistically analyzed and presented in table 4.20. The data revealed significant differences among all the treatments. The maximum chlorophyll 'a' was found under treatment T₈-

Mulching of Subabul biomass (1.62 mg g^{-1}), and the minimum was found under treatment T₁₁: Control (1.21 mg g^{-1}). While chlorophyll 'b' was found maximum under the treatment T₆- Mulching of Rice bean biomass (1.07 mg g^{-1}) and the minimum was found under the treatment T₃- Soil incorporation of Tephrosia biomass (1.07 mg g^{-1}). The total chlorophyll content was observed in the treatment T₈- Mulching of Subabul biomass (2.72 mg g^{-1}) and the minimum in the treatment T₁₁: Control (2.13 mg g^{-1}).

The above results are in conformity with the earlier studies done by Zhang *et al.* (2015) in their studies; they reported that the application of straw mulch significantly improves crop photosynthesis and yield.

Table 4.18: Chlorophyll content (mg g^{-1}) of the Bael leaves (Sept, 2020)

Treatments	Chl. a	Chl. b	Total Chl.
T ₁ - Soil incorporation of Vegetable Soybean biomass	$1.56^{abc} \pm 0.09$	$0.95^{bcd} \pm 0.23$	$2.52^{abc} \pm 0.31$
T ₂ - Mulching of Vegetable Soybean biomass	$1.39^{bcd} \pm 0.08$	$1.09^{ab} \pm 0.11$	$2.49^{bc} \pm 0.19$
T ₃ - Soil incorporation of Tephrosia biomass	$1.60^{ab} \pm 0.19$	$0.84^d \pm 0.06$	$2.45^{bcd} \pm 0.25$
T ₄ - Mulching of Tephrosia biomass	$1.43^{bcd} \pm 0.08$	$1.01^{abc} \pm 0.18$	$2.44^{bcd} \pm 0.24$
T ₅ - Soil incorporation of Rice bean biomass	$1.32^{cd} \pm 0.09$	$0.97^{abcd} \pm 0.17$	$2.30^{bcd} \pm 0.21$
T ₆ - Mulching of Rice bean biomass	$1.46^{bcd} \pm 0.15$	$1.13^a \pm 0.18$	$2.60^{ab} \pm 0.33$
T ₇ - Soil incorporation of Subabul biomass	$1.39^{bcd} \pm 0.17$	$1.03^{abc} \pm 0.14$	$2.43^{bcd} \pm 0.30$
T ₈ - Mulching of Subabul biomass	$1.7^a \pm 0.18$	$1.02^{abc} \pm 0.18$	$2.72^a \pm 0.35$
T ₉ - Soil incorporation of weed	$1.30^d \pm 0.05$	$0.89^{cd} \pm 0.09$	$2.20^{cd} \pm 0.15$
T ₁₀ - Mulching of weed	$1.51^{abc} \pm 0.26$	$1.01^{abc} \pm 0.07$	$2.53^{abc} \pm 0.24$
T ₁₁ - Control	$1.21^d \pm 0.29$	$0.92^{cd} \pm 0.10$	$2.13^d \pm 0.24$
	<i>SE(m) ±</i>	0.09	0.05
	<i>C.D. (5%)</i>	0.27	0.16
	<i>C.V. (%)</i>	11.21	9.50

4.2 To study the effect of basin enrichment on soil physical, chemical, and biological properties in the plant basin.

4.2.1 Effect of treatments on the bulk density of basin soil

The data pertaining to the effect of basin enrichment through the application of biomass under different treatments on bulk density (g cm^{-3}) of basin soil were statistically analyzed and presented in table 4.26. The data revealed a significant difference among all

the treatments. The bulk density of basin soil at depth 0-15 cm was found maximum both for initial and final in treatment T₁₁: Control (1.43 g cm⁻³ and 1.39 g cm⁻³) respectively, while minimum was in the treatment T₇- Soil incorporation of Subabul biomass (1.27 g cm⁻³) and at final in the treatment T₄- Mulching of Tephrosia biomass (1.24 g cm⁻³).

Table 4.19: Bulk density of basin soil

Treatments	Soil: Bulk density (g cm ⁻³)			
	Basin Area (0- 15 cm)		Basin Area (15- 30cm)	
	July- 19	Dec- 20	July- 19	Dec- 20
T ₁ - Soil incorporation of Vegetable Soybean biomass	1.30 ^{bcd} ± 0.03	1.28 ^{cd} ± 0.02	1.35 ^{cd} ± 0.04	1.30 ^c ± 0.01
T ₂ - Mulching of Vegetable Soybean biomass	1.32 ^{bc} ± 0.04	1.29 ^{bcd} ± 0.01	1.37 ^{bcd} ± 0.04	1.33 ^{bc} ± 0.02
T ₃ - Soil incorporation of Tephrosia biomass	1.31 ^{bcd} ± 0.05	1.28 ^{cd} ± 0.03	1.36 ^{cd} ± 0.03	1.31 ^c ± 0.01
T ₄ - Mulching of Tephrosia biomass	1.28 ^{cd} ± 0.02	1.24 ^d ± 0.05	1.33 ^d ± 0.03	1.29 ^c ± 0.02
T ₅ - Soil incorporation of Rice bean biomass	1.31 ^{bcd} ± 0.04	1.25 ^d ± 0.04	1.31 ^d ± 0.04	1.27 ^c ± 0.02
T ₆ - Mulching of Rice bean biomass	1.29 ^{bcd} ± 0.01	1.26 ^{cd} ± 0.02	1.41 ^{abc} ± 0.04	1.32 ^{bc} ± 0.04
T ₇ - Soil incorporation of Subabul biomass	1.27 ^d ± 0.02	1.25 ^d ± 0.03	1.35 ^{cd} ± 0.03	1.30 ^c ± 0.02
T ₈ - Mulching of Subabul biomass	1.29 ^{cd} ± 0.02	1.27 ^{cd} ± 0.03	1.34 ^d ± 0.05	1.28 ^c ± 0.01
T ₉ - Soil incorporation of weed	1.33 ^b ± 0.02	1.31 ^{bc} ± 0.03	1.42 ^{ab} ± 0.05	1.37 ^{ab} ± 0.01
T ₁₀ - Mulching of weed	1.39 ^a ± 0.01	1.33 ^b ± 0.03	1.45 ^a ± 0.05	1.39 ^a ± 0.08
T ₁₁ - Control	1.43 ^a ± 0.04	1.39 ^a ± 0.01	1.46 ^a ± 0.04	1.42 ^a ± 0.05
<i>SE(m) ±</i>	0.02	0.02	0.02	0.02
<i>C.D. (5%)</i>	0.05	0.05	0.06	0.06
<i>C.V. (%)</i>	2.14	2.34	2.76	2.59

Similarly, bulk density of basin soil at depth 15- 30 cm was found maximum both for initial and final in the treatment T₁₁: Control (1.46 g cm⁻³ and 1.42 g cm⁻³) respectively, while the minimum was found both for initial and final in the treatment T₅- Soil incorporation of Rice bean biomass (1.31 g cm⁻³ and 1.27 g cm⁻³) respectively.

The above results are in conformity with the earlier studies done by Jordan *et al.* (2010) in their studies; they reported that the application of mulch significantly improved the Bulk density, porosity and aggregate stability of soil with respect to control. Dahiya *et*

al. (2003) also indicated by an experiment that when sugarcane trash is used as mulch, it significantly decreased the bulk density and thereby enhancing the soil physical property.

4.2.2 Effect of treatments on the bulk density of alley soil

The data pertaining to the effect of basin enrichment through the application of biomass under different treatments on bulk density (g cm^{-3}) of alley soil were statistically analyzed and presented in table 4.27. The data revealed a significant difference among all the treatments. The bulk density of alley soil at depth 0-15 cm was found maximum both for initial and final in treatment T₁₁: Control (1.38 g cm^{-3} and 1.36 g cm^{-3}) respectively, while the minimum was found initially in the treatment T₇- Soil incorporation of Subabul biomass (1.26 g cm^{-3}) and at final in the treatment T₇- Soil incorporation of Subabul biomass (1.24 g cm^{-3}) which was at par with the treatment T₃- Soil incorporation of Tephrosia biomass (1.24 g cm^{-3}).

Table 4.20 Bulk density of alley soil

Treatments	Soil: Bulk density (g cm^{-3})			
	Alley Area (0- 15 cm)		Alley Area (15- 30 cm)	
	July- 19	Dec- 20	July- 19	Dec- 20
T ₁ - Soil incorporation of Vegetable Soybean biomass	1.29 ^{cde} ±0.03	1.26 ^{bc} ±0.01	1.33 ^{cd} ±0.02	1.29 ^{cd} ±0.02
T ₂ - Mulching of Vegetable Soybean biomass	1.27 ^{de} ±0.04	1.27 ^{bc} ±0.03	1.31 ^d ±0.02	1.31 ^{bcd} ±0.03
T ₃ - Soil incorporation of Tephrosia biomass	1.30 ^{bde} ±0.01	1.24 ^c ±0.03	1.33 ^{cd} ±0.01	1.28 ^{cd} ±0.02
T ₄ - Mulching of Tephrosia biomass	1.29 ^{cde} ±0.01	1.27 ^{bc} ±0.03	1.32 ^{cd} ±0.01	1.31 ^{bcd} ±0.03
T ₅ - Soil incorporation of Rice bean biomass	1.31 ^{bde} ±0.03	1.28 ^{bc} ±0.01	1.35 ^{bcd} ±0.06	1.33 ^{bc} ±0.06
T ₆ - Mulching of Rice bean biomass	1.33 ^{abc} ±0.06	1.29 ^{bc} ±0.03	1.34 ^{bcd} ±0.05	1.30 ^{bcd} ±0.03
T ₇ - Soil incorporation of Subabul biomass	1.26 ^e ±0.03	1.24 ^c ±0.06	1.30 ^d ±0.02	1.28 ^{cd} ±0.01
T ₈ - Mulching of Subabul biomass	1.27 ^{de} ±0.04	1.26 ^{bc} ±0.03	1.32 ^{cd} ±0.02	1.29 ^{cd} ±0.02
T ₉ - Soil incorporation of weed	1.32 ^{bcd} ±0.02	1.27 ^{bc} ±0.06	1.39 ^{ab} ±0.04	1.30 ^{bcd} ±0.01
T ₁₀ - Mulching of weed	1.35 ^{ab} ±0.04	1.31 ^{ab} ±0.05	1.37 ^{bc} ±0.06	1.35 ^{ab} ±0.05
T ₁₁ - Control	1.38 ^a ±0.03	1.36 ^a ±0.02	1.42 ^a ±0.02	1.39 ^a ±0.01
<i>SE(m) ±</i>	0.02	0.02	0.02	0.02
<i>C.D. (5%)</i>	0.05	0.06	0.05	0.05
<i>C.V. (%)</i>	2.47	2.75	2.41	2.35

Similarly, bulk density of alley soil at depth 15- 30 cm was found maximum both for initial and final in the treatment T₁₁: Control (1.42 g cm^{-3} and 1.39 g cm^{-3}) respectively,

while the minimum was found both for initial and final in the treatment T₇- Soil incorporation of Subabul biomass (1.30 g cm⁻³ and 1.28 g cm⁻³) respectively.

4.2.3 Effect of treatments on the pH of basin soil

The data pertaining to the effect of basin enrichment through the application of biomass under different treatments on Bulk density (g cm⁻³) of basin soil were statistically analyzed and presented in table 4.28. The data revealed a significant difference among all the treatments. The pH of basin soil at depth 0-15 cm was found maximum initially in the treatment T₁- Soil incorporation of Vegetable Soybean biomass (5.36) and at final in treatment T₉- Soil incorporation of weed (5.63) respectively, while the minimum was found initially in the treatment T₃- Soil incorporation of Tephrosia biomass (4.82) and at final in the treatment T₄- Mulching of Tephrosia biomass (5.05) respectively.

Table 4.21: pH of basin soil

Treatments	Soil: pH			
	Basin Area (0- 15 cm)		Basin Area (15- 30cm)	
	July- 19	Dec- 20	July- 19	Dec- 20
T ₁ - Soil incorporation of Vegetable Soybean biomass	5.36 ^a ± 0.23	5.26 ^{bcd} ± 0.6	5.05 ^{cd} ± 0.04	5.13 ^d ± 0.15
T ₂ - Mulching of Vegetable Soybean biomass	5.34 ^a ± 0.04	5.53 ^{ab} ± 0.41	5.11 ^c ± 0.10	5.27 ^{cd} ± 0.13
T ₃ - Soil incorporation of Tephrosia biomass	4.82 ^e ± 0.15	5.09 ^d ± 0.17	4.82 ^d ± 0.15	5.35 ^{bcd} ± 0.14
T ₄ - Mulching of Tephrosia biomass	4.99 ^{cde} ± 0.08	5.05 ^d ± 0.19	5.09 ^{cd} ± 0.02	5.08 ^d ± 0.09
T ₅ - Soil incorporation of Rice bean biomass	4.86 ^{de} ± 0.05	5.13 ^{cd} ± 0.17	5.17 ^c ± 0.02	5.40 ^{bcd} ± 0.9
T ₆ - Mulching of Rice bean biomass	5.1 ^{abcde} ± 0.11	5.31 ^{abcd} ± 0.17	5.62 ^a ± 0.04	5.50 ^{abc} ± 0.43
T ₇ - Soil incorporation of Subabul biomass	5.28 ^{abc} ± 0.33	5.51 ^{ab} ± 0.44	5.32 ^{bc} ± 0.12	5.57 ^{abc} ± 0.37
T ₈ - Mulching of Subabul biomass	5.14 ^{abcd} ± 0.23	5.56 ^{ab} ± 0.39	5.20 ^c ± 0.35	5.54 ^{abc} ± 0.13
T ₉ - Soil incorporation of weed	5.31 ^{ab} ± 0.10	5.63 ^{ab} ± 0.48	5.10 ^{cd} ± 0.17	5.51 ^{abc} ± 0.08
T ₁₀ - Mulching of weed	5.03 ^{bcde} ± 0.14	5.35 ^{abcd} ± 0.26	5.32 ^{bc} ± 0.30	5.79 ^a ± 0.23
T ₁₁ - Control	5.08 ^{abcde} ± 0.19	5.48 ^{abc} ± 0.38	5.15 ^c ± 0.05	5.62 ^{ab} ± 0.24
<i>SE(m) ±</i>	0.10	0.15	0.09	0.12
<i>C.D. (5%)</i>	0.30	0.38	0.28	0.34
<i>C.V. (%)</i>	3.44	5.80	3.16	3.75

Similarly, pH of basin soil at depth 15- 30 cm was found maximum initially in the treatment T₆- Mulching of Rice bean biomass (5.62) and at final in the treatment T₁₀- Mulching of weed (5.79) respectively, while the minimum was found initially in the treatment T₃- Soil incorporation of Tephrosia biomass (4.82) and at final in the treatment T₁- Soil incorporation of Vegetable Soybean (5.13) respectively.

The above results are in conformity with the earlier studies done by Sangsinga *et al.* (1988) in their studies; they reported that application of prunings from inoculated leucaena resulted in higher soil organic C, total N, pH and available NO₃.

4.2.4 Effect of treatments on the pH of alley soil

The data pertaining to the effect of basin enrichment through the application of biomass under different treatments on pH of alley soil were statistically analyzed and presented in table 4.28. The data revealed a significant difference among all the treatments. The pH of alley soil at depth 0-15 cm was found maximum initially in the treatment T₈- Mulching of Subabul biomass (5.61) and at final in the treatment T₉- Soil incorporation of weed (6.07) respectively, while the minimum was found initially in the treatment T₄- Mulching of Tephrosia biomass (4.89), T₃- Soil incorporation of Tephrosia biomass (4.82) and at final in the treatment T₂- Mulching of Vegetable Soybean biomass (4.99) respectively.

Similarly, pH of alley soil at depth 15- 30 cm was found maximum both for initial and final in the treatment T₉- Soil incorporation of weed (5.74 and 6.00) respectively, while the minimum was found initially in the treatment T₄- Mulching of Tephrosia biomass (4.88) and at final in the treatment T₂- Mulching of Vegetable Soybean biomass (5.07) respectively.

Table 4.22: pH of alley soil

Treatments	Soil: pH			
	Alley Area (0- 15 cm)		Alley Area (15- 30 cm)	
	July- 19	Dec- 20	July- 19	Dec- 20
T ₁ - Soil incorporation of Vegetable Soybean biomass	5.15 ^{abcd} ± 0.22	5.13 ^{cd} ± 0.27	5.01 ^{cd} ± 0.29	5.21 ^{bc} ± 0.52
T ₂ - Mulching of Vegetable Soybean biomass	5.09 ^{bcd} ± 0.25	4.99 ^d ± 0.12	5.02 ^{cd} ± 0.46	5.07 ^c ± 0.11
T ₃ - Soil incorporation of Tephrosia biomass	4.91 ^d ± 0.16	5.23 ^{bcd} ± 0.23	4.95 ^{cd} ± 0.22	5.17 ^c ± 0.63
T ₄ - Mulching of Tephrosia biomass	4.89 ^d ± 0.13	5.12 ^{cd} ± 0.50	4.88 ^d ± 0.10	5.10 ^c ± 0.08
T ₅ - Soil incorporation of Rice bean biomass	4.99 ^{cd} ± 0.12	5.10 ^{cd} ± 0.49	5.06 ^{cd} ± 0.21	5.24 ^{bc} ± 0.11
T ₆ - Mulching of Rice bean biomass	4.94 ^d ± 0.36	5.16 ^{bcd} ± 0.20	5.06 ^{cd} ± 0.05	5.35 ^{bc} ± 0.22
T ₇ - Soil incorporation of Subabul biomass	5.25 ^{abcd} ± 0.33	5.01 ^d ± 0.31	5.30 ^{abcd} ± 0.43	5.28 ^{bc} ± 0.06
T ₈ - Mulching of Subabul biomass	5.61 ^a ± 0.27	5.66 ^{ab} ± 0.32	5.43 ^{abc} ± 0.32	5.59 ^{abc} ± 0.35
T ₉ - Soil incorporation of weed	5.41 ^{abc} ± 0.14	6.07 ^a ± 0.52	5.74 ^a ± 0.34	6.00 ^a ± 0.21
T ₁₀ - Mulching of weed	5.56 ^{ab} ± 0.46	5.59 ^{abc} ± 0.21	5.11 ^{bcd} ± 0.05	5.56 ^{abc} ± 0.55
T ₁₁ - Control	5.31 ^{abcd} ± 0.28	5.19 ^{bcd} ± 0.36	5.62 ^{ab} ± 0.33	5.77 ^{ab} ± 0.27
<i>SE(m) ±</i>	0.16	0.18	0.17	0.19
<i>C.D. (5%)</i>	0.47	0.52	0.51	0.57
<i>C.V. (%)</i>	5.28	5.78	5.78	6.14

4.2.5 Effect of treatments on electrical conductivity of basin soil

The data pertaining to the effect of basin enrichment through the application of biomass under different treatments on electrical conductivity ($\mu\text{S cm}^{-1}$) of basin soil were statistically analyzed and presented in table 4.30. The data revealed a significant difference among all the treatments. The EC of basin soil at depth 0-15 cm was found maximum both for initial and final in the treatment T₄- Mulching of Tephrosia biomass (210.40 $\mu\text{S cm}^{-1}$ and 133.14 $\mu\text{S cm}^{-1}$) respectively, while minimum both for initial and final was found in the treatment T₁₁- Control (78.83 $\mu\text{S cm}^{-1}$ and 50.84 $\mu\text{S cm}^{-1}$) respectively.

Similarly, EC of basin soil at depth 15- 30 cm was found maximum initially T₃- Soil incorporation of Tephrosia biomass (208.39 $\mu\text{S cm}^{-1}$) and at final in the treatment T₁- Soil incorporation of Vegetable Soybean biomass (95.26 $\mu\text{S cm}^{-1}$) respectively, while the minimum was found initially in the treatment T₁₀- Mulching of weed (119.65 $\mu\text{S cm}^{-1}$) and at final in the treatment T₁₁- Control (54.91 $\mu\text{S cm}^{-1}$) respectively.

The above results are in conformity with the earlier studies done by Okonkwo *et al.* (2009) in their studies; they reported that there was an increasing trend in EC value of soil in the alley plots as compared to control.

Table 4.23: Electrical conductivity of basin soil

Treatments	Soil: Electrical Conductivity ($\mu\text{S cm}^{-1}$)				
	Basin Area (0- 15 cm)		Basin Area (15- 30 cm)		
	July- 19	Dec- 20	July- 19	Dec- 20	
T ₁ - Soil incorporation of Vegetable Soybean biomass	106.89 ^{de} ±14.46	98.42 ^b ±4.13	76.83 ^a ±12.54	95.26 ^a ±15.78	
T ₂ - Mulching of Vegetable Soybean biomass	137.24 ^{cd} ±20.10	62.53 ^{cd} ±8.06	105.94 ^c ±72.43	65.86 ^{bc} ±10.71	
T ₃ - Soil incorporation of Tephrosia biomass	203.90 ^{ab} ±29.18	93.87 ^b ±4.30	208.39 ^a ±36.24	74.97 ^{abc} ±16.56	
T ₄ - Mulching of Tephrosia biomass	210.40 ^a ±55.62	133.14 ^a ±46.59	133.63 ^{bc} ±54.05	85.89 ^a ±9.30	
T ₅ - Soil incorporation of Rice bean biomass	157.93 ^{bc} ±32.11	55.27 ^{cd} ±7.26	95.07 ^c ±7.58	65.90 ^{bc} ±11.54	
T ₆ - Mulching of Rice bean biomass	72.91 ^e ±18.54	61.77 ^{cd} ±6.18	70.86 ^c ±5.36	62.00 ^c ±5.15	
T ₇ - Soil incorporation of Subabul biomass	160.13 ^{bc} ±11.14	70.99 ^{bcd} ±17.24	123.63 ^{bc} ±39.39	75.42 ^{abc} ±13.27	
T ₈ - Mulching of Subabul biomass	148.78 ^{cd} ±47.95	82.98 ^{bc} ±20.79	122.89 ^{bc} ±44.66	55.03 ^c ±24.35	
T ₉ - Soil incorporation of weed	112.06 ^{cde} ±32.35	59.86 ^{cd} ±4.18	178.13 ^{ab} ±40.09	60.55 ^c ±2.43	
T ₁₀ - Mulching of weed	135.02 ^{cd} ±11.47	62.31 ^{cd} ±8.41	119.65 ^{bc} ±63.09	66.99 ^{bc} ±4.90	
T ₁₁ - Control	78.83 ^e ±35.07	50.84 ^d ±9.35	121.36 ^{bc} ±43.40	54.91 ^c ±15.00	
	<i>SE(m) ±</i>	16.76	10.40	23.72	7.32
	<i>C.D. (5%)</i>	49.45	30.67	69.97	21.58
	<i>C.V. (%)</i>	20.95	23.81	33.31	18.27

4.2.6 Effect of treatments on electrical conductivity of alley soil

The data pertaining to the effect of basin enrichment through the application of biomass under different treatments on electrical conductivity ($\mu\text{S cm}^{-1}$) of alley soil were statistically analyzed and presented in table 4.30. The data revealed a significant difference among all treatments. The EC of alley soil at depth 0-15 cm was found maximum initially in treatment T₃- Soil incorporation of Tephrosia biomass (174.20 $\mu\text{S cm}^{-1}$) and at final in treatment T₁- Soil incorporation of Vegetable Soybean biomass (104.73 $\mu\text{S cm}^{-1}$) respectively, while minimum was found initially in the treatment T₉- Soil incorporation of weed (61.96 $\mu\text{S cm}^{-1}$) and at final in treatment T₁₁- Control (48.30 $\mu\text{S cm}^{-1}$) respectively.

Similarly, EC of alley soil at depth 15- 30 cm was found maximum initially in the treatment T₃- Soil incorporation of Tephrosia biomass (174.7 $\mu\text{S cm}^{-1}$) and at final in the

treatment T₈- Mulching of Subabul biomass (88.47 $\mu\text{S cm}^{-1}$) respectively, while the minimum was found initially in the treatment T₁₀- Mulching of weed (62.67 $\mu\text{S cm}^{-1}$) and at final in the treatment T₉- Soil incorporation of weed (50.83 $\mu\text{S cm}^{-1}$) respectively.

Table 4.24: Electrical conductivity of alley soil

Treatments	Soil: Electrical Conductivity ($\mu\text{S cm}^{-1}$)			
	Alley Area (0- 15 cm)		Alley Area (15- 30 cm)	
	July- 19	Dec- 20	July- 19	Dec- 20
T ₁ - Soil incorporation of Vegetable Soybean biomass	74.37 ^{bc} ±4.61	104.73 ^a ±24.93	81.52 ^{bc} ±19.58	68.56 ^{bc} ±5.77
T ₂ - Mulching of Vegetable Soybean biomass	80.63 ^{bc} ±22.75	59.33 ^{cd} ±6.95	84.56 ^{bc} ±14.51	59.21 ^{bcd} ±5.28
T ₃ - Soil incorporation of Tephrosia biomass	174.20 ^a ±14.23	96.07 ^{ab} ±5.31	174.7 ^a ±50.15	69.12 ^b ±2.51
T ₄ - Mulching of Tephrosia biomass	152.38 ^a ±32.50	70.52 ^{cd} ±24.96	114.79 ^a ±15.18	64.24 ^{bcd} ±8.34
T ₅ - Soil incorporation of Rice bean biomass	146.33 ^{abc} ±73.36	54.02 ^d ±5.83	79.32 ^{bc} ±18.74	56.06 ^{bcd} ±5.51
T ₆ - Mulching of Rice bean biomass	87.97 ^{bc} ±20.48	80.80 ^{bc} ±22.52	74.21 ^c ±4.12	61.05 ^{bcd} ±20.60
T ₇ - Soil incorporation of Subabul biomass	126.30 ^{ab} ±41.82	65.27 ^{cd} ±5.71	76.45 ^{bc} ±24.49	64.69 ^{bcd} ±3.89
T ₈ - Mulching of Subabul biomass	89.05 ^{bc} ±46.53	63.30 ^{cd} ±10.94	159.83 ^a ±14.11	88.47 ^a ±14.51
T ₉ - Soil incorporation of weed	61.96 ^c ±12.61	51.38 ^d ±7.70	101.66 ^{bc} ±16.89	50.83 ^d ±4.38
T ₁₀ - Mulching of weed	61.99 ^c ±15.84	69.64 ^{cd} ±13.92	62.67 ^c ±6.88	52.99 ^{cd} ±6.17
T ₁₁ - Control	87.47 ^{bc} ±12.74	48.30 ^d ±15.92	77.43 ^{bc} ±24.72	60.68 ^{bcd} ±8.33
<i>SE(m) ±</i>	17.74	8.10	13.46	5.32
<i>C.D. (5%)</i>	52.33	23.90	39.71	15.69
<i>C.V. (%)</i>	29.40	20.22	23.59	14.56

4.2.7 Effect of treatments on soil organic carbon of basin area

The data pertaining to the effect of basin enrichment through the application of biomass under different treatments on soil organic carbon of basin area were statistically analyzed and presented in table 4.31. The data revealed a significant difference among all the treatments. The SOC (%) of basin soil at depth 0-15 cm was found maximum both for initial and final in the treatment T₈- Mulching of Subabul biomass (0.82 % and 0.97 %) respectively, while the minimum was found initially in the treatment T₉- Soil incorporation of weed (0.52 %) and at final in the treatment T₁₁- Control (0.60 %) respectively.

Similarly, SOC (%) of basin soil at depth 15- 30 cm was found maximum initially in the treatment T₈- Mulching of Subabul biomass (0.66 %) and at final in the treatment T₇- Soil incorporation of Subabul biomass (0.84 %) respectively, while the minimum was found initially in the treatment T₃- Soil incorporation of Tephrosia biomass (0.48 %) and at final in the treatment T₁₁- Control (0.53 %) respectively.

The above results are in conformity with the earlier studies done by Kumar *et al.* (2014); Rahman *et al.* (2010) and Youkhana and Idol (2009) in their studies; they reported that soil organic carbon significantly increased in an alley cropping system using a different source of mulch as compared to control.

Table 4.25: Soil organic carbon of basin area

Treatments	Soil: Organic Carbon (%)			
	Alley Area (0- 15 cm)		Alley Area (15- 30 cm)	
	July- 19	Dec- 20	July- 19	Dec- 20
T ₁ - Soil incorporation of Vegetable Soybean biomass	0.74 ^{ab} ± 0.10	0.85 ^{ab} ± 0.12	0.62 ^{abc} ± 0.08	0.67 ^{bc} ± 0.10
T ₂ - Mulching of Vegetable Soybean biomass	0.61 ^{bcd} ± 0.02	0.74 ^{bcd} ± 0.05	0.53 ^{cd} ± 0.09	0.54 ^c ± 0.07
T ₃ - Soil incorporation of Tephrosia biomass	0.72 ^{abc} ± 0.05	0.87 ^{ab} ± 0.16	0.48 ^d ± 0.02	0.82 ^a ± 0.07
T ₄ - Mulching of Tephrosia biomass	0.60 ^{bcd} ± 0.07	0.82 ^{abc} ± 0.06	0.56 ^{bcd} ± 0.03	0.79 ^{ab} ± 0.06
T ₅ - Soil incorporation of Rice bean biomass	0.78 ^a ± 0.07	0.85 ^{ab} ± 0.03	0.60 ^{abc} ± 0.03	0.72 ^{ab} ± 0.05
T ₆ - Mulching of Rice bean biomass	0.61 ^{bcd} ± 0.07	0.82 ^{abc} ± 0.09	0.58 ^{bcd} ± 0.02	0.66 ^{bc} ± 0.15
T ₇ - Soil incorporation of Subabul biomass	0.74 ^{abc} ± 0.13	0.94 ^a ± 0.06	0.63 ^{ab} ± 0.06	0.84 ^a ± 0.11
T ₈ - Mulching of Subabul biomass	0.82 ^a ± 0.10	0.97 ^a ± 0.07	0.66 ^a ± 0.07	0.75 ^{ab} ± 0.03
T ₉ - Soil incorporation of weed	0.51 ^d ± 0.03	0.76 ^{bcd} ± 0.08	0.57 ^{abcd} ± 0.06	0.66 ^{bc} ± 0.11
T ₁₀ - Mulching of weed	0.58 ^{cd} ± 0.19	0.67 ^{cd} ± 0.06	0.60 ^{abc} ± 0.03	0.70 ^{ab} ± 0.11
T ₁₁ - Control	0.58 ^{bcd} ± 0.19	0.60 ^d ± 0.12	0.50 ^d ± 0.08	0.53 ^{bc} ± 0.03
<i>SE(m) ±</i>	0.05	0.05	0.03	0.04
<i>C.D. (5%)</i>	0.16	0.15	0.09	0.14
<i>C.V. (%)</i>	14.72	11.31	9.59	11.65

4.2.8 Effect of treatments on soil organic carbon of alley area

The data pertaining to the effect of basin enrichment through the application of biomass under different treatments on soil organic carbon (%) of alley area were statistically analyzed and presented in table 4.32. The data revealed a significant difference among all the treatments. The SOC (%) of alley soil at depth 0-15 cm was found maximum initially in the treatment T₇- Soil incorporation of Subabul biomass (0.72 %), which was at par with the treatment T₁- Soil incorporation of Vegetable Soybean biomass and at final in the treatment T₃- Soil incorporation of Tephrosia biomass (0.79 %) respectively, while the minimum was found initially in the treatment T₁₀- Mulching of weed (0.50 %) and at final in the treatment T₁₁- Control (0.53 %) respectively.

Similarly, SOC (%) of alley soil at depth 15- 30 cm was found maximum initially in the treatment T₂- Mulching of Vegetable Soybean biomass (0.66 %) and at final in the treatment T₈- Mulching of Subabul biomass (0.82 %) respectively, while the minimum was found both for initial and final in the treatment T₁₁- Control (0.44% and 0.53 %) respectively.

Table 4.26: Soil organic carbon of alley area

Treatments	Soil: Organic Carbon (%)			
	Alley Area (0- 15 cm)		Alley Area (15- 30 cm)	
	July- 19	Dec- 20	July- 19	Dec- 20
T ₁ - Soil incorporation of Vegetable Soybean biomass	0.72 ^a ± 0.08	0.67 ^{bc} ± 0.02	0.56 ^{abc} ± 0.05	0.64 ^{bc} ± 0.04
T ₂ - Mulching of Vegetable Soybean biomass	0.68 ^a ± 0.09	0.71 ^{abc} ± 0.01	0.66 ^a ± 0.05	0.61 ^{bc} ± 0.13
T ₃ - Soil incorporation of Tephrosia biomass	0.64 ^{abc} ± 0.08	0.79 ^a ± 0.03	0.58 ^{abc} ± 0.07	0.73 ^{ab} ± 0.04
T ₄ - Mulching of Tephrosia biomass	0.60 ^{abcd} ± 0.07	0.74 ^{abc} ± 0.15	0.52 ^{cd} ± 0.05	0.75 ^{ab} ± 0.07
T ₅ - Soil incorporation of Rice bean biomass	0.58 ^{abcd} ± 0.09	0.66 ^{bc} ± 0.10	0.59 ^{abc} ± 0.04	0.69 ^{abc} ± 0.05
T ₆ - Mulching of Rice bean biomass	0.54 ^{bcd} ± 0.01	0.77 ^{ab} ± 0.01	0.63 ^{abc} ± 0.05	0.53 ^c ± 0.08
T ₇ - Soil incorporation of Subabul biomass	0.72 ^a ± 0.05	0.75 ^{ab} ± 0.04	0.54 ^{bcd} ± 0.07	0.67 ^{abc} ± 0.12
T ₈ - Mulching of Subabul biomass	0.63 ^{abcd} ± 0.14	0.69 ^{abc} ± 0.01	0.60 ^{abc} ± 0.03	0.82 ^a ± 0.08
T ₉ - Soil incorporation of weed	0.65 ^{ab} ± 0.07	0.66 ^c ± 0.07	0.61 ^{abc} ± 0.07	0.81 ^a ± 0.12
T ₁₀ - Mulching of weed	0.50 ^d ± 0.05	0.65 ^c ± 0.04	0.59 ^{abc} ± 0.05	0.61 ^{bc} ± 0.16
T ₁₁ - Control	0.51 ^{cd} ± 0.09	0.53 ^d ± 0.07	0.44 ^d ±	0.55 ^c ± 0.05
<i>SE(m) ±</i>	0.04	0.04	0.03	0.05
<i>C.D. (5%)</i>	0.14	0.12	0.10	0.15
<i>C.V. (%)</i>	13.45	9.76	10.26	13.53

4.2.9 Effect of treatments on available nitrogen of basin soil

The data pertaining to the effect of basin enrichment through the application of biomass under different treatments on available nitrogen (kg ha^{-1}) of basin soil were statistically analyzed and presented in table 4.33. The data revealed a significant difference among all the treatments. The available nitrogen (kg ha^{-1}) of basin soil at depth 0-15 cm was found maximum both for initial and final in the treatment T₈- Mulching of Subabul biomass (279.66 kg ha^{-1} and 302.60 kg ha^{-1}) respectively, while the minimum was found both for initial and final in the treatment T₁₁- Control (205.34 kg ha^{-1} and 222.36 kg ha^{-1}) respectively

Table 4.27: Available nitrogen of basin soil

Treatments	Soil: Available Nitrogen (kg ha^{-1})			
	Basin Area (0- 15 cm)		Basin Area (15- 30 cm)	
	July- 19	Dec- 20	July- 19	Dec- 20
T ₁ - Soil incorporation of Vegetable Soybean biomass	261.38 ^{ab} ±33.9	264.96 ^{bc} ±24.5	252.71 ^a ±24.0	263.80 ^a ±12.40
T ₂ - Mulching of Vegetable Soybean biomass	247.83 ^{ab} ±14.4	275.96 ^{ab} ±12.1	263.36 ^a ±5.02	270.21 ^a ±25.82
T ₃ - Soil incorporation of Tephrosia biomass	253.43 ^{ab} ±33.7	281.60 ^{ab} ±2.3	264.87 ^a ±22.79	274.08 ^a ±26.41
T ₄ - Mulching of Tephrosia biomass	267.14 ^{ab} ±13.6	277.03 ^{ab} ±6.1	256.74 ^a ±30.82	261.71 ^a ±9.53
T ₅ - Soil incorporation of Rice bean biomass	239.04 ^b ±20.2	255.46 ^{bc} ±30.8	244.76 ^{ab} ±13.97	250.39 ^a ±15.61
T ₆ - Mulching of Rice bean biomass	256.11 ^{ab} ±17.4	238.73 ^{cd} ±33.0	254.74 ^a ±10.98	258.79 ^a ±22.35
T ₇ - Soil incorporation of Subabul biomass	277.64 ^a ±17.8	282.03 ^{ab} ±9.8	258.73 ^a ±6.45	265.61 ^a ±9.69
T ₈ - Mulching of Subabul biomass	279.66 ^a ±22.4	302.60 ^a ±32.0	271.98 ^a ±27.06	280.20 ^a ±22.49
T ₉ - Soil incorporation of weed	238.04 ^{bc} ±17.5	258.66 ^{bc} ±15.1	215.59 ^{bc} ±35.31	256.25 ^a ±20.31
T ₁₀ - Mulching of weed	250.48 ^{ab} ±29.9	277.46 ^{ab} ±19.4	245.75 ^{ab} ±10.25	250.70 ^a ±11.46
T ₁₁ - Control	205.34 ^c ±17.6	222.36 ^d ±19.7	207.03 ^c ±34.15	212.06 ^b ±33.49
<i>SE(m) ±</i>	16.07	10.67	12.01	11.28
<i>C.D. (5%)</i>	33.13	31.47	35.44	33.53
<i>C.V. (%)</i>	11.24	6.92	8.36	7.56

Similarly, available nitrogen (kg ha^{-1}) of basin soil at depth 15- 30 cm was found maximum both for initial and final in the treatment T₈- Mulching of Subabul biomass (271.98 kg ha^{-1} and 280.20 kg ha^{-1}) respectively, while the minimum was found both for initial and final in the treatment T₁₁- Control (207.03 kg ha^{-1} and 212.06 kg ha^{-1}) respectively.

The above results are in conformity with the earlier studies done by Okonkwo *et al.* (2009); Issac *et al.* (2003) and Kaur *et al.* (2000) in their studies; they marked a significant increase in soil nitrogen in an alley cropping system using a different source of mulch as compared to control.

4.2.10 Effect of treatments on available nitrogen of alley soil

The data pertaining to the effect of basin enrichment through the application of biomass under different treatments on available nitrogen (kg ha^{-1}) of alley soil were statistically analyzed and presented in table 4.34. The data revealed a significant difference among all the treatments. The available nitrogen (kg ha^{-1}) of alley soil at depth 0-15 cm was found maximum initially in the treatment T₄- Mulching of Tephrosia biomass ($274.51 \text{ kg ha}^{-1}$) and at final in the treatment T₈- Mulching of Subabul biomass ($296.78 \text{ kg ha}^{-1}$) respectively, while the minimum was found both for initial and final in the treatment T₁₁- Control ($211.58 \text{ kg ha}^{-1}$ and $232.51 \text{ kg ha}^{-1}$) respectively.

Table 4.28: Available nitrogen of alley soil

Treatments	Soil: Available Nitrogen (kg ha^{-1})			
	Alley Area (0- 15 cm)		Alley Area (15- 30 cm)	
	July- 19	Dec- 20	July- 19	Dec- 20
T ₁ - Soil incorporation of Vegetable Soybean biomass	252.04 ^{abc} ±24.35	260.17 ^{bcde} ±28.62	237.64 ^{abc} ±21.54	256.57 ^{ab} ±13.52
T ₂ - Mulching of Vegetable Soybean biomass	233.03 ^{bcd} ±23.44	273.62 ^{abcd} ±12.13	236.45 ^{abc} ±22.35	247.24 ^{ab} ±23.72
T ₃ - Soil incorporation of Tephrosia biomass	259.51 ^{ab} ±13.21	277.76 ^{abc} ±21.51	238.98 ^{abc} ±19.71	257.71 ^{ab} ±15.71
T ₄ - Mulching of Tephrosia biomass	274.51 ^a ±27.46	289.42 ^{ab} ±15.50	241.63 ^{ab} ±32.69	261.89 ^{ab} ±21.05
T ₅ - Soil incorporation of Rice bean biomass	204.61 ^d ±18.13	250.33 ^{cde} ±13.56	200.93 ^{cd} ±14.50	248.58 ^{ab} ±39.94
T ₆ - Mulching of Rice bean biomass	225.76 ^{bcd} ±42.97	256.24 ^{cde} ±31.66	188.75 ^d ±12.12	241.98 ^{ab} ±29.67
T ₇ - Soil incorporation of Subabul biomass	251.79 ^{abc} ±21.45	276.59 ^{abcd} ±10.88	252.49 ^{ab} ±39.10	265.69 ^a ±26.72
T ₈ - Mulching of Subabul biomass	264.22 ^{ab} ±15.22	296.78 ^a ±9.59	264.80 ^a ±17.54	267.30 ^a ±14.04
T ₉ - Soil incorporation of weed	230.48 ^{bcd} ±25.75	244.47 ^{de} ±15.57	235.73 ^{abc} ±31.11	230.05 ^{bc} ±13.34
T ₁₀ - Mulching of weed	235.43 ^{abcd} ±13.12	248.74 ^{cde} ±10.19	229.59 ^a ±42.97	228.25 ^{bc} ±14.93
T ₁₁ - Control	211.58 ^{cd} ±17.26	232.51 ^e ±31.71	216.46 ^{bcd} ±25.96	204.87 ^c ±18.21
<i>SE(m) ±</i>	13.86	10.96	13.12	11.67
<i>C.D. (5%)</i>	40.89	32.34	38.71	34.44
<i>C.V. (%)</i>	9.99	7.18	9.83	8.20

Similarly, available nitrogen (kg ha^{-1}) of alley soil at depth 15- 30 cm was found maximum both for initial and final in the treatment T₈- Mulching of Subabul biomass (264.80 kg ha^{-1} and 267.30 kg ha^{-1}) respectively, while the minimum was found both for initial and final in the treatment T₁₁- Control (216.46 kg ha^{-1} and 204.87 kg ha^{-1}) respectively.

4.2.11 Effect of treatments on available phosphorus of basin soil

The data pertaining to the effect of basin enrichment through the application of biomass under different treatments on available phosphorus (kg ha^{-1}) of basin soil were statistically analyzed and presented in table 4.35. The data revealed a significant difference among all the treatments. The available phosphorus (kg ha^{-1}) of basin soil at depth 0-15 cm was found maximum initially in the treatment T₇- Soil incorporation of Subabul biomass (30.81 kg ha^{-1}) and at final in the treatment T₄- Mulching of Tephrosia biomass (42.28 kg ha^{-1}) respectively, while the minimum was found both for initial and final in the treatment T₁₁- Control (13.98 kg ha^{-1} and 18.41 kg ha^{-1}) respectively.

Table 4.29: Available phosphorus of basin soil

Treatments	Soil: Available Phosphorus (kg ha^{-1})			
	Basin Area (0- 15 cm)		Basin Area (15- 30 cm)	
	July- 19	Dec- 20	July- 19	Dec- 20
T ₁ - Soil incorporation of Vegetable Soybean biomass	22.62 ^c ±2.15	30.95 ^{abc} ±2.00	21.97 ^{abc} ±3.60	31.38 ^{ab} ±0.78
T ₂ - Mulching of Vegetable Soybean biomass	16.89 ^{cd} ±4.10	22.50 ^c ±4.88	19.86 ^{bcd} ±3.16	33.58 ^a ±3.17
T ₃ - Soil incorporation of Tephrosia biomass	22.92 ^{bc} ±8.25	29.18 ^{abc} ±8.95	24.32 ^{abc} ±6.05	35.79 ^a ±3.29
T ₄ - Mulching of Tephrosia biomass	32.40 ^a ±4.16	42.28 ^a ±11.57	30.60 ^a ±6.85	30.94 ^{ab} ±1.46
T ₅ - Soil incorporation of Rice bean biomass	24.72 ^{abc} ±3.43	27.37 ^{bc} ±7.32	20.44 ^{bcd} ±7.37	28.01 ^{abc} ±11.42
T ₆ - Mulching of Rice bean biomass	19.03 ^{cd} ±2.22	22.82 ^c ±3.67	25.45 ^{ab} ±5.50	17.54 ^d ±10.14
T ₇ - Soil incorporation of Subabul biomass	30.81 ^{ab} ±5.46	39.56 ^{ab} ±18.06	27.80 ^{ab} ±4.71	22.38 ^{bcd} ±4.33
T ₈ - Mulching of Subabul biomass	22.50 ^c ±5.39	28.73 ^{abc} ±9.34	22.52 ^{abc} ±5.95	28.05 ^{abc} ±8.40
T ₉ - Soil incorporation of weed	21.73 ^{cd} ±5.42	18.93 ^c ±6.11	13.00 ^d ±3.29	23.73 ^{bcd} ±10.34
T ₁₀ - Mulching of weed	19.34 ^{cd} ±6.92	25.54 ^c ±1.76	23.69 ^{abc} ±4.09	14.83 ^d ±3.69
T ₁₁ - Control	13.98 ^d ±3.49	18.41 ^c ±3.74	15.86 ^{cd} ±4.81	20.65 ^{cd} ±8.84
<i>SE(m) ±</i>	2.71	4.73	2.99	3.32
<i>C.D. (5%)</i>	8.00	13.95	8.81	9.78
<i>C.V. (%)</i>	20.92	29.42	23.18	22.03

Similarly, available phosphorus (kg ha^{-1}) of basin soil at depth 15- 30 cm was found maximum initially in the treatment T₄- Mulching of Tephrosia biomass (30.60 kg ha^{-1}) and at final in the treatment T₃- Soil incorporation of Tephrosia biomass (35.79 kg ha^{-1}) respectively, while the minimum was found initially in the treatment T₉- Soil incorporation of weed (13.00 kg ha^{-1}) and at final in the treatment T₁₀- Mulching of weed (14.83 kg ha^{-1}) respectively.

The above results are in conformity with the earlier studies done by Kumar *et al.* (2014); Larbi *et al.* (1993) and Yamoah *et al.* (1986) in their studies; they reported that the available phosphorus was significantly more in the alley plots as compared to control.

4.2.12 Effect of treatments on available phosphorus of alley soil

The data pertaining to the effect of basin enrichment through the application of biomass under different treatments on available phosphorus (kg ha^{-1}) of alley soil were statistically analyzed and presented in table 4.36. The data revealed a significant difference among all the treatments. The available phosphorus (kg ha^{-1}) of alley soil at depth 0-15 cm was found maximum initially in the treatment T₁- Soil incorporation of Vegetable Soybean biomass (33.61 kg ha^{-1}) and at final in the treatment T₈- Mulching of Subabul biomass (34.94 kg ha^{-1}) respectively, while the minimum was found initially in the treatment T₁₁- Control (14.98 kg ha^{-1}) and at final in the treatment T₉- Soil incorporation of weed (16.00 kg ha^{-1}) respectively.

Similarly, available phosphorus (kg ha^{-1}) of alley soil at depth 15- 30 cm was found maximum initially in the treatment T₅- Soil incorporation of Rice bean (33.77 kg ha^{-1}) and at final in the treatment T₄- Mulching of Tephrosia biomass (35.31 kg ha^{-1}) respectively, while the minimum was found both for initial and final in the treatment T₁₁- Control (16.07 kg ha^{-1} and 21.43 kg ha^{-1}) respectively.

Table 4.30: Available phosphorus of alley soil

Treatments	Soil: Available Phosphorus (kg ha ⁻¹)			
	Alley Area (0- 15 cm)		Alley Area (15- 30 cm)	
	July- 19	Dec- 20	July- 19	Dec- 20
T ₁ - Soil incorporation of Vegetable Soybean biomass	33.61 ^a ±8.47	21.50 ^{bcd} ±7.68	24.51 ^{abc} ±4.24	23.80 ^{bcd} ±6.71
T ₂ - Mulching of Vegetable Soybean biomass	22.30 ^{ab} ±7.44	31.50 ^{ab} ±8.19	14.96 ^c ±4.46	30.00 ^{abc} ±1.12
T ₃ - Soil incorporation of Tephrosia biomass	28.17 ^{ab} ±13.98	21.53 ^{bcd} ±4.33	28.51 ^{ab} ±2.46	31.71 ^{ab} ±3.53
T ₄ - Mulching of Tephrosia biomass	33.06 ^a ±11.54	31.89 ^{ab} ±3.87	24.50 ^{abc} ±5.52	35.31 ^a ±5.40
T ₅ - Soil incorporation of Rice bean biomass	15.31 ^b ±4.57	28.32 ^{abc} ±7.19	33.77 ^a ±6.67	25.12 ^{bcd} ±0.93
T ₆ - Mulching of Rice bean biomass	26.27 ^{ab} ±11.07	29.92 ^{ab} ±4.97	22.51 ^{bc} ±13.14	21.80 ^{cd} ±9.15
T ₇ - Soil incorporation of Subabul biomass	29.81 ^a ±4.72	30.78 ^{ab} ±8.69	23.40 ^{abc} ±5.23	27.92 ^{abc} ±2.04
T ₈ - Mulching of Subabul biomass	32.16 ^a ±3.19	34.94 ^a ±8.49	29.99 ^{ab} ±5.23	28.98 ^{abc} ±0.86
T ₉ - Soil incorporation of weed	15.68 ^b ±4.83	13.38 ^d ±3.11	30.24 ^{ab} ±5.53	21.84 ^{cd} ±7.17
T ₁₀ - Mulching of weed	22.27 ^{ab} ±3.72	17.56 ^{cd} ±8.41	25.05 ^{abc} ±5.90	18.05 ^d ±6.04
T ₁₁ - Control	14.98 ^b ±5.38	16.00 ^d ±7.57	16.07 ^c ±5.14	21.43 ^{cd} ±1.70
<i>SE(m) ±</i>	4.48	4.13	3.58	2.93
<i>C.D. (5%)</i>	13.22	12.18	10.55	8.65
<i>C.V. (%)</i>	31.21	28.36	24.90	19.53

4.2.13 Effect of treatments on exchangeable potassium of basin soil

The data pertaining to the effect of basin enrichment through the application of biomass under different treatments on exchangeable potassium (kg ha⁻¹) of basin soil were statistically analyzed and presented in table 4.37. The data revealed a significant difference among all the treatments. The exchangeable potassium (kg ha⁻¹) of basin soil at depth 0-15 cm was found maximum initially in the treatment T₈- Mulching of Subabul biomass (307.68 kg ha⁻¹) and at final in the treatment T₄- Mulching of Tephrosia biomass (327.37 kg ha⁻¹) respectively, while the minimum was found initially in the treatment T₁₁- Control (237.98 kg ha⁻¹) and at final in the treatment T₁₀- Mulching of weed (238.90 kg ha⁻¹) respectively.

Table 4.31: Exchangeable potassium of basin soil

Treatments	Soil: Exchangeable Potassium (kg ha ⁻¹)			
	Basin Area (0- 15 cm)		Basin Area (15- 30 cm)	
	July- 19	Dec- 20	July- 19	Dec- 20
T ₁ - Soil incorporation of Vegetable Soybean biomass	238.96 ^{cd} ±34.61	252.51 ^{bc} ±19.21	219.89 ^{bc} ±40.35	239.45 ^{bc} ±30.24
T ₂ - Mulching of Vegetable Soybean biomass	242.19 ^{bcd} ±21.93	243.83 ^{bc} ±17.90	257.60 ^{ab} ±70.33	245.74 ^{bc} ±32.32
T ₃ - Soil incorporation of Tephrosia biomass	287.35 ^{abc} ±25.87	281.24 ^{abc} ±13.88	287.41 ^a ±0.60	273.99 ^{ab} ±14.05
T ₄ - Mulching of Tephrosia biomass	295.50 ^{abc} ±9.81	327.37 ^a ±5.05	256.48 ^{ab} ±7.74	281.20 ^{ab} ±22.51
T ₅ - Soil incorporation of Rice bean biomass	282.43 ^{abc} ±11.69	275.38 ^{abc} ±27.53	246.23 ^{abc} ±36.30	273.27 ^{ab} ±15.06
T ₆ - Mulching of Rice bean biomass	200.74 ^d ±31.60	261.92 ^{bc} ±47.44	221.10 ^{bc} ±17.92	250.79 ^{bc} ±36.21
T ₇ - Soil incorporation of Subabul biomass	299.34 ^{ab} ±50.26	327.18 ^a ±44.47	289.12 ^a ±4.71	312.42 ^a ±18.87
T ₈ - Mulching of Subabul biomass	307.68 ^a ±60.17	299.33 ^{ab} ±1.55	278.88 ^a ±10.66	274.24 ^{ab} ±29.87
T ₉ - Soil incorporation of weed	242.19 ^{bcd} ±21.93	247.49 ^{bc} ±45.88	245.76 ^{abc} ±42.30	250.16 ±45.37
T ₁₀ - Mulching of weed	254.34 ^{abcd} ±38.20	238.90 ^c ±43.75	212.78 ^{bc} ±30.15	242.37 ^{bc} ±22.47
T ₁₁ - Control	237.98 ^{cd} ±12.90	249.55 ^{bc} ±39.56	200.90 ^c ±26.52	225.31 ^c ±12.02
<i>SE(m) ±</i>	19.74	19.21	18.55	15.10
<i>C.D. (5%)</i>	58.23	56.67	54.73	44.56
<i>C.V. (%)</i>	13.02	12.18	13.01	10.03

Similarly, exchangeable potassium (kg ha⁻¹) of basin soil at depth 15- 30 cm was found maximum was found both for initial and final in the treatment T₇- Soil incorporation of Subabul biomass (289.12 kg ha⁻¹ and 312.42 kg ha⁻¹) respectively, while the minimum was found both for initial and final in the treatment T₁₁- Control (200.90 kg ha⁻¹ and 225.31 kg ha⁻¹) respectively.

The above results are in conformity with the earlier studies done by Kumar *et al.* (2014) and Yamoah *et al.* (1986) in their studies; they reported high content of potassium in the alley plots as compared to control.

4.2.14 Effect of treatments on exchangeable potassium of alley soil

The data pertaining to the effect of basin enrichment through the application of biomass under different treatments on exchangeable potassium (kg ha⁻¹) of alley soil were statistically analyzed and presented in table 4.38. The data revealed a significant difference among all the treatments. The exchangeable potassium (kg ha⁻¹) of alley soil at depth 0-15 cm was found maximum initially in the treatment T₆- Mulching of Rice bean biomass

(306.57 kg ha⁻¹) and at final in the treatment T₇- Soil incorporation of Subabul (306.94 kg ha⁻¹) respectively, while the minimum was found both for initial in the treatment T₁₁- Control (203.26 kg ha⁻¹ and 214.17 kg ha⁻¹) respectively.

Table 4.32: Exchangeable potassium of alley soil

Treatments	Soil: Exchangeable Potassium (kg ha ⁻¹)			
	Alley Area (0- 15 cm)		Alley Area (15- 30 cm)	
	July- 19	Dec- 20	July- 19	Dec- 20
T ₁ - Soil incorporation of Vegetable Soybean biomass	213.76 ^d ±22.17	276.25 ^{abc} ±24.42	210.04 ^{de} ±7.73	235.91 ^c ±39.14
T ₂ - Mulching of Vegetable Soybean biomass	205.81 ^d ±51.38	232.16 ^{cd} ±27.50	240.72 ^{abcd} ±42.74	232.12 ^c ±30.07
T ₃ - Soil incorporation of Tephrosia biomass	299.55 ^a ±18.27	281.09 ^{abc} ±55.93	256.83 ^{ab} ±29.63	270.92 ^{abc} ±34.76
T ₄ - Mulching of Tephrosia biomass	287.82 ^{ab} ±2.89	302.19 ^{ab} ±34.22	276.97 ^a ±60.30	318.13 ^{ab} ±49.19
T ₅ - Soil incorporation of Rice bean biomass	239.88 ^{bcd} ±54.49	254.19 ^{bcd} ±19.78	255.84 ^{abc} ±38.97	266.28 ^{abc} ±62.34
T ₆ - Mulching of Rice bean biomass	306.57 ^a ±43.21	275.55 ^{abc} ±44.06	216.41 ^{bcd} ±4.43	204.13 ^c ±33.84
T ₇ - Soil incorporation of Subabul biomass	298.91 ^a ±50.18	306.94 ^a ±10.36	273.5 ^a ±19.36	260.15 ^{abc} ±11.21
T ₈ - Mulching of Subabul biomass	279.59 ^{abc} ±1.59	281.66 ^{abc} ±16.85	245.32 ^{abcd} ±24.79	326.35 ^a ±50.00
T ₉ - Soil incorporation of weed	259.84 ^{abcd} ±23.78	277.87 ^{abc} ±13.78	213.75 ^{cde} ±6.61	251.25 ^{bc} ±34.55
T ₁₀ - Mulching of weed	229.33 ^{cd} ±55.05	246.91 ^{cd} ±10.68	244.41 ^{ab} ±14.58	255.54 ^{bc} ±49.53
T ₁₁ - Control	203.26 ^d ±10.16	214.17 ^d ±29.56	196.16 ^e ±16.65	207.93 ^c ±12.00
<i>SE(m) ±</i>	19.41	17.81	14.53	23.70
<i>C.D. (5%)</i>	57.27	52.62	42.87	69.91
<i>C.V. (%)</i>	13.09	11.52	10.52	15.96

Similarly, exchangeable potassium (kg ha⁻¹) of alley soil at depth 15- 30 cm was found maximum initially in the treatment T₄- Mulching of Tephrosia biomass (276.97 kg ha⁻¹) and at final in the treatment T₈- Mulching of Subabul biomass (326.35 kg ha⁻¹) respectively, while the minimum was found both for initial and final in the treatment T₁₁- Control (196.16 kg ha⁻¹ and 207.93 kg ha⁻¹) respectively.

4.2.15 Effect of treatments on zinc content of basin soil

The data pertaining to the effect of basin enrichment through the application of biomass under different treatments on zinc (mg kg⁻¹) content of basin soil were statistically analyzed and presented in table 4.39. The data revealed a significant difference among all the treatments. The zinc (mg kg⁻¹) content of basin soil at depth 0-15 cm was found

maximum both for initial and final in the treatment T₃- Soil incorporation of Tephrosia biomass (2.36 mg kg⁻¹ and 2.48 mg kg⁻¹) respectively, while the minimum was found initially in the treatment T₁₁- Control (1.24 mg kg⁻¹) and at final in the treatment T₆- Mulching of Rice bean biomass (1.16 mg kg⁻¹) respectively.

Similarly, zinc (mg kg⁻¹) content of basin soil at depth 15- 30 cm was found maximum both for initial and final in the treatment T₄- Mulching of Tephrosia biomass (0.90 mg kg⁻¹ and 1.10 mg kg⁻¹) respectively, while the minimum was found both for initial and final in the treatment T₁₁- Control (1.06 mg kg⁻¹ and 1.30 mg kg⁻¹) respectively.

Table 4.33: Zinc content of basin soil

Treatments	Soil: Zinc (mg kg ⁻¹)			
	Basin Area (0- 15 cm)		Basin Area (15- 30 cm)	
	July- 19	Dec- 20	July- 19	Dec- 20
T ₁ - Soil incorporation of Vegetable Soybean biomass	1.36 ^c ±0.06	1.50 ^b ±0.16	1.18 ^{cd} ±0.04	1.40 ^{cde} ±0.44
T ₂ - Mulching of Vegetable Soybean biomass	1.64 ^{bc} ±0.14	1.44 ^b ±0.22	1.22 ^{cd} ±0.30	1.14 ^e ±0.20
T ₃ - Soil incorporation of Tephrosia biomass	2.36 ^a ±0.92	2.28 ^a ±0.34	1.80 ^a ±0.02	2.20 ^a ±0.74
T ₄ - Mulching of Tephrosia biomass	1.98 ^{ab} ±0.40	2.34 ^a ±0.58	1.64 ^{ab} ±0.12	1.94 ^{ab} ±0.12
T ₅ - Soil incorporation of Rice bean biomass	1.42 ^{bc} ±0.14	1.54 ^b ±0.20	1.28 ^{cd} ±0.08	1.34 ^{de} ±0.20
T ₆ - Mulching of Rice bean biomass	1.44 ^{bc} ±0.24	1.16 ^b ±0.24	1.44 ^{bc} ±0.04	1.26 ^{de} ±0.10
T ₇ - Soil incorporation of Subabul biomass	1.56 ^{bc} ±0.06	1.52 ^b ±0.48	1.58 ^{ab} ±0.06	1.68 ^{bcd} ±0.14
T ₈ - Mulching of Subabul biomass	1.62 ^{bc} ±0.18	1.86 ^{ab} ±0.86	1.46 ^{bc} ±0.32	1.88 ^{abc} ±0.20
T ₉ - Soil incorporation of weed	1.44 ^{bc} ±0.32	2.38 ^a ±0.74	1.62 ^{ab} ±0.26	1.94 ^{ab} ±0.18
T ₁₀ - Mulching of weed	1.36 ^c ±0.42	1.40 ^b ±0.08	1.46 ^{bc} ±0.20	1.60 ^{de} ±0.26
T ₁₁ - Control	1.24 ^c ±0.18	1.36 ^b ±0.24	1.06 ^d ±0.20	1.30 ^{de} ±0.08
<i>SE(m) ±</i>	0.20	0.26	0.10	0.18
<i>C.D. (5%)</i>	0.58	0.78	0.30	0.52
<i>C.V. (%)</i>	21.53	26.77	12.66	18.80

4.2.16 Effect of treatments on zinc content of alley soil

The data pertaining to the effect of basin enrichment through the application of biomass under different treatments on zinc (mg kg⁻¹) content of alley soil were statistically analyzed and presented in table 4.40. The data revealed a significant difference among all the treatments. The zinc (mg kg⁻¹) content of alley soil at depth 0-15 cm was found maximum initially in treatment T₂- Mulching of Vegetable Soybean biomass (2.12 mg kg⁻¹)

and at final in treatment T₈- Mulching of Subabul biomass (2.82 mg kg⁻¹) respectively, while the minimum was found initially in the treatment T₁₁- Control (1.28 mg kg⁻¹) and at final in treatment T₂- Mulching of Vegetable Soybean biomass (1.48 mg kg⁻¹) respectively.

Similarly, zinc (mg kg⁻¹) content of alley soil at depth 15- 30 cm was found maximum both for initial and final in the treatment T₈- Mulching of Subabul biomass (1.68 mg kg⁻¹ and 1.90 mg kg⁻¹) respectively, while the minimum both for initial and final was found in the treatment T₁₁- Control (1.28 mg kg⁻¹ and 1.16 mg kg⁻¹) respectively.

Table 4.34: Zinc content of alley soil

Treatments	Soil: Zinc (mg kg ⁻¹)			
	Alley Area (0- 15 cm)		Alley Area (15- 30 cm)	
	July- 19	Dec- 20	July- 19	Dec- 20
T ₁ - Soil incorporation of Vegetable Soybean biomass	1.60 ^{cd} ±0.32	1.76 ^{cde} ±0.34	1.30 ^c ±0.32	1.22 ^{de} ±0.12
T ₂ - Mulching of Vegetable Soybean biomass	2.12 ^a ±0.12	1.48 ^{de} ±0.36	1.46 ^{abc} ±0.38	1.62 ^{abcd} ±0.70
T ₃ - Soil incorporation of Tephrosia biomass	1.68 ^{bc} ±0.12	1.80 ^{cde} ±0.66	1.40 ^{bc} ±0.26	1.46 ^{bcde} ±0.46
T ₄ - Mulching of Tephrosia biomass	1.54 ^{cd} ±0.28	1.86 ^{cde} ±0.52	1.34 ^c ±0.28	1.68 ^{abcd} ±0.08
T ₅ - Soil incorporation of Rice bean biomass	2.00 ^{ab} ±0.40	2.16 ^{bc} ±0.60	1.48 ^{abc} ±0.26	1.70 ^{abc} ±0.14
T ₆ - Mulching of Rice bean biomass	1.66 ^{bc} ±0.18	1.98 ^{cd} ±0.90	1.30 ^c ±0.28	1.36 ^{cde} ±0.12
T ₇ - Soil incorporation of Subabul biomass	1.48 ^{cd} ±0.18	1.88 ^{cde} ±0.56	1.46 ^{abc} ±0.30	1.60 ^{abcde} ±0.14
T ₈ - Mulching of Subabul biomass	1.74 ^{bc} ±0.12	2.82 ^a ±0.26	1.68 ^a ±0.34	1.90 ^a ±0.20
T ₉ - Soil incorporation of weed	1.76 ^{abc} ±0.04	2.62 ^{ab} ±0.48	1.58 ^{ab} ±0.26	1.84 ^{ab} ±0.10
T ₁₀ - Mulching of weed	1.56 ^{cd} ±0.24	1.98 ^{cd} ±0.52	1.46 ^{bc} ±0.20	1.34 ^{cde} ±0.24
T ₁₁ - Control	1.28 ^d ±0.22	1.72 ^{cde} ±0.66	1.28 ^c ±0.28	1.16 ^e ±0.20
<i>SE(m) ±</i>	0.28	0.20	0.22	0.16
<i>C.D. (5%)</i>	0.72	0.66	0.20	0.44
<i>C.V. (%)</i>	12.83	17.04	18.72	17.44

4.2.17 Effect of treatments on copper content of basin soil

The data pertaining to the effect of basin enrichment through the application of biomass under different treatments on copper (mg kg⁻¹) content of basin soil were statistically analyzed and presented in table 4.41. The data revealed a significant difference among all the treatments. The copper (mg kg⁻¹) content of basin soil at depth 0-15 cm was found maximum initially in the treatment T₄- Mulching of Tephrosia biomass (2.02 mg kg⁻¹) and at final in the treatment T₇- Soil incorporation of Subabul biomass (1.68 mg kg⁻¹)

respectively, while the minimum was found both for initial and final in the treatment T₁₁- Control (1.14 mg kg⁻¹ and 0.98 mg kg⁻¹) respectively.

Similarly, copper (mg kg⁻¹) content of basin soil at depth 15- 30 cm was found maximum initially in the treatment T₈- Mulching of Subabul biomass (1.60 mg kg⁻¹) and at final in the treatment T₄- Mulching of Tephrosia biomass (1.74 mg kg⁻¹) respectively, while the minimum was found initially in the treatment T₁₀- Mulching of weed (0.98 mg kg⁻¹) and at final in the treatment T₁₁- Control (1.10 mg kg⁻¹) respectively.

Table 4.35: Copper content of basin soil

Treatments	Soil: Copper (mg kg ⁻¹)			
	Basin Area (0- 15 cm)		Basin Area (15- 30 cm)	
	July- 19	Dec- 20	July- 19	Dec- 20
T ₁ - Soil incorporation of Vegetable Soybean biomass	1.36 ^{cd} ±0.18	1.48 ^{ab} ±0.26	1.10 ^{cd} ±0.10	1.34 ^{bcd} ±0.20
T ₂ - Mulching of Vegetable Soybean biomass	1.50 ^{bcd} ±0.12	1.66 ^a ±0.14	1.26 ^{abcd} ±0.26	1.48 ^{abc} ±0.06
T ₃ - Soil incorporation of Tephrosia biomass	1.34 ^{cd} ±0.14	1.44 ^{ab} ±0.12	0.66 ^{abcd} ±0.20	1.34 ^{bcd} ±0.24
T ₄ - Mulching of Tephrosia biomass	2.02 ^a ±0.32	1.60 ^a ±0.04	1.32 ^{abc} ±0.16	1.74 ^a ±0.10
T ₅ - Soil incorporation of Rice bean biomass	1.60 ^{bc} ±0.10	1.46 ^{ab} ±0.32	1.48 ^{ab} ±0.30	1.52 ^{abc} ±0.04
T ₆ - Mulching of Rice bean biomass	1.46 ^{bcd} ±0.22	1.22 ^{bc} ±0.14	1.30 ^{abcd} ±0.30	1.18 ^{cd} ±0.50
T ₇ - Soil incorporation of Subabul biomass	1.46 ^{bcd} ±0.14	1.68 ^a ±0.16	1.56 ^a ±0.14	1.44 ^{abcd} ±0.10
T ₈ - Mulching of Subabul biomass	1.80 ^{ab} ±0.44	1.56 ^{ab} ±0.32	1.60 ^a ±0.06	1.54 ^{abc} ±0.14
T ₉ - Soil incorporation of weed	1.42 ^{bcd} ±0.34	1.58 ^{ab} ±0.10	1.14 ^{bcd} ±0.36	1.60 ^a ±0.12
T ₁₀ - Mulching of weed	1.52 ^{bcd} ±0.24	1.30 ^{abc} ±0.44	0.98 ^d ±0.14	1.74 ^a ±0.16
T ₁₁ - Control	1.14 ^d ±0.08	0.98 ^c ±0.24	1.18 ^{bcd} ±0.06	1.10 ^d ±0.30
<i>SE(m) ±</i>	0.14	0.12	0.12	0.12
<i>C.D. (5%)</i>	0.42	0.38	0.36	0.38
<i>C.V. (%)</i>	16.17	15.22	16.52	15.00

4.2.18 Effect of treatments on copper content of alley soil

The data pertaining to the effect of basin enrichment through the application of biomass under different treatments on copper (mg kg⁻¹) content of alley soil were statistically analyzed and presented in table 4.42. The data revealed a significant difference among all the treatments. The copper (mg kg⁻¹) content of alley soil at depth 0-15 cm was found maximum both for initial and final in the treatment T₈- Mulching of Subabul biomass (1.64 mg kg⁻¹ and 1.82 mg kg⁻¹) respectively, while the minimum was found

initially in the treatment T₉- Soil incorporation of weed (1.08 mg kg⁻¹) and at final in the treatment T₁₁- Control (1.24 mg kg⁻¹) respectively.

Similarly, copper (mg kg⁻¹) content of alley soil at depth 15- 30 cm was found maximum initially in the treatment T₅- Soil incorporation of Rice bean biomass (1.58 mg kg⁻¹) and at final in the treatment T₈- Mulching of Subabul biomass (1.68 mg kg⁻¹) respectively, while the minimum was found both for initial and final in the treatment T₁₁- Control (1.06 mg kg⁻¹ and 1.04 mg kg⁻¹) respectively.

Table 4.36: Copper content of alley soil

Treatments	Soil: Copper (mg kg ⁻¹)			
	Alley Area (0- 15 cm)		Alley Area (15- 30 cm)	
	July- 19	Dec- 20	July- 19	Dec- 20
T ₁ - Soil incorporation of Vegetable Soybean biomass	1.08 ^e ±0.20	1.52 ^{abc} ±0.16	1.14 ^c ±0.14	1.20 ^{cd} ±0.20
T ₂ - Mulching of Vegetable Soybean biomass	1.56 ^{ab} ±0.24	1.32 ^c ±0.38	1.20 ^{bc} ±0.22	1.08 ^{cd} ±0.06
T ₃ - Soil incorporation of Tephrosia biomass	1.40 ^{abcd} ±0.18	1.34 ^{bc} ±0.10	1.44 ^a ±0.20	1.38 ^{abcd} ±0.44
T ₄ - Mulching of Tephrosia biomass	1.52 ^{ab} ±0.16	1.48 ^{abc} ±0.16	1.12 ^c ±0.14	1.40 ^{abc} ±0.24
T ₅ - Soil incorporation of Rice bean biomass	1.28 ^{bcde} ±0.14	1.68 ^{ab} ±0.24	1.58 ^a ±0.24	1.42 ^{abc} ±0.24
T ₆ - Mulching of Rice bean biomass	1.50 ^{abc} ±0.22	1.74 ^a ±0.28	1.18 ^c ±0.06	1.60 ^{ab} ±0.36
T ₇ - Soil incorporation of Subabul biomass	1.48 ^{abc} ±0.04	1.70 ^{ab} ±0.16	1.44 ^a ±0.20	1.34 ^{abcd} ±0.16
T ₈ - Mulching of Subabul biomass	1.64 ^a ±0.24	1.82 ^a ±0.36	1.40 ^{ab} ±0.18	1.68 ^a ±0.24
T ₉ - Soil incorporation of weed	1.08 ^e ±0.28	1.54 ^{abc} ±0.32	1.20 ^{bc} ±0.16	1.16 ^{cd} ±0.04
T ₁₀ - Mulching of weed	1.24 ^{cde} ±0.12	1.28 ^c ±0.24	1.16 ^c ±0.18	1.16 ^{cd} ±0.10
T ₁₁ - Control	1.14 ^{de} ±0.10	1.24 ^c ±0.16	1.06 ^c ±0.20	1.04 ^d ±0.20
<i>SE(m) ±</i>	0.10	0.12	0.08	0.12
<i>C.D. (5%)</i>	0.28	0.36	0.20	0.34
<i>C.V. (%)</i>	12.00	14.25	10.81	15.00

4.2.19 Effect of treatments on manganese content of basin soil

The data pertaining to the effect of basin enrichment through the application of biomass under different treatments on manganese (mg kg⁻¹) content of basin soil was statistically analyzed and presented in table 4.43. The data revealed a significant difference among all treatments. The manganese (mg kg⁻¹) content of basin soil at depth 0-15 cm was found maximum initially in treatment T₁₀- Mulching of weed (140.24 mg kg⁻¹) and at final in treatment T₃- Soil incorporation of Tephrosia biomass (153.66 mg kg⁻¹) respectively,

while minimum was found initially in treatment T₁₁- Control (88.62 mg kg⁻¹) and at final in treatment T₂- Mulching of Vegetable Soybean biomass (100.04 mg kg⁻¹) respectively.

Similarly, manganese (mg kg⁻¹) content of basin soil at depth 15- 30 cm was found maximum initially in the treatment T₈- Mulching of Subabul biomass (142.32 mg kg⁻¹) and at final in the treatment T₄- Mulching of Tephrosia biomass (123.94 mg kg⁻¹) respectively, while the minimum was found both for initial and final in the treatment T₁₁- Control (77.16 mg kg⁻¹ and 95.56 mg kg⁻¹) respectively.

Table 4.37: Manganese content of basin soil

Treatments	Soil: Manganese (mg kg ⁻¹)			
	Basin Area (0- 15 cm)		Basin Area (15- 30 cm)	
	July- 19	Dec- 20	July- 19	Dec- 20
T ₁ - Soil incorporation of Vegetable Soybean biomass	104.18 ^{cd} ±8.60	122.84 ^{bcd} ±16.38	96.18 ^{def} ±8.18	108.62±17.32
T ₂ - Mulching of Vegetable Soybean biomass	90.48 ^d ±8.70	100.12 ^e ±16.84	104.90 ^{cde} ±10.24	101.70±26.92
T ₃ - Soil incorporation of Tephrosia biomass	135.48 ^{ab} ±8.10	153.66 ^a ±21.02	129.54 ^{ab} ±8.30	118.60±3.80
T ₄ - Mulching of Tephrosia biomass	122.78 ^{abc} ±5.34	130.24 ^{abcd} ±19.10	114.46 ^{bcd} ±24.40	123.94±23.86
T ₅ - Soil incorporation of Rice bean biomass	110.28 ^{bcd} ±26.92	116.98 ^{bcd} ±20.30	103.60 ^{cde} ±16.88	113.00±13.30
T ₆ - Mulching of Rice bean biomass	121.88 ^{abc} ±17.34	141.26 ^{abc} ±10.48	91.78 ^{def} ±17.08	111.80±7.16
T ₇ - Soil incorporation of Subabul biomass	138.02 ^{ab} ±12.72	144.32 ^{ab} ±8.16	124.58 ^{abc} ±10.96	118.38±7.70
T ₈ - Mulching of Subabul biomass	102.32 ^{cd} ±30.20	117.74 ^{bcd} ±10.00	142.32 ^a ±9.78	117.14±8.14
T ₉ - Soil incorporation of weed	106.12 ^{cd} ±32.08	124.1 ^{bcd} ±26.86	85.48 ^{ef} ±17.98	106.36±7.76
T ₁₀ - Mulching of weed	140.24 ^a ±21.36	108.78 ^{de} ±9.80	123.58 ^{abc} ±14.34	123.40±25.06
T ₁₁ - Control	88.62 ^d ±26.04	115.12 ^{cde} ±12.28	77.16 ^f ±3.46	95.56 ±3.18
<i>SE(m) ±</i>	8.88	9.42	7.84	8.38
<i>C.D. (5%)</i>	26.22	26.12	23.10	NS
<i>C.V. (%)</i>	13.46	13.90	12.50	13.89

4.2.20 Effect of treatments on manganese content of alley soil

The data pertaining to the effect of basin enrichment through the application of biomass under different treatments on manganese (mg kg⁻¹) content of alley soil were statistically analyzed and presented in table 4.44. The data revealed a significant difference among all the treatments. The manganese (mg kg⁻¹) content of alley soil at depth 0-15 cm was found maximum initially in the treatment T₇- Soil incorporation of Subabul biomass (146.48 mg kg⁻¹) and at final in the treatment T₂- Mulching of Vegetable Soybean (149 mg kg⁻¹) respectively, while the minimum was found initially in the treatment T₁₁- Control

(112.28 mg kg⁻¹) and at final in the treatment T₆- Mulching of Rice bean biomass (111.78 mg kg⁻¹) respectively.

Similarly, manganese (mg kg⁻¹) content of alley soil at depth 15- 30 cm was found maximum initially in treatment T₉- Soil incorporation of weed 128.54 mg kg⁻¹) and at final in the treatment T₁₀- Mulching of weed (126.10 mg kg⁻¹) respectively, while the minimum was found initially in treatment T₁- Soil incorporation of Vegetable Soybean biomass (82.28 mg kg⁻¹) and at final in treatment T₁₁- Control (92.26 mg kg⁻¹) respectively.

Table 4.38: Manganese content of alley soil

Treatments	Soil: Manganese (mg kg ⁻¹)			
	Alley Area (0- 15 cm)		Alley Area (15- 30 cm)	
	July- 19	Dec- 20	July- 19	Dec- 20
T ₁ - Soil incorporation of Vegetable Soybean biomass	120.70 ^c ±14.02	139.92 ^{ab} ±10.18	82.28 ^e ±5.76	113.32 ^a ±7.04
T ₂ - Mulching of Vegetable Soybean biomass	128.24 ^{bc} ±8.84	149.00 ^a ±8.86	115.06 ^{abcd} ±9.84	124.12 ^{ab} ±6.54
T ₃ - Soil incorporation of Tephrosia biomass	116.94 ^c ±14.68	121.02 ^{cd} ±9.06	98.98 ^{cde} ±24.04	120.38 ^{ab} ±19.08
T ₄ - Mulching of Tephrosia biomass	117.00 ^c ±13.42	130.48 ^{bc} ±7.34	108.40 ^{abcd} ±11.02	130.48 ^{ab} ±7.34
T ₅ - Soil incorporation of Rice bean biomass	145.26 ^{ab} ±9.80	127.58 ^{bcd} ±11.44	119.82 ^{abc} ±5.80	126.38 ^{ab} ±7.46
T ₆ - Mulching of Rice bean biomass	128.22 ^{bc} ±6.84	111.78 ^d ±7.16	106.58 ^{bcd} ±15.66	117.62 ^b ±14.94
T ₇ - Soil incorporation of Subabul biomass	146.48 ^a ±16.28	122.20 ^{bcd} ±7.06	121.52 ^{ab} ±16.84	138.94 ^a ±15.96
T ₈ - Mulching of Subabul biomass	121.74 ^c ±11.02	139.92 ^{ab} ±9.22	111.98 ^{abcd} ±11.14	113.18 ^b ±7.00
T ₉ - Soil incorporation of weed	124.94 ^c ±8.80	129.84 ^{bcd} ±8.42	128.54 ^a ±17.36	123.84 ^{ab} ±12.10
T ₁₀ - Mulching of weed	114.32 ^c ±15.30	66.43 ^{abc} ±14.28	116.98 ^{abc} ±4.14	126.10 ^{ab} ±10.22
T ₁₁ - Control	112.28 ^c ±9.50	62.51 ^{bcd} ±16.02	94.70 ^{de} ±8.90	92.26 ^c ±12.18
<i>SE(m) ±</i>	6.18	6.20	7.44	6.76
<i>C.D. (5%)</i>	18.20	18.26	21.92	19.94
<i>C.V. (%)</i>	8.54	8.25	11.75	9.70

4.2.21 Effect of treatments on Iron content of basin soil

The data pertaining to the effect of basin enrichment through the application of biomass under different treatments on iron (mg kg⁻¹) content of basin soil were statistically analyzed and presented in table 4.45. The data revealed a significant difference among all the treatments. The iron (mg kg⁻¹) content of basin soil at depth 0-15 cm was found maximum initially in the treatment T₆- Mulching of Rice bean biomass (106.66 mg kg⁻¹) and at final in the treatment T₃- Soil incorporation of Tephrosia biomass (110.58 mg kg⁻¹)

respectively, while minimum both for initial and final was found in the treatment T₁₁- Control (82.34 mg kg⁻¹ and 85.24 mg kg⁻¹) respectively.

Similarly, iron (mg kg⁻¹) content of basin soil at depth 15- 30 cm was found maximum initially in the treatment T₅- Soil incorporation of Rice bean biomass (88.50 mg kg⁻¹) and at final in the treatment T₆- Mulching of Rice bean biomass (105.06 mg kg⁻¹) respectively while minimum both for initial and final was found in the treatment T₁₁- Control (66.72 mg kg⁻¹ and 80.90 mg kg⁻¹) respectively.

Table 4.39: Iron content of basin soil

Treatments	Soil: Iron (mg kg ⁻¹)			
	Basin Area (0- 15 cm)		Basin Area (15- 30 cm)	
	July- 19	Dec- 20	July- 19	Dec- 20
T ₁ - Soil incorporation of Vegetable Soybean biomass	90.44 ^{cd} ±7.61	94.00 ^{bcde} ±5.34	80.26 ^{ab} ±6.04	84.04 ^c ±3.06
T ₂ - Mulching of Vegetable Soybean biomass	105.52 ^{ab} ±4.08	100.96 ^{abcd} ±17.62	83.02 ^{ab} ±7.14	91.96 ^{abc} ±8.42
T ₃ - Soil incorporation of Tephrosia biomass	95.74 ^{bc} ±5.28	110.58 ^a ±10.14	72.32 ^{bc} ±8.14	93.88 ^{abc} ±17.96
T ₄ - Mulching of Tephrosia biomass	88.88 ^{cd} ±12.68	101.94 ^{abcd} ±5.40	82.16 ^{ab} ±5.94	85.96 ^c ±3.86
T ₅ - Soil incorporation of Rice bean biomass	95.78 ^{bc} ±6.76	97.52 ^{bcde} ±8.80	88.50 ^a ±12.14	99.92 ^{ab} ±7.04
T ₆ - Mulching of Rice bean biomass	106.66 ^a ±3.20	93.34 ^{cde} ±5.66	81.56 ^{ab} ±8.28	52.53 ^a ±4.24
T ₇ - Soil incorporation of Subabul biomass	87.88 ^{cd} ±3.36	103.98 ^{abc} ±6.30	78.50 ^{abc} ±4.06	88.00 ^{bc} ±5.76
T ₈ - Mulching of Subabul biomass	102.50 ^{ab} ±5.06	99.52 ^{abcd} ±4.50	82.90 ^{abc} ±4.24	92.64 ^{abc} ±4.92
T ₉ - Soil incorporation of weed	102.12 ^{ab} ±2.62	90.76 ^{de} ±12.78	68.02 ^c ±7.42	90.78 ^{bc} ±10.16
T ₁₀ - Mulching of weed	88.46 ^{cd} ±2.38	104.08 ^{ab} ±9.02	81.56 ^{ab} ±1.64	81.82 ^c ±2.06
T ₁₁ - Control	82.34 ^d ±2.40	85.24 ^e ±7.70	66.72 ^c ±13.80	80.90 ^c ±2.06
<i>SE(m) ±</i>	3.52	4.28	4.02	4.54
<i>C.D. (5%)</i>	10.40	12.76	11.86	13.50
<i>C.V. (%)</i>	6.42	7.54	8.85	8.70

4.2.22 Effect of treatments on iron content of alley soil

The data pertaining to the effect of basin enrichment through the application of biomass under different treatments on iron (mg kg⁻¹) content of alley soil was statistically analyzed and presented in table 4.46. The data revealed a significant difference among all treatments. The iron (mg kg⁻¹) content of alley soil at depth 0-15 cm was found maximum initially in treatment T₁- Soil incorporation of Vegetable Soybean biomass (118.04 mg kg⁻¹) and at final in treatment T₃- Soil incorporation of Tephrosia biomass (114.24 mg kg⁻¹)

respectively, while minimum was found initially in treatment T₁₀- Mulching of weed (76.18 mg kg⁻¹) and at final in treatment T₁₁- Control (88.28 mg kg⁻¹) respectively.

Similarly, iron (mg kg⁻¹) content of alley soil at depth 15- 30 cm was found maximum initially in the treatment T₁- Soil incorporation of Vegetable Soybean biomass (92.04 mg kg⁻¹) and at final in the treatment T₃- Soil incorporation of Tephrosia biomass (94.16 mg kg⁻¹) respectively, while minimum both for initial and final was found in the treatment T₁₁- Control (59.52 mg kg⁻¹ and 75.22 mg kg⁻¹) respectively.

Table 4.40: Iron content of alley soil

Treatments	Soil: Iron (mg kg ⁻¹)			
	Alley Area (0- 15 cm)		Alley Area (15- 30 cm)	
	July- 19	Dec- 20	July- 19	Dec- 20
T ₁ - Soil incorporation of Vegetable Soybean biomass	118.04 ^a ±2.84	113.8 ^a ±3.12	92.04 ^a ±8.40	70.10 ^{bcd} ±7.98
T ₂ - Mulching of Vegetable Soybean biomass	105.28 ^{abc} ±6.02	111.04 ^{ab} ±5.20	81.36 ^{ab} ±19.4	91.00 ^{ab} ±9.40
T ₃ - Soil incorporation of Tephrosia biomass	100.36 ^{bc} ±5.76	114.24 ^a ±4.54	69.70 ^{bcd} ±8.88	94.16 ^a ±4.54
T ₄ - Mulching of Tephrosia biomass	91.80 ^{cd} ±3.96	96.48 ^{de} ±2.08	86.46 ^{ab} ±5.42	67.58 ^d ±6.86
T ₅ - Soil incorporation of Rice bean biomass	106.24 ^{ab} ±5.66	102.40 ^{bcd} ±2.20	81.70 ^{ab} ±14.22	87.54 ^{abc} ±4.42
T ₆ - Mulching of Rice bean biomass	101.20 ^{bc} ±3.36	105.14 ^{bc} ±1.18	70.54 ^{bcd} ±12.78	88.84 ^{abc} ±14.88
T ₇ - Soil incorporation of Subabul biomass	98.12 ^{bc} ±4.18	101.96 ^{cd} ±4.34	54.12 ^d ±4.94	64.76 ^d ±3.76
T ₈ - Mulching of Subabul biomass	77.16 ^e ±11.98	95.74 ^{de} ±6.24	61.82 ^{cd} ±4.80	86.20 ^{abc} ±10.44
T ₉ - Soil incorporation of weed	84.58 ^{de} ±8.60	88.54 ^e ±8.02	70.58 ^{bcd} ±10.02	84.60 ^{abc} ±2.20
T ₁₀ - Mulching of weed	76.18 ^e ±16.26	92.36 ^e ±5.34	74.50 ^{bc} ±9.12	87.64 ^{abc} ±8.62
T ₁₁ - Control	84.50 ^{de} ±5.20	88.28 ^e ±8.42	59.52 ^{cd} ±9.74	75.22 ^{cd} ±6.04
<i>SE(m) ±</i>	4.58	2.92	5.64	4.78
<i>C.D. (5%)</i>	12.60	8.70	16.90	14.24
<i>C.V. (%)</i>	8.36	5.03	13.52	10.08

4.2.23 Effect of treatments on calcium content of basin soil

The data pertaining to the effect of basin enrichment through the application of biomass under different treatments on calcium (mg 100g⁻¹ of soil) of basin soil were statistically analyzed and presented in table 4.47. The data revealed a significant difference among all the treatments. The calcium (mg 100g⁻¹ of soil) of basin soil at depth 0-15 cm was found maximum initially in the treatment T₆- Mulching of Rice bean biomass (45.28 mg 100g⁻¹ of soil) and at final in the treatment T₈- Mulching of Subabul biomass (62.58 mg

100g⁻¹ of soil) respectively, while minimum both for initial and final was found in the treatment T₁₁- Control (32.56 mg 100g⁻¹ of soil and 40.06 mg 100g⁻¹ of soil) respectively.

Similarly, calcium (mg 100g⁻¹ of soil) of basin soil at depth 15- 30 cm was found maximum initially in the treatment T₂- Mulching of Vegetable Soybean biomass (42.54 mg 100g⁻¹ of soil) and at final in the treatment T₈- Mulching of Subabul biomass (53.52 mg 100g⁻¹ of soil) respectively, while minimum both for initial and final was found in the treatment T₁₁- Control (31.21 mg 100g⁻¹ of soil and 36.96 mg 100g⁻¹ of soil) respectively.

Table 4.41: Calcium of basin soil

Treatments	Soil: Calcium (mg 100g ⁻¹ of soil)			
	Alley Area (0- 15 cm)		Alley Area (15- 30 cm)	
	July- 19	Dec- 20	July- 19	Dec- 20
T ₁ - Soil incorporation of Vegetable Soybean biomass	32.36 ^a ±1.10	40.66 ^e ±4.55	31.86 ^c ±2.40	40.96 ^{cd} ±5.31
T ₂ - Mulching of Vegetable Soybean biomass	35.32 ^{de} ±1.47	58.05 ^{ab} ±5.55	42.54 ^a ±2.66	48.82 ^{abc} ±10.08
T ₃ - Soil incorporation of Tephrosia biomass	42.24 ^{ab} ±2.43	56.68 ^{abc} ±3.98	37.02 ^{abc} ±2.94	52.72 ^{ab} ±3.40
T ₄ - Mulching of Tephrosia biomass	36.15 ^{cde} ±3.81	41.23 ^{de} ±4.83	40.55 ^{ab} ±2.54	39.86 ^{cde} ±5.02
T ₅ - Soil incorporation of Rice bean biomass	31.58 ^e ±1.70	42.27 ^{cde} ±15.67	32.00 ^c ±2.01	30.16 ^e ±4.58
T ₆ - Mulching of Rice bean biomass	45.28 ^a ±3.36	39.63 ^e ±0.79	31.77 ^c ±2.04	39.97 ^{cde} ±5.12
T ₇ - Soil incorporation of Subabul biomass	41.49 ^{ab} ±2.80	39.45 ^e ±0.05	38.66 ^{ab} ±5.93	42.97 ^{bcd} ±3.86
T ₈ - Mulching of Subabul biomass	37.69 ^{bcd} ±2.88	62.58 ^a ±17.24	35.46 ^{bc} ±3.42	53.52 ^a ±6.56
T ₉ - Soil incorporation of weed	35.74 ^{cde} ±2.77	55.15 ^{abcd} ±8.64	34.80 ^{bc} ±2.86	52.72 ^{ab} ±8.18
T ₁₀ - Mulching of weed	40.16 ^{bc} ±3.74	46.53 ^{bcd} ±2.81	37.60 ^{abc} ±6.53	40.51 ^{cd} ±4.51
T ₁₁ - Control	32.56 ^e ±2.49	40.06 ^{de} ±7.62	31.21 ^c ±4.45	36.96 ^{de} ±3.20
<i>SE(m) ±</i>	1.62	5.08	2.18	3.35
<i>C.D. (5%)</i>	4.77	15.04	6.43	9.88
<i>C.V. (%)</i>	7.50	18.53	10.56	13.35

4.2.24 Effect of treatments on calcium content of alley soil

The data pertaining to the effect of basin enrichment through the application of biomass under different treatments on calcium (mg 100g⁻¹ of soil) of alley soil were statistically analyzed and presented in table 4.48. The data revealed a significant difference among all the treatments. The calcium (mg 100g⁻¹ of soil) of alley soil at depth 0-15 cm was found maximum initially in the treatment T₄- Mulching of Tephrosia biomass (45.40 mg

100g⁻¹ of soil) and at final in the treatment T₈- Mulching of Subabul biomass (54.15 mg 100g⁻¹ of soil) respectively, while minimum both for initial and final was found in the treatment T₁₁- Control (33.54 mg 100g⁻¹ of soil and 35.02 mg 100g⁻¹ of soil) respectively.

Similarly, calcium (mg 100g⁻¹ of soil) of alley soil at depth 15- 30 cm was found maximum initially in the treatment T₄- Mulching of Tephrosia biomass (43.55 mg 100g⁻¹ of soil) and at final in the treatment T₇- Soil incorporation of Subabul biomass (50.17 mg 100g⁻¹ of soil) respectively, while minimum both for initial and final was found in the treatment T₁₁- Control (33.14 mg 100g⁻¹ of soil and 33.55 mg 100g⁻¹ of soil) respectively.

Table 4.42: Calcium of alley soil

Treatments	Soil: Calcium (mg 100g ⁻¹ of soil)			
	Alley Area (0- 15 cm)		Alley Area (15- 30 cm)	
	July- 19	Dec- 20	July- 19	Dec- 20
T ₁ - Soil incorporation of Vegetable Soybean biomass	37.36 ^{bc} ±6.17	44.26 ^{bcd} ±3.51	38.66 ^{abc} ±4.77	44.15 ^{ab} ±3.55
T ₂ - Mulching of Vegetable Soybean biomass	43.58 ^{ab} ±5.43	41.72 ^{bcd} ±3.08	41.23 ^{ab} ±2.57	37.29 ^{cbc} ±1.07
T ₃ - Soil incorporation of Tephrosia biomass	37.01 ^{bc} ±2.20	41.08 ^{bcd} ±10.39	36.71 ^{bc} ±5.39	43.30 ^{ab} ±5.84
T ₄ - Mulching of Tephrosia biomass	45.40 ^a ±2.84	41.64 ^{bcd} ±2.19	43.55 ^a ±3.54	42.93 ^{ab} ±2.99
T ₅ - Soil incorporation of Rice bean biomass	40.00 ^{abc} ±4.03	37.76 ^{cd} ±4.01	39.18 ^{abc} ±1.65	44.88 ^{ab} ±1.44
T ₆ - Mulching of Rice bean biomass	38.35 ^{bc} ±2.33	39.97 ^{cd} ±3.54	34.64 ^c ±1.04	46.12 ^a ±3.38
T ₇ - Soil incorporation of Subabul biomass	38.66 ^{abc} ±5.93	49.44 ^{ab} ±9.30	35.56 ^{bc} ±4.79	50.17 ^a ±4.63
T ₈ - Mulching of Subabul biomass	35.35 ^c ±2.39	54.15 ^a ±10.46	34.11 ^c ±4.92	48.29 ^a ±7.05
T ₉ - Soil incorporation of weed	33.69 ^c ±4.41	40.65 ^{bcd} ±3.93	41.10 ^{ab} ±2.87	45.58 ^a ±5.40
T ₁₀ - Mulching of weed	39.35 ^{abc} ±2.88	46.50 ^{abc} ±4.05	36.55 ^{bc} ±1.65	42.95 ^{ab} ±1.73
T ₁₁ - Control	33.54 ^c ±0.95	35.02 ^d ±4.14	33.14 ^c ±1.17	33.55 ^c ±6.58
<i>SE(m) ±</i>	2.32	3.14	2.05	2.67
<i>C.D. (5%)</i>	6.84	9.25	6.05	7.88
<i>C.V. (%)</i>	10.46	12.65	9.43	10.62

4.2.25 Effect of treatments on magnesium content of basin soil

The data pertaining to the effect of basin enrichment through the application of biomass under different treatments on magnesium (mg 100g⁻¹ of soil) content of basin soil were statistically analyzed and presented in table 4.49. The data revealed a significant difference among all the treatments. The magnesium (mg 100g⁻¹ of soil) content of basin

soil at depth 0-15 cm was found maximum initially in the treatment T₈- Mulching of Subabul biomass (29.38 mg 100g⁻¹ of soil) and at final in the treatment T₇- Soil incorporation of Subabul biomass (28.30 mg 100g⁻¹ of soil) respectively, while minimum both for initial and final was found in the treatment T₁₁- Control (15.64 mg 100g⁻¹ of soil and 15.92 mg 100g⁻¹ of soil) respectively.

Similarly, magnesium (mg 100g⁻¹ of soil) content of basin soil at depth 15- 30 cm was found maximum both for initial and final in the treatment T₄- Mulching of Tephrosia biomass (25.96 mg 100g⁻¹ of soil and 28.69 mg 100g⁻¹ of soil) respectively, while minimum both for initial and final was found in the treatment T₁₁- Control (13.06 mg 100g⁻¹ of soil and 12.14 mg 100g⁻¹ of soil) respectively.

Table 4.43: Magnesium content of basin soil

Treatments	Soil: Magnesium (mg 100g ⁻¹ of soil)			
	Basin Area (0- 15 cm)		Basin Area (15- 30 cm)	
	July- 19	Dec- 20	July- 19	Dec- 20
T ₁ - Soil incorporation of Vegetable Soybean biomass	26.06 ^{ab} ±6.41	25.04 ^{ab} ±4.30	20.61 ^{ab} ±3.43	19.61 ^{bcd} ±0.74
T ₂ - Mulching of Vegetable Soybean biomass	17.82 ^{cd} ±3.54	26.88 ^{ab} ±1.14	22.24 ^{ab} ±4.77	22.20 ^{abc} ±5.99
T ₃ - Soil incorporation of Tephrosia biomass	28.90 ^a ±2.23	27.12 ^{abc} ±3.74	15.42 ^{bc} ±3.12	25.44 ^{abc} ±8.88
T ₄ - Mulching of Tephrosia biomass	22.21 ^{abcd} ±1.63	24.10 ^{abc} ±7.37	25.96 ^a ±6.81	28.69 ^a ±6.55
T ₅ - Soil incorporation of Rice bean biomass	21.25 ^{bcd} ±1.94	23.63 ^{abc} ±3.78	22.52 ^{ab} ±1.91	23.78 ^{abc} ±3.60
T ₆ - Mulching of Rice bean biomass	19.34 ^{bcd} ±5.22	22.75 ^{abc} ±3.20	21.68 ^{ab} ±7.12	21.90 ^{abc} ±6.35
T ₇ - Soil incorporation of Subabul biomass	20.42 ^{bcd} ±0.98	28.30 ^a ±3.55	19.35 ^{abc} ±1.71	27.18 ^{ab} ±5.39
T ₈ - Mulching of Subabul biomass	29.38 ^a ±5.80	24.44 ^{ab} ±4.85	20.14 ^{abc} ±1.25	26.92 ^{ab} ±3.86
T ₉ - Soil incorporation of weed	19.29 ^{bcd} ±8.31	21.48 ^{bcd} ±0.62	15.99 ^{bc} ±4.15	17.42 ^{cd} ±4.55
T ₁₀ - Mulching of weed	23.81 ^{abc} ±1.73	17.31 ^{cd} ±3.71	16.00 ^{bc} ±2.13	18.65 ^{bcd} ±6.51
T ₁₁ - Control	15.64 ^d ±3.39	15.92 ^d ±2.49	13.06 ^c ±2.00	12.14 ^d ±1.63
<i>SE(m) ±</i>	2.59	2.31	2.41	3.01
<i>C.D. (5%)</i>	7.63	6.80	7.12	9.06
<i>C.V. (%)</i>	20.19	17.10	21.59	24.00

4.2.26 Effect of treatments on magnesium content of alley soil

The data pertaining to the effect of basin enrichment through the application of biomass under different treatments on magnesium (mg 100g⁻¹ of soil) content of alley soil were statistically analyzed and presented in table 4.50. The data revealed a significant difference among all the treatments. The magnesium (mg 100g⁻¹ of soil) content of alley soil

at depth 0-15 cm was found maximum initially in the treatment T₈- Mulching of Subabul biomass (33.48 mg 100g⁻¹ of soil) and at final in the treatment T₇- Soil incorporation of Subabul biomass (32.52 mg 100g⁻¹ of soil) respectively, while minimum both for initial and final was found in the treatment T₁₁- Control (17.72 mg 100g⁻¹ of soil and 20.23 mg 100g⁻¹ of soil) respectively.

Table 4.44: Magnesium content of alley soil

Treatments	Soil: Magnesium (mg 100g ⁻¹ of soil)			
	Alley Area (0- 15 cm)		Alley Area (15- 30 cm)	
	July- 19	Dec- 20	July- 19	Dec- 20
T ₁ - Soil incorporation of Vegetable Soybean biomass	26.61 ^{abcd} ±5.54	27.42 ^{abc} ±3.43	21.90 ^a ±1.50	17.98 ^c ±3.66
T ₂ - Mulching of Vegetable Soybean biomass	18.91 ^{bcd} ±8.81	27.91 ^{abc} ±3.61	22.01 ^a ±1.61	24.38 ^{bc} ±6.62
T ₃ - Soil incorporation of Tephrosia biomass	21.42 ^{bcd} ±3.53	30.28 ^{ab} ±7.83	19.02 ^{abcd} ±6.95	23.34 ^{bc} ±3.56
T ₄ - Mulching of Tephrosia biomass	31.63 ^a ±6.75	25.62 ^{bcd} ±4.46	15.76 ^{cde} ±1.22	17.09 ^c ±5.73
T ₅ - Soil incorporation of Rice bean biomass	29.19 ^{ab} ±6.17	25.91 ^{abcd} ±2.82	15.43 ^{cde} ±3.37	26.89 ^{ab} ±11.61
T ₆ - Mulching of Rice bean biomass	28.35 ^{abc} ±4.44	28.31 ^{abc} ±7.08	20.87 ^{ab} ±3.23	20.98 ^{bc} ±9.39
T ₇ - Soil incorporation of Subabul biomass	29.35 ^{abc} ±8.45	32.52 ^a ±2.56	20.16 ^{abc} ±1.05	20.85 ^{bc} ±2.74
T ₈ - Mulching of Subabul biomass	33.48 ^a ±5.16	22.79 ^{cd} ±4.15	19.52 ^{abc} ±3.37	31.72 ^a ±13.23
T ₉ - Soil incorporation of weed	20.32 ^{cde} ±4.52	31.38 ^{ab} ±6.96	20.19 ^{abc} ±2.83	26.85 ^{ab} ±11.69
T ₁₀ - Mulching of weed	19.33 ^{cde} ±5.50	27.33 ^{abc} ±1.50	16.79 ^{abcd} ±2.05	19.20 ^c ±3.11
	17.72 ^e ±0.83	20.23 ^d ±4.75	13.02 ^d ±1.87	17.68 ^c ±5.23
<i>SE(m) ±</i>	3.47	2.24	1.79	2.48
<i>C.D. (5%)</i>	10.22	6.61	5.27	7.30
<i>C.V. (%)</i>	23.89	14.25	16.63	19.10

Similarly, magnesium (mg 100g⁻¹ of soil) content of alley soil at depth 15- 30 cm was found maximum initially in the treatment T₂- Mulching of Vegetable Soybean biomass (22.01 mg 100g⁻¹ of soil) and at final in the treatment T₅- Soil incorporation of Rice bean biomass (26.89 mg 100g⁻¹ of soil) respectively, while minimum both for initial and final was found in the treatment T₁₁- Control (13.02 mg 100g⁻¹ of soil and 17.68 mg 100g⁻¹ of soil) respectively.

4.2.27 Effect of treatments on bacterial populations of soil

The data pertaining to the effect of basin enrichment through the application of biomass under different treatments on bacterial populations of soil were statistically analyzed and presented in table 4.51. The data revealed a significant difference among all

the treatments. In July -2019, the maximum bacterial population was observed in the treatment T₈- Mulching of Subabul biomass (13 x 10⁶ cfu g⁻¹ of soil) and the minimum was found under the treatment T₁₁-Control (4 x10⁶ cfu g⁻¹ of soil). In September 2020, the maximum bacterial population was observed in the treatment T₈- Mulching of Subabul biomass (29 x 10⁶ cfu g⁻¹ of soil) and the minimum was found under the treatment T₁₁-Control (8 x10⁶ cfu g⁻¹ of soil). In December 2020, the maximum bacterial population was found in the treatment T₂-Mulching of Vegetable Soybean biomass (23 x10⁶ cfu g⁻¹ of soil) and the minimum was found in the treatment T₁₁- Control (6.66 x10⁶ cfu g⁻¹ of soil).

Table 4.45: Soil bacterial count

Soil bacterial count (10 ⁶ cfu g ⁻¹ of soil)			
Treatments	July-2019	Sept.-2020	Dec-2020
T ₂ -Mulching of Vegetable Soybean biomass	8.33 ^{bc} ± 1.15	18.00 ^{bc} ± 7.93	23.00 ^a ± 2.64
T ₄ - Mulching of Tephrosia biomass	10.33 ^{ab} ± 3.05	20.00 ^{ab} ± 6.11	8.66 ^c ± 4.72
T ₆ - Mulching of Rice bean biomass	5.66 ^{cd} ± 3.05	22.33 ^{ab} ± 4.72	12.66 ^{bc} ± 3.05
T ₈ - Mulching of Subabul biomass	13.00 ^a ± 2.00	29.66 ^a ± 6.50	19.00 ^{ab} ± 4.58
T ₁₀ - Mulching of weed	6.00 ^{cd} ± 2.00	21.66 ^{ab} ± 6.50	9.00 ^c ± 1.73
T ₁₁ -Control	4.00 ^d ± 1.73	8.00 ^c ± 2.64	6.66 ^c ± 2.51
<i>SE(m) ±</i>	1.26	3.21	2.04
<i>C.D. (5%)</i>	3.98	10.13	6.43
<i>C.V. (%)</i>	27.74	27.94	26.85

The above results are in conformity with the earlier studies done by Lalruatsangi *et al.* (2018); Krishnakumar *et al.* (2005); Tiquia *et al.* (2002); Kaur *et al.* (2000) and Chander *et al.* (1998) in their studies they reported that use of mulch in an alley cropping significantly improves microbial population, augments microbial activity, dehydrogenase activity compared to non-mulching soil.

4.2.28 Effect of treatments on fungal populations of soil

The data pertaining to the effect of basin enrichment through the application of biomass under different treatments on fungal populations of soil were statistically analyzed

and presented in table 4.51. The data revealed a significant difference among all the treatments. In July -2019, the maximum fungal count was observed in the treatment T₄ - Mulching of Tephrosia biomass (18.33 x 10³ cfu g⁻¹ of soil) and the minimum was found under the treatment T₁₁-Control (6.66 x10³ cfu g⁻¹ of soil). In September 2020, the maximum fungal count was observed in the treatment T₂- Mulching of Vegetable Soybean (48.66 x 10³ cfu g⁻¹ of soil) and the minimum was found under the treatment T₁₁-Control (22.66 x10³ cfu g⁻¹ of soil). In December 2020, maximum fungal count was found in the treatment T₄ - Mulching of Tephrosia biomass (30.33 x10³ cfu g⁻¹ of soil) and the minimum was found in the treatment T₁₁- Control (1 x10⁴ cfu g⁻¹ of soil).

Table 4.46: Soil fungal count

Soil fungal count (10³ cfu g⁻¹ of soil)			
Treatments	July-2019	Sept.-2020	Dec-2020
T ₂ - Mulching of Vegetable Soybean biomass	13.00 ^b ± 1.00	48.66 ^a ± 9.07	23.33 ^{ab} ± 7.00
T ₄ - Mulching of Tephrosia biomass	18.33 ^a ± 5.68	48.00 ^a ± 5.56	30.33 ^a ± 3.51
T ₆ - Mulching of Rice bean biomass	10.66 ^{bc} ± 3.21	23.33 ^c ± 3.21	24 ^a ± 5.13
T ₈ - Mulching of Subabul biomass	15.00 ^{ab} ± 1.73	34.66 ^b ± 3.05	27.00 ^a ± 2.00
T ₁₀ - Mulching of weed	12.00 ^b ± 1	45.33 ^{ab} ± 6.35	15.33 ^{bc} ± 4.04
T ₁₁ -Control	6.66 ^c ± 3.21	22.66 ^c ± 4.04	10.00 ^c ± 3.60
<i>SE(m) ±</i>	1.65	3.47	2.65
<i>C.D. (5%)</i>	5.22	10.86	8.17
<i>C.V. (%)</i>	22.78	16.09	20.79

The above results are in conformity with the earlier studies done by Lalruatsangi *et al.* (2018); they performed a field experiment to study the effects of paddy straw and rice husk mulching. The study revealed that the microbial population of the soil was found to be highly significant. The highest microbial population count for fungi was observed in rice husk mulch (119.34 ×10⁵ cfu/g) as compared to paddy straw mulch (54.77 ×10⁵ cfu/g) while no microbial growth of fungi was observed under control (no mulch).

The present investigation entitled “RHIZOSPHERIC STUDY IN BAEI (*Aegle marmelos* Correa) UNDER ALLEY CROPPING OF DIFFERENT BIOMASS YIELDING PLANTS” was carried out at ICAR-RCER, FSRCHPR, Plandu, Ranchi, Jharkhand during the period from July 2019- December 2020 with the following objectives:

1. To study the effect of basin enrichment on plant growth, yield and root distribution of Bael plants
2. To study the effect of basin enrichment on soil physical, chemical and biological properties in the plant basin

The soil of the experimental field was sandy loam in texture having acidic pH. The field was laid out in Randomized block design (RBD), comprising 4 replications and 11 treatments. The parameters taken under study for the present research were plant height, trunk diameter, canopy spread, fruit yield/plant, chlorophyll content of leaves, root weight, root volume, soil physical, chemical, and biological property. The data on various parameters were recorded under different treatments and analyzed statistically with the help of analysis of variance to draw a valid conclusion. The inferences and salient finding drawn from the result of the experiments are summarized as below:

To study the effect of basin enrichment on plant growth, yield and root distribution of Bael plants

- The experimental finding revealed that different treatments had no significant effect on the growth performance of Bael. The growth parameters like plant height, trunk diameter, canopy spread, fruit yield/plant were statistically at par in treated and control plots.

- The effect of basin enrichment through the application of biomass under different treatments had resulted in significant changes in root weight and root volume relative to control. In general, the fresh weight of thick size root at a radial distance of 50 cm and depth 30 cm was found maximum initially in treatment T₈: Mulching of Subabul biomass (3.65 g) and at final in the treatment T₄: Mulching of Tephrosia biomass (6.7g) respectively while the minimum was found both for initial and final in the treatment T₁₁: Control (1.76 g and 2.08 g). The dry weight of thick size root at a radial distance of 50 cm and depth 30 cm was found maximum initially in treatment T₈: Mulching of Subabul biomass (2.05 g) and at final in the treatment T₄: Mulching of Tephrosia biomass (2.90 g) respectively, while the minimum was found both for initial and final in the treatment T₁₁: Control (0.96 g and 1.11g) respectively.

- Similarly, fresh weight of thick size root at a radial distance of 50 cm and depth 60 cm was found maximum both for initial and final in the treatment T₂: Mulching of Vegetable Soyabean biomass (3.07 g and 3.86 g) respectively, while the minimum was found both for initial and final in the treatment T₁₁: Control (1.33 g and 1.05 g) respectively. The dry weight of thick size root at a radial distance of 50 cm and depth 60 cm was found maximum both for initial and final in the treatment T₂: Mulching of Vegetable Soyabean biomass (1.96 g and 2.47 g) respectively, while the minimum was found both for initial and final in the treatment T₁₁: Control (0.75 g and 0.80 g) respectively.

- The fresh weight of thick size root at a radial distance of 100 cm and depth 30 cm was found maximum initially in treatment T₈: Mulching of Subabul biomass (2.41g) and at final in the treatment T₄: Mulching of Tephrosia biomass (3.20 g) respectively, while the minimum was found both for initial and final in the treatment T₁₁: Control (0.99 g and 1.59 g) respectively. The dry weight of thick size root at a radial distance of 100 cm and depth 30 cm was found maximum initially in treatment T₈: Mulching of Subabul biomass (1.32 g) and

at final in the treatment T₄: Mulching of Tephrosia biomass (1.93 g) respectively, while the minimum was found both for initial and final in the treatment T₁₁: Control (0.59 g and 0.89 g) respectively.

- Similarly, fresh weight of thick size root at a radial distance of 100 cm and depth 60 cm was found maximum both for initial and final in the treatment T₈: Mulching of Subabul biomass (2.21 g and 3.09 g) respectively, while the minimum was found both for initial and final in the treatment T₁₁: Control (0.70 g and 1.58 g) respectively. The dry weight of thick size root at a radial distance of 100 cm and depth 60 cm was found maximum both for initial and final in the treatment T₈: Mulching of Subabul biomass (1.27 g and 1.97 g) respectively, while the minimum was found both for initial and final in the treatment T₁₁: Control (0.70 g and 1.58 g) respectively.

- The fresh weight of medium size root at a radial distance of 50 cm and depth 30 cm was found maximum initially in treatment T₈: Mulching of Subabul biomass (1.44 g) and at final in the treatment T₆: Mulching of Rice bean biomass (1.90 g) respectively, while the minimum was found both for initial and final in the treatment T₁₁: Control (0.49 g and 1.13 g) respectively. The dry weight of medium size root at a radial distance of 50 cm and depth 30 cm was found maximum initially in treatment T₈: Mulching of Subabul biomass (0.69 g) and at final in the treatment T₆: Mulching of Rice bean biomass (0.93 g) respectively, while the minimum was found both for initial and final in the treatment T₁₁: Control (0.23 g and 0.61 g) respectively.

- Similarly, fresh weight of medium size root at a radial distance of 50 cm and depth 60 cm was found maximum both for initial and final in the treatment T₈: Mulching of Subabul biomass (1.21 g and 1.32 g) respectively, while the minimum was found both for initial and final in the treatment T₁₁: Control (0.22 g and 0.30 g) respectively. The dry weight

of medium size root at a radial distance of 50 cm and depth 60 cm was found maximum both for initial and final in the treatment T₈: Mulching of Subabul biomass (0.79 g and 0.82 g) respectively, while the minimum was found both for initial and final in the treatment T₁₁: Control (0.12 g and 0.16 g) respectively.

- The fresh weight of medium size root at a radial distance of 100 cm and depth 30 cm was found maximum both for initial and final in treatment T₈: Mulching of Subabul biomass (0.84 g and 0.98 g) respectively, while the minimum was found both for initial and final in the treatment T₁₁: Control (0.28 g and 0.33 g) respectively. The dry weight of medium size root at a radial distance of 100 cm and depth 30 cm was found maximum both for initial and final in treatment T₈: Mulching of Subabul biomass (0.45 g and 0.51 g) respectively, while the minimum was found both for initial and final in the treatment T₁₁: Control (0.14 g and 0.18 g) respectively.

- Similarly, fresh weight of medium size root at a radial distance of 100 cm and depth 60 cm was found maximum initially in the treatment T₈: Mulching of Subabul biomass (0.70 g) and at final in the treatment T₄: Mulching of Tephrosia biomass (1.52 g) respectively, while the minimum was found both for initial and final in the treatment T₁₁: Control (0.22 g and 0.33 g) respectively. The dry weight of medium size root at a radial distance of 100 cm and depth 60 cm was found maximum initially in the treatment T₁₀: Mulching of weed (0.36 g) and at final in the treatment T₄: Mulching of Tephrosia biomass (0.78 g) respectively, while the minimum was found both for initial and final in the treatment T₁₁: Control (0.11 g and 0.20 g) respectively.

- The fresh weight of fibrous size root at a radial distance of 50 cm and depth 30 cm was found maximum initially in the treatment T₄: Mulching of Tephrosia biomass (0.71 g) and at final in treatment T₈: Mulching of Subabul biomass (0.78 g) respectively, while the minimum was found both for initial and final in the treatment T₁₁: Control (0.37 g and

0.31g) respectively. The dry weight of fibrous size root at a radial distance of 50 cm and depth 30 cm was found maximum initially in the treatment T₄: Mulching of Tephrosia biomass (0.39 g) and at final in treatment T₈: Mulching of Subabul biomass (0.49 g) respectively, while the minimum was found both for initial and final in the treatment T₁₁: Control (0.22 g and 0.18 g) respectively.

- Similarly, fresh weight of fibrous size root at a radial distance of 50 cm and depth 60 cm was found maximum initially in the treatment T₈: Mulching of Subabul biomass (0.40 g) and at final in the treatment T₄: Mulching of Tephrosia biomass (0.48 g) respectively, while the minimum was found both for initial and final in the treatment T₁₁: Control (0.25 g and 0.27 g) respectively. Similarly, dry weight of fibrous size root at a radial distance of 50 cm and depth 60 cm was found maximum both for initial and final in treatment T₈: Mulching of Subabul biomass (0.23 g and 0.30 g) respectively, while the minimum was found both for initial and final in the treatment T₁₁: Control (0.14 g and 0.14 g) respectively.

- The fresh weight of fibrous size root at a radial distance of 100 cm and depth 30 cm was found maximum both for initial and final in treatment T₄: Mulching of Tephrosia biomass (0.42 g and 0.45 g) respectively while the minimum was found both for initial and final in the treatment T₁₁: Control (0.21 g and 0.23 g) respectively. The dry weight of fibrous size root at a radial distance of 100 cm and depth 30 cm was found maximum initially in the treatment T₄: Mulching of Tephrosia biomass (0.23 g) and at final in treatment T₈: Mulching of Subabul biomass (0.22 g) respectively, while the minimum was found both for initial and final in the treatment T₁₁: Control (0.12 g and 0.16 g) respectively.

- Similarly, fresh weight of fibrous size root at a radial distance of 100 cm and depth 60 cm was found maximum both for initial and final in treatment T₈: Mulching of Subabul biomass (0.24 g and 0.27 g) respectively, while the minimum was found both for initial and final in the treatment T₁₁: Control (0.15 g and 0.16 g) respectively. The dry weight of fibrous

size root at a radial distance of 100 cm and depth 60 cm was found maximum initially in the treatment T₈: Mulching of Subabul biomass (0.14 g) and at final in the treatment T₄: Mulching of Tephrosia biomass (0.17 g) respectively, while the minimum was found both for initial and final in the treatment T₁₁: Control (0.07 g and 0.09 g) respectively.

- The addition of biomass under treatments showed a significant effect on chlorophyll content bael leaves relative to control. In July – 2019, total chlorophyll content was recorded highest in the treatment T₇: Soil incorporation of Subabul biomass (2.65 mg g⁻¹) and lowest in the treatment T₁₁: Control (1.88 mg g⁻¹). And in September- 2020, total chlorophyll content was recorded highest in the treatment T₈: Mulching of Subabul biomass (2.72 mg g⁻¹) and minimum in the treatment T₁₁: Control (2.13 mg g⁻¹)

To study the effect of basin enrichment on soil physical, chemical and biological properties in the plant basin

- Soil physical: The result of the experiment revealed that there was a significant effect of treatments on bulk density and soil moisture content. The bulk density was found highest in control compared to the other treatments in both basin and alley area. Similarly, soil moisture content was also observed highest in all the treatments relative to control in both basin and alley area.

- Soil Chemical: All the treatments showed a significant effect on the chemical content of the soil. The soil chemical properties like soil pH, organic C, available N, available P, exchangeable K, Ca, Mg and micronutrient were increased due to alley cropping practice respectively, as compared to the control and the initial status of the experimental soil.

- Soil Biological: All the treatments had a significant effect on the biological property of soil. The maximum soil bacteria were noted under the treatment T₈: Mulching of

Subabul biomass (29.66×10^6 cfu g^{-1} of soil) in the month of September- 2020, and the lowest was noted under the treatments T₁₁: Control (4×10^6 cfu g^{-1} of soil) in the month of July- 2019. Similarly, the fungal count was observed maximum under the treatment T₂: Mulching of Vegetable Soyabean biomass (48.66×10^3 cfu g^{-1} of soil) in the month of September- 2020 while the minimum was observed in T₁₁: Control (6.66×10^3 cfu g^{-1} of soil) in the month of July- 2019 respectively.

Conclusion

On the basis of results, the following conclusion can be drawn; the application of basin enrichment showed a significant effect on root weight, root volume, chlorophyll content of leaves. Also, significant changes were observed in soil physical, chemical and biological properties compared to control and initial value. Though, all the treatments were found superior over the control. The best among all the treatments were T₈: Mulching of Subabul biomass, followed by T₇: Soil incorporation of Subabul biomass and T₄: Mulching of Tephrosia biomass, and may be recommended to farmers.

However, future studies on various aspects such as quality, the quantity of Bael fruit, identification of soil microbes and quantification of leaching loss of nutrients with respect to different treatments may be suggested.

CHAPTER- 6

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