INFLUENCE OF PRESOWING TREATMENTS ON SEED AND FOLIAR APPLICATION ON SEEDLINGS OF ARJUN

(*Terminalia arjuna* Roxb.)

THESIS

Submitted to
Dr. Panjabrao Deshmukh Krishi Vidyapeth, Akola
in partial fulfilment of the requirements
for the Degree of

MASTER OF SCIENCE
IN
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(AGROFORESTRY)

By
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DECLARATION OF STUDENT

I Hereby declare that the experimental Work and its interpretation of thesis titled "**INFLUENCE OF PRESOWING TREATMENT ON SEED AND FOLIAR APPLICATION ON SEEDLING OF ARJUN (*Terminalia Arjuna* Roxb.)**" or part thereof has neither been submitted for any other degree or diploma of an University Degree nor the data have been derived from any thesis / publications of any University or scientific Organization. The source of material used and or assistance received during the course of investigation have been duly acknowledged.

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Date: / / 2018 — Enrollment No. KK-376

CERTIFICATE

This is to certify that the thesis entitled **"Influence of presowing treatments on seed and foliar application on seedling of Arjun (*Terminalia arjuna* Roxb.)"** Submitted in partial fulfillment of the requirements for the degree of **"Master of Science in Forestry (Silviculture and Agroforestry)"** Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola is a record of bonafide research work carried out by **BHAWAR KRUTIKA VINAYAK** under my guidance and supervision.

The subject of the thesis has been approved by the student's Advisory Committee.

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THESIS APPROVED BY THE STUDENT'S ADVISORY COMMITTEE INCLUDING EXTERNAL EXAMINER (AFTER VIVA–VOCE)

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D) Abbreviations

%	:	Per cent
°C	:	Degree Celsius
Cm	:	Centimeter
cm^2	:	Centimeter square
CRF	:	Cumulative rainfall
DAS	:	Days after sowing
et al	:	et alia (And others)
Etc		Etcetera
Fig.	:	Figure
G	:	Gram
GA_3	:	Gibberellic Acid
Hrs	:	Hour (s)
i.e.	:	id. est. (that is)
IBA	:	Indole Butyric acid
Kg	:	Kilogram
M	:	Metre
m^2	:	Metre square
m^3	:	Metre cube
Mg	:	Milli gram
Min	:	Minutes
Mm	:	Milli meter
N	:	Nitrogen
NS	:	Non significant
P	:	Potassium
Ppm	:	parts per million
RF	:	Rainfall
S.E.(m)	:	Standard error of mean
Viz	:	Namely
Vs	:	Verses
Yr	:	Year

E) THESIS ABSTRACT

a)	**Title of the Thesis**	:	**INFLUENCE OF PRESOWING TREATMENTS ON SEED AND FOLIAR APPLICATION ON SEEDLING OF ARJUN *(Terminalia arjuna* Roxb.)**
b)	**Full name of student**	:	**BHAWAR KRUTIKA VINAYAK**
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j)	**Signature, Name and Address of forwarding Authority**	:	

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ABSTRACT

An investigation concern to " Influence of pre sowing treatments on seed and foliar application on seedling of Arjun (*Terminalia arjuna* Roxb.)" was carried out during 2017- 2018 at Department of Forestry,Dr.P.D.K.V.Akola. Nursery Unit, Main garden, Department of Horticulture, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola. with

objectives, to study the effect of different treatments on seed germination of *Terminalia arjuna,* to study the effect of different foliar applications on seedling growth and vigour of *Terminalia arjuna,*to find out the suitable seed treatment and suitable foliar applications for better seed germination, seedling growth and vigour of *Terminalia arjuna*.

In an experiment *Terminalia arjuna* seeds were treated with eight different treatments and one control, soaking treatment in Gibberllic acid (GA_3) at dual concentration of 20 and 40 ppm, soaking treatment in indole-3-butyric acid (IBA) at dual concentration of 20 and 40 ppm, soaking in cow dung slurry for 6 hrs and 12 hrs, soaking in hot water treatment for 6 hrs and 12 hrs, with foliar application of urea 0.5% and 1% with three replications.

The results of investigation indicated that, in the various seed treatments, the seed treated with GA_3 soaking in Gibberllic acid for 20 ppm prior to sowing gave maximum germination percentage.

In respect of growth parameters *viz .,* height of seedling (cm) was maximum in T_3 (10.40) i.e. IBA 20 ppm for 10 min. seedling vigour percentage was maximum in T_2 (86.9) i.e. GA_3 40 ppm for 10 min. collar diameter (cm) was maximum in T_1 (0.33) i.e. GA_3 treatment 20 ppm for 10 min. root shoot ratio was maximum in T_8 (0.84) i.e. hot water treatment for 12 hrs. chlorophyll content (mg/100g) was found maximum in T_6 (3.26) i.e. cow dung slurry for 12 hrs. dry matter content (g) was found maximum in T_7 (7.40) i.e. hot water treatment for 6 hrs. number of leaves of seedling were found superior in seed treated with GA_3 for 20 ppm for 10 min followed by seed soaking in cowdung slurry (for 12 hrs.) and hot water treatment for (6hrs.) along with foliar application urea (0.5%).

CHAPTER I

INTRODUCTION

1.1 Background information

Terminalia arjuna family Combretaceae is commonly known as Arjun, Arjuna. It is native to India. It is naturally found throughout the greater part of Indian Peninsula along rivers, streams, ravines and dry watercourses, reaching a large size on fertile alluvial loam. It extends Northwards to the Sub-Himalayan tract, where it is distributed along the banks of streams; In Punjab it is a cultivated tree. It is common in chota Nagpur and Orissa. It is extensively planted in India for shade or in avenues even in dry and hot region. In favorable localities, especially along the bank of streams, the tree attain very large size. Two trees 8.6m.and 10.6m. in girth, have been recorded in Jammu (Kadambi,1954). In its natural habitat, the absolute maximum shade temperature varies from 35 to 47.5^0c. and the relative minimum from 0 to 15.5^0c and the normal rainfall from 75 to 190 mm. In parts of the west coast, it is found thriving even in regions with rainfall as high as 380 mm. Since the growth largely depends on moisture supplied by streams, the actual rainfall received is not of much significance (Kadambi, 1954).

A large handsome tree, with a spreading crown and dropping branches, common in most parts of India and also planted in many parts for shade and ornament. Stems rarely long or straight, generally always buttressed and often fluted; wood is brown, very hard; bark very thick, grey or pinkish green, smooth, exfoliating in large, thin, irregular sheets; leaves sub-opposite, oblong or elliptic, coriaceous usually 10-15cm. long, occasionally 25cm., cordate, shortly acute or obtuse at the apex; flowers in panicled spikes; fruits 2.5-5.0 cm. long nearly glabrous, ovoid or ovoid oblong with 5-7 hard, winged angles (Anon,1976).

The seeds are ripen during February to May. About 100 seeds weight 128g. Germinative capacity varies; it is generally 40-50%. The seeds are fit for collection during April-May. Germination starts in 20 days and it is completed in 7-8 weeks. In Madhya Pradesh, the completion

for germination ranges from 17-53 days (Gupta, 1936-38). Under the natural conditions germination takes place in the rainy season, and may actually commence with the early showers before the monsoon proper. By artificially, *T.arjuna* can successfully be raised by means of stumps as well as by air layering.30 day old rooted layers show better survival after transplantation (Singh, 1969).

T.arjuna has widely used in ayurvedic medicine for the treatment of cancer, dermatological and gynaecological complaints, heart disease and urinary disorders. The bark is acrid, an astringent and tonic and is useful in high blood pressure and ulcer. The cancer cell growth inhibitory constituent has been isolated from the bark, stem and leaves of *T.arjuna*. It is also useful in the treatment of fracture, inflammation and wounds. The wood is used for building, agriculture implements, carts and boats, water troughs, electric traps, tool handles.(Orwa, 2009).

The hard seed coat of Arjun is the major hindrance in achieving good and uniform germination especially when large plantation are to be raised (Naik, 2010).The dormancy of seed is understand the presence of a hard seed coat that prevent absorption of oxygen and water. Such a hard seed coat is common in members of family Leguminosae. In a few species, water and oxygen are unable to penetrate in certain seeds because entry is blocked by a cork like filling in a small opening in the seed coat. Vigorous shaking of the seed sometimes dislodges this plug, allowing germination. The treatment is called as impaction. The dormancy of seed can be broken by several methods such as scarification, stratification (Salisbury, 2009).

The presence of azatobacter in soil has beneficial effect on plants, but the abundance of these bacteria is related to many factors, soil physico- chemical and microbiological properties. Its abundance varies as per the depth of soil profile. azatobacter are much more abundant in the rhizosphore of plants in the surrounding soil and this abundance depends on the crop species. (Jnawali, 2015).

Trichoderma is a very effective biological mean for plant disease management especially the soil born. It is a free living fungus

which is common in soil and root ecosystem. It is highly interactive in root, soil and foliar environments. It reduces growth, survival or infections caused by pathogens by different mechanism like competition, antibiosis, mycoparasitism, hyphal interactions and enzyme secretions. (Singh,2010).

More recently, foliar feeding has been widely used and accepted as an essential part of crop production, especially on horticultural crop and forestry crop. The benefits of foliar feeding have been well documented and increasing efforts have been made to achieve consistent responses. The purpose of foliar feeding is not to replace soil fertilization. Supplying a plant's major nutrient needs (nitrogen, phosphorus, and potassium) is most effective and economical via soil application. However, foliar application has proven to be an excellent method of supplying plant requirements for secondary nutrients and micronutrients while supplementing N-P-K needs for short and/or critical growth stage periods

Urea is commonly used for foliar application because of its high solubility and its rapid efficiently absorbed by leaves (Scagel, 2007).

In Arjun there is a problem of seed germination and survivability of seedlings. Therefore, in the present study an effort has been made to improve the germination of seeds by different pre-sowing treatments. Synchronization and rapid emergence of seedlings are the commonly reported benefits of pre-sowing treatments. Effect of pre sowing treatment on germination and foliar application on seedling growth has been studies.

1.2 Importance and Need of study

The sapwood of arjun is pinkish- white and the heartwood is brown to dark brown, very hard, lustrous, strong and heavy. The odourless, coarse textured wood is streaked with dark lines and has irregularly interlocked grains. Timber is locally used for carts, agriculture implements, water troughs, traps, boat building, house holding, electric poles, tool handles and jetty piles.

The fuel from these wood makes excellent charcoal and firewood, with calorific value of 5030 Kcal/kg and 5128 Kcal/kg for the heartwood and sapwood respectively.

Terminalia arjuna has been widely used in medicine for the treatment of cancer, dermatological and gynaecological complaints, heart diseases and urinary disorders. The bark is acrid, an astringent and tonic, and is useful in treatment of high blood pressure and ulcers. The cancer cell growth inhibitory constituent has been isolated from bark, stem and leaves of *Terminalia arjuna*. Luteolin has also been shown to have specific anti- bacterial activity against Neisseia gonorrhea. It can also be used as alexiteric, stypic, tonic and anthelmintic and it is useful in fractures, inflammation, wounds and ulcers.

The bark and fruit are used as tanning and dying material. The tannage can be used for making fine upper leather and excellent sole leather. The leaves is used for fodder which contain 9- 11% crude protein and 14- 20% crude fibre (Orwa, 2009).

In view of above importance and utilization of arjun tree, the present investigation is to be undertaken to find out suitable, effective seed treatment and foliar application to ensure faster and maximum germination of species so as to ensure the supply of good seedling of *Terminalia arjuna* with the following objectives.

1.3 Objectives:-

1. To study the effect of different treatments on seed germination of *Terminalia arjuna.*
2. To study the effect of different foliar applications on seedling growth and vigour of *Terminalia arjuna.*
3. To find out the suitable seed treatment and suitable foliar applications for better seed germination, seedling growth and vigour of *Terminalia arjuna.*

1.4 Hypothesis

The use of seed treatment has become very common for improving the germination and enhancing subsequent seedling growth. Different pre- sowing treatments are used to enhance the rate, uniformity of emergence and germination in many tree crops. These treatments include soaking in hot water for two durations 6 and 12 hrs, soaking in Gibberellic Acid (GA_3) at dual concentration of 20 and 40 ppm, soaking in Indole -3-Butyric acid (IBA) at dual concentration of 20 and 40 ppm, soaking in cow dung slurry for 6 and 12 hrs. and control (untreated seed).

Using these treatments it would possible to enhance germination of *Terminalia arjuna*

1.5 Scope and limitation of the study

It is known that, *Terminalia arjuna* has the economical as well as medicinal value hence the quality planting material of *Terminalia arjuna* is very important.

The *Terminalia arjuna* has been used as rootstock in vegetative propagation. It can easily stands with long period of drought. Therefore it should be helpful in plantation or drought prone area.

Looking to the above stated facts for obtaining more number of plants the present study was undertaken to evaluate the influence of pre sowing treatments on seed and foliar application on seedling of *Terminalia arjuna* at Department of Forestry, Post Graduate Institute, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola.

The intensity of seed treatment in respect of concentration of growth hormones and duration of treatment affect the seed germination and growth of seedlings. Higher concentration of seed treating growth harmones may adversely affect the seed germination and seedling growth, while low concentration not so effective in germination and also for seedling growth. Hence, for better seed germination and desirable seedling growth the chemicals which are proved good for seed treatment in other crops are not so effective for *Terminalia arjuna* seed treatment.

In view of above the investigation was carried out on Influence of presowing treatments on seed and foliar application on seedling of Terminalia arjuna. with different seed treatments during year 2017-18.

CHAPTER II

REVIEW OF LITERATURE

Arjun is a very useful tree which has the high sustainability even in wastelands. Arjun propagated by sexual method. The seed of Arjun have seed coat dormancy. Therefore, the effort is necessary to find out a proper seed treatment for breaking the seed coat dormancy for maximum seed germination and rapid growth of seedlings through foliar application.

Keeping this interest in view, the literature pertaining on these aspects in *Terminalia arjuna* and other trees has been reviewed in this chapter under various objectives.

2.1 Review on different treatments for seed germination of *Terminalia arjuna*.

Burns *et al.* (1969) observed that, the soaking of sweet orange seeds in water or various concentrations of Gibberellic Acid for 24 hours prior to planting increased their rate of germination under cool conditions. Larger and more uniform seedlings also followed some of the Gibberellic Acid seed soak treatments in these test.

Nagao and Sakai (1979) observed that, the soaking of Alexandra palm (*Archontophoenix alexandrae)* for 24 or 72 hr. in water and further accelerated by a 72 hr. treatment with 100 0r 1000 ppm GA, but not with benzyladenine or naphthalene acetic acid(NAA).

Wan and Hor (1983) observed that, the oil palm seeds soaking in solution of GA_3 and ethephon prior to heat treatment was in effective in breaking there dormancy. Oil palm seed results that, GA_3 improved seed germination at 30,45 and 60 days after heat treatment.

Rai *et al*. (1986) reported beneficial effects of cow dung slurry treatment on germination of Ain (*Terminalia tomentosa)* and Red sanders (*Pteridocarpus santalinus)*. Cow dung attracts termites, which in turn feed on fibrous seed coat resulting in germination. Similarly, Maithini *et al.* (1991) obtained higher germination by treating seeds of *Desmodium tilaefolium* in cow dung slurry for 3 days compared to control. Prasanna *et*

*al. (*1999) observed 70% germination in seed of Red sanders when seeds were soaked in cow dung slurry for 24 hrs. followed by concentrated H_2SO_4 treatment for 10 minutes.

Bankar (1987) study that, Germination percent in Karonda (*Carrissa carandas*) the seeds treated with GA_3 at 25- 100 ppm for 24 hr. were planted and germination was assessed after 43, 50 58 days later. Germination after 43 days was 0.4% in the control and 1.6- 6.8% in the treated seeds. On the 58^{th} day control germination was 49.2% and in seeds treated with GA_3 at 25 ppm it was 67.0%.

Ratan and Reddy (1993) stated that, the influence of water soaking (12 hours and 24 hours) on seed germination and seedling growth of custard apple seeds. They found that seeds soaking in water for 24 hours gave highest germination (71%), maximum seedling vigour compared to other treatments and control. Whereas 12 hours soaked seeds showed maximum plant height (22.75cm), root length (7.63cm) which remained at par with 24 hours treatment.

Gopikumar *et al.* (1993*)* observed that, the highest germination of Jackfruit (*Artocarpus heterophyllus)*and *Artocarpus hirsute* takes place when seed were treated with cold water while, in *Teminalia tomentosa* and *Terminalia paniculate* shows highest germination when seed were treated with Gibberellic Acid 250 ppm for two hours under Trichur (Kerala) conditions.

Kumar (1994) observed that, the roseringed parakeet (*Psittacula krameri*) is reported for the first time damaging the fruits of the tree *Terminalia arjuna* in New Delhi. The birds pluck the fruits from the tree and after cutting the fibrous portion, eat the fleshy cotyledons of the seed.

Bhardwaj *et al*. (1994) observed that, The *Terminalia bellerica* and *Terminalia chebula* seedling was better when seeds were collected in the first fortnight of January and sowing was done in the march. Germination and growth of seedling of *T. bellerica* penetrated with H_2SO_4 for 12 minute and *T.chebula* seeds soaked in cold water for 24 hrs before a 5 week of stratification in cowdung. Other seed treatments including

stratification, soaking in cold water, soaking in conc.H_2SO_4 for 8-10 minute and soaking in 100-200 ppm. GA_3 for 24 hrs and other stratification period in cowdung.

Nayak *et al.* (1999) observed that, Among the various treatment given to seed of Bael (*Aegle marmelos*),water soaking result in highest percentage of germination (80%) which was closely followed by concentrated sulfuric acid treatment for 20 min. (76%) and least percent of germination occurred with concentrated sulfuric acid (10min) + thiourea 1 percent (20%). Although water soaking resulted in highest percentage of germination, it took longer time for initiation and completion of germination as compared to concentrated sulfuric acid, which resulted in quicker germination.

Kumar *et al*. (2000) observed that, the successful plantation with many indigenous species have been raised in the southern districts of Andhra Pradesh. The performance of the plantation raised under semi-mechanical method (i.e. uprooting and ploughing) proved to be better than that of the plantations raised without uprooting the existing growth. As seen from the growth data*, Pterocarpus santalinus* is showing maximum growth in terms of height. Whereas *Terminalia arjuna* has shown maximum girth at breast height. *Derris indica* is showing maximum height growth,among all species.

Naidu *et al.* (2001) reported that, the germination Red sanders (*Pterocarpus santalinus)* seeds by influence of plant growth regulators like gibberllic acid, indole butyric acid and indole acetic acid was studied. Gibberellic acid was found to be more effective in improving the seed germination in red sanders than either IBA or IAA.

Pampanna and Sulikeri (2001) studied that, the seeds of Sapota treated with GA and ethrel each at 400 ppm which resulted higher germination rate (90%). Seedling raised from the seed presoaked in GA 400 ppm. Produced significantly higher root length, shoot length, no.of leaves and seedling vigour also maximum with GA and ethrel.

Hossain *et al.* (2005) observed that, the effect of different seed treatment on germination and seedling growth in *Terminalia chebula*. Six presowing treatment were carried out. Control, (T_1) was depulped, (T_2) was depulped and soaked in cold water for 12 hrs, (T_3) was depulped and soaked in cold water for 24hrs, (T_4) was depulped and soaked in cold water for 48 hrs.(T_5) was hot water for 2 min. Seed germination started in 29 days after sowing and continuous upto 86 days. The highest germination percentage in T_4 was (66.7%), in T_3 was (60%), in T_0 was (48.9%). Shoot length, root length, collar diameter, and leaf no. followed in higher value T_4, $T_5$and T_3 resp. Therefore,T_4 is more effective germination and production of quality seedling in *T.chebula*.

Dhaka *et al.* (2009) observed that, an application of GA_3 at 450, 500 and 550 ppm concentrations influenced growth and development of seedlings of lime. Seed treatment with GA_3 500 ppm for 40 hours before sowing also increased the length of seedlings (8.94 cm) as compared to GA_3 450 ppm and 550 ppm treatment.

Naik *et al*. (2010) observed that, the hard seed coat of *T.arjuna* is the major hinderance in the germination. They treated seed with boiling water, H_2SO_4, HNO_3, effect of cowdung slurry and tap water. Then effect of gibberllic acid, thiourea and benzyaldenin. But the present study reveals the significance of seed treatment for enhancing seed germination and seedling growth. The propogation of *T.arjuna* through seeds can be raised by treating with H_2SO_4 for 20 minute and presoaking for 18hrs in GA_3 and BA150 ppm.

Harshavardhan (2011) studied that presowing treatment on jackfruit. Seeds were soaked in gibberellic acid, naphthalene acetic acid, potassium nitrate in water for 12 hours and 24 hours then sown in polybag. Soaking seed in GA_3 200 ppm for 24 hours resulted in higher percent of germination (77.3%), higher absolute growth rate (0.62 cm./day). Maximum number of leaves, leaf area per seedling . Seeds treated with NAA 50 ppm for 24 hours have recorded maximum primary root length (15.25 cm) and maximum secondary root length (17.35 cm).

Tadros *et al.* (2012) observed that, the seeds of Australian babul (*Leucaena leucocephala)* and *Acacia farnesiana* having a dormancy causing delayed germination. In first experiment three presowing applied control, sandpaper scarification, soaking in water. In another experiment, seeds are soaked in water at room temperature. The result suggested that blade scarification of *A. farnesiana* seeds and soaking of *L.leucocephala* seeds in 70^0C water for 20 minute are effective treatment to break seed dormancy.

Caliskan (2012) observed that, the fig seed treated with several treatment such as water for 24 hour, GA_3 at 500 and 1000 ppm for 24 hr. 3% KNO_3 for 24 hr, and stratification at 4^0c for 7, 14 and 21 days on seed germination. The result found that application of GA_3 increased the germination and emergence of fig seeds. The highest percentage of germination and emergence were obtained with GA_3 at 500 or 1000 ppm for both cultivars.

Akshatha *et al.* (2013) reported that, the seeds of *T.arjuna* were irradiated with different sources of gamma radiation ranging from 0 to 200 Gy. Using the 60co source.The effect of gamma radiation on the growth and biochemical constituents were compared to control plants. Germination speed at 25 Gy was found which double to be 0.65 compared to unirradicated seeds. An increase in germination percentage, vigour index and relative growth rate in terms of dry weight was noticed at lower doses of radiation treatment.

Maku *et al*. (2014) found that, IAA, IBA, NAA and GA_3 could be used on seed germination on *Tetrapleura tetraptera*. IAA for 0.005g/ml, IBA for 0.01g/ml, NAA for 0.015g/ml and GA_3 for 0.02g/ml. The result found that IAA, IBA and NAA could be used for rapid regeneration of *T. tetraptera* in natural forest and GA_3 should be excluded in the pretreatment sowing of *Tetrapleura tetraptera.*

Patel and Mankad *(*2014) found that, effect of different concentrations of GA_3 on seed germination of Aidan tree (*Tithonia rotundifolia)* Blake was studied. The maximum percentage of seed germination was at 500 ppm GA_3.

Haider *et al.* (2014) stated that, the germination percentage of *Acacia catechu* seeds were tested in nursery and field condition. The germination tests were conducted in both germination tray and nursery bed. They suggested pre-sowing treatment of *A.catechu* seed in cold water for 24hrs. is suggested for nursery raising.

Gunaga *et al.* (2015) found that, the one year stored seeds of Alexandrian laurel (*Calophyllum inophyllum)* are not germinate in control. Whereas fresh seed resulted in 40% germination in control. Decoated seed fetched the germination improvement upto 88.3% in fresh seed and 20% in one year old seeds. Seed thickness and seed length showed significant positive association with seed germination. It results that the use of fresh seeds followed by decoating of seeds to achieve higher germination in *Calophyllum inophyllum.*

Khatana *et al*. (2015) observed that, the fresh, moderate uniform in size and viable seeds of Kagzi Lime were treated (soaked) with six different levels of GA_3 for 12 hours and sown in prepared raised seed bed in the field and net house condition. The results revealed that the seeds treated with 500 mg/l GA_3 took significantly less time for 75 per cent germination (29.25 days) as well as recorded maximum germination (83.50 %), plant height (24.33 cm), number of leaves (30.03), length of seedling (36.48 cm), thickness of primary roots (2.07 mm), girth of seedling at top (1.01 cm), middle (1.00 cm) and bottom (1.14 cm), fresh weight of seedling (20.81 g), dry weight of seedling (11.58 g), total leaf area of seedling (8.28 cm^2) as well as survival (74.45 %) at 120 DAS, respectively as compared to rest of the treatments.

Das (2015) observed that, the seed germination of pre sowing treatment of Agar (*Aquilaria agallocha)* and *Shorea robusta*. They treated with control, soaking in normal and hot water, immension in 80% conc. H_2SO_4. The result of analysis showed no difference between seed source but the germination percentage among the species was significant with each other.

Sharaf *et al.* (2016) resulted that, seeds of each citrus rootstock were subjected to soaking for 24 hours in one of either GA_3 or

$ZnSO_4$ solutions (each at 500, 1000, 1500 and 2000 ppm), beside tap water as control for investigating their effect on two germination parameters (total number of germinated seeds & germination percentages) after 6 weeks from sowing (planting) and two growth measurements (average plant height just before transplanting and survival % of translocated seedlings after two weeks). Data obtained during both experimental seasons revealed obviously all pre sowing soak treatments increased significantly both germination measurements (total germinated seeds & germination %) and two parameters of induced seedlings (average plant height & survival **%** of translocated seedlings) as compared to control (soak for 24 hours in tap water) with both citrus rootstock.

Parmar *et al.* (2016) studied that , the various treatments on seed of Custurd apple such as GA_3 100 and 200 mg/l, KNO_3 1% and 2%,Thiourea 500 and 1000 mg/l, fresh cow dung and urine (1:2 ratio) and hot water treatment. From these treatments GA_3 (200mg/l) for 12 hours was found best result for maximum germination and seedling growth of custard apple.

Palepad *et al*. (2017) observed that, the seed treatment on custard apple such as GA_3 with 1000 ppm solution minimized the days (10.27) taken foe germination and improve the germination percentage (88.33%). Similar trend observed in growth parameters such as seedling height, girth of plant, number of leaves, leaf area, fresh and dry weight of plant.

Rusdy (2017) studied that, the seed of *Leucaena leucocephala* treated with hot water, mechanical and acid scarification. The best results is soaking in sulphuric acid for 20 and 24 minutes for highest percentage of seedling emergence, plant height, number of leaves. Acid scarification is the best method for *Leucaena leucocephala*.

Samodiya (2017) studied that, the effect on growth parameter on Okra. T_1(GA_3 50 ppm) require minimum number of days for start germination (2.07 days) and 100% germination (9.35 days), the maximum plant height was found (102.08cm), height test weight (7.84 g), seedling shoot length (16.24 cm) and days required to first flowering was found to be

earliest in (34.31days) and first harvesting (40.83 days)was recorded. In T_3 (NAA 50 ppm) requires fruit weight (15.09g), dry fruit weight (4.96g) fruit yield per plot (4.48kg) and yield per hectare (89.21) was recorded.

Phatak (2017) observed that, the seeds of *Rauvolfia serpentina* treated with GA_3 (1000 mg/l) treatment was found to be the best, highest speed for germination(1.37) and germination percentage (50%). The GA_3 treatment resulted in 46.94% reduction in no. of days to complete germination, 633.93% increased speed of germination and 344.55% increased germination percentage over the control.

Patel (2018) studied that, the various treatments on Red sanders such as T_1 (Tap water for 4 days), T_2 (Tap water for 8 days), T_3 (Lukewarm water for 4 days), T_4 (Lukewarm water for 8 days), T_5 (GA_3 250 ppm for 1 day), T_6 (GA_3 500 ppm for 1 day), T_7 (10% sulphuric acid for 1 day), T_8 (10% HCL for 1 day), T_9 (10% nitric acid for 1 day),T_{10} (separating seeds from pods with a sharp knife or scalpel and sown directly) and T_{11} (Control). The best presowing treatment are T_5 (GA_3 250 ppm for 1 day) and T_{10} (separating seeds from pods with a sharp knife or scalpel and sown directly.

Vijaylakshmi *et al.* (2017) observed that, the seeds of Red sanders treated with soaking in water 24h, 48h, 72h and acid scarification of pods with concentrated H_2SO_4 for 6 and 8 minutes. It results that soaking in water 48h treatment showed better germination percentage as compared to acid scarification.

Jaiswal *et al*. (2018) observed that, the seeds of Kagzi lime treated with growth regulators and chemicals such as, GA_3, NAA, KNO_3 and Thiourea. It results that GA_3 80 ppm is the best treatment which maximize height, number of leaves per plant, fresh weight and dry weight of shoot.

Patil *et al*. (2018) observed that, the seeds of Jamun treated with various treatment such as, control (S_1), water soaking for 24 hrs. (S_2), hot water (100^0 c) for 5 sec.(S_3), GA_3 200 mg/l for 10 min. (S_4), KNO_3 0.5% for 10 min.(S_5) and thiourea 0.5% for 10 min. in (S_6) It results that

seeds soaked in water for 24 hr. is the best treatment for germination percentage, no. of leaves, height, stem diameter of jamun

2.2 Reviews on different foliar application on seedling growth and vigour of *Terminalia arjuna.*

Sharma *et al. (*1990) observed that, Urea at 0%, 2%, 4%, KNO_3 at 0%, 1.5%, 3% and NAA at 0 or 400 ppm. were applied as foliar spray at flowering time to 10 year old mango trees. It significantly increased the fruit set and significantly decreased the fruit drop.

Dubey *et al.* (2003) concluded that, foliar application on Khasi papeda (*Citrus latipes*) of Gibberellic Acid 50 ppm or 30 ppm + I% urea may be effective to enhance overall growth of seedlings of *Citrus latipes* rootstocks, to make them ideal for seedling.

Jadhav *et al.* (2006) studied that, on the seedlings of Rangpur lime apply urea (1%) and growth regulators GA_3 at 50 or 100 ppm and IAA at 40 or 60 ppm singly or in combination with urea on the growth of Rangpur lime (*Citrus limonia*). The growth regulators were sprayed at one month interval starting at 30 days after transplanting; number of leaves was significantly enhanced by the treatments and values of these parameters generally increased with increase in concentration of growth regulator IAA 60 ppm +1 % urea resulted in the greatest number of leaves 60.2 per plant.

Wojcik (2006) observed that, the effect of postharvest sprays of Boron and urea on apple tree yield and fruit quality. (1) postharvest Boron spray three to four weeks before leaf abscission at the rate of 1-2 kg/ha. (2) postharvest urea N spray at the same time as Boron spraying at the rate of 18.4 kg/ha. (3) combined Boron spray with urea at the same time and at the same rate. Results indicate that under Boron deficiency condition. Post harvesting Boron sprays are successful in improving reproductive growth and should be recommended without the addition of urea.

Yildirim *et al.* (2007) observed that, the effect of foliar application on broccoli. Different concentrations of urea (0.0, 0.4, 0.8, 1.0%) apply on broccoli. 0.8% and 1.0% resulted in larger heads, weightier

heads and plants as well as higher plants. It results 0.61% and 0.96% concentrations of urea spray could be successfully used to obtain better growth and yield in broccoli.

Tariq *et al.* (2007) observed that, the foliar application on sweet orange. Such as zinc, manganese, boron (0.4, 0.2, 0.4 kg/ha). The result found that zinc, manganese or zinc and boron may be applied as foliar spray in combination with urea and surfactance for getting the maximum yield and improved quality of citrus fruit under prevailing condition.

EL-Tanany *et al.* (2011) results proved that, holding irrigation period for 45 days with urea spraying twice was efficient in increasing the ammonium concentrations in lime leaves and produced the highest number of flowers / branch and fruit set / branch. The data also revealed that holding irrigation for 45 or 60 days with urea spraying twice; gave the highest fruit yield / tree comparing withholding irrigation period for 15 days and without urea spray (control treatments).

Dalal (2011) observed that, foliar application on Ber of urea (2%) and zinc sulphate (0.5%) at peak flowering and second growth increased the fruit yield over control. The maximum fruit yield (71.33kg/tree) was observed with urea and minimum (52.19 kg/tree) in the control. A significantly positive correlation was observed between yield and N and Mn contents.

Supnar (2012) studied that, the application of plant growth regulator on Rangpur lime. Application of Gibberllic acid (50 and100 ppm), urea spray of 1%, IAA (50 and100 ppm), GA_3(50 and100 ppm) in combination with urea 1% and IAA 50 and100 ppm in combination with urea 1% and cow urine 5% and 10%. The present study investigate that the application of GA_3 100 ppm and urea 1% apply five times in monthly interval after transplanting.

Chaplot (2013) evaluate that, the effect of foliar spray of nutrients on growth of different tree species in nursery. Foliar application of phosphoric acid 0.1% at 45 and 90 days after showing of seeds in polybags

recorded maximum growth of Acacia species which was significantly higher over water spray and ammonium molybdenum 0.01% followed by DAP, thiourea and urea.

Thamer *et al*. (2014) results showed that, spraying with 1% urea increased significantly all the vegetative characteristics (leaves number, leaves area, branch number, stem diameter, total vegetative and root dry weight, mineral content of leaves, chlorophyll content and branches total carbohydrate).

CHAPTER III

MATERIAL AND METHODS

Seeds of many tree species germinate readily when subjected to favorable conditions of moisture and temperature. Many other species posses some degree of seed coat dormancy, where seed coat is hard some form of pretreatment is essential in artificial regeneration, in order to obtain a reasonably high germination rate in a short time.

Pretreatment to germinate seed coat dormancy and speed up germination is thus one important type of pre-treatment. Keeping in view the same investigation on the studies on “Influence of presowing treatments on seeds and foliar application on seedlings of Arjun (*Terminalia arjuna*)” was carried out at Main Garden, Nursery Unit, Department of Horticulture, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola during the year 2017-18. The details about material used and methods adopted during the course of investigation are given in this chapter.

3.1 Material

3.1.1 Climate and weather conditions

Akola is a city in Vidarbha region in the state of Maharashtra in central India. Geographically, Akola is located at latitude 20.7° North and longitude 77.07° east. It is at an altitude of 925 ft (282 m) above sea level. Akola has a tropical savanna climate (Köppen climate classification *Aw*), and people predominately wear cotton clothes. Akola has a National Weather Station which serves as the local weather centre. Annual temperatures range from a high of 47.6 °C (117.68 °F) to a low of 2.2 °C (35.96 °F). Akola lies on the Tropic of Cancer and becomes very hot during the summer, especially in May. Although it can be very hot in the day, it is cooler at night. The annual rainfall averages 711mm. Most of the rainfall occurs in the monsoon season between June and September, but some rain does fall during January and February.

3.1.2 Selection of seed

The fresh Arjun seed were collected from the mother tree of *Terminalia arjuna* located near the Main Garden, Department of Horticulture in Dr. P.D.K.V., Akola campus (Plate 1 and 2). The selection of mother tree was based on observations viz., Tree height (m), Age (yrs), Girth (D.B.H. in cm), Canopy (m), Estimated seed yield/tree (kg), Month of flowering, Time of fruiting, Average no. of fruit/bunch, 100 seed weight (g), Number of branches, Seed size. (Appendix I)

3.1.3 Preparation of potting mixture

The seed was treated with the eight different treatments and one control. The seeds were sown in poly bags. For filling polythene bags, potting mixture of soil, FYM, and riversilt in the ratio of 2:1:1 and 4g Tricoderma, 4g Azatobacter was used. Size of poly bag is 6×9. The germination of the seeds and seedlings performance was observed.

3.1.4 Sowing of seeds

After completion of treatments, the treated as well as untreated seed were sown immediately in poly bags on 10 September 2017 after sowing the seeds were lightly covered with thin layer of soil. Labels specifying each treatment and replication were fixed up immediately.

3.1.5 Irrigation

Irrigation was provided to seeds sown in poly bags using water can and maintained the proper moisture level. The poly bags was watered every day and then required till germination takes place with the help of watering can. The treatments to be given are as follows

3.1.6 Treatment details

Factor - A : Seed treatment

1. T_1 - GA_3 treatment for (Immersion in 20 ppm for 10 min.)
2. T_2 - GA_3 treatment for (Immersion in 40 ppm for 10 min.)
3. T_3 - IBA treatment for (Immersion in 20 ppm for 10 min.)
4. T_4 - IBA treatment for (Immersion in 40 ppm for 10 min)

5. T_5 - Seed soaking in cow dung slurry for (6 hrs)
6. T_6 - Seed soaking in cow dung slurry for (12 hrs)
7. T_7 - Seed soaking in Hot water for (6 hours).
8. T_8 - Seed soaking in Hot water for (12 hours).
9. T_9 - Control

Factor - B : Foliar spray

1. U_1 - Urea- 0.5%- (45,60 Days after sowing)
2. U_2 - Urea- 1% - (45,60 Days after sowing)

3.2 Methodology

3.2.1 Experimental layout

In present investigation an experiment was conducted in Factorial completely randomized design with nine treatments and three replication.

Table 1. Details of Experiment

Sr. No.	Particulars	Details
1	Common name	Arjun
2	Name of the tree species	*Terminalia arjuna (Roxb.)*
3	Family	Combretaceae
4	Design of experiment	Factorial Completely Randomized Design
5	Number of treatments	Factor A = 9 Factor B = 2
6	Number of replications	3 (Three)
7	Year of the study	2017
8	No. of seeds per treatments per replication	15
9	Date of sowing	10 September 2017

3.2.2 Statistical analysis

The data collected on various observations during the course of investigation were statistically analyzed using computer software Microsoft Excel to explore the possible treatment variations. The Analysis of Variance (ANOVA) and OPSTAT software were used for the analysis as described by Sheoran Programmer, Computer Section, CCS HAU, Hisar.

3.2.3 Treatments combinations

T1U1	T5U1
T1U2	T5U2
T2U1	T6U1
T2U2	T6U2
T3U1	T7U1
T3U2	T7U2
T4U1	T8U1
T4U2	T8U2
T9 (Absolute control)	

3.3 Observations were recorded

3.3.1 The observations was taken on the following parameters

3.3.1.1 Germination parameters

i. Days required for seed germination

ii. Germination percentage(%)

iii. Germination period

iv. Days for early sprout

v. Seedling vigour (%)

3.3.1.2 Growth parameters

i. Number of leaves per seedling after (30, 60, 90) DAS

ii. Height of seedling (cm) after (30,60,90) DAS

iii. Collar diameter of seedling after (30,60,90) DAS

iv. Leaf area $(cm)^2$ after (90) DAS

v. Number of branches per seedling after 45 DAS

vi. Dry weight of plant (g) after (90) DAS

vii. Root shoot ratio

viii. Chlorophyll content (mg/100g)

ix. Absolute growth rate (g/day)

x. Relative growth rate (g/day)

xi. Final survival percentage after (90) DAS

The observation for seedlings growth performance was taken at 30, 60, and 90 days after sowing to see the difference in the performance of the seedlings due to different treatments.

3.3.1.1 Observations on germination parameters

i. Days required for germination

The treatments was observe daily for recording the observations of germination since the date of sowing computing the difference between date of sowing and plumule emergence were recorded.

ii. Germination percentage

The germination percentage was calculated as the percent of germinating seeds starting from the first germination to no further germination. Germination percentage was calculated by number of germinating seedling divided by the total number of seeds sown in poly bags and multiplied by 100.

$$\text{Germination (\%)} = \frac{\text{Number of seeds germinated}}{\text{Total number of seeds sown}} \times 100$$

iii. Germination period

The germination period was calculated as the difference between initial and final emergence (number of days) recorded.

Plate 1.Collection of seed of *Terminalia arjuna*

Plate 2.Seeds of Arjun

iv. Seedling vigour (%)

Seed vigour was calculated by total number of healthy seedlings divided by the number of total seedlings and multiplied by 100. (Abdul-Baki and Anderson, 1973)

$$\text{Seed vigour (\%)} = \frac{\text{Number of healthy seedlings}}{\text{Number of germinated seedlings}} \times 100$$

3.3.1.2 Observations on growth parameters

i. Number of leaves per seedling

Number of leaves per plant was count from the five randomly selected plants and after computing the mean, it was calculated as an average number of leaves per plant. The average number of leaves per seedling is work out. The observations is record at 30, 60,and 90 DAS.

ii. Height of the seedling (cm)

Height of observational five randomly selected seedlings is measured in centimeters from the ground level to the grown tip with the help of measuring tape. The observation is record at 30, 60 and 90 DAS. The average plant height is work out from each treatment.

iii. Collar diameter of seedling (cm)

The diameter of the observational seedlings is measure in millimeters at 2 cm above the ground level with the help of vernier caliper and after computing the mean; it is record as stem diameter. The observation is record at30, 60 and 90 DAS

iv. Leaf area (cm) ^{2}

Leaf area is calculated by the leave traced on a graph paper. Leaf area of observational seedlings is estimate at 90 DAS. It is record as average leaf area in centimeter square.

v. Dry weight of plant (g)

The weighed fresh plants are place in brown paper bags, properly labeled and dried on oven at 60º C and after stabilization weight, this stabilized weight was record and after computing the mean, average dry weight of plant was recorded in grams.

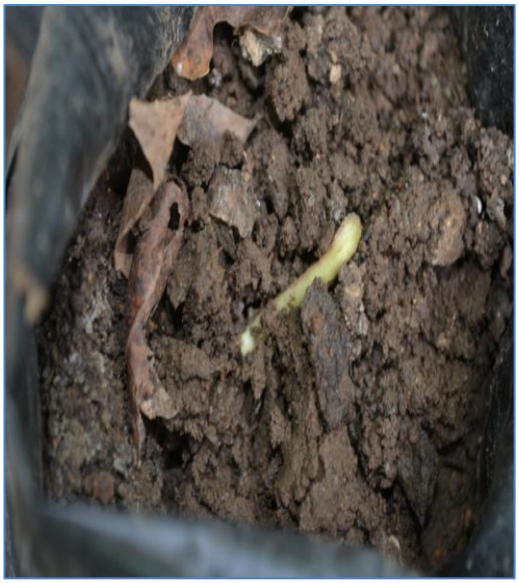

Plate 3. Germination of Arjun (*Terminalia arjuna*) After 8 Days

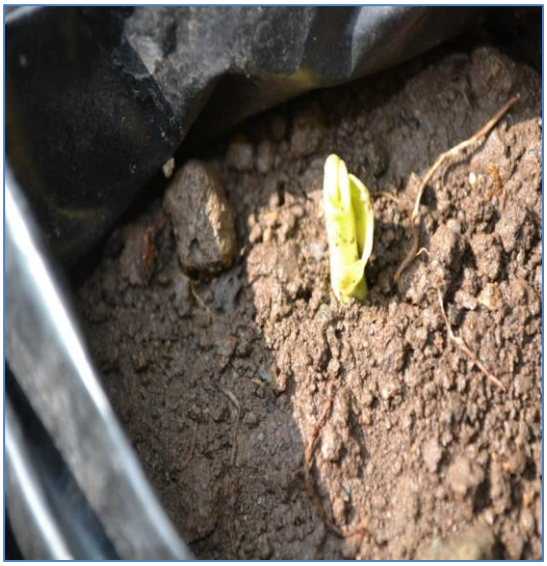

Plate 4. Germination after 10 DAS

Plate 5.Germination after12DAS

Plate 6.Germination after 14 DAS

Plate 7.Germination after 25 DAS

Plate 8.Number of leaves 30 DAS

Plate 9. Number of leaves at 60 DAS

Plate 10.Number of leaves 90 DAS

Plate 11.Height of seedling at 30 DAS

Plate 12.Height of seedling at 60 DAS

Plate 13.Height of seedling at 90 DAS

Plate 14.Collar diameter at 60 DAS

Plate15.Collar diameter 90 DAS

Plate 16.Foliar spray of urea

Plate 17.Estimation of chlorophyll content

vi. Root/shoot ratio

The weighed roots are placed in brown bags after separating from the seedlings, properly labeled and dried in oven at 60º C, also weighed shoots separately, stabilized weight is record at 90 days old seedlings and computing the average dry weight of root and shoot after dividing give average root : shoot ratio.

vii. Leaf chlorophyll content (mg/g)

The chlorophyll content of the leaves was estimated at 90 days after sowing in milligrams/gram by the following procedure

i. 0.0375 g of leaf sample was accurately weighed on electronic mono pan balance and about 10 ml of DMSO (Dimethyle Sulphor oxide) was added to the leaf sample.

ii. The samples was kept for two hours in autoclave at 60^0C.

iii. After two hours, all the chlorophyll was extracted in the solution.

iv. The optical density was calibrate at 652 nm for total chlorophyll.

$$\text{Total chlorophyll} = \frac{\text{OD at 652 nm} \times 100}{34.5} \times \frac{V}{100 \times W}$$

Where,

OD= Optical density

V = Final volume i.e. 10 ml of DMSO

W = Weight of fresh leaves (g)

viii. Absolute growth rate (g/day)

Absolute growth rate was calculated by formula as suggested by West *et al.* (1920). The dry weight of plant was recorded at 90 days after sowing and 180 days after sowing respectively. It is expressed as gram of dry matter produced per day.

$$\text{Absolute growth rate} = \frac{W_2 - W_1}{t_2 - t_1}$$

Where,

W_2 : Dry weight of plant at T_2 days

W_1 : Dry weight of plant at T_1 days

t_2 : Days of observation (W_2)

t_1 : Days of observation (W_1)

ix. Relative growth rate (g/day)

Relative growth rate was calculated by formula suggested by West *et al.* (1920). The dry weight of plants was recorded at 90 and 180 days after sowing respectively.

$$\text{Relative growth rate} = \frac{\text{Log}_e W_2 - \text{Log}_e W_1}{t_2 - t_1}$$

Where,

W_2 : Dry weight of plant at T_2 days

W_1 : Dry weight of plant at T_1 days

t_2 : Days of observation (W_2)

t_1 : Days of observation (W_1)

CHAPTER IV

RESULTS AND DISCUSSION

The result of an experiment entitled, “Influence of presowing treatments on seeds and foliar application on Arjun (*Terminalia_arjuna* Roxb.)” was carried out during the year 2017-18 at Department of Forestry, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola with following observation.

The result of the investigation based on the various observations viz., days required for initial seed germination, germination percentage (%), germination period, days for early sprout, seedling vigour (%) after (90) DAS, final survival (%) after (90) DAS, number of leaves per seedling after (30, 60, 90) DAS, height of seedling (cm) after (30, 60 and 90) DAS, collar diameter of seedling after (30, 60 and 90) DAS, leaf area $(cm)^2$ after (90) DAS, dry weight of plant (g) after (90) DAS, root shoot ratio (90) DAS, chlorophyll content mg/100gm (90) DAS, absolute growth rate g/day (90) DAS and relative growth rate g/day (90) DAS are presented and discussed in this chapter under following headings and sub headings.

Foliar application of Urea 0.5% and 1% was sprayed 45 and 60 days after sowing. Therefore, observation taken before 60 days were analyzed in CRD one factor and observation after 60 days was analyzed in FCRD design.

4.1 Effect of seed treatment on days required for seed germination, days required for early recruits, germination period and germination percentage

Seeds are an integral part of any tree improvement strategy. The suitability and availability of seeds have the potential to seriously impact the regeneration rates in either natural or artificial conditions. Hence, a tree breeder is usually interested in collecting seeds from different provenances or progenies in order to make recommendations based on results of germination trials for proper selection for large-scale afforestation or plantation establishment.

Table 2. Effect of seed treatment on days required for seed germination, days required for early recruits, germination period and germination percentage

Seed Treatment	Days required for seed germination	Days required for early sprout	Germination period	Germination percent
T_1 - GA_3 20 ppm for 10 min.	9.00	16.4	33.1	68.7 (56.16)*
T_2 - GA_3 40 ppm for 10 min.	9.20	17.8	35.3	60.7 (51.28)*
T_3 - IBA 20 ppm for 10 min.	8.98	17.9	34.3	53.0 (46.76)*
T_4 - IBA 40 ppm for 10 min.	10.20	18.3	35.9	51.0 (45.53)*
T_5 - Cow-dung slurry for 6 hrs.	9.00	18.0	33.9	50.8 (45.59)*
T_6 - Cow-dung slurry for 12 hrs.	10.15	18.2	35.3	48.4 (43.56)*
T_7 - Hot water for 6 hrs.	8.00	16.2	32.4	47.3 (43.5)*
T_8 - Hot water for 12 hrs.	15.9	22.5	39.2	38.8 (38.56)*
T_9 - Control	9.80	19.9	33.9	42.0 (40.39)*
'F'- Test	Sig.	Sig.	Sig	Sig.
SE(m)±	0.42	0.56	1.37	4.12
C.D.at 5 %	1.27	1.68	2.79	8.39

The value in brackets ()* are angular transformation value

Data recorded in Table 2 and depicted in fig. 1, revealed that seed treated significantly influenced on day required for seed germination of *Terminalia arjuna.*

The minimum days required for initial seed germination of *Terminalia arjuna* was observed in T_7 (8 days). i.e. Hot water treatment for 6 hrs. which is followed by treatment T_3 (8.9 days) i.e IBA treatment (20 ppm for 10 min.) and T_1 (9 days) i.e. GA_3 20 ppm for 10 min. However, the maximum days required for initial seed germination (15.9 days) is in T_8 Hot water for 12 hrs.

As regarding to, days required for early recruits, the data presented in Table 2, and depicted in Fig. 2, indicated that seed treatment

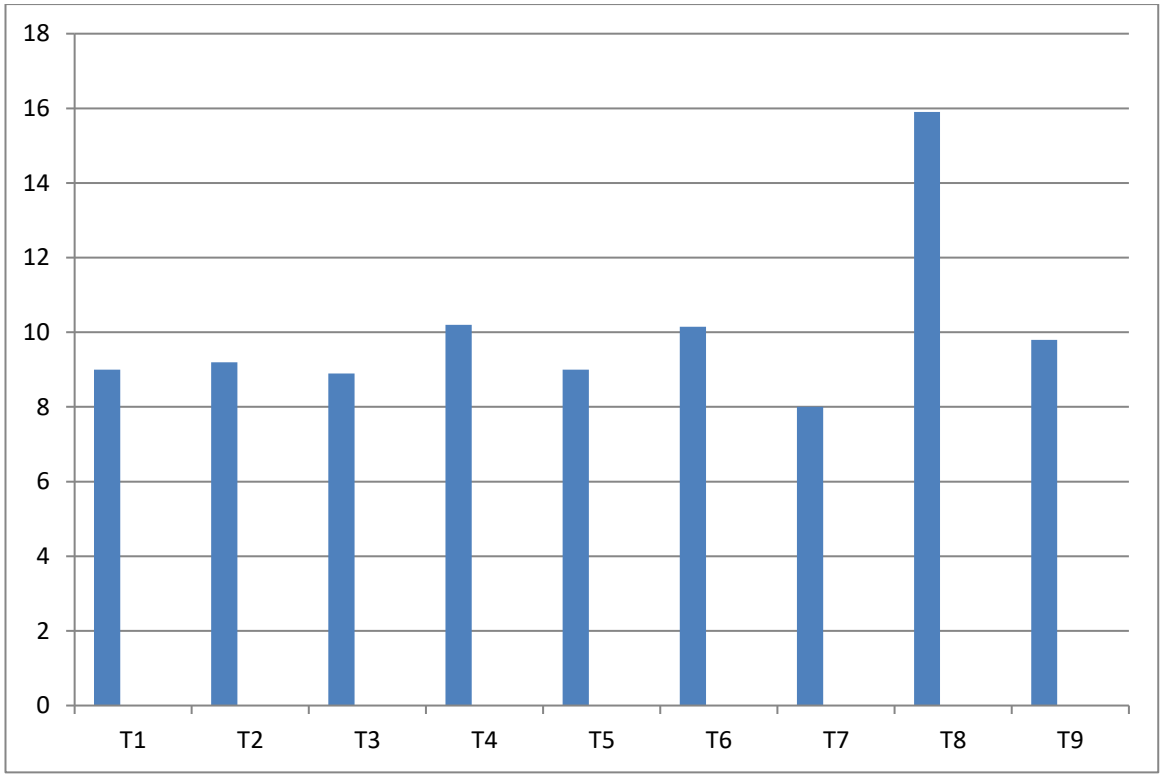

Fig. 1 Effect of seed treatment on Days for seed germination

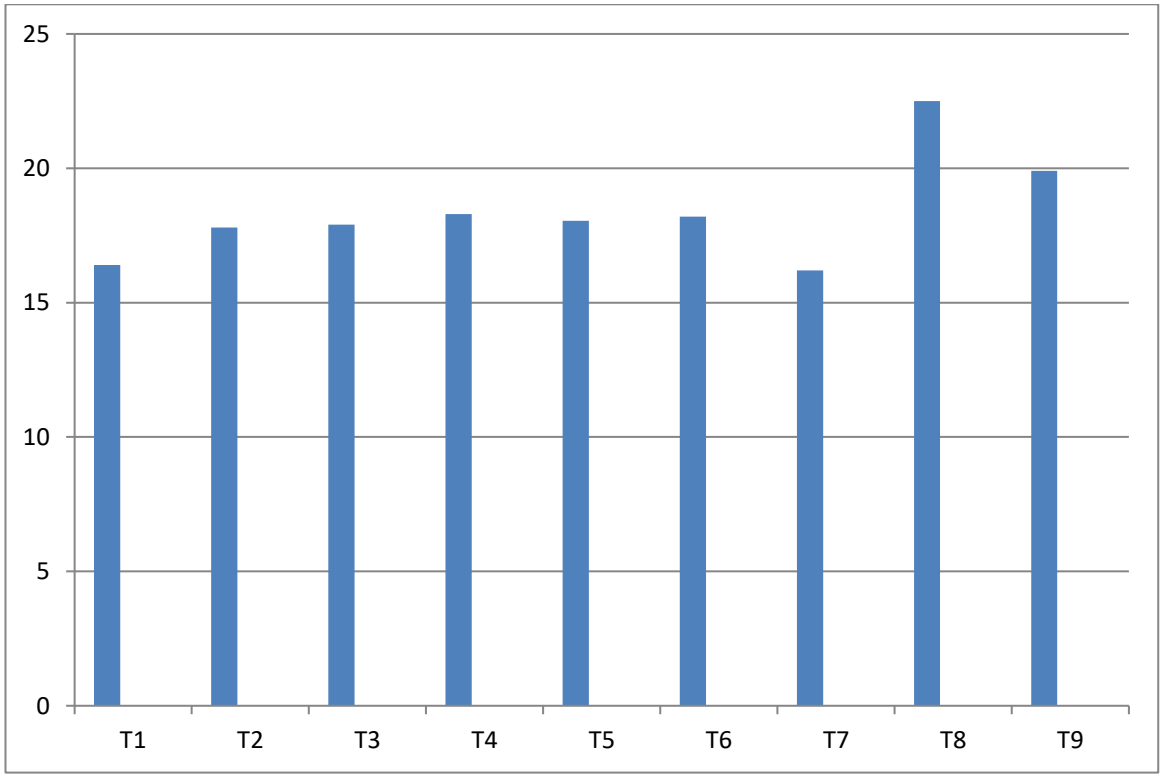

Fig .2 Effect of seed treatments on day required for early sprout

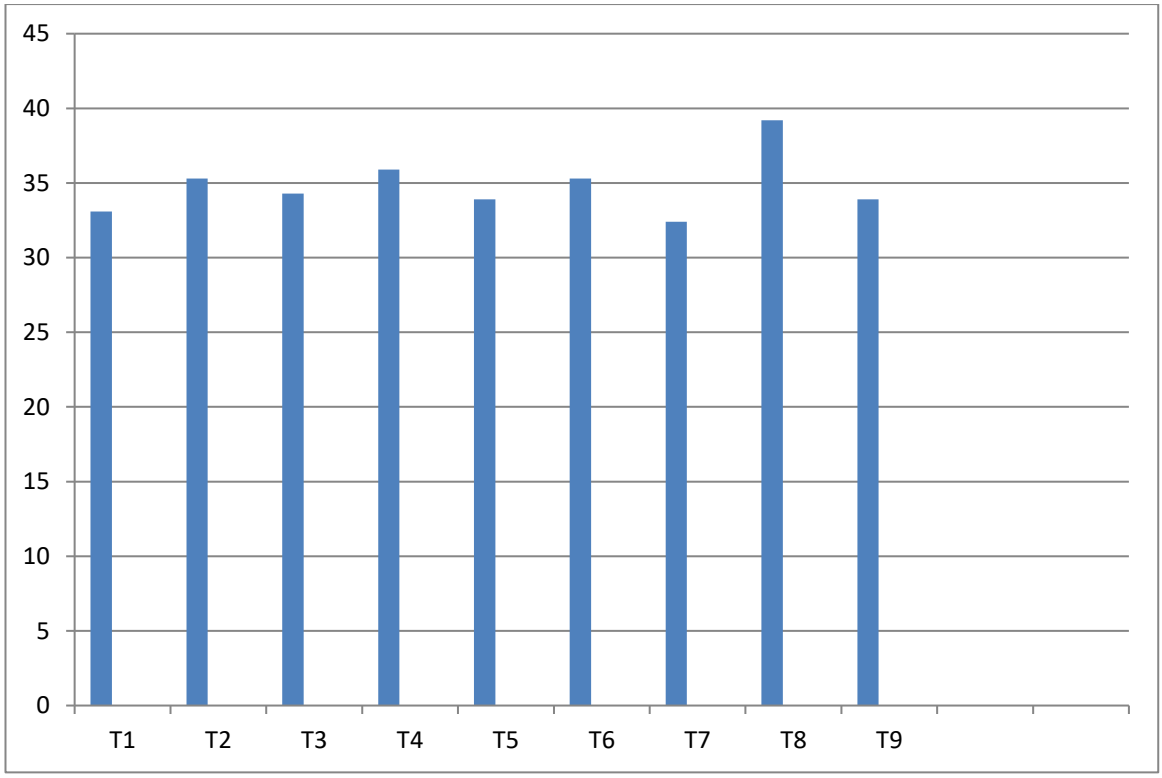

Fig. 3 Effect of seed treatment on germination period

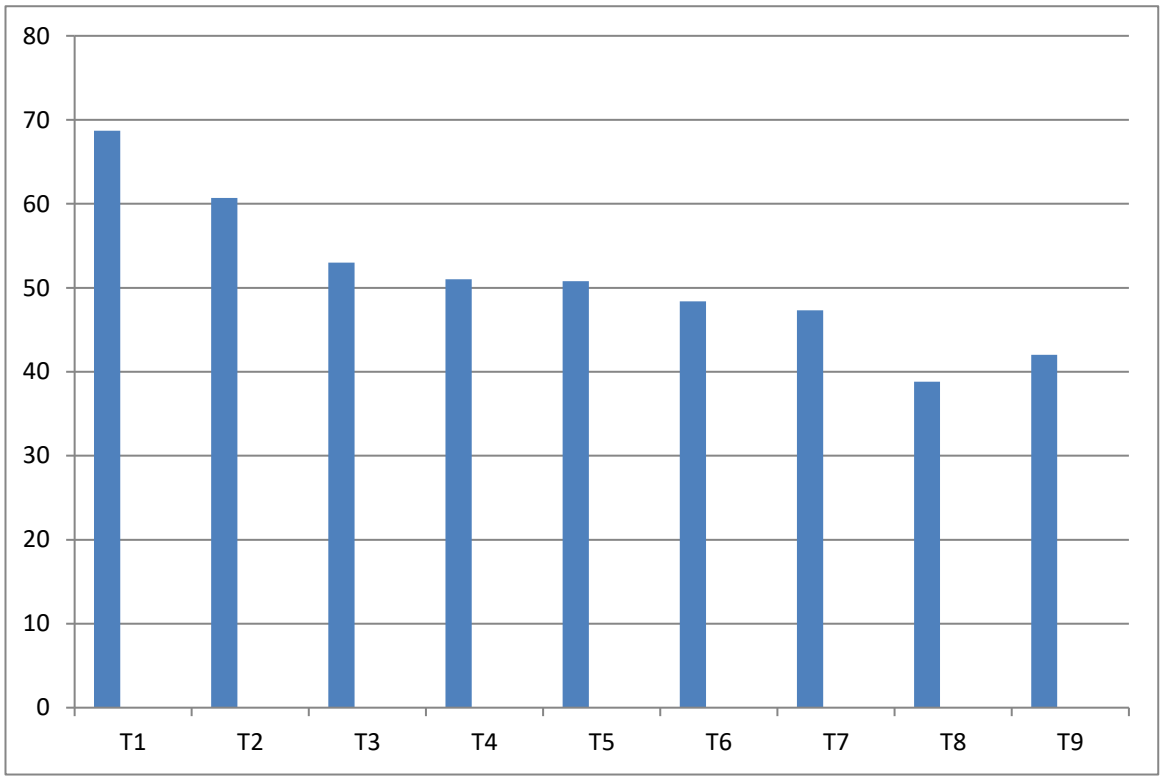

Fig.4 Effect of seed treatment on Germination percentage

was significantly influenced the days required for early recruits of *Terminalia arjuna*

4.2 Effect of seed treatments and foliar application on seedling vigour.

The minimum days required for early recruits after the day required for seed germination were observed in treatment T_7 (16.2 days) i.e. Hot water treatment for 6 hrs. This was found at par with (16.4 days) in T_1 treatment i.e GA_3 (20 ppm for 10 min) However, maximum days required for early recruits of *Terminalia arjuna* were recorded in T_8 (22.5 days) i.e. hot water treatment for 12 hrs.

Table 3. Effect of seed treatments and foliar application on seedling vigour

Seedling vigour			
Seed treatment	**Foliar spray**		**(Mean A)**
	Urea(0.5%)	**Urea(1%)**	
T_1 - GA_3 20 ppm for 10 min.	86.3 (68.51)*	87.0 (69.01)*	86.6 (68.76)*
T_2 - GA_3 40 ppm for 10 min.	88.0 (69.75)*	85.8 (68.11)*	86.9 (68.93)*
T_3 - IBA 20 ppm for 10 min.	86.8 (68.75)*	82.6 (65.66)*	84.7 (67.20)*
T_4 - IBA 40 ppm for 10 min.	81.8 (64.99)*	82.6 (65.66)*	82.2 (65.32)*
T_5 - Cow-dung slurry for 6 hrs.	85.3 (67.54)*	86.8 (68.70)*	86.0 (68.14)*
T_6 - Cow-dung slurry for 12 hrs.	84.3 (66.70)*	81.1 (64.65)*	82.7 (65.67)*
T_7 - Hot water for 6 hrs.	85.1 (67.39)*	81.1 (64.65)*	83.1 (66.02)*
T_8 - Hot water for 12 hrs.	82.0 (64.92)*	83.0 (65.66)*	82.5 (65.2)*
T_9 - Control	-		83.6 (66.1)*
Mean B	84.98 (66.40)*	83.79 (66.09)*	-

Interaction of seed treatment and foliar application on seedling vigour				
Factors	**Factor (A)**	**Factor (B)**	**Factor (A X B)**	**Control Vs Other**
F test	NS	NS	NS	NS
S.E.(m) ±	2.71	2.71	2.71	2.71
C.D. at 5%	7.41	3.70	10.4	7.86

The value in parenthesis are angular transformation value.

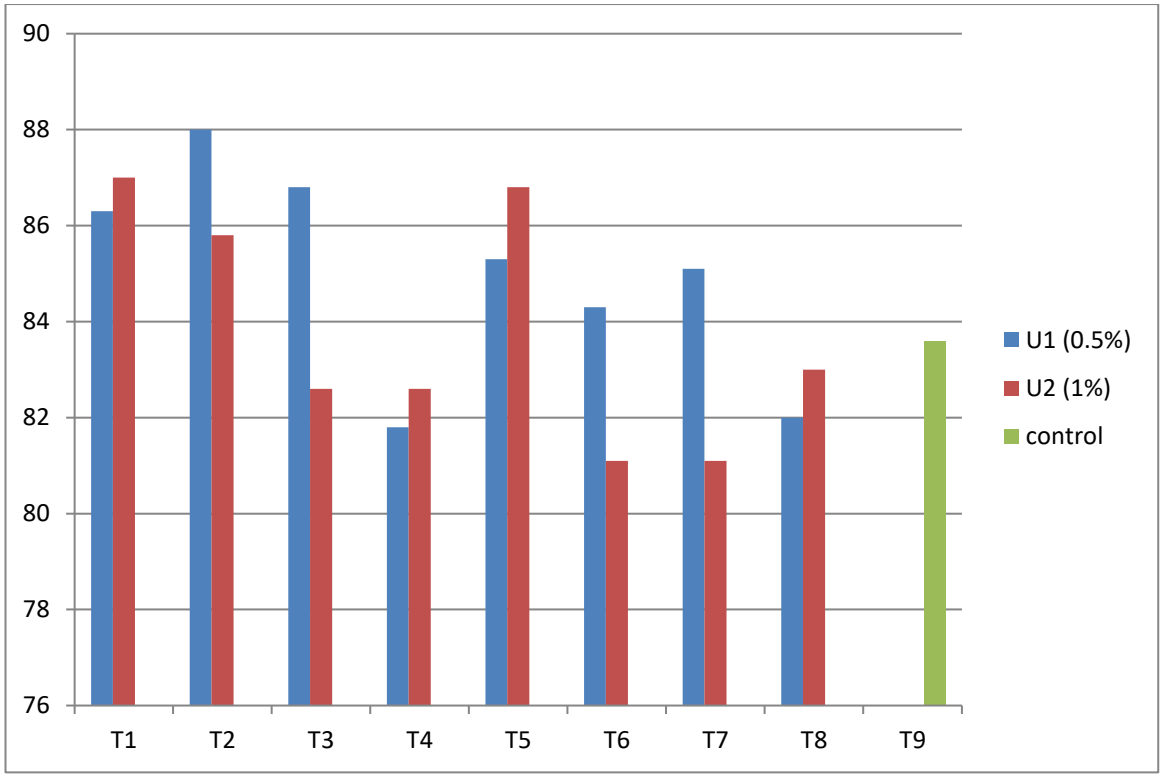

Fig. 5 Effect of seed treatment and foliar application on seedling vigour

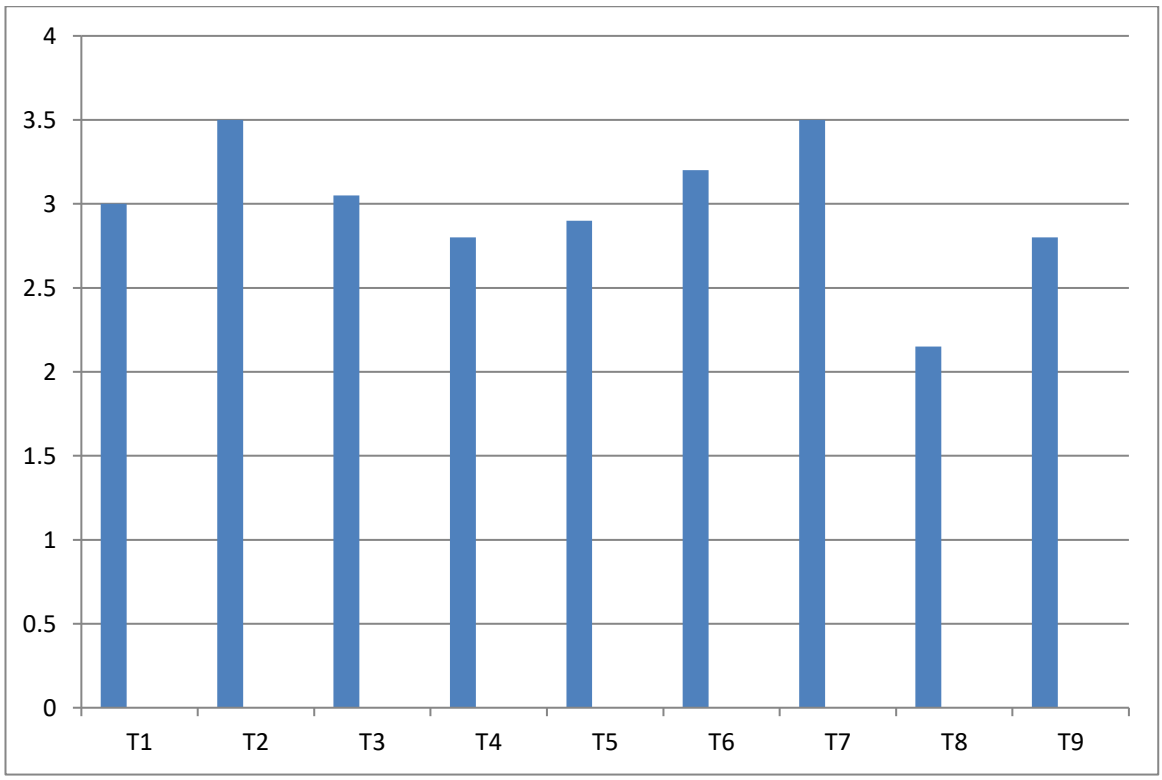

Fig. 6 Effect of seed treatment on Number of leaves at 30 DAS

As regarding to, germination period the data presented in Table 2, and depicted in Fig. 3, indicated that, seed treatment significantly the germination period of *Terminalia arjuna*.

The minimum germination period was observed in treatment T_7 (32.4) i.e. hot water for (6hrs.) which was found at par with (33.16) in treatment T_1 i.e. GA_3 treatment (20 ppm for 10 min), (33.5) in treatment T_5 i.e. cow dung slurry for (6 hrs.) and in treatment T_9 i.e. control.

As regarding to germination percent the data presented in Table 2, and depicted in Fig. 4, indicated that seed treatment significantly influenced the germination percentage of *Terminalia arjuna.*

4.3. Effect of seed treatment on Number of leaves at 30 DAS

The maximum germination percentage was observed in treatment T_1 i.e. GA_3 20 ppm for 10 min. (68.7%) as which was found at par with (60.7%) in treatment T_2 i.e. GA_3 40 ppm for 10 min. and (53.05%) in treatment T_3 IBA 20 ppm for 10 min. However minimum percentage were recorded T_9 (42%) i.e. control.

Table 4 . Effect of seed treatment on Number of leaves at 30 DAS

Seed treatment	**30 Days**
T_1 - GA_3 20 ppm for 10 min.	3
T_2 - GA_3 40 ppm for 10 min.	3.5
T_3 - IBA 20 ppm for 10 min.	3.05
T_4 - IBA 40 ppm for 10 min.	2.8
T_5 - Cow-dung slurry for 6 hrs.	2.9
T_6 - Cow-dung slurry for 12 hrs.	3.2
T_7 - Hot water for 6 hrs.	3.5
T_8 - Hot water for 12 hrs.	2.1
T_9 - Control	2.8
F test	NS
S.E.(m)±	0.51
CD at 5%	-

The data presented in Table 3 and depicted in Fig.5, indicated that seed treatment not significantly influenced on seedling vigour of *Terminalia arjuna*.

4.4 Effect of seed treatments and foliar application on Number of leaves at 60 DAS

The maximum seedling vigour was observed in treatment T_2 (86.9) i.e. GA_3 treatment (40 ppm for 10 min.) which was found at par with (86.6) in treatment T_1 i.e. GA_3 treatment (20 ppm for 10 min.) and (86.08) in treatment T_5 i.e. cow dung slurry treatment for(6hrs.) However, minimum seedling vigour was recorded T_4 (82.25) i.e. IBA treatment (40 ppm for 10 min.).

Table 5. Effect of seed treatments and foliar application on Number of leaves at 60 DAS

Number of Leaves of seedling at 60 days after sowing				
Seed treatment	**Foliar spray**			**(Mean A)**
	Urea(0.5%)	**Urea(1%)**		
T_1 - GA_3 20 ppm for 10 min.	8.00	7.80		7.93
T_2 - GA_3 40 ppm for 10 min.	5.40	5.73		5.57
T_3 - IBA 20 ppm for 10 min.	10.13	6.27		8.20
T_4 - IBA 40 ppm for 10 min.	5.27	6.07		5.67
T_5 - Cow-dung slurry for 6 hrs.	6.13	6.53		6.33
T_6 - Cow-dung slurry for 12 hrs.	7.33	6.40		6.87
T_7 - Hot water for 6 hrs.	7.73	7.53		7.63
T_8 - Hot water for 12 hrs.	4.40	4.20		4.30
T_9 - Control	-			5.93
Mean B	6.80	6.33		-
Interaction of seed treatment and foliar application on Number of leaves				
Factors	**Factor (A)**	**Factor (B)**	**Factor (A X B)**	**Control Vs Other**
F test	Sig	NS	NS	NS
S.E.(m) ±	0.81	0.81	0.81	0.81
C.D. at 5%	2.22	1.11	3.15	2.36

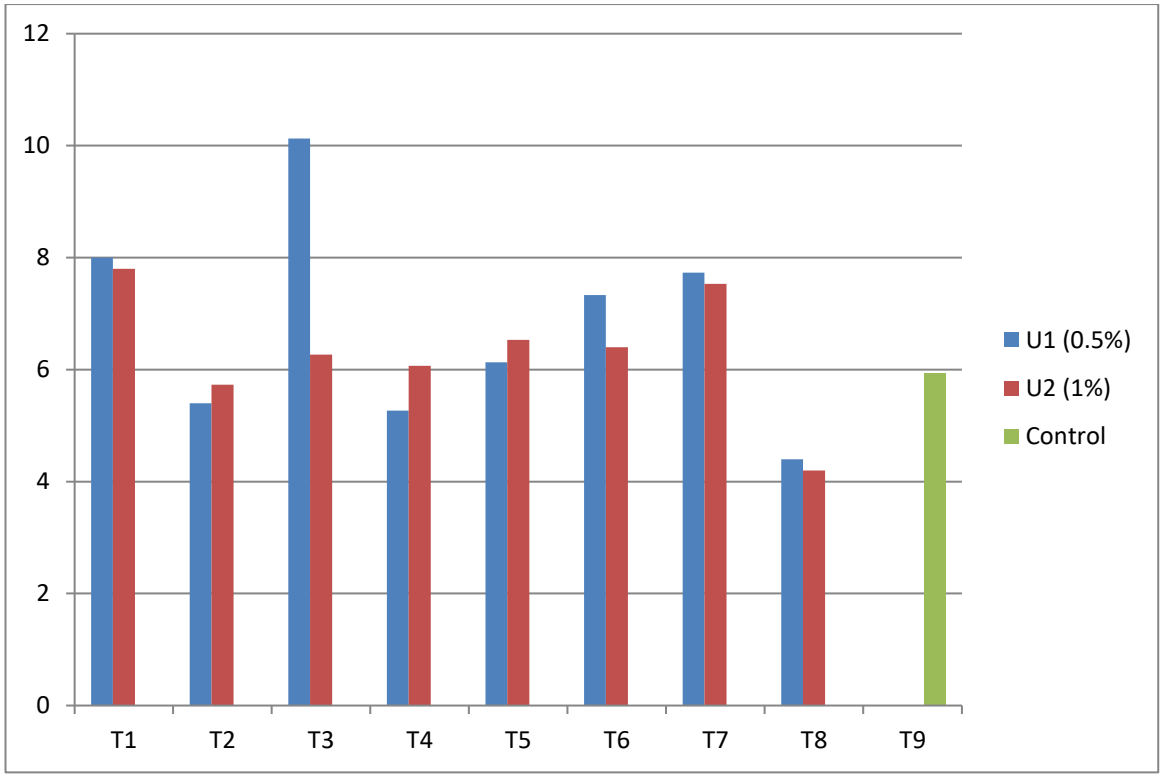

Fig. 7 Effect of seed treatment and foliar application on Number of leaves 60 DAS

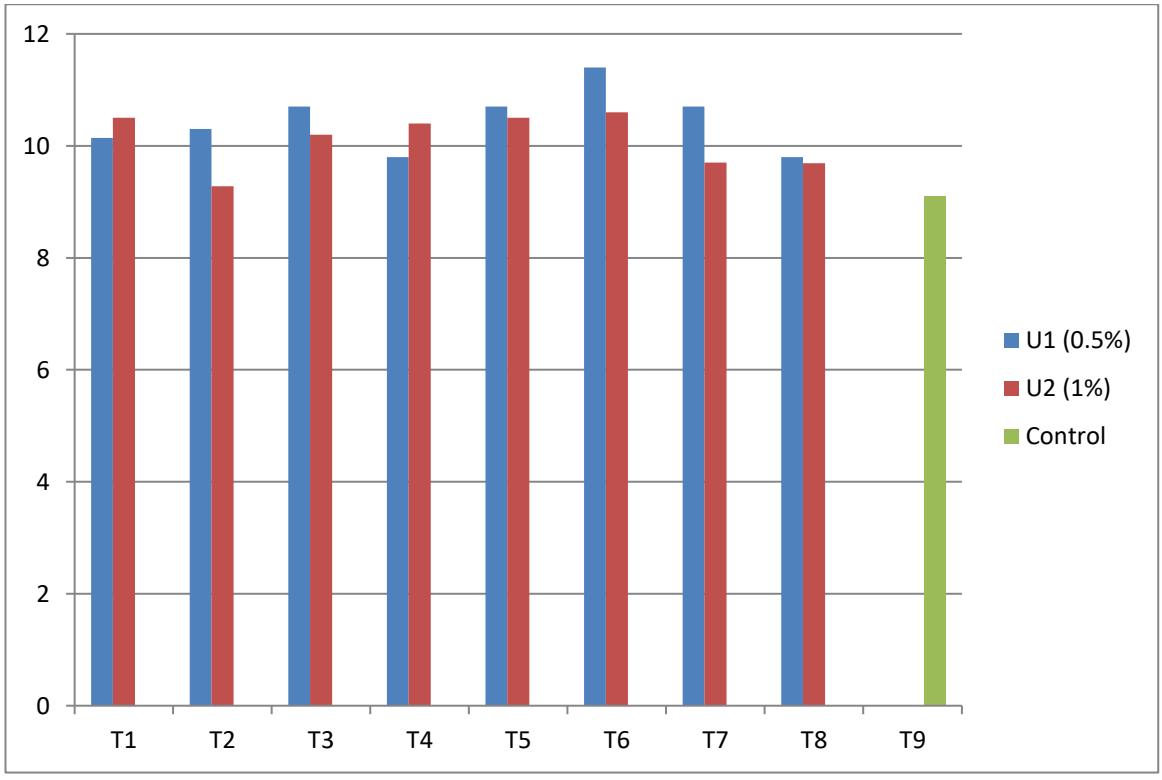

Fig. 8 Effect of seed treatment and foliar application of Number of leaves at 90 DAS

The data presented in Table 4, and depicted in Fig. 6, indicated that seed treatment influenced the number of leaves of *Terminalia arjuna.*

The number of leaves of Terminalia arjuna at 30 days interval upto 60 days upto sowing presented in Table 8 and depicted in Fig. 10 indicated that, number of leaves of Terminalia arjuna are recorded at monthly interval was non significant by the seed treatment.

The number of leaves at 30 days after sowing was found in seed treatment T_2 (3.2) i.e. GA_3 treatment, (40 ppm for 10 min.) T_7 (3.2) i.e. Hot water for (6 hrs.).

The data represented in Table 5, and depicted in fig.7, indicated that seed treatment and foliar application non significantly influenced on number of leaves of *Terminalia arjuna*.

As regarding to seed treatment the number of leaves recorded at 60 days after was found maximum in T_3 (8.20) i.e. IBA treatment (20 ppm for 10 min.) as which was found at par with (7.93) T_1 i.e. GA_3 treatment (20 ppm for 10 min.) and (7.63) i.e. T_7 i.e. hot water treatment for 6 hrs. However, minimum number of leaves was recorded (4.30) T_8 i.e. hot water treatment for 12 hrs.

As regarding to foliar application the number of leaves recorded at 60 days after sowing was found maximum in (6.80) in foliar application of (0.5%) of urea.

The interaction effect of seed treatment and foliar application on the number of leaves of *Terminalia arjuna* recorded at 60 days after sowing was found maximum in foliar application of 0.5% in treatment (10.13) T_3U_1 i.e. IBA treatment (20 ppm for 10 min) which was followed by (8) T_1U_1 i.e. GA_3 (20 ppm for 10 min) However, minimum was recorded (4.40) treatment T_8 i.e. hot water treatment for 12 hrs.

As compared to 30 days number of leaves , maximum number of leaves was observed in T_1 (7.93) i.e. GA_3 treatment (20 ppm for 10 min)

4.5 Effect of seed treatments and foliar application on Number of leaves at 90 DAS

The data presented in Table 6, and depicted in fig.8 , indicated that seed treatment and foliar application non significantly influenced on number of leaves of *Terminalia arjuna* **.**

Table 6. Effect of seed treatments and foliar application on Number of leaves at 90 DAS

Number of Leaves of seedling at 90 days after sowing			
Seed treatment	**Foliar spray**		**(Mean A)**
	Urea(0.5%)	**Urea(1%)**	
T_1 - GA_3 20 ppm for 10 min.	10.14	10.50	10.32
T_2 - GA_3 40 ppm for 10 min.	10.30	09.28	09.83
T_3 - IBA 20 ppm for 10 min.	10.70	10.24	10.50
T_4 - IBA 40 ppm for 10 min.	09.80	10.40	10.10
T_5 - Cow-dung slurry for 6 hrs.	10.70	10.50	10.67
T_6 - Cow-dung slurry for 12 hrs.	11.40	10.60	11.02
T_7 - Hot water for 6 hrs.	10.72	09.70	10.25
T_8 - Hot water for 12 hrs.	09.80	09.69	09.76
T_9 - Control	-		09.10
Mean B	10.48	10.13	-

Interaction of seed treatment and foliar application on Number of leaves				
Factors	**Factor (A)**	**Factor (B)**	**Factor (A X B)**	**Control Vs Other**
F test	Sig	Sig	NS	Sig
S.E.(m) ±	0.30	0.30	0.30	0.30
C.D. at 5%	0.62	0.31	0.88	0.66

As regarding to seed treatment the number of leaves recorded at 90 days after sowing was found maximum in T_6 (11.02) i.e. cow dung slurry for 12 hrs. as which was found at par with T_5 (10.67) i.e. cow dung slurry for 6 hrs. and (10.50) T_3 i.e. IBA treatment (20 ppm for 10 min.) However, minimum number of leaves (9.10) T_9 i.e. control.

As regarding to foliar application the number of leaves recorded at 90 days after sowing was found maximum in (10.48) in foliar application of (0.5%) urea.

The interaction effect of seed treatment and foliar application on the number of leaves of *Terminalia arjuna* recorded at 90 days after sowing was found maximum in foliar application of (0.5%) urea , cow dung slurry for 12 hrs.(11.4) T_6U_1 as which was found at par with (10.72) T_7U_1 i.e. hot water for 12 hrs. and (10.7) T_5U_1 i.e. cow dung for 6 hrs. and (10.7) T_3U_1 IBA treatment (20 ppm for 10 min) However, minimum was recorded (9.8) treatment T_8U_1 hot water treatment for 12 hrs. and (9.8) treatment T_4U_1 IBA treatment (40 ppm for 10 min)

As compared to 60 days number of leaves, maximum number of leaves was observed in 90 days in T_6 (11.02) i.e. cow dung slurry treatment (for 12 hrs.)

4.6 Effect of seed treatment on seedling height of 30 DAS

The seedling height at 30 days interval upto 60 days sowing represented in Table 7 and depicted in Fig.9 indicated that seedling height of *Terminalia arjuna* recorded at monthly interval was significantly influenced by the seed treatment and foliar application.

Table 7. Effect of seed treatment on seedling height of 30 DAS

Seed treatment	**30 Day**
T_1 - GA_3 20 ppm for 10 min.	3.5
T_2 - GA_3 40 ppm for 10 min.	3.6
T_3 - IBA 20 ppm for 10 min.	3.9
T_4 - IBA 40 ppm for 10 min.	3.4
T_5 - Cow-dung slurry for 6 hrs.	3.6
T_6 - Cow-dung slurry for 12 hrs.	3.4
T_7 - Hot water for 6 hrs.	3.6
T_8 - Hot water for 12 hrs.	3.2
T_9 - Control	3.7
F test	Sig.
S.E.(m)±	0.38
CD at 5%	1.15

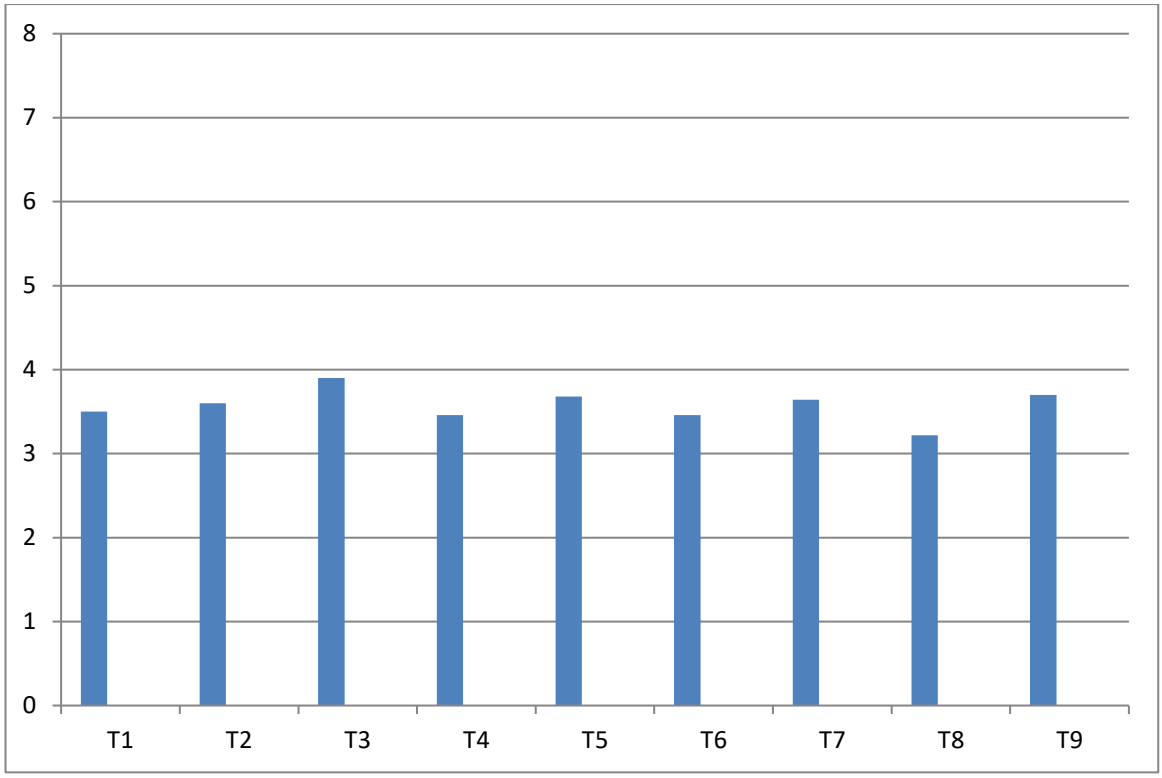

Fig.9 Effect of seed treatment on seedling height of 30 DAS

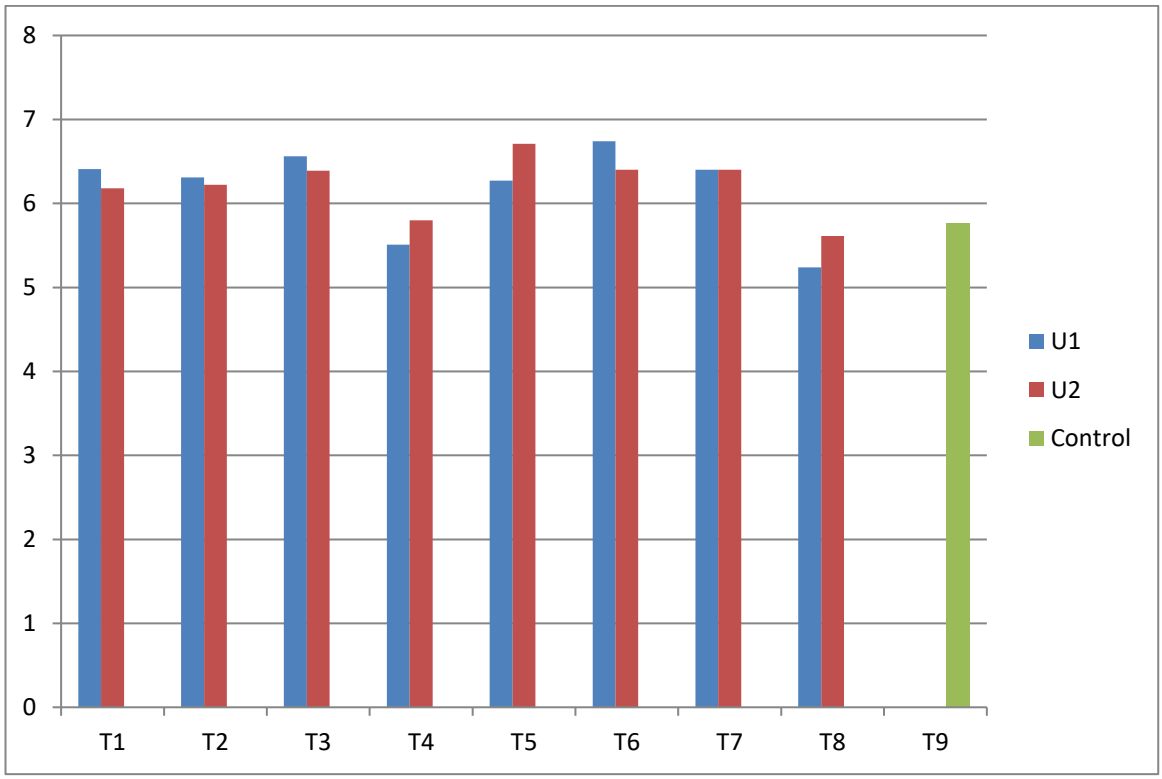

Fig.10 Effect of seed treatment and foliar application on seedling height at 60 DAS

The seedling height recorded at 30 days after sowing was found maximum in treatment T_3 (3.9 cm.) i.e. IBA treatment (20 ppm for 10 min.) as which was found at par with (3.7 cm.) T_9 i.e. control and (3.6 cm.) T_5 Cow dung slurry for 6 hrs. However, minimum seedling height was recorded (3.2 cm.) in treatment T_8 i.e. Hot water soaking for 12 hrs.

4.7 Effect of seed treatment and foliar application on seedling height at 60 DAS

The data presented in table 8 and depicted in fig.10 , indicated that seed treatment and foliar application influenced on seedling height.

Table 8. Effect of seed treatment and foliar application on seedling height at 60 DAS

Seedling height at 60 days (cm) after sowing			
seed treatment	**Foliar spray**		**Mean A**
	Urea (0.5%)	**Urea (1 %)**	
T_1 - GA_3 20 ppm for 10 min.	6.41	6.18	6.30
T_2 - GA_3 40 ppm for 10 min.	6.31	6.22	6.27
T_3 - IBA 20 ppm for 10 min.	6.56	6.39	6.48
T_4 - IBA 40 ppm for 10 min.	5.51	5.80	5.66
T_5 - Cow-dung slurry for 6 hrs.	6.27	6.71	6.49
T_6 - Cow-dung slurry for 12 hrs.	6.74	6.40	6.57
T_7 - Hot water for 6 hrs.	6.40	6.40	6.41
T_8 - Hot water for 12 hrs.	5.24	5.61	5.43
T_9 - Control	-		5.76
Mean B	6.18	6.22	-

Interaction of seed treatment and foliar application on seedling height				
Factors	**Factor (A)**	**Factor (B)**	**Factor (A X B)**	**Control Vs other**
F test	Sig	NS	Sig	Sig
S.E.(m) ±	0.99	0.99	0.99	0.99
C.D. at 5%	0.20	0.10	0.28	0.21

As regarding to seed treatment the seedling height recorded at 60 days after sowing was found maximum in T_6 (6.57 cm) i.e. cow dung slurry for (12 hrs.) and (6.49 cm) in T_5 i.e. cow dung slurry for (6 hrs.) as which was found at par with (6.48 cm) in T_3 i.e. IBA treatment (Immersion in 20 ppm for 10 min.), (6.41 cm) T_7 i.e. seed soaking in hot water for (6 hrs.) However, minimum seedling height was recorded (5.43 cm) T_8 i.e. hot water treatment for (12 hrs.).

4.8 Effect of seed treatment and foliar application on seedling height at 90 DAS

As regarding to foliar application the seedling height recorded at 60 days after sowing was found maximum in (6.22 cm) in foliar application of 1% of urea.

Table 9. Effect of seed treatment and foliar application on seedling height at 90 DAS

Seedling height at 90 days (cm) after sowing			
Seed treatment	**Foliar spray**		**Mean A**
	Urea (0.5%)	**Urea (1%)**	
T_1 - GA_3 20 ppm for 10 min.	10.14	10.34	10.24
T_2 - GA_3 40 ppm for 10 min.	10.20	09.31	09.76
T_3 - IBA 20 ppm for 10 min.	10.70	10.04	10.40
T_4 - IBA 40 ppm for 10 min.	09.80	10.26	10.04
T_5 - Cow-dung slurry for 6 hrs.	11.04	08.22	10.19
T_6 - Cow-dung slurry for 12 hrs.	10.14	09.78	09.93
T_7 - Hot water for 6 hrs.	08.63	08.28	09.97
T_8 - Hot water for 12 hrs.	08.12	08.32	08.46
T_9 - Control	-		08.12
Mean B	10.11	09.64	-

Interaction of seed treatment and foliar application on seedling height				
Factors	**Factor (A)**	**Factor (B)**	**Factor (A X B)**	**Control Vs other**
F test	NS	Sig	NS	Sig
S.E.(m) ±	0.612	0.612	0.612	0.612
C.D. at 5%	1.244	0.622	1.760	1.32

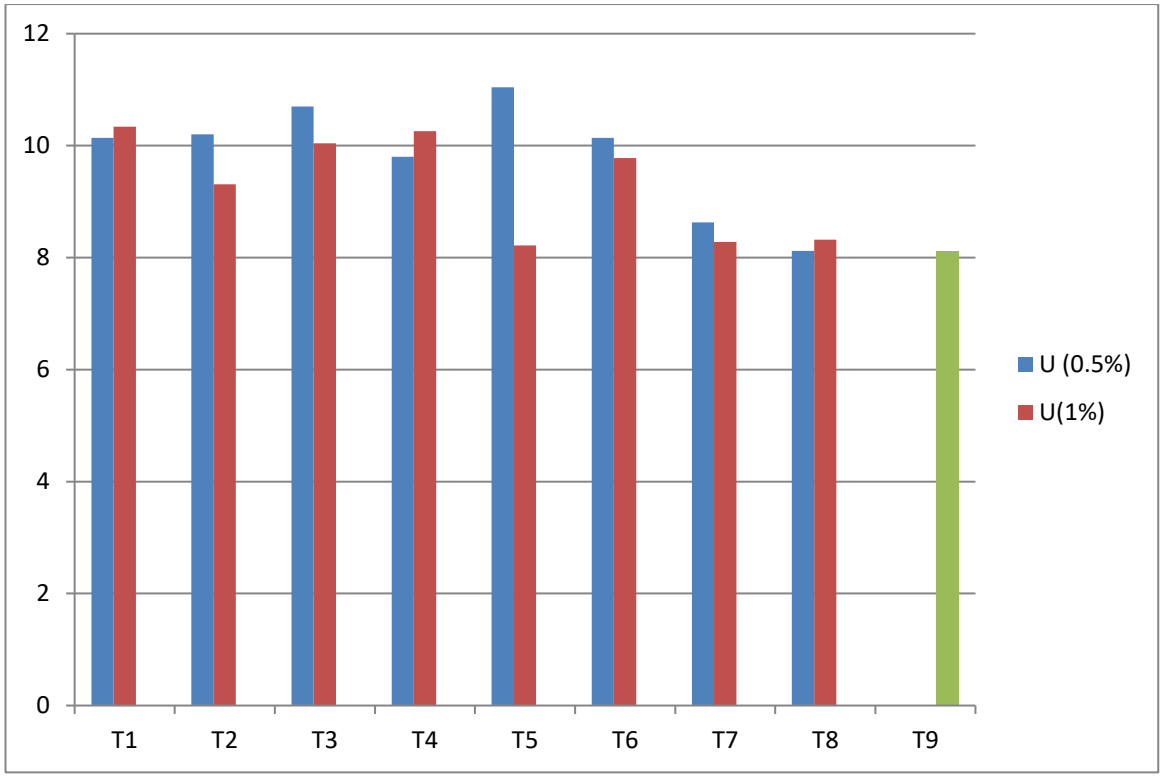

Fig.11 Effect of seed treatment and foliar application on seedling height at 90 DAS

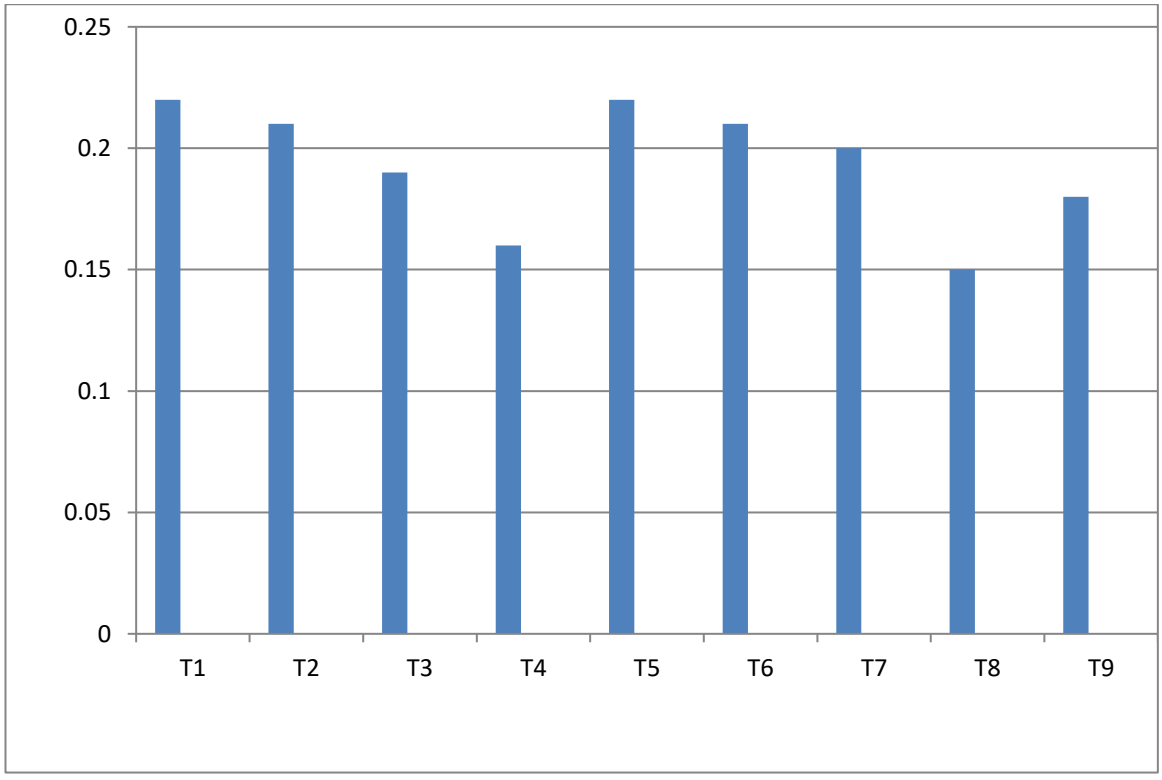

Fig. 12 Effect of seed treatment on collar diameter at 30 DAS

The interaction effect of seed treatment and foliar application on seedling height recorded at 60 days after sowing was found in foliar application of 1% urea T_5U_2 (6.71 cm) i.e. cow dung slurry for (6hrs.) which was found at par with (6.40 cm) T_7U_2 i.e. hot water treatment for (6hrs.) and (6.40 cm) in T_6U_2 i.e. cow dung slurry for (12 hrs.) However, minimum seedling height was observed in T_8U_2 in hot water treatment for (12 hrs.).

As compared to 30 days seedling height, mean maximum seedling height was observed in 90 days seedling height in T_6 (6.57 cm) i.e. cow dung slurry for 12 hrs.

The data presented in Table 9, and depicted in Fig.11, indicated that seed treatment and foliar application influenced on seedling height of *Terminalia arjuna* **.**

As regarding to seed treatment the seedling height recorded at 90 days after sowing. The maximum height recorded in T_3 (10.40 cm) i.e. IBA treatment (20 ppm for 10 min.) and T_1 (10.24 cm) i.e. GA_3 treatment (20 ppm for 10 min.) as which was at found at par with (10.19 cm) in T_5 i.e. cow dung slurry for (6 hrs), (10.04 cm.) T_4 IBA treatment (40 ppm for 10 min.) However, minimum seedling height was recorded (8.12 cm) T_9 i.e. control.

As regarding to foliar application the seedling height recorded at 90 days after sowing was found significant (10.11 cm) in foliar application of 0.5% of Urea.

The interaction effect of seed treatment and foliar application on seedling height at 90 days after sowing was recorded maximum in foliar application of urea (0.5%) in treatment T_5U_1 (11.04 cm) i.e. Cow dung slurry for (6 hrs.) as which was found at par with (10.14 cm) in T_1 GA_3 (20 ppm for 10 min.) , (10.14 cm) in T_6 (cow dung slurry for 12 hrs.) However, minimum seedling height was recorded in T_8 (8.12 cm) hot water treatment for 12 hrs.

As compared to 60 days seedling height, the maximum seedling height was observed in 90 days in T_3 (10.40 cm) i.e. IBA treatment (20 ppm for 10 min).

4.9 Effect of seed treatment on collar diameter at 30 DAS

The collar diameter at 30 days interval from sowing presented in Table 10 and depicted in Fig.12 indicated that, Collar diameter of *Terminalia arjuna* recorded at monthly interval was non significantly influenced by the seed treatment.

Table 10. Effect of seed treatment on collar diameter at 30 DAS

Seed treatment	**30 Days**
T_1 - GA_3 20 ppm for 10 min.	0.22
T_2 - GA_3 40 ppm for 10 min.	0.21
T_3 - IBA 20 ppm for 10 min.	0.19
T_4 - IBA 40 ppm for 10 min.	0.16
T_5 - Cow-dung slurry for 6 hrs.	0.22
T_6 - Cow-dung slurry for 12 hrs.	0.21
T_7 - Hot water for 6 hrs.	0.20
T_8 - Hot water for 12 hrs.	0.15
T_9 - Control	0.18
F test	NS
S.E.(m)±	0.02
CD at 5%	0.06

The collar diameter at 30 days after sowing was found maximum in treatment T_1 (0.22 cm) i.e. GA_3 treatment (20 ppm for 10 min.), T_5 (0.22 cm) i.e. Cow dung slurry treatment for (6 hrs.) as which was found at par with T_2 (0.21 cm) i.e. GA_3 treatment (40 ppm for 10 min.), T_6 (0.21 cm) i.e. Cow dung slurry treatment for (12 hrs.) However, minimum collar diameter was recorded (0.15 cm) in treatment T_8 Hot water treatment for 12 hrs.

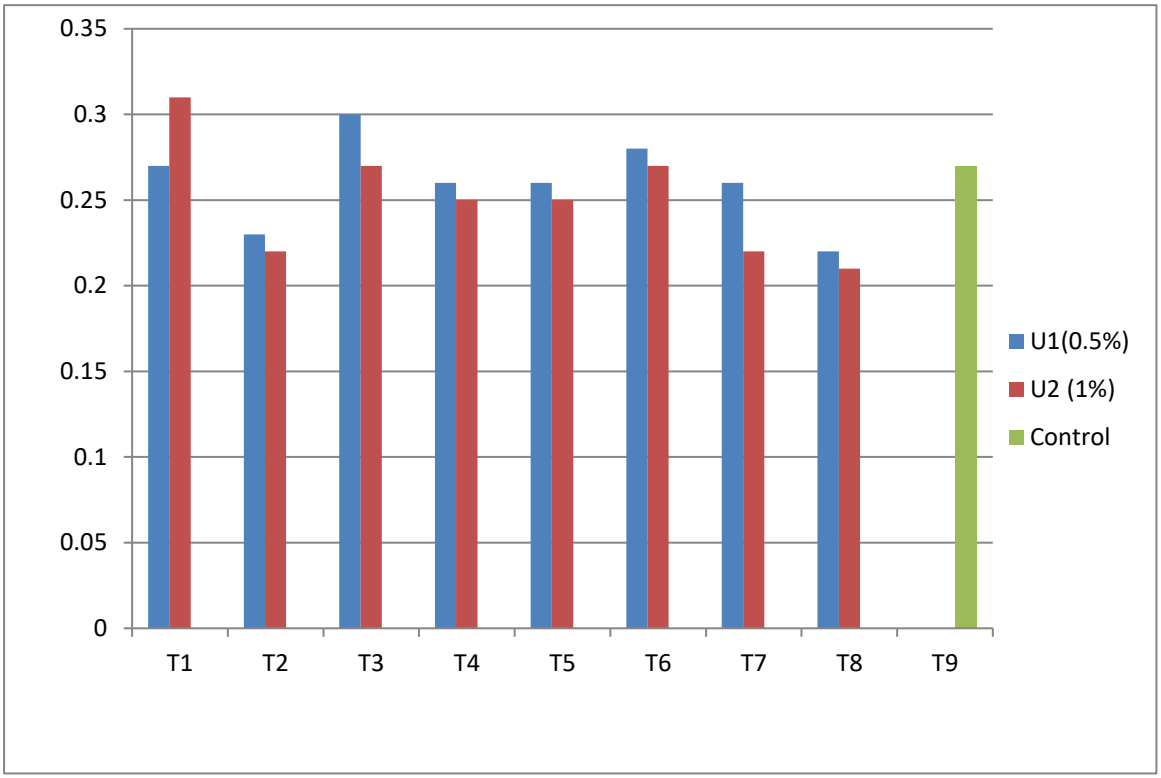

Fig. 13 Effect of seed treatment and foliar application on collar diameter at 60 DAS

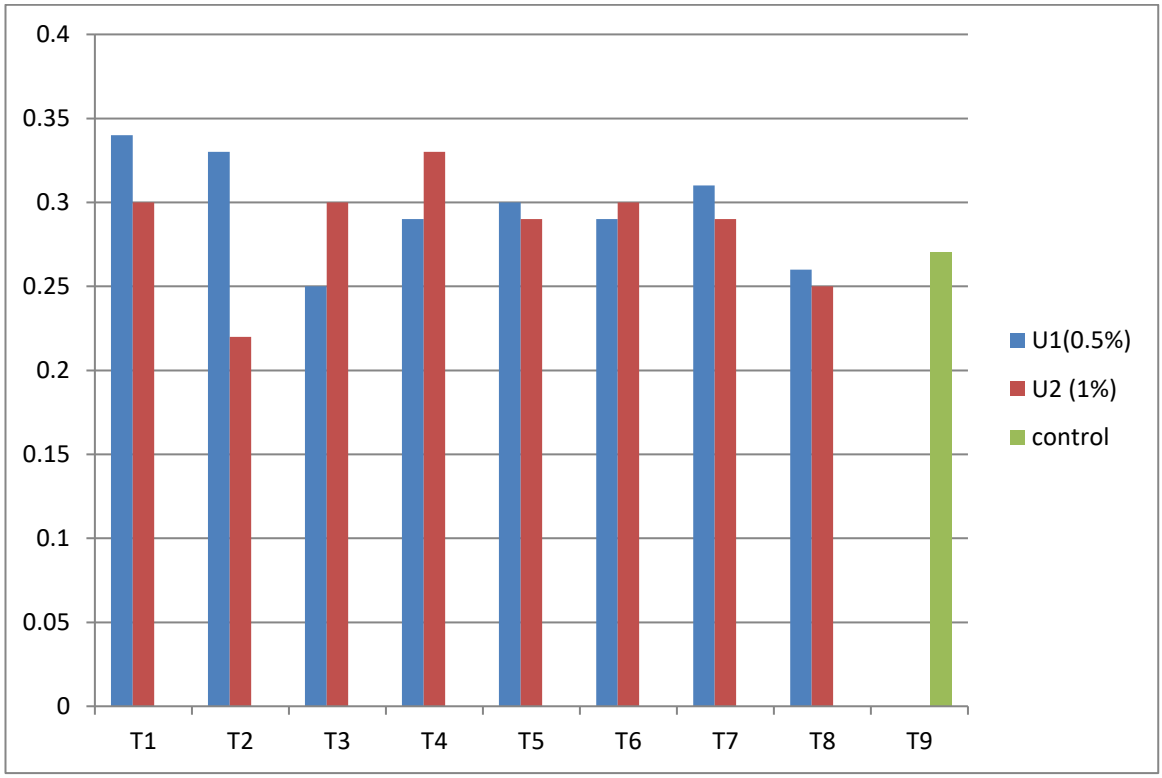

Fig. 14 Effect of seed treatment and foliar application on collar diameter at 90 DAS

4.10 Effect of seed treatments and foliar application on collar diameter at 60 DAS

The data presented in Table 11, and depicted in Fig. 13, indicated that seed treatment and foliar application influenced on collar diameter of *Terminalia arjuna* .

Table 11. Effect of seed treatments and foliar application on collar diameter at 60 DAS

Collar diameter of seedling at 60 days (cm) after sowing			
Seed treatment	**Foliar spray**		**(Mean A)**
	Urea (0.5%)	**Urea (1%)**	
T_1 - GA_3 20 ppm for 10 min.	0.27	0.31	0.29
T_2 - GA_3 40 ppm for 10 min.	0.23	0.22	0.23
T_3 - IBA 20 ppm for 10 min.	0.30	0.27	0.29
T_4 - IBA 40 ppm for 10 min.	0.26	0.25	0.26
T_5 - Cow-dung slurry for 6 hrs.	0.26	0.25	0.26
T_6 - Cow-dung slurry for 12 hrs.	0.28	0.27	0.28
T_7 - Hot water for 6 hrs.	0.26	0.22	0.24
T_8 - Hot water for 12 hrs.	0.22	0.21	0.22
T_9 - Control	-		0.27
Mean B	0.26	0.25	-

Interaction of seed treatment and foliar application on collar diameter				
Factors	**Factor (A)**	**Factor (B)**	**Factor (A X B)**	**Control Vs Other**
F test	Sig	NS	NS	NS
S.E.(m) ±	0.02	0.02	0.02	0.02
C.D. at 5%	0.02	0.01	0.03	0.02

As regarding to seed treatment the collar diameter recorded at 60 days after sowing was found maximum in T_1 (0.29 cm) i.e. GA_3 treatment (20 ppm for 10 min.), T_3 (0.29 cm) i.e. IBA treatment (20 ppm for 10 min.) as which was found at par with (0.28 cm) T_6 i.e. cow dung slurry for (12 hrs.) However, minimum collar diameter was recorded (0.22 cm) T_8 i.e. Hot water for (12 hrs.)

As regard to foliar application the collar diameter recorded at 60 days after sowing was found maximum in (0.26 cm) in foliar application of (0.5%) Urea.

The interaction effect of seed treatment and foliar application on collar diameter recorded at 60 days after sowing was found in foliar application of Urea (1%). T_1U_2 (0.31 cm) i.e. GA_3 (20 ppm for 10 min.) as which was found at par with (0.27 cm) T_3U_2 i.e. IBA treatment (20 ppm for 10 min.), (0.27 cm) T_6U_2 i.e. Cow dung slurry for 12 hrs. However , minimum collar diameter was recorded (0.21 cm) T_8U_2 Hot water treatment for 12 hrs.

As compared to 30 days collar diameter, mean maximum collar diameter in 60 days collar diameter was observed in T_1 (0.29 cm) i.e. GA_3 treatment (20 ppm for 10 min.) and T_3 (0.29 cm) i.e. IBA treatment (20 ppm for 10 min.)

4.11 Effect of seed treatments and foliar application on collar diameter at 90 DAS

The data presented in Table 12, and depicted in fig.14, indicated that seed treatment and foliar application influenced on collar diameter of *Terminalia arjuna*.

As regarding to seed treatment the collar diameter recorded at 90 days after sowing was found maximum in T_1(0.33 cm) i.e. GA_3 treatment (20 ppm for 10 min.) as which was found at par with (0.32 cm) T_4 IBA treatment (40 ppm for 10 min.) However , minimum collar diameter (0.26 cm) T_8 i.e. Hot water treatment for 12 hrs.

As regard to foliar application the collar diameter recorded at 90 days was found (0.30 cm) in foliar application of Urea (0.5%).

The interaction effect of seed treatment and foliar application on collar diameter recorded at 90 days after sowing was found maximum in foliar application of urea (0.5%) in treatment (0.34 cm) T_1U_1 i.e. GA_3 (20 ppm for 10 min.) as which was found at par with (0.33 cm) T_1U_2 i.e. GA_3 (40 ppm for 10 min.) and (0.31 cm) T_7U_1 i.e. Hot water treatment for 12 hrs.

However, minimum collar diameter was recorded (0.25 cm) T_3U_1 i.e. IBA treatment (20 ppm for 10 min.)

Table 12. Effect of seed treatments and foliar application on collar diameter at 90 DAS

Collar diameter of seedling at 90 days (cm) after sowing			
Seed treatment	**Foliar spray**		**(Mean A)**
	Urea(0.5%)	**Urea(1%)**	
T_1 - GA_3 20 ppm for 10 min.	0.34	0.30	0.33
T_2 - GA_3 40 ppm for 10 min.	0.33	0.22	0.28
T_3 - IBA 20 ppm for 10 min.	0.25	0.30	0.28
T_4 - IBA 40 ppm for 10 min.	0.29	0.33	0.32
T_5 - Cow-dung slurry for 6 hrs.	0.30	0.29	0.30
T_6 - Cow-dung slurry for 12 hrs.	0.29	0.30	0.30
T_7 - Hot water for 6 hrs.	0.31	0.29	0.30
T_8 - Hot water for 12 hrs.	0.26	0.25	0.26
T_9 - Control	-		0.29
Mean B	0.30	0.29	-

Interaction of seed treatment and foliar application on collar diameter				
Factors	**Factor (A)**	**Factor (B)**	**Factor (A X B)**	**Control Vs Other**
F test	NS	NS	NS	NS
S.E.(m) ±	0.04	0.04	0.04	0.04
C.D. at 5%	0.08	0.04	0.11	0.08

As compared to 60 days collar diameter, mean maximum collar diameter was observed in 90 days in (0.33 cm) i.e. GA_3 treatment (20 ppm for 10 min.).

4.12 Effect of seed treatments and foliar application on leaf area (cm^2)

The data presented in Table 13, and depicted in Fig.15, indicated that, seed treatment not significantly influenced the leaf area index of *Terminalia arjuna.*

Table 13. Effect of seed treatments and foliar application on leaf area (cm^2)

Leaf area (cm^2)			
Seed treatment	**Foliar spray**		**(Mean A)**
	Urea(0.5%)	**Urea(1%)**	
T_1 - GA_3 20 ppm for 10 min.	6.18	6.03	6.11
T_2 - GA_3 40 ppm for 10 min.	5.9	6.16	6.03
T_3 - IBA 20 ppm for 10 min.	6.46	6.89	6.68
T_4 - IBA 40 ppm for 10 min.	6.4	5.97	6.19
T_5 - Cow-dung slurry for 6 hrs.	6.28	6.36	6.32
T_6 - Cow-dung slurry for 12 hrs.	7.03	6.83	6.93
T_7 - Hot water for 6 hrs.	6.66	6.96	6.82
T_8 - Hot water for 12 hrs.	6.15	5.14	5.65
T_9 - Control	-		4.36
Mean B	6.39	6.30	-

Interaction of seed treatment and foliar application on leaf area				
Factors	**Factor (A)**	**Factor (B)**	**Factor (A X B)**	**Control Vs Other**
F test	Sig	NS	NS	Sig
S.E.(m) ±	0.37	0.37	0.37	0.37
C.D. at 5%	0.77	0.38	1.08	0.81

As regarding to seed treatment maximum leaf area was observed in treatment T_6 (6.93) i.e. cow dung slurry for (12 hrs.) which was found at par with T_7 (6.82) i.e. hot water treatment for (6 hrs.) and T_3 (6.68) i.e. IBA treatment (20 ppm for 10 min.) However, minimum leaf area of *Terminalia arjuna* was recorded (4.36) in T_9 control.

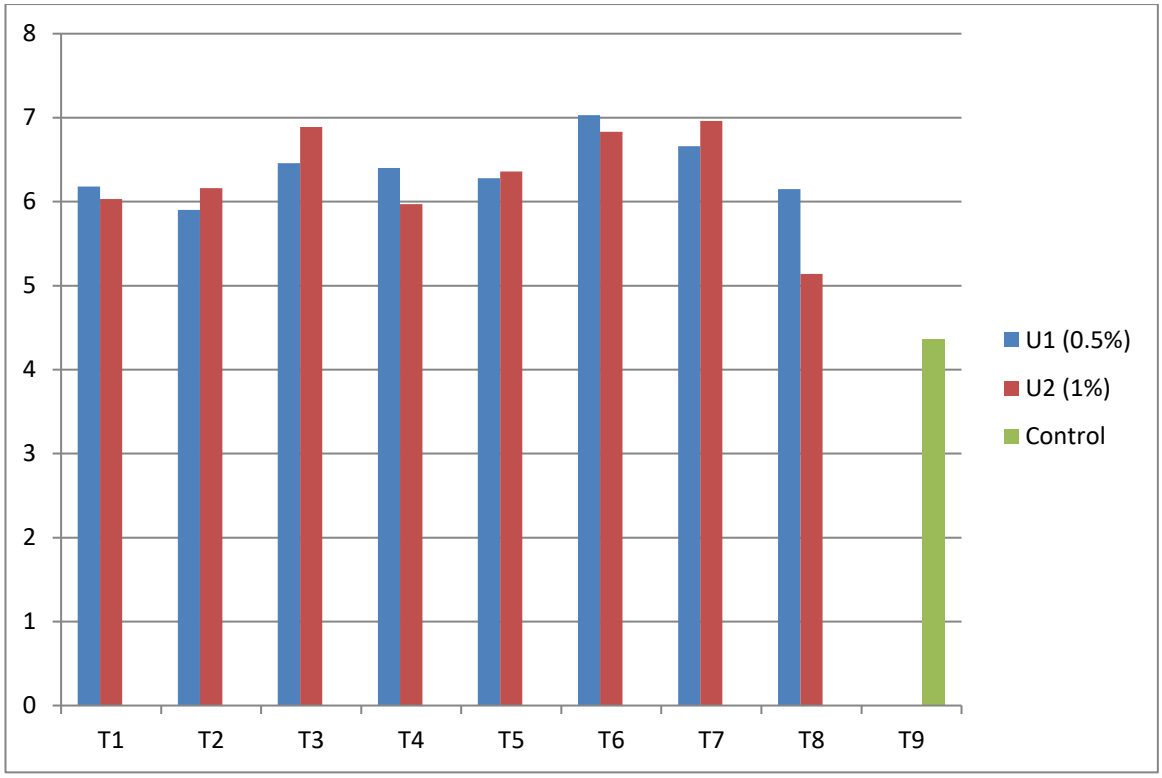

Fig.15 Effect of seed treatment and foliar application on leaf area (cm^2)

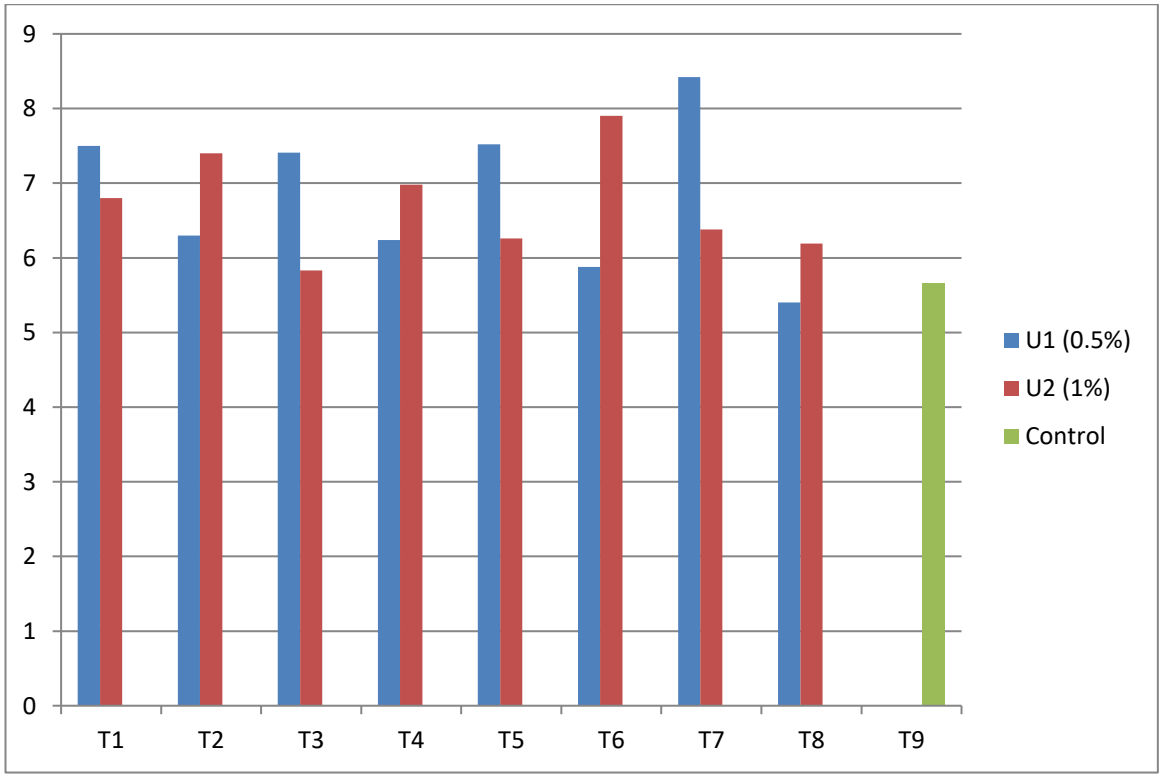

Fig. 16 Effect of seed treatment and foliar application on dry weight of

plant (gm) after 90 days

As regarding to foliar application the leaf area recorded at 90 days after sowing was found maximum in (6.39) in foliar application of (0.5%) of urea.

The interaction effect of seed treatments and foliar application on leaf area was observed maximum in treatment T_6U_1 (7.03) i.e. cow dung slurry for (12 hrs.) which was found at par with T_7U_1 (6.66) i.e. hot water treatment for (6 hrs.) and T_4U_1 (6.4) i.e. IBA treatment (40 ppm for 10 min) However, minimum leaf area of *Terminalia arjuna* was found (5.9) in T_2U_1 GA_3 treatment (40 ppm for 10 min.)

The similar results of leaf area founded by Khatana *et al.* (2015) in Kagzi lime.

4.13 Effect of seed treatment on Number of branches of seedling after 45 DAS

As regarding to seed treatment on seed , Number of branches after 45 DAS was found similar in all seedlings in all treatments i.e. (1) branch was found.

4.14 Effect of seed treatments and foliar application on dry weight of plant in(gm) after 90 Days

The data presented in Table 14, and depicted in fig.16 , indicated that, seed treatment non significantly influenced the dry weight of *Terminalia arjuna*.

As regarding to seed treatment the maximum dry weight was observed in treatment T_7 (7.40) i.e. hot water for 6 hrs. which was found at par with T_1 (7.18) i.e. GA_3 treatment (20 ppm for 10 min) and T_5 (6.89) i.e. cow dung slurry for (6 hrs.), T_6 (6.89) i.e. cow dung slurry for (12 hrs.) However, minimum dry weight of *Terminalia arjuna* was recorded (5.66) in T_9 i.e. control.

Table 14. Effect of seed treatments and foliar application on dry weight of plant in(gm) after 90 Days

Dry weight of plant in (gm) after 90 Days			
Seed treatment	**Foliar spray**		**(Mean A)**
	Urea(0.5%)	**Urea(1%)**	
T_1 - GA_3 20 ppm for 10 min.	7.50	6.80	7.18
T_2 - GA_3 40 ppm for 10 min.	6.30	7.40	6.88
T_3 - IBA 20 ppm for 10 min.	7.41	5.83	6.63
T_4 - IBA 40 ppm for 10 min.	6.24	6.98	6.62
T_5 - Cow-dung slurry for 6 hrs.	7.52	6.26	6.89
T_6 - Cow-dung slurry for 12 hrs.	5.88	7.90	6.89
T_7 - Hot water for 6 hrs.	8.42	6.38	7.40
T_8 - Hot water for 12 hrs.	5.40	6.19	5.80
T_9 - Control	-		5.66
Mean B	6.85	6.72	-

Interaction of seed treatment and foliar application on Dry weight of plant				
Factors	**Factor (A)**	**Factor (B)**	**Factor (A X B)**	**Control Vs Other**
F test	NS	NS	NS	NS
S.E.(m) ±	1.94	1.94	1.94	1.94
C.D. at 5%	3.94	1.97	5.57	4.18

The results of dry weight are conformity with Hossain *et al.* (2005) in *Terminalia chebula* and Khatana *et al.(*2015) in Kagzi lime.

4.15 Effect of seed treatments and foliar application on root shoot ratio

The data presented in Table 15 and depicted in Fig. 17 , indicated that, seed treatments and foliar application not significantly influenced the root shoot ratio of *Terminalia arjuna*.

Table 15. Effect of seed treatments and foliar application on root shoot ratio

Root shoot ratio			
Seed treatment	**Foliar spray**		**(Mean A**
	Urea(0.5%)	**Urea(1%)**	
T_1 - GA_3 20 ppm for 10 min.	0.53	0.77	0.65
T_2 - GA_3 40 ppm for 10 min.	0.56	0.46	0.51
T_3 - IBA 20 ppm for 10 min.	0.47	0.59	0.54
T_4 - IBA 40 ppm for 10 min.	0.54	0.47	0.51
T_5 - Cow-dung slurry for 6 hrs.	0.45	0.51	0.49
T_6 - Cow-dung slurry for 12 hrs.	0.54	0.56	0.55
T_7 - Hot water for 6 hrs.	0.50s	0.51	0.51
T_8 - Hot water for 12 hrs.	1.21	0.47	0.84
T_9 - Control	-		0.57
Mean B	0.60	0.55	-

Interaction of seed treatment and foliar application on root shoot ratio				
Factors	**Factor (A)**	**Factor (B)**	**Factor (A X B)**	**Control Vs Other**
F test	NS	NS	NS	NS
S.E.(m) ±	0.16	0.16	0.16	0.16
C.D. at 5%	0.33	0.16	0.47	0.35

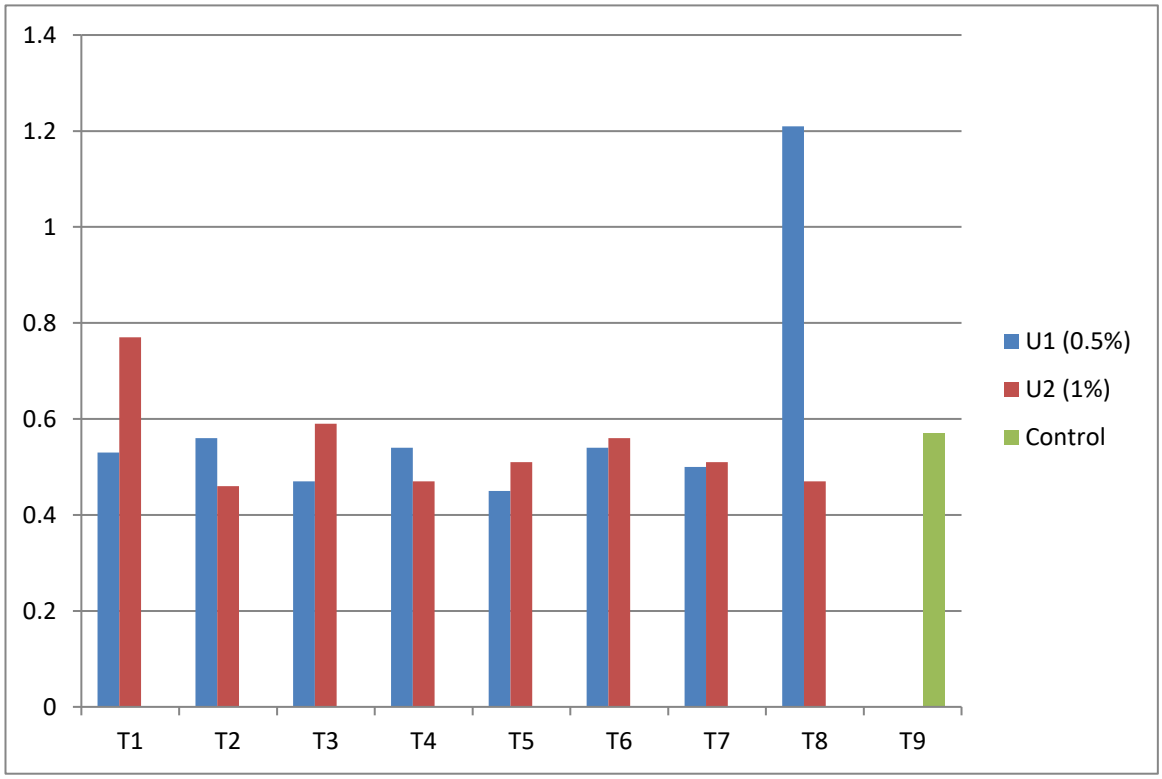

Fig. 17 Effect of seed treatments and foliar application on root / shoot ratio of plant after 90 Days

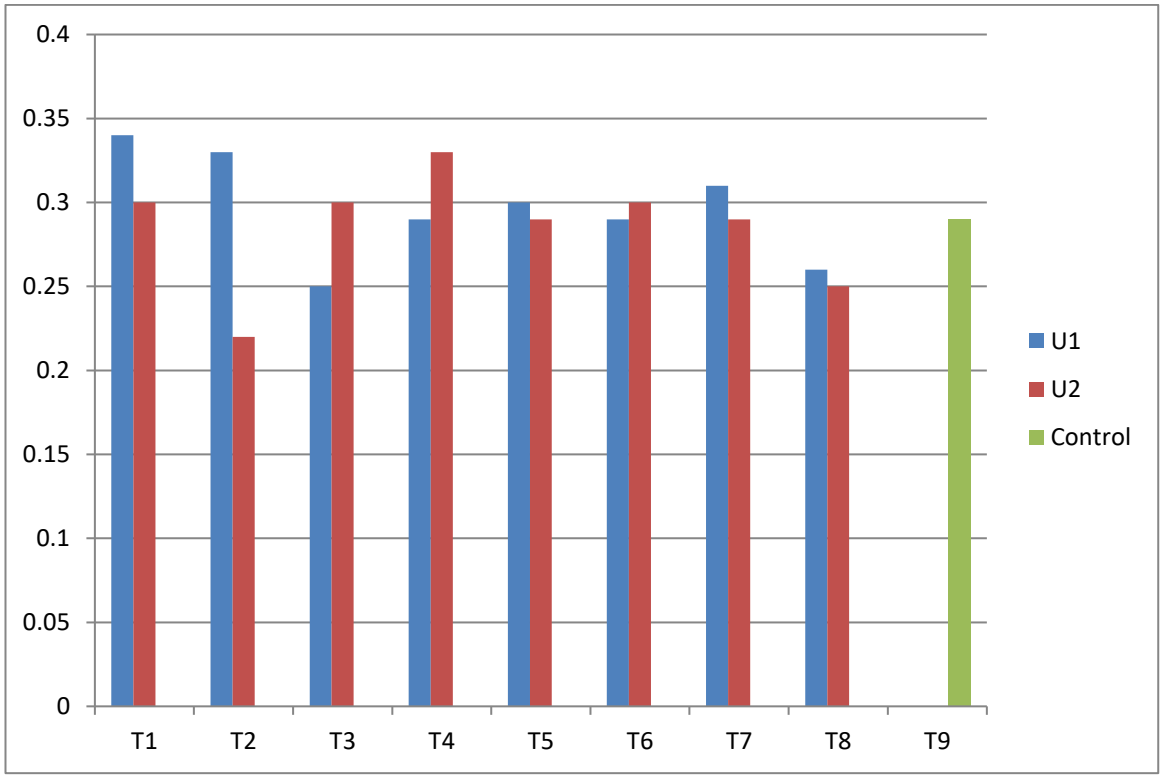

Fig . 18 Effect of seed treatment and foliar application on chlorophyll content of plant after 90 Days

As regarding to seed treatment highest root shoot ratio was observed in treatment T_8 (0.84) i.e. hot water treatment for (12 hrs.) which was found at par with (0.65) T_1 GA_3 treatment (20 ppm for 10 min.) and (0.57) T_9 i.e. control.

4.16 Effect of seed treatments and foliar application on root shoot ratio

The data presented in Table 16, and depicted in Fig 18 , indicated that, seed treatment non significantly influenced the chlorophyll content of *Terminalia arjuna*.

Table 16. Effect of seed treatments and foliar application on chlorophyll content of plant after 90 Days

Chlorophyll content of plant after 90 Days			
Seed treatment	**Foliar spray**		**(Mean A**
	Urea(0.5%)	**Urea(1%)**	
T_1 - GA_3 20 ppm for 10 min.	1.16	1.20	1.18
T_2 - GA_3 40 ppm for 10 min.	1.27	1.28	1.28
T_3 - IBA 20 ppm for 10 min.	2.57	2.59	2.58
T_4 - IBA 40 ppm for 10 min.	3.00	3.02	3.01
T_5 - Cow-dung slurry for 6 hrs.	2.26	2.24	2.25
T_6 - Cow-dung slurry for 12 hrs.	3.24	3.27	3.26
T_7 - Hot water for 6 hrs.	1.90	1.88	1.89
T_8 - Hot water for 12 hrs.	2.00	1.97	1.99
T_9 - Control	-		1.80
Mean B	2.18	2.18	-

Interaction of seed treatment and foliar application on chlorophyll content				
Factors	**Factor (A)**	**Factor (B)**	**Factor (A X B)**	**Control Vs Other**
F test	Sig	NS	NS	Sig
S.E.(m) ±	0.012	0.012	0.012	0.012
C.D. at 5%	0.025	0.012	0.036	0.027

As regarding to seed treatment the maximum chlorophyll content was observed in treatment T_6 (3.26) i.e. cow dung slurry treatment for 12 hrs. which was found at par with (3.01) T_4 i.e. IBA treatment (40 ppm for 10 min.) However, minimum chlorophyll content of *Terminalia arjuna* was recorded (1.18) in T_1 i.e. GA_3 treatment (20 ppm for 10 min.)

As regarding to foliar application the chlorophyll content recorded at 90 days after sowing was found maximum in (2.18) in foliar application of (0.5%) of urea and (1%) of urea.

The interaction effect of seed treatment and foliar application on chlorophyll content was observed maximum in treatment T_6U_2 (3.27) i.e. hot water treatment for (12 hrs.) as which was found at par with T_6U_1 (3.24) i.e. hot water treatment for (6 hrs.) However, minimum chlorophyll content of *Terminalia arjuna* was recorded (1.2) in T_1U_2 i.e. GA_3 treatment (20 ppm for 10 min.)

4.17 Effect of seed treatments and foliar application on Absolute growth rate

The data presented in Table 17, and depicted in Fig.19 , indicated that, absolute growth rate of *Terminalia arjuna* non significant by seed treatment and foliar application.

The maximum absolute growth rate of *Terminalia arjuna* was observed in T_3 (0.04) IBA treatment (20 ppm for 10 min.) and T_5 cow dung slurry for (6 hrs.) and T_7 hot water treatment for (6 hrs.) However , minimum absolute growth rate of *Terminalia arjuna* (0.02) in T_8 hot water for (12 hrs.) and T_9 control.

Table 17. Effect of seed treatments and foliar application on Absolute growth rate

Absolute growth rate (gm/day)			
Seed treatment	**Foliar spray**		**(Mean A**
	Urea(0.5%)	**Urea(1%)**	
T_1 - GA_3 20 ppm for 10 min.	0.036	0.030	0.03
T_2 - GA_3 40 ppm for 10 min.	0.029	0.035	0.03
T_3 - IBA 20 ppm for 10 min.	0.034	0.043	0.04
T_4 - IBA 40 ppm for 10 min.	0.019	0.041	0.03
T_5 - Cow-dung slurry for 6 hrs.	0.047	0.028	0.04
T_6 - Cow-dung slurry for 12 hrs.	0.028	0.034	0.03
T_7 - Hot water for 6 hrs.	0.042	0.029	0.04
T_8 - Hot water for 12 hrs.	0.020	0.019	0.02
T_9 - Control	-		0.02
Mean B	0.03	0.03	-
Interaction of seed treatment and foliar application on absolute growth rate			
Factors	**Factor (A)**	**Factor (B)**	**Factor (A X B)**	**Control Vs Other**
F test	NS	NS	NS	NS
S.E.(m) ±	0.011	0.011	0.011	0.011
C.D. at 5%	0.022	0.011	0.032	0.024

4.18 Effect of seed treatments and foliar application on Relative growth rate

The data presented in Table 18, and depicted in Fig. 20 , indicated that, relative growth rate of *Terminalia arjuna* non significant by seed treatment and foliar application. The maximum relative growth rate of *Terminalia arjuna* was observed in T_9 i.e. (0.005) in control. As well as similar result was found in T_1, T_2, T_3, T_4, T_5, T_6, T_7, T_8.

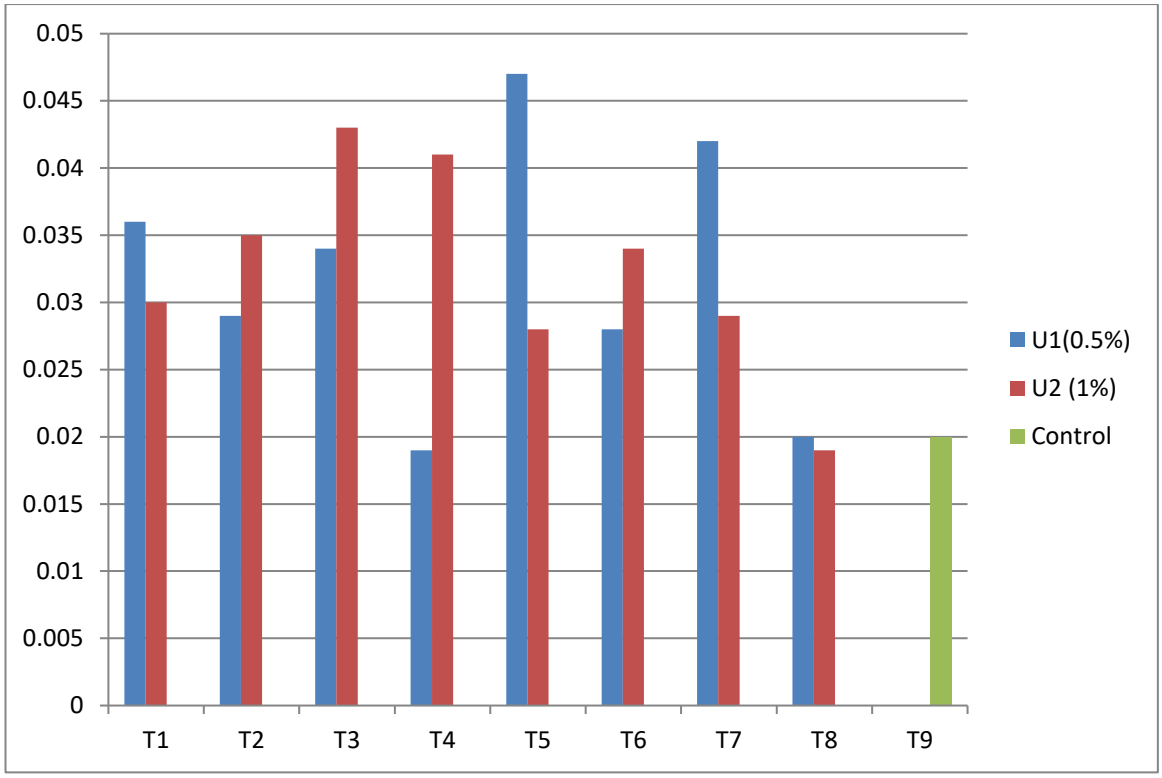

Fig. 19 Effect of seed treatment and foliar application on Absolute growth rate

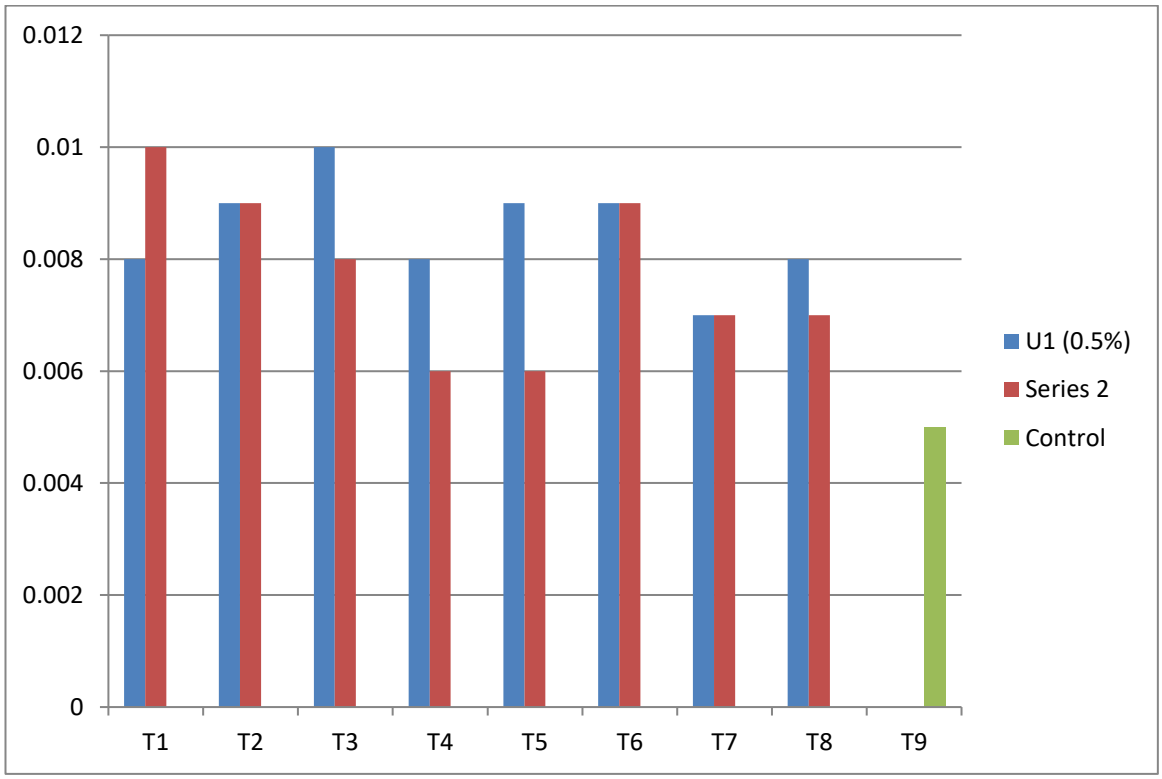

Fig. 20 Effect of seed treatment and foliar application on relative growth rate

Table 18. Effect of seed treatments and foliar application on Relative growth rate

Relative growth rate (gm/day)			
Seed treatment	**Foliar spray**		**(Mean A)**
	Urea(0.5%)	**Urea(1%)**	
T_1 - GA_3 20 ppm for 10 min.	0.008	0.010	0.001
T_2 - GA_3 40 ppm for 10 min.	0.009	0.009	0.001
T_3 - IBA 20 ppm for 10 min.	0.01	0.008	0.001
T_4 - IBA 40 ppm for 10 min.	0.008	0.006	0.001
T_5 - Cow-dung slurry for (6 hrs.	0.009	0.006	0.001
T_6 - Cow-dung slurry for (12 hrs.	0.009	0.009	0.001
T_7 - Hot water for 6 hrs.	0.007	0.007	0.001
T_8 - Hot water for 12 hrs.	0.008	0.007	0.001
T_9 - Control	-		0.005
Mean B	0.01	0.01	-
Interaction of seed treatment and foliar application on Relative growth rate			
Factors	**Factor (A)**	**Factor (B)**	**Factor (A X B)**	**Control Vs Other**
F test	NS	NS	NS	Sig
S.E.(m) ±	0.001	0.001	0.001	0.001
C.D. at 5%	0.002	0.004	0.003	0.002

4.19 Effect of seed treatments and foliar application on final survival percentage at 90 DAS

The data presented in Table 19 and depicted in Fig.21, indicated that final survival percentage not significantly influenced on seedling of *Terminalia arjuna*.

As regarding to seed treatment the maximum survival percentage was observed in treatment T_8 (38.67 %) i.e. Hot water treatment (20 ppm for 10 min) which was found at par with (36.14%) in treatment T_6 i.e. cow dung slurry treatment (for 12 hrs.) However,

minimum survival percentage was recorded (34.72%) in T_8 hot water for treatment(6 hrs.)

Table 19. Effect of seed treatments and foliar application on final survival percentage at 90 DAS

Final survival % 90 Days after sowing			
Seed treatment	**Foliar spray**		**Mean A**
	Urea(0.5%)	**Urea(1%)**	
T_1 - GA_3 20 ppm for 10 min.	34.5 (32.13)*	35.7 (34.20)*	35.16 (33.16)*
T_2 - GA_3 40 ppm for 10 min.	35.3 (33.40)*	36.4 (35.33)*	35.88 (34.36)*
T_3 - IBA 20 ppm for 10 min.	35.1 (33.20)*	36.3 (35.47)*	35.86 (34.33)*
T_4 - IBA 40 ppm for 10 min.	37.1 (36.47)*	36.5 (35.47)*	36.84 (34.97)*
T_5 - Cow-dung slurry for 6 hrs.	35.9 (34.47)*	35.3 (33.47)*	35.64 (33.97)*
T_6 - Cow-dung slurry for 12 hrs.	36.7 (35.73)*	36.2 (34.93)*	36.14 (35.33)*
T_7 - Hot water for 6 hrs.	34.7 (32.40)*	34.7 (32.47)*	34.72 (32.43)*
T_8 - Hot water for 12 hrs.	38.6 (39.00)*	38.7 (39.13)*	38.67 (39.06)*
T_9 - Control	-		35.63 (33.93)*
Mean B	34.6 (32.01)*	35.0 (32.10)*	-

Interaction of seed treatment and foliar application on Final survival percentage				
Factors	**Factor (A)**	**Factor (B)**	**Factor (A X B)**	**Control Vs Other**
F test	Sig	Sig	Sig	Sig
S.E.(m) ±	4.12	4.12	4.12	4.12
C.D. at 5%	8.39	4.19	11.8	8.90

As regarding to foliar application maximum survival percentage was recorded at 90 days after sowing was found maximum in (53.88) in foliar application of (1%) urea.

The interaction effect of seed treatment and foliar application on survival percentage of Terminalia arjuna was significantly influenced by

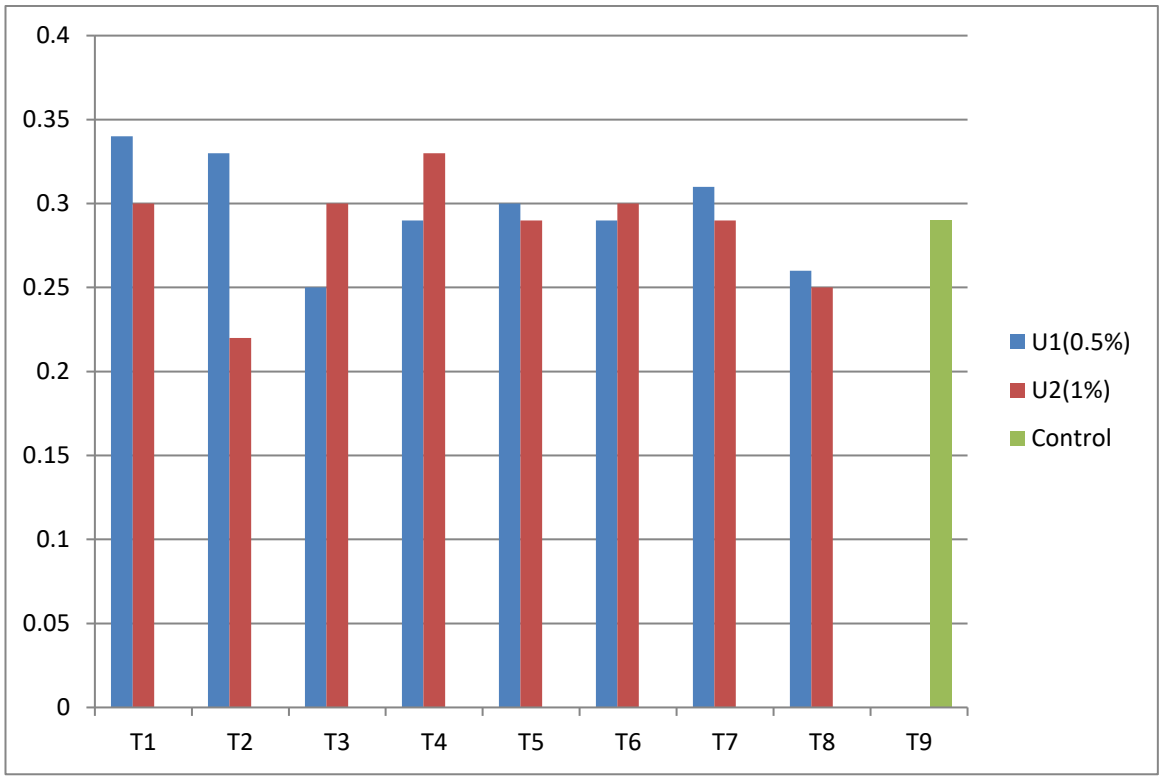

Fig. 21 Effect of seed treatment and foliar application of Final survival percentage 90 DAS

seed treatment and foliar application maximum survival percentage was observed in treatment T_8U_2 (38.7%) i.e. Hot water treatment for (12 hrs.) which was found at par with (36.5%) in treatment T_4U_2 i.e. IBA treatment for (40 ppm for 10 min) and (36..4%) in treatment T_2U_2 i.e. GA_3 treatment (immersion of 40 ppm for 10 min.) However, minimum survival percentage was recorded (34.7%) in T_7U_2 i.e. hot water treatment for (6hrs.)

The results of survival percentage are conformity with Khatana *et al.* (2015) in Kagzi lime and Dubey et al. (2003) conclude that foliar application of gibberellic acid 50 ppm 0r 30 ppm + 1% urea may be effective to enhance overall growth of seedlings of Citrus latipes rootstock, to make them ideal for seedlings.

CHAPTER V

SUMMARY AND CONCLUSIONS

The present investigation entitled, “Influence of pre-sowing treatments on seeds and foliar application on arjun (*Terminalia arjuna*)” was carried out during the year 2017-18 at nursery of Dept.of Forestry and main garden, Department of Horticulture, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola. An experiment was laid out in Factorial Completely Randomized Design with objectives to study the effect of different treatments for seed germination of *Terminalia arjuna*, to study the effect of different foliar application on seedling growth and vigour of *Terminalia arjuna* and to find out the suitable seed treatment and suitable foliar application for better seed germination, seedling growth and vigour of *Terminalia arjuna* with eight seed treatments and one control i.e. GA_3 treatment immersion in 20 ppm and 40 ppm for 10 minutes respectively, IBA treatment immersion in 20 ppm and 40 ppm for 10 minutes respectively, seed soaking in cow dung slurry for (6 hrs). and (12 hrs) respectively, seed soaking in hot water for (6 hrs) and (12 hrs)respectively, and Control (untreated seed). and foliar application of 0.5% urea and 1% urea on seedling after 45, 60 days after sowing.

The observations based on the various morphological characters viz., days required for initial seed germination in that minimum days required was 8.00 i.e.(T_7) and maximum in 15.9 i.e.(T_8), germination percentage was maximum in T_1 i.e. 68.7% and minimum in T_9 i.e.42.0%, germination period was observed maximum in T_8 i.e.(39.2) and minimum in T_5 i.e.(33.9), days for early recruits was observed maximum in T_8 i.e.(22.5) and minimum in T_7 i.e.(16.2), seedling vigour (%) was observed maximum in T_2 i.e. (86.9) and minimum in T_4 i.e.(82.2), final survival (%) after (90) DAS was observed maximum in T_8 i.e.(38.67) and minimum in T_7 i..e. (34.72), number of leaves per seedling after (30, 60, 90) DAS, height of seedling (cm) after (30, 60, 90) DAS, collar diameter of seedling (cm) after (30, 60, 90) DAS, leaf area $(cm)^2$ after (90) DAS was observed maximum in T_6 i.e.(6.93) and minimum in T_9 i.e. (4.36), dry weight of plant (g) after (90)

DAS was observed maximum in T_7 i.e.(7.40) and minimum in T_9 i.e.(5.66), root shoot ratio was observed maximum in T_8 i.e. (0.84) and minimum in T_5 i.e. (0.49), chlorophyll content mg/g was observed maximum in T_6 i.e.(3.26) and minimum in T_1 i.e. (1.18),absolute growth rate (g/day) was observed maximum in T_7 i.e. (0.04) and minimum in T_9 i.e. (0.02) and relative /growth rate (g/day) was observed maximum in T_9 i.e. (0.005) and minimum in T_1 i.e. (0.001) were observed based on means of three replications was also a part of study.

Conclusions

From the results of present investigation, the responses of seed treatments and foliar application were found non significant with some exceptional treatments.

In the different seed treatments, the seed treated with GA_3 treatment (Immersion in 20 ppm for 10 min.) prior to sowing gave the maximum germination percentage and seedling vigour.The seedling growth parameters viz. seedling height, collar diameter, Number of leaves, leaf area, Absolute growth rate, Dry weight of seedling registered maximum in seed treatment with cow dung slurry treatment for (12hrs.) and hot water treatment for (6hrs.) IBA treatment (Immersion of 20 ppm for 10 min.) gave maximum chlorophyll content of seedlings. Hence, it could be conclude that, cow dung slurry for (12 hrs.) and hot water treatment for (6hrs.) with foliar application of urea (0.5%) after 45 days with moderate vegetative growth and higher survival percentage of seedlings.

The above conclusion was based on the findings of experimental period of study. However, an extensive trial may be conducted to confirm the above result.

CHAPTER VI

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Signature of Student

APPENDIX I

The passport data regarding mother tree of *Terminalia arjuna* recorded at Department of Forestry, Dr. PDKV , Akola

Character of Mother tree of *Terminalia arjuna*	Observation Recorded
Tree height (m)	13.05
Age (yrs)	18 yrs
Girth (D.B.H. in cm)	49.72 cm
Canopy (m)	8.5
Month of flowering	April- July
Time of fruiting	February - May
Seed weight (100)	128
Number of branches	35