

**EFFECT OF *Terminalia arjuna* (ARJUN) TREE ON THE  
PERFORMANCE OF PADDY CROP UNDER BUND  
BASED AGROFORESTRY SYSTEM**

**M. Sc. (FORESTRY) THESIS**

**By**

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**DEPARTMENT OF FORESTRY COLLEGE OF  
AGRICULTURE**

**INDIRA GANDHI KRISHI VISHWAVIDYALAYA  
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**EFFECT OF *Terminalia arjuna* (ARJUN) TREE ON THE  
PERFORMANCE OF PADDY CROP UNDER BUND  
BASED AGROFORESTRY SYSTEM**

**Thesis**

**Submitted to the**

**Indira Gandhi Krishi Vishwavidyalaya, Raipur**

**By**

**Taman Sahu**

**IN PARTIAL FULFILLMENT OF THE REQUIREMENTS**

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**IN**

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## CERTIFICATE I

This is to certify that the thesis "**Effect of *Terminalia arjuna* (Arjun) tree on the Performance of Paddy Crop Under Bund Based Agroforestry System**" submitted in partial fulfilment of the requirements for the degree of **Master of Science in Forestry** of the Indira Gandhi Krishi Vishwavidyalaya, Raipur is a record of the bonafide research work carried out by **Mr. Taman Sahu** under my guidance and supervision. The subject of the thesis has been approved by Student's Advisory Committee and the Director of Instructions.

No part of the thesis has been submitted for any other degree or diploma or has been published/published part has been fully acknowledged. All the assistance and help received during the courses of the investigation have been duly acknowledged by him.

Date: 23-08-2021


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## CERTIFICATE II

This is to certify that the thesis entitled “**Effect of *Terminalia arjuna* (Arjun) Tree on the Performance of Paddy Crop Under Bund Based Agroforestry System” Crop**” submitted by **Taman Sahu** to Indira Gandhi Krishi Vishwavidyalaya, Raipur (C.G.) in partial fulfilment of the requirements for the degree of **Master of Science in Forestry** in the Department of **FORESTRY** has been approved by the external examiner and Student’s Advisory Committee after oral examination, under the chairmanship of head of the Department.

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Approved/Not approved

Director of the Instructions

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*Taman*  
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## LIST OF ABBREVIATION

ACRONYMS	DESCRIPTION
%	Percent
&	And
=	Equal to
>	More thane
CD	Critical Difference
AFS	Agroforestry system
°C	Degree centigrade
cm	Centimeter
DBH	Diameter at breast height
GBH	Girth at breast height
<i>et al</i>	And other/co worker
Fig.	Figure
/ha	Per hectare
<i>i.e.</i>	That is
g	Gram
m	Meter
m <sup>2</sup>	Meter square
q	Quintal
q/ha	Quintal per hectare
NS	Non significance
S	Significance
SEm	Stander error of mean
SEd	Standard error of difference
RBD	Randomized Block Design
Vit.	Vitamin

---

a) Title of the Thesis	Effect of <i>Terminalia arjuna</i> (Arjun) Tree on the Performance of Paddy Crop Under Bund Based Agroforestry System
b) Full Name of the Student	Taman Sahu
c) Major subject	Forestry
d) Name and Address of the Major Advisor	Dr. Lalji Singh, Professor & Head Department of Forestry, IGKV Raipur (C.G.) 492012
e) Degree to be awarded	M.Sc. (Forestry)

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Signature of Major Advisor

Signature of the student

Date:

Signature of Head of the Department

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## THESIS ABSTRACT

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a) Title of the Thesis	Effect of <i>Terminalia arjuna</i> (Arjun) Tree on the Performance of Paddy Crop Under Bund Based Agroforestry System
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e) Degree to be awarded	M.Sc. (Forestry)

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Signature of Major Advisor



Signature of the student



Date:

23/08/2021

Signature of Head of the Department



## ABSTRACT

To study the Effect of *Terminalia arjuna* (Arjun) Tree on the Performance of Paddy Crop Under Bund Based Agroforestry System, an experiment was conducted on the farmer's field in Katalbod of Kurud block of Dhamtari district (C.G.), during the *rabi* season (July-November) year 2020-21.

The research work was carried out in a Randomized Block Design (RBD) with one control. Diameter at breast height (DBH) and crown width ranges from 16.55-27.69 cm and 5.28-8.65 m, respectively. Data on the growth and yield of paddy were recorded at 1 m, 3 m, 5 m, 7 m, and 9 m and control >9 m from tree trunk. The results showed that the bund agroforestry of *Terminalia arjuna* (Arjun) had an adverse effect on the growth and yield of paddy, which differed from the different DBH and crown width of the tree row and distance from the tree bund.

Due to higher crown width and closeness to the tree, the growth of paddy, *i.e.* the number of hills/m<sup>2</sup> and the number of tillers/m<sup>2</sup> of paddy, were drastically reduced. The highest number of hills/m<sup>2</sup> (31) and tillers/m<sup>2</sup> (317.67) were recorded at a distance of 9 m from tree 1 and the lowest number of hills and tillers were found at a distance of 1-3 m from the tree line of *Terminalia arjuna* (Arjun) . Whereas the lowest reduction in yield attributes like panicle weight/tiller (2.10 g), grain weight/m<sup>2</sup> (546.41 g) and test weight (11.07 g) of paddy, respectively, were observed at a distance of 9 m from tree 1, and the highest reduction was observed at a distance of 1 m from tree 3, (0.81 g), (104.91 g) and (6.34 g), respectively, in comparison with all other distances. However, the grain yield of paddy recorded from tree 1, (54.64 q/ha), and straw yield of paddy recorded from tree 2 (45.01 q/ha), at a distance of 9 m respectively, which was substantially higher relative to 7 m from the tree and from the control plot. The highest (57.12%) harvest index was found on the control plot, followed by tree 1 (55.72%) at 9 m from the tree line.

Thus, the results of the present study indicate that the maximum reduction in the yield was observed near the tree line, *i.e.* 1-5 m. The decrease followed the order: tree1 > tree2 >, and tree3 at all distances from the base of the tree. Thus, it can be concluded that the minimum crown width and increasing distance from the tree line of *Terminalia arjuna* (Arjun) had less effect on the growth and yield of paddy as compared to the trees with maximum crown width and closeness to the tree or tree line

## शोधग्रंथ

शोधग्रंथ का शीर्षक:	मेड़ आधारित कृषि वानिकी प्रणाली के तहत धान की फसल के प्रदर्शन पर <i>टर्मिनेलिया अर्जुना</i> (अर्जुन) के पेड़ का प्रभाव
विद्यार्थी का नाम:	टामन साहू
प्रमुख विषय:	वानिकी
प्रमुख सलाहकार का नाम व पता:	डॉ. लाल जी सिंह प्राध्यापक एवं विभागाध्यक्ष (वानिकी विभाग), इंदिरा गांधी कृषि विश्वविद्यालय रायपुर छत्तीसगढ़ 492012

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मुख्य सलाहकार के हस्ताक्षर

  
विद्यार्थी का हस्ताक्षर

दिनांक 23/08/2024

  
विभागाध्यक्ष के हस्ताक्षर

## सारांश

मेड़ आधारित कृषि वानिकी प्रणाली के तहत धान की फसल के प्रदर्शन पर *टर्मिनेलिया अर्जुना* (अर्जुन) के पेड़ के प्रभाव का अध्ययन करने के लिए, खरीफ मौसम (जुलाई-नवंबर) वर्ष 2020-21 के दौरान धमतरी जिले (सी. जी.) के कुरुद ब्लॉक के कतलबोड़ ग्राम में किसान के खेत पर किया गया।

अनुसंधान कार्य एक कंट्रोल के साथ एक रेन्डोमाइज्ड ब्लॉक डिजाइन (आरबीडी) में किया गया था। डी बी एच (सीने की ऊंचाई पर व्यास) और क्राउन की चौड़ाई क्रमशः 16.55-27.69 सेमी और 5.28-8.65 मीटर थी। धान की वृद्धि और उपज पर डेटा का पेड़ से 1, 3, 5, 7, 9 मीटर और कंट्रोल >9 मीटर की दूरी पर दर्ज किया गया था। परिणामों से पता चला कि *टर्मिनेलिया अर्जुना* के बंड एग्रोफोरेस्ट्री का धान की वृद्धि और उपज पर प्रतिकूल प्रभाव पड़ा, जो विभिन्न डीबीएच और पेड़ की क्राउन चौड़ाई और पेड़ के मेड़ से दूरी से भिन्न था। क्राउन की बढ़ती चौड़ाई और पेड़ की निकटता के कारण, धान की वृद्धि, यानी हिल्स की संख्या/मी<sup>2</sup> और धान के टिलर/मी<sup>2</sup> की संख्या में भारी कमी आई। सबसे अधिक संख्या में हिल्स/मी<sup>2</sup>

(31) और टिलर/मी<sup>2</sup> (317.67) पेड़ 1 से 9 मीटर की दूरी पर दर्ज की गई हैं और सबसे कम संख्या में हिल्स और टिलर *टर्मिनोलिया अर्जुना* पेड़ की रेखा से 1–3 मीटर की दूरी पर पाए गए हैं। जबकि धान के बाली का वजन/टिलर (2.10 ग्राम), बीज का वजन/एम<sup>2</sup> (546.41 ग्राम) और टेस्ट वेट (11.07 ग्राम) जैसे उपज गुणों में सबसे कम कमी क्रमशः पेड़ 1 से 9 मीटर की दूरी पर देखी गई, और अन्य सभी दूरियों की तुलना में पेड़ 3, (0.81 ग्राम), (104.91 ग्राम) और (6.34 ग्राम) से 1 मीटर की दूरी पर सबसे अधिक कमी देखी गई। हालांकि, पेड़ 1 (54.64 क्विंटल/हेक्टेयर) से दर्ज धान की उपज, और पेड़ 2 (45.01 क्वि. /हेक्टेयर) से दर्ज धान की पुआल उपज क्रमशः 9 मीटर की दूरी पर 7 मीटर की तुलना में काफी अधिक थी। पेड़ से और कंट्रोल प्लाट से सबसे अधिक (57.12 क्वि./हेक्टेयर ) फसल सूचकांक कंट्रोल प्लाट पर पाया गया, इसके बाद वृक्ष 1 (55.72 क्वि./हेक्टेयर ) वृक्ष रेखा से 9 मीटर की दूरी पर पाया गया।

इस प्रकार, वर्तमान अध्ययन के परिणामों से विदित होता है कि उपज में अधिकतम कमी पेड़ की रेखा के पास, यानी 1–5 मीटर के पास देखी गई, सभी दूरी पर पेड़ 1 > पेड़ 2 > , और पेड़ 3 कमी ने पेड़ की आधार रेखा से क्रम का पालन किया। इस प्रकार, यह निष्कर्ष निकाला जा सकता है कि *टर्मिनोलिया अर्जुना* की वृक्ष रेखा से न्यूनतम क्राउन की चौड़ाई और बढ़ती दूरी का धान की वृद्धि और उपज पर कम प्रभाव पड़ता है, जबकि अधिकतम क्राउन चौड़ाई और पेड़ या पेड़ की रेखा से निकटता वाले पेड़ों की तुलना में

# CHAPTER 1

## INTRODUCTION

---

Agroforestry is the deliberate integration of trees with agricultural crops and/or livestock either simultaneously or sequentially on the same unit of land (Nair, 1993). Agroforestry has the capacity of recuperation and preservation of soil fertility, to control and prevent soil erosion, to control water harvesting and eutrophication of streams and rivers, to increase local biodiversity, to reduce process of becoming acidic soil (acidification), to reduce fuel pressure on natural forests and to provide livestock feed, to increase productivity and also to improve people's livelihoods in each developing country and its also provides high quality water covering a high percentage of the soil surface (Stadtmuller, 1994).

Over the years, agroforestry has caught the world's attention, especially in developing countries, where both forests and agricultural land are subjected to intense stress due to population pressure and industrialization. Adoption of agroforestry in India has turned out to be inevitable due to limited land area, low forestland productivity, increased biotic pressure on wood, fodder and other minor forest products, and degradation of the environment, soil and water resources etc. AFS began in the late 1970's (De las Salas, 1979; Stepler and Nair, 1987). The classification, possible biological and socio-economic benefits as well as drawbacks, and the inventory of typical agroforestry systems (AFS), mostly in the tropics, were initially the emphasis (Budowski, 1982; Nair, 1989).

Agroforestry is the sensible integration of woody perennials with crops and/or animals on the same unit of land for meeting the multiple demand of the future like food, fodder, fire wood, timber and other ancillary benefits. It facilitates the nutrient recycling, improves the soil fertility, arrests soil erosion and land degradation, conserves soil and water, improves village environment, conserves biodiversity and serves as a major carbon sink. Well-managed agroforestry system (AFS) can increase overall productivity (Bustamanate *et al.*, 1998; Bolivar *et al.*, 1999), thus-sequestering carbon (Lopez *et al.*, 1999 and Andrade, 1999), a possible additional economic gain for livestock farmers realizing the importance of this kind of land use, emphasis is being given to agro-forestry in agricultural field bunds and permanent fallow lands for stabilizing food soil enrichment in agroforestry.

The amount of soil enrichment depends on the species of the crop, management methods, litter quantity and consistency. There is a need for careful selection of species and effective management of trees and crops to maximize development and tremendous effects within the system and to reduce negative competitive effects. However, the main disadvantage of this is that the trees create a shading effect on the crops, which causes the crops to have a tendency to give low yields. Light is the key limiting factor for understory vegetation growth, as the increased standing density of trees (Acciaresi *et al.*, 1994) limits light penetration.

However, the yield of the crop can be improved by manipulating the tree canopy, which can assist the related crop. Pruning reduces the tree canopy, thereby facilitating more entry of sunlight. It has become an essential practice to decrease competition with associated crops both above and below-ground (Fownes and Anderson, 1991).

Agroforestry is an alternative agricultural policy based on the growing of trees with crops. It is a land use option that reduces vulnerability to climate and environmental change and increases the scope of livelihood. It improves the economic conditions of farmers, besides conserving the natural resources of soil, water, and biological diversity. Trees on farm lands help in increasing agricultural resilience to meet the challenges of global climate change (Mbow *et al.*, 2014; Lasco *et al.*, 2014).

Several agroforestry technologies and systems have been developed in diverse agro-ecological zones of the country. These systems have ensured higher returns to the farmers and, additionally, ensured livelihood security and protection against crop failure due to climatic deviations, mainly in the inarid and semi-arid conditions of the country (Sarvade and Singh, 2014).

Tree litter improves soil fertility not only through the addition of nutrients to the soil by mineralization, but also by adding soil organic matter to the soil (Dollinger and Jose, 2018). The systematic integration of trees with crops improves microclimatic conditions, which has a positive effect on the consequences of productivity. The trees regulate the complex of environmental changes, affecting not only the available light but also the air temperature, soil moisture content, soil temperature, wind movement, relative humidity, rainfall infiltration, evapo-

transpiration, soil structure, micro-fauna, reduced pest and disease complexes, etc. (Sileshi *et al.*, 2007). Agro-forestry systems, along with maintaining ecological balance, uplift the socioeconomic status of the farmers and substantially contribute to the production of wood for industries and other commercial purposes. It offers a cost-effective and ecologically viable option for large-scale diversification in agriculture on one hand and environmental betterment on the other (Nayak *et al.*, 2014).

One of the most important commercial food crops by far is rice (*Oryza sativa* L.). Its annual yield worldwide is approximately 535 million tons. The domestication and cultivation of rice is one of the most important events in history that has had the greatest impact on the most people. Rice is a nutritious cereal crop and the main source of energy. It provides adequate amounts of protein, zinc, and niacin, *i.e.* vitamin B<sub>3</sub>. However, rice is deficient in Ca (calcium), Fe (iron), and vitamins like vit. B<sub>1</sub> (thiamine) and vit. B<sub>2</sub> (riboflavin). Rice protein has the property of high digestibility (approx. 88%) among other cereal proteins. It provides sufficient fibre for easy digestion and minerals. It accounts for 50-80% of the everyday calorie intake from rice.

Rice is one of the world's most labour-intensive cereal crops. It is also a water-thirsty crop. It depends on rain or irrigated water. It also needs hot weather after a period of rain. The country that has the largest area under rice cultivation is India. In India, the rice crop occupies an area of 437.73 million hectares with a production of 118.430 million tons (INDIA STAT, 2020). It is one of the chief grains of India. It demands a temperature of around 25<sup>0</sup>C and above and a rainfall of more than 100 cm. It feeds more than 60% of the population of India and is the 2<sup>nd</sup> largest rice producer in the world after China, with more than 10% of global production share, and with a production increase of 3.5 times in the last 60 years. Some major producing states are West Bengal, Uttar Pradesh, Andra Pradesh, Punjab, Tamil Nadu, Odisha, Bihar, and Chhattisgarh (MOSPI-GOI).

The ayurvedic plant *Terminalia arjuna* (Arjun) Roxb. has significant medicinal value. It is also known as Arjuna, Arjun, Indradru, Partha, and Veeravriksha (Sharma *et al.*, 2005). It is a member of the Combretaceae family, which includes nearly 200 species worldwide. Nearly 24 species of *Terminalia* have

been identified in India, with *Terminalia arjuna* (Arjun) and *Terminalia spp.* being among the most notable.

The tree is large, about 60-80 feet in height, evergreen with a spreading crown and having drooping branches. New leaves appear in the hot season (February to April). This tree is exotic in India. In India, it is found in Uttar Pradesh, South Bihar, Madhya Pradesh, Delhi and the Deccan region near ponds, rivers and banks of streams (Ali *et al.*, 2003). *Terminalia arjuna* (Arjun) leaves are simple, with crenulations, and are borne sub-opposite. They are coriaceous, oblong or elliptic, and have a short acute or obtuse apex. Their upper faces are pale or dark green, with a pale brown lower face. White sessile bisexual flowers appear in short auxiliary spikes or in a terminal panicle arrangement on the tree. *Terminalia arjuna* (Arjun) fruits are drupe-like, ovoid, fibrous-woody, and smooth-skinned, with five oblique and bent upwards hard wings or angles. The stem bark is plain, smooth, and pinkish-gray in colour. The bark is smooth and reddish in colour from the inside.

The arjuna is seen across the Indian Subcontinent, and is usually found growing on river banks or near dry river beds in Uttar Pradesh, Bihar, Maharashtra, Madhya Pradesh, West Bengal, Odisha, and south and central India, along with Sri Lanka and Bangladesh. It has also been planted in Malaysia, Indonesia, and Kenya. (Rastogi, 2008).

Since ancient times, *Terminalia arjuna* (Arjun) has been valued as a source of medicine (Ayurveda, Siddha, and Unani), tannins, tassar silk, timber, and fuel (Paarakh, 2010). Farmers get high cash returns on a short-term tree harvest period by using the agroforestry (Rice + Arjun) scheme, and labour input on farms is spread more evenly across the year.

Since ancient times, medicinal plants have been a major source of therapeutic agents for curing diseases. *Terminalia arjuna* (Arjun) Roxb. Wight and Arn. is a widely used and useful medicinal plant in traditional Indian medicine for the treatment of a variety of diseases. This systematic analysis covers ethnomedical, phytochemical, pharmacognostical, and pharmic aspects. This plant has a good safety record when used in combination with other conventional drugs. This review highlights various medicinal properties of *Terminalia arjuna* (Arjun) through

different studies, such as antioxidant, hypotensive, anti-atherogenic, anti-inflammatory, anti-carcinogenic, anti-mutagenic, and gastro-productive effects.

In bund plantations, except for those liking shade or sensitive shade conditions, tree shade is assumed to be responsible for low yields of associated crops. When the tree remains unpruned, this issue is more acute. Shade has a pronounced effect on rice development. It affects the increase in plant height, decreases the number of tillers and panicle/hill and panicle/grains, and decreases grain yield. Shade stimulates cellular expansion and rapid division of cells, leading to an increased leaf length and height of the plant (Schoch, 1972). Shading treatment has shown the tallest plants, while the smallest plants are found in shade-free areas (Miah *et al.*, 1999). The shading effect of trees may be attributed to less rice yield near the boundary plantation trees. Again, the trees also contend with water and nutrient crops. Reports of timber which is deliberately maintained in upland rice (*Oryza sativa* L.) fields are rare. (Hocking and Islam 1995).

Studies on bund based agroforestry systems of *Acacia nilotica*, *Butea monosperma*, and *Eucalyptus* species have been done in Chhattisgarh by many workers, but similar studies related to *Terminalia species* are not available. Hence, in view of the above, the study has been planned with the following objectives.

**Objectives:-**

- 1) To study the effect of tree age on paddy crop.
- 2) To study the effect of tree on crop with varying distance.
- 3) To study the effect of crown on crop performance.

## CHAPTER - II

### REVIEW OF LITERATURE

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In this chapter attempt has been made to review the work on “Effect of *Terminalia arjuna* tree on the Performance of Paddy Crop Under Bund Based Agroforestry System”. The work is broadly reviewed under the following heads.

- 2.1 Agroforestry system with crop.
- 2.2 Effect of tree age on paddy crop.
- 2.3 Effect of tree on crop with varying distance.
- 2.4 Effect of crown on crop performance.

#### **2.1 Agroforestry system with crop**

The main agro-forestry activities include progressing fallows, taungya (raising annual agricultural crops during forestry plantation), home gardens, alley cropping, planting multi-purpose bushes and shrubs on farmland, boundary planting, farm woodlots, orchards or tree gardens, planting/cropping combinations, trees on pasture and apiculture trees, shelterbelts, windbreaks, conservation hedges, fodder banks, stay fences, etc. (Nair, 1993; Sinclair, 1999).

Dhyani and Tripathi (1999) reported tree growth, survival and crop yield under different agrisilvicultural practices using different species at Barapani, Meghalaya. The results revealed positive effects of intercropping on height and diameter growth, crown width and timber volume of tree species of alder, albizzia, and cherry, but this was not so in the case of mandarin. Also, it was highlighted that better growth and timber production was obtained in tree-crop combinations due to application of fertilizers and weeding.

Vishwanath *et al.*, (2000) calculated the benefit cost ratio and internal rate of returns in an *Acacia nilotica* based agroforestry system. They concluded that through practicing this system, farmers get higher cash returns on a short-term (10-year) basis. They also studied the interactive effects of *Acacia* tree species on associated paddy crop growth along with overall productivity in areas of central India and found that, except for crop yield, not all other parameters were affected by the presence of woody perennials.

Broadhead *et al.*, (2003) stated that in order to minimize competition for water and other nutrients in an agroforestry system during the cropping period, there should be temporal separation of resource use between trees and associated crops. Also, root-shoot pruning is found to be beneficial for reducing competition. In their experimental trial, they found that shading of trees reduces crop yield significantly.

Newaj *et al.*, (2003) in their studies of *Albizia procerra* based agroforestry systems found that an alteration was found in grain yield, *i.e.* deterioration in association with tree crops. Also, one barrier was placed around the tree crops in order to counteract the competition between trees and associated crops, and this barrier was found to be very effective. From the overall study, it was concluded that the placing of galvanized sheet around the tree can be suggested to farmers for utilizing the best possible benefits from the given agroforestry system.

IWMI (2007) in their report found that trees and agroforestry play an important role as far as the agriculture landscape in the region of the Indus-Ganges basin is concerned. These results were concluded after their vast field study and reports from remote sensing. It was also mentioned that to improve the livelihood, economic security and increased productivity of the present land system, diversification of cropping areas to agroforestry crop systems or planting bunds and boundaries stand as the best alternative.

Ajit *et al.*, (2010) mentioned that in India, agroforestry practices are very old, but the advent story of organized agroforestry research began in 1979 in Imphal, the capital of Manipur, when a seminar on agroforestry was organized by the Indian Council of Agricultural Research (ICAR), New Delhi, to accumulate and compile data pertaining to the research and development of agroforestry in India.

Yadav *et al.*, (2011) studied the *Prosopis cineria* based agroforestry system. Their findings showed an increase in organic carbon, available N, P and K content in the silvi-pastoral system as compared to no Khejri soil. The Khejri based system gave higher fodder production to meet demands for food, fodder, fuel wood and small timber.

Shweta *et al.*, (2015) investigated the effect of different types of agriculture crops on the growth performance of guava under a guava-based agroforestry system.

The results concluded enhanced nutrient status of soil, increased height and diameter of Guava trees when intercropped with mung bean.

Zhang *et al.*, (2016) conducted an experiment on the Jujube-wheat intercropping system. They found a relationship between root length densities and root densities of the intercropped species. They concluded from the experiments that root growth, biomass accumulation and yield were significantly affected in the intercropped treatments.

## **2.2 Effect of tree age on paddy crop.**

Calstellono and Prevoster (1961) noticed that poplars planted in rows in any direction have no significant effect on yields of crops up to the 4th year of planting. Ranasinghe and Mayhead (1990) reported that a 2-year-old tree of *Populus deltoides* affects the yield of beans over a certain distance. However, 1-year-old trees did not affect the yield.

Ralhan, *et al.*, (1992) studied wheat yield under five age classes of poplar and compared it with wheat yield under pure cropping. A substantial reduction in wheat yield (23.3%) under three-year-old poplar plantation was observed. Maximum MAI (GBH, 20 cm) was recorded in a three-year-old poplar planting. Pruning after the third year permitted some recovery in yield. The reduction in wheat yield was significantly correlated with MAI (GBH) of poplar and occurred even under one- and two-year-old poplar planting.

Sharma *et al.*, (1994) observed that the grain and straw yield of both the crops (pearl millet and cluster bean) was reduced in the close vicinity of the 4-year-old plantations of both the trees (*Acacia tortilis* and *Zizyphus rotundifolia*).

Ralhan *et al.* (1996) observe that the soil organic carbon increased significantly with tree age in 0–15 cm soil layer, being 18% higher under 3-year plantation than in the soils under 1-year of plantation. It further increased by 18.5% in soils under 6-year plantation. Similar trend was observed in 15–30 cm soil layer.

Solanki and Ram Newaj, (1996) noticed that the effect of *Populus deltoides* on wheat yield under five age classes *viz.*, (one year, two years, three years, four years and six year old plantations). A similar result was also found in the case of 12 MPTS and three spacing (2m x 4m, 2m x 6m and 2m x 10m) with four crop rotations

under tree/crop interface in association with subabul. Wheat and chickpea recorded a relative grain yield of 74.7 and 55.2 per cent, respectively.

Sharma *et al.* (2000) studied the impact of poplar (*Populus deltoides*) on the growth of wheat at an early stage of growth and found that, depending on the age and growth of the tree, the distance from the poplar tree line significantly affected the yield of wheat and mustard crops up to 4 to 6 m from the tree line.

Dhanda and Verma (2001) reported an increase in tree height growth with age of more than 3-5 years of growth and after 17 between 6 to 9 years of growth; it decreased to 3.1-3.4 m/yr. The wheat grain yield showed a declining trend, but the decline rate was negligible and non-significant in the third and fourth years. During the third year, the wheat grain yield decreased by 50 percent. At one, two, three, and four-year old poplar plantations, the decrease in grain yield was 11, 39, 50, and 54 percent respectively as opposed to the control (open condition).

Newaj (2003) noticed that field crops (cereals, pulses, oilseeds) respond differentially when grown in association with woody components. Trees, being the dominant partners in the agroforestry system cause a consistent and progressive increase or decrease in the yield of crops depending upon the species, planting geometry, and age of the tree.

Bargali *et al.*, (2009) found that under 6-yr-old tree, there was an increase (4%) in grain yield. With an increase in tree canopy size, the plant density and effective tillers are also reduced. Percent yield reduction showed a significant positive correlation with tree age, crown diameter and DBH. After the removal of 10% of basal tree branches (in 12–28-yr-old trees), the crown diameter of trees was reduced (0.81–3.77%), plant density (0.05–1%), effective tillers (1.19–5.8%) and grain yield (1.52–2.92%) increased significantly, and plant height decreased (0.09–1.32%) over the unmanaged (without cutting the tree branches) condition.

Chauhan *et al.*, (2009) observe that the age of poplar (*P. deltoides*) trees is recorded as the most important factor influencing grain yield of intercropped wheat. On an average, reduction in grain yield (var. PBW 343) was 20.10 percent under 1-yr old poplar plantation, which increased to 54 per cent under 4-yr old plantation. While comparing the crop yield under block and boundary planting models, wheat and paddy yield (grain and straw) substantial reduction was recorded in poplar based

system than the tree-less plots. The grain yield of wheat crop was maximum under control plots; i.e., 4.55t per ha, which was higher than the crop grown under boundary plantation (3.28 t per ha) and lowest at block plantation (2.03 t per ha).

Chauhan *et al.*, (2011) observed that the plant height of the wheat crop decreased with advancement of the age of the poplar trees and the maximum plant height was measured under measind control plots (devoid of poplar trees). The plant height in the open was significantly higher than under block poplar plantations. On an average, a 10.7 to 23.3 percent decrease in plant height was observed under plantations of different ages as compared to the wheat crop in the open.

### **2.3 To study the effect of tree on crop with varying distance.**

The above and below ground interactions in alley cropping were critically examined by Singh *et al.*, (1989) and they found that the growth and yield of corps declined from 15 to 30% than that of sole crops as the distance from the tree rows decreased from 5 m to 0.3 m.

Kohli *et al.*, (1990) studied the effect of the shelter belt of six-year old *Eucalyptus treticornis* on six winter crops in terms of plant density, root and shoot growth and observed an adverse effect up to 11m from the tree row. However, beyond 11 m, no influence of the tree was noticed.

Puri and Bangarwa (1992) reported that the variation in grain yield was not significant between east and south directions but varied significantly between north and west directions at all distances except 7 m.

Khybri *et al.*, (1992) studied the effect of 3 tree species on the yield of paddy and wheat and reported that the yield of both the crops was significantly affected up to a distance of 5 m. The reduction in yield of crops was 39 per cent at 1 m, 33 per cent from 1-2 m, 25 per cent from 2-3 m and 12 per cent from 3-5 m distance.

Khan and Ehrenreich (1994) observed the influence of boundary planting of *Acacia nilotica* on the growth and yield of associated wheat (*Triticum aestiveum*) crops under irrigated conditions. The results indicated that close proximity to trees adversely affected tillers per m<sup>2</sup>, grains per spike or 1000 grain weight, but grain yield was slightly lowest near the largest trees.

Chirko *et al.*, (1996) studied at the effect of direction and distance from Paulownia trees on wheat production and found that a distance of 2.5-20 m from trees increased yield (45.7 kg/ha), but there was no difference in direction effects.

Dhillon *et al.*, (1998) studied the effect of single scattered *Indica* (Kikar) trees, on growth and yield of rainfed wheat in North-West India. The lowest yields of biomass and grain were recorded from the southern aspect and the near-tree plots. Compared to an open field. The tree association resulted in a decrease in biomass and grain yields of 23.7% and 36.5%, respectively. The highest reduction for both grain (47.6%) and biomass yield (35.4%) was reported on the southern aspect. The grain yield reported at 1 and 3 m distance from the base of the tree was 49.8 and 46.8% lower than that of the open field, while the reduction at 8 m distance was comparatively lower (14.3%). The production of biomass also experienced the lowest reduction at 8 m distance (9.9%). However, it was maximum (31.6%) at a distance of 3m from the tree base.

Pandey *et al.*, (1999) reported that paddy yield was positively related to distance from the tree. The impact of the trees was maximum at 2m from the tree, where crop yield was reduced by 44% and declined with increasing distance (to a 14% reduction at 8 m). There was an increasing relationship between the percentage decrease in the parameters and the distance, indicating that the greater the distance, the smaller the effect of the tree.

Barakoti *et al.*, (2000) studied the effect of *Bauhinia purpurea* on the yield of crops (maize and finger millet) and observed that the yield was severely affected near tree rows. Furthermore, they found that the direction of the tree has less effect than the distance between the trees.

Alam *et al.*, (2001) observed the performance of paddy cv. BRII (Mukta) as an understory crop grown in association with 8 year old selected tree species, *viz.* Albida, Jhau, Eucalyptus, Akashmoni, and Sissoo in different orientations as studied. Out of five paddy associations, the given the highest total yield of 4.354 t/ha. The Sissoo-paddy association gave the lowest total yield of 2.54 t/ha. The paddy association reduced 20.63% yield compared to the open field. As regard to orientations, south 3.0 meters from the tree base gave the highest total yield, 4.838 t/ha.

Muchiri *et al.*, (2002) reported that the impact of trees on resource availability increases with tree size but decreases with distance from the tree row. The influence of *Grewia* on the wheat produced varied according to the distance of the tree. Competition for growth and yield was more pronounced in the close vicinity of the tree at 1 and 2 m. The more negative effect in the close vicinity of trees can be ascribed to more competition for moisture, nutrients and light, which is also evident from the present study.

Singh *et al.*, (2003) studied the effect of boundary plantation of poplar (*Populus deltoides* M.) on the growth and yield of paddy and reported that the growth parameters of paddy were significantly affected up to a distance of 12 m with respect to the number of tillers and 8 m with respect to the leaf area index. However, plant height increased significantly with increasing distance from the tree line up to 12 m.

Kaushal and Verma (2003) found that growing and yielding wheat crops were negatively affected below the tree crown of *Grewia optiva*, while increasing distance from the tree trunk. Plant height and the number of tillers per plant decreased significantly at 1 m distance compared to other distances. Grain and straw yield also showed the highest reduction at 1 m distance in the close proximity of the tree, where a reduction of about 51.9 % compared to control at 8 m distance was reported. In addition, yield increased linearly with increases in distance from the base of the tree.

Babu *et al.*, (2008) observed that chili and sweet gourd's growth and yield grew rapidly as distance from the tree increased. In the control area, the tallest plant and the highest length of leaves were found. With growing distance from the tree, the leaf size, plant height, diameter, leaf length, leaf breadth, number of fruits per plant, weight of fruits per plant, yield, etc. gradually increased. The highest yield of sweet gourd (13.05 t/ha) and chilli (4.1 t/ha) was observed under control treatment. The lowest yield of sweet gourd (7.20 t/ha) and chilli (3.30 t ha<sup>-1</sup>) was observed close to 3 ft. away from the tree. They concluded that *Eucalyptus* boundary plantation has a negative impact on yield components of chilli and sweet gourd.

Chauhan *et al.* (2008) observed that an increase in distance between tree rows resulted in higher growth in height, diameter at breast height, crown diameter and crown length of trees, and grain yield in the maize crop.

Singh *et al.*, (2008) in their study on *Butia monosperma* trees have observed the density of  $136.0 \pm 2.55$  stems /ha, a basal cover of  $8.2 \pm 0.63$  m<sup>2</sup>/ha and a canopy cover of  $20.80 \pm 3.18$  m trees. Studies on the crop showed that the shoot number increased with increasing distance from the trees. The shoot number ranged from  $205.0 \pm 5.2$  m to  $305.6 \pm 9.8$  m<sup>2</sup> and the highest shoot number was obtained for D5. The reduction (percentage) in shoot number increased with decreasing distance. Reduction was lowest (3.1%) for D4 and highest (32.9%) for D1. Shoot biomass varied between  $9.8 \pm 0.25$  Mg/ ha to  $12.6 \pm 0.40$  Mg/ha. It increased with increasing distance from the tree base. The reduction in shoot biomass was minimum (22.2 %) for D4 and maximum (1.5 %) for D1.

#### **2.4 To study the effect of crown on crop performance.**

Malik and Sharma (1990) reported the reductions of over 30% for crops growing at a distance of less than 10 m from the tree line. Thus, despite the use of drought-adapted plants, water competition is likely to play a major role in the productivity of agroforestry systems, especially in dry areas.

Monteith *et al.*, (1991) recorded that beneath canopy temperature also showed more reduction at 1 and 2m, which again can be ascribed to the direct shading effect of *Grewia* on wheat. Reduced temperatures below trees have also been reported.

Ong *et al.*, (1992) studied the effect of *Leucaena leucocephala* on maize and observed that total maize yields under improved trees were only 50% of the sole maize yield, which increased to 80% due to pruning, indicating the benefits of pruning in reducing tree-crop competition.

Sae-Lee *et al.*, (1992) studied that the higher soil fertility was found in the positions closer to the tree base, while grain yields, biomass, and number of tillers were lower, and paddy was taller and had more unfilled grain. Shading was deduced to be the key factor responsible for the depressed paddy yields and growth at positions closer to the tree base, especially in the highly shaded *S. saman*.

Salazari *et al.* (1993) observed that alley cropping of three leguminous species (*Inga eciulis*, *Leucaena leucocephala*, and *Erythrina sp.*) with agriculture crop (paddy). Pruning materials of these species are used as mulch. The paddy yield was higher with *L. leucocephala* and *Erythrinu* mulch than *Inga edulis* mulch. In general, paddy yields were reduced.

Nazir *et al.*, (1993) conducted a trial in Pakistan. Wheat was sown parallel to *Dalbergia sisso* trees at a distance of 0.2, 3, 4, 5, 6, 7 and 8 hours to shade day-1. Increasing duration at shading decreased plant height, number of fertile tillers per unit area, number of grains per spike, 1000-grain weight, grain protein concentration and percentage DM and grain yield. The yield was 2.99, 2.96, 2.11, 2.57, 2.4, 2.12, 1.64, and 1.32 t/ha, with zero, two, three, four, five, six, seven and eight hours of shade per day, respectively.

Vitryakon *et al.*, (1995) reported that shading from trees decreased paddy yield but increased plant height, but application of leaf litter from *Dipterocarpus obtusifolius* increased paddy yield in shaded conditions.

Miah *et al.*, (1995) observed that the mean light availability on crop rows decreased as they approached the tree rows across the alleys. The rate of decrease was greater in unpruned than in pruned alleys. Paddy and mung bean yields decreased linearly with the reduced percent of light incidence. Paddy yields decreased 47 kg/ha and mung bean yields decreased more in pruned conditions (13 kg/ha) than in unpruned conditions (9 kg/ha).

Viswanath *et al.*, (1996) observed that trees did not significantly affect crop parameters except grain yield. Grain yield was reduced to 28-30% immediately below the tree canopy and gradually increased away from the spread of the crown. They also reported that soil organic matter and available N were significantly affected by trees, being respectively 48 and 16% higher under the canopy than in control open plots.

Leonardi (1996) reported that shading (60% light reduction) reduced vegetative and fruit growth. Shading increases plant height. Shading also reduced chlorophyll content, stomata density, transpiration rate and photosynthetic rate. The yield of peppers decreased with an increasing number of shade levels.

Hocking and Islam (1998) noticed that over a five-year period, four crops were grown under 17 tree species at 8 x 8 m spacing in wetland paddy fields. All tree species grew well in paddy fields, at rates comparable to their growth in forest plantations.

Nandal *et al.*, (1999) noticed that the 5 wheat cultivars under the sissoo trees. In their experiment, grain yield, dry matter yield, leaf area index, spikelets/m, grains/spike and test weights were reduced under the tree canopy compared with crops growing in the open place.

Salish *et al.*, (2003) studied the relative performance of wheat cultivars in fields having different shading intensities brought by eucalyptus. Wheat grain yield decreased significantly with the increase in shade duration due to eucalyptus plantation on the eastern side of the wheat field. The photosynthetic rate and specific leaf weight of wheat also decreased significantly with the increase in shade duration. However, chlorophyll-a and chlorophyll-b content per unit leaf fresh weight increased with an increase in shade duration.

Chauhan *et al.*, (2013) evaluated an agri-horticultural model involving poplar (*Populus deltoids*) as a timber tree component, fruit trees, and agronomic crops, *viz.*, turmeric (*Curcuma longa*) and moong (*Vigna radiata*) for yield. Net photosynthesis, stomatal conductance, and transpiration in both crops were higher in open areas than in shaded ones. Agronomic crops showed initially better performance under partial shade in the yield and yield contributing parameters, and decreased as the poplar canopy advanced in age. Changes in these parameters showed an inverse relationship with canopy age and vice versa, with more yield reduction under the fifth year old canopy followed by the preceding years and control. The transpiration rate (E) of crops was lowest under shade conditions irrespective of the crop used in the experiment, leading to more water use efficiency in shade conditions than in the open. There was a gradual reduction in crop yield with advancement of age, but the economic benefits of intercropping were two to three times higher than traditional crop rotation.

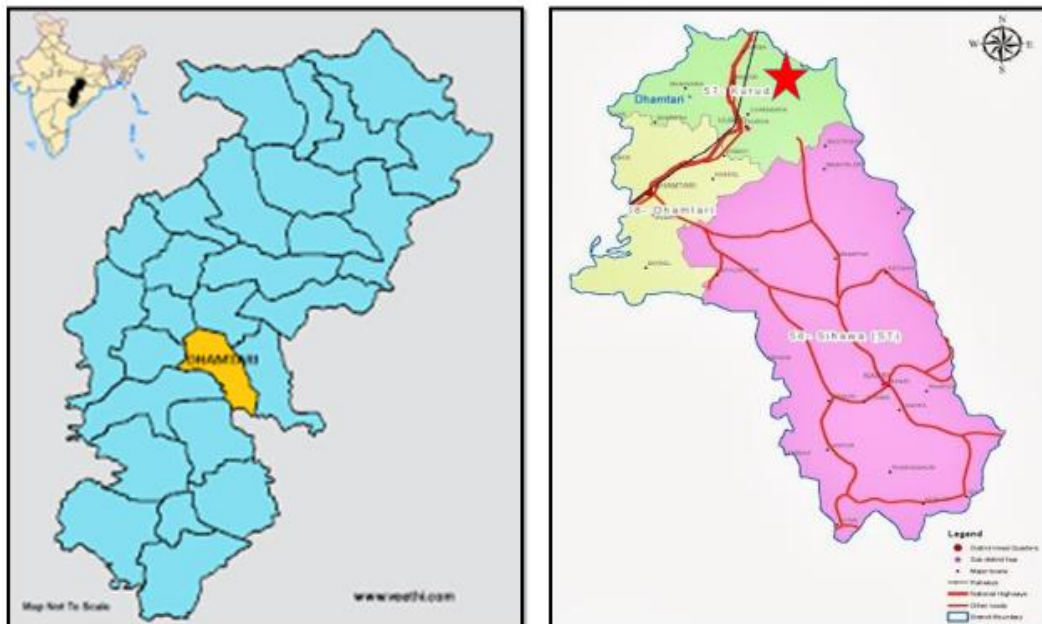
## CHAPTER – III

# MATERIAL AND METHODS

### Description of Study Area

#### 3.1 Experimental site

The present study entitled “**Effect of *Terminalia arjuna* (Arjun) Tree on the Performance of Paddy Crop under Bund Based Agroforestry System**” was carried out in the experimental field of village Katalbod of Dhamtari district (C.G.), during *kharif* season (July-November) in the year 2020-21. The details of the study site, materials used, procedure, and the techniques followed during the study are presented in this chapter. The details are as follow:

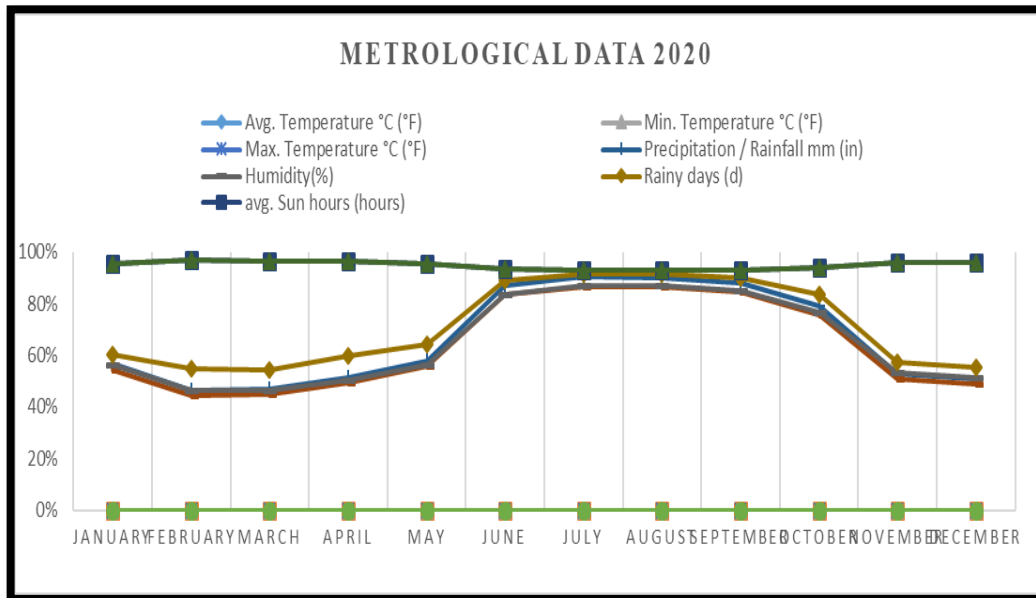


**Fig. 3.1: Map of the study area**

#### 3.2 Climate

The climate is tropical and it is influenced by monsoon conditions. The year is divisible into three seasons, viz., rainy (mid-June-September), winter (November-February) and summer (April-mid June). October and March comprise transition periods between the rainy and winter, and between the winter and summer seasons. The mean monthly values of temperature and rainfall is plotted in Figure 3.2. The mean monthly temperature varies between 21°C (December) and 35°C (May), and

the annual temperature averages 27°C. The mean annual rainfall is 1247.0 mm, 95% of which occurs during the rainy season. About 8 months of the year are dry.



**Fig. 3.2: Climatic graph of study area**

### 3.3 Soil of experimental site

Soils of this order are tropical black with tremendous swell-shrink behaviour, deep (> 50r\_m) with high base saturation and dominated by smectite kinds of clay minerals. These soils swell on wetting and shrink on drying, which induces the development of wide, deep cracks and a mostly angular, blocky structure. The cracking, followed by filling of cracks and swelling, results in the development of a 'galgai micro-relief. They are dominantly observed in lower topographic positions or on flat terrain at the foot of gentle slopes. They are mostly neutral to alkaline in reaction and fertile with high base status. In Chhattisgarh, there are two sub-groups under Vertisols, i.e., Chromic Haplusterts and Typic Haplusterts.

### 3.4 Experimental Details

The experimental details followed and methods adopted are given below

- Agro-forestry system : Agri-silviculture
- Structural Component : The system based on the following component
- Tree component : *Terminalia arjuna* (Arjun)
- Field Crop : Paddy (*Oryza sativa*)

### **3.4.1 Variety of paddy**

The paddy variety Samba Mashuri (BPT-5204) was sown in the present experiment, which is suitable for medium land and has good tillering properties. It is susceptible to many biotic stresses and exhibits incomplete panicle emergence. The duration of the aforesaid mentioned variety is 130-140 days, plant height 95-105 cm, medium bold type of grain, and average yield of 60-65 q/ha.

### **3.4.2 Planting geometry and tree characteristics**

The basic features of the *Terminalia arjuna* (Arjun) tree dimensions, *i.e.*, DBH, crown width, and distance between the trees are given in Table 4.1 of chapter 4. The distance from tree to tree ranges between 3 m and 5 m. The tree DBH and crown width range from 16.55-27.69 cm and 5.28-8.65 m, respectively.

### **3.5 Experimental Design:**

The experiment was carried out in a Randomized Block Design (RBD) with one control. An initial survey was conducted in the village of Katalbod in Kurud Tehsil of District Dhamtari to demarcate the precise paddy fields containing the tree species *Terminalia arjuna* (Arjun) as a part of field bund agroforestry. Consequently, an experimental plot in Katalbod village was selected for the present study. The agricultural fields selected for research work have been mainly subjected to paddy cultivation for the last few years. In all paddy fields, the paddy variety Samba Mashuri (BPT-5204) was grown. The tree components present in the field bunds were 15-20-year-old.

#### **3.5.1 Distances:**

Four perpendicular lines as four replicates were taken for each tree and divided into 5 distance classes (treatments) D1 (1m), D2 (3m), D (5m), D4 (7m) and D5 (9m) and the centre of the field from the tree base at a 30 degree angle from each other.

#### **3.5.2 Replications:**

Four lines running at 30 degree angles from each other from the tree line toward the centre of the field represent four replications.

### **3.5.3 Sample plots:**

The sample plots of 0.25 m<sup>2</sup> were laid down by using a quadrat of an iron square frame, at the centre of each distance mentioned in the above section, from the tree line towards the centre of the field on four perpendicular lines.

### **3.5.4 Control:**

Control or open areas with the assumption that there will be no effect of the tree on growth and yield of the crop because it is away from the canopy spread.

## **3.6 Experimental Methodology**

In each quadrat, the number of hills was counted along with the number of tillers. The mean tiller value was multiplied with the number of hills to find out the total number of tillers in the quadrat. At harvesting, 5 tillers were removed and kept in labelled polythene bags and brought to the laboratory from each quadrat estimate the biomass and yield. Tiller density and shoot biomass were measured when the crop was at its peak growth. The sample for grain yield was taken when the crop was harvestable.

### **3.6.1 Observation recorded for tree**

#### **3.6.1.1 Girth at breast height (GBH)**

The girth at breast height (GBH) of a standing tree was measured at 1.37 m above the ground level with the help of a measuring tape.

#### **3.6.1.2 Crown width**

The width of a crown was measured by projecting the edges of the crown to the ground in north-south and east-west directions through the use of tape and their mean value was calculated and expressed in meters.

### **3.6.2 Observation recorded for crop**

#### **3.6.2.1 Number of hills/m<sup>2</sup>**

The numbers of hills before harvesting were recorded by placing the quadrat in the crop field and the data was counted and recorded.

#### **3.6.2.2 Number of tillers/m<sup>2</sup>**

The number of tillers/m<sup>2</sup> in each sample plot were counted for each sample plot.

#### **3.6.2.3 Shoot length (cm)**

The shoot length (cm) of the sample was measured by using measuring tape.

#### **3.6.2.4 Panicle weight/tiller (g)**

The panicle weight/plant (g) were measured by using a weighing balance.

#### **3.6.2.5 Grain weight/m<sup>2</sup> (g)**

The grain weight/m<sup>2</sup> of paddy for each distance and replicates are measured.

#### **3.6.2.6 Test weight of paddy**

The test weight of paddy for each distance and replicates are measured.

#### **3.6.2.7 Grain yield (q/ha)**

The total output was taken out by placing a 0.25 m<sup>2</sup> quadrat in each paddy replication plot and the crop was manually harvested with the help of a sickle. Grains received from paddy have been weighed for yield and converted into the clean grains received have been weighed to record grain yield in kg and converted into quintal basis (q/ha).

#### **3.6.2.8 Straw yield (q/ha)**

The straw yield of each sample was found by subtracting the grain weight from the biological yield obtained per sample. The yield received from straw was recorded in kg per sample and was converted to q/ha.

#### **3.6.2.9 Harvest index**

The Harvest index percent is the ratio of grain yield to biological yield. It was accessed by paddy by using the formula:

$$\text{Harvest index} = \frac{\text{Economical yield (Grain yield)}}{\text{Biological yield (Grain yield + straw yield)}} \times 100$$

#### **3.6.2.10 Yield Reduction percent**

Yield reduction is the difference between gross and net yields. It is referred to as the reduction in yield, and it is given as a percentage.

### **3.7 Statistical Analysis:**

All observations recorded from this experimental study were tabulated in a systemic manner. Values were given as a means of their respective number of replications used. The data was statistically analysed using ANOVA for randomized block design (RBD). The significant difference was tested through an F-test at a 5% level of significance. The standard error of means (SEm) and CD were calculated where the F-test was significant for comparing treatment means (Panse and Shukhatme, 1978).



**Plate 1: A view of paddy crop and *Terminalia arjuna* in bund agroforestry**



**Plate 2: Study site during measurement**

RESULTS AND DISCUSSIONS

The experiment was carried out in a farmer's field in Katalbod village, Dhamtari district (C.G.) to investigate the effect of *Terminalia arjuna* (Arjun) bund agroforestry system on paddy growth and yield, as well as the effect of tree age, different distances from the tree line, and the effect of tree crown width on paddy growth and yield.

4.1 Growth characteristics of *Terminalia arjuna* (Arjun)

The *Terminalia arjuna* (Arjun) trees were grown naturally or artificially on field bund in the north-south direction of the tree row.

Tree girth, diameter at breast height (DBH) and crown width are given in Table 4.1. The distance from tree to tree ranged between 1.5 to 3 m. Tree DBH, and crown width ranged respectively, between 16.55 to 27.69 cm, and 5.28 m to 8.65 m.

Table 4.1: Tree dimension of *Terminalia arjuna* (Arjun)

Tree	Girth (cm)	DBH (cm)	Crown width (m)
T1	52 cm.	16.55 cm.	5.28
T2	64 cm.	20.37 cm.	7.57
T3	87 cm.	27.69 cm.	8.65

T1, T2 and T3 respectively represented the tree one, tree two and tree three.

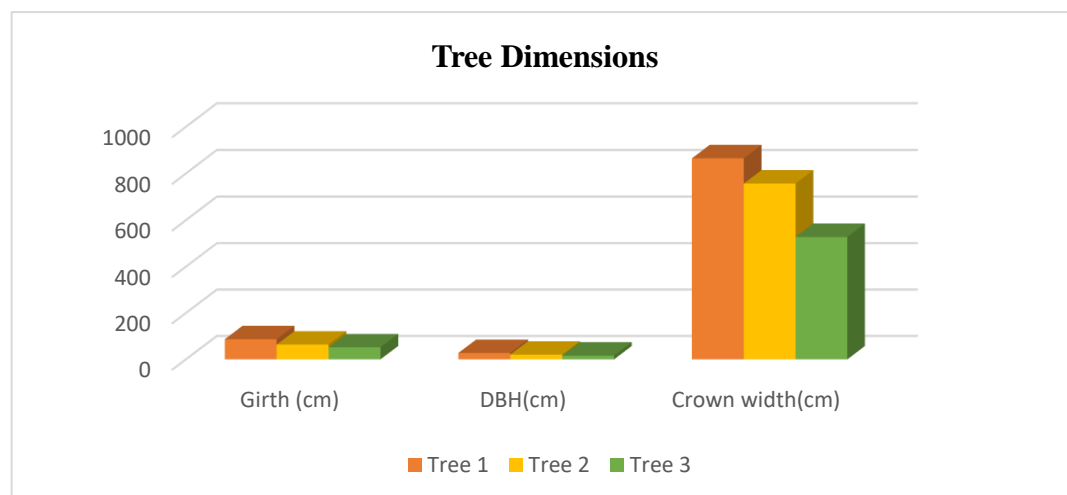


Fig. 4.1: Tree dimension of *Terminalia arjuna* (Arjun)

## 4.2 Growth characteristics of paddy crop

Observations of the number of hills, number of tillers and grain yield were measured while comparing crop parameters at different distances. A distance of 12 meters was treated as the maximum (control) and it was assumed that beyond this distance, the effect of the tree would be negligible.

### 4.2.1 Number of hills/m<sup>2</sup>

Table 4.2.1 reveals that the number of hills increased as the distance from the trees increased in the case of all the three trees. The number of hills was highest under the control plot and lowest at the close distance of 1 m from the tree.

The interaction studies showed that the lowest number of hills (highest reduction) was observed in the immediate vicinity of the tree, i.e. 1-3 m. As the distance from the tree line increased, the number of hills increased and the declining percentage decreased. A significant reduction of up to 9 m was reported at the trees 1 (31), 2 (30) and 3 (29) hills, respectively.

The most important effects of combining trees and agricultural crops in mixtures are the result of microclimate changes, which in turn affect the production of all components of the system. However, crops grown in different aspects and at different distances from the tree line face completely different microenvironments that have a direct impact on their growth and yield.

Crown diameter and DBH showed a significant positive correlation with tree age and the number of hills ranged from 20 at 1 m distance under tree 3 to 31 at 9 m distance from the base of the tree under tree 1 (Figure 4.2). Similarly, on average, the maximum reduction was observed under tree 1 and the minimum under tree 3 compared to the open field result recorded by Bargali *et al.*, in 2009.

**Table 4.2.1 Average number of hills/m<sup>2</sup>**

Treatments with distance	No. of hills/m <sup>2</sup>		
	Tree 1 (16.55 cm.)	Tree 2 (20.37 cm)	Tree 3 (27.69 cm)
T1 = 1 m	21.00	21.00	<b>20.00</b>
T2 = 3 m	22.00	22.00	21.00
T3 = 5 m	26.00	25.00	25.00
T4 = 7 m	27.00	27.00	26.00
T5 = 9 m	<b>31.00</b>	30.00	29.00
Control	33.00	33.00	33.00
Mean	26.67	26.33	25.67
SEm±	0.40	0.38	0.43
C.D. at 5%	1.22	1.16	1.30

**Fig. 4.2 Average number of hills/m<sup>2</sup>****4.2.2 Number of tillers/m<sup>2</sup>**

The perusal of data in Table 4.2.2 reveals that the number of tillers/m<sup>2</sup> increased as the distance from trees increased under all the trees, i.e. tree 1 to tree 3. The mean numbers of tillers were highest under control plot and lowest near trees, explain Table 4.2.2 indicate 1m from tree bund.

The tillers increased significantly at different distances from the tree line up to a distance of 9 m from the tree row. The decrease was maximum at all distances up to a distance of 3 m. The tillers/m<sup>2</sup> observed in tree 1, was a maximum (317.67) at a distance of 9 m. The lowest tiller/m<sup>2</sup> (148.18) was recorded in tree 3 at a distance of 1 m.

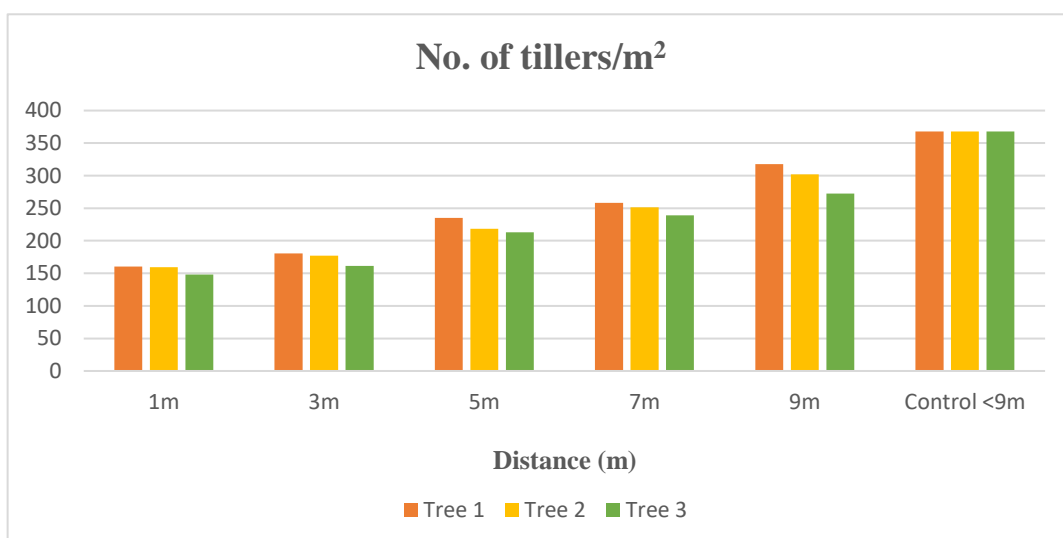
The distance from the tree line shows that the distance at which the negative impact of the tree line were detected varied from one aspect to another.

The maximum number of tillers/m<sup>2</sup> reported for paddy transplanted at a distance of 9 m from the base of the tree line (tree 1) is due to the highest percentage of interception of solar radiation by paddy crops (Kiran and Agnihotri, 2001). The maximum reduction in the number of tillers/m<sup>2</sup> near the tree line (tree 1) at 1 m can be due to the higher shade intensity in this aspect (Mcmaster *et al.* 1987). The data also shows that when light filtering of the tiller number is most affected during the early vegetative phase. This result is confirmed by the results of Fischer (1975), Willey and Holliday (1971).

With the increased distance from the tree line, the number of tillers/m<sup>2</sup> of paddy was found to increase, which is in line with the findings of Sharma *et al.* (1994), Chauhan *et al.* (1995), and Singh *et al.* (2003). At the closest distances from the tree line, a substantial decrease in the number of tillers/m<sup>2</sup> was observed, which could be due to the low light intensity and low temperature caused by the shadow cast by the boundary-plantation. This is consistent with the findings of Lalitha *et al.*, (1999), Kemp and Whingwiri (1980). Instead of raising the tiller number, the other factor may also be the diversion of energy for increasing plant height (George *et al.*, 1998).

**Table 4.2.2 Number of tillers/m<sup>2</sup>**

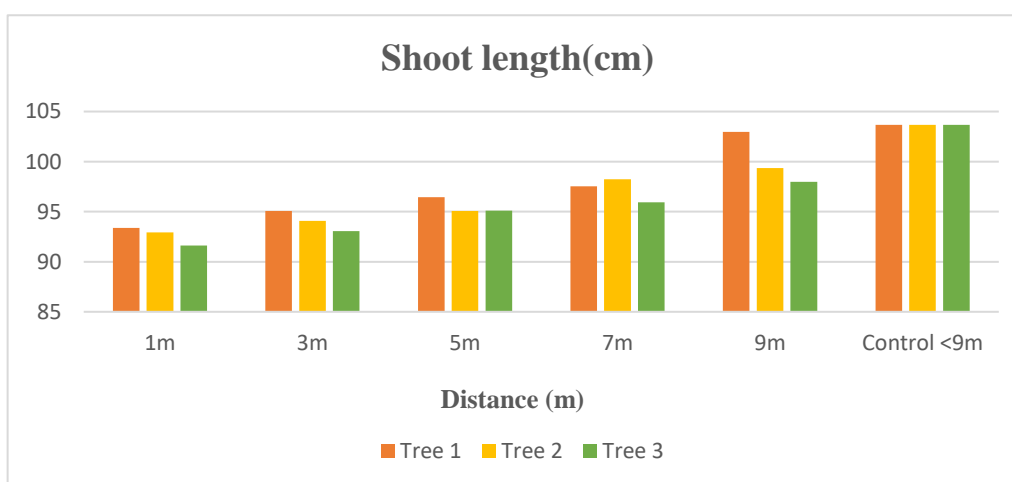
Treatments with distance	No. of Tillers/m <sup>2</sup>		
	Tree 1 (16.55 cm.)	Tree 2 (20.37 cm)	Tree 3 (27.69 cm)
T1 = 1 m	160.50	159.20	<b>148.18</b>
T2 = 3 m	180.35	177.08	161.40
T3 = 5 m	235.06	218.30	213.15
T4 = 7 m	258.18	251.57	239.28
T5 = 9 m	<b>317.67</b>	302.09	272.36
Control	367.90	367.90	367.90
Mean	253.28	246.02	233.71
SEm±	8.22	4.911	4.37
C.D. at 5%	25.03	14.94	13.31

**Fig. 4.3 Number of tillers/m<sup>2</sup>****4.2.3 Shoot length (cm)**

The shoot length of paddy was positively affected due to the bund plantation of *Terminalia arjuna* (Arjun). The data presented in Tables 4.2.3 indicates that the paddy crop growing on different aspects differs significantly with respect to shoot length. Among the different planting aspects, the maximum (102.96 cm) shoot length was found at 9 m distance from the tree line in tree 1 and the lowest shoot length (91.63 cm) was observed at 1 m distance in tree 3. This might be due to the shoot length being negatively affected below the tree crown of *Terminalia arjuna* (Arjun) while increasing distance from the tree trunk. The shoot length decreased significantly at 1 m distance compared to other distances.

**Table 4.2.3 Shoot length (cm)**

Shoot length(cm)			
Treatments with distance	Tree 1 (16.55 cm.)	Tree 2 (20.37 cm)	Tree 3 (27.69 cm)
T1 = 1 m	93.39	92.94	<b>91.63</b>
T2 = 3 m	95.06	94.08	93.05
T3= 5 m	96.44	95.08	95.11
T4= 7 m	97.53	98.23	95.93
T5= 9 m	<b>102.96</b>	99.36	97.98
Control	103.66	103.66	103.66
Mean	98.59	97.26	95.77
SEm±	2.78	1.61	1.90
C.D. at 5%	8.46	4.91	5.77

**Fig. 4.4 Shoot length (cm)****4.2.4 Panicle weight/tiller (g)**

The data presented in Table 4.2.4 shows that the of panicle weight/tiller under *Terminalia arjuna* (Arjun) bund based agroforestry system was recorded maximum in the control plot and successive reduction in panicle weight were observed as the distance from the tree was reduced. Thus, it was maximum in the control plot and minimum at a distance of 1 m from the base of the tree.

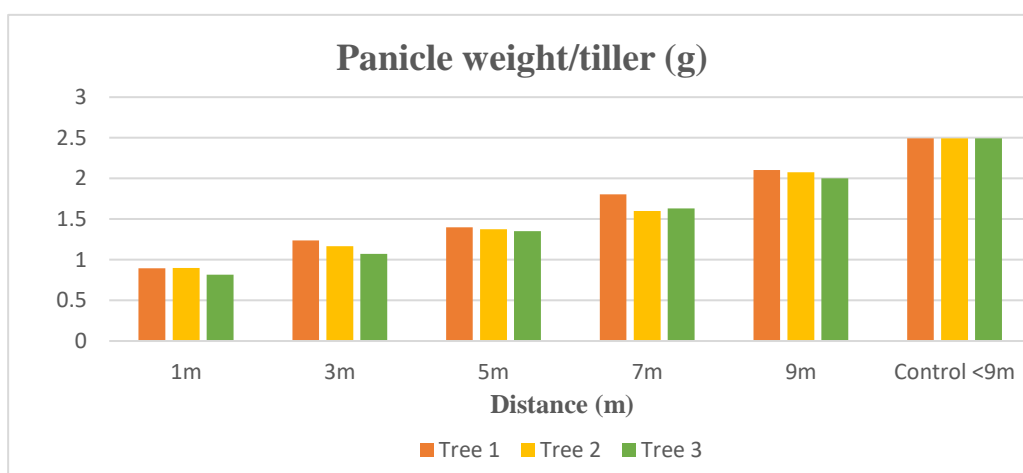
A significant difference in control was observed in the Panicle weight/tiller of paddy up to a distance of 9 m from the tree line. The Panicle weight/tiller recorded a maximum (2.49 g) in the control plot, which was closely followed by distance at 9 m (2.10 g) from tree 1, while the minimum (0.81 g) was recorded in tree 3 at a distance of 1 m.

The Panicle weight/tiller of paddy in trees 1, 2 and 3 was observed to be statistically significant, up to a distance of 9 m from the tree line and control plot. However, at a distance of 1-3 m from the tree line, the highest reduction was found and the lowest reduction was found at a distance of 7-9 m from the tree line.

When the temperature is more favourable and the leaves are turgidly resulting in an increased rate of photosynthesis, the minimum reduction in yield and yield attributes away from the tree line is due to higher light intensity on this aspect. On the other hand, when the temperature is less favourable and the leaves are less turgid, the area near the tree line receives low light, restricting the photosynthetic effectiveness of the crop in this aspect. These results are in conformity with the studies of Moss *et al.*, (1961) and Dhillon *et al.*, (1979, 1982, and 1984).

**Table 4.2.4 Panicle weight/tiller (g)**

<b>Panicle weight/tiller (g)</b>			
Treatments with distance	Tree 1 (16.55 cm.)	Tree 2 (20.37 cm)	Tree 3 (27.69 cm)
T1 = 1 m	0.89	0.9	<b>0.81</b>
T2 = 3 m	1.23	1.16	1.07
T3= 5 m	1.4	1.37	1.35
T4= 7 m	1.80	1.6	1.63
T5= 9 m	<b>2.10</b>	2.07	2.00
Control	2.49	2.49	2.49
Mean	1.66	1.59	1.57
SEm±	0.10	0.11	0.07
C.D. at 5%	0.31	0.36	0.23



**Fig. 4.5 Panicle weight/tiller (g)**

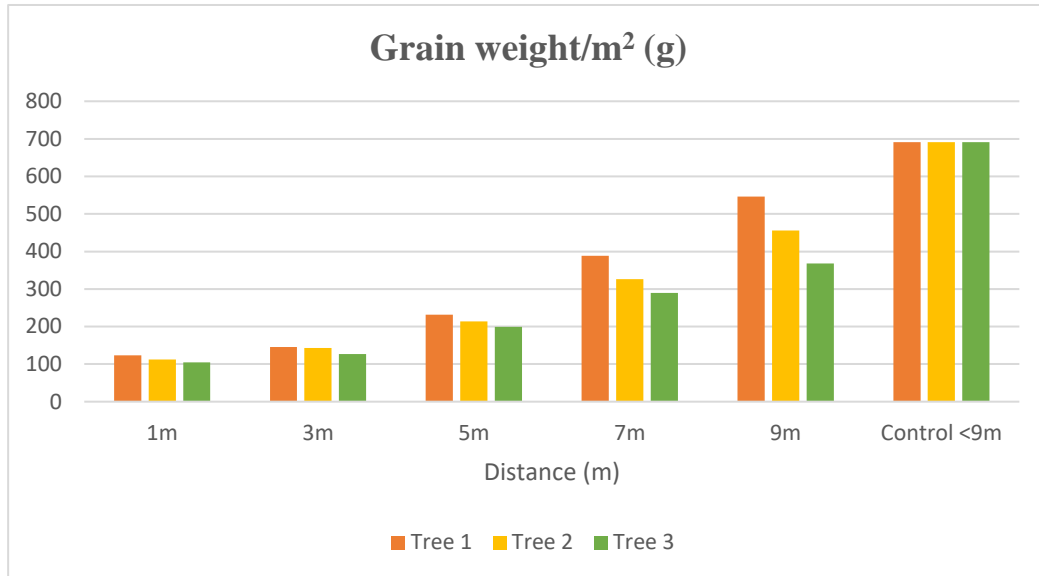
#### 4.2.5 Grain weight/m<sup>2</sup>

Grain weight/m<sup>2</sup> is given in Table 4.2.5, which shows that maximum grain weight/m<sup>2</sup> (546.41 g) was recorded at a 9 m distance from tree 1 as compared to tree 2 (455.43 g) and tree 3 (367.72 g). The lowest Grain Weight/m<sup>2</sup> (104.91 g) was recorded in tree 3 at 1 m from the tree line.

The reduction in yield under the influence of tree had been reported by several workers (Sharma *et al.* 1996, Hocking *et al.*, 1997). Puri *et al.*, 1994 reported that *Acacia nilotica* (L.) tree reduced crop yield under its canopy, and this reduction varies with distance from tree trunk. The reduction in yield under the trees may be caused by the shade and hence, lower photosynthetic rates (Bremner 1972).

**Table 4.2.5 Grain weight/m<sup>2</sup>**

Treatments with distance	Grain weight/m <sup>2</sup> (g)		
	Tree 1 (16.55 cm.)	Tree 2 (20.37 cm)	Tree 3 (27.69 cm)
T1 = 1 m	123.07	112.40	<b>104.91</b>
T2 = 3 m	145.66	142.73	126.40
T3 = 5 m	232.05	213.41	199.25
T4 = 7 m	388.35	326.63	289.88
T5 = 9 m	<b>546.41</b>	455.43	367.72
Control	690.97	690.97	690.97
Mean	354.61	323.85	296.07
SEm±	5.033	2.73	2.99
C.D. at 5%	15.38	8.30	9.12



**Fig 4.6 Grain weight/m<sup>2</sup>**

#### 4.2.6 Test weight of paddy (g)

Table 4.6 shows that the test weight of paddy and demonstrates that the test weight of paddy was most extreme in charge (12.15 g) and was fundamentally more prominent at 9 m distance from tree 1 (11.07) than at tree 2 (10.56) and tree 3 (10.04) at 9 m, while the base test weight was recorded at 1 m distance from tree 1 (6.41), tree 2 (6.37) and tree 3 (6.34) altogether.

The difference in test weight was statistically significant between tree 3 from the tree line and tree 2 and up to a distance of 9 m from the tree line, and tree 1 was significantly reduced at 9 m from the tree line relative to their respective controls. While, in terms of control, the reduction was not significant on tree 3 at a distance of 9 m from the tree line. However, the highest reduction was found at a distance of 1 m from the tree line and the lowest reduction was found at 9 m from the tree line.

Nazir *et al.*, (1993) stated that increasing duration of shading might decrease the number of test weights, grain protein concentration and grain yield.

**Table 4.2.6 Test weight of paddy (g)**

Treatments with distance	Test weight (g)		
	Tree 1 (16.55 cm.)	Tree 2 (20.37 cm)	Tree 3 (27.69 cm)
T1 = 1 m	6.41	6.37	<b>6.34</b>
T2 = 3 m	7.96	7.72	7.62
T3 = 5 m	8.83	8.64	8.54
T4 = 7 m	9.99	9.59	9.38
T5 = 9 m	<b>11.07</b>	10.56	10.04
Control	12.15	12.15	12.15
Mean	9.40	9.17	9.01
SEm±	0.22	0.25	0.21
C.D. at 5%	0.68	0.75	0.64

**Fig. 4.7 Test weight of paddy (g)****4.2.7 Grain yield q/ha**

Due to the boundary planting of *Terminalia arjuna* (Arjun), the grain yield of paddy was adversely affected and the impact varied with the crown width and distance from the tree line (Table 4.2.7).

The data shown in the table reveals a major difference in the grain yield of paddy due to distance from the tree. At a distance of 9 m from tree 1 (54.64 q/ha) and the control plot (69.09 q/ha), the highest grain yield was observed, which was significantly higher than the grain yield recorded at other distances. The average reduction was observed for tree 1 (12.30 q/ha), followed by tree 2 (11.24 q/ha) and tree 3 (10.49 q/ha) at a distance of 1 m from the line of the tree (Fig.4.8).

The data clearly shows that the maximum reduction in grain yield of paddy was observed near the tree line (1-3 m) and that the loss of grain yield decreased at each successive distance from the tree line relative to control as the distance from the tree line increased. The grain yield reduction was statistically significant at a distance of up to 9 m from the tree line

The crown width and distance studies from the tree line showed that the grain yield of paddy was significantly reduced on different DBH of trees up to various distances, being the highest up to 9 m from tree 3 and tree 2 and tree 1 up to 7 m. At all distances, the reduction was greatest at 1-3 m from the tree line, which decreased successively as the distance from the tree line increased. However, a reduction in grain yield was not observed beyond the 7 m distance from tree 3.

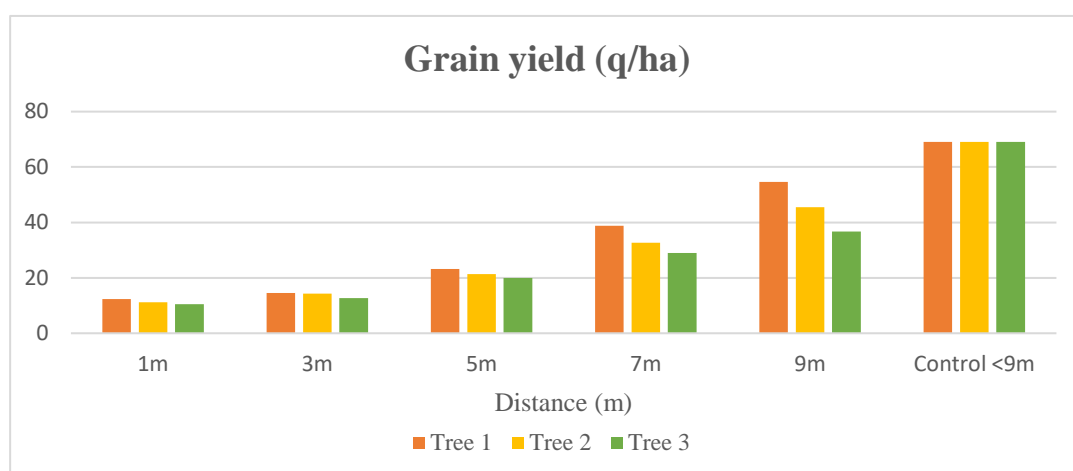
Sharma *et al.*, (1994) stated that the reduction in the yield of paddy grown in association with trees reflects competition for growth resources such as radiant energy, nutrients, and moisture.

A significantly higher grain yield was observed at a distance of 9 m from the tree row during the current investigation. Dhillon *et al.*, (1984) and Kumar (1996) have stated that maximum grain yield was away from the tree row. A number of workers have also reported reductions in yield components due to shading effects; for example, reduced number of effective tillers (Kemp and Whingwiri, 1980), reduced number of grains (Rawson and Ruwali, 1972; Fischer, 1975), and reduced weight of grain (Fischer, 1975; Kemp and Whingwiri, 1980).

Sharma and Singh (1992), Sharma *et al.*, (1994), Chauhan *et al.*, (1995), and Singh *et al.*, (2003) have also observed an increase in grain yield with the increased distance from the tree line. The increase in grain yield with the increased distance from the tree line is due to the increased light intensity and can also be attributed to the decreased competition with the increased distance from the tree line between the tree roots (Khybri *et al.*, 1992; Saroj *et al.*, 1999)

**Table 4.2.7 Grain yield q/ha**

Treatments with distance	Grain yield (q/ha)		
	Tree 1 (16.55 cm.)	Tree 2 (20.37 cm)	Tree 3 (27.69 cm)
T1 = 1 m	12.31	11.24	<b>10.49</b>
T2 = 3 m	14.56	14.27	12.64
T3= 5 m	23.20	21.34	19.92
T4= 7 m	38.83	32.66	28.99
T5= 9 m	<b>54.64</b>	45.54	36.77
control	69.09	69.09	69.09
Mean	35.46	32.39	29.61
SEm±	2.01	1.09	1.19
C.D. at 5%	6.12	3.32	3.64

**Fig. 4.8 Grain yield q/ha****4.2.8 Straw yield q/ha**

The effect on straw yield (q/ha) of paddy due to crown width and distance from the tree line is tabulated in Table 4.2.8.

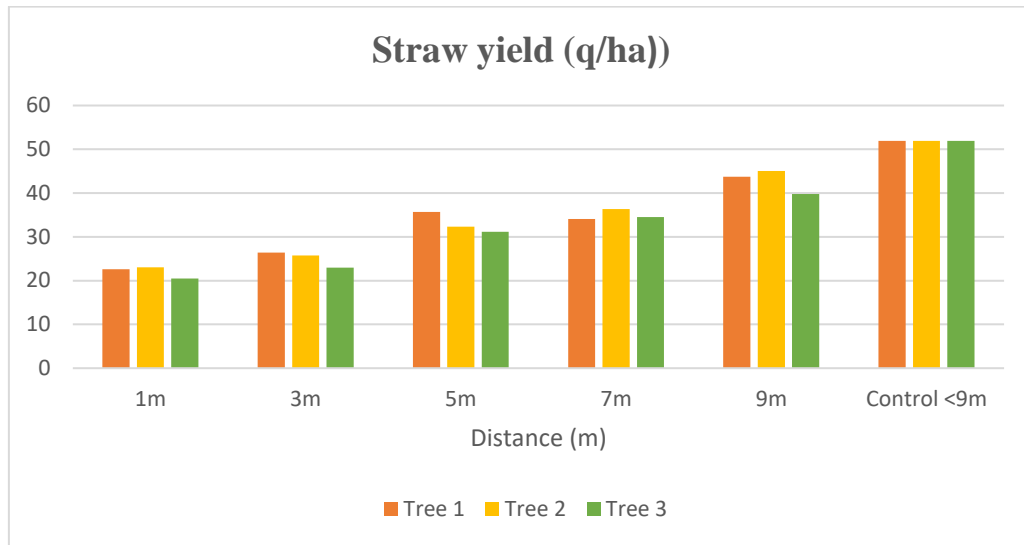
The data indicates that, relative to all other distances, the straw yield of paddy reported at a distance of 9 m from the tree (25.01 q/ha) was significantly greater. The straw yield was nearly equal to that reported at a distance of 9 m from tree 1 (43.69 q/ha) and from tree 3 (39.75 q/ha). The straw yield was significantly higher than that observed on the control plot (51.91 q/ha). The reduction was therefore in order; tree 3>tree 1> and tree 2 at all distances from the line of the tree. Fig.4.9 clearly shows that the decline in straw yield has successively decreased with the increasing distance from the tree line and crown width.

The effect of crown width and tree line distance indicates that a statistically significant reduction in paddy straw yield was observed up to 7 m away from tree 1 (34.11q/ha), 5 m away from tree 2 (32.35 q/ha) and up to 7 m away from tree 3 (34.54 q/ha).

The straw yield of paddy was also substantially higher away from the tree line as compared to all other distances, which is attributed to the higher intensity of light due to low crown width. On the tree line, around 1-3 m, followed by 5-7 m, the highest reduction in straw yield was found, suggesting a lower reduction in straw yield (Fig. 4.9). Sharma *et al.*, (1994) have reported similar results. The highest reduction in straw yield is attributed to the largest reduction in these aspects of the number of tillers (Pant and Bana, 1998). At the different distances from the tree line, the straw yield was significantly reduced up to a distance of 9 m from the tree line, which is in accordance with the findings of Sharma (1992), Singh *et al.*, (2003). The maximum reduction at the closest distances from the tree line is due to increased competition for light and other growth resources (Pandey *et al.*, 1999), which resulted in a decrease in the number of tillers and a decrease in lateral shoot growth, thereby affecting the paddy straw yield (McMaster *et al.*, 1987).

**Table 4.2.8 Straw yield q/ha**

Treatments with distance	Straw yield (q/ha)		
	Tree 1 (16.55 cm.)	Tree 2 (20.37 cm)	Tree 3 (27.69 cm)
T1 = 1 m	22.61	23.02	<b>20.51</b>
T2 = 3 m	26.42	25.74	22.94
T3= 5 m	35.69	32.35	31.13
T4= 7 m	34.11	36.34	34.54
T5= 9 m	43.69	<b>45.01</b>	39.75
control	51.91	51.91	51.91
Mean	35.69	35.76	33.50
SEm±	3.39	2.09	2.25
C.D. at 5%	10.33	6.37	6.86



**Fig. 4.9 Straw yield q/ha**

#### 4.2.9 Harvest index percent

The studies reveal that the harvest index of paddy was significantly reduced at different crown widths at different distances, with a maximum distance of up to 9 m from the tree line. Increasing crown width and decreasing the distance from the tree line were observed as the decrease in the harvest index percent.

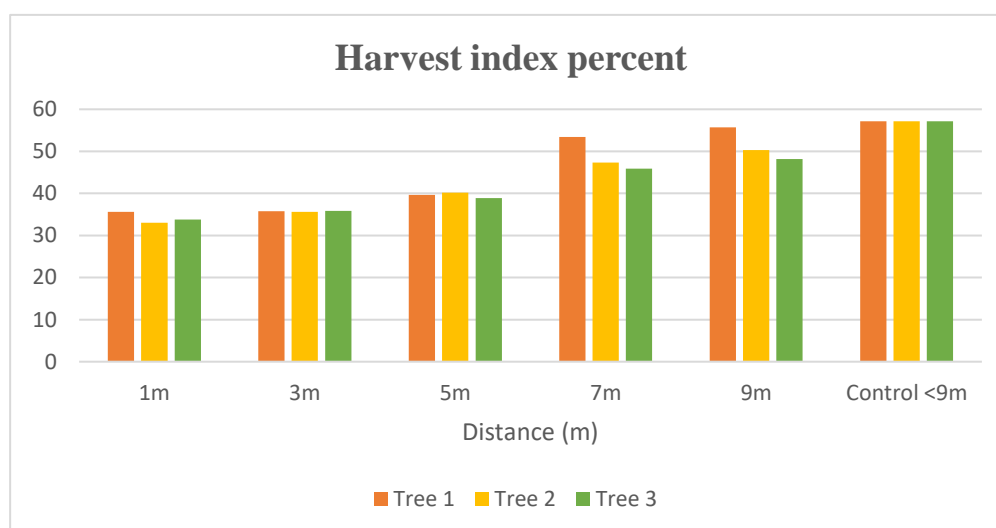
Table 4.2.9 shows the impact of crown width and distance from the tree line on the harvest index percent of paddy. The harvest index percent was registered maximum (55.72%) at 9 m distance from tree 1, followed by 7 m distance (53.42%) from tree 1. However, the highest reduction percent was found to be at 1 m away from tree 2 (33.03%), followed by 1 m away from tree 1 (33.76%) and 1 m away from tree 1 (35.58%) Fig.4.10.

The data indicates that with the increasing distance from the tree line, the harvest index percent increases. Compared to control, a significant reduction in the harvest index of paddy up to a distance of 9 m was observed. At 1 m distance from tree 2 (33.03%), the average percent decrease in harvest index was highest, which reduced successively as the distance from the tree line increased to the lowest (55.72%) at 9 m distance from tree 1 (Fig.4.10).

At the closest distances (1-3 m) from the tree line (Table 4.2.9) the harvest index was significantly reduced, which may be due to a more proportionate reduction in grain yield than straw yield at the closest distances from the tree line. The observations of Sharma *et al.*, (1994) support the present result.

**Table 4.2.9 Harvest index percent**

<b>Harvest index percent</b>			
Treatments with distance	Tree 1 (16.55 cm.)	Tree 2 (20.37 cm)	Tree 3 (27.69 cm)
T1 = 1 m	35.58	<b>33.03</b>	33.76
T2 = 3 m	35.79	35.59	35.83
T3 = 5 m	39.63	40.15	38.91
T4 = 7 m	53.42	47.30	45.87
T5 = 9 m	<b>55.72</b>	50.30	48.20
Control	57.12	57.12	57.12
Mean	46.25	43.92	43.26
SEm±	2.76	1.43	1.66
C.D. at 5%	8.40	4.36	5.06

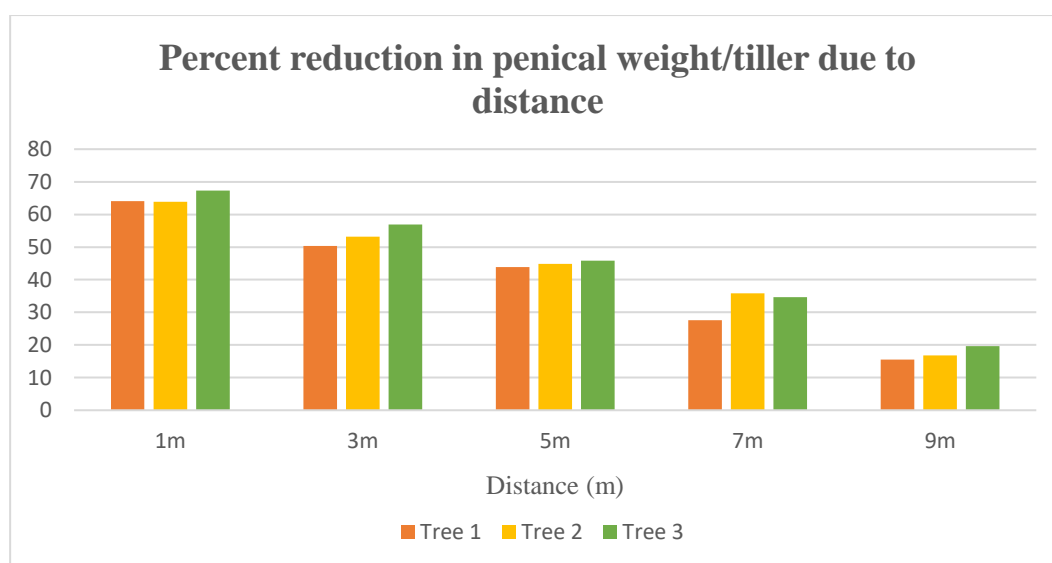
**Fig. 4.10 Harvest index percent****4.2.10 Yield reduction**

The impact of crown width and distance from the tree line on paddy yield reduction percent is shown in Table 4.2.10. At 1 m distance from the tree line, the highest yield reduction percent of Panicle weight/tiller was observed ( $65.10 \pm 0.78\%$ ), and the lowest yield reduction percent of panicle weight/tiller ( $17.33 \pm 0.86\%$ ) was observed at 1 m distance from the tree line.

When the temperature is less favourable and the leaves are less turgid, the area near the tree line receives low light, restricting the photosynthetic effectiveness of the crop in this aspect. The yield reduction of paddy was found to be highest near the tree line. These results are in conformity with the studies of Moss *et al.*, (1961).

**Table 4.2.10 Percent reduction in Panicle weight/tiller due to distance**

<b>Percent reduction in Panicle weight/tiller due to distance</b>				
Distance from Tree Line	Tree 1	Tree 2	Tree 3	Yield reduction (%)
1m	64.10	63.90	67.31	<b>65.10 ±0.78</b>
3m	50.34	53.15	56.96	53.48±1.35
5m	43.84	44.85	45.85	44.85±0.41
7m	27.60	35.82	34.62	32.68±1.81
9m	15.56	16.77	19.66	<b>17.33±0.86</b>



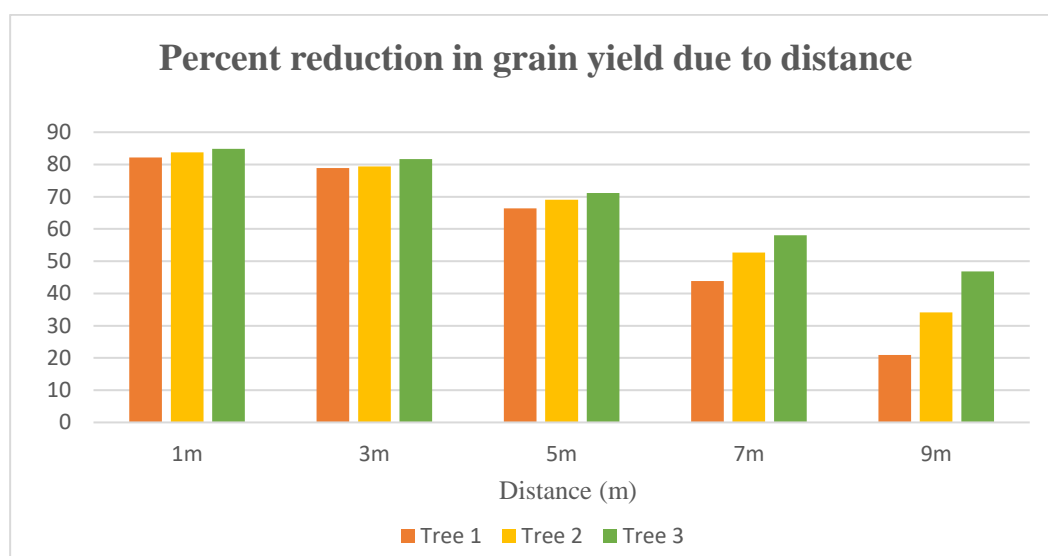
**Fig 4.11 Percent reduction in Panicle weight/tiller due to distance**

Similarly, Table 4.2.11 represent the percent drop in grain yield due to distance was highest (83.58±0.53%) at 1 m distance from the tree line and lowest (33.93±5.27%) at 9 m distance from the tree line.

Whereas, the other half of yield reduction is due to the competition between the tree and crop for light, moisture, nutrients, etc. and the modification of micro-environmental conditions (Srinidhi *et al.*, 2007).

**Table 4.2.11 Percent reduction in grain yield due to distance**

Percent reduction in grain yield due to distance				
Distance from Tree Line	Tree 1	Tree 2	Tree 3	Yield reduction (%)
1m	82.19	83.73	84.81	<b>83.58±0.53</b>
3m	78.92	79.34	81.70	79.99±0.61
5m	66.42	69.11	71.16	68.90±0.97
7m	43.80	52.73	58.04	51.52±2.93
9m	20.92	34.09	46.78	<b>33.93±5.27</b>



**Fig. 4.12 Percent reduction in grain yield due to distance**

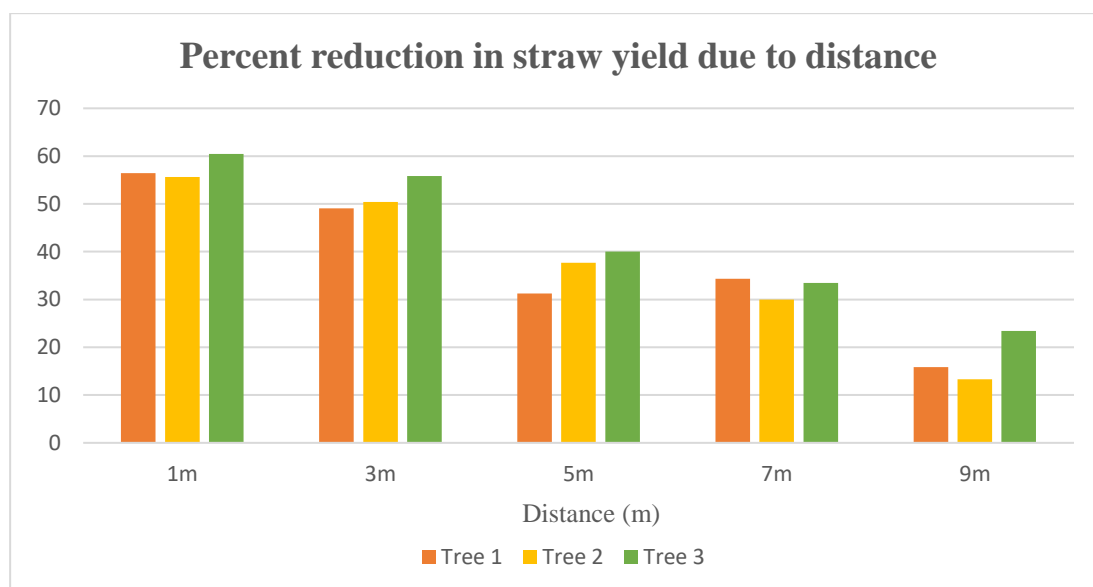
The percent reduction in straw yield due to distance is shown in table 4.2.12. The minimum ( $17.51\pm 2.15\%$ ) straw yield reduction due to distance was observed at a 9 m distance from the tree line and the maximum ( $57.52\pm 1.05\%$ ) at 1 m distance from the tree line.

Light, moisture and nutrients are the most important limiting factors which influence the overall growth and yield of agroforestry systems. Significant yield reduction by tree species could be due to their shading effect and below ground competition for resources. Allelopathic effect is important cause of crop yield reduction in agroforestry systems (Prasad *et al.*, 2010).

The trees reduce crop yield under their canopy, and this reduction varies with distance from the trunk. The reduction in yield under the trees may be caused due to the shade and, hence, lower photosynthetic rates. (Bargali *et al.*, 2009)

**Table 4.2.12 Percent reduction in straw yield due to distance**

Percent reduction in straw yield due to distance				
Distance from Tree Line	Tree 1	Tree 2	Tree 3	Yield reduction (%)
1m	56.44	55.64	60.48	<b>57.52±1.05</b>
3m	49.10	50.40	55.80	51.77±1.45
5m	31.25	37.68	40.03	36.32±1.85
7m	34.30	29.99	33.45	32.58±0.93
9m	15.83	13.29	23.43	<b>17.51±2.15</b>



**Fig.4.13 Percent reduction in straw yield due to distance**

The current research revealed that Arjuna's boundary plantation had a significant adverse effect on almost all paddy yield parameters, such as number of hills/m<sup>2</sup>, number of tillers/m<sup>2</sup>, panicle weight/tiller, grain weight/m<sup>2</sup> and test weight. All these paddy parameters were observed as low as possible near the tree line, and a gradual increase in the value of all these parameters was reported as the distance from the tree line increased. Up to a distance of 9 m from the tree line, the shadowing phenomenon due to trees was reported. At the closest distance from the tree line, the light intercepted by the tree canopy was maximal, which decreased successively with

the growing distance from the tree line. Diffused radiation, which was previously intercepted and transmitted, perhaps many times through the foliage of the tree canopy, was the main source of radiation to the paddy crop under the tree canopies. Thus, the paddy crop was prevented from reaching a large amount of photosynthetically active radiation (Ong *et al.*, 1996), eventually resulting in low output and allocation of photosynthates. The reduced number of grains/panicle, grain weight, spikelet/panicle, and productive tillers and higher percent sterility are therefore due to the reduced supply of assimilates (Fischer and Stockman, 1980; Jenner, 1980).

The growth of roots is reduced more than the growth of aerial components under low light intensity (Pendleton and Weibel, 1965; Pandey *et al.*, 1999) due to decreased allocation of carbohydrates to roots under shaded conditions (Wardlaw, 1970). The decrease in paddy yield and yield characteristics due to decreased light intensity is not expressed exclusively through photosynthesis, but can also be expressed through root growth as an indirect plant growth function (Pendleton and Weibel, 1965). Thus, in terms of nutrient and water uptake, the crop also suffered. Although they may be present in adequate quantity, due to reduced root system growth, they could not be used by the paddy plants. This is in accordance with Sharma (1997) findings.

## CHAPTER-V

# SUMMARY AND CONCLUSIONS

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The natural abundance of *Terminalia arjuna* (Arjun) trees on field bunds in the Chhattisgarh plain is a very common feature of agricultural fields. One such field in Katalbod village of Kurud tehsil of Dhamtari district was selected to investigate the “Effect of *Terminalia arjuna* (Arjun) tree on the Performance of Paddy Crop Under Bund Based Agroforestry System” during the year 2020-21 in the *kharif* season (July-November). Of late, farmers have complained about the adverse effect of arjun trees on the adjoining crop.

The effect of *Terminalia arjuna* (Arjun) on growth and yield of paddy Samba Mashuri (BPT-5204) with respect to different DBH, viz; 16.55, 20.37, 27.69, cm. crown width, viz; 5.28, 7.57, 8.65, m. and distances from the tree line, viz; 1, 3, 5, 7, 9 m and control beyond 9 m was studied. A randomized block design (RBD) with one control was set out for the experiment. The important findings of the studies are as follows:

### **GROWTH OF PADDY**

Due to increasing crown width and closeness to the tree, the number of hills/m<sup>2</sup> of paddy was drastically reduced. The maximum number of hills/m<sup>2</sup> at different distances from the line of the tree was reported at a distance of 9 m (31) from tree 1 and the minimum number of hills/m<sup>2</sup> was found at the nearest distance, i.e. 1-3 m from the tree line. Various aspects at various distances from the tree line influenced the number of hills of paddy.

The maximum number of paddy tillers/m<sup>2</sup> was found (317.67) at a distance of 9 m from the base of the tree 1 and the minimum number of tillers/m<sup>2</sup> was found to be lower (148.18) at a distance of 1 m from tree 3.

### **YIELD ATTRIBUTES**

The minimum reduction in panicle weight/tiller (2.105 g) was observed at a distance of 9 m from tree 1 and the maximum decrease (0.815 g) was observed at a distance of 1 m under tree 3, in comparison with all other distances. The maximum reduction was observed at different distances from the line of the tree at a distance of 1-5m from the tree line, which decreased successively with the rise in distance

from the tree line, which indicates that panicle weight/tiller (g) was substantially increased due to decreased crown width and increased distances from the tree line.

At various aspects and distances from the tree line, the grain weight/m<sup>2</sup> was greatly reduced. The minimum reduction in the grain weight/m<sup>2</sup> was observed at a distance of 9 m from tree 1 (546.41g) and the maximum reduction (104.91g) relative to all other aspects was observed at a distance of 1 m from tree 3. Grain weight was found to increase progressively with decreasing DBH and increasing distance from the line of the tree.

At 9 m from the tree base, we observed significantly higher test weights among the various aspects. However, at tree 1 (11.07 g), the test weight was slightly greater than that of tree 2 (10.56 g) and tree 3 (10.04 g) at 9 m from the tree line. At 1 m, followed by 3, 5 and 7 m from the tree line, the maximum reduction was found.

## **YIELD OF PADDY**

### **Grain yield**

The minimum (10.49 q/ha) grain yield was observed at 1 m distance from tree 3 followed by tree 2 (11.24 q/ha) and tree 1 (12.31 q/ha) due to the trees which reflect competition for growth resources such as radiant energy, nutrients, and moisture. The maximum (54.64 q/ha) grain yield was found at a distance of 9 m from tree 1 followed by tree 2 (45.54 q/ha) and at 7m distance from tree 1 (38.83 q/ha).

### **Straw yield**

Because of the increased crown width and decreasing distances from the line of the tree, the straw yield decreased significantly. The maximum straw yield was observed at 9 m under tree 2 (45.013 q/ha) and the minimum straw yield was at 1 m under tree 3 (20.515 q/ha). The maximum reduction was observed at 1 m, accompanied by distances of 3, 5, 7, and 9 m from the tree line. In comparison to control, the straw yield varied significantly up to 9 m away from the line of the tree.

### **Harvest index**

The highest (57.323%) harvest index percent was found in the control plot, followed by tree 1 (55.725%), tree 2 (50.00%) and tree 3 (48.208%) at a distance of 9 m from the tree line, and the lowest at 1 m from the tree line at tree 2 (33.03), followed by tree 1 (33.588%) and tree 3 (33.76%). Due to the higher DBH and crown

width of the arjun tree and the decreasing distance from the tree line, the adverse effect of the tree line on harvest index percent was observed.

### **Yield reduction**

The highest reduction ( $65.10 \pm 0.781\%$ ) in panicle weight yield was found at 1m distance from the tree line, followed by 3m ( $53.48 \pm 1.356\%$ ), 5m ( $44.85 \pm 0.41\%$ ), 7m ( $32.68 \pm 1.813\%$ ) and at 9m ( $17.33 \pm 0.86\%$ ).

The highest reduction ( $83.58 \pm 0.538\%$ ) in grain yield was found at 1m distance from the tree line, followed by 3m, 5m, 7m, and at 9m ( $33.93 \pm 5.279\%$ ) distance from the tree line.

The highest reduction ( $57.52 \pm 1.059\%$ ) in straw yield was found at 1m distance from the tree line, followed by 3m, 5m, 7m, and at 9m ( $17.51 \pm 2.154\%$ ) distance from the tree line. Due to the higher DBH and crown width of the arjun tree and the decreasing distance from the tree line, the adverse effect of the tree line on harvest index percent was observed.

### **CONCLUSION**

The following conclusions may be drawn from the present study

- The results showed that the bund agroforestry of *Terminalia arjuna* (Arjun) had an adverse effect on the growth and yield of paddy.
- The effect on growth resources of *Terminalia arjuna* (Arjun) boundary plantation differs with the different DBH and crown width of the tree row and distance from the tree line. Thus, the adverse impact of the tree line on maximum growth and paddy yield near the tree line.
- The yield and yield characteristics of paddy increase as the distance from the line of the tree increases.
- The width of the crown has an important effect, as the trees significantly reduce the yield and yield attributes of paddy to the maximum width of the crown and have less impact on the minimum width of the crown.
- In the competition between trees and crops, light is the main factor. In various ways, the tree canopy at variable distances from the tree line decreased the strength of light.

- The width of the crown has an important effect, as the trees significantly reduce the yield and yield attributes of paddy to the maximum width of the crown and have less impact on the minimum width of the crown.
- In the competition between trees and crops, light is the main factor. In various ways, the strength of light was decreased by the tree canopy at variable distances from the tree line.

### **SUGGESTIONS FOR FUTURE STUDY**

It is believed that tree shade is responsible for poor yields of associated crops, except those which are shade-loving or tolerant of shade conditions. However, to validate the result, further study is needed to observe the effect of different levels of canopy on yield attributes through photoactive radiation studies, soil nutrient pools, canopy management, root competition etc.

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## RESUME

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