EFFECT OF ORGANIC AND INORGANIC GROWTH REGULATORS ON GERMINATION AND VIGOUR OF DIFFERENT PULSE SEEDS

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Approved by:

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Supervisor	**Co-Supervisor**

(Prof. Dr. A. K. M. Ruhul Amin)
Chairman Examination Committee

CERTIFICATE

This is to certify that the thesis entitled "EFFECT OF ORGANIC AND INORGANIC GROWTH REGULATORS ON GERMINATION AND VIGOUR OF DIFFERENT PULSE SEEDS submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of ***MASTER OF SCIENCE IN AGRONOMY,*** *embodies the result of a piece of bonafide research work carried out by* ***Md. Mizanur Rhaman Registration No. 05-1631****, under my supervision and guidance. No part of this thesis has been submitted for any other degree or diploma.*

I further certify that any help or sources of information as has been availed of during the course of this work has been duly acknowledged & style of the thesis have been approved and recommended for submission.

Dated:

Dhaka, Bangladesh

Professor Dr. Md. Jafar Ullah
Department of Agronomy
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SAU, Dhaka

EFFECT OF DIFFERENT ORGANIC AND INORGANIC GROWTH REGULATORS ON THE GERMINATION AND VIGOUR OF DIFFERENT PULSE SEEDS

ABSTRACT

Four separate pot experiments were carried out on four pulse crops in Rabi season during 2010 to 2011. The experiments were conducted to evaluate the effect of $GA_{3,}$ lemon juice and tamarind leaf extract on germination and vigour of pulse seed (lentil, chickpea, grasspea and cowpea).The experiments were done with cultivar, BARI Masur-4, BARI Chola-6, BARI Khesari-2 and BARI Felon-1 with three growth regulators: gibberellin, lemon juice and tamarind leaf extract. During Rabi season 2010 to 2011, three concentrations of gibberellins (10, 20 and 30 ppm), three concentrations of lemon juice (2, 4 and 6 %), three concentrations of tamarind leaf extract (0.05%, 0.1% and 0.15%) with two soaking time duration ; six hours and twelve hours with control. In Rabi seasons, in case of lentil, plant length continued to increase till harvest of young seedlings. Gibberellin(GA_3) improve germination percentage of lentil, chickpea, grass pea and cowpea; Seedlings length ,dry matter and germination index of all crops; vigour index of all crops except grass pea, and speed of germination in lentil, chickpea and grass pea. Lemon juice enhanced germination percentage, seedling length, vigour index and germination index in cowpea. Tamarind leaf extract increased the germination percentage in lentil, chickpea, grass pea and cowpea; seedling length in grass pea; vigour index in lentil, chickpea and cowpea; speed of germination in lentil, chickpea and grass pea. In comparison with plant growth regulators, length, weight, was found to be positively correlated and in most cases, relationships were significant.

LIST OF CONTENTS

LIST OF TABLES

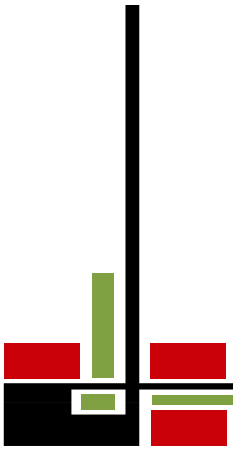
LIST OF FIGURES

LIST OF APPENDICES

LIST OF ABBREVIATIONS AND ACRONYMS

AEZ	=	Agro-Ecological Zone
BARI	=	Bangladesh Agricultural Research Institute
BBS	=	Bangladesh Bureau of Statistics
GA	=	Gibbrelic acid
ppm	=	Parts per million
et al.	=	And others
N	=	Nitrogen
J	=	Journal
ABA	=	Abscisic acid
CRD	=	completely randomized design
DAS	=	Days after setting
ha^{-1}	=	Per hectare
G	=	gram (s)
cm	=	Centimeter
µg	=	Micro gram
SAU	=	Sher-e-Bangla Agricultural University
BAU	=	Bangladesh Agricultural University
VI	=	Vigour Index
No.	=	Number

PGRs	=	Plant Growth Regulators
Wt.	=	Weight
LSD	=	Least Significant Difference
^{0}C	=	Degree Celsius
NS	=	Not significant
mm	=	millimeter
Max	=	Maximum
Min	=	Minimum
%	=	Percent
cv.	=	Cultivar
NPK	=	Nitrogen, Phosphorus and Potassium
CV%	=	Percentage of coefficient of variance
Hr or h	=	Hour
T	=	Ton
Fig	=	Figure
ml	=	Milliliter



Chapter I

Introduction

CHAPTER 1

INTRODUCTION

Human beings consume animal and plant proteins for normal growth and development. Animal protein is costly, not easily transportable and storable for long time. On the other hand, plant protein is cheaper than animal protein, and also easily transportable and storable. Pulse crops like lentil, chickpea, soybean, green gram, black gram, grass pea etc have been recognized as valuable sources of dietary plant protein in many countries of the world. Amongst plant sources, pulses contain maximum protein and provide vitamin B. In addition pulse crops improve soil health. Legumes as intercrop with major crops have beneficial effect both on crops and soil· Pulse crops are capable of fixing atmospheric nitrogen in soil in association with microbes.

Pulses contribute about 8 % of the total major food grain production (BBS 2011). In Bangladesh, pulses play an important role in the daily diet of people. The nutritional quality of pulse depends on its protein concentration, amino acid makeup and protein digestibility. The protein of pulse is highly digestible (6-90%) in human body. On the other hand, cereal protein is mostly lost during processing as it remains in the aleurone layer of the seed coat. It is believed that a ten parts of cereal to one part of pulse is an optimum combination that forms a need food chart in our diet (Kaul 1980). Pulses are used as an ideal food, meet adult human requirements for all essential amino acids excepting sulphur-

containing amino acids viz. methionine and cystine (Ashur et al. 1973), plant residues after harvest are used as fodder and feeds for cattle, goats, buffalos, poultry birds. lt has also got medicinal value. It plays an important role in the cropping patterns because of its inclusion as mixed or intercrop with cereal, mustard, and other crops. It does not deplete soil fertility like other crops, rather improves it with nitrogen and carbon. About 103 - 141 kg nitrogen/ ha is added in the soil when pulse is grown in one season (Gowda and Kaul 1982). Moreover, the loss of symbiotically fixed nitrogen from soil is less than the nitrogen being lost from chemical fertilizers (Singh 1986).

The pulse crops have a long root system for which it can grow well with limited soil moisture. After the popularization of wheat cultivation in Bangladesh, pulses crops have been pushed onto marginal land. Moreover, recently increased irrigation facilities have favoured increased boro rice cultivation reducing further the areas of pulse cultivation.

Until 2010-2011, boro rice and wheat areas increased by 6.9% and 1.8% per year respectively, whereas pulses areas decreased by 6.2% per year (BBS 2011) though the benefit ratio of pulses (1.97) was high compared to boro rice (1.39) and wheat (1.44) Miah *et al.* (1991). In Bangladesh cereal based cultivation has increased at the expense of crops, and as a result due to protein deficit the nation is experiencing unbalanced nutritional status.

With the advent of increased boro rice and wheat cultivation, the pulses were pushed ahead to poor fertile land under low levels of management.As a result, pulse, is subjected to a number of abiotic stresses, and its growth and development suffer, and as a result the yield obtained is poor.

It is well known that crop growth is directly related to the increased biomass (dry matter) production in a plant body. Moreover, grain yield of plant is a function of biomass accumulation and it could be due to poor dry matter production and or internal hormonal imbalance.

As human population is increasing at the rate of almost 2.5% and the yields of pulses have remained almost static, to meet the national demand import of pulses have increasing. In order to feed the increasing population of Bangladesh and to save foreign exchange, there is an urgent need for concerted effort to improve the yield level of all the pulses.

Improved cultivars, proper crop management practices and judicious application of growth regulating substances can induce expected increase in yield.

Yield and quality of a crop is referred to its genetic potentiality and are regulated different morphological and physiological characteristics, which are optimally activated with agronomic managements. Growth, development and yields of crops are controlled by two internal factors, nutrition and hormone. Modern cultivars may be used to ensure high potential yield.

The potential yield of a crop depends not only on its genetic makeup but also on agronomic managements. The other approach, a quite scientific one but not practiced in some countries including Bangladesh is the use of growth regulating chemicals, either natural ones or synthetic ones. From the middle of twentieth century it has been realized by many scientists that judicious use of plant growth regulators (PGRs) at some suitable- growth stage may help to exploit the physiological potentials towards increasing crop yield.

Plant growth and development are regulated by a number of intrinsic and extrinsic factors, which can be modified in various ways. The morphological, physiological and biochemical processes of plant growth are subjected to improvement using different inputs. Of the different inputs, use of growth stimulating chemicals which has tremendous potentialities, can be considered. In recent years, growth and vigour of plants are controlled by influencing the plant's metabolism directly with the application of specific growth-regulating chemicals (Salisbury and Ross, 1969).

The term plant growth regulators (PGRs) cover the broad category of organic compounds other than nutrients. A large number of synthetic compounds exhibit PGR- like activity and marketed for commercial use, particularly naphthalene acetic acid (NAA), GA_3, Auxin etc. Other natural substances with hormone-like activity have also been isolated and identified from different sources. PGRs can exert a range of effects. Some exert quite different effects when used in different plants; and sometimes the same PGRs at identical concentrations can have quite different effects on different organs of the same

plant. Moreover, different, concentrations of the same chemical elicit different responses in the same tissue. Growth regulators can promote, inhibit or otherwise modify physiological processes. These growth-stimulating chemicals used are capable of modifying growth and development, increase the yield and also improve the quality of products. Auxin and auxin related compounds were some of the first compounds used in agriculture. It is evident that modern agriculture, PGRs has been used in many countries. The impact of PGRs in manipulating physiological processes in crop production include germination, vigour, nutrient uptake from soil, photosynthesis, respiration, partitioning of assimilate, growth suppression, defoliation and post harvest ripening (Nickell, 1982; Rahman and Nath, 1993; Kathiresan and Balasubramanian,1995). The growth regulators were also found to be effective in changing the biochemical properties including protein and amino acids (Oluwatosin, 1997).

The main obstacle of popularizing plant growth regulators for common use is the cost of the chemicals. But in recent times, some plant growth regulators have become popularized because of their low cost and easy availability. If growth regulators can be used extensively, they will not remain so expensive. Besides, they act complementary to other of inputs such as fertilizers, insecticides etc. These growth regulators can also be solelly used either being imbibed in seeds or sprayed on foliage.

Poor germination and subsequent establishment of different pulse seed is a general problem in grain pulse production. Moreover, seedling establishment is further aggravated due to incidence of weeds which is a stronger competitor especially during seedling establishment. Improvement in germination capability and increasing seed vigour might be one option to make the growing pulse seedling more competitive with those of weeds. There are evidences that different natural and synthetic growth regulators improve seed germination and seedling vigour of many crops (Aldosaro et al, 1981; Whitehead and Nelson, 1992; Nobuko, 1998; Burguieres *et al*, 2007; Mohanty and Sahoo, 2006; Renugadevi and Vijayageetha, 2009).

These growth regulators may be of natural origin or synthetic. Recently folic acid and vitamin C were used in pea by Burguieres *et al*, 2007 in the concentration range of 0–500 μM as exogenous growth enhancers to stimulate pea (*Pisum sativum*) seedling vigour. Barh *et al.* (2008) pointed out carrying out an experiment with tomato juice and found that low concentration of tomato juice (2%) that contains 0.30mg/100ml ascorbic acid and 0.109% total sugars accelerated its own germination in a significant way and also showed better seedling vigor similar to the pre-treatment with 0.20 mg/100 ml Ascorbic acid.

The growth regulators both from organic (*Emblica officinalis*, lemon, etc.) and inorganic sources along with some traditional growth regulators were tried to increase the germination and vigour of different pulse seeds.

Some growth regulators when used in higher concentration, act as herbicides (Wort, 1969). In Bangladesh a large number of experiments have been undertaken in many field and horticultural crops on gibberelic acid to evaluate germination and vigour seed and it was found to have increased the growth and yield of various economically important crop plants including cereals, legumes, vegetables, fibers, oilseeds, medicinal plants, beverages, narcotics etc (Roy *et al.*, 1972, Khatun, 1973, Fattah *et al.*, 1976a; Mallik, 1976, Khatun, 1977, Mohsin *et al.*, A 1977; Chowdhury, 1978; Hussain *et al*., 1980a; Mondal, 1999).

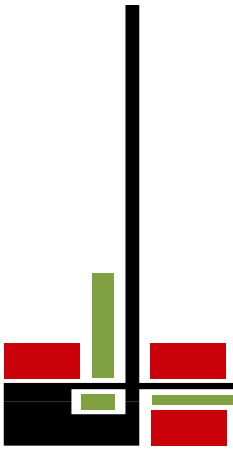
However this growth regulator was found to increase the growth and yield of many field and horticultural crops (Singh *et al*., 1972; Patel, 1992, Kar *et al*., 1993; Patel and Saxena, 1994; Uddin *et al.*,1994, Klasa *et al*., 1996, Lakshmamma and Rao, 1996; Karim, 2005). Works regarding the effect of growth regulators on pulse seed germination is very limited worldwide and is either lacking or scanty under Bangladesh condition. Thus there is scope to carry out experiments with growth regulators and to enhance our knowledge.

Moreover, it is also important to study more about the performance of on the germination, vigour and others attributes of different pulse. The present investigation has been undertaken to find out the effect of growth regulators individually or in combination on the following aspects of pulse:

i) to increase the seed germination of pulse seeds under soaking in varying concentrations of different natural and synthetic growth regulators.

ii) to evaluate vigour of different pulse seeds under soaking in varying concentrations of different natural and synthetic growth regulators.

iii) to evaluate seedling parameters of different pulses under soaking in varying concentrations of different natural and synthetic growth regulators.



Chapter II

Review of Literature

CHAPTER 2

REVIEW OF LITERATURE

Three basic food elements i.e. carbohydrate, protein and fat are required daily to provide energy for normal growth and development of human beings. However, the dietary pattern of Bangladeshi people at present is dominated by carbohydrates in the form of cereals, which is more than the body requirement. This is due to the fact that protein and fat production, either from animal or from plant sources are lower in comparison to our requirement and also is expensive in comparison to the carbohydrates. Animal protein is very expensive. Therefore, major portion of population depend on plant protein.

Among plants, pulse-producing crops are still the main source of protein. They contain over three times more protein as is obtained in cereals (Gowda and Kaul, 1982).

At present, in many countries of the world the strategy is to maximize the production of yield of crops with minimum use of fertilizers and other agrochemicals. Use of growth stimulating chemicals for increasing production of yield has drawn the attention of plant physiologists all over the world (Fattah and Roy, 1972, Jahan and Fattah, 1991, Begum *et al.*, 1992, Mondal and Fattah, 1996, Fattah *et al.*, 1998a, Fattah *et al*., (1998b).

The literature regarding the growth stimulating chemicals are huge but scattered. An attempt has, therefore, been taken to review the related but

scattered information regarding pulse and the use of growth regulators, especially gibbrellic acid, lemon juice, tamarind leaf extract with the respect of soaking time. The review of this research work was done under four pulse crop's seeds such as lentil, chickpea, grass pea and cowpea.

The chickpea (*Cicer arietinum*) is a legume crop of the family Fabaceae, subfamily Faboideae which is an ancient legume that has been cultivated in India, Africa, the Middle East, the Mediterranean and Ethiopia for centuries (Oplinger *et al.*, 1997; Berrada *et al.*, 1999).

Chickpea is a drought tolerant, cool-season, legume crop. It performs best in silt loam or sandy soils with good drainage. Chickpea does not tolerate wet soils (Corp *et al*., 2004)

The Grasspea (*Lathyrus sativus**)*** is a legume crop under the family Fabaceae commonly grown for human consumption and livestock feed in Asia and East Africa. It is a particularly important crop in areas that are prone to drought and famine, and is thought of as an 'insurance crop' as it produces reliable yields when all other crops fail. Flour made from grass peas (Spanish: almorta) is the main ingredient for the *gachas manchegas* or *gachas de almorta*. Accompaniments for the dish vary throughout La Mancha. This is an ancient Manchego cuisine staple, generally consumed during the cold winter months. The dish is generally eaten directly out of the pan it was cooked in, using either a spoon or a simple slice of bread. This dish is commonly consumed

immediately after removing it from the fire, being careful not to burn one's lips or tongue.

Grasspea flour is exceedingly difficult to obtain outside of Castile-La Mancha, especially in its pure form. Commercially available *almorta* flour is mixed with wheat flour due to the fact that grass peas are toxic if consumed in significantly large quantities for prolonged periods of time (Rao *et al.*, 1964).

The Cowpeas are dicotyledoneous crop that belonging to the family Fabaceae, subfamily- Faboideae, (Verdcourt, 1970,). It has chromosome number 2n = 22.It's scientific name is Vigna unguiculata (L) Walp. and other synonyms are D0lich0s. unguiculata L, Dolichos sinensis L and Wgncz sinensis Hassk. Cowpea plants are trailing or climbing types. Its leaves are trifoliate and inflorescence bears white, yellowish or purplish flowers.

Plant growth regulators (PGRs) have a particularly interesting role in modern agriculture (Ashraf *et al*., 2011). In Greece and others European countries the PGRs are commonly used on food crops (melon, pepper, celery etc) in order to improve and accelerate plant productivity. The knowledge of their metabolic and transport pathways will lead to new opportunities to manipulate regulator levels and thus regulate plant growth. PGRs can have quite different effects on different plants; sometimes even the same PGR at identical concentrations can have quite different effects on different organs of the same plant. Besides, different concentrations of the same chemical can have different responses from the same tissue . PGRs can promote, inhibit or modify physiological

processes, if used properly they can modify growth and development, increase yields and can also improve the quality of yield.

The impact of plant growth regulators on physiological processes of crop plant includes germination, propagation, nutrient uptake from soil, photosynthesis, transpiration, flowering, fruiting, partitioning of assimilate, growth suppression, defoliation and post harvest ripening . Auxin and auxin-related compounds are some of the PGRs that were first used in agriculture.

Gibberellins have been used by researchers, but it does not seem to have been used in any other countries in South Asia. It has been found that the application of gibberellins influenced positively on the germination and vigour of various economically important crop plants such as cereals, legumes, vegetables, fruits, fibers, oilseeds, medicinal, beverages, and narcotics.

Other investigators around the world also found that application of appropriate concentration of salts of naphthenic acid effected the physiological and biochemical activities of different plants which lead to higher yield (Guseinov *et al*., 1956, Yureva, 1965, Wort, 1969, Fattah and Wort, 1970a, Fattah *et al.*, 1976a, Fattah and Pasha, 1978, Hussain *et al.*,1980a, Huq *et al*., 1986,Hossain and Fattah,1990, Jahan *et al*., 1991, Begum *et al*.,1992, Mondal and Fattah, 1996 and Jahan *et al*.,1997).

Growth regulators have been found to increase seedling length by accelerating cell division and elongating internodes (Brain and Hemming, 1958) and increase biomass yield (Kelaiya *et al*., 1991; Saxena, 1994). The growth

regulators were also found to have effective role in increasing the chemical properties such as protein and amino acids (Oluwatosin, 1997). The growth regulators may be used extensively, if they are inexpensive and if they act supplementary to other types of inputs such as fertilizers, insecticides etc. These growth regulators can be used either being imbibed in seed or sprayed on foliage. But limited works regarding the effect of growth regulators on pulses has been carried out in scientific world or in Bangladesh. Due to the increasing demands and wide adaptability, pulse research is now driving more international attention. The International Institute of Tropical Agriculture (IITA, 1981) has strong programme for pulse research. India, Philippines, USA, and Australia, have now allocated additional budget for its research. In Bangladesh cowpea, chickpea, black gram and grass pea are generally cultivated as a pulse crop. Although,pulses play an insignificant role in our agricultural field in terms of acreage and production, but for its excellent taste, market price and nutritional value it is now occupying a significant place in our cropping system. It contains about three times more protein than the cereals. It improves soil fertility and is an excellent source of quality fodder (Gowda and Kaul, 1982). However, the yield of pulse crops is still very low compared to wheat, which is also grown in rice cropping pattern.

Like many other crops, germination and growth can be increased by applying growth regulators. There is evidence that gibberelic acid can also be used in crop production for increasing yield. It is therefore, important to investigate ways to increase the germination and vigour's of pulse crop.

Germination percentages, germination index and speed of germination:

Gibberellic acid (GA3) is known to be concerned in the regulation of plant responses to the external environment (Chakrabarti and Mukherji, 2003), also, application of another plant growth bio-regulator has increased the saline tolerance of many crop plants (Haroun *et al.*, 1991; Hoque and Haque, 2002). GA3 has also been shown to alleviate the effects of salt stress on water use efficiency (Aldesuquy and Ibrahim, 2001).

Significant difference between growth regulators treatments on germination index, highest germination index was obtained by soaking in GA3 at concentration of 10 ppm plus IAA at concentration of 6 ppm (16.76%) was also seen by soaking in GA3 at concentration of 10 ppm(16.66%). Similar results were recorded by some of the other researchers (Sharma *et al*., 1999).

Das Gupta *et al*. (1994) observed the more effectiveness of low concentration of GA3 to restore the retardation in water content, this may able to tolerance to water stress. Ahmad *et al.*(1998); Harris *et al.*(1999) shown that varied in seed germination and root shoot elongation by different treatments, the pre-soaking with different treatments evident that soaked seed could improve in germination and seedling establishment. The soaking period of 24 hrs increased the total uptake of water which help the maximum imbibitions rate. Same

experiment was conducted in Black gram and Horse gram by Mohanty and Sahoo (2006).

Larcher & Prado (2000) commented that GA_3 (gibberellin) induces mRNA, which in turn produces the synthesis of a-amilase, protease, nuclease and others. On the other hand, on auxin's effects on membrane permeability and primary root growth during germination viable.

Gibberellin (GA), induces embryo growth and stimulates the germination process. Therefore, in comparison to water-irrigated seeds, no substantial change in germination was observed under GA3treatment. GA3 is well-documented regulator of germination and associated enzymes with generally having promotive effects (Fincher, 1989).

Effect on seedling length of different pulses

Rahim, A. M. (2005) reported that application of 1.0 mg GABA per litre increased the plant height in soybean. Islam *et al.* (2004) observed that 0.664 ml GABA per litre enhanced plant height significantly in lentil.

It was observed by some researchers (Ouzounidou *et al.,* 2008; Yamaguchi, 2008; Yu *et al.,* 2009) that gibberellins play a major role in diverse growth processes including seed development, organ elongation, senescence .

Santner *et al*. (2009) showed that GAs is synthesized from geranyl geranyl diphosphate in a multi enzyme pathway that is subject to complex regulation. Further, GA levels are influenced by other hormones such as ethylene.

Effect on fresh weight of different pulse seedlings

Low concentration of IAA was found to promote plant growth, whereas high concentrations inhibited root growth ,thus indicating that effect of IAA depends on the concentration(Arshad and Frankenberger,1991;Keyeo *et al.*,2011).

Effect on dry matter of different pulse seedlings

Kar(1993) obtained maximum dry matter yield of chickpea due to GA application. Tickoo *et al*. (1974) noticed increase in dry matter of chickpea with 75 ppm GA.

Kalita *et al.* (1995) spraying 100 ppm NAA at 40 DAS on the foliage found increased total dry matter of green gram. But applying 100 ppm NAA combination with 3.i% P_2O_5, resulted in further increasing in seed yield. And applying 100 ppm NAA in combination with 3.00 % P_2O_5, resulted in further increase in dry matter in leaf, stem and root along with total dry matter.

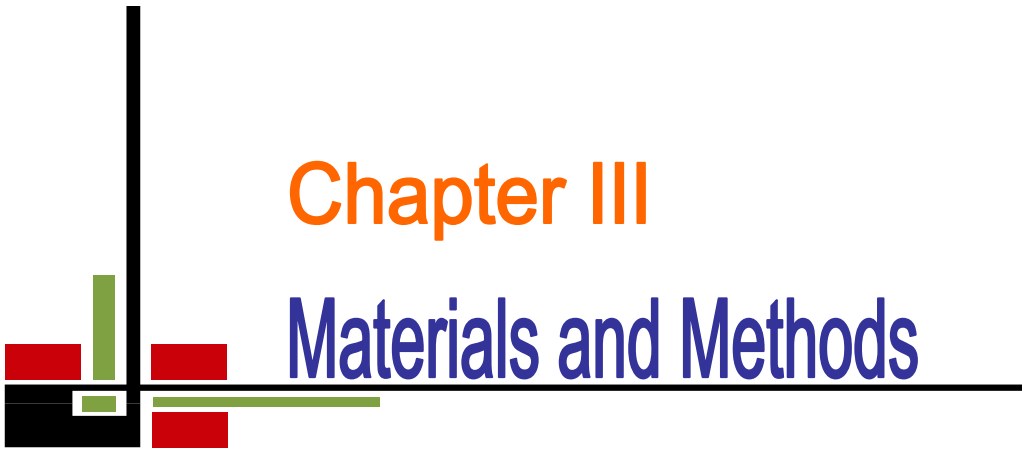
Karim (2005) applying different concentrations of NAA on chickpea and found that spraying NAA on the foliage at concentration of 20 ppm resulted highest dm/plant. The dm was found to decrease with further increase in the concentration.

Fattah *et al.* (1976c) reported that in BR-3 rice, maximum dry weight was obtained with seed soaking in 10 or 15 ppm solution or spraying on foliage with 5 ppm solution of KNap.

Karim (2005) carried out experiments applying different concentrations of KNap and NAA on chickpea. It was found that spraying on the foliage at concentration of 1500 ppm resulted in the highest dm/plant. Further increase in the concentration, the dm was decreased.

Effect on vigour index of different pulse

Burguieres (2007) observed that vitamin C in the concentration range of 0-500 as exogenous growth enhancers to stimulate pea (Pisum sativum) seedling vigour. It also observed by Burguieres that 50 μM folic acid and 500 μM vitamin c were optimum in maximumlly enhancing seed vigour and potentially seedling performance according to both agronomic and biological seed vigour.



Chapter III

Materials and Methods

CHAPTER 3

MATERIALS AND METHODS

3.1. Experimental site:

The research work relating to determine the effect of organic and inorganic growth regulators on germination and vigour which was conducted at the Agronomy Research laboratory of Sher-e-Bangla Agricultural University, Dhaka-1207 during November 2010 to March 2011.

3.2. Geographical Location:

The experimental area was situated at 23°77'N latitude and 90°33'E longitude at an altitude of 8.6 meter above the sea level . The experimental lab belongs to the Agro-ecological zone of "The Modhupur Tract", AEZ-28. The experimental site was shown in the map of AEZ of Bangladesh in Appendix I.

3.3. Climate:

Area has subtropical micro climate (room condition), characterized by medium temperature, low relative humidity during the Rabi season (October-March).

3.4 Planting materials:

Seed: The genetically pure and physically healthy seeds of different pulses (lentil, chickpea, grass pea and cowpea) were collected from of Bangladesh Agricultural Research Institute (BARI), Gazipur.

Pot: 13 cm diameter sized pots were used to perform the study . The study was initiated in October 2010. In total, 4 experiments were completed.

3.5. Different treatments and their concentration*:*

Seeds were soaked in different concentrations of three growth regulators namely 1. Lemon juice (*Citrus limon*) with three concentrations (L1= 2%, L2=4%, L3=6 %), 2. Tamarind leaf extract (*Tamarindus indica*) with three concentrations (T1= 0.05*%, T2*=0.1*%* and *T3*=0.15%*) (g smashed leaf/100 ml distilled water) and* 3. Gibberellin (GA_3) (G)with three concentrations (G1= 10 ppm, G2=20 ppm and G3=30 ppm) for 6 hours (H1)and 12 hours (H2)along with soaking in distilled water for 6 hours (S6)and 12 hours (S12)and also another one performing standard germination test without soaking (S0).

As such each experiment had 21 treatments as follows:

S0 = Without soaking

S6 = Soaking in distilled water for 6 hours

S12 = Soaking in distilled water for 12 hours

L1H6 = Soaking in lemon juice 2% for 6 hours

L1H12 = Soaking in lemon juice 2% for 12 hours

L2H6 = Soaking in lemon juice 4% for 6 hours

L2H12 = Soaking in lemon juice 4% for 6 hours

L3H6 = Soaking in lemon juice 6% for 6 hours

L3H12 = Soaking in lemon juice 6% for 6 hours

T1H6 = Soaking in tamarind leaf extruct 0.05% for 6 hours

T1H12 = Soaking in tamarind leaf extruct 0.05% for 12 hours

T2H6 = Soaking in tamarind leaf extruct 0.1% for 6 hours

T2H12 = Soaking in tamarind leaf extruct 0.1% for 12 hours

T3H6 = Soaking in tamarind leaf extruct 0.15% for 6 hours

T3H12 = Soaking in tamarind leaf extruct 0.15% for 12 hours

G1H6 = Soaking in gibberellin 10 ppm for 6 hours

G1H12 = Soaking in gibberellin 10 ppm for 12 hours

G2H6 = Soaking in gibberellin 20 ppm for 6 hours

G2H12 = Soaking in gibberellin 20 ppm for 12 hours

G3H6 = Soaking in gibberellin 30 ppm for 6 hours

G3H12 = Soaking in gibberellin 30 ppm for 12 hours

Each crop seed was evaluated in a single experiemt and as such using lentill, chickpea, grasspea and cowpea seeds four experiments were conducted.

Replications: 3

Design: Completely randomized design (CRD)

3.6. Conducting the experiments:

i. Seeds of lentil-4, BARI chickpea-6, BARI grasspea-2 and BARI cowpea-1 were used in this study.

ii. In each experiment, hundred seeds in each pot were placed excepting that for cowpea 50 seeds/pot were placed.

iii. The seeds were placed on sands in plastic pots of 13 cm dia.

iv. The performance of natural and synthetic growth regulators was evaluated on the basis of laboratory germination test by collecting different germination parameters e.g. germination % and seedling growth parameters i.e. shoot length, shoot fresh and dry weight, vigour index, speed of germination and germination index. However, in all the experiments, all the data could not be taken due to some limitations.

3.7. Methods of preparation of extracts and growth regulator solutions.

i) Lemon juice preparation:

Lemon was cut and squeezed, the juice was filtered. Lemon juice solution was made as follows;

2% = 10 ml in 500 ml

4% = 20 ml in 500 ml

6% = 30 ml in 500 ml

ii) Tamarind leaf extract

1. *Tamarindus indica* fresh leaves(w/v)

= 0.5, 1 and 1.5 g fresh smashed leaves/L of distilled water (= 0, 0.05, 0.1 and 0.15%).

iii) GA_3:

1 mg/mL stocks was made by dissolving 20 mg of GA_3 in 20 ml 50% (v:v) ethanol (in distilled water). For this 0.040 g (40 mg) of GA_3 (1000 mg = 1.0 g) was measured and poured it in a flux. Then added to it 20 ml ethanol and 20 ml water (i.e. 50% ethanol) and stirred periodically as long as required and stored overnight. This was stirred again to dissolve the GA_3. When dissolved

completely added to it 460 ml water to raise the volume up to 500 ml i.e. 0.04 g in 500 ml = 0.04/500*100%=0.008% = 80 ppm (.008*10,000).

Then to make 10 ppm, take 62.5 ml of stock solution, dilute 8 times by raising the volume to 500 ml (80/10=8 times). ie. 62.5 ml stock of 80 ppm in 500 ml volume.

To make 20 ppm, take 125 ml of stock solution, dilute 4 times to raise the volume to 500 ml (80/10=8 times). ie. 125 ml stock of 80 ppm in 500 ml volume.

To make 30 ppm, take 187.5 ml of stock solution, dilute to raise the volume to 500 ml water ie, 187.5 ml stock of 80 ppm in 500 ml volume.

3.8. Recording of data

For recording length, 20 seedlings in each pot were selected randomly. For assessing fresh and dry weight, seedlings of whole pot were considered.

3.8.1. Germination percentage

Germination meant when either cotyledons or plumule emerged above the sand upper surface (AOSA, 1983). The number of days was counted from the date of placement.

3.8.2. Seedling length (cm)

The plant height was measured from ground level to tip of the stem/ longest leaf.

3.8.3. Seedling fresh weight

For the seedlings fresh weight determination, the seedlings were removed from the pots at the time of harvest and then the weights of seedling were recorded.

3.8.4. Seedling dry weight

For dry weight determination, the seedlings were removed and dried in an electric oven at 70°C temperature for 48 hours. Then the dry weight was recorded

3.8.5. Vigour index

Vigour index = seedling length X germination % (Abdul-Baki and Anderson, 1973)

3.8.6. Germination index

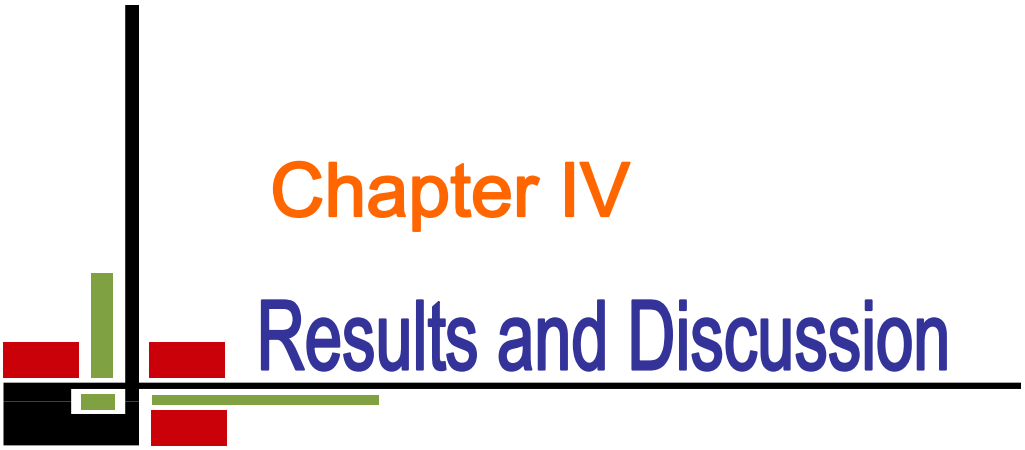
Germination index= no. of germinated seeds/days of first count+…+…+no. of germinated seeds/days of final count .

3.8.7. Speed of germination (No. of seeds germinated/day)

Speed of germination = n/d; where, n =number of seedlings germinated on day ‘d’, d = day after planting.

3.8.8. **Statistical analysis:** Mean data of the characters were subjected to multivariate analysis. Univariate analysis of the individual character was done for all characters under study using the mean values and was estimated using MSTAT-C computer programme. LSD was performed for all the characters to test the differences between the means of the different data. Mean, range and co-efficient of variation (CV %) were also estimated using MSTAT-C.

Chapter IV



Results and Discussion

CHAPTER 4

RESULTS AND DISCUSSION

Growth and development of plants are regulated by a number of intrinsic and extrinsic factors, which can be modified in various ways, the morphological, physiological and biochemical processes of plant growth can be controlled by the application of plant growth regulators (PGRs). Hence, the effect of growth regulators on growth and development is economically important. PGRs are being vigorously investigated by plant physiologist and agronomists in many countries of the world. Four pieces of research work have been undertaken to evaluate the response of germination and vigour of pulse to PGRs. The primary objective was that following PGRs treatments, which will give higher seed germination, germination index, highest plant length, highest fresh weight, dry weight and highest speed of germination.

During the present study, it was found that following treatments of Gibberellins, lemon juice and tamarind leaf extract differing in soaking time the studied parameters were affected, but the magnitude of effect depended on the concentrations of PGRs.

The results obtained in this study have been explained, discussed and evaluated in the light of available literature. Result obtained from the present study have been presented and discussed in this chapter. The data have been presented in different tables and figures .The results have been presented and discussed, and possible interpretations are given under the following headings.

4.1. Experiment 1: Effect of lemon juice (L), tamarind leaf extracts (T) and gibberellin (G) under 6 and 12 hours soaking on the seed germination, vigour and seedling parameters of lentil seeds

4.1.1. Effect on germination percentage on lentil:

Germination of lentil started from three days after sowing which ranged from zero to 19.02% at this DAS (Table 1). The non soaked and most of the tamarind treated seeds did not germinate. The non-soaked treatment always showed the lowest germination%. Germination was also improved due to soaking. However the improvement due to soaking for 12 hours was not so great as compared to those soaked for 6 hours. Gibberellic acid treated seeds showed higher germination values. The six hour soaked G2 treatment showed the highest germination percentage. Other treatments showed lower germination percentage than the seeds soaked for six hours (S6).

At 4 DAS germination ranged from 7.98% (non-soaked) to 84.82 % (G2H6). At 6 DAS instead of G2H6, G3H12 gave the highest germination percentage. At the later stages this trend was continued by G3H12 showing the highest germination percentage. At these DAS T1H12, G1H2, G2H12, G3H6 showed remarkably higher values than S12. Seeds soaked for 12 hours showed higher value than those soaked for 6 hours.

Table 1: Effect of lemon juice, tamarind leaf extract and gibberellin on the germination percentage of lentil seeds

	Germination(%)				
Treatments	3DAS	4 DAS	6 DAS	7 DAS	10 DAS
S0	0.00	7.98	44.44	52.77	55.91
S6	1.38	14.46	82.11	84.88	88.74
S12	1.81	23.51	79.17	84.25	84.57
L1H6	2.75	15.52	57.00	39.75	53.62
L1H12	0.30	15.11	58.12	38.34	60.00
L2H6	3.10	17.25	28.63	31.40	34.84
L2H12	1.17	9.34	25.81	25.63	28.12
L3H6	0.00	12.26	35.34	39.69	51.72
L3H12	0.00	13.05	29.59	27.02	31.49
T1H6	0.00	17.52	67.67	73.57	72.15
T1H12	0.00	33.22	87.19	88.92	88.92
T2H6	0.96	37.04	63.90	67.38	67.70
T2H12	1.03	26.52	82.85	82.85	82.85
T3H6	0.29	27.76	68.86	80.05	81.06
T3H12	1.61	35.85	78.13	78.13	78.13
G1H6	5.52	60.70	82.35	82.35	82.35
G1H12	17.25	71.47	87.95	89.02	93.63
G2H6	19.03	84.81	88.80	90.40	89.44
G2H12	6.55	68.33	90.28	90.92	91.25
G3H6	16.44	74.75	91.08	89.77	90.05
G3H12	13.37	77.56	98.92	99.78	99.80
LSD(0.05)	4.56	17.00	11.76	12.06	11.45
CV (%)	4.34	6.45	5.89	6.08	5.90

Here,
DAS =Days after setting
S0 = Without soaking;
S6 = Soaking in distilled water for 6 hours;
S12 = Soaking in distilled water for 12 hours; ;
L1H6 = Soaking in lemon juice 2% for 6 hours;
L1H12 = Soaking in lemon juice 2% for 12 hours;
L2H6 = Soaking in lemon juice 4% for 6 hours;
L2H12 = Soaking in lemon juice 4% for 6 hours;
L3H6 = Soaking in lemon juice 6% for 6 hours;
L3H12 = Soaking in lemon juice 6% for 6 hours;
T1H6 = Soaking in tamarind leaf extruct 0.05% for 6 hours;
T1H12 = Soaking in tamarind leaf extruct 0.05% for 12 hours
T2H6 = Soaking in tamarind leaf extruct 0.1% for 6 hours;
T2H12 = Soaking in tamarind leaf extruct 0.1% for 12 hours;
T3H6 = Soaking in tamarind leaf extruct 0.15% for 6 hours;
T3H6 = Soaking in tamarind leaf extruct 0.15% for 6 hours
G1H6 = Soaking in gibberellin 10 ppm for 6 hours
G1H12 = Soaking in gibberellin 10 ppm for 12 hours
G2H6 = Soaking in gibberellin 20 ppm for 6 hours
G2H12 = Soaking in gibberellin 20 ppm for 12 hours
G3H6 = Soaking in gibberellin 30 ppm for 6 hours
G3H12 = Soaking in gibberellin 30 ppm for 12 hours

4.1.2. Effect on seedling length of lentil:

Seedling length has been found to be influenced by lemon juice and tamarind leaf extract. There are evidences that the seedling length is greatly influenced by the application of growth regulartors. Lakshmamma and Rao (1996) found that the black gram seedlings length on spraying with 5- 20ppm NAA at flowering stage was progressively increased. Uddin *et al.* **(**1994) by spraying 500ppm NAA on the foliage of lablab bean at 72DAS, observed a significant increase in internodes length. It was observed that even by soaking seeds in 25-50ppm NAA, seedling length of soybean was increased (Maske *et al*, 1997). However, the seedling length was found to decrease when seeds were soaked in highly concentrated (150ppm) NAA solution.

Similar result was found in this study. Higher concentration of different growth regulators reduced the seedling length. In this experiment with lentil it was found that different seedling length ranged from 0.99% (with S0) to 3.09% (with G2H12) (Fig. 1).

At 5 DAS, the mean seedling length ranged from 1.49 cm to 3.097cm with LSD 0.3259 at 0.05% level of significance. At 7 DAS, G1H12 and G3H6 showed the highest seedling lengths (6.61cm and 6.12 cm respectively) whereas T1H12 and L1H12 showed the lowest value (2.6). At 10 DAS, the treatments did not show appreciable difference in comparison to S12 but the difference was noticed when compared with S0, S6 and L3H12 (6% lemon juice with 12 hours soaking). Probably at higher concentration (6% or more) of

lemon juice with 12 hours reduced the cell elongation of seedlings which intern reduced the seedling length. The analysis of variance revealed highly significant differences among the treatments with respect to seedling length.

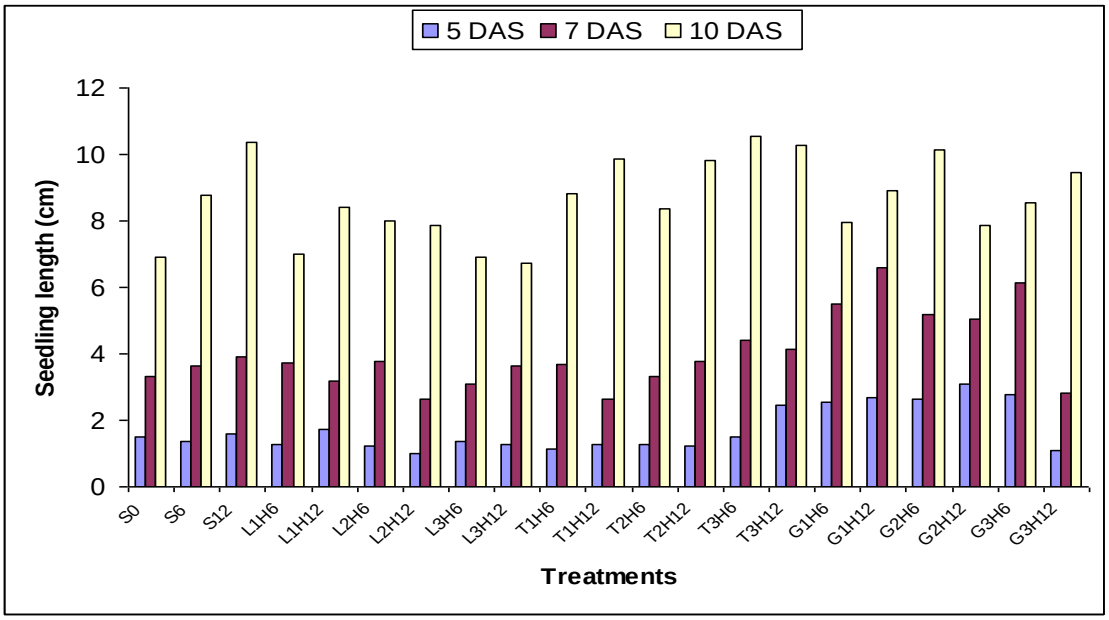


Fig. 1: Effect of lemon juice, tamarind leaf extract and gibberellins on the seedling length of lentil [LSD (0.05): 1.34, 1.65 and 2.35 at 5, 7 and 10 DAS respectively]

Here,
DAS =Days after setting
S0 = Without soaking;
S6 = Soaking in distilled water for 6 hours;
S12 = Soaking in distilled water for 12 hours; ;
L1H6 = Soaking in lemon juice 2% for 6 hours;
L1H12 = Soaking in lemon juice 2% for 12 hours;
L2H6 = Soaking in lemon juice 4% for 6 hours;
L2H12 = Soaking in lemon juice 4% for 6 hours;
L3H6 = Soaking in lemon juice 6% for 6 hours;
L3H12 = Soaking in lemon juice 6% for 6 hours;
T1H6 = Soaking in tamarind leaf extruct 0.05% for 6 hours;
T1H12 = Soaking in tamarind leaf extruct 0.05% for 12 hours
T2H6 = Soaking in tamarind leaf extruct 0.1% for 6 hours;
T2H12 = Soaking in tamarind leaf extruct 0.1% for 12 hours;
T3H6 = Soaking in tamarind leaf extruct 0.15% for 6 hours;
T3H6 = Soaking in tamarind leaf extruct 0.15% for 6 hours
G1H6 = Soaking in gibberellin 10 ppm for 6 hours
G1H12 = Soaking in gibberellin 10 ppm for 12 hours
G2H6 = Soaking in gibberellin 20 ppm for 6 hours
G2H12 = Soaking in gibberellin 20 ppm for 12 hours
G3H6 = Soaking in gibberellin 30 ppm for 6 hours
G3H12 = Soaking in gibberellin 30 ppm for 12 hours

4.1.3. Effect on seedling dry matter of lentil:

At 3 DAS, the seedling dry matter was lowest with S0 (0.21g) while the highest with T1H12 (0.45g) and T2H12 (0.43g) (Table 2). The G2H6 (0.37g) and G3H12 (0.38g) treatments also showed higher dry weight as compared with the non-soaked and soaked treatments. The soaked treatments also showed significantly higher dry matter (0.37g) than S0 (386.73g).

4.1.4. Effect on vigour index of lentil:

The vigour index was found highly significant with all treatments. Likewise, the maximum vigour index was found with G2H6 (908.03) and G3H12 (978.86) which were remarkably higher even than S12 (877.48). S0, L2H6, L2H12 and L3H12 were showed the lower vigour index (386.73). The use of gibberelin and tamarind leaf extract gave better result than lemon juice treated seeds (Table 2).

4.1.5. Effect on germination index of lentil:

Against the lowest germination index of S0 (27), T1H12 (44.43) and all the gibberellin concentrations gave much higher germination index (44.64) (Table 2). In comparison to S0, the said parameter was improved by soaking seeds in only distilled water with 12 hours, S12 (40.17) which was again improved by the treatments T1H12 and all the gibberellin concentrations.

4.1.6. Effect on speed of germination of lentil:

The speed of germination was 6.59cm with a range of 2.13 to 5.17 cm. The S0 treatment showed the minimum speed of germination (5.59cm) and the G1H12 showed the maximum speed of germination (60.36cm). The speed of germination was improved by the G2H6 and G3H6 which again was improved by the treatments of G1H12 (Table 2).

Table 2: Effect of lemon juice, tamarind leaf extract and gibberellin on final seedling dry matter, vigour index, germination index and speed of germination of lentil at 10 days after setting

Treatments	Final seedling dry matter (g/pot)	Vigour index	Germination index	Speed of germination (Number/day)
S0	0.21	386.73	22.53	5.59
S6	0.37	779.44	38.76	8.87
S12	0.33	877.48	40.17	8.46
L1H6	0.20	375.33	25.34	5.36
L1H12	0.20	504.98	25.04	6.00
L2H6	0.18	277.86	18.09	3.48
L2H12	0.17	220.82	13.50	2.81
L3H6	0.21	358.57	19.80	5.17
L3H12	0.18	212.26	15.20	3.15
T1H6	0.38	636.15	33.38	7.22
T1H12	0.45	877.32	44.43	8.89
T2H6	0.34	565.04	36.62	6.77
T2H12	0.43	813.85	40.90	8.28
T3H6	0.33	855.07	38.06	8.11
T3H12	0.34	801.43	41.50	7.81
G1H6	0.32	655.02	50.74	8.23
G1H12	0.34	836.45	60.36	9.36
G2H6	0.37	908.03	64.20	8.94
G2H12	0.31	716.28	56.43	9.12
G3H6	0.31	770.86	61.18	9.01
G3H12	0.38	978.86	65.75	10.37
LSD (0.05)	0.05	102.56	15.39	1.93
CV (%)	5.08	6.95	7.05	5.49

Here,
DAS =Days after setting
S0 = Without soaking;
S6 = Soaking in distilled water for 6 hours;
S12 = Soaking in distilled water for 12 hours; ;
L1H6 = Soaking in lemon juice 2% for 6 hours;
L1H12 = Soaking in lemon juice 2% for 12 hours;
L2H6 = Soaking in lemon juice 4% for 6 hours;
L2H12 = Soaking in lemon juice 4% for 6 hours;
L3H6 = Soaking in lemon juice 6% for 6 hours;
L3H12 = Soaking in lemon juice 6% for 6 hours;
T1H6 = Soaking in tamarind leaf extruct 0.05% for 6 hours;
T1H12 = Soaking in tamarind leaf extruct 0.05% for 12 hours
T2H6 = Soaking in tamarind leaf extruct 0.1% for 6 hours;
T2H12 = Soaking in tamarind leaf extruct 0.1% for 12 hours;
T3H6 = Soaking in tamarind leaf extruct 0.15% for 6 hours;
T3H6 = Soaking in tamarind leaf extruct 0.15% for 6 hours
G1H6 = Soaking in gibberellin 10 ppm for 6 hours
G1H12 = Soaking in gibberellin 10 ppm for 12 hours
G2H6 = Soaking in gibberellin 20 ppm for 6 hours
G2H12 = Soaking in gibberellin 20 ppm for 12 hours
G3H6 = Soaking in gibberellin 30 ppm for 6 hours
G3H12 = Soaking in gibberellin 30 ppm for 12 hours

Expt 2: Effect of lemon juice (L), tamarind leaf extract (T) and gibberellin (G) under 6 and 12 hours soaking on the seed germination, vigour and seedling parameters of chickpea

4.2.1. Effect on germination percentage of chickpea

Germination of chickpea started from three days after sowing. It ranged from 0-39.47, 48.93-91.89 and 60-95.23% at 3, 4 and 5 DAS respectively (Fig. 2). The non soaked at most of the cases lemon treated seeds showed lower values than other treatments. Germination improved due to soaking; however the difference in improvement due to soaking for 12 hours was not so great as compared to those soaked for 6 hours. Gibberellic acid treated seeds like in lentil showed the higher germination values of 53 (G3H12), 91.89 (G2H6) and 92.85 (G1H12) at the respective DAS. Some tamarind treated seeds (T2H6) at 4 DAS and (T1H6) at 6 DAS showed higher values than seeds even than S12.

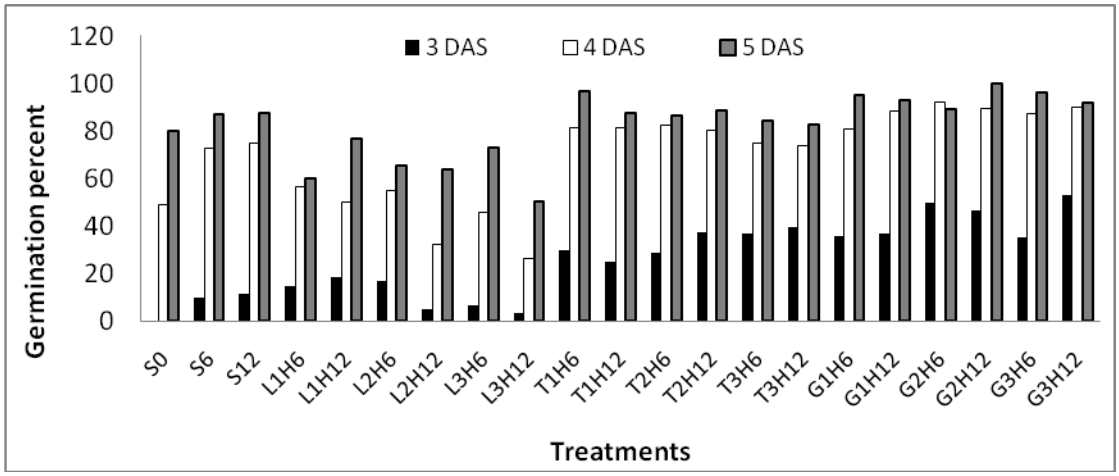


Fig.2: Effect of lemon juice, tamarind leaf extract and gibberellin on germination percentage of Chickpea [LSD (0.05): 11.78, 9.78 and 15.89 at 3, 4 and 5 DAS respectively].

Here,
DAS =Days after setting
S0 = Without soaking;
S6 = Soaking in distilled water for 6 hours;
S12 = Soaking in distilled water for 12 hours; ;
L1H6 = Soaking in lemon juice 2% for 6 hours;
L1H12 = Soaking in lemon juice 2% for 12 hours;
L2H6 = Soaking in lemon juice 4% for 6 hours;
L2H12 = Soaking in lemon juice 4% for 6 hours;
L3H6 = Soaking in lemon juice 6% for 6 hours;
L3H12 = Soaking in lemon juice 6% for 6 hours;
T1H6 = Soaking in tamarind leaf extract 0.05% for 6 hours;
T1H12 = Soaking in tamarind leaf extract 0.05% for 12 hours
T2H6 = Soaking in tamarind leaf extract 0.1% for 6 hours;
T2H12 = Soaking in tamarind leaf extract 0.1% for 12 hours;
T3H6 = Soaking in tamarind leaf extract 0.15% for 6 hours;
T3H6 = Soaking in tamarind leaf extract 0.15% for 6 hours
G1H6 = Soaking in gibberellin 10 ppm for 6 hours
G1H12 = Soaking in gibberellin 10 ppm for 12 hours
G2H6 = Soaking in gibberellin 20 ppm for 6 hours
G2H12 = Soaking in gibberellin 20 ppm for 12 hours
G3H6 = Soaking in gibberellin 30 ppm for 6 hours
G3H12 = Soaking in gibberellin 30 ppm for 12 hours

4.2.2. Effect on seedling length of chickpea

Seedling length was monitored at 6, 8 and 10 DAS. At 6 DAS the seedling length ranged from 2.69 cm (with S0) to 6.47 cm (with G1H12) (Fig. 3). At 8 DAS, G1H12 (6.47cm) and G3H6 (9.43cm) showed the highest seedling length where L2H6 (5.09 cm) gave lowest seedling length. Such effect of these two treatments was also seen at 10 DAS (over 20 cm).

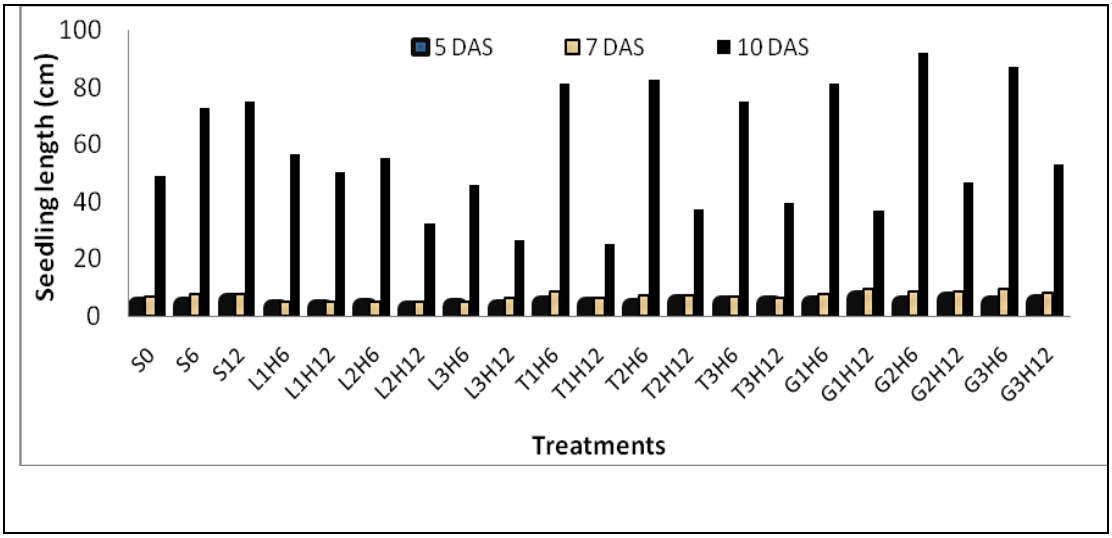


Fig. 3: Effect of lemon juice, tamarind leaf extract and gibberellin on the seedling length of chickpea [LSD (0.05): 1.63, 1.78 and 4.86 at 5,7 and 10 DAS respectively]

Here,

DAS =Days after setting
S0 = Without soaking;
S6 = Soaking in distilled water for 6 hours;
S12 = Soaking in distilled water for 12 hours; ;
L1H6 = Soaking in lemon juice 2% for 6 hours;
L1H12 = Soaking in lemon juice 2% for 12 hours;
L2H6 = Soaking in lemon juice 4% for 6 hours;
L2H12 = Soaking in lemon juice 4% for 6 hours;
L3H6 = Soaking in lemon juice 6% for 6 hours;
L3H12 = Soaking in lemon juice 6% for 6 hours;
T1H6 = Soaking in tamarind leaf extruct 0.05% for 6 hours;
T1H12 = Soaking in tamarind leaf extruct 0.05% for 12 hours
T2H6 = Soaking in tamarind leaf extruct 0.1% for 6 hours;
T2H12 = Soaking in tamarind leaf extruct 0.1% for 12 hours;
T3H6 = Soaking in tamarind leaf extruct 0.15% for 6 hours;
T3H6 = Soaking in tamarind leaf extruct 0.15% for 6 hours
G1H6 = Soaking in gibberellin 10 ppm for 6 hours
G1H12 = Soaking in gibberellin 10 ppm for 12 hours
G2H6 = Soaking in gibberellin 20 ppm for 6 hours
G2H12 = Soaking in gibberellin 20 ppm for 12 hours
G3H6 = Soaking in gibberellin 30 ppm for 6 hours
G3H12 = Soaking in gibberellin 30 ppm for 12 hours

4.2.3. Effect on seedling fresh weight of chickpea

Seedling fresh weight was found at the lowest with S0 (7.36 g) whereas highest with G2H6 (31.50) which also give significantly higher value than other treatments (Table 3).

4.2.4. Effect on Seedling dry matter of chickpea

The seedling dry matter at 10 DAS was lowest with S0 while the highest with T1H12 (0.45 g) and T2H12 (0.43 g) (Table 3). G2H6 (1.06g), G2H12 (1.06g) and G1H12 (0.99g) treatments also showed higher dry weight as compared with the non-soaked (0.59g) and soaked treatments (0.75g). The soaked treatments also showed significantly higher dry matter than S0. The dry

weights of non soaked seedlings were improved by soaking the seeds at 12 hours. The dry weight of this water soaked seedlings were improved by tamarind leaf extract and gibberelin treatments.

4.2.5. Effect on vigour index of chickpea

The maximum vigour index was found with G3H6 and G3H12 which was remarkably higher even than S12. G2H12 also gave expected vigour index. L3H6 showed the lowest vigour index (387) among the all treatments. Here it should be mentioned that higher concentration of lemon juice enhances the reduction of vigour growth (Table 3).

4.2.6. Effect on germination index of chickpea

The germination was found to be improved by Tamarind and gibberellins treatments (Table 3). Gibberellins treated seeds showed significantly higher germination index values with the highest over 78 with G2H6 and G3H12. Tamarind treated seeds also showed higher germination index over 64 than even water soaked for 12 hours (61).

4.2.7. Effect on speed of germination of chickpea

The speed of germination was 3.56 cm with a range of 4.55cm to11.62 cm.The L3H12 showed significantly minimum value of the speed of germination and the maximum speed of germination was recorded in the G2H6 which gave significantly higher value than other treatments (Table).

Table3: Effect of lemon juice, tamarind leaf extract and gibberellin on final seedling dry matter, vigour index, germination index and speed of germination of chickpea at 10 days after sowing

Treatments	Final seedling fresh matter(g/pot)	Final seedling dry matter(g/pot)	Vigour index	Germination index	Speed of germination
S0	7.36	0.59	672	33.51	7.98
S6	10.50	0.75	1010	44.87	8.91
S12	12.50	0.83	1169	46.22	9.06
L1H6	26.50	0.51	666	35.20	6.22
L1H12	27.50	0.70	682	37.52	6.20
L2H6	26.50	0.40	624	36.55	6.29
L2H12	24.00	0.54	618	25.79	5.38
L3H6	27.00	0.42	451	31.16	5.31
L3H12	22.50	0.61	415	20.55	4.55
T1H6	7.50	0.65	903	54.72	8.33
T1H12	5.25	0.49	748	51.98	8.75
T2H6	6.07	0.64	842	53.21	8.63
T2H12	5.52	0.54	771	56.00	8.86
T3H6	6.42	0.58	797	53.49	8.42
T3H12	7.00	0.70	941	53.95	8.55
G1H6	20.50	0.88	1786	56.94	8.93
G1H12	14.50	0.99	1904	59.09	9.29
G2H6	31.50	1.06	2441	66.13	11.62
G2H12	14.00	1.06	2050	64.46	10.00
G3H6	11.50	0.84	1984	59.02	9.60
G3H12	14.84	0.85	1634	65.00	9.50
LSD(0.05)	4.62	0.27	350	5.84	1.96
CV (%)	8.64	4.49	10	7.738.56	11.38

Here,
DAS =Days after setting
S0 = Without soaking;
S6 = Soaking in distilled water for 6 hours;
S12 = Soaking in distilled water for 12 hours; ;
L1H6 = Soaking in lemon juice 2% for 6 hours;
L1H12 = Soaking in lemon juice 2% for 12 hours;
L2H6 = Soaking in lemon juice 4% for 6 hours;
L2H12 = Soaking in lemon juice 4% for 6 hours;
L3H6 = Soaking in lemon juice 6% for 6 hours;
L3H12 = Soaking in lemon juice 6% for 6 hours;
T1H6 = Soaking in tamarind leaf extruct 0.05% for 6 hours;
T1H12 = Soaking in tamarind leaf extruct 0.05% for 12 hours
T2H6 = Soaking in tamarind leaf extruct 0.1% for 6 hours;
T2H12 = Soaking in tamarind leaf extruct 0.1% for 12 hours;
T3H6 = Soaking in tamarind leaf extruct 0.15% for 6 hours;
T3H6 = Soaking in tamarind leaf extruct 0.15% for 6 hours
G1H6 = Soaking in gibberellin 10 ppm for 6 hours
G1H12 = Soaking in gibberellin 10 ppm for 12 hours
G2H6 = Soaking in gibberellin 20 ppm for 6 hours
G2H12 = Soaking in gibberellin 20 ppm for 12 hours
G3H6 = Soaking in gibberellin 30 ppm for 6 hours
G3H12 = Soaking in gibberellin 30 ppm for 12 hours

Expt 3: Effect of lemon juice (L), tamarind leaf extracts (T) and gibberellin (G) under 6 and 12 hours soaking on the seed germination, vigour and seedling parameters of grass pea

4.3.1. Effect on germination percentage of grasspea

Germination of grass pea started from three days after sowing. It ranged from 0-25.78, 11-38.33 and 67-92.63% at 3, 4 and 5 DAS respectively (Fig. 4). The non-soaked at all the cases showed lower values than other treatments. L3H12 also showed lower germination percentage. Soaking in water improved a lot in germination but with a narrow difference between S6 and S12. Among the treatments, T3H6, G2H6 and S12and T3H6 at 5, 7 and10 DAS showed higher germination percentage.

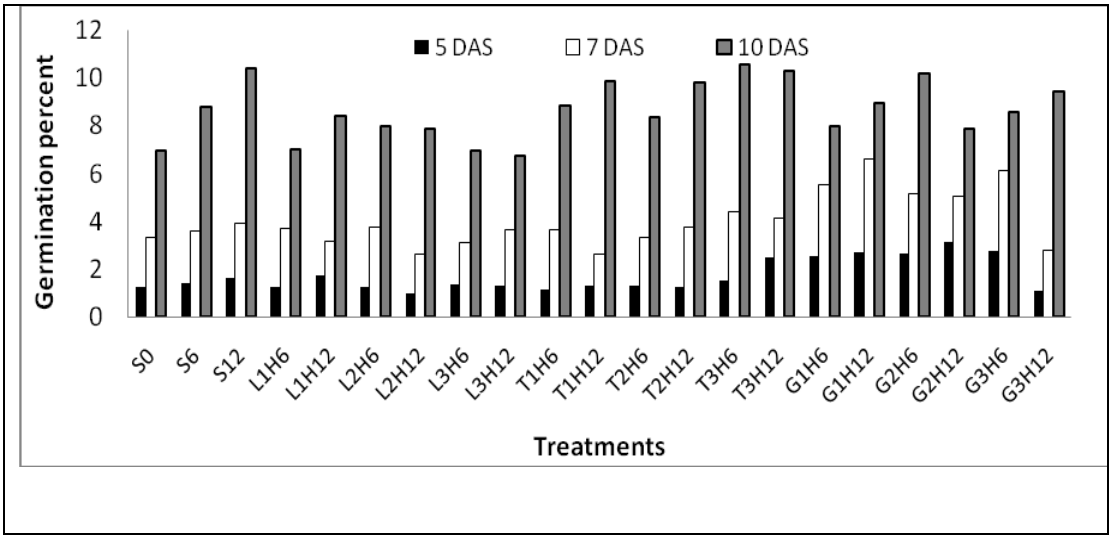


Fig. 4: Effect of lemon juice, tamarind leaf extract and gibberellin on the germination percentage of grasspea seeds **[LSD (0.05): 4.51, 9.04 and 10.31 at 5, 7 and 10 DAS respectively]**

Here,

DAS =Days after setting
S0 = Without soaking;
S6 = Soaking in distilled water for 6 hours;
S12 = Soaking in distilled water for 12 hours; ;
L1H6 = Soaking in lemon juice 2% for 6 hours;
L1H12 = Soaking in lemon juice 2% for 12 hours;
L2H6 = Soaking in lemon juice 4% for 6 hours;
L2H12 = Soaking in lemon juice 4% for 6 hours;
L3H6 = Soaking in lemon juice 6% for 6 hours;
L3H12 = Soaking in lemon juice 6% for 6 hours;
T1H6 = Soaking in tamarind leaf extruct 0.05% for 6 hours;
T1H12 = Soaking in tamarind leaf extruct 0.05% for 12 hours
T2H6 = Soaking in tamarind leaf extruct 0.1% for 6 hours;
T2H12 = Soaking in tamarind leaf extruct 0.1% for 12 hours;
T3H6 = Soaking in tamarind leaf extruct 0.15% for 6 hours;
T3H6 = Soaking in tamarind leaf extruct 0.15% for 6 hours
G1H6 = Soaking in gibberellin 10 ppm for 6 hours
G1H12 = Soaking in gibberellin 10 ppm for 12 hours
G2H6 = Soaking in gibberellin 20 ppm for 6 hours
G2H12 = Soaking in gibberellin 20 ppm for 12 hours
G3H6 = Soaking in gibberellin 30 ppm for 6 hours
G3H12 = Soaking in gibberellin 30 ppm for 12 hours

4.3.2. Effect on seedling length of grass pea

Seedling length was monitored at 5, 7 and 10 DAS (Fig. 5). At 5 DAS the seedling length ranged from 2.89 cm with S0 to 3.77 cm with T2H12 (Table 8). At 8 DAS, T2H12 showed the highest germination percent (12.34 cm). But at 10 DAS treatments showed lower seedling length than the water soaked ones.

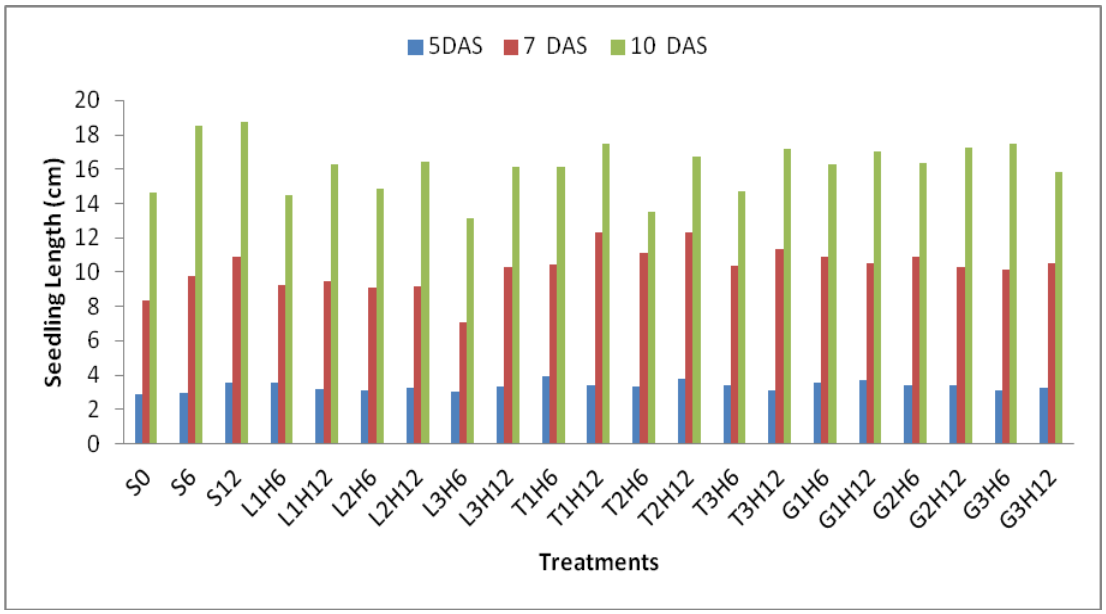


Fig5: Effect of lemon juice, tamarind leaf extract and gibberellin on the seedlings of grass pea seeds [LSD (0.05):0.5347, 1.213 and 2.011 at 5, 7 and 10 DAS respectively]

Here,
DAS =Days after setting
S0 = Without soaking;
S6 = Soaking in distilled water for 6 hours;
S12 = Soaking in distilled water for 12 hours; ;
L1H6 = Soaking in lemon juice 2% for 6 hours;
L1H12 = Soaking in lemon juice 2% for 12 hours;
L2H6 = Soaking in lemon juice 4% for 6 hours;
L2H12 = Soaking in lemon juice 4% for 6 hours;
L3H6 = Soaking in lemon juice 6% for 6 hours;
L3H12 = Soaking in lemon juice 6% for 6 hours;
T1H6 = Soaking in tamarind leaf extruct 0.05% for 6 hours;
T1H12 = Soaking in tamarind leaf extruct 0.05% for 12 hours
T2H6 = Soaking in tamarind leaf extruct 0.1% for 6 hours;
T2H12 = Soaking in tamarind leaf extruct 0.1% for 12 hours;
T3H6 = Soaking in tamarind leaf extruct 0.15% for 6 hours;
T3H6 = Soaking in tamarind leaf extruct 0.15% for 6 hours
G1H6 = Soaking in gibberellin 10 ppm for 6 hours
G1H12 = Soaking in gibberellin 10 ppm for 12 hours
G2H6 = Soaking in gibberellin 20 ppm for 6 hours
G2H12 = Soaking in gibberellin 20 ppm for 12 hours
G3H6 = Soaking in gibberellin 30 ppm for 6 hours
G3H12 = Soaking in gibberellin 30 ppm for 12 hours

4.3.3. Effect on seedling dry matter of grasspea

Seedling dry matter at 10 DAS was lowest with S0 (8.17g) while the highest with T2H12 (13.51 g) (Table 4). G2H6 also showed higher seedling dry weight than S12. Treatments did not have effect on vigour index. But the germination index was found to be improved by Tamarind (T1H12 and T2H12).S0 showed significantly lower germination index than S6 and S12 maintaining little differences between S6 and S12.

4.3.4. Effect on germination index of grasspea

Germination index of grasspea was found to be improved by tamarind and gibberellins treatments (Table 4).Gibberellin treated seeds showed significantly higher germination index values with the highest over 78 with G2H6 and G3H12. Tamarind treated seeds also showed higher germination index than even water soaked for 12 hours whereas S0 gave significantly lower germination index than other treatments.

4.3.5. Effect on vigour index of grasspea

The maximum vigour index was found with S12,G1H12 and T1H12 which were also gave significantly higher vigour index value. L3H6 and S0 were showed the significantly lower vigour index compare with the others(Table 4).

4.3.6. Effect on speed of germination of grasspea

The speed of germination was 3.56 with a range of 2.13 to 5.17cm. The S0 showed the minimum speed of germination and the maximum speed of germination was recorded in the T2H12 (Table 4).

Table 4: Effect of lemon juice, tamarind leaf extract and gibberellin on final seedling dry matter, vigour index, germination index and speed of germination of grasspea at 10 days after setting

Treatments	Final seedling dry matter (g/pot)	Vigour index	Germination index	Speed of germination
S0	8.18	989	20.38	6.75
S6	10.53	1541	26.59	8.30
S12	11.31	1587	29.83	8.45
L1H6	10.42	1231	29.24	8.50
L1H12	10.76	1283	29.69	7.89
L2H6	10.00	1136	27.28	7.65
L2H12	10.31	1199	28.09	7.30
L3H6	10.00	956	28.09	7.28.
L3H12	10.92	1147	28.11	7.11
T1H6	10.80	1300	28.04	8.05
T1H12	11.03	1452	33.43	8.32
T2H6	10.99	1067	35.38	7.90
T2H12	13.51	1548	30.10	9.26
T3H6	11.21	1161	35.10	7.90
T3H12	12.42	1392	30.48	8.11
G1H6	10.87	1400	32.89	8.60
G1H12	11.98	1566	35.48	9.20
G2H6	11.62	1482	37.34	9.05
G2H12	10.55	1511	35.46	8.75
G3H6	10.38	1494	35.51	8.55
G3H12	10.21	1308	37.21	8.28
LSD(0.05)	1.49	207.9	1.92	0.55
CV (%)	5.08	6.95	7.05	5.49

Here,
DAS =Days after setting
S0 = Without soaking;
S6 = Soaking in distilled water for 6 hours;
S12 = Soaking in distilled water for 12 hours; ;
L1H6 = Soaking in lemon juice 2% for 6 hours;
L1H12 = Soaking in lemon juice 2% for 12 hours;
L2H6 = Soaking in lemon juice 4% for 6 hours;
L2H12 = Soaking in lemon juice 4% for 6 hours;
L3H6 = Soaking in lemon juice 6% for 6 hours;
L3H12 = Soaking in lemon juice 6% for 6 hours;
T1H6 = Soaking in tamarind leaf extruct 0.05% for 6 hours;
T1H12 = Soaking in tamarind leaf extruct 0.05% for 12 hours
T2H6 = Soaking in tamarind leaf extruct 0.1% for 6 hours;
T2H12 = Soaking in tamarind leaf extruct 0.1% for 12 hours;
T3H6 = Soaking in tamarind leaf extruct 0.15% for 6 hours;
T3H6 = Soaking in tamarind leaf extruct 0.15% for 6 hours
G1H6 = Soaking in gibberellin 10 ppm for 6 hours
G1H12 = Soaking in gibberellin 10 ppm for 12 hours
G2H6 = Soaking in gibberellin 20 ppm for 6 hours
G2H12 = Soaking in gibberellin 20 ppm for 12 hours
G3H6 = Soaking in gibberellin 30 ppm for 6 hours
G3H12 = Soaking in gibberellin 30 ppm for 12 hours

Expt 4: Effect of lemon juice (L), tamarind leaf extracts (T) and gibberellin (G) under 6 and 12 hours soaking on the seed germination, vigour and seedling parameters of cowpea

4.4.1. Effect on germination percentage of cowpea

Germination of cowpea started from 5 days after sowing (Fig. 6). It ranged from 0-81.52, 22.22-95 and 30.43-95.34% at 5, 6 and 9 DAS respectively. The non-soaked and soaked for 6 hours in all the cases showed lower values than soaked for 12 hours. Among the treatments, L1H6, T1H12, T2-3H12, and all the Gibberelin at all the DAS showed higher germination %.

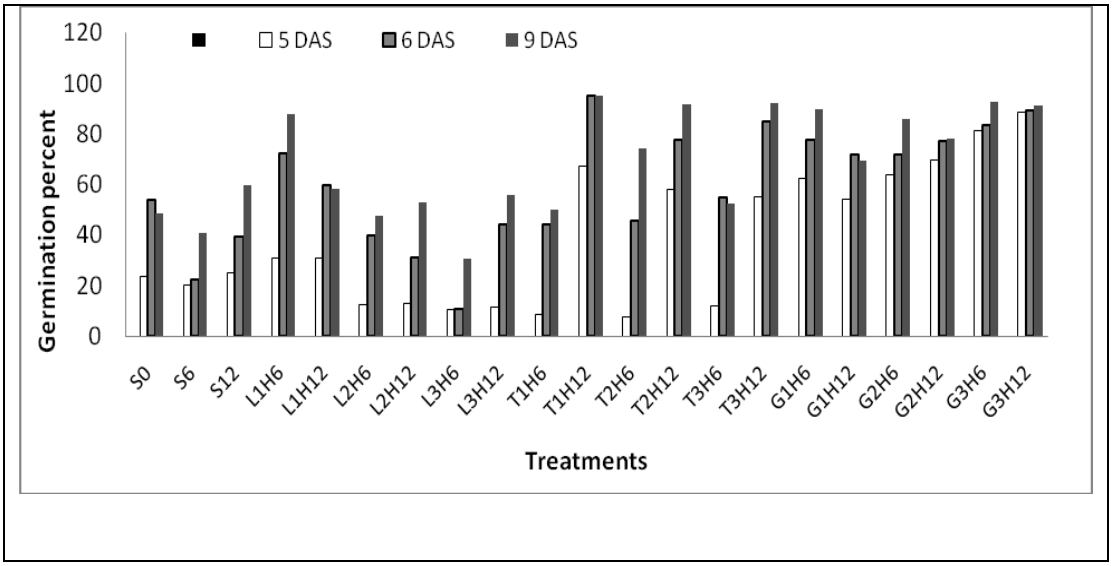


Fig.6: Effect of lemon juice, tamarind leaf extract and gibberellin on the seedling length of cowpea seeds [LSD (0.05): 16.56, 17.45 and 18.34 at 5, 7 and 10 DAS respectively]

Here,
DAS =Days after setting
S0 = Without soaking;
S6 = Soaking in distilled water for 6 hours;
S12 = Soaking in distilled water for 12 hours; ;
L1H6 = Soaking in lemon juice 2% for 6 hours;
L1H12 = Soaking in lemon juice 2% for 12 hours;
L2H6 = Soaking in lemon juice 4% for 6 hours;
L2H12 = Soaking in lemon juice 4% for 6 hours;
L3H6 = Soaking in lemon juice 6% for 6 hours;
L3H12 = Soaking in lemon juice 6% for 6 hours;
T1H6 = Soaking in tamarind leaf extruct 0.05% for 6 hours;
T1H12 = Soaking in tamarind leaf extruct 0.05% for 12 hours
T2H6 = Soaking in tamarind leaf extruct 0.1% for 6 hours;
T2H12 = Soaking in tamarind leaf extruct 0.1% for 12 hours;
T3H6 = Soaking in tamarind leaf extruct 0.15% for 6 hours;
T3H6 = Soaking in tamarind leaf extruct 0.15% for 6 hours
G1H6 = Soaking in gibberellin 10 ppm for 6 hours
G1H12 = Soaking in gibberellin 10 ppm for 12 hours
G2H6 = Soaking in gibberellin 20 ppm for 6 hours
G2H12 = Soaking in gibberellin 20 ppm for 12 hours
G3H6 = Soaking in gibberellin 30 ppm for 6 hours
G3H12 = Soaking in gibberellin 30 ppm for 12 hours

4.4.2. Effect on seedling length of cowpea

Seedling length was monitored at 10 and 11 DAS (Fig. 7). At 10 DAS, the seedling length ranged from 6.6 cm (with S0) to 14.57 cm (with G3H12). At 11 DAS G2H12, G3H12 and most of the gibberellin showed the significently higher seedling lengths (over 15 cm).

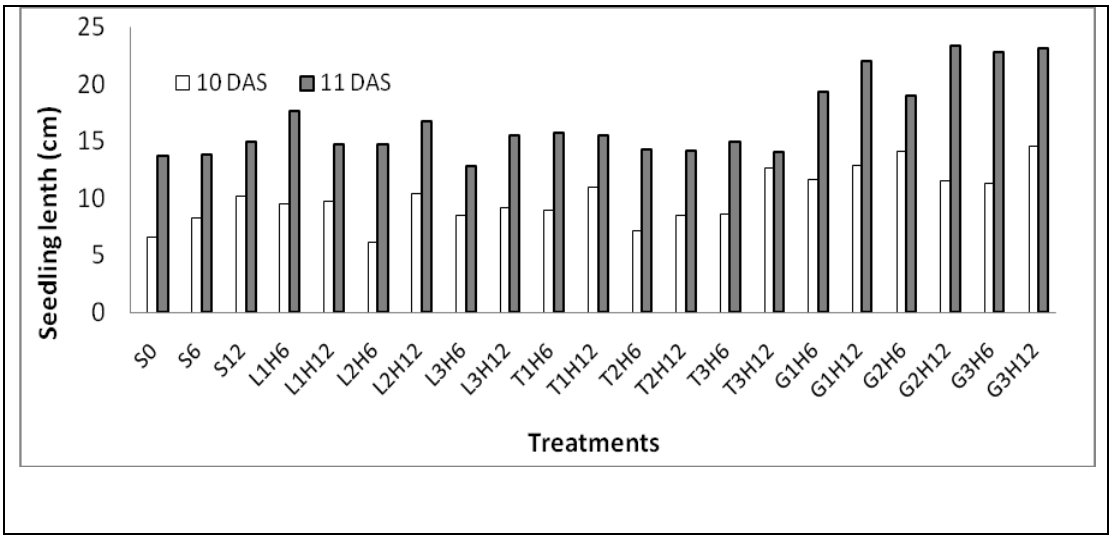


Fig. 7: Effect of lemon juice, tamarind leaf extract and gibberellin on the seedling length of cowpea seeds [LSD (0.05): 1.38, and 4.87 at 10 and 11 DAS respectively]

Here,
DAS =Days after setting
S0 = Without soaking;
S6 = Soaking in distilled water for 6 hours;
S12 = Soaking in distilled water for 12 hours; ;
L1H6 = Soaking in lemon juice 2% for 6 hours;
L1H12 = Soaking in lemon juice 2% for 12 hours;
L2H6 = Soaking in lemon juice 4% for 6 hours;
L2H12 = Soaking in lemon juice 4% for 6 hours;
L3H6 = Soaking in lemon juice 6% for 6 hours;
L3H12 = Soaking in lemon juice 6% for 6 hours;
T1H6 = Soaking in tamarind leaf extruct 0.05% for 6 hours;
T1H12 = Soaking in tamarind leaf extruct 0.05% for 12 hours
T2H6 = Soaking in tamarind leaf extruct 0.1% for 6 hours;
T2H12 = Soaking in tamarind leaf extruct 0.1% for 12 hours;
T3H6 = Soaking in tamarind leaf extruct 0.15% for 6 hours;
T3H6 = Soaking in tamarind leaf extruct 0.15% for 6 hours
G1H6 = Soaking in gibberellin 10 ppm for 6 hours
G1H12 = Soaking in gibberellin 10 ppm for 12 hours
G2H6 = Soaking in gibberellin 20 ppm for 6 hours
G2H12 = Soaking in gibberellin 20 ppm for 12 hours
G3H6 = Soaking in gibberellin 30 ppm for 6 hours
G3H12 = Soaking in gibberellin 30 ppm for 12 hours

4.4.3. Effect on seedling fresh weight of cowpea

Seedling fresh weight at 11 DAS ranged from 12-26.78 g , the highest being with T3H12 (Table 5). Tamarind treatments except T1 - T3 with H12, G1-G3 with H6 had significantly higher fresh weight than S12.

4.4.4. Effect on seedling dry matter of cowpea

At 10 DAS the seedling dry matter of cowpea was lowest with S0 (8.17g while the highest with T2H12 (13.51g) (Table 5). T3H12 and T2H12 also had significantly higher seedling dry weight than S12 whereas L3H12 had the significantly lowest dry matter.

4.4.5. Effect on vigour index of cowpea

The maximum vigour index was found with G3H6 and G3H12 which was significantly higher value even than S12. S0 and L3H6 treatment showed the significantly lower vigour index among the all treatments (Table 5).

4.4.6. Effect on germination index of cowpea

Effect on germination index in cowpea was found to be improved by tamarind and gibberellins treatments (Table 5). Gibberellins treated seeds showed higher germination index values with the highest over 78 with G2H6 and G3H12. Tamarind treated seeds also showed higher germination index over 64 than even water soaked for 12 hours (61).

4.4.7. Effect on speed of germination of cowpea

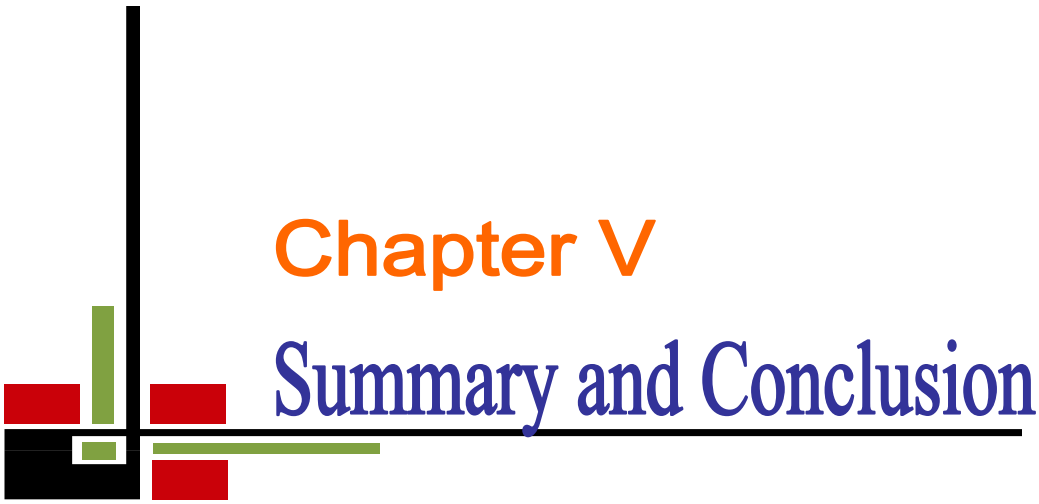
The speeds of germination were range of 3.04 to 9.53cm. The L3H6 showe d the significantly minimum speed of germination whereas T1H12 and G3H6 were gave the maximum speed of germination (Table 5).

Table 5. Effect of lemon juice, tamarind leaf extract and gibberellin on final seedling fresh weight, dry matter, vigour index, germination index and speed of germination of cowpea at 11days after setting

Treatments	Final seedling fresh matter (g/pot)	Final seedling dry matter/pot	Vigour index	Germination index	Speed of germination
S0	19.98	1.35	662	34.38	4.86
S6	21.00	1.40	565	23.30	4.08
S12	23.58	1.56	890	34.06	5.98
L1H6	16.43	1.36	1546	51.96	8.81
L1H12	12.26	1.07	858	40.75	5.83
L2H6	17.81	1.45	698	26.83	4.75
L2H12	15.21	1.35	887	26.22	5.30
L3H6	12.00	1.05	387	14.46	3.04
L3H12	16.60	0.98	864	29.81	5.58
T1H6	21.00	1.13	783	27.41	5.00
T1H12	23.29	1.21	1472	71.74	9.53
T2H6	21.55	1.69	1062	33.83	7.44
T2H12	24.79	1.59	1296	63.35	9.19
T3H6	24.67	1.81	779	31.63	5.24
T3H12	26.79	1.58	1295	64.25	9.25
G1H6	24.00	1.76	1737	64.21	9.00
G1H12	20.43	1.75	1527	54.60	6.96
G2H6	25.67	1.15	1627	62.29	8.60
G2H12	21.32	1.74	1826	63.35	7.83
G3H6	25.60	1.49	2114	72.87	9.30
G3H12	27.00	1.70	2106	79.24	9.13
LSD (0.05)	10.21	0.34	387	9.56	0.83
CV (%)	8.90	9.76	12	11.34	6.38

Here,

DAS =Days after setting
S0 = Without soaking;
S6 = Soaking in distilled water for 6 hours;
S12 = Soaking in distilled water for 12 hours; ;
L1H6 = Soaking in lemon juice 2% for 6 hours;
L1H12 = Soaking in lemon juice 2% for 12 hours;
L2H6 = Soaking in lemon juice 4% for 6 hours;
L2H12 = Soaking in lemon juice 4% for 6 hours;
L3H6 = Soaking in lemon juice 6% for 6 hours;
L3H12 = Soaking in lemon juice 6% for 6 hours;
T1H6 = Soaking in tamarind leaf extruct 0.05% for 6 hours;
T1H12 = Soaking in tamarind leaf extruct 0.05% for 12 hours
T2H6 = Soaking in tamarind leaf extruct 0.1% for 6 hours;
T2H12 = Soaking in tamarind leaf extruct 0.1% for 12 hours;
T3H6 = Soaking in tamarind leaf extruct 0.15% for 6 hours;
T3H6 = Soaking in tamarind leaf extruct 0.15% for 6 hours
G1H6 = Soaking in gibberellin 10 ppm for 6 hours
G1H12 = Soaking in gibberellin 10 ppm for 12 hours
G2H6 = Soaking in gibberellin 20 ppm for 6 hours
G2H12 = Soaking in gibberellin 20 ppm for 12 hours
G3H6 = Soaking in gibberellin 30 ppm for 6 hours
G3H12 = Soaking in gibberellin 30 ppm for 12 hours



Chapter V

Summary and Conclusion

CHAPTER 5

SUMMARY AND CONCLUSION

Reviewing the results obtained in the expt 1 covering the e ffect of lemon juice (L), tamarind leaf extract (T) and gibberellins (G) under 6 and 12 hours soaking on the seed germination, vigour and seedling parameters of lentil seeds showed that initially the germination of lentil started from three days after sowing which ranged from zero to 19.02% at this DAS**.** The non soaked and most of the tamarind treated seeds did not germinate. The six hour soaked G2 treatment showed the highest germination percentage. At the later stages this trend was continued by G3H12 showing the highest germination percentage. At these DAS T1H12, G1H2, G2H12, G3H6 showed remarkably higher values than S12. Seeds soaked for 12 hours showed higher value than those soaked for 6 hours.

G1H12 and G3H6 showed the highest seedling length**s** (6.61 and 6.12 cm respectively) whereas T1H12 and L1H12 showed the lowest value (2.6). The G2H6 (0.37) and G3H12 (0.38) treatments showed higher dry weight as compared with the non-soaked and soaked treatments.

The maximum vigour index was found with G2H6 (908.03) and G3H12 (978.86) which was remarkably higher even than S12 (877.48). S0 showed the lowest vigour index (386.73).

The lowest germination index of S0 (27), T1H12(44.43) and all the gibberellin concentrations gave much higher germination index (44.64)**.**

The S0 treatment showed the minimum speed of germination (5.59) and the G1H12 showed the maximum speed of germination(60.36).

Reviewing the results of e xpt 2,effect of lemon juice (L), tamarind leaf extract (T) and gibberellin (GA3) under 6 and 12 hours soaking on the seed germination, vigour and seedling parameters of chickpea, it was observed that the g ermination improved due to soaking; however the difference in improvement due to soaking for 12 hours was not so great as compared to those soaked for 6 hours. Gibberellic acid treated seeds showed the higher germination values of 53 (G3H12), 91.89 (G2H6) and 92.85 (G1H12) at the 3,4 and 5 DAS. Some tamarind treated seeds (T2H6) at 4 DAS and (T1H6) at 6 DAS showed higher values than seeds even than S12.

At 8 DAS , G1H12 (6.47) and G3H6 (9.43) showed the highest seedling length where L2H6 (5.09) gave lowest seedling length. Such effect of these two treatments was also seen at 10 DAS (over 20 cm). Seedling fresh weight was found at the lowest with S0 (7.36 g) whereas highest with G2H6.

The seedling dry matter at 10 DAS was lowest with S0 while the highest with T1H12 (0.45 g) and T2H12 (0.43 g)**.** The maximum vigour index was found with G3H6 and G3H12 which was remarkabl**y** higher even than S12. G2H12 also gave expected vigour index. L3H6 showed the lowest vigour index (387) among the all treatments.

Gibberellins treated seeds showed higher germination index values with the highest over 78 with G2H6 and G3H12. Tamarind treated seeds also showed higher germination index over 64 than even water soaked for 12 hours (61).

The L3H6 showed the minimum speed of germination and the maximum speed of germination was recorded in the T1H12.

Reviewing the results of the experiment(3) Effect of lemon juice (L), tamarind leaf extract (T) and gibberellin (G) under 6 and 12 hours soaking on the seed germination, vigour and seedling parameters of grass pea it was observed that the treatment L3H12 also showed lower germination percentage. Soaking in water improved a lot in germination but with a narrow difference between S6 and S12. Among the treatments, T3H6, G2H6 and S12and T3H6 at 5, 7 and10 DAS showed highe**r** germination percentage.

At 8 DAS**,** T2H12 showed the highest germination percent (12.34 cm). But at 10 DAS treatments showed lower seedling height than the water soaked ones. Seedling fresh weight of grass pea was the lowest with S0 (7.36 g) whereas

highest with G2H6**.** Seedling dry matter of grasspea at 10 DAS was lowest with S0 (8.17while the highest with T2H12 (13.51 g)**.**

Gibberellin treated seeds showed higher germination index values with the highest over 78 with G2H6 and G3H12. Tamarind treated seeds also showed higher germination index than even water soaked for 12 hours.

The maximum vigour index was found with G2H6 and G3H12 (908-941) which was remarkabl**y** higher even than S12. S0 showed the lowest vigour index.

The S0 showed the minimum speed of germination and the maximum speed of germination was recorded in the T2H12).

Reviewing the results of the e xpt 4, **'**Effect of lemon juice (L), tamarind leaf extract (T) and gibberellin (G) under 6 and 12 hours soaking on the seed germination, vigour and seedling parameters of cowpea' it was observed that The non-soaked and soaked for 6 hours in all the cases showed lower values than soaked for 12 hours. Among the treatments, L1, T1H12, T2-3H12, and all the G at all the DAS showed higher germination %.

At 10 DAS the seedling length ranged from 6.6 cm (with S0) to 14.57 cm (with G3H12) (Table 11). At 11 DAS L1H6,L2-3H12, and most of the gibberellin showed higher seedling lengths (over 15 cm).

Seedling fresh weight at 11 DAS ranged from 12-26.78 g **,** the highest being with T3H12**.**

At 10 DAS the seedling dry matter of cowpea was lowest with S0 (8.17 while the highest with T2H12 (13.51 g).

Gibberellins treated seeds showed higher germination index values with the highest over 78 with G2H6 and G3H12. Tamarind treated seeds also showed higher germination index over 64 than even water soaked for 12 hours (61).

The maximum vigour index was found with G2H6 and G3H12 (908 - 941) which was remarkably higher even than S12. S0 showed the lowest vigour index.

The speed of germination was 3.56 cm with a range of 2.13 to 5.17. The L3H6 showed the minimum speed of germination and the maximum speed of germination was recorded in the G3H6).

From the results of the study, it may be concluded that the performance of pulses were better in respect of growth regulator's components when soaking the seeds at low or medium concentrations among these growth regulators. But higher concentration of different growth regulators with defined time schedule may make an insignificant effect in many of those parameters (as in the case of lemon juice). However, such result has made the basis for further study that should be conducted in different seasons with different organic and inorganic growth regulators or substances involving different parameters of the production of pulses from embryo formation stage to harvest. Further research is, therefore, necessary to achieve at a definite conclusion.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Chapter 6

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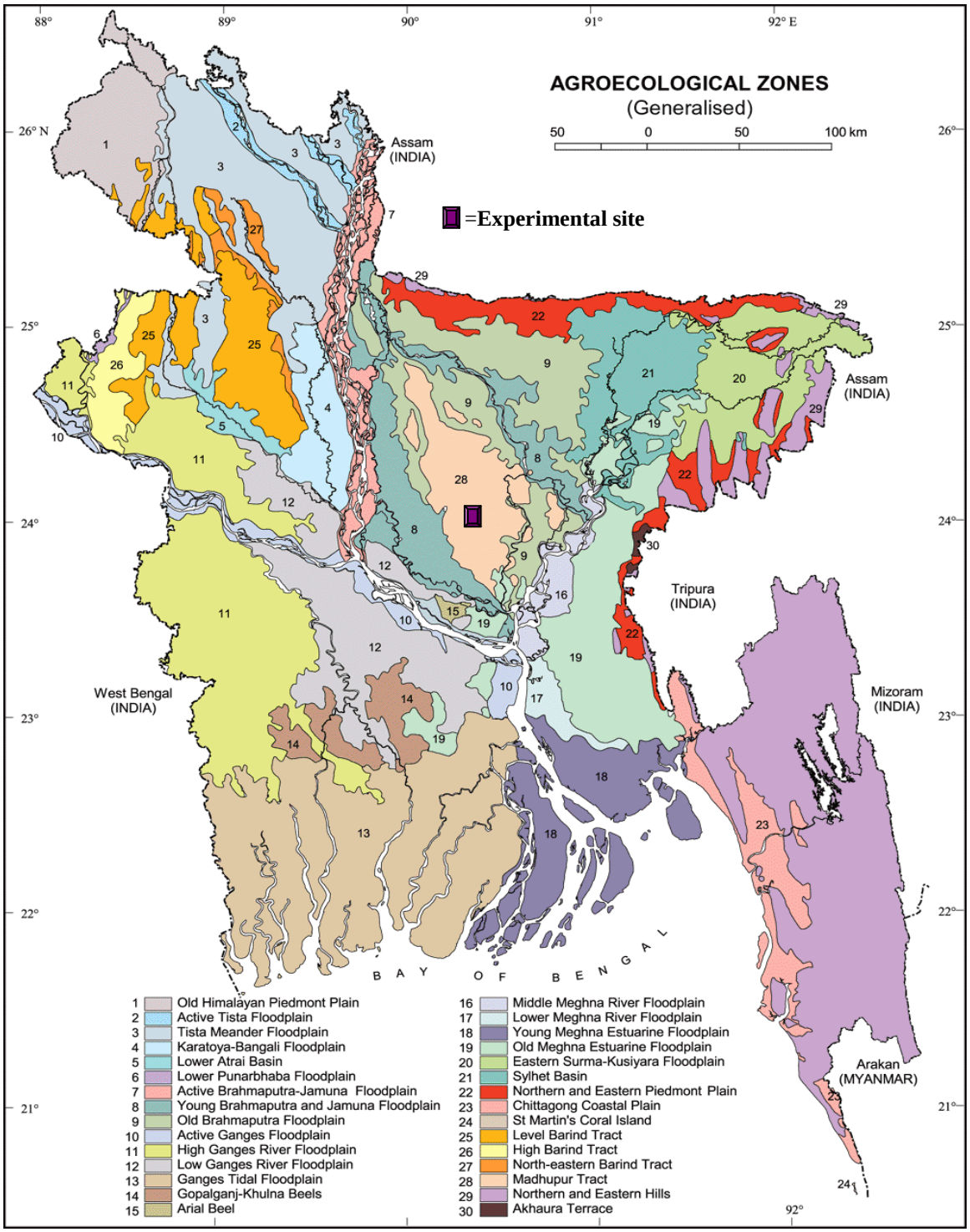
Appendices

APPENDICES

Appendix I. Experimental location on the map of Agro-ecological Zones of Bangladesh



Appendix II. Monthly average Temperature, Relative Humidity and Total Rainfall and sunshine of the experimental site during the period from October, 2010 to March, 2011

Month	Air temperature (°c)		Relative humidity (%)	Rainfall (mm) (total)	Sunshine (hr)
	Maximum	Minimum			
October, 2010	34.8	18.0	77	227	5.8
November, 2010	32.3	16.3	69	0	7.9
December, 2010	29.0	13.0	79	0	3.9
January, 2011	28.1	11.1	72	1	5.7
February, 2011	33.9	12.2	55	1	8.7
March, 2011	34.6	16.5	67	45	7.3

Source: Bangladesh Meteorological Department (Climate & Weather Division), Agargoan,

Appendix III. Plates

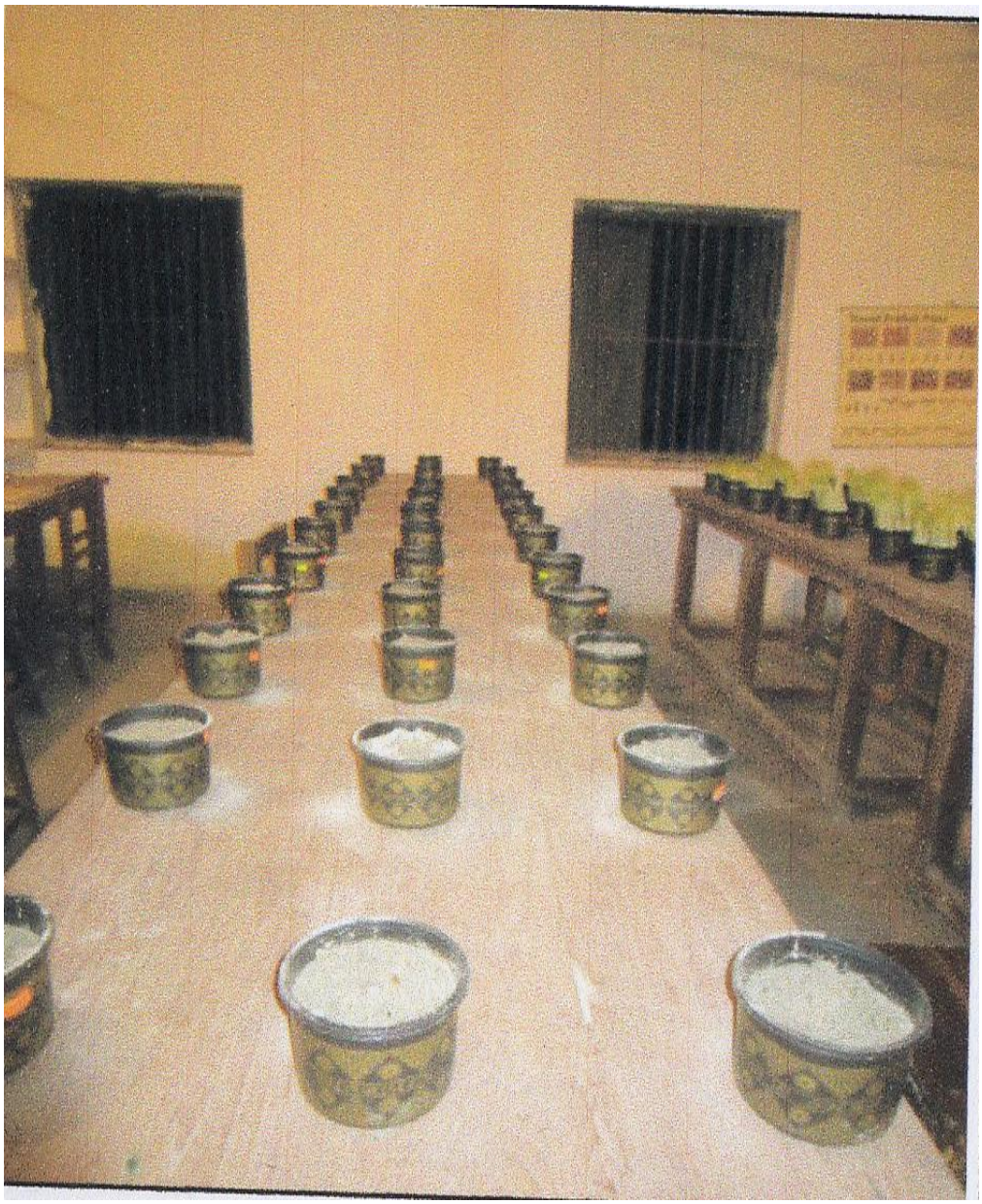


Plate 1. Photograph showing the set up of an experiment

Plate 2. Photograph showing the germination of an experiment with lentil seeds

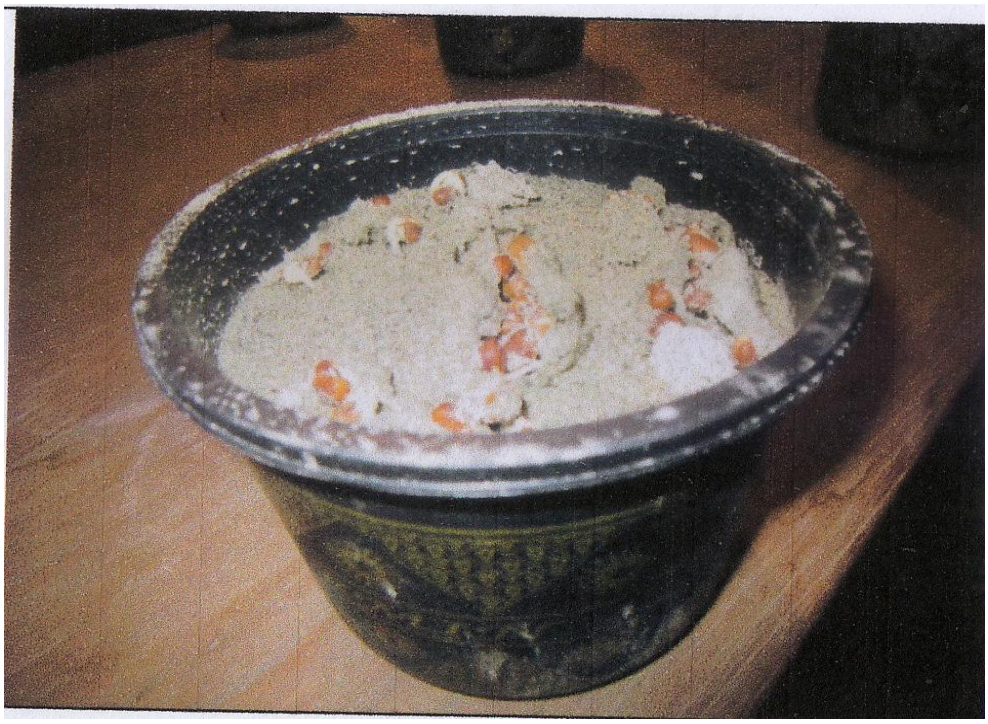


Plate 3. Photograph showing germinating cowpea seeds

Plate 4. Photograph showing the seedling growth difference soaked and non soaked lentil seeds

Plate 5. Photograph showing seedling growth difference under water Soaked and lemon juice soaked chickpea seeds

Plate 6. Photograph showing seedlings growth difference gibberellins treated and non soaked chickpea seeds

Plate 7. Photograph showing germination of chickpea seeds

Plate 8. Photograph showing grass pea seedling growth difference under Water soaked and lemon juice soaked

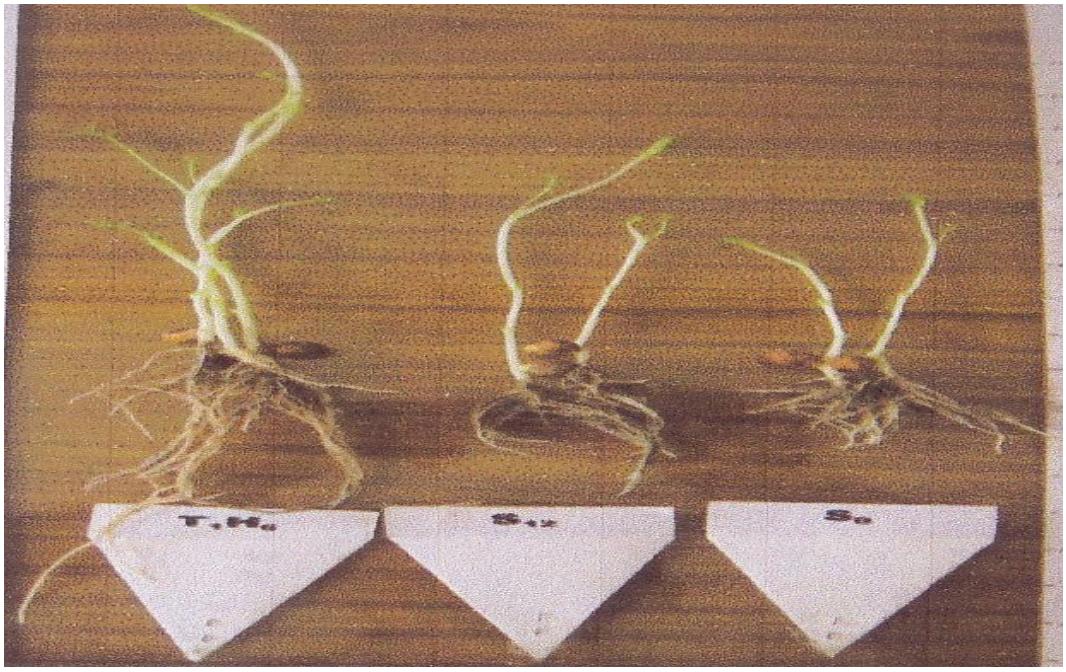


Plate 9. Photograph showing chickpea seedling growth difference under water soaked and tamarind leaf extract soaked chickpea seeds

Plate 10. Photograph showing seedling growth difference under water soaked for 6 hours, water soaked for 12 hours and gibberellin soaked chickpea seeds

Plate 11. Photograph showing germinating Grass pea seedlings

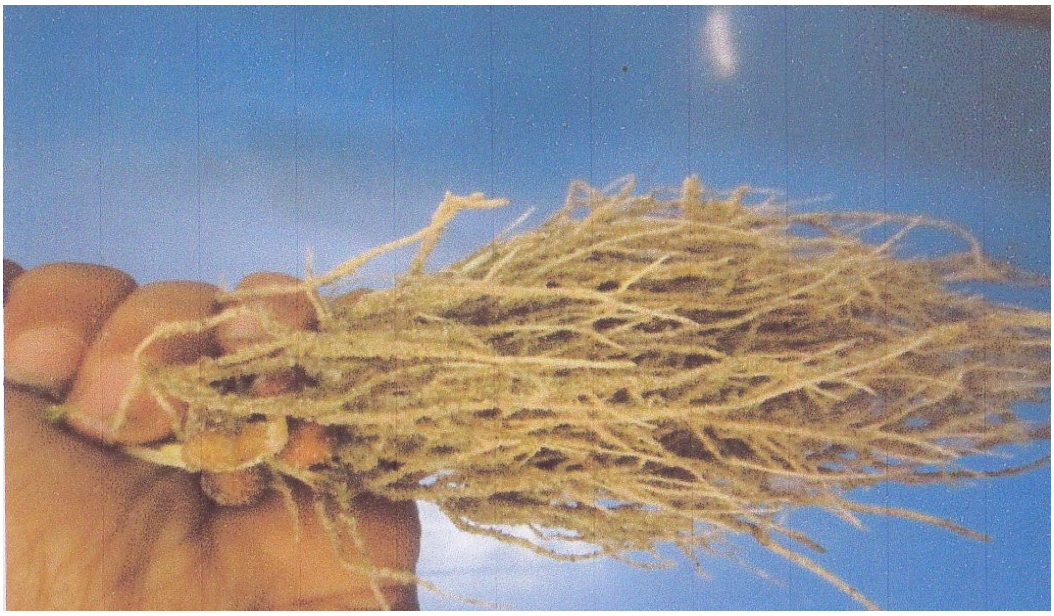


Plate 12. Photograph showing chickpea roots extracted from a deposited Pots

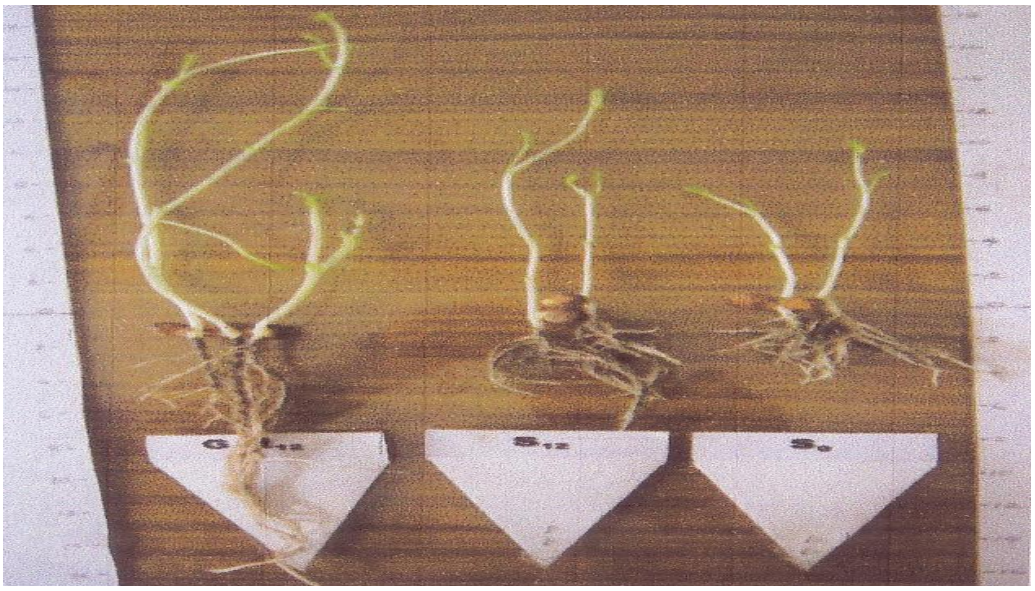


Plate 13. Photograph showing grass pea seedling growth difference under water soaked and gibberelin soaked chickpea seed

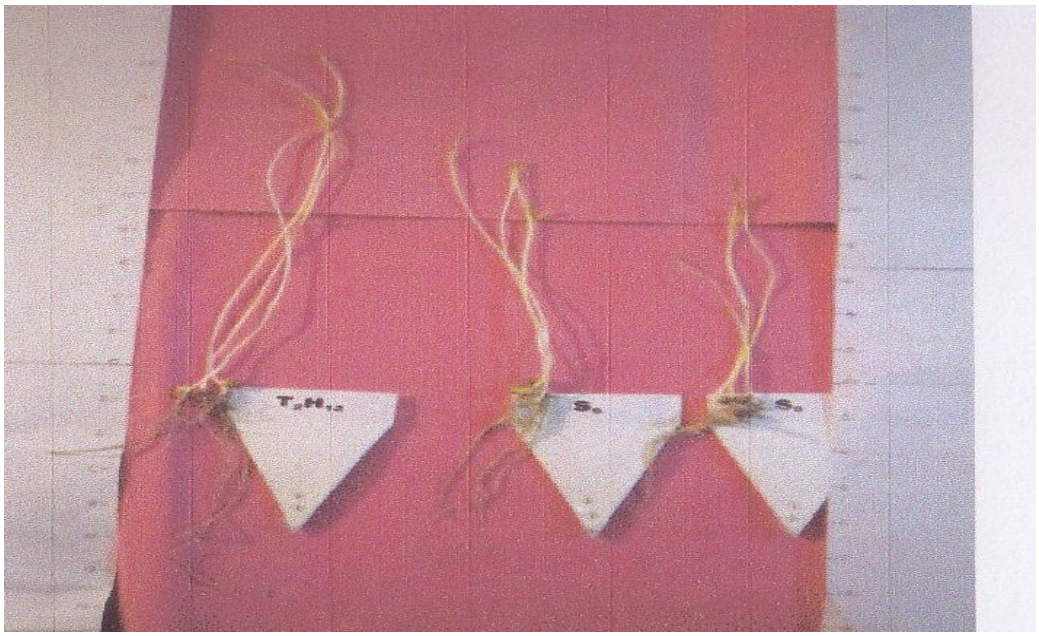


Plate 14. Photograph showing grass pea seedling growth difference under water soaked and Tamarind leaf extract soaked

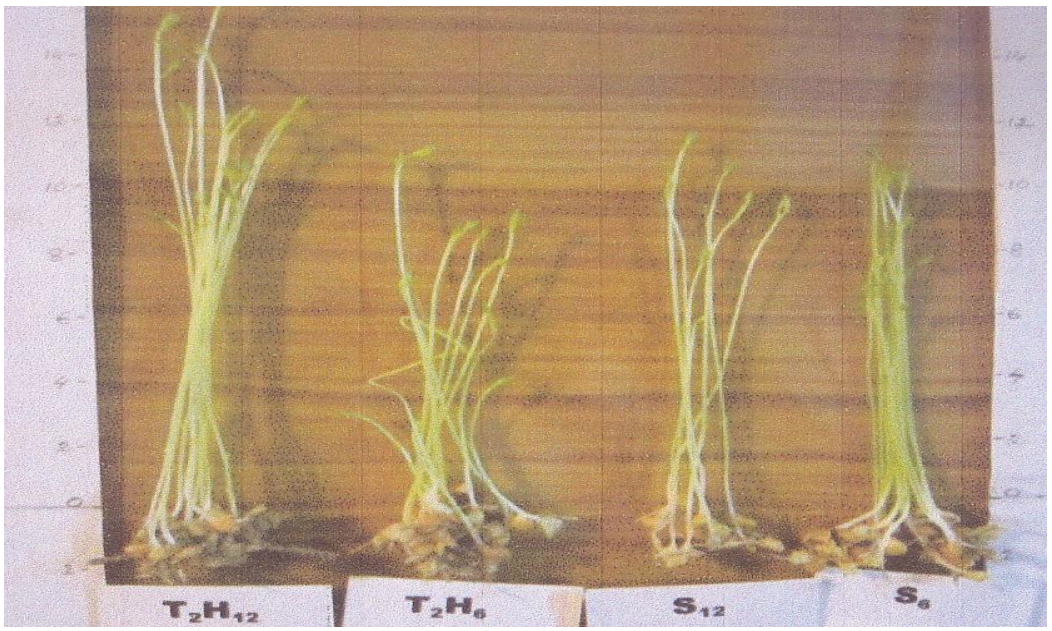


Plate 15. Photograph showing seedling growth difference under water soaked and tamarind leaf extract soaked