NITROGEN MANAGEMENT IN BIDI TOBACCO (*Nicotiana tabacum* L.) NURSERY

BY

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(Registration No. 04-2886-2016)

B. A. COLLEGE OF AGRICULTURE

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NITROGEN MANAGEMENT IN BIDI TOBACCO (*Nicotiana tabacum* L.) NURSERY

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(AGRICULTURE)
IN
AGRONOMY

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CERTIFICATE

This is to certify that the thesis entitled “Nitrogen management in bidi tobacco (*Nicotiana tabacum* L.) nursery” submitted by **Patel Pinalben Bharatbhai** (**Reg. No. 04-2886-2016)** in partial fulfilment of the requirements for the award of the degree of **MASTER OF SCIENCE (Agriculture)** in the subject of **AGRONOMY** of the Anand Agricultural University is a record of bonafide research work carried out by her under my personal guidance and supervision and the thesis has not previously formed the basis for the award of any degree, diploma or other similar title.

Place : Anand | **(K. M. Gediya)**
Date : / 07 / 2018 | MAJOR ADVISOR

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DECLARATION

Date: / 07 / 2018

This is to certify that whole of the research work reported in the thesis in partial fulfilment of the requirement for the award of the degree of **Master of Science (Agriculture)** in the subject of **Agronomy** is the result of investigation done by undersigned under the direct guidance and supervision of **Dr. K. M. Gediya**, Associate Research Scientist, Bidi Tobacco Research Station, Anand Agricultural University, Anand and no part of the research work has been submitted for any other degree so far.

Place: Anand **(Pinal Patel)**

Date: / 07 / 2018

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NITROGEN MANAGEMENT IN BIDI TOBACCO (*Nicotiana tabacum* L.) NURSERY

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ABSTRACT

A field experiment was conducted during *kharif* season of the year 2017 at Bidi Tobacco Research Station, Anand Agricultural University, Anand (Gujarat) to study "Nitrogen management in bidi tobacco (*Nicotiana tabacum* L.) nursery". The soil of the experimental field was loamy sand in texture, low in organic carbon and available nitrogen, medium in available phosphorus and high in available potassium with slightly alkaline (pH 8.15) in reaction.

The twelve nitrogen management treatments viz., T_1 (RDN 180 kg N as Basal), T_2 (RDN + Foliar spray Urea 1.0 % at 20 DAS), T_3 (RDN + Foliar spray Urea 2.0 % at 20 DAS), T_4 (RDN + Foliar spray Urea 1.0 % at 30 DAS), T_5 (RDN + Foliar spray Urea 2.0 % at 30 DAS), T_6 (75% RDN + Foliar spray Urea 1.0 % at 20 DAS), T_7 (75% RDN + Foliar spray Urea 2.0. % at 20 DAS), T_8 (75% RDN + Foliar spray Urea 1.0 % at 30 DAS), T_9 (75% RDN + Foliar spray Urea 2.0. % at 30 DAS), T_{10} (75% RDN + Foliar spray Ammonium sulphate 0.5 % at 30 DAS), T_{11} (75% RDN + Foliar spray Cow urine 1 % at 30 DAS) and T_{12} (75% RDN + Foliar spray Vermiwash 2.0 % at 30 DAS) were studied in Randomized Block Design with four replications.

Plant stand recorded at 15 DAS was not affected significantly due to different nitrogen management treatments.

Periodical crop growth rate recorded at 30, 45 and 60 DAS indicated that maximum crop growth rate was achieved under treatment T_5 (RDN + Foliar spray Urea 2.0 % at 30 DAS).

Nitrogen management treatments could not affect the relative growth rate recorded at 30 DAS. At 45 DAS, relative growth rate was higher under treatment T_5 (RDN + Foliar spray Urea 2.0 % at 30 DAS). The highest relative growth rate recorded at 60 DAS was observed under treatment T_9 (RDN + Foliar spray Urea 2.0 % at 30 DAS).

Net assimilation rate recorded at 30 DAS was not affected significantly due to different nitrogen management treatments. At 45 DAS, net assimilation rate was higher under treatment T_5 (RDN + Foliar spray Urea 2.0 % at 30 DAS). Treatment T_{11} (75% RDN + Foliar spray 1.0% Cow urine at 30 DAS) recorded significantly higher value of net assimilation rate at 60 DAS.

Among the growth parameters, leaf area and chlorophyll content (SPAD value) recorded at 30, 45 and 60 DAS were significantly influenced by nitrogen management treatments. Leaf area and chlorophyll content were improved significantly due to treatment T_5 (RDN + Foliar spray Urea 2.0 % at 30 DAS). Significantly lower leaf area and chlorophyll content were observed under treatment T_1 (Control).

Number of damped seedlings at 45 and 60 DAS were significantly influenced due to nitrogen management treatments. Treatment T_5 (RDN + Foliar spray Urea (2.0 % at 30 DAS) recorded significantly lower value of number of damped seedlings at 45 and 60 DAS.

At 30, 45 and 60 DAS, treatment T_5 (RDN + Foliar spray Urea 2.0 % at 30 DAS) registered higher fresh and dry matter accumulation of bidi tobacco seedling. But, it was statistically at par with treatment T_{12} (75% RDN + Foliar spray vermiwash 2.0 % at 30 DAS) and T_{11} (75% RDN + Foliar spray Cow urine 1.0% at 30 DAS).

Treatment T_{12} (75% RDN + Foliar spray Vermiwash 2.0 % at 30 DAS) recorded higher root and shoot length of bidi tobacco seedlings at 45 and 55 DAS.

Nitrogen management treatments could not affect the number of transplantable seedlings recorded at 55 DAS. At 45 DAS, higher number of transplantable seedlings were achieved under treatment T_{12} (75% RDN + Foliar spray Vermiwash 2.0 % at 30 DAS), T_{11} (75% RDN + Foliar spray Cow urine 1.0% at 30 DAS) and T_5 (RDN + Foliar spray Urea (2.0 % at 30 DAS).

Treatment T_{12} (75% RDN + Foliar spray Vermiwash 2.0 % at 30 DAS) recorded significantly the lowest number of non transplantable seedlings at 45 and 55 DAS among all nitrogen management treatments.

Number of total seedlings recorded at 55 DAS was not affected significantly due to different nitrogen management treatments. At 45 DAS, the highest number of total seedlings was achieved under treatment $T_{5,}$ $T_{8,}$ $T_{9,}$ T_{11} and T_{12}.

The post harvest nutrients (nitrogen, phosphorus and potash) contents in bidi tobacco seedlings was significantly influenced by nitrogen management treatments. Higher nitrogen content of bidi tobacco seedlings was observed under treatment $T_{5,}$ T_{11} and T_{12}. However, phosphorus and potash contents of bidi tobacco seedlings were higher under treatment T_{12} (75% RDN + Foliar spray Vermiwash 2.0 % at 30 DAS) T_{11} (75% RDN + Foliar spray Cow urine 1.0% at 30 DAS).

Organic carbon and available nutrients (nitrogen, phosphorus and potassium) status of soil recorded at harvest was not affected significantly due to different nitrogen management treatments.

Maximum net realization of 602.548×10^3 ₹ ha^{-1} with BCR of 5.22 was obtained from treatment T_{12} (75% RDN + Foliar spray 2.0% Vermiwash at 30 DAS). In terms of net realization and BCR, the treatments next in order were treatments T_{11} (75% RDN + Foliar spray Cow urine 1.0% at 30 DAS) and T_5 (RDN + Foliar spray Urea 2.0 % at 30 DAS) with net realization of 590.241×10^3 ₹ ha^{-1} and 580.055×10^3 ₹ ha^{-1} and BCR value of 5.15 and 4.89 respectively.

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Place: Anand

(Patel Pinal)

Date: / 07 / 2018

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LIST OF ABBREVIATIONS AND SYMBOLS

%	Per cent
@	At the rate of
₹	Rupees
^0C	degree Celsius
$-^1$	Per
AAU	Anand Agricultural University
Anon.	Anonymous
AS	Ammonium sulphate
BCR	Benefit-cost ratio
Ca	Calcium
$CaCl_2$	Calcium chloride
CD	Critical differences
CGR	Crop growth rate
Cm	Centimetre
cm^2	Centimetre square
CV	Co-efficient of variance
cv.	Cultivar
DAS	Days after sowing
df	Degree of freedom
dS m^{-1}	desi siemens per metre
EC	Emulsifiable concentration
EC	Electrical conductivity
et al.	*et allii* : and others
etc.	Etcetera and rest, so on
Fig.	Figure
FYM	Farm Yard Manure
G	Gram
ha^{-1}	Per hectare
hrs	Hours
K	Potassium

K_2O	Potassium oxide
kg ha^{-1}	Kilogram per hectare
kg	Kilogram
Km	Kilometre
KNO_3	Potassium nitrate
L	Labour
L	Litre
M	Metre
m^2	Square metre
Max.	Maximum
me	Milli equivalent
mg	Milli gram
$MgCl_2$	Magnesium Chloride
Min.	Minimum
ml	Milli litre
mm	Milli metre
N	Nitrogen
NAR	Net assimilation rate
No.	Number
NS	Non-significant
OC	Organic Carbon
P	Phosphorus
P_2O_5	Phosphorus pentoxide
pH	Potential of hydrogen ions
q ha^{-1}	Quintal per hectare
RDF	Recommended dose of fertilizer
RDN	Recommended dose of Nitrogen
RGR	Relative growth rate
RH	Relative humidity
SEm $\pm$	Standard error of mean
SPAD	Soil Plant Analysis Development

Sr.	Serial
Std.	Standard
t ha^{-1}	Tonne per hectare
Var.	Variety
viz.,	Namely

CONTENTS

1. INTRODUCTION

Tobacco (*Nicotiana tabacum* L.) is the most widely grown commercial non-food crop in the world. Tobacco belongs to the order Tubiflorae and family *Solanaceae*. Commercially important species are *Nicotiana tabacum* L. and *Nicotiana rustica* L. It is believed to have been introduced in India from its native Central America by Portuguese in 1603. The name "Nicotiana" as well as "nicotine" was given in the honour of Jean Nicot, French ambassador to Portugal who in 1559 sent it as a medicine to the court of Catherine de Medicine (Anon., 1960 and Gopalachari, 1984). This plant is considered one of the few crops entering world trade entirely on the leaf basis and it is valued for its leaf containing nicotine. It is an important commercial crop in view of revenue generation, export earnings and employment potential. It is aptly called the golden leaf of India.

The area under tobacco in the world is 42.9 lakh hectares with a production of 7.49 million tonnes and productivity of 1745 kg ha^{-1}.The major tobacco growing countries in the world are China, India, USA, Brazil, Turkey, Russia, Italy and Zimbabwe. During 2014, China was the biggest tobacco producer having production of 2995.4 thousand metric tons. India was the 3rd largest producer after China and Brazil (Anon., 2014). The crop occupies less than 0.24% of the net cultivated area and earns sizable amount of foreign exchange (5869 crores), central excise and state tax including VAT, entry tax etc. (29000 crores) to the nation besides providing direct and indirect employment to 45.7 million people including 6 million farmers and 39.7 million workers (Anon., 2015[a]). India produces 7-8% of world's tobacco. Tobacco is an important foreign exchange earner grown over 0.46 million hectare (9.6% of world area) in India having the production of 0.74 million tonnes with 1612 kg ha^{-1} average productivity in 2014-15 (Anon., 2015[b]). Thus, the crop is a lifeline for sizable chunk of population, particularly rural women, tribal and other weaker sections of the society (Krishnamurthy, 2011).

In India, tobacco is grown mainly in Andhra Pradesh, Gujarat, Karnataka, Uttar Pradesh, Bihar, West Bengal, Maharashtra and Tamil Nadu. By virtue of the dominant role played by this commercial crop, Indian Central Tobacco Committee (ICTC) established Central Tobacco Research Institute in Rajahmundry (Andhra Pradesh) in 1947. Rajahmundry houses the core research institute. Gujarat occupies

1.37 lakh ha area, producing 240 million kg of tobacco with productivity of 1710 kg ha^{-1} (Anon., 2015[b]). Gujarat ranks second in area, production and productivity of tobacco next to Andhra Pradesh. Among various types of tobacco, bidi tobacco shares about 30% of the total tobacco area and about 40% of tobacco production in the country. Gujarat stands first in bidi tobacco production in India. Bidi tobacco is also grown in Nipani area comprising Belgaum district of Karnataka and part of Kolhapur and Sangli districts of Maharashtra state having 33,000 hectares area. It is also grown to some extent in Andhra Pradesh, Madhya Pradesh and Rajasthan. Among different types of tobacco grown in Gujarat, bidi tobacco occupies 81%, chewing (*Lal* and *Kala chopadia* and *rustica*) comprise 18% and Hookah (*Gadaku*) tobacco is having 0.5 to 1.0% area. The production of bidi tobacco in Gujarat is largely concentrated in Middle Gujarat Zone comprising Kheda, Anand, Mahisagar and Vadodara districts (90 % of total production of Gujarat) besides a small area in Panchmahals and Dahod districts. Bidi tobacco industry is essentially a cottage industry employing more than 30 lakh of rural population. Bidi tobacco plays a vital role in the national economy in generating employment and revenue.

Raising nursery is an important aspect of tobacco cultivation. There are various advantages of nursery growing. In nursery, it is easy and convenient to look after the tender and young seedlings in small and compact area, also it provides favourable conditions for growth and helps in getting an early crop. For nursery raising, capital of land, seed and other sources should be ensured. Tobacco seeds are very small and egg-shaped with thick seed coat. In *Nicotiana tabacum* the average weight of the seed is 0.08 to 0.09 mg and there are 10,000 - 12,000 seeds per gram. In *Nicotiana rustica*, the seed is larger and about three times heavier. The emerging seedlings are tiny and delicate, therefore seeds are unsuitable for sowing directly in the field. Hence they are sown in small areas called nurseries or seed beds and tended carefully till the seedlings attain a particular size before transplanting in the main field.

Nitrogen is one of the elements which is needed in all parts of plant life. Farmers are increasingly persuaded to use more nitrogen fertilizer in order to improve crop yield (Khodabandeh, 1997). Tradionally supply of nutrient to tobacco crop has been through the conventional fertilizers i.e. Urea, Ammonium Sulphate etc. However with the changing seenario, foliar application which has been found to be good complementary source of nutrition beneficial for boosting the yield as well as productivity of tobacco crop.

Foliar feeding is a relatively new and controversial technique. In many cases aerial spray of nutrients is preferred and gives quicker and better results than the soil application. Now-a-days, development of foliar fertilizers and their application techniques have been suggested by numerous agri-agencies. Recently foliar application of nutrients has become an important practice in crop production while soil application of fertilizers is the basic method. Recently foliar fertilization is widely used practice to correct nutritional deficiencies in plants and has potential advantages over soil application and it may increase the efficacy of fertilizer use. Similarly, in terms of seedlings it is more efficient than soil fertilization for both macro and micronutrients in different soil types (Arif *et al.,* 2006, Ali *et al.,* 2008, Alam *et al.,* 2010).

Foliar application of nitrogenous fertilizer is an important method because plants can absorb the nutrients much quicker, and smaller quantities may be required for normal growth as against the large quantities of the same generally required for soil application (Mudaliar, 1959).

Hinsvark *et al.* (1953) found that a good portion of nitrogen applied as Urea spray is absorbed readily by plants in several hours. The application of nitrogen had considerable influence on size, shape, yield and quality of the leaf. Thus, response of tobacco to nitrogen has been almost of universal observance. It is recognized that supplementary foliar fertilization during crop growth can improve the mineral status of plants and increase the crop yield (Kolota and Osinska, 2001).

Urea can be supplied to plants through the foliage, facilitating optimal nitrogen management, which minimizes nitrogen losses to the environment. Most plants absorb foliar applied urea rapidly and hydrolyze the urea in the cytosol (Witte *et al.* 2002). Sometimes, the availability of urea becomes inadequate for the farmer at sowing time. In such situation the foliar application of plant nutrient is effective and economical for some crops. Furthermore, it has been observed that fertilizer efficiency particularly urea application through soil is not as effective as if it is applied to plants through foliage along with soil application, because only 20 to 50% of the soil applied nitrogen is recovered by annual crops. Even several researchers have shown that foliar nitrogen application has higher recovery rather than soil application (Bajwa, 1992)

Cow urine can be used as a foliar spray or applied to the soil. Cow urine contains significant amounts of both nitrogen and potassium. Research shows that only 20% of nitrogenous materials consumed by cattle is absorbed and 80% is excreted in urine and dung. After decomposition urine should be mixed with water and sprayed. For smaller plants 1 litre of urine with 10 litre of water, while for mature plants mix 1 litre in 5 litre of water should be sprayed thoroughly starting from the top of plants (Anon., 2004).

Cow urine is one of the ingredients of "Panchagavya" (urine, dung, milk, curd, and ghee) which is capable of treating many diseases as it has several medicinal properties and it is the best remedy to cure fungal and bacterial diseases. It has an excellent germicidal power, antibiotics and antimicrobial activity. Therefore, cow urine can kill varieties of germs and it also boosts immunity. Cow urine contains many beneficial elements, that is, chemical properties, potentialities and constituents which help in removing all the ill effects and imbalances of body caused by infectious agents. Cow urine contains 95% water, 2.5% urea, and the remaining 2.5% a mixture of salts, hormones, enzymes, and minerals. It has been considered that cow urine is very useful in agricultural operations as a bio fertilizer and bio pesticide as it can kill number of pesticide and herbicide resistant bacteria, viruses, and fungi. Cow urine in combination with plant extracts is used to prepare disinfectant which is biodegradable and ecofriendly with good antibacterial action. Majority of people in India use cow urine to get rid of various diseases due to its therapeutic values. Cow urine has several biological activities such as antioxidant, anti-diabetic, antitumor, antiprotozoal, and molluscicidal.

Vermiwash is a liquid that is collected after the passage of water through a column of worm action. It is a mixture of excretory products and mucus secretion of earthworms along with micronutrients from the soil organic molecules. Foliar application of vermiwash is more advantageous due to absence of nutrient leaching, which is often encountered when performing soil amendments. It contains nitrogen as nitrogenous excretory product and growth promoting hormones and essential enzymes and influence resistance in plants. It is applied as foliar spray. These are beneficial for growth and development of plant and stimulate the yield and productivity of crops and also microbial study of vermiwash found that nitrogen fixing bacteria like azotobacter, agrobacterium and rhizobium and some phosphate solubilizing bacteria are also found in vermiwash. Ismail (1997) reported that vermiwash was very effective for foliar application of nurseries, lawns and orchids.

Therefore, the present investigation was undertaken to study the effect of "Nitrogen management in bidi tobacco (*Nicotiana tabacum* L.) nursery" with the following objectives:

1. To study the effect of foliar application of fertilizer, cow urine and vermiwash on growth of transplantable seedlings
2. To study the effect of foliar application of fertilizer, cow urine and vermiwash on number of transplantable seedlings

2. REVIEW OF LITERATURE

Bidi tobacco (*Nicotiana tabacum* L.) occupies an important place as a commercial crop in India as well as world. Bidi tobacco nursery raising is handicapped by several factors and one of the most limiting is nutrient management.

This chapter deals with the research work carried out on effect of nitrogen management in bidi tobacco nursery. A brief summary of research work carried out by various research workers in India and abroad are presented here. The effect of foliar application of Urea, Ammonium sulphate, cow urine and vermiwash on growth attributes of bidi tobacco nursery are briefly reviewed here as under.

2.1 EFFECT OF FOLIAR SPRAY OF UREA

2.2 EFFECT OF FOLIAR SPRAY OF AMMONIUM SULPHATE

2.3 EFFECT OF FOLIAR SPRAY OF COW URINE

2.4 EFFECT OF FOLIAR SPRAY OF VERMIWASH

2.1 Effect of foliar spray of Urea

Button and Hawkins (1958) conducted an experiment on two commercial potato farms in Connecticut River Valley to study the effect of foliar application of urea on potato. The foliar applications of urea were applied at weekly intervals in 80 gallons of water per acre. The results showed that foliar application of urea was an effective means of supplying part of the nitrogen for potatoes. Foliar applications of urea could be used as a means of supplying additional nitrogen, when the plants were too large to be side-dressed.

A field experiment was conducted on foliar fertilizer application by Ramu and Muthuswamy (1964) on brinjal. Results revealed that 2 per cent urea was effective for vigorous and healthier growth of brinjal cv. Pusa Purple Long.

Tiwari and chhonkar (1967) observed an increase in growth of tomato by foliar application of urea and stated that foliar nutrition in tomato helped to increase the growth, yield and content of chlorophyll ‘a’ and ‘b’ and carotenoid in the leaf tissues.

Mitra and De (1968) found that application of 120 kg N as 1/2 through the soil and half of the fertilizer applied as foliar spray resulted in a marked increase in egg plant growth and yield.

Chowdary and De (1969) obtained increased yield of tomato through application of half of nitrogen to the soil and half as foliar spray as compared to soil application of entire nitrogen.

Singh and Sadhu (1970) conducted an experiment during 1962-63 at Ludhiana to study 4 levels of urea spraying 1, 1.5, 2, and 2.5 per cent in brinjal and reported as the highest yield with an application of (1%) urea spray.

Verma *et al*. (1970) observed that 1.25 per cent urea as foliar spray produced significantly higher growth, yield and vitamin 'C' content in tomato.

An experiment was conducted by Hovadik and Vrany (1970) with single and repeated foliar treatments of urea at 0.5 to 1.5 per cent. They reported that foliar application of urea had a favourable effect on capsicum and tomato growth and yield, and this was especially marked in plants artificially infected with a vigorous strain of *Fusarium sp.* They found that urea treated plants produced higher yields than infected plants or non-infected controls.

Rani *et al.* (1970) conducted an experiment at Research Farm of the Department of Vegetable Science, Haryana Agricultural University, Hisar during winter season of 2014-2015, to study the 4 levels of urea spraying 0.5, 1.0, 1.5, and 2.0 per cent in garlic and reported that increasing concentration of urea from 0.5 to 1.5 per cent caused an increase in vegetative growth parameters of garlic plant but higher concentration (2.0%) of urea fertilizer decreased the plant growth parameters.

Bid *et al.* (1971) carried out a field experiment to investigate the effects on 2 varieties up to 120 kg N ha^{-1}, half applied initially to the soil and half in 6 splits application to the soil or 1 per cent foliar spray. They found that maximum yield of brinjal were obtained with soil treatment of 80 kg N ha^{-1} and with foliar treatment of 40 kg N ha^{-1}.

Dhuria and Shukla (1973) conducted a field experiment at experimental station of the Indian Institute of Horticulture Research, Hessaraghatta, Bangalore during winter season of 1969 to study the suitability and response of four different varieties to foliar nutritional with urea. It was observed that foliar application of urea alone did not give good yield but when applied with soil application, increased the yield. The higher yield of tomato was recorded with 50 kg N ha^{-1} applied on soil followed by spray 23 kg N ha^{-1} as urea.

Muthukrishanan *et al.* (1974) conducted pot experiment with tomato plants which sprayed with 0.5 per cent urea. They observed that urea spraying increased phosphorus uptake as indicated by greatly enhanced phosphorus activity in the developing fruits. The acid soluble protein and lipid fractions showed the largest increases.

Chaudhuri and De (1975) reported that nitrogen and phosphorus increased yield, dry matter content and uptake of nitrogen and phosphorus by tomato plants. Foliar application of a part of these fertilizers were superior to soil application in increasing tomato yield, dry matter production and uptake of N and P. Foliar application of N and P were 2.02 and 1.63 times more efficient respectively, in increasing tomato yield than corresponding soil application.

Shakyawar (1986) worked on chilli to see the effect of different grades of fertilizer and urea spray on growth and yield of chilli in Rewa Zone and reported that 1 per cent urea spray gave better result in comparison to other treatments.

Shelp and Shattuck (1986) investigated in pruned plants metabolisms of foliar applied urea and accumulation of carbon by developing fruits. They suggested that foliar application of urea may be useful for studied source-sink relation in tomato plants.

Singh (1987) conducted a field trial during 1973-74 to 1975-76 with tobacco cv. Dixie shade grown on silty loam soil and gave nitrogen in a single dressing at sowing or in 2 split dressing at sowing and as a foliar spray. He observed that different parameters relating to cigar smoking score decreased with increasing N rates, but were slightly better with split application of N than with a single N application. He also found that yield response per kg N at 125 kg N ha^{-1} was higher with 67 per cent of nitrogen was supplied at sowing and rest as a foliar spray than N when applied in single dressing.

Das and Singh (1989) conducted a field experiment on tomato cv. LE 79 during 1985-88 at Bhubaneswar, India where N was applied as a basal dressing (40 kg ha^{-1}), top dressing (20 to 40 kg ha^{-1}) and foliar spray (10, 20 or 30 kg ha^{-1}), alone or in various combinations. Significant increases in yield and biomass were observed with nitrogen applied as basal dose + foliar spray as compared with other treatments.

A study was carried out by Das and Patro (1989) on tomato cv. Marglobe at Bhubaneswar, India, during 1979-80. Seedlings (33 days old) were planted in plots treated with 30 kg N, 50 kg P_2O_5 and 50 kg K_2O ha^{-1}. Micronutrients, 0.075 per cent Mo (as ammonium molybdate), 0.10 per cent Zn (as zinc sulphate), 0.25 per cent B (as boric acid), 0.04 per cent Cu (as copper sulphate), alone or in combination, and/or 2 per cent urea, were applied as foliar sprays. Effects on growth, yield, disease (bacterial wilt, viruses) incidence and fruit quality were tabulated. The best plant growth and the highest yield (298 q ha^{-1}) were obtained with urea followed by Mo or B. Cu reduced wilt infection to 23.63 per cent as compared with 35.46 per cent in the control.

A field experiment was carried out at Coastal Research and Education Center, Department of Horticulture, Clemson University, Charleston, by Regina and Robert (1990) find out the effect of nutritional regimes on tomato seedlings nutritionally conditioned with solutions containing factorial combinations of nitrogen at 25, 75 and 225 mg $litre^{-1}$, Phosphorus at 5, 15 and 45 mg $litre^{-1}$ and potash at 25, 75 and 225 mg $litre^{-1}$. They observed that fresh shoot weight, plant height, leaf number, stem diameter, shoot and root dry weights and total chlorophyll were increased with increasing rate of N from 25 to 225 mg $litre^{-1}$.

Millard and Robinson (1990) conducted a field trial at Wartle, Aberdeenshire, UK to assess fertilizer use efficiency and using nitrogen labelled fertilizer with potatoes cv. Maris piper during 1985 and 1986, respectively. They reported that late application of nitrogen as foliar sprays could benefit crop with long growing season and reduce environmental N losses.

Takebe and Yoneyama (1992) conducted a field experiments at Andosol soil in the spring and summer seasons to determine the total ascorbic acid concentration in leaves and tubers of potatoes. They found that ascorbic acid concentration in potato leaves were increased by 108-121 per cent with foliar application of urea.

Chung *et al.* (1992) carried out an experiment at Department of Horticulture Collage of Agricultural, Chonum, Korea supplied 2, 4, 8, 16, 32 me N $litre^{-1}$ to tomato plant at third-true leaf stage and observed that plant height increased with increasing nutrient concentration, except at the highest concentration where it was not significant. They also found that dry weight increased with increasing nitrogen concentration.

Batra *et al.* (1993) conducted an experiment during 1998-90 at Hisar, Haryana, India to determine the plant survival, growth and seedlings and tubers yield of true potato seeds (TPS) in nursery beds. They found that foliar application of 0.1 per cent urea on alternate days starting at 5 days after germination gave comparable seedlings tubers yield to those from seedlings left in situ.

Liptay and Nicholls (1993) worked out to observe the effect of nitrogen supply during greenhouse seedling production affect subsequent tomato root growth in field during 1988-89 at Agriculture Canada, Research Station, Harrow, Canada. They reported that root growth in field increased exponentially when rate was increased from 50 to 350 mg $litre^{-1}$. The optimum N range for maximum survival, growth and early yield in the field was 100-200 mg $litre^{-1}$. Strength of the seedlings stem increased with nitrogen rate curvilinearlly.

Czuba (1994) conducted an experiment during 1990-91 in Poland to determine the urea use efficiency by foliar application methods to potatoes. He observed that foliar application gave higher yields and greater N use efficiency than solid urea. The best urea concentration for foliar application on potatoes was 4-6 per cent and recommended numbers of application were 3-5 by which yield was increased 3-6 t ha^{-1}. From the experiment it was also found that, the effectiveness of foliar applied urea 90-160 per cent of that of solid urea.

Bernard *et al.* (1996) carried out an experiment at Department of Vegetable Crop, University of California, Davis during 1994. They studied the foliar application of urea (0.2%) in tomato plants. Results, revealed that plant biomass and plant height increased at the concentration of urea 0.2 per cent but higher urea concentration decreased the growth and leaf damage also.

Agronomic effects of application of foliar fertilizers in different combinations were investigated in potatoes by Jablonski and Dryjankka (1998). It was observed that the highest marketable yield increased at a low rate of nitrogen fertilizers as foliar application.

Grzeskiewicz and Trawezynski (1999) evaluated the effects of foliar application of 6 liquid fertilizers and nitrogen applied to soil at different doses (0, 50 and 100 kg N ha^{-1}) on potato tubers yield during 1994-96. It was observed that significant yield increased (14% on average) for two edible varieties in combination with 4 time's foliar application of fertilizers.

Swierczewska *et al.* (1999) studied the foliar nutrition efficiency during 1993-95 by applying 6 per cent urea, 5 per cent magnesium sulphate and multiple micronutrient fertilizer on potatoes. It was found that all combinations of nitrogen with micro nutrients and/ or magnesium increased tuber yield. Nitrogen use efficiency was 60 per cent from the foliar applied urea and 48 per cent as a soil application.

A field experiment was conducted by Singh *et al*. (2000) in Uttar Pradesh, India to find out the suitable rate and application of nitrogen fertilizer for obtaining optimum growth and yield of tomato cv. Pusa Hybrid 2. They found that nitrogen at 80 kg ha^{-1} applied split (40 kg ha^{-1} basal + 20 kg ha^{-1} top dressing + 20 kg ha^{-1} foliar) produced the highest biomass and yield. They also reported that increasing nitrogen rates resulted in increasing biomass and yield.

A field experiment was conducted by Al-Sahhaf (2000) in the middle region of Iraq to evaluate the effect of foliar application of urea (46% N) and 4 (Vegas, Ace 55, Super Marmande and K 537) tomato cultivar during 1995 and 1996, respectively. He reported that leaf number were significantly increased by foliar application of urea in Vegas and Packmor.

Bhutto (2003) used six treatments of urea (0, 0.50, 1.00, 1.50, 2.00 and 2.50 %) to investigate the effect of nitrogen on different parameters of tomato. Foliar application containing 2.0 per cent urea gave the highest tomato yield (15.65 kg) while 14.81 kg and 14.77 kg mean fruit yield plot $^{-1}$ was observed under 2.50 and 1.50 per cent urea, respectively. Application of 2 per cent foliar urea gave maximum yield of 14908 kg ha $^{-1}$ while 2.50 and 1.50 per cent urea gave 14105 and 14070 kg mean fruit yield ha^{-1}, respectively. Positive effect was observed when plot was sprayed with urea on growth and yield parameters of tomato.

Valadabadi and Farahani (2010) conducted a field experiment at Islamic Azad University, Iraq during 2005 to study the effect of pattern on physiological growth indices in maize (*Zea mays* L.) under nitrogenous fertilizer application. Total dry weight (TDW), leaf area index (LAI), relative growth rate (RGR) and crop growth rate (CGR) were significantly affected by the rate of nitrogen fertilizers. Nitrogen at 520 kg ha^{-1} gave significantly higher total dry weight, leaf area index, relative growth rate and crop growth rate.

Mondal and Abdullah (2011) conducted a field experiment at Bangladesh during 2010 to study the effect of foliar application of urea fertilizer on growth and yield of tomato and find out optimum concentration of foliar application of urea for maximum growth and yield of tomato, an experiment was conducted with different concentration of foliar application of urea fertilizer, namely, control 2500 ppm (0.25%), 5000 ppm (0.50%), 7500 ppm (0.75%) and 10000 ppm (1%). They reported that maximum plant height, number of leaves and number of green leaves per plant found the highest with an application of (1%) urea spray then the control treatment.

Anwar *et al.* (2011) conducted an experiment at Department of potato and vegetatively propagated crops, Horticulture Research Institute Agriculture Research Centre, Giza, Egypt during summer season of 2009-10 to study the effect of different rates of nitrogen and potassium fertilization (100%, 75% and 50% of recommended dose) and foliar application with urea and citrate potassium at rates of 0.05 and 1 per cent and their interactions on plant growth, fresh and dry weight, yield and its components and chemical constituents of potato plants. The results showed that foliar application of urea and citrate potassium at a rate of 1 per cent significantly increased plant growth, yield and its components. This might be due to stimulating effect of urea through improving physiological performance of plants and multiple advantage of foliar application method as rapid and efficient response to plant needs.

Fatma *et al.* (2013) conducted an experiment at Vegetable Research Department, National Research Centre, Dokki, Giza, Egypt during 2010-2012 to study the response of potato plants to the foliar spraying of urea, i.e. 2 per cent and 3 per cent. The urea as foliar spraying at 3 per cent level caused an increase in values of all plant growth parameters, i.e. plant height, number of leaves as well as total fresh and dry weight of whole plant and its different organs. Moreover, the better plant growth was recorded with that plants which received the higher urea level, i.e. 3 per cent.

Abdul and Habeeb (2014) conducted a field experiment at Department of Horticulture and Landscape, College of Agriculture Bagdad (Iraq) during 2012 to study 4 levels of urea spraying; control, 1.5 g liter^{-1} (1.5%), 3 g liter^{-1} (3%) and 4.5 g liter^{-1} (4.5%) in tomato crop. Results revealed that 4.5 per cent (Urea) spray was significantly superior with respect to plant height, number of leaves and higher yield as compared to control.

An experiment was conducted by Singh *et al.* (2015) during two spring summer seasons at Vegetable Research Centre, Pantnagar, Uttarakhand during 2013 to study the foliar application of urea in cultivar of chili PC 7 (Pant C 3). Urea was used as solution of 0.5, 1.0, 1.5 and 2.0 per cent and pH was neutralized using slaked lime. Simple water spray was considered as control. Among all the treatments, T_4 (urea @ 2.0%) showed maximum plant height, number of branches plant^{-1}, stem diameter, fruits weight plant^{-1}, dry weight fruit $^{-1}$, fruit dry weight, number of seeds fruit $^{-1}$, 1000-seed weight and seed yield plant^{-1} which were superior than control.

Khan *et al.* (2015) conducted an experiment during 2013-14 at Institute of Horticultural Sciences, University of Agriculture, Faisalabad Pakistan to study the effect of foliar application of urea on productivity of potato. In this experiment foliar application of urea reduced nitrogen losses and increased plant nitrogen use efficiency. Foliar applications of nitrogenous fertilizer (urea) were given after 30 days of sowing with one week interval in five split doses. Result revealed that foliar application of nitrogen resulted in increasing plant growth, yield and quality of potato.

Kaur *et al.* (2015) carried out field experiment at Punjab Agricultural University, Ludhiana during 2012-13 to study the effect of foliar application of mineral nutrients on growth attributes of pigeon pea. All the treatments of mineral nutrients (1mM $CaCl_2$, 2mM $CaCl_2$, 0.5% KNO_3, 1% KNO_3, 0.1% $MgCl_2$, 0.2% $MgCl_2$, 1% urea and 2% urea) showed positive effect on growth attributes. Amongst all the treatments, 2 per cent urea application caused maximum increase in growth attributes viz., plant height, number of branches, leaf area, Leaf area index, Shoot length weight, crop growth rate and relative growth rate. These growth attributes showed significant positive correlation with yield.

Shitahun (2017) carried out field experiment at Hawassa Agricultural College Farm, Sothern Nations and Nationalities states of Ethiopia to quantify the effect of increasing the level of nitrogen fertilizer from 0 to 100 kg ha^{-1} application on the growth and dry matter application. The study quantified the effect of nitrogen on leaf area index, leaf area ratio, crop growth rate, net assimilation rate and total dry weight. Leaf area index, leaf area ratio, crop growth rate and net assimilation rate were significantly affected by the rate of nitrogen fertilizers. Nitrogen at 100 kg ha^{-1} gave significantly higher leaf area index, leaf area ratio, growth rate and assimilation rate.

It is summarized from the review narrated above that tobacco and other solanaceae crops responded favourably to foliar fertilizer of urea. The result revealed from the review that tobacco seedlings responded adequately to application of 1 per cent and 2 per cent urea spray under different soil.

2.2 Effect of foliar spray of Ammonium sulphate

Mohammad and Dehnavard (2017) conducted an experiment at Faculty of Agriculture, Trabiat Modares University Tehran, Iran during 2012, to study the effects of foliar application of ammonium sulphate on growth and fruit quality of tomato plants. An experiment was conducted with different concentration of foliar application of ammonium sulphate (0, 50, 100 and 200 mm). They reported that foliar application of ammonium sulphate in moderate concentrations could have beneficial effects on plant growth and quality of tomato fruit. Foliar application of ammonium sulphate showed some negative effects on growth and yield of tomato plants.

2.3 Effect of foliar spray of Cow urine

It is reported that cow urine also contains many elements that are needed by plant, such as: nitrogen, phosphorus, potassium, calcium, sodium and others. Among these elements, largely macro nutrients which are essential to its existence and cannot be replaced by other nutrients for plant growth and development (Phrimantoro, 1995).

Misra *et al.* (2002) observed that seed hardening with cow urine recorded higher germination percentage and seedling length of asparagus as compared to that of control.

Oliveira *et al.* (2009) reported that soil and leaf applications of cow urine was applied at different concentrations (0.00, 0.25, 0.50, 0.75, 1.00 and 1.25 %) on fresh stem mass (FSM), dry stem mass (DSM), stem length (SL), fresh root mass (FRM) and dry root mass (DRM) and commercial yield (CY). An increase in cow urine concentrations increased the performance of all lettuce characteristics, except dry root mass, which presented reduction and dry stem mass and fresh root mass, which were not affected. The highest yield was obtained with the concentration of 1.25 per cent (17.00 t ha^{-1}) applied to leaves and with 1.01 per cent (14.92 t ha^{-1}), applied to soil, corresponding, respectively to increases of 28.1 per cent and 47.3 per cent in comparison to the control.

Jandaik *et al*. (2015) conducted an experiment at Solan, Himachal Pradesh to study the effect of foliar application of cow urine on growth and yield of Methi and found out the optimum concentration of foliar application of cow urine for growth and yield of Methi. An experiment was conducted with different concentration of foliar application of cow urine, namely control, (1.0%), (2.0%), (3.0%), (4.0%) and (5.0%). They reported that maximum plant height, shoot length, root length, number of leaves, leaf length and chlorophyll content found the highest with an application of (5.0%) cow urine spray then the control treatment.

Kumar and Shashidhar (2016) conducted an experiment at Main Agricultural Research Station, University of Agricultural Sciences, Dharwad during winter season of 2014-2015. They reported that maximum plant height, number of leaves and yield content found the highest with an application of (5.0%) cow urine spray then the control treatment in onion seedlings.

It is summarized from the review narrated above that solanaceae crops responded favourably to foliar spray of cow urine. The result revealed from review that tobacco seedlings responded adequately to application of cow urine 1 to 5 per cent. Application of cow urine foliar spray favourably influenced the growth and yield of crop.

2.4 Effect of foliar spray of Vermiwash

Adams (1986) carried out an experiment at Hyderabad during 1983-84. Result revealed that vermiwash application had a positive effect in bringing colour to tomato fruits, since nitrogen is the main component for synthesis of lycopene along with other micronutrients.

Rai and Bansiwal (2008) opined that vermiwash is a nutrient rich liquid produced by earthworms, feeding on organic waste material and plants residues. It is also non-toxic and ecofriendly, which arrests bacterial growth and forms as a protective layer for their survival and growth. Vermiwash contains N, P, K, Ca and hormones such as auxin, cytokinine, some other secretions and many useful microbes like heterotrophic bacteria, fungi etc. The quality of vermiwash produced by earthworms depends on the vermicompost that is used.

Ansari (2008) carried out an experiment during 1998-2000 at Shivri farm of Uttar Pradesh Bhumi Sudhar Nigam, Lucknow, India to study the effect of vermicompost and vermiwash in reclaimed sodic soils on the productivity of spinach (*Spinacia oleracea*), onion (*Allium cepa*) and potato (*Solanum tuberosum*). The result revealed that yield of spinach was significantly higher than control in plots treated with vermiwash (1:5 v/v in water). The yield of onion was significantly higher than control in plots treated with vermiwash (1:10 v/v in water), whereas the average weight of onion bulbs was significantly greater than control in plots amended with vermiwash (1:5 v/v in water). The yield of potato and average weight of potato tubers (78.85 g per piece) were significantly higher in plots treated with vermiwash as compared to control (4.02 t ha^{-1} and 52.51 g $piece^{-1}$, respectively).

Siddappa and Hedge (2011) conducted a field experiment at Kittur Rani Channamma Collage of Horticulture, Gokak Karnataka during 2006-07. Results, revealed that foliar spray of vermiwash produced vigorous growth with significantly higher fresh leaf yield (13.07 t ha^{-1}) as compared to control (11.13 t ha^{-1}). Among nutritional treatments, RDF + FYM (10.00 kg $plant^{-1}$) with vermiwash foliar spray at 50 per cent dilution recorded higher fresh leaf yield (17.74 t ha^{-1}) followed by FYM + RDF without vermiwash (15.79 t ha^{-1}) and FYM along with vermiwash (15.65) compared to control in curry leaf.

Meghvansi *et. al*. (2012) observed that vermiwash applied at 20 per cent showed good response on Naga chilli (*Capsicum assamicum*). The foliar spray of 20 per cent vermiwash showed increase in chlorophyll content by 11.93 per cent and increase in shoot height by 27.47 per cent as compared with control in Naga chilli. Vermiwash spray applied at 20 per cent resulted in increasing the yield attributes of Naga chilli (*Capsicum assamicum*) to the tune of 43.47 per cent average fruit weight and 23.07 per cent increase in seeds number $fruit^{-1}$ in comparison with control.

Hemant *et al.* (2015) conducted a field experiment at Vermicomposting centre of Charak Udyan Jiwaji University, Gwalior during 2012 to study the effect of vermiwash on growth and development of tomato plants. Application of vermiwash showed significant improvement in growth of plants i.e. length of shoot as well as number of leaves plant^{-1}.

Pradeep and Sharanappa (2013) conducted a field experiment at College of Agriculture, University of Agricultural Sciences, GKVK, Bengaluru, Karnataka during *Kharif* 2011-12 to study the effect of vermiwash spray on growth and yield of Chilli. Application of enriched biodigested liquid manure (EBDLM) 125 kg N equivalent (eq.) ha^{-1} + 3 sprays of vermiwash (3%) recorded significantly higher plant height (87.0 cm), branches plant^{-1} (32.9), leaf-area index (2.00) and leaf-area duration (51.9 days) compared to control treatment.

Devan *et.al.* (2013) noted that role of vermiwash, as foliar spray on growth of plant and its impact in comparison with plant growth regulators on exomorphological characters of *Abelmoschus esculentus* were investigated. Results of the study showed that vermiwash exhibited better effect in parameters viz., growth, plant height, length and diameter of internode, number of leaves, root length, leaf surface area, wet and dry weight of root and shoot of *Abelmoschus esculentus*. Among various foliar treatments used in the study, spray of 15 per cent vermiwash showed growth enhancing effects followed by Gibberellic acid (100 gm ml^{-1}) and Naphthalene acetic acid (100 g ml^{-1}). Maximum root length (18.100 cm) and plant biomass (44.47 g) was recorded in vermivash spray at 15 per cent as compare to control.

Fathima and Sekar (2014) conducted an experiment at Post Graduate and Research Department of Botany, Chennai, India to study on growth promoting effects of vermiwash on germination of vegetable crops. To study two levels of vermiwash spraying at a where rations of 10 per cent and 20 per cent in experiment. The germination percentage and seedling growth in terms of length of hypocotyl and radical were maximum in 10 per cent vermiwash treatment.

Subha and Prabha (2014) conduceted an experiment at Department of Biotechnology, Karunya University, Coimbatore, Tamil Nadu, India. Study was done on effect of vermiwash on growth parameters such as root and shoot length, number of leaf count in *Capsicum frutescens* after 30 days of planting. Selected plant *C. frutescens* showed the maximum root length (9 cm), shoot length (45 cm) and leaf count (22) in vermiwash treatment on 30 days after planting when compared to control.

Jadhav *et al.* (2014a) conducted a field experiment at ASPEE, Agricultural Research and Development Foundation (ARDF), TANSA Farm, Mumbai during *rabi 2013*-14 to study the effect of different levels of vermiwash spray on growth and yield of Radish cv. Local. Among all the treatments, RDF 100% as fertigation and vermiwash foliar thrice times spray of 2 per cent at 15, 30 and 45 DAS recorded significantly higher plant height (84.10 cm), root length (18.37 cm), number of branches^{-1} (6.80) in radish.

Jadhav and Patel (2014b) conducted a field experiment at ASPEE, Agricultural Research and Development foundation (ARDF), TANSA Farm, Mumbai during *rabi* 2013-14 to study the effect of different levels of vermiwash spray on growth and yield of Fenugreek cv. Local. The experiment consisted of five treatments involving spraying of vermiwash viz., 0.5, 1, 1.5 and 2 per cent by mixing with simple water and control. Vermiwash foliar thrice times spray of 2 per cent at 15, 30 and 45 DAS recorded significantly higher plant height (84.10 cm), root length (18.37 cm), number of branches^{-1} (6.80), total number of pods plant^{-1} (34.48), straw weight plot^{-1} (0.85 kg), seed weight (1161.33 kg) and straw weight (2833.7 kg ha^{-1}). Also it recorded maximum harvest index (29.03%), net maximum realization 39,620.80 ha^{-1} and cost benefit ratio 1:3.17 among other treatments.

Sundararasu and Jeyasankar (2014) conducted an experiment at Wet laboratory, PG and Research Department of Zoology, Musiri, Tamilnadu during 2013 to study the effect of vermiwash on growth and productivity of brinjal plants. The results, revealed that vermiwash spray enhanced the growth (plant height and number of leaves) and yield parameters (number of flowers and fruits plants^{-1})

Jaybhaye and Bhalerao (2015) conduceted an experiment at Botany Department, Wilson College, Mumbai University, Mumbai, Maharashtra, India to study the effect of vermiwash on growth parameters of Brinjal (*Solanum melongena* L.). Vermiwash added in soil as well as sprayed on *Solanum melongena* L. showed a significant improvement in growth of plants i.e., length of shoot as well as number of leaves plants^{-1}.

Tiwari and Singh (2016) conducted a field experiment at Department of Zoology, D. D. U. Gorakhpur University, Gorakhpur U.P. India during 2015-16. Foliar applications vermiwash obtained from animal dung and municipal solid waste (sewage and sludge) combined with bio-pesticides neem (*Azadiracta indica*) oil, aqueous extract of leaf, bark and vermiwash alone caused significant enhancement of growth, start early flowering, enhance productivity as well as significant reduction ($P>0.05$) in pest infestation of tomato crop. The highest growth of tomato (50.09±1.29 cm) and significantly early flowering were observed after foliar application of mixture of vermiwash.

Sundararasu (2016) conducted an experiment during 2013-14 at PG and Research Department of Zoology, Arignar Anna Government Arts College, Musiri, Tamilnadu India, on effect of vermiwash on growth and yielding pattern of selected vegetable crop Chilli, *Capsicum annuum*). An application of vermiwash at 30 days after sowing recorded significantly higher number of leaves and plant height. They also reported that organic carbon, total potassium, total calcium and magnesium were significantly higher at 50:50 ratio.

Makkar *et al.* (2017) conducted an experiment during 2015-16 at Department of Punjab Agricultural University (PAU), Ludhiana (Punjab), India to study the effect of vermicompost and vermiwash as supplement to improve seedling, plant growth and yield in *Linum usitassimum* L. They concluded that foliar application of 50 per cent vermicompost and vermiwash had synergistic effect in linum plant. Vermiwash application had shortened the life cycle of linum and improved the growth parameters like stem diameter, root volume, branching ratio, biomass allocation, fruit weight etc.

Alaghemand *et al.* (2017) conducted an experiment during 2012 at University of Guilan Campus, Agriculture Faculty, Rasht, Iran to study the effect of vermicompost and vermiwash on qualitative and quantitative factors of chemical content, development and yield of fenugreek. The results revealed that vermiwash and vermicompost combination spray enhanced plant height, internode length, number of pods plant^{-1}, yield and protein content.

Sheikh and Dakhane (2018) carried out an experiment during two years 2014-2015 and 2015-2016 at College of Horticulture, RVSKVV, Mandsaur (M.P.) to study the effects of vermiwash on seed germination and seedling vigour in ashwagandha (*withania somnifera* L). Maximum germination percentage (%), seedlings shoot length and vigour index were obtained when seeds were sown in field with 80 per cent vermiwash. Thus, the result of the present study clearly suggested that 80 per cent vermiwash could be used directly in soil for improvement in seed germination and seedling growth.

From the above cited review of literature it can be concluded that foliar spray of vermiwash improved the growth and yield attributes of different crops including germination, plant height, shoot length, root length, leaf area, and number of leaves plant^{-1}.

3. MATERIALS AND METHODS

The details of materials used, experimental methods followed and techniques adopted during the course of present investigation on "Nitrogen management in bidi tobacco (*Nicotiana tabacum* L.) nursery" are furnished in this chapter.

3.1 EXPERIMENTAL SITE

In order to achieve the pre-set objectives of the present investigation, a field experiment was conducted in *kharif* season of the year 2017 in plot No. 2C at Bidi Tobacco Research Station, Anand Agricultural University, Anand, Gujarat.

3.2 PHYSIOGRAPHIC SITUATION

3.2.1 Location

Geographically, Anand is situated at $22^{\circ}35'$ North latitude and $72^{\circ}56'$ East longitude at an elevation of about 45.1 meters above the mean sea level.

3.2.2 Climate and weather condition

Anand is situated at about 70 km away from the Arabian Sea coast and hence this region enjoys a typical sub-tropical climate with dry and hot summer, fairly cold and dry winter and moderately humid monsoon. The monsoon commences by the third week of June and retreats by middle of September with an average rainfall of 864 to 870 mm received entirely from the south west monsoon current. In general, rainfall is adequate in this region but partial failure of rain once in three or four years is very common. July and August are the months of heavy precipitation and there is no rainfall in winter and summer in almost all parts of Gujarat.

Except some sporadic showers in *Rabi* season, winter is severe and sets in the month of November and continues till the end of January. Summer is hot and dry, spread over for the months of April-May. The meteorological data on average weekly maximum and minimum temperature, rainfall, relative humidity and wind velocity recorded at the Agro-Meteorological Observatory, Anand Agricultural University, Anand during the experimental period of the year 2017 is given in Table 3.1.

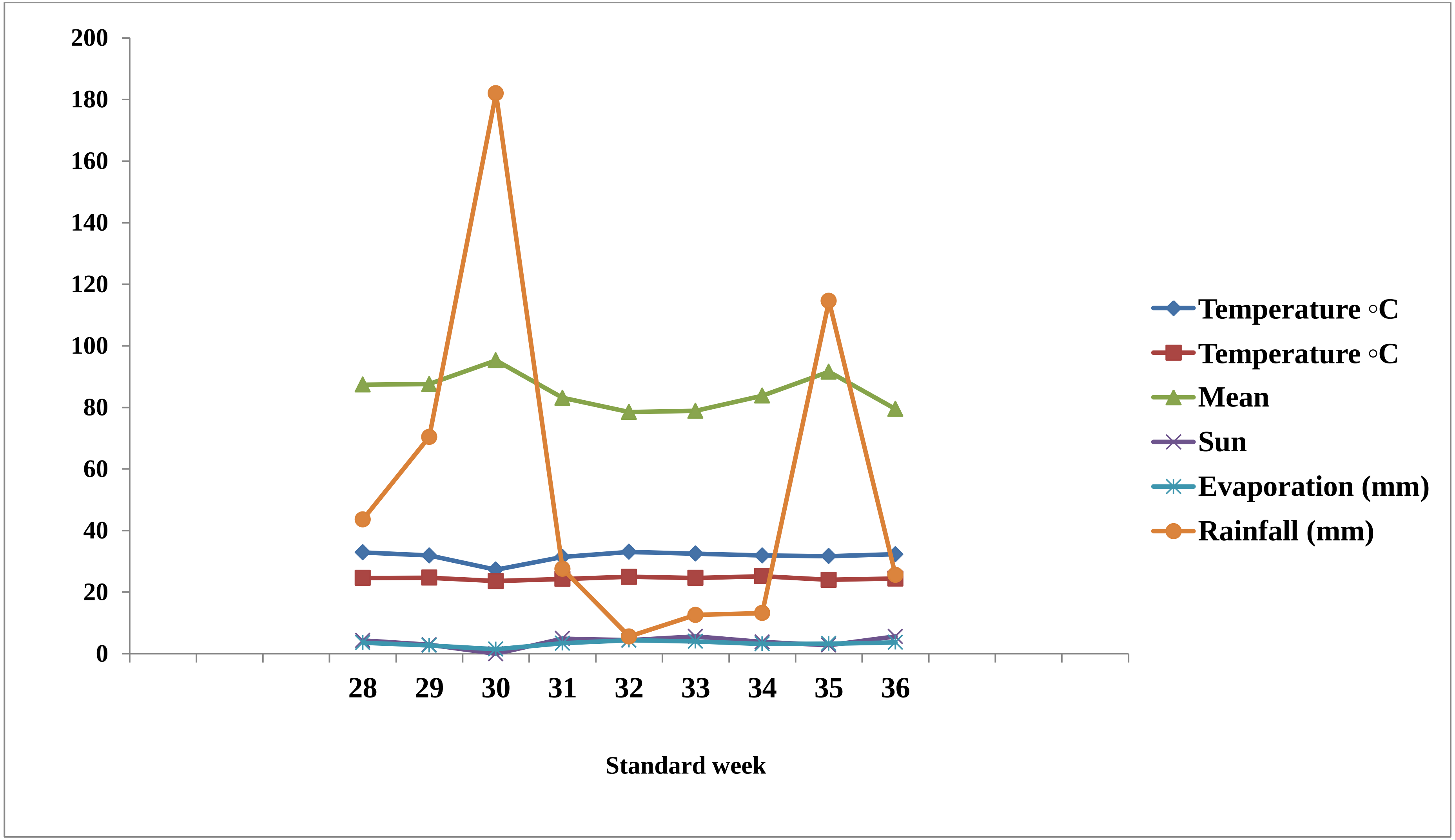


Fig 3.1 Mean weekly weather parameters recorded during the crop season (2017)

Table 3.1: Mean weekly weather parameters recorded during the crop season (2017)

Month / Year	Std. Week	Date	Temperature ^{0}C			Mean RH (%)	Sun shine hrs day^{-1}	Evaporation (mm)	Rainfall (mm)
			Max.	Min.	Mean				
July 2017	27	2-8	33.1	25.7	29.4	76.6	3.9	4.3	16.4
	28	9-15	32.9	24.6	28.8	87.4	4.3	3.6	43.6
	29	16-22	31.9	24.7	28.3	87.6	2.9	2.7	70.4
	30	23-29	27.3	23.6	25.5	95.3	0.0	1.5	182.0
	31	30-5	31.4	24.3	27.9	83.1	4.9	3.4	27.6
August 2017	32	6-12	33.1	25.0	29.1	78.5	4.4	4.4	5.6
	33	13-19	32.5	24.6	28.6	78.9	5.6	4.0	12.6
	34	20-26	31.9	25.2	28.5	83.8	3.8	3.2	13.2
	35	27-2	31.7	24.0	27.8	91.6	2.8	3.3	114.6
Sept. 2017	36	3-9	32.3	24.4	28.3	79.5	5.6	3.7	25.6

3.3 SOIL CHARACTERISTICS

Soil of the experimental site is loamy sand and locally known as "*Goradu*" soil. The soil is alluvial by nature of origin, very deep, well drained and fairly moisture retentive. Soil responds well to fertilizers, manures and irrigation. Soil is suitable for range of crops of tropical and sub-tropical regions. A composite soil sample was collected from the experimental plot No. 2 C to a depth of 0-15 cm before sowing. It was analysed for determining physico-chemical properties of soil and presented in Table 3.2. Its pH was alkaline and low in soluble salts. The experimental site was deficient in organic carbon and available nitrogen, medium in available phosphorus and available potassium.

Table 3.2: Physico-chemical properties of experimental plot

Sr. No.		Soil properties	Values at soil depth (0-15 cm)	Methods employed
1.	**PHYSICAL PROPERTIES**			
	Mechanical fraction (%)			International Pipette Method (Piper,1980)
	(a)	Coarse sand	0.89	
	(b)	Fine sand	83.30	
	(c)	Silt	10.90	
	(d)	Clay	4.91	
	(e)	Textural class	Loamy sand	
2.	**CHEMICAL PROPERTIES**			
	(a)	Soil pH (1:2.5, Soil : Water ratio)	8.15	Potentiometric method (Jackson, 1973)
	(b)	Electrical Conductivity ($dS\ m^{-1}$) at 25^0C	0.50	Conductivity meter method (Jackson, 1973)
	(c)	Organic Carbon (%)	0.45	Walkley and Black method (Jackson, 1973)
	(d)	Available N ($kg\ ha^{-1}$)	130	Alkaline $KMnO_4$ method (Subbiah and Asija, 1956)
	(e)	Available P_2O_5 ($kg\ ha^{-1}$)	39	Olsen's method (Chopra and Kanwar, 1976)
	(f)	Available K_2O ($kg\ ha^{-1}$)	250.70	Flame Photometry Method (Jackson, 1973)

3.4 CROPPING HISTORY OF THE EXPERIMENTAL PLOT

Table 3.3: Cropping history of experimental plot for preceding two years

Year	Season	Crop	Fertilizer (kg ha^{-1}) applied		
			N	P_2O_5	K_2O
2015-16	*Summer*	Fallow	-	-	-
	Kharif	Bidi tobacco nursery	180	0	0
	Rabi	Fallow	-	-	-
2016-17	*Summer*	Fallow	-	-	-
	Kharif	Bidi tobacco nursery	180	0	0
	Rabi	Fallow	-	-	-
2017-18	*Summer*	Fallow	-	-	-
	Kharif	Present experiment	180	0	0
	Rabi	Fallow	-	-	-

3.5 TREATMENT DETAILS

Total twelve treatments comprising of different nitrogen management practices were included in the investigation and details of the treatments were shown in Table 3.4.

Table 3.4: Details of treatments

Treatment	Treatment details
T_1	RDN (180 kg N as Basal)
T_2	RDN + Foliar spray Urea (1.0 % at 20 DAS)
T_3	RDN + Foliar spray Urea (2.0 % at 20 DAS)
T_4	RDN + Foliar spray Urea (1.0 % at 30 DAS)
T_5	RDN + Foliar spray Urea (2.0 % at 30 DAS)
T_6	75% RDN + Foliar spray Urea (1.0 % at 20 DAS)
T_7	75% RDN + Foliar spray Urea (2.0. % at 20 DAS)
T_8	75% RDN + Foliar spray Urea (1.0 % at 30 DAS)
T_9	75% RDN + Foliar spray Urea (2.0. % at 30 DAS)
T_{10}	75% RDN + Foliar spray Ammonium sulphate (0.5 % at 30 DAS)
T_{11}	75% RDN + Foliar spray Cow urine (1.0 % at 30 DAS)
T_{12}	75% RDN + Foliar spray Vermiwash (2.0 % at 30 DAS)

3.6 EXPERIMENTAL DESIGN AND LAYOUT

The experiment was laid out in Randomised Block Design with four replications as per plan shown in Fig. 1. Other details of the experiment are as under:

1.	Experimental Design	:	Randomized Block Design
2.	Number of Treatments	:	12
3.	Number of Replications	:	4
4.	Total number of plots	:	48
5.	Plot size	:	1.20 × 1.20 m
6.	Crop & Variety	:	Bidi tobacco (var. GABT 11)
7.	Seed rate	:	5 kg ha^{-1}
8.	Method of sowing	:	Broadcasting
9.	Fertilizer	:	RDF (180 kg N ha^{-1})
10.	Sowing time	:	10.07.2017

Note: From 180 kg N ha^{-1}, 45, 90 and 45 kg N was applied from FYM, castor cake and Ammonium Sulphate, respectively as basal.

3.7 CROP AND VARIETY

Bidi tobacco variety GABT 11 was selected for the present experiment. It was released in 2013 by Bidi Tobacco Research Station, Anand Agricultural University, Anand, Gujarat. It matures within 235 days. It has dark green foliage, more number of leaves and capacity of least seedling damage by leaf eating caterpillar in nursery conditions, shy suckering habit, with a yield potential of 4500 kg ha^{-1}.

3.8 CULTURAL OPERATIONS

3.8.1 Pre- sowing cultural operations

3.8.1.1 Land preparation

The field was digged manually in summer season with the help of spade. After that thorough levelling of field was carried out with the help of wooden as well as iron rakes. Nursery bed was prepared as 48 plots each with 1.20 m length and 1.20 m width.

Table 3.5: Calendar of cultural operations followed during course of investigation

Sr. No.	Field operation	Date of operation
1.	Initial soil sampling	25-06-2017
2.	Digging and levelling	04-07-2017
3.	Basal application of FYM, Castor cake	06-07-2017
4.	Field layout, preparation of beds and water channels	21-06-2017
5.	Basal application of Ammonium sulphate	07-07-2017
6.	Sowing	10-07-2017
7.	Fertilizer foliar application	
	Urea spray (1% and 2%) 20 DAS	29-07-2017
	Urea spray (1% and 2%) 30 DAS	09-08-2017
	Cow urine and Vermiwash spray 30 DAS	09-08-2017
8.	Water spraying (morning and evening time)	10- 07-17 to 31-08-17
9.	Weeding operation	20-7-2017
		01-08-2017
		09-08-2017
		14-08-2017
10.	Plant protection measures	
	Ridomil	10-08-2017
	Bordeaux mixture	04-08-2017
		04-09-2017
	Chloropyriphos	17-07-2017
		21-08-2017
11.	Uprooting of seedlings	
	45 DAS	24-08-17
	55 DAS	05-09-17

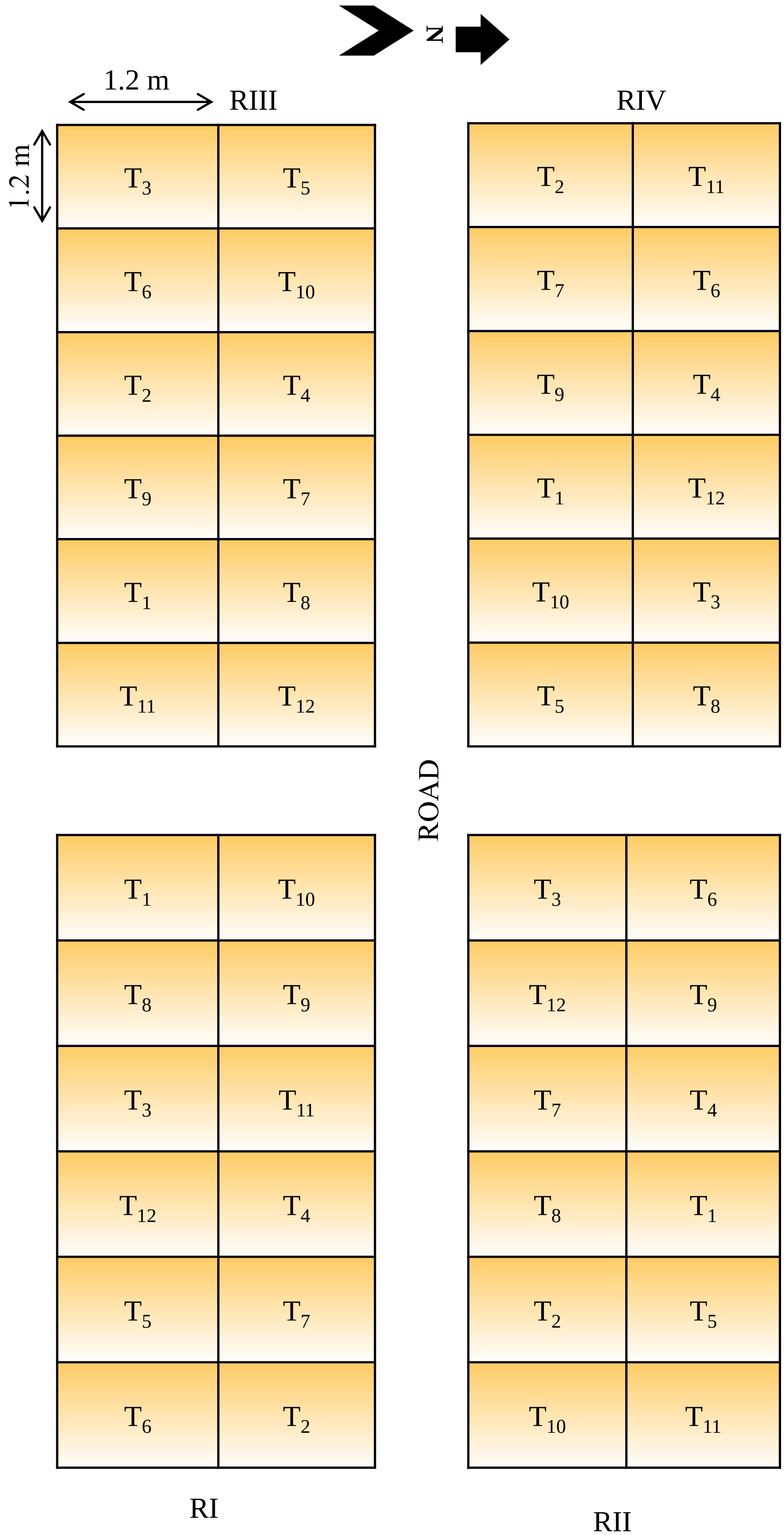
3.8.2 Post- sowing cultural operations

3.8.2.1 Manure and fertilizer application

A nursery was fertilized with 180 kg N ha^{-1} of which 45 kg nitrogen from FYM, 90 kg Nitrogen from Castor cake and 45 kg Ammonium sulphate were applied as basal.

3.8.2.2 Sowing

Bidi tobacco seeds of GABT 11 variety were weighed separately (0.72 g plot^{-1}) for sowing. The weighed seeds were mixed with water in water cane



Design : RBD **Replication :** Four **Plot Size :** 1.2 x 1.2 m = 1.44 m^2

Fig. 3.2 Layout plan of the field experiment

Plate 3.1 Field view of experimental plot

and broadcasted in each plot of nursery bed on 10th July, 2017 and covered with light stick.

3.8.2.3 Irrigation

Irrigation was given by rose can just after sowing to facilitate the germination. Then the beds were covered with agro shade net of 90%. There after spraying of water was carried out with rose cane twice in a day during morning and evening time. The agro shade net was removed gradually after germination of seeds.

3.8.2.4 Plant protection

Termite: Due to sandy loam soil of these area there might be chance of termite infestation to germinated seedling therefore precaution measure the beds were drenched with Chloropyriphos at 0.04% (Chloropyriphos 20 EC 20 ml in 10 litre water). (Table: 3.5)

Damping off: There was slight infestation of damping off disease therefore controlling it nursery beds were drenched with Ridomil at 3 kg ha^{-1} and Bordeaux mixture at 0.6%. (Table: 3.5)

3.9 APPLICATION METHOD OF FOLIAR SPRAY OF FERTILIZERS

Spraying was done in the morning hours. The solutions were sprayed on the foliage in the form of a fine mist with the help of a sprayer. The first spray was given at 20 days after sowing and second spray was given at 30 DAS. Quantity of water required for each plot was taken and measured fertilizer were thoroughly mixed. Spraying was done by using sprayer fitted with flat-fan nozzle using 500 litre of water ha^{-1}.

3.9.1 Application of Urea

Urea was selected as the source of nitrogen. It is readily soluble in water and contains a high concentration of nitrogen (46%). Urea solutions of different concentration used in this experiment were prepared by dissolving the required quantity of urea in measured volume of water. Since urea is highly hygroscopic, the required solutions were prepared immediately after weighing the fertilizer taken from a freshly open bag.

Preparation of Urea solution:

A stock solution of 2.0 per cent urea was prepared by diluting 20 g of urea with 1000 ml of water in a volumetric flask.

3.9.2 Application of Ammonium sulphate

Ammonium sulphate was selected as a source of nitrogen. It is readily soluble in water and contains a concentration of nitrogen (21%) and sulphur (24%). Ammonium sulphate solutions of different concentration used in this experiment were prepared by dissolving the required quantity of ammonium sulphate in measured volume of water. Since Ammonium sulphate is hygroscopic, the required solutions were prepared immediately after weighing the fertilizer taken from a freshly open bag.

Preparation of Ammonium sulphate solution:

A stock solution of 0.5 per cent ammonium sulphate was prepared by diluting 5 g of ammonium sulphate with 1000 ml of water in a volumetric flask.

3.9.3 Application of Cow urine

Collection of Cow Urine. Fresh cow urine was collected in a sterile container from a local variety of cow. The urine was filtered through Whatman No. 1 filter paper to get rid of debris and precipitated material and was stored in air tight container at 4 ^{0}C before use.

Preparation of Cow urine Solution:

A stock solution of 1.0 per cent cow urine was prepared by diluting 10 ml of cow urine with 1000 ml water in a volumetric flask.

3.9.4 Application of Vermiwash

Preparation of Vermiwash Solution:

A stock solution of 2.0 per cent vermiwash was prepared by diluting 20 ml of vermiwash with 1000 ml of water in a volumetric flask.

3.10 HAND WEEDING OPERATIONS

Weeding was done whenever necessary to keep the plots free from weeds. The newly emerged weeds were uprooted carefully after complete emergence of transplanted seedlings and whenever necessary. (Table: 3.5)

Plate 3.2 Foliar spray of fertilizer

3.11 BIOMETRIC OBSERVATIONS

3.11.1 Experimental observations

The experimental observations on bidi tobacco seedlings were taken and presented under the following heads.

3.11.1.1 Plant stand (Germination count)

Plant stand was taken randomly with of quadrate (5 cm × 5 cm) at 5 places per plot was calculated at 15 DAS by counting the number of seedlings from each plot randomly.

3.11.1.2 Crop Growth Rate (CGR)

Crop growth rate associated with bidi tobacco nursery in experimental area was recorded at 30, 45 and 60 DAS from all the treatments. The data on CGR counts were taken randomly with the help of a quadrate (5 cm × 5 cm) at 5 places per plot for each treatment and then converted in per 100 cm^2. The data on plant dry weight count were analysed using following formula.

$$CGR = \frac{W_2 - W_1}{t_2 - t_1}$$

Where,

CGR = crop growth rate

W_1 and W_2 = Dry weight of plant at 30, 45 and 60 DAS

t_1 and t_2 = Time of dry weight of plant at 30, 45 and 60 DAS

3.11.1.3 Relative Growth Rate (RGR)

Relative growth rate associated with bidi tobacco nursery in experimental area was recorded at 30, 45 and 60 DAS from all the treatments. The data on RGR counts were taken randomly with the help of a quadrate (5 cm × 5 cm) at 5 places per plot for each treatment and then converted in per 100 cm^2. The data on plant dry weight count were analysed using following formula.

$$RGR = \frac{\log W_2 - \log W_1}{t_2 - t_1}$$

Where,

RGR = Relative growth rate

W_1 and W_2 = Dry weight of plant at 30, 45 and 60 DAS

t_1 and t_2 = Time of dry weight of plant at 30, 45 and 60 DAS

Log = Natural logarithm

3.11.1.4 Net Assimilation Rate (NAR)

Net assimilation rate associated with bidi tobacco nursery in experimental area was recorded at 30, 45 and 60 DAS from all the treatments. The data on NAR counts were taken randomly with the help of a quadrate (5 cm × 5 cm) at 5 places per plot for each treatment and then converted in per 100 cm^2. The data on plant dry weight count were analysed using net assimilation rate. NAR is the net gain of assimilate by the plant per unit of leaf area and time. Age of the plant can distort this reading as this measurement assumes that the relationship between plant weight and leaf area is linear and, later growth phases may have the growth rate of leaf area exceed that of dry matter or vice versa. The data on plant dry weight count were analysed using following formula.

$$NAR = \frac{(W_2 - W_1)\ (\log L_2 - \log L_1)}{(t_2 - t_1)\ (L_2 - L_1)}$$

Where,

NAR = Net assimilation rate

W_1 and W_2 = Dry weight of plant at 30, 45 and 60 DAS

t_1 and t_2 = Time of dry weight of plant at 30, 45 and 60 DAS

L_1 and L_2= leaf area of plant at 30, 45 and 60 DAS

Log = Natural logarithm

3.11.1.5 Leaf Area (cm^2)

Seedlings leaves were randomly selected for leaf area measurement and leaf area was measured with the help of leaf area metre and the average leaf area in square centimetre was calculated.

3.11.1.6 Chlorophyll content (SPAD value) at 30, 45, 60 DAS

Chlorophyll content measure instrument SPAD value (Soil Plant Analysis Development) associated with bidi tobacco nursery in experimental area were recorded at 30, 45 and 60 DAS from all the treatments. The chlorophyll content was recorded separately for each sample and average value of chlorophyll content seedling^{-1} was worked out by chlorophyll measurement instrument. The chlorophyll content was measured in between 9:30 to 10:30 a.m. hour on clear sky day.

3.11.1.7 Number of damped seedlings plot^{-1} at 30, 45, 60 DAS

In bidi tobacco nursery there was absence of number of damped seedlings recorded at 30 DAS. Number of damped seedlings was recorded separately for each sample and average value of damped seedlings was worked out and subjected to statistical analysis.

3.11.1.8 Fresh weight of 10 seedlings (g)

A Same selected ten plants from each plot at 45 and 55 DAS were used for fresh weight estimation. Fresh weight was recorded separately for each sample and average value of fresh weight accumulation seedling^{-1} was worked out and subjected to statistical analysis.

3.11.1.9 Dry weight of 10 seedlings (g)

A same selected ten plants from each plot at 45 and 55 DAS were used for dry matter estimation. These plants were allowed to sun dry for three days and oven dry at 70^{0}C till constant weight. Dry weight was recorded separately for each sample and average value of dry matter accumulation seedling^{-1} was worked out and subjected to statistical analysis.

3.11.1.10 Root length of seedlings (cm)

Ten seedlings were chosen at random from each plot and their root length in centimetre was measured from base of the plant to the tip of the root at 45 and 55 DAS. Average root length per seedling was worked out and subjected to statistical analysis.

3.11.1.11 Shoot length of seedlings (cm)

Ten seedlings were chosen at random from each plot and their shoot length was measured in centimetre from base of the plant to the apex of the shoot at 45 and 55 DAS. Average shoot length per seedling was worked out and subjected to statistical analysis.

3.11.1.12 Number of seedlings

Number of transplantable and non-transplantable bidi tobacco seedlings were recorded separately from an area of 1.44 m^2 of each plot at the time of first (45 DAS) and second (60 DAS) pulling of seedlings.

Table 3.6: Observations recorded

Sr. No.	Characters	Sample size	Time of recording
A: Growth Parameters			
1	Germination count	Number 25 cm^{-2} (Randomly selected)	At 15 DAS
2	Crop growth rate (mg cm^{-2} day^{-1})	Randomly selected ten plants from each plot	At 30, 45 and 60 DAS
3	Relative growth rate (mg $^{-1}$g^{-1} day^{-1})	Randomly selected ten plants from each plot	At 30, 45 and 60 DAS
4	Net assimilation rate (mg.cm^2 day^{-1})	Randomly selected ten plants from each plot	At 30, 45 and 60 DAS
5	Leaf area (cm^2)	Randomly selected ten plants from each plot	At 30, 45 and 60 DAS
6	Chlorophyll content	Randomly selected ten plants from each plot	At 30, 45 and 60 DAS
7	Number of damped seedlings plot $^{-1}$	Randomly plants from each plot	At 30, 45 and 60 DAS
8	Fresh weight (g seedlings)	Randomly selected ten plants from each plot	At 30, 45 and 60 DAS
9	Dry weight (g seedlings)	Randomly selected ten plants from each plot	At 30, 45 and 60 DAS
10	Root length (cm)	Randomly selected ten plants from each plot	At 45 and 55 DAS
11	Shoot length (cm)	Randomly selected ten plants from each plot	At 45 and 55 DAS
B: Transplantable and non transplantable seedlings			
1	Transplantable seedlings	Number m^{-2}	At 45 and 55 DAS
2	Non Transplantable seedlings	Number m^{-2}	At 45 and 55 DAS
3	Total seedlings	Number m^{-2}	At 45 and 55 DAS
C: Nutrient status of soil			
1	Available nitrogen status of soil (kg ha^{-1})	As per procedure	Final
2	Available phosphorus status of soil (kg ha^{-1})	As per procedure	Final
3	Available potassium status of soil (kg ha^{-1})	As per procedure	Final
4	Organic Carbon (%)	As per procedure	Final
D: Nutrient status of plant at harvest			
1	Available nitrogen content of plant (%)	As per procedure	Final
2	Available phosphorus content of plant (%)	As per procedure	Final
3	Available potassium content of plant (%)	As per procedure	Final

3.12 ANALYSIS OF PLANT

A same selected ten plants from each plot at harvest were used for plant analysis. These plants were allowed to sun dry for three days and oven dry at 70^0C till constant weight. Dry plant sample grinding by grinder and sieved with plastic wire mesh to determine N (%), P_2O_5 (%) and K_2O (%) from plant.

3.13 ANALYSIS OF SOIL

Initial and final soil samples were taken from 0-15 cm soil depth; dried and ground to fine powder by china clay mortar and sieved with plastic wire mesh to determine pH, EC, available N (kg ha^{-1}), available P_2O_5 (kg ha^{-1}), available K_2O (kg ha^{-1}) and organic carbon from soil.

3.14 STATISTICAL ANALYSIS

Statistical analysis for different characters (Steel and Torrie, 1982) was carried out on computer at Computer Centre, B. A. College of Agriculture, AAU, Anand. Standard error of mean (SE_m) and Co-efficient of variation (CV %) were worked out and same were presented in respective Tables.

3.15 ECONOMICS

In order to evaluate the most effective remunerative treatment, relative economics of each treatment was calculated. The gross realization in terms of rupees per hectare was worked out for each treatment considering prevailing market price of transplantable bidi tobacco seedlings. Likewise, cost of cultivation was also worked out considering expenses incurred for cultural operations and materials used for respective treatments. Net realization under each treatment was worked out by subtracting cost of cultivation from gross realization. The benefit: cost ratio (BCR) was calculated on the basis of formula given below:

$$BCR = \frac{\text{Total income (₹ ha}^{-1}\text{)}}{\text{Total expenditure (₹ ha}^{-1}\text{)}}$$

4. RESULTS AND DISCUSSIONS

The results obtained from the present investigation on "Nitrogen management in bidi tobacco (*Nicotiana tabacum* L.) nursery" carried out during *kharif* season of the year 2017 are presented along with statistical inferences in this chapter. Also the results of field experiment have been critically discussed here. It has been attempted to establish effect and cause relationship in light of various evidence and literature. The successful cultivation of bidi tobacco crop depends on timely availability of healthy seedlings. Raising of bidi tobacco nursery is an important phase of bidi tobacco cultivation. Nitrogen management plays a vital role in increasing number of healthy seedlings. The objective of the experiment was to figure out the impact of foliar application of different source of nitrogen in tobacco nursery to quantify the efficacy of different nitrogen application on seedling growth in tobacco nursery and to find out the effect of different treatments on tobacco seedlings. So, to fulfil the above objectives of the experiment, the results and discussion of various parameters are presented here under the following heads.

4.1 Effect of weather parameters on crop

4.2 Effect of different treatments on growth attributes of tobacco seedlings.

4.3 Effect of different treatments on tobacco seedlings.

4.4 Effect of different treatments on chemical analysis of plant and soil.

4.5 Effect of different treatments on economics.

4.1 EFFECT OF WEATHER PARAMETERS ON CROP

The weather conditions play a key role among the various factors responsible for affecting the yield and performance of the crop. The various weather parameters pertaining to *kharif* crop season of the year 2017 are presented in Table 3.1. It is evident from the data that all the meteorological parameters were congenial for normal growth and development of the crop. The maximum and minimum temperatures were found normal. The crop received sufficient duration of sunlight as evidenced from the data on bright sunshine hours. As a result, the crop growth was normal and hence it was inferred that the entire effect on different growth and yield attributes of the crop were assigned to the treatments effect only.

4.2 EFFECT OF DIFFERENT TREATMENTS ON GROWTH ATTRIBUTES OF TOBACCO SEEDLINGS

4.2.1 Plant stand at 15 DAS

The perusal of data on plant stand counted at 15 DAS were presented in Table 4.1 and their analysis of variance is depicted in Appendix I. Results illustrated in Table 4.1 revealed that none of the treatments exerted their significant effect on plant stand recorded at 15 DAS. It indicated that basal application of fertilizers might have not any adverse effect on plant stand.

Table 4.1: Plant stand at 15 DAS as influenced by different nitrogen management treatments

Sr. No.	Treatments	Plant stand 25 cm^{-2} 15 DAS
T_1	RDN (180 kg N as Basal)	5.52
T_2	RDN + Foliar spray Urea (1.0 % at 20 DAS)	5.53
T_3	RDN + Foliar spray Urea (2.0 % at 20 DAS)	5.63
T_4	RDN + Foliar spray Urea (1.0 % at 30 DAS)	5.73
T_5	RDN + Foliar spray Urea (2.0 % at 30 DAS)	5.85
T_6	75% RDN + Foliar spray Urea (1.0 % at 20 DAS)	5.48
T_7	75% RDN + Foliar spray Urea (2.0 % at 20 DAS)	5.58
T_8	75% RDN + Foliar spray Urea (1.0 % at 30 DAS)	5.60
T_9	75% RDN + Foliar spray Urea (2.0 % at 30 DAS)	5.70
T_{10}	75% RDN + Foliar spray Ammonium sulphate (0.5 % at 30 DAS)	5.73
T_{11}	75% RDN + Foliar spray Cow urine (1.0 % at 30 DAS)	5.73
T_{12}	75% RDN + Foliar spray Vermiwash (2.0 % at 30 DAS)	5.75
	SEm. ±	0.09
	CD at 5%	NS
	CV%	3.21

4.2.2 Crop growth rate (CGR)

Data pertaining to crop growth rate recorded at 30, 45 and 60 DAS influenced due to different nitrogen management treatments are presented in Table 4.2 and their analysis of variance is depicted in Appendix I.

The data given in Table 4.2 revealed that crop growth rate recorded at 30 DAS was significantly affected due to different treatments. Baring treatment T_5 (RDN+ Foliar spray Urea 2.0% at 30 DAS) and treatment T_{12} (75% RDN + Foliar spray Vermiwash 2.0% at 30 DAS) recorded significantly the highest CGR (4.80 mg day^{-1}). On the contrary, treatment T_1 (control) recorded significantly lower CGR (3.45 mg day^{-1}) than all other treatments except treatment T_6 and T_7.

It is evident from the data given in Table 4.2 that the difference in crop growth rate recorded at 45 DAS was significantly influenced due to different treatments. Significantly higher crop growth rate (11.80 mg day^{-1}) was observed under treatment T_5 (RDN + Foliar spray Urea 2.0% at 30 DAS) which was comparable with treatments T_{11} and $T_{12.}$ Data further indicated that significantly lower crop growth rate (6.83 mg day^{-1}) was recorded under treatment T_6 (75% RDN + Foliar spray of Urea 1.0% at 20 DAS which was at par with $T_{1,}$ $T_{7,}$ T_8 and T_9 treatments.

A perusal of data provided in Table 4.2 indicated that nitrogen management treatments exerted their significant effect on crop growth rate recorded at 60 DAS. Treatment T_5 (RDN + Foliar spray Urea 2.0% at 30 DAS) recorded significantly higher CGR (13.68 mg day^{-1}) over rest of the treatments. However, it was statistically at par with treatments T_{12} (75% RDN + foliar spray vermiwash 2.0% at 30 DAS) and T_{11} (75% RDN+ foliar spray cow urine 1% at 30 DAS). Significantly lower crop growth rate (8.28 mg day^{-1}) was recorded under treatment T_1 (control) which was at par with T_2 treatment.

Table 4.2: Crop growth rate as influenced by different nitrogen management treatments

Sr. No.	Treatments	Crop growth rate (mg day^{-1})		
		30 DAS	**45 DAS**	**60 DAS**
T_1	RDN (180 kg N as Basal)	3.45	7.53	8.28
T_2	RDN + Foliar spray Urea (1.0 % at 20 DAS)	3.85	9.01	9.08
T_3	RDN + Foliar spray Urea (2.0 % at 20 DAS)	3.93	9.83	10.17
T_4	RDN + Foliar spray Urea (1.0 % at 30 DAS)	4.15	10.00	10.75
T_5	RDN + Foliar spray Urea (2.0 % at 30 DAS)	4.80	11.80	13.68
T_6	75% RDN + Foliar spray Urea (1.0 % at 20 DAS)	3.56	6.83	9.83
T_7	75% RDN + Foliar spray Urea (2.0 % at 20 DAS)	3.76	7.40	10.50
T_8	75% RDN + Foliar spray Urea (1.0 % at 30 DAS)	4.01	7.50	10.92
T_9	75% RDN + Foliar spray Urea (2.0 % at 30 DAS)	4.05	7.65	11.27
T_{10}	75% RDN + Foliar spray Ammonium sulphate (0.5 % at 30 DAS)	4.31	9.36	11.33
T_{11}	75% RDN + Foliar spray Cow urine (1.0 % at 30 DAS)	4.31	11.11	12.92
T_{12}	75% RDN + Foliar spray Vermiwash (2.0 % at 30 DAS)	4.71	11.10	13.00
	SEm ±	0.13	0.37	0.47
	CD at 5%	0.38	1.07	1.36
	CV%	6.51	8.23	8.64

With regard to periodical crop growth rate, treatment T_5 (RDN + Foliar spray urea 2.0% at 30 DAS) indicated higher values of crop growth rate recorded at 30, 45 and 60 DAS as compare to all other treatments except treatment T_{11} (75% RDN + foliar spray cow urine 1.0% at 30 DAS) and treatment T_{12} (75% RDN + foliar spray vermiwash 2.0% at 30 DAS). Thus, the results clearly showed that application of urea 2.0% at 30 DAS increased CGR which was comparable with vermiwash spray 2.0% at 30 DAS and cow urine spray 1.0% at 30 DAS. It might be due to that increment in crop growth rate due to nitrogen fertilizer application could be attributed to the effect of nitrogen on cell division and elongation, which lead to growth and increased height of the stems and leaves (Rabinowitch and Kamenetsky, 2002).

The growth rate was increased more rapidly when foliar application of urea was applied at the rate of 20000 ppm compared to soil application possibly due to the rapidly available nitrogen, which might have encouraged more vegetative growth and development. These findings are in line of those reported by Valadabadi and Farahani (2010), Kaur *et al.* (2015), Shitahun (2017).

4.2.3 Relative growth rate (RGR)

Data on periodical relative growth rate recorded at 30, 45 and 60 DAS influenced due to different treatments are illustrated in Table 4.3 and their analysis of variance is depicted in Appendix I.

The perusal of data on relative growth rate recorded at 30 DAS were presented in Table 4.3. Results illustrated in Table 4.3 revealed that none of the treatments exerted their significant effect on relative growth rate recorded at 30 DAS.

It is apparent from the data depicted in Table 4.3 that all the nitrogen management treatments differed significantly in respect to relative growth rate recorded at 45 DAS. Significantly higher relative growth rate (0.024 mg mg^{-1} day^{-1}) was observed under treatment T_5 (RDN + Foliar spray urea 2.0% at 30 DAS) and T_{11} (75% RDN + Foliar spray Cow urine 1.0% at 30 DAS) which were comparable with treatments T_1, T_2, T_3, T_4 and T_{12}. The result further indicated that treatments T_6, T_8 and T_9 recorded significantly lower but equal relative growth rate (0.019 mg mg^{-1} day^{-1}). However, these treatments were statistically at par with T_7 and T_{10} treatments.

Table 4.3: Relative growth rate as influenced by different nitrogen management treatments

Sr. No.	Treatments	Relative growth rate (mg mg^{-1} day^{-1})		
		30 DAS	45 DAS	60 DAS
T_1	RDN (180 kg N as Basal)	0.020	0.022	0.013
T_2	RDN + Foliar spray Urea (1.0 % at 20 DAS)	0.020	0.023	0.012
T_3	RDN + Foliar spray Urea (2.0 % at 20 DAS)	0.020	0.023	0.013
T_4	RDN + Foliar spray Urea (1.0 % at 30 DAS)	0.020	0.023	0.013
T_5	RDN + Foliar spray Urea (2.0 % at 30 DAS)	0.021	0.024	0.014
T_6	75% RDN + Foliar spray Urea (1.0 % at 20 DAS)	0.020	0.019	0.015
T_7	75% RDN + Foliar spray Urea (2.0 % at 20 DAS)	0.020	0.020	0.015
T_8	75% RDN + Foliar spray Urea (1.0 % at 30 DAS)	0.021	0.019	0.015
T_9	75% RDN + Foliar spray Urea (2.0 % at 30 DAS)	0.020	0.019	0.016
T_{10}	75% RDN + Foliar spray Ammonium sulphate (0.5 % at 30 DAS)	0.020	0.021	0.014
T_{11}	75% RDN + Foliar spray Cow urine (1.0 % at 30 DAS)	0.020	0.024	0.014
T_{12}	75% RDN + Foliar spray Vermiwash (2.0 % at 30 DAS)	0.021	0.023	0.014
	SEm ±	0.001	0.001	0.0007
	CD at 5%	NS	0.002	0.002
	CV%	5.36	7.56	9.96

A close examination of data (Table 4.3) indicated that nitrogen management treatments manifested their significant influence on relative growth rate recorded at 60 DAS. Treatment T_9 (75% RDN + Foliar spray Urea 2.0. % at 30 DAS) recorded significantly higher relative growth rate (0.016 mg mg^{-1} day^{-1}) which was at par with other treatments except $T_{1,}$ $T_{2,}$ $T_{3,}$ and T_4 treatments. Whereas minimum relative growth rate (0.012 mg mg^{-1} day^{-1}) was observed under treatment T_2, but it was at par with $T_{1,}$ $T_{3,}$ and T_4 treatments.

With regard to periodical relative growth rate, treatment T_5 (RDN + Foliar spray Urea 2.0% at 30 DAS) indicated higher values of relative growth rate recorded at 30, 45 and 60 DAS. Thus, the results clearly showed that application of urea 2 per cent at 30 DAS increased RGR. This might be due that increase in RGR due to urea 2 per cent treated plants can be attributed to increased leaf longevity in these plants as compared to their control. This could also be due to increased photosynthetic efficiency by retaining more chlorophyll content and efficient translocation. These results are in agreement with those obtained by Valadabadi and Farahani (2010), Kaur *et al.* (2015).

4.2.4 Net assimilation rate (NAR)

The data regarding the effects of nitrogen management treatments on net assimilation rate recorded at 30, 45 and 60 DAS in tobacco seedlings are presented in Table 4.4 and their analysis of variance is given in Appendix - I.

The perusal of data on net assimilation rate observed at 30 DAS were presented in Table 4.4. Results revealed that non of the treatments exerted their significant effect on net assimilation rate recorded at 30 DAS.

It is obvious from the data given in Table 4.4 that the difference in net assimilation rate recorded at 45 DAS was influenced due to different nitrogen management treatments. Significantly higher net assimilation rate (0.0348 mg cm^2 day^{-1}) was observed under treatment T_5 (RDN + Foliar spray Urea 2.0% at 30 DAS) which was at par with treatments $T_{3,}$ $T_{4.}$ T_{11} and $T_{12.}$ Whereas minimum relative growth rate (0.0228 mg cm^2 day^{-1}) was observed under treatment T_6 (75% RDN+ Foliar spray Urea 1.0% at 20 DAS), but it was at par with treatments $T_{7,}$ T_8 and T_9.

Table 4.4: Net assimilation rate as influenced by different nitrogen management treatments

Sr. No.	Treatments	Net assimilation rate (mg cm^2 day^{-1})		
		30 DAS	45 DAS	60 DAS
T_1	RDN (180 kg N as Basal)	0.0129	0.0282	0.0257
T_2	RDN + Foliar spray Urea (1.0 % at 20 DAS)	0.0127	0.0299	0.0250
T_3	RDN + Foliar spray Urea (2.0 % at 20 DAS)	0.0123	0.0308	0.0271
T_4	RDN + Foliar spray Urea (1.0 % at 30 DAS)	0.0127	0.0309	0.0275
T_5	RDN + Foliar spray Urea (2.0 % at 30 DAS)	0.0141	0.0348	0.0346
T_6	75% RDN + Foliar spray Urea (1.0 % at 20 DAS)	0.0119	0.0228	0.0280
T_7	75% RDN + Foliar spray Urea (2.0 % at 20 DAS)	0.0123	0.0242	0.0293
T_8	75% RDN + Foliar spray Urea (1.0 % at 30 DAS)	0.0129	0.0240	0.0301
T_9	75% RDN + Foliar spray Urea (2.0 % at 30 DAS)	0.0126	0.0237	0.0308
T_{10}	75% RDN + Foliar spray Ammonium sulphate (0.5 % at 30 DAS)	0.0133	0.0289	0.0297
T_{11}	75% RDN + Foliar spray Cow urine (1.0 % at 30 DAS)	0.0132	0.0341	0.0348
T_{12}	75% RDN + Foliar spray Vermiwash (2.0 % at 30 DAS)	0.0139	0.0327	0.0330
	SEm ±	0.0005	0.001	0.0014
	CD at 5%	NS	0.004	0.004
	CV%	7.05	8.98	9.20

A critical examination of results in Table 4.4 substantiates the significant influence of different nitrogen management treatments on net assimilation rate recorded at 60 DAS. Treatment T_{11} (75% RDN + Foliar spray Cow urine 1.0% at 30 DAS) recorded significantly higher value of net assimilation rate (0.0348 mg cm^2 day^{-1}). However, it was statistically at par with treatments T_5, T_9 and $T_{12.}$ Whereas significantly lower value of net assimilation rate (0.0250 mg cm^2 day^{-1}) was registered by RDN + Foliar spray Urea 1.0 % at 20 DAS (T_2), but it was statistically at par with $T_{1,}$ $T_{3,}$ T_4 and T_6 treatments.

With respect to periodical net assimilation rate, treatment T_5 (RDN+ Foliar spray Urea 2.0% at 30 DAS) indicated higher values of net assimilation rate recorded at 30, 45 and 60 DAS. Thus, the results clearly showed that application of urea 2% at 30 DAS increased NAR. It might be due that increase in NAR in response to increasing nitrogen fertilizer levels is due to the increase in the number of cells, leading to a higher development of leaves with higher photosynthetic potential. An increase in age of plant caused decrease in NAR. These results are similar to those reported by Shitahun (2017), Shivay *et al.* (2014), Sinclair and Shiraiwa (1993).

4.2.5 Leaf area

The mean data on leaf area recorded at 30, 45 and 60 DAS as influenced by varying nitrogen management treatments are presented in Table 4.5 and their analysis of variance is depicted in Appendix I.

A perusal of data depicted in Table 4.5 revealed that leaf area (128.8 cm^2) was significantly higher due to treatment T_5 (RDN + Foliar spray Urea 2.0 % at 30 DAS) as compared to other treatments, But it was statistically at par with treatments T_9, $T_{10,}$ T_{11} and $T_{12.}$ Significantly the lowest value of leaf area (102.5 cm^2) was registered under RDN as control (T_1).

The differences in leaf area recorded at 45 DAS due to different nitrogen management treatments were found significant. Higher Leaf area (169.2 cm^2) was observed under treatment T_5 (RDN + Foliar spray Urea 2.0 % at 30 DAS) which was statically at par with treatments T_{12} (75% RDN + Foliar spray Vermiwash 2.0% at 30 DAS) and T_4 (RDN + Foliar spray Urea 1.0 % at 30 DAS). Significantly the lowest value of leaf area (131.8 cm ^{2}) was registered under RDN as control (T_1).

Table 4.5: Leaf area as influenced by different nitrogen management treatments

Sr. No.	Treatments	Leaf area (cm^2)		
		30 DAS	45 DAS	60 DAS
T_1	RDN (180 kg N as Basal)	102.5	131.8	149.5
T_2	RDN + Foliar spray Urea (1.0 % at 20 DAS)	111.3	153.8	162.8
T_3	RDN + Foliar spray Urea (2.0 % at 20 DAS)	120.0	159.7	167.2
T_4	RDN + Foliar spray Urea (1.0 % at 30 DAS)	122.8	163.0	175.7
T_5	RDN + Foliar spray Urea (2.0 % at 30 DAS)	128.8	169.2	176.5
T_6	75% RDN + Foliar spray Urea (1.0 % at 20 DAS)	111.3	150.5	155.3
T_7	75% RDN + Foliar spray Urea (2.0 % at 20 DAS)	116.5	150.8	158.8
T_8	75% RDN + Foliar spray Urea (1.0 % at 30 DAS)	121.3	152.0	155.6
T_9	75% RDN + Foliar spray Urea (2.0 % at 30 DAS)	124.3	156.8	161.5
T_{10}	75% RDN + Foliar spray Ammonium sulphate (0.5 % at 30 DAS)	125.8	156.9	160.8
T_{11}	75% RDN + Foliar spray Cow urine (1.0 % at 30 DAS)	126.0	158.3	164.5
T_{12}	75% RDN + Foliar spray Vermiwash (2.0 % at 30 DAS)	128.5	168.7	174.0
	SEm ±	2.0	3.1	3.1
	CD at 5%	5.9	8.9	8.9
	CV%	3.4	4.0	3.8

The significant variation in leaf area at 60 DAS was observed with different nitrogen management treatments. Treatment T_5 (RDN + Foliar spray Urea 2.0 % at 30 DAS) recorded significantly higher value of leaf area (176.5 cm^2) but, it was statistically at par with treatments T_4 and $T_{12.}$ Whereas significantly lower value of leaf area (149.5 cm^2) was registered by treatment T_1 (RDN as control), but it was statistically at par with T_6 and T_8 treatments.

With regard to periodical leaf area, treatment T_5 (RDN+ Foliar spray Urea 2.0% at 30 DAS) indicated higher values of leaf area recorded at 30, 45 and 60 DAS. Thus, the results clearly showed that application of urea 2% at 30 DAS increased leaf area. These results are in agreement with those obtained by Mondal and Abdullah (2011), Kaur *et al.* (2015) and Shitahun (2017) who reported that urea application on crops increased leaf area, leaf-area index and leaf-area duration compared to control treatment.

This finding are in accordance with those reported by Murata (1969). Nitrogen is an indispensable elementary constituent of numerous organic compounds (amino acid, protein, nucleic acid and chlorophyll) of general importance. The increment in vegetative growth parameters of tobacco plant with higher rate of foliar application of fertilizer might be due to that nitrogen plays an important role in photosynthesis by improving leaf area index and chlorophyll content.

4.2.6 Chlorophyll content (SPAD value)

The data regarding the effects of nitrogen management treatments on chlorophyll content in tobacco seedlings at 30, 45 and 60 DAS are presented in Table 4.6 and their analysis of variance is given in Appendix - I.

The experimental results pointed out that different nitrogen management treatments succeeded to significant influence on chlorophyll content in tobacco at 30 DAS. The data furnished in Table 4.5 revealed that chlorophyll content (31.7%) was significantly higher in treatment T_5 (RDN + Foliar spray Urea 2.0 % at 30 DAS) as compared to other treatments. It was remained statistically at par with T_4 and T_{12} treatments. Whereas significantly lower value of chlorophyll content (23.6%) was registered by treatment T_1 (RDN as control) but, it was at par with $T_{2,}$ $T_{3,}$ $T_{6,}$ T_7 T_8 and T_9 treatments.

Table 4.6: Chlorophyll content (SPAD value as influenced by nitrogen management treatments

Sr. No.	Treatments	Chlorophyll content (%)		
		30 DAS	45 DAS	60 DAS
T_1	RDN (180 kg N as Basal)	23.6	29.9	22.4
T_2	RDN + Foliar spray Urea (1.0 % at 20 DAS)	26.9	36.8	28.7
T_3	RDN + Foliar spray Urea (2.0 % at 20 DAS)	27.2	37.9	29.3
T_4	RDN + Foliar spray Urea (1.0 % at 30 DAS)	29.3	38.7	30.0
T_5	RDN + Foliar spray Urea (2.0 % at 30 DAS)	31.7	40.0	31.4
T_6	75% RDN + Foliar spray Urea (1.0 % at 20 DAS)	25.1	32.3	24.0
T_7	75% RDN + Foliar spray Urea (2.0 % at 20 DAS)	25.4	34.9	24.9
T_8	75% RDN + Foliar spray Urea (1.0 % at 30 DAS)	26.1	35.9	25.8
T_9	75% RDN + Foliar spray Urea (2.0 % at 30 DAS)	26.3	36.4	26.6
T_{10}	75% RDN + Foliar spray Ammonium sulphate (0.5 % at 30 DAS)	27.6	37.0	27.7
T_{11}	75% RDN + Foliar spray Cow urine (1.0 % at 30 DAS)	27.8	37.4	29.9
T_{12}	75% RDN + Foliar spray Vermiwash (2.0 % at 30 DAS)	29.0	39.6	30.9
	SEm ±	1.32	1.06	1.13
	CD at 5%	3.81	3.04	3.27
	CV%	9.73	5.81	8.2

From the data given in Table 4.6, it is revealed that nitrogen management treatments had significantly influence on chlorophyll content at 45 DAS. Higher chlorophyll content (SPAD value) (40.0%) was observed under treatment T_5 (RDN + Foliar spray Urea 2.0 % at 30 DAS) and it was remained statistically at par with $T_{10,}$ $T_{3,}$ $T_{4.}$ T_{11} and T_{12} treatments. On the contrary, being statistically at par each other T_1 (RDN as control) and T_6 (75% RDN + foliar spray urea 1.0% at 20 DAS) treatments recorded significantly the lowest chlorophyll content (29.90%).

The differences in chlorophyll content at 60 DAS due to different nitrogen management treatments were found significant. Treatment T_5 (RDN + Foliar spray Urea 2.0 % at 30 DAS) recorded significantly higher value of chlorophyll content (31.4%). However, it was at par with treatments $T_{2,}$ $T_{3,}$ $T_{4,}$ T_{11} and $T_{12.}$ Whereas significantly lower value of chlorophyll content (22.4%) was registered by RDN as control, but it was statistically at par with T_6 and T_7 treatments.

With respect to periodical chlorophyll content, treatment T_5 (RDN+ Foliar spray Urea 2.0% at 30 DAS) indicated higher values of chlorophyll content recorded at 30, 45 and 60 DAS. Thus, the results showed that an application of urea 2.0% at 30 DAS increased chlorophyll content.

Among all the treatments, SPAD chlorophyll meter values increased with increasing urea concentration. SPAD chlorophyll meter readings were correlated with tissue total nitrogen concentrations determined by laboratory analysis, which means that chlorophyll meter readings gave the increased values with increasing urea doses. The effect of soil nitrogen treatment and foliar urea applications on chlorophyll readings in the study is in good agreement with the results of Villeneuve *et al.* (2002) and Westerveld *et al.* (2003). They proved that SPAD chlorophyll meter readings in leaves were correlated with tissue total nitrogen concentrations. This phenomenon may cause that an addition of mineral nitrogen or foliar urea application increased the total nitrogen content in leaves. This finding is also in accordance with those reported by Murata (1969).

4.2.7 Number of damped seedlings

The mean data on number of damped seedlings recorded at 45 and 60 DAS as influenced by varying nitrogen management treatments are presented in Table 4.7 and their analysis of variance is given in Appendix - I.

Table 4.7: Number of damped seedlings as influenced by different nitrogen management treatments

Sr. No.	Treatments	Number of damped seedlings $plot^{-1}$	
		45 DAS	60 DAS
T_1	RDN (180 kg N as Basal)	7.00	7.75
T_2	RDN + Foliar spray Urea (1.0 % at 20 DAS)	6.25	7.25
T_3	RDN + Foliar spray Urea (2.0 % at 20 DAS)	6.00	7.00
T_4	RDN + Foliar spray Urea (1.0 % at 30 DAS)	5.25	6.75
T_5	RDN + Foliar spray Urea (2.0 % at 30 DAS)	4.25	5.00
T_6	75% RDN + Foliar spray Urea (1.0 % at 20 DAS)	6.75	7.25
T_7	75% RDN + Foliar spray Urea (2.0 % at 20 DAS)	6.25	7.00
T_8	75% RDN + Foliar spray Urea (1.0 % at 30 DAS)	5.75	6.25
T_9	75% RDN + Foliar spray Urea (2.0 % at 30 DAS)	5.50	6.00
T_{10}	75% RDN + Foliar spray Ammonium sulphate (0.5 % at 30 DAS)	5.00	5.75
T_{11}	75% RDN + Foliar spray Cow urine (1.0 % at 30 DAS)	4.75	5.25
T_{12}	75% RDN + Foliar spray Vermiwash (2.0 % at 30 DAS)	5.00	5.25
	SEm ±	0.28	0.32
	CD at 5%	0.80	0.91
	CV%	9.84	9.94

T_1: Control

T_2: RDN + Foliar spray Urea (1.0 % at 20 DAS)

T_3 : RDN + Foliar spray Urea
(2.0 % at 20 DAS)

T_4 : RDN + Foliar spray Urea
(1.0 % at 30 DAS)

T_5 : RDN + Foliar spray Urea
(2.0. % at 30 DAS)

T_6: 75 % RDN + Foliar spray Urea
(1.0 % at 20 DAS)

Plate 4.1 a Growth of bidi tobacco seedlings under nitrogen management treatments at 45 DAS

T_7: 75 % RDN + Foliar spray Urea (2.0 % at 20 DAS)

T_8: 75% RDN + Foliar spray Urea (1.0 % at 30 DAS)

T_9 : 75% RDN + Foliar spray Urea (2.0. % at 30 DAS)

T_{10} : 75% RDN + Foliar spray Ammonium sulphate (0.5 % at 30 DAS)

T_{11}: 75% RDN + Foliar spray cow urine (1.0 % at 30 DAS)

T_{12}: 75% RDN + Foliar spray vermiwash (2.0 % at 30 DAS)

Plate 4.1 b Growth of bidi tobacco seedlings under nitrogen management treatments at 45 DAS

Data illustrated in Table 4.7 revealed that number of damped seedlings (4.25 plot^{-1}) was significantly lower in treatment T_5 (RDN + Foliar spray Urea 2.0 % at 30 DAS) as compared to other treatments. However, it was remained statistically at par with T_{11}, T_{12} and T_{10} treatments. Significantly higher number of damped seedlings (7.00 plot^{-1}) was registered under treatment T_1 (RDN as control) but, it was statistically at par with $T_{2,}$ T_6 and T_7 treatments.

The differences in damped seedlings recorded at 60 DAS due to different nitrogen management treatments were found significant. Treatment T_5 (RDN + Foliar spray Urea 2.0 % at 30 DAS) recorded significantly lower number of damped seedlings (5.00 plot^{-1}). However, it was statistically at par with treatments $T_{10,}$ T_{11} and $T_{12.}$ Whereas significantly higher number of damped seedlings (7.75 plot^{-1}) was registered due to control (T_1), but it was statistically at par with T_2 and T_3 treatments.

With respect to number of damped seedlings, treatment T_5 (RDN + Foliar spray Urea 2.0% at 30 DAS) indicated lower values of damped seedlings recorded at 45 and 60 DAS. Thus, the results clearly showed that application of urea 2% at 30 DAS decreased number of damped seedlings. This finding is in accordance with those reported by Abro *et al.* (2014). They found that incidence of Damping-off varied from fertilizer to fertilizer which indicates the impact of the fertilizers on the disease resistance toward damping-off.

4.2.8 Fresh weight of 10 seedlings (g)

Data pertaining to fresh weight of ten seedlings at 30, 45 and 60 DAS as influenced due to different nitrogen management treatments are presented in Table 4.8 and their analysis of variance is depicted in Appendix I.

The statistical analysis revealed that nitrogen management treatments significantly affected fresh weight of 10 seedlings at 30 DAS. Fresh weight of 10 seedlings (0.60 g) recorded at 30 DAS recorded at 30 DAS was significantly higher in treatment T_5 (RDN + Foliar spray Urea 2.0 % at 30 DAS) as compared to other treatments. But, it was statistically at par with $T_{4,}$ $T_{10.}$ T_{11} and T_{12} treatments. Significantly lower value of fresh weight of 10 seedlings (0.44 g) was registered under treatment T_1 (RDN as control) which was statistically at par with $T_{6.}$ T_7 and T_8 treatments.

Table 4.8: Fresh weight of 10 seedlings as influenced by different nitrogen management treatments

Sr. No.	Treatments	Fresh weight of 10 seedlings (g)		
		30 DAS	45 DAS	60 DAS
T_1	RDN (180 kg N as Basal)	0.44	2.38	3.33
T_2	RDN + Foliar spray Urea (1.0 % at 20 DAS)	0.53	3.63	3.83
T_3	RDN + Foliar spray Urea (2.0 % at 20 DAS)	0.54	3.73	3.85
T_4	RDN + Foliar spray Urea (1.0 % at 30 DAS)	0.56	3.78	3.98
T_5	RDN + Foliar spray Urea (2.0 % at 30 DAS)	0.60	4.35	4.55
T_6	75% RDN + Foliar spray Urea (1.0 % at 20 DAS)	0.47	3.03	3.35
T_7	75% RDN + Foliar spray Urea (2.0 % at 20 DAS)	0.48	3.15	3.83
T_8	75% RDN + Foliar spray Urea (1.0 % at 30 DAS)	0.49	3.23	3.90
T_9	75% RDN + Foliar spray Urea (2.0 % at 30 DAS)	0.52	3.38	3.95
T_{10}	75% RDN + Foliar spray Ammonium sulphate (0.5 % at 30 DAS)	0.55	3.48	4.18
T_{11}	75% RDN + Foliar spray Cow urine (1.0 % at 30 DAS)	0.57	3.53	4.43
T_{12}	75% RDN + Foliar spray Vermiwash (2.0 % at 30 DAS)	0.59	4.00	4.48
	SEm ±	0.01	0.11	0.11
	CD at 5%	0.05	0.32	0.31
	CV%	7.32	6.46	5.53

Data showed in Table 4.8 revealed that different treatments had significantly influence on fresh weight of 10 seedlings of tobacco at 45 DAS. The highest fresh weight of 10 seedlings (4.35 g) was observed under treatment T_5 (RDN + Foliar spray Urea 2.0 % at 30 DAS). Significantly the lowest fresh weight of 10 seedlings (2.38 g) was registered under treatment T_1 (RDN as control).

Data furnished in Table 4.8 indicated that nitrogen management treatments significantly influenced on fresh weight of ten seedlings at 60 DAS. The highest fresh weight of 10 seedlings (4.55 g) was observed under treatment T_5 (RDN + Foliar spray Urea 2.0 % at 30 DAS). On the contrary, being treatments at par each other treatments T_1 (RDN as control) and T_6 (75% RDN + Foliar spray urea 1.0% at 20 DAS) recorded significantly the lowest value of fresh weight of 10 seedlings.

With regard to periodical fresh weight of 10 seedlings recorded treatment T_5 (RDN + Foliar spray Urea 2.0% at 30 DAS) indicated higher values of fresh weight of ten seedlings recorded at 30, 45 and 60 DAS. Thus, the results showed that the highest fresh weight was found under treatment T_5 (RDN + Foliar spray Urea 2.0 % at 30 DAS). It might be due to that more amount of nitrogen is required for the production of protein used in the formation of chlorophyll. As increasing amount of nitrogen become available, the leaves of plant become greener and growth increased, which ultimately recorded in increase of fresh weight. These results are in agreement with those obtained by Das and Singh (1989), Benard *et. al.* (1996), Singh *et.al.* (2000) and Fatma *et al.* (2013) who reported that foliar spraying of urea 2 % and 3 % application on vegetable crops increased fresh weight and average weight compared to control treatment.

4.2.9 Dry weight of 10 seedlings (g)

The data regarding the effects of nitrogen management treatments on dry weight of ten tobacco seedlings at 30, 45 and 60 DAS are presented in Table 4.9 and their analysis of variance is given in Appendix - I.

Data furnished Table 4.9 indicate that various nitrogen management treatments significantly differed in respect to dry weight of 10 seedlings. The data analysed in Table 4.9 indicated that dry weight of 10 seedlings (0.14 g) was significantly higher in treatment T_5 (RDN + Foliar spray Urea 2.0 % at 30 DAS) and T_{12} (75% RDN + Foliar spray Vermiwash 2.0 % at 30 DAS) as compared to other treatments except T_{10} and T_{11} treatments. Significantly lower value of dry weight of 10 seedlings (0.10 g) were registered under RDN as control (T_1) which was statistically at par with T_2. T_6 and T_7 treatments.

Table 4.9: Dry weight of 10 seedlings as influenced by different nitrogen management treatments

Sr. No.	Treatments	Dry weight of 10 seedlings (g)		
		30 DAS	45 DAS	60 DAS
T_1	RDN (180 kg N as Basal)	0.10	0.21	0.34
T_2	RDN + Foliar spray Urea (1.0 % at 20 DAS)	0.11	0.25	0.39
T_3	RDN + Foliar spray Urea (2.0 % at 20 DAS)	0.12	0.27	0.42
T_4	RDN + Foliar spray Urea (1.0 % at 30 DAS)	0.12	0.28	0.44
T_5	RDN + Foliar spray Urea (2.0 % at 30 DAS)	0.14	0.32	0.52
T_6	75% RDN + Foliar spray Urea (1.0 % at 20 DAS)	0.11	0.21	0.36
T_7	75% RDN + Foliar spray Urea (2.0 % at 20 DAS)	0.11	0.23	0.38
T_8	75% RDN + Foliar spray Urea (1.0 % at 30 DAS)	0.12	0.23	0.40
T_9	75% RDN + Foliar spray Urea (2.0 % at 30 DAS)	0.12	0.24	0.41
T_{10}	75% RDN + Foliar spray Ammonium sulphate (0.5 % at 30 DAS)	0.13	0.27	0.44
T_{11}	75% RDN + Foliar spray Cow urine (1.0 % at 30 DAS)	0.13	0.30	0.49
T_{12}	75% RDN + Foliar spray Vermiwash (2.0 % at 30 DAS)	0.14	0.30	0.50
	SEm±	0.00	0.01	0.01
	CD at 5%	0.01	0.02	0.01
	CV%	4.60	4.13	2.73

The close examination of data showed that nitrogen management treatment significantly influenced the dry weight of 10 seedlings at 45 DAS. Treatment T_5 (RDN + Foliar spray Urea 2.0 % at 30 DAS) recorded significantly higher dry weight of 10 seedlings (0.32 g). However, it was at par with treatments T_{11} and $T_{12.}$ Whereas significantly lower value dry weight of 10 seedlings (0.21 g) was observed under the treatments T_1 and T_6, but there were statistically at par with T_7 and T_8 treatments.

It was observed from the data given in Table 4.9 that differences in dry weight of 10 seedlings recorded at 60 DAS were found significant due to nitrogen management treatments. Treatments T_5 (RDN+ Foliar spray Urea 2.0 % at 30 DAS) recorded significantly the highest dry weight of 10 seedlings (0.52 g). On the contrary, treatment T_1 (control) significantly the lowest number of dry weight of 10 seedlings (0.34 g) than all other treatments.

With respect to dry weight of 10 seedlings treatment T_5 (RDN + Foliar spray Urea 2.0% at 30 DAS) indicated higher values of dry weight of 10 seedlings recorded at 30, 45 and 60 DAS. Thus, the results clearly showed that application of urea 2% at 30 DAS increased dry weight of 10 seedlings. It might be due to that a nitrogen is the main constituent of all amino acids in proteins and lipids that act as structural compounds of the chloroplast. Leaf dry matter content increased as nitrogen rate increased. An increase in leaf area leads to an increase in rate of dry matter accumulation because light interception is directly related to leaf area.

These results are similar to those reported by Magdatena (2003), Makar *et al.* (2017), Meghvansi *et. al.* (2012), Devan *et.al.* (2013), Chaudhuri and De (1975), Fatma *et. al* (2013), Singh *et.al.* (2015).

4.2.10 Root length of seedlings

The analysis of data on root length of seedlings recorded at 45 and 55 DAS as affected by different nitrogen management treatments were presented as Table 4.10 and their analysis of variance is depicted in Appendix I.

The outcome of the statistical analysis corresponding to root length of seedlings recorded at 45 DAS as influenced by varying nitrogen management treatments are presented in Table 4.10. The data revealed that root length of seedlings (2.55 cm) was significantly the highest due to application of 75% RDN +

Foliar spray Vermiwash 2.0% at 30 DAS (T_{12}). Significantly the lowest root length of seedlings (1.00 cm) was registered under treatment T_1 (RDN as control).

Table 4.10: Root length of seedlings as influenced by different nitrogen management treatments

Sr. No.	Treatments	Root length of seedlings (cm)	
		45 DAS	55 DAS
T_1	RDN (180 kg N as Basal)	1.00	2.10
T_2	RDN + Foliar spray Urea (1.0 % at 20 DAS)	1.96	3.38
T_3	RDN + Foliar spray Urea (2.0 % at 20 DAS)	2.05	3.50
T_4	RDN + Foliar spray Urea (1.0 % at 30 DAS)	2.14	3.59
T_5	RDN + Foliar spray Urea (2.0 % at 30 DAS)	2.24	3.71
T_6	75% RDN + Foliar spray Urea (1.0 % at 20 DAS)	1.55	2.89
T_7	75% RDN + Foliar spray Urea (2.0 % at 20 DAS)	1.69	3.05
T_8	75% RDN + Foliar spray Urea (1.0 % at 30 DAS)	1.75	3.25
T_9	75% RDN + Foliar spray Urea (2.0 % at 30 DAS)	2.0	3.30
T_{10}	75% RDN + Foliar spray Ammonium sulphate (0.5 % at 30 DAS)	2.24	3.48
T_{11}	75% RDN + Foliar spray Cow urine (1.0 % at 30 DAS)	2.20	3.91
T_{12}	75% RDN + Foliar spray Vermiwash (2.0 % at 30 DAS)	2.55	4.30
	SEm. ±	0.07	0.14
	CD at 5%	0.22	0.40
	CV%	8.16	8.44

It is clear from the data presented in Table 4.10 that differences in root length of seedlings recorded at 55 DAS were changed due to varying nitrogen management treatments. Treatment T_{12} (75% RDN + Foliar spray Vermiwash 2.0% at 30 DAS) recorded significantly higher root length of seedlings (4.3 cm). However, it was at par with treatment $T_{11.}$ Whereas significantly the lowest value root length of seedlings (2.10 cm) was observed under the treatment T_1 (control).

With respect to root length of seedlings treatment T_{12} (75% RDN + Foliar spray Vermiwash 2.0% at 30 DAS) indicated higher values of root length of seedlings recorded at 45 and 55 DAS. Thus, the results clearly showed that application of vermiwash 2% at 30 DAS increased root length of seedlings.

It might be due to that the length of root may vary among the treatments due to variation in nutrient element (nitrogen). Generally, vermiwash in adequate supply of nutrient element is suitable for proper root growth and enhance uptake of nutrient from the soil as well as increase of seedlings.

These results are similar to those reported by Jandaik *et al.* (2015), Jadhav *et. al.* (2014a), Jadhav *et.al.* (2014b), Fathima and sekar (2014) Varghese and Prabha (2014).

4.2.11 Shoot length of seedlings

The data regarding the effects of nitrogen management treatments on shoot length of seedlings recorded at 45 and 55 DAS are presented in Table 4.11 and their analysis of variance is given in Appendix - I.

The data given in Table 4.11, it is revealed that shoot length of seedlings recoded at 45 DAS differed significantly due to nitrogen management treatments. Shoot length of seedlings (1.49 cm) was significantly the highest due to treatment T_{12} (75% RDN + Foliar spray Vermiwash 2.0% at 30 DAS). Significantly the lowest shoot length of seedlings (0.68 cm) was registered under treatment T_1 (RDN as control).

A significant variation in shoot length of seedlings recorded at 55 DAS was observed due to nitrogen management treatments. Treatment T_{12} (75% RDN + Foliar spray Vermiwash 2.0% at 30 DAS) recorded significantly higher shoot length of seedling (1.92 cm). However, it was statistically at par with treatment $T_{5.}$ Whereas significantly the lowest value shoot length of seedlings (0.86 cm) was observed under the treatment T_1 (control).

Table 4.11: Shoot length of seedlings as influenced by different nitrogen management treatments

Sr. No.	Treatments	Shoot length of seedlings (cm)	
		45 DAS	55 DAS
T_1	RDN (180 kg N as Basal)	0.68	0.86
T_2	RDN + Foliar spray Urea (1.0 % at 20 DAS)	0.99	1.05
T_3	RDN + Foliar spray Urea (2.0 % at 20 DAS)	1.08	1.35
T_4	RDN + Foliar spray Urea (1.0 % at 30 DAS)	1.11	1.42
T_5	RDN + Foliar spray Urea (2.0 % at 30 DAS)	1.23	1.74
T_6	75% RDN + Foliar spray Urea (1.0 % at 20 DAS)	0.78	1.35
T_7	75% RDN + Foliar spray Urea (2.0 % at 20 DAS)	0.86	1.37
T_8	75% RDN + Foliar spray Urea (1.0 % at 30 DAS)	0.91	1.39
T_9	75% RDN + Foliar spray Urea (2.0 % at 30 DAS)	0.93	1.42
T_{10}	75% RDN + Foliar spray Ammonium sulphate (0.5 % at 30 DAS)	1.18	1.56
T_{11}	75% RDN + Foliar spray Cow urine (1.0 % at 30 DAS)	1.34	1.62
T_{12}	75% RDN + Foliar spray Vermiwash (2.0 % at 30 DAS)	1.49	1.92
	SEm ±	0.04	0.06
	CD at 5%	0.11	0.18
	CV%	7.70	9.06

With regard to shoot length of seedlings, treatment T_{12} (75% RDN + Foliar spray Vermiwash 2.0% at 30 DAS) indicated higher values of shoot length of seedling recorded at 45 and 55 DAS. Thus, the results showed that application of vermiwash 2% at 30 DAS increased shoot length of seedlings. These results are in agreement with those obtained by Hemant *et al*. (2013) and Fathima and Sekar (2014) who reported that foliar spraying of vermiwash application on vegetable crops increased shoot length compared to control treatment.

These results are also similar to those reported by Subha and Prabha (2014), Jaybhaye and Bhalerao (2015).

4.3 Effect of different treatments on tobacco seedlings

4.3.1 Number of transplantable seedlings ha^{-1}

Data pertaining to number of transplantable seedlings ha^{-1} recorded at 45 and 55 DAS as influenced due to different nitrogen management treatments are presented in Table 4.12 and their analysis of variance is depicted in Appendix I.

The result given in Table 4.12 showed perceptible improvement in number transplantable seedlings ha^{-1} recoded at 45 DAS due to nitrogen management treatments. Number of transplantable seedlings ha^{-1} significantly higher in treatment T_{12} (75% RDN + Foliar spray vermiwash 2.0% at 30 DAS) (2425×10^3 ha^{-1}) but, it was statically at par with treatments T_{11} and T_5. Significantly the lowest number of transplantable seedlings ha^{-1} was registered under T_1 treatment (RDN as control) (1908×10^3 ha^{-1}).

It is evident from the data (Table 4.12) that nitrogen management treatments failed to exert their significant influence on number of transplantable seedlings ha^{-1} at 55 DAS in tobacco nursery. Results depicted in Table 4.12 revealed that none of the treatments exerted their significant effect on number of transplantable seedlings ha^{-1} at 55 DAS.

Table 4.12: Number of transplantable seedlings as influenced by different nitrogen management treatments

Sr. No.	Treatments	No. of transplantable seedlings (10^3) ha^{-1}		
		45 DAS	**55 DAS**	**Total**
T_1	RDN (180 kg N as Basal)	1908	1250	3158
T_2	RDN + Foliar spray Urea (1.0 % at 20 DAS)	1974	1259	3233
T_3	RDN + Foliar spray Urea (2.0 % at 20 DAS)	1979	1259	3238
T_4	RDN + Foliar spray Urea (1.0 % at 30 DAS)	2012	1267	3280
T_5	RDN + Foliar spray Urea (2.0 % at 30 DAS)	2344	1302	3646
T_6	75% RDN + Foliar spray Urea (1.0 % at 20 DAS)	1983	1259	3241
T_7	75% RDN + Foliar spray Urea (2.0 % at 20 DAS)	2026	1267	3293
T_8	75% RDN + Foliar spray Urea (1.0 % at 30 DAS)	2118	1276	3394
T_9	75% RDN + Foliar spray Urea (2.0 % at 30 DAS)	2179	1285	3464
T_{10}	75% RDN + Foliar spray Ammonium sulphate (0.5 % at 30 DAS)	2205	1285	3490
T_{11}	75% RDN + Foliar spray Cow urine (1.0 % at 30 DAS)	2370	1293	3663
T_{12}	75% RDN + Foliar spray Vermiwash (2.0 % at 30 DAS)	2425	1302	3727
	SEm ±	43.5	33.5	58.1
	CD at 5%	125.1	NS	167.3
	CV%	4.1	5.3	3.4

Total number of transplantable seedlings ha^{-1} was significantly influenced by nitrogen management treatments. Treatment T_{12} (75% RDN + Foliar spray vermiwash 2.0% at 30 DAS) recorded significantly higher number of total transplantable seedlings ha^{-1} (3727×10^3 ha^{-1}). However, it was statically at par with treatments T_5 and $T_{11.}$ Whereas significantly lower number of total transplantable seedlings ha^{-1} (3158×10^3 ha^{-1}) was observed under the treatment T_1. but, it was statistically at par with $T_{2,}$ $T_{3,}$ $T_{4,}$ T_6 and T_7 treatments.

Treatments T_{12}, T_{11}, $T_{5,}$ and T_1 registered 3727×10^3 ha^{-1}, 3663×10^3 ha^{-1} and 3646×10^3 ha^{-1}, 3158×10^3 ha^{-1} total transplantable seedlings, respectively. The per cent increase in number of total transplantable seedlings under the treatments $T_{12,}$ T_{11} and T_5 over T_1 was to the tunes of 18.02, 15.99 and 15.45 per cent, respectively.

With regard to number of transplantable seedlings ha^{-1}, treatment T_{12} (75% RDN + Foliar spray vermiwash 2.0% at 30 DAS) indicated higher number of transplantable seedlings ha^{-1} recorded at 45 and 55 DAS as compared to all other treatments except treatment T_5 and T_{11}. Thus, the results clearly showed that application of vermiwash spray 2% at 30 DAS increased number of transplantable seedlings ha^{-1} which was comparable with cow urine 1.0% at 30 DAS and urea 2.0% at 30 DAS treatments.

An application of 75% RDN + foliar spray vermiwash 2.0% at 30 DAS (T_{12}) also recorded higher values of CGR, RGR, NAR, leaf area, chlorophyll content, Fresh and dry weight of seedlings, root and shoot length of seedlings as well as lower number of damped seedlings which favours healthy growth of seedlings ultimately resulting more number of transplantable seedlings.

4.3.2 Number of non transplantable seedlings ha^{-1}

The outcome of the investigation on number non transplantable seedlings recorded at 45 and 55 DAS as influence by various nitrogen management treatments are presented in Table 4.13 and their analysis of variance is depicted in Appendix I.

Table 4.13: Number of non transplantable seedlings as influenced by different nitrogen management treatments

Sr. No.	Treatments	No. of non transplantable seedlings (10^3) ha^{-1}	
		45 DAS	55 DAS
T_1	RDN (180 kg N as Basal)	2083	882
T_2	RDN + Foliar spray Urea (1.0 % at 20 DAS)	2043	832
T_3	RDN + Foliar spray Urea (2.0 % at 20 DAS)	2023	793
T_4	RDN + Foliar spray Urea (1.0 % at 30 DAS)	1970	736
T_5	RDN + Foliar spray Urea (2.0 % at 30 DAS)	1797	707
T_6	75% RDN + Foliar spray Urea (1.0 % at 20 DAS)	1970	745
T_7	75% RDN + Foliar spray Urea (2.0 % at 20 DAS)	1965	771
T_8	75% RDN + Foliar spray Urea (1.0 % at 30 DAS)	1962	738
T_9	75% RDN + Foliar spray Urea (2.0 % at 30 DAS)	1962	736
T_{10}	75% RDN + Foliar spray Ammonium sulphate (0.5 % at 30 DAS)	1840	793
T_{11}	75% RDN + Foliar spray Cow urine (1.0 % at 30 DAS)	1814	793
T_{12}	75% RDN + Foliar spray Vermiwash (2.0 % at 30 DAS)	1788	694
	SEm. ±	36.5	15.4
	CD at 5%	105.0	44.2
	CV%	3.8	4.0

Results indicated that there were significant differences in number of non transplantable seedlings due to various nitrogen management treatments. Treatment T_{12} (75% RDN + Foliar spray Vermiwash 2.0% at 30 DAS) recorded significantly lower number of non transplantable seedlings (1788 × 10^3 ha^{-1}). However, it was statistically at par with treatments T_5, T_{10}, T_{11}. Significantly the highest number of non transplantable seedlings (2083 × 10^3 ha^{-1}) was registered under treatment T_1.

An effect of nitrogen management treatments on number non transplantable seedlings recorded at 55 DAS was deduced significant. The data revealed that Treatment T_{12} (75% RDN + Foliar spray Vermiwash 2.0% at 30 DAS) recorded significantly lower number of non transplantable seedlings (694 × 10^3 ha^{-1}) which was statistically at par with treatments T_4, T_5, T_8 and T_9. Significantly the highest number of number of non transplantable seedlings (882 × 10^3 ha^{-1}) was registered under treatment T_1 (control).

With respect to number of non transplantable seedlings ha^{-1}, treatment T_{12} (75% RDN + Foliar spray Vermiwash 2.0% at 30 DAS) indicated minimum number of non transplantable seedlings ha^{-1} recorded at 45 and 55 DAS. Thus, the results clearly showed that application of vermiwash 2% at 30 DAS decrease number of non transplantable seedlings ha^{-1}.

The result Table 4.12 clearly showed that maximum number of transplantable seedlings ha^{-1} were obtain under the treatment T_{12} (75% RDN + Foliar spray Vermiwash 2.0% at 30 DAS) which might be ultimately resulted into lower number of non transplantable seedlings.

4.3.3 Number of total seedlings ha^{-1}

Data pertaining to number of total seedlings ha^{-1} recorded at 45 and 55 DAS as influenced due to different nitrogen management treatments are presented in Table 4.14 and their analysis of variance is depicted in Appendix I.

Number of total seedlings recorded at 45 DAS presented in Table 4.14 was found significant. Significantly higher number of total seedlings ha^{-1} (4214 × 10^3 ha^{-1}) was observed under treatment T_{12} (75% RDN + Foliar spray Vermiwash 2.0% at 30 DAS) and it was at par with treatments T_{11}, T_8, T_5 and T_9. While significantly lower number of total seedlings ha^{-1} (3953 × 10^3 ha^{-1}) was registered under treatment T_6 but, it was at par with T_1 T_2 T_3 T_4 T_7 and T_{12}.

Table 4.14: Number of total seedlings as influenced by different nitrogen management treatments

Sr. No.	Treatments	No. of total seedlings (10^3) ha^{-1}	
		45 DAS	**55 DAS**
T_1	RDN (180 kg N as Basal)	3991	2132
T_2	RDN + Foliar spray Urea (1.0 % at 20 DAS)	4017	2090
T_3	RDN + Foliar spray Urea (2.0 % at 20 DAS)	4002	2052
T_4	RDN + Foliar spray Urea (1.0 % at 30 DAS)	3983	2003
T_5	RDN + Foliar spray Urea (2.0 % at 30 DAS)	4141	2009
T_6	75% RDN + Foliar spray Urea (1.0 % at 20 DAS)	3953	2003
T_7	75% RDN + Foliar spray Urea (2.0 % at 20 DAS)	3991	2038
T_8	75% RDN + Foliar spray Urea (1.0 % at 30 DAS)	4080	2014
T_9	75% RDN + Foliar spray Urea (2.0 % at 30 DAS)	4141	2021
T_{10}	75% RDN + Foliar spray Ammonium sulphate (0.5 % at 30 DAS)	4045	2078
T_{11}	75% RDN + Foliar spray Cow urine (1.0 % at 30 DAS)	4184	2087
T_{12}	75% RDN + Foliar spray Vermiwash (2.0 % at 30 DAS)	4214	1997
	SEm. ±	52.2	31.7
	CD at 5%	150.1	NS
	CV%	2.6	3.1

The perusal of data on number of total seedlings ha^{-1} recorded at 55 DAS were presented in Table 4.14. Results revealed that none of the treatments exerted their significant effect on number of total seedlings ha^{-1} recorded at 55 DAS.

With regard to periodical number total seedlings ha^{-1}, treatment T_{12} (75% RDN + Foliar spray Vermiwash 2.0% at 30 DAS) indicated the highest values of total seedlings ha^{-1} recorded at 45 and 55 DAS.

Further, the results presented as Table 4.12 and Table 4.13 clearly shows that an application of 75 % RDN with foliar spray 2.0% vermiwash at 30 DAS produced maximum number of transplantable seedlings and number of non transplantable seedlings. Which ultimately resulted into higher number total seedlings ha^{-1}.

4.4 Effect of different treatments on chemical analysis of plant and soil

4.4.1 Effect of different treatments on nutrients content of plant

The results corresponding to the influence of varying nitrogen management treatments nutrients (N, P and K) content in bidi tobacco seedlings have been cited in Table 4.15 and their analysis of variance is given in Appendix - I.

It is discerning from the Table 4.15 that nitrogen content in bidi tobacco seedlings recorded at harvest was significantly influenced due to nitrogen management treatments. Observed higher nitrogen content in bidi tobacco seedlings recorded at harvest higher (2.25 %) was observed under Treatment T_5 (RDN + Foliar spray of Urea 2.0% at 30 DAS) however, it was at par with treatments T_{12} and $T_{11.}$ Significantly lower nitrogen content in bidi tobacco seedlings recorded at harvest (1.86 %) was registered under control (T_1). However, it was statistically at par with $T_{6,}$ T_7 and T_8 treatments.

A keen observation of data (Table 4.15) showed that nitrogen management treatments significantly influenced an available phosphorus content in bidi tobacco seedlings recorded at harvest. Phosphorus content (0.50%) in bidi tobacco seedlings recorded at harvest higher was observed under Treatment T_{12} (75 % RDN + Foliar spray 2.0% Vermiwash at 30 DAS) but, it was at par with T_5 and $T_{11.}$ On the contrary, significantly the lowest but equal phosphorus content (0.30%) in bidi tobacco seedlings recorded at harvest was registered under T_1 and T_6 treatments.

Table 4.15: Nutrient contents of plant as influenced by different nitrogen management treatments

Sr. No.	Treatments	Nutrient contents of plant		
		N%	P%	K%
T_1	RDN (180 kg N as Basal)	1.86	0.30	0.37
T_2	RDN + Foliar spray Urea (1.0 % at 20 DAS)	2.02	0.38	0.41
T_3	RDN + Foliar spray Urea (2.0 % at 20 DAS)	2.03	0.41	0.42
T_4	RDN + Foliar spray Urea (1.0 % at 30 DAS)	2.06	0.42	0.42
T_5	RDN + Foliar spray Urea (2.0 % at 30 DAS)	2.25	0.48	0.42
T_6	75% RDN + Foliar spray Urea (1.0 % at 20 DAS)	1.97	0.30	0.39
T_7	75% RDN + Foliar spray Urea (2.0 % at 20 DAS)	1.97	0.34	0.40
T_8	75% RDN + Foliar spray Urea (1.0 % at 30 DAS)	1.98	0.35	0.40
T_9	75% RDN + Foliar spray Urea (2.0 % at 30 DAS)	2.00	0.38	0.41
T_{10}	75% RDN + Foliar spray Ammonium sulphate (0.5 % at 30 DAS)	2.07	0.38	0.43
T_{11}	75% RDN + Foliar spray Cow urine (1.0 % at 30 DAS)	2.18	0.48	0.44
T_{12}	75% RDN + Foliar spray Vermiwash (2.0 % at 30 DAS)	2.25	0.50	0.45
	SEm ±	0.04	0.01	0.006
	CD at 5%	0.12	0.03	0.017
	CV%	4.2	5.97	2.98

Statistical analysis of data (Table 4.15) revealed that nitrogen management treatments significantly influenced available potassium content in bidi tobacco seedlings at harvest. Potassium content (0.45%) in bidi tobacco seedlings at harvest higher was observed under treatment T_{12} (75% RDN + Foliar spray 2.0% Vermiwash at 30 DAS). But, it was statistically at par with treatments T_{10} and T_{11}. Significantly the lowest potassium content (0.37%) in bidi tobacco seedlings at harvest was registered under treatment T_1 (control).

With respect to nutrient contents in bidi tobacco seedlings, treatment T_5 (RDN + foliar spray Urea 2.0% at 30 DAS) indicated higher value of nitrogen content in bidi tobacco seedlings recorded at harvest. However, available phosphorus and potash contents of tobacco seedlings was higher under treatment T_{12} (75% RDN + Foliar spray Vermiwash 2.0 % at 30 DAS). It might be due that application of nitrogen increased available nitrogen status in the soil thereby increased absorption of nitrogen from soil solution and accumulated in the plant which ultimately increased nitrogen content in leaves.

The results are in conformity with these reported by Vagen (2003). They reported that nitrogen uptake in plant appeared to increase with increasing fertilizer nitrogen application. The data obtained in this study concur with those of Karitonas (2003) who showed that nitrogen fertilization increased N, P, K, Ca and Mg concentrations in leaves of crop. In addition, it was observed that foliar urea applications elevated the N and K content high in lettuce (Padem and Alan 1995), and N, K and Fe content in tomato (Alan and Padem 1994).

4.4.2 Effect of different treatments on nutrients status of soil

Data on post harvest available soil nutrients (N, P, K and O.C) status of soil as influenced by various nitrogen management treatments are reported in Table 4.16 and their analysis of variance is depicted in Appendix I.

An appraisal of data presented in Table 4.16 showed that different nitrogen management treatments on available nutrients status of soil did not exert their significant effect on organic carbon, available nitrogen, phosphorus and potassium status of the soil after harvest of the crop.

Table 4.16: Nutrients status of soil as influenced by different nitrogen management treatments

Sr. No.	Treatments	Nutrients (O.C, N, P and K) status of soil			
		N (kg ha^{-1})	P_2O_5 (kg ha^{-1})	K_2O (kg ha^{-1})	O.C%
T_1	RDN (180 kg N as Basal)	139	46.9	202	0.53
T_2	RDN + Foliar spray Urea (1.0 % at 20 DAS)	140	46.7	202	0.52
T_3	RDN + Foliar spray Urea (2.0 % at 20 DAS)	141	47.3	202	0.52
T_4	RDN + Foliar spray Urea (1.0 % at 30 DAS)	141	48.8	203	0.53
T_5	RDN + Foliar spray Urea (2.0 % at 30 DAS)	142	48.0	204	0.54
T_6	75% RDN + Foliar spray Urea (1.0 % at 20 DAS)	139	47.2	202	0.53
T_7	75% RDN + Foliar spray Urea (2.0 % at 20 DAS)	140	46.1	203	0.53
T_8	75% RDN + Foliar spray Urea (1.0 % at 30 DAS)	140	46.8	203	0.53
T_9	75% RDN + Foliar spray Urea (2.0. % at 30 DAS)	140	46.7	204	0.53
T_{10}	75% RDN + Foliar spray Ammonium sulphate (0.5 % at 30 DAS)	141	46.2	204	0.53
T_{11}	75% RDN + Foliar spray Cow urine (1.0% at 30 DAS)	141	47.0	204	0.53
T_{12}	75% RDN + Foliar spray Vermiwash (2.0 % at 30 DAS)	142	49.0	204	0.53
	SEm ±	0.82	0.95	1.4	0.0
	CD at 5%	NS	NS	NS	NS
	CV%	1.2	4.0	1.4	1.3

4.5 EFFECT OF DIFFERENT TREATMENTS ON ECONOMICS

The details of income, total expense and benefit cost ratio for individual treatments are worked out and present in Table 4.17. The cost of cultivation of tobacco seedlings and their details of cost incurred in treatment application are furnished in Appendix II.

Table 4.17 Economics as influenced by different nitrogen management treatments

Treat.	No. of transplantable seedlings (× 10^3) ha^{-1}	Gross income (× 10^3) ₹ ha^{-1}	Total cost (× 10^3) ₹ ha^{-1}	Net realization (× 10^3) ₹ ha^{-1}	BCR ratio
T_1	3158	631600	149073	482527	4.24
T_2	3233	646600	149109	497491	4.34
T_3	3238	647600	149145	498455	4.34
T_4	3280	655800	149109	506691	4.40
T_5	3646	729200	149145	580055	4.89
T_6	3241	648400	142370	506030	4.55
T_7	3293	658600	142406	516194	4.62
T_8	3394	678800	142370	536430	4.77
T_9	3464	692800	142406	550394	4.86
T_{10}	3490	698000	142367	555649	4.90
T_{11}	3663	732600	142359	590241	5.15
T_{12}	3727	745400	142852	602548	5.22

For sound recommendation of any agronomic treatment, it is necessary to work out economics of treatments. In the present investigation, the results on economics (Table 4.17) revealed that maximum net realization of ₹ 6,02,548 ha^{-1} with BCR of 1 : 5.22 was obtained from treatment T_{12} (75 % RDN with foliar spray 2.0% vermiwash at 30 DAS). The next in line was (₹ 5, 90,241 ha^{-1}) 75 % RDN with foliar spray 1.0% cow urine at 30 DAS treatment (T_{11}) and (₹ 5, 80,055 ha^{-1}) RDN with foliar spray of urea 2.0% at 30 DAS (T_5) treatment. Further, revealed that lower net realization of ₹ 4,82,527 ha^{-1} with BCR of 1: 4.24 was obtained from treatment T_1 (RDN as control).

Further, the results presented as Table 4.17 as well as Table 4.12 clearly shows that an application of 75 % RDN with foliar spray 2.0% vermiwash at 30 DAS produced maximum number of transplantable seedlings and accrued required lower cost as compare to other treatments. Which ultimately resulted into higher net realization and BCR ratio.

5. SUMMARY AND CONCLUSION

The present investigation was carried out during the *kharif* season of the year 2017 on loamy sand soil at Bidi Tobacco Research Station, Anand Agricultural University, Anand to evaluate "nitrogen management in bidi tobacco (*Nicotiana tabacum* L.) nursery".

The experiment was laid out in Randomized Block Design with 4 replications. The twelve nitrogen management treatments *viz.*, RDN (T_1), RDN + Foliar spray Urea 1.0 % at 20 DAS (T_2), RDN + Foliar spray Urea 2.0 % at 20 DAS (T_3), RDN + Foliar spray Urea 1.0 % at 30 DAS (T_4), RDN + Foliar spray Urea 2.0 % at 30 DAS (T_5), 75% RDN + Foliar spray Urea 1.0 % at 20 DAS (T_6), 75% RDN + Foliar spray Urea 2.0. % at 20 DAS (T_7), 75% RDN + Foliar spray Urea 1.0 % at 30 DAS (T_8), 75% RDN + Foliar spray Urea 2.0. % at 30 DAS (T_9), 75% RDN + Foliar spray Ammonium sulphate 0.5 % at 30 DAS (T_{10}), 75% RDN + Foliar spray Cow urine 1.0 % at 30 DAS (T_{11}) and 75% RDN + Foliar spray Vermiwash 2.0 % at 30 DAS (T_{12}) were studied.

During the present investigation, treatments effects on plant stand at 15 DAS CGR, RGR, NAR, Leaf area, Chlorophyll content (SPAD value), number of damped seedlings, fresh and dry weight bidi tobacco 10 seedlings at 30, 45 and 60 DAS, root and shoot length of seedlings at 45 and 55 DAS, as well as number of transplantable, non transplantable, total seedlings at 45 and 55 DAS, Organic carbon, available N, P, K status in soil sample and N, P, K content in plant sample were studied.

The results and discussed presented in the preceding chapters have been summarized here after.

5.1 Effect of treatments on growth attributes of tobacco seedlings

1. Plant stand recorded at 15 DAS was not affected significantly due to different nitrogen management treatments.
2. Periodical crop growth rate recorded at 30, 45 and 60 DAS were significantly influenced due to nitrogen management treatments. Being at par with each other treatments T_5 (RDN + Foliar spray Urea 2.0% at 30 DAS) and T_{12} (75% RDN + Foliar spray Vermiwash 2.0% at 30 DAS) recorded significantly the

highest CGR. Significantly lower crop growth rate was recorded under treatment T_1 (control) which was at par with treatments T_2 and $T_{6.}$

3. The nitrogen management treatments could not affect relative growth rate recorded at 30 DAS. Relative growth rate (RGR) recorded at 45 DAS was higher under application of treatments T_5 (RDN + Foliar spray Urea 2.0% at 30 DAS) and T_{11} (75% RDN + Foliar spray Cow urine 1.0% at 30 DAS. It was at par with treatments $T_{1,}T_{2,}$ T_3 T_4 and $T_{12.}$ At 60 DAS, treatment T_9 (75% RDN + Foliar spray Urea 2.0% at 30 DAS) recorded significantly higher relative growth rate which was at par with all other treatments except $T_{1,}$ $T_{2,}$ $T_{3,}$ and T_4 treatments.

4. Net assimilation rate recorded at 30 DAS was not affected significantly due to different nitrogen management treatments. At 45 DAS, significantly higher net assimilation rate was observed under treatment T_5 (RDN + Foliar spray Urea 2.0% at 30 DAS) which was at par with treatments $T_{4,}$ T_{11} and $T_{12.}$ However, NAR at 60 DAS was higher under treatment T_{11} (75% RDN + Foliar spray 1.0% Cow urine at 30 DAS) but, it was at par with treatments $T_{5,}$ T_9 and T_{12}. Significantly lower net assimilation rate was recorded under treatments T_6 (75% RDN + Foliar spray of Urea 1.0% at 20 DAS) and T_2 (RDN + Foliar spray Urea 1.0 % at 20 DAS) and was at par with treatments $T_{1,}$ T_2 and $T_{3.}$

5. Leaf area recorded at 30, 45 and 60 DAS were significantly influenced due to nitrogen management treatments. Data indicated that maximum leaf area recorded at 30, 45 and 60 DAS was achieved by treatment T_5 (RDN + Foliar spray Urea 2.0 % at 30 DAS). Significantly lower leaf area was observed under treatment T_1 (Control).

6. Treatment T_5 (RDN + Foliar spray Urea (2.0 % at 30 DAS) recorded higher chlorophyll content (SPAD value) of bidi tobacco seedling at 30, 45 and 60 DAS. Significantly lower value of chlorophyll content was registered by treatment T_1 (control).

7. At 45 and 60 DAS, treatment T_5 (RDN + Foliar spray Urea (2.0 % at 30 DAS) recorded significantly lower number of damped seedlings. However, it was statically at par with treatments T_{11}, T_{12} and T_{10}. Significantly higher number of damped seedlings was registered under treatment T_1 (Control). It was at par with $T_{2,}$ T_6 and T_7 treatments.

8. At 30, 45 and 60 DAS, treatment T_5 (RDN + Foliar spray Urea (2.0 % at 30 DAS) registered higher fresh and dry matter accumulation of bidi tobacco seedling. Treatment T_5 statically at par with treatment T_{12} (75% RDN + Foliar spray vermiwash 2.0 % at 30 DAS). Significantly lower value of fresh and dry weight of 10 seedlings were observed under the treatment T_1 (Control).
9. Treatment T_{12} (75% RDN + Foliar spray Vermiwash (2.0 % at 30 DAS) recorded higher root length of bidi tobacco seedling at 45 and 55 DAS. Significantly the lowest root length of seedlings was registered under treatment T_1 (Control).
10. Results on shoot length of bidi tobacco seedlings at 45 and 55 DAS recorded that treatment T_{12} (75% RDN + Foliar spray Vermiwash (2.0 % at 30 DAS) helped in achieving higher shoot length of seedlings. Significantly the lowest shoot length of seedlings was registered under treatment T_1 (Control).

5.2 Effect of different treatments on tobacco seedlings

1. At 45 DAS, higher number of transplantable seedlings was achieved under treatment T_{12} (75% RDN + Foliar spray vermiwash 2.0 % at 30 DAS). Next in order were treatments T_{11} (75 % RDN + Foliar spray 1.0% cow urine at 30 DAS) and T_5 (RDN + Foliar spray Urea (2.0 % at 30 DAS) as well as treatments T_8 and T_9. Treatment T_1, T_2, T_3, T_4, T_6, T_7 and T_{10} registered lower number of transplantable seedlings. The nitrogen management treatments could not affect the number of transplantable seedlings recorded at 55 DAS.
2. Treatment T_{12} (75% RDN + Foliar spray Vermiwash 2.0 % at 30 DAS) recorded significantly lower number of non transplantable seedlings at 45 and 55 DAS among nitrogen management treatments. Treatment T_1 (RDN as control) registered the highest number of non transplantable seedlings.
3. At 45 DAS, higher number of total seedlings was achieved under treatment T_{12} (75% RDN + Foliar spray Vermiwash 2.0 % at 30 DAS). Treatment T_1 (RDN as control) registered lower number of total seedlings.

5.3 Effect of different treatments on chemical analysis of soil and plant

1. At harvest, nutrients (nitrogen, phosphorus and potassium) contents in tobacco seedlings were significantly influenced by nitrogen management treatments. Higher nitrogen content of tobacco seedlings was observed under treatment T_5

(RDN + Foliar spray Urea (2.0 % at 30 DAS). However, phosphorus and potash contents of tobacco seedlings was higher under treatment T_{12} (75% RDN + Foliar spray Vermiwash 2.0 % at 30 DAS).

2. Organic carbon and available nutrients (Nitrogen, Phosphorus and Potassium) status of soil recorded at harvest was not affected significantly due to different nitrogen management treatments.

5.4 Effect of treatments on economics

1. In the present investigation, the results on economics recorded that maximum net realization of 602.548×10^3 ₹ ha^{-1} with BCR of 5.22 was obtained by treatment T_{12} (75% RDN + foliar spray 2.0% vermiwash at 30 DAS). In terms of net realization and BCR, the treatments next in order were treatments T_{11} (75% RDN + Foliar spray Cow urine 1.0 % at 30 DAS) and T_5 (RDN + Foliar spray Urea 2.0 % at 30 DAS) in net realization of 590.241×10^3 ₹ ha^{-1} and 580.055×10^3 ₹ ha^{-1} and BCR value of 5.15 and 4.89, respectively.

Conclusion

It can be concluded from the present investigation that higher number of transplantable seedlings of bidi tobacco, net realization and benefit cost ratio (BCR) could be achieved either with an application of 75% RDN + Foliar spray 2.0% Vermiwash at 30 DAS or application of 75% RDN + Foliar spray Cow urine 1 % at 30 DAS or application of RDN + Foliar spray Urea 2.0 % at 30 DAS.

REFERENCES

Abdul, R. & Habeeb, T. (2014). The role of spraying nitrogen on growth and nutritional value of fruits in different tomato genotypes. *The Iraqi J. of Agri. Sci.*, **74** (Special Issue), 82-90.

Abro, M. A., Syed, R. N., Yasmin, A., Abro, A., Kumar, A. & Nicot, P. C. (2014). Different nitrogen fertilization regimes influences the susceptibility of lettuce plants to *Botrytis unerea* and *Sclerotina scleotiorum*. *Sci. int.* (Lahore), **26** (1), 325-329.

Adams, P. (1986). Mineral Nutrition. In the tomato crop, Artherton, J. G and Rudish, *J (Ed) Chapman and Hall Ltd*. pp: 281-324.

Alaghemand, S., Ayyubi, H., Hasanpour, E., Olfati, J. A., Saadatian, M., Hamidoghli, Y., Kazemi, S. & Karimi, H. (2017). Effects of organic fertilizers on growth and biochemical characteristics of fenugreek. *Acta Agri. Slovenica*, **109** (2), 197 – 203.

Alam, S. S., Moslehuddin, A. Z. M., Islam, M. R. & Kamal, A. M. (2010). Soil and foliar application of nitrogen for boro rice. *J. Bangladesh Agril. Univ*., **8** (2), 199–202.

Alan, R. & Padem, H. (1994). The influence of some foliar fertilizers on growth and chemical composition of tomatoes under greenhouse conditions. In: Proc. Solanacea in Mild Winter Climates. *Acta Hort*., 366: 397–404.

Ali, S., Khan, A. R., Mairaj, G., Arif, M., Fida, M. & Bibi, S. (2008). Assessment of different crop nutrients management practices for improvement of crop yield. *Aust. J. Crop Sci.*, **2** (3), 150-157.

Al-sahhaf, F. H. (2000). Effect of the application of urea and agriton on growth and yield of four tomato cultivars (*Lycopersicon esculentum* Mill.) *Dirasat Agril. Sci*., **27** (1), 112-130.

Anonymous (1960). Indian Central Tobacco Committee (Ministry of Food & Agriculture, Government of India). *"Indian Tobacco: A monograph"*. Madras.

Anonymous (2004). Foliar spray of cow urine. Retrieved from http://www. everythingorganicnursery.com/files/Cow urine.

Anonymous (2014). *Leading countries in tobacco production.* Retrieved from https://www.statista.com/statistics/261173/leading countries in tobacco production/

Anonymous (2015[a]). Annual Report. Bidi Tobacco Research Station, Anand Agricultural University, Anand, pp: 18-20.

Anonymous (2015[b]). Agricultural Statistics at a glance, Government of India, Ministry of Agriculture & Farmers Welfare, Department of Agriculture, Cooperation & Farmers Welfare, Directorate of Economics and Statistics.

Ansari, A. (2008). Effect of vermicompost and vermiwash on the productivity of spinach (*Spinacia oleracea*), onion (*Allium cepa*) and potato (*Solanum tuberosum* L.). *World J. of Agril. Sci.,* **4** (5), 554-557.

Anwar, R. S. M., Awad, E. M. M. & I. A. S (2011). Effect of different rates of nitrogen and potassium fertilization on growth, yield and quality of potato plants under sandy soil conditions. *J. Plant Production, Mansoura Univ.,* **2** (8), 983 – 993.

Arif, M., Chohan, M. A., Ali, S. & Khan, S. (2006). Response of wheat to foliar application of nutrients. *J. Agri. Bio. Sci.*, **1,** 30-34.

Bajwa, M. I. (1992). Soil fertility management for sustainable agriculture. *Proc. 3rd National Congress of Soil Science, held at Lahore from 20th to 22nd March* 1990, pp: 7-25.

Batra, V. K., Malik, Y. S. & Pandita, M. L. (1993). Effect of fertilizer treatments and size of seedling on establishment in relation to seedling tuber production in nursery beds. *Haryana Agril. Uni. J. Res*., **23** (2), 77-82.

Bernard, A. L., Nicoulaud & Bloom, A. J. (1996). Absorption and assimilation of foliarly applied urea in tomato. *J. American society of Horti. Sci.,* **121** (6), 1117-1121.

Bhardwaj, M., Kaur, P. & Babbar, I. (2015). Effect of vermicompost and vermiwash on growth of vegetables. *Res. J. of Animal, Veterinary and Fishery Sci.,* **3** (4), 9-12.

Bhutto, A. G. (2003). Effect of foliar application of urea on the growth and fruit yield of tomato (*Lycopersicon esculentum* L.). A Thesis submitted to the Sindh Agric. Univ, Tandojam Pak.

Bid, N. N., Das, P. K. & Dhua, S. P. (1971). Studies on the relative efficiencies of soil and foliar application of urea on brinjal (*Solanum melongena* L.). *Hort. Tech*., **8** (3-4), 261-264.

Button, E. F. & Hawkins, A. (1958). Foliar application of urea to potatoes. *American Potato Journal*, **35**, 558-572.

Chaudhuri, B. B. & De, R. (1975). Effect of soil and foliar application of nitrogen and phosphorus on the yield of tomato (*Lycopersicum esculentum* Mill.). *Soil Sci. Plant Nutri*., **21** (1), 57-62.

Chopra, S. L. & Kanwar, J. S. (1976). *Analytical Agricultural Chemistry*. New Delhi: Kalyani Publishers.

Chowdary, B. B. & De, R. (1969). Foliar fertilization for increased tomato yield. *Indian Farming*, **19**, 45-47.

Chung, S. L., Seo, B. S. & Lee, B. S. (1992). Effects of nitrogen, potassium levels and their interaction on the growth and development of hydroponically grown tomato. *J. Kor. Sci*., **33** (3), 244-251.

Czuba, R. (1994). The results of foliar nutrition of field crops. Response of plants to foliar nitrogen application. (Cited from potato Abstr.) **21** (1), 127.

Das, R. C. & Patro, R. S. (1989). Effect of micronutrient mixture and urea on growth, yield and quality of tomato (*Lycopersicon esculentum* Mill.). *Orissa J. of Horti.*, **17** (1 & 2), 37-45.

Das, T. K. & Singh, D. N. (1989). Effect of soil and foliar application of nitrogen on fruiting and yield of tomato. *Orissa. J. Hort.*, **17** (1-2), 69-73.

Devan, E., Kaleena P. K., Fathima, M. & Hemavathi, M. (2013). Influence of vermiwash and plant growth regulators on the exomorphological characters of *Abelmoschus esculentus* (Linn.) Moench. *African J. of Basic & Applied Sci.*, **5** (2), 82-90.

Dhuria, H. S & Shukla, V. (1973). Foliar application of urea on tomato. *Indian J. of Horti.*, **30**, 425-427.

Fathima, M. & Sekar, M. (2014). Studies on growth promoting effects of vermiwash on the germination of vegetable crops. *Int. J. of Current Microbiology & Applied Sci.*, **3** (6), 564-570.

Fatma, A., rizk, A. M., Shaheen, S. M. & Ommima, A. S. (2013). The productivity of potato plants affected by urea fertilizer as foliar spraying and humic acid added with irrigation water. *Middle East J. of Agri. Res.*, **2** (2), 76-83.

Gopalachari, N. C. (1984). Tobacco, publication & information division, Indian Council of Agricultural Research, New Delhi.

Grzeskiewicz, H. & Trawezynski, C. (1999). Foliar application of multicomponent liquid fertilizers in edible potato. (Cited from CAB Abstr.) **209**, 149-155.

Hemant, Samadhiya, Puneeta, Dandotiya, Jaya, Chaturvedi & Agrawal, O. P. (2015). Effect of vermiwash on the growth and development of leaves and stem of tomato plants. *Int. J. of Current Res.*, **5** (10), 3020-3023.

Hinsvark, O. N., Wittwer, S. H. & Tukey, H. B. (1953). The metabolism of foliar applied urea relative rate of CO_2 production by certain vegetable plants treated with labelled urea. *Plant Physiol*., **28** (1), 70–76.

Hovadik, A. & Vrany, J. (1970). The effect of foliar application of urea on the rhizosphere micro flora and the growth of tomatoes and peppers. (Cited from Hort. Abstr.) **41** (3), 6380.

Ismail, S. A. (1997). Vermicology: The Biology of Earthworms. Orient Longman Ltd. Chennai, India.

Jablonski, K. & Dryjanska, M. (1998). The influence of foliar application of on the yield, yield structure and chemical composition of potato tubers. (Cited from CAB Abstr.) **72**, 115-121.

Jackson, M. L. (1973). *Soil chemical analysis*. New Delhi: Prentice hall of India Private Ltd.

Jadhav, K. P. & Patel, D. J. (2014b). Effect of different levels of vermiwash spray on growth and yield of fenugreek cv. Local variety. *Int. J. of develop. Res.*, **4** (8), 1547-1549.

Jadhav, P. B., Kireeti, A., Patil, N., Dekhane, S. & Patel, D. J. (2014a). Effect of different levels of vermiwash spray on growth and yield of radish cv. local variety. *The Asian J. of horti.*, **9 (**2), 445-449.

Jandaik, S., Thakur, P. & Kumar, V. (2015). Efficacy of cow urine as plant growth enhancer and antifungal agent. Hindawi Publishing Corporation advances in agriculture. Article ID 620368, 1-7.

Jaybhaye, M. M. & Bhalerao, S. A. (2015). Effect of vermiwash on the growth parameters of (*Solanum melongena* L.) brinjal plant. *Int. J. of Current Res. in Biosci. & Plant Biology.*, **2** (9), 24-29.

Karitonas, R. (2003). Development of a nitrogen management tool for broccoli. In: Proc. XXVI. IHC-Fertil. Strateg. Field Veg. Prod. *Acta Hort*., 627, 125–129.

Kaur, G., Ghai1, N., Kaur, J. & Singh, S. (2015). Growth efficiency and yield of pigeonpea (*Cajanus cajan* L.) as affected by foliar application of mineral nutrients. *J. of Plant Sci. & Res.*, **2** (2), 01-09.

Khan, R. W., Khan, I., Muzammil, J. M., Ashraf, U., Samin, G., Anwer, A., Adnan, M. & Bashir, M. (2015). Phosphorous and foliar applied nitrogen improved productivity and quality of potato. *American J. of Plant Sci.*, **6**, 144-149.

Khodabandeh, N. (1997). Ind. Plant Agron. Publication of Tehran University.

Kolota, E. & Osinska, M. (2001). Efficiency of foliar nutrition of field vegetables grown at different nitrogen rates. In: Proc. IC Environ. Probl. N-Fert. *Acta Hort*., **563**, 87–91.

Krishnamurthy, V. (2011). Tobacco- New Dimensions at the 219th meeting of the governing body of the ICAR Society on 4.01.2011 at the NASC complex, New Delhi. Retrieved from http://www.ctri.org.in.

Kumar, S. H. M. & Shashidhar, T. R. (2016). Effect of foliar application of growth regulators and bio stimulants on growth and yield of onion var. Bhima Shakti. *J. Farm Sci.*, **29** (1), 50-52.

Liptay, A. & Nicholls, S. (1993). Nitrogen supply during greenhouse transplant production affects subsequent tomato root growth in the field. *J. Amer. Soc. Hort. Sci.*, **118** (3), 339-342.

Magdatena, V. C. (2003). Salinity and nitrogen rate effects of the growth and yield of chilli pepper plants. *J. Soil Sci.*, 67: 1781-1789.

Makkar, C., Singh, J. & Chander P. (2017). Vermicompost and vermiwash as supplement to improve seedling, plant growth and yield in (*Linum usitassimum* L.) for organic agriculture. *Int. J. Recycl. Org. Waste Agri.*, **6**, 203–218.

Meghvansi, M. K., Mohammad, H., Gupta, R., Gogoi, H. K. & Singh L. (2012). Vegetative and yield attributes of Okra and Naga Chilli as affected by foliar sprays of vermiwash on acidic soil. Journal of Crop Improvement, **26** (4) 520-531.

Millard, P. & Robinson, D. (1990). Effect of the timing and rate of nitrogen fertilization on the growth and recovery of fertilizer nitrogen within the potato (*Solanum tuberosum* L.). *Crop. Fertilizer Res.*, **21** (3), 133-140.

Misra, S. K., Singh, P. V. & Singh, S. K. (2002). Standardization of propagation techniques in asparagus. *Annals of Agricul. Res.*, **23** (4), 608-610.

Mitra, P. C. & De, R. (1968). Brinjal production through foliar fertilization. *Indian Farming*, **19**, 23-24.

Mohammad, K. S. & Dehnavard, S. (2017). Characterization of tomato growth and fruit quality under foliar ammonium sprays. *Open Agriculture*, **2**, 531–536.

Mondal & Abdullah (2011). Effect of foliar application of urea on the growth and yield of tomato. *Front. Agric. China*, **5** (3), 372-374.

Mudaliar, V. T. (1959). Principles of Agronomy. Central Art Press, Mcnichol Road, Chetpur, Madras. **31**, 345–364.

Murata, Y. (1969). Physiological response to nitrogen in plants. 235-259.

Muthukrishnan, C. R., Srinivasan, C. & Shanmughan, A. (1974). Effect of foliar application of urea on uptake and distribution of P^{32} in tomato. *Mysore J. Agril. Sci.*, **8** (4), 545-548.

Oliveira, N. L. C., Puiatti, M., Santos, R. H. S., Cecon, P. R. & Rodrigues, P. H. R. (2009). Soil and leaf fertilization of lettuce crop with cow urine. *Horti. Brasileira,* **27**, 431-437.

Padem, H., & Alan R. (1995). The effect of foliar fertilizers on yield, chlorophyll and chemical content of lettuce (*Lactuca sativa* L.). *Ataturk Univ. J. Agric. Fac*., **26**, 21–34.

Phrimantoro. (1995). Cow urine as element of plant. Hara Stockholm Environment Institute, Ecosan Res Series, 2009-1, website http://agrotechnopark. blogspot.in/2011/08/cow-urine-as-element-of-plant-hara.html.

Piper, C. S. (1980). *Soil and plant analysis*. Bombay: Hans Publication.

Pradeep & Sharanappa (2013). Effect of organic production techniques on the growth, yield, quality and economics of chilli (*Capsicum annuum* L.) and soil quality in dry zone of Karnataka. *Indian J. of Agronomy,* **59** (1), 151-156.

Rabinowitch, H. D. & Kamenetsky, R. (2002) Shallots (*A. cepa Aggregatum* group). Allium crop science: recent advances. CABI, Wallington, UK, pp 409–430.

Rai, N. & Bansiwal (2008). Vermiwash: an excellent source of nutrition for plant growth. *Electronic J. of Environ. Sci.*, **1**, 19-21.

Ramu, N. & Muthuswamy (1964). Preliminary studies on foliar application of nitrogen in bhendi and brinjal. *Madras Agri. Journal,* **51**, 80-81.

Rani, P. V., Panghal, P. S., Rana, M. K. & Duhan, D. S. (1970). Response of garlic to foliar application of urea and micro nutrients. *Int. J. of Tropical Agri.,* **33** (4), 2845-2849.

Regina, R. M. & Robert, R. J. (1990). Nitrogen, phosphorus and potassium fertility regimes affects tomato transplant growth. *Hort. Science*, **26** (2), 141-142.

Shakyawar, M. P. (1986). Effect of different fertilizers and urea spray on growth and yield of chilli. Thesis, submitted to JNKVV campus, Rewa.

Sheikh, S. A. & Dakhane, V. (2018). Effects of vermiwash on seed germination and seedling vigour in ashwagandha (*Withania somnifera* L). *Int. J. of Current Engineering & Scientific Res.*, **5** (1), 262-266.

Shelp, B. J. & Shattuck, V. I. (1986). Accumulation of C^{14} from foliar applied urea by developing tomato fruits. *Hort. Science*, **21** (5), 1178-1179.

Shitahun, A. (2017). The effect of nitrogen on the growth and dry matter accumulation of wheat *(T. aestivum* L.*). Int. J. of Agril. & Bio- chem. Sci.*, **1** (1), 9-16.

Shivay, Y. S., Singh, R. P. & Pandey, C. S. (2002). Physiological analysis of growth in maize (*Zea mays* L.) as influenced by cropping systems and nitrogen levels. *Indian J. of Plant Physiol.*, **7** (2), 126-130.

Siddappa, R. & Hedge, N. K. (2011). Effect of foliar spray of vermiwash and nutritional treatments on growth and yield performance of curry leaf var. suvasini. *The Asian J. of Horti.*, **6** (1), 68-70.

Sinclair, T. R. & Shiraiwa, T. (1993). Soybean radiation use efficiency as influenced by non-uniform specific leaf nitrogen distribution and diffuse radiation. *Crop Science*, **33**, 808–812.

Singh, A. K., Singh, P. K. & Gaur, G. S. (2000) Determination of nitrogen doses and its method of application for growth and yield of tomato (*Lycopersicon esculentum* Mill.) var. Pusa hybrid-2. *Haryana J. Hort. Sci.*, **29** (3- 4), 263-264.

Singh, D. K., Gusain, M. S. & Rana, D. K. (2015). Response of foliar feedings of urea and zinc on growth and yield of chili cv. Pant C-3. *Indian J. Hort*., **72** (3), 441- 443.

Singh, K. & Sandhu, D. S. (1970). Nutritional requirement of brinjal (*solanum melongena* L.). *Punjab Hort. Journal*, **10**, 103-110.

Singh, K. D. (1987). Studies on soil versus foliar application of nitrogen in relation to yield and smoking scores in cigar wrapper tobacco. *Ann. Agric. Res.*, **8** (2), 194-200.

Steel, R. G. D. & Torrie, J. H. (1982). *Principles and Procedures of Statistics*. New Delhi: Mc. Graw Hill Book Company.

Subbiah, B. V. & Asija, G. L. (1956). A rapid procedure for the estimation of available nitrogen in soil. *Current Science*, **25**, 259-260.

Subha, M. V. & Prabha, M. L. (2014). Biochemical characterization of vermiwash and its effect on growth of *Capsicum frutescens. Malaya J. of Biosci.,* **1** (2), 86-91.

Sundararasu, K. & Jeyasankar, A. (2014). Effect of vermiwash on growth and yield of brinjal (*solanum melongena* L.*). Asian J. of Sci. & Tech.*, **5** (3), 171-173.

Sundararasu, K. (2016). Effect of vermiwash on growth and yielding pattern of selected vegetable crop chilli (*Capsicum annuum* L.). *Int. J. of Advanced Res. in Biological Sci.*, **3** (9), 155-160.

Swierczewska, M., sztuder, H. & Bien, E. (1999). Evaluation of potato foliar nutrition efficiency. (Cited from CAB Abstr., **23**, 24-28.

Takebe, M. & Yoneyama, T. (1992). Changes of ascorbic acid concentrations in the leaves and tubers of sweet potato (*Ipomoea batatus* Lam.) and potato (*solanum tuberosum* L.). *Japanese J. soil Sci. Plant Nutri*., **63** (4), 447-454.

Tiwari, R. N. & Chhonkar, V. S. (1967). Studies on the effect of foliar application of urea on growth and yield of tomato. *Indian J. of Horti.,* **24**, 173-180.

Tiwari, S. K. & Singh, K. (2016). Combined effect of liquid bio fertilizer with bio pesticide on yield of tomato (*solanum lycopersicum* L.) and infestation of *helicoverpa armigera* (hubner). *J. of Biological Innovation,* **5** (1), pp: 144-163.

Vagen, I. M. (2003). Nitrogen uptake in a broccoli crop. Nitrogen dynamics on a relative time scale. In: Proc. XXVI IHC-Fertil. Strateg. Field Veg. Prod. *Acta Hort.*, **627**, 195–202.

Valadabadi, S. A. & Farahani, H. A. (2010). Effects of planting density and pattern on physiological growth indices in maize (*Zea mays* L.) under nitrogenous fertilizer application. *J. of Agri. Exten. And Rural Develp.,* **2** (3), 40-47.

Varghese, S. M. & Prabha, M. L. (2014). Biochemical characterization of Vermiwash and its effect on growth of Capsicum frutescens. *Malaya J. Biosciences*. **1** (2), 86- 91.

Verma, A. N., Shrivastava, D. C. & Shafma, R. K. (1970). Effect of urea spray on growth and quality or tomato. *Mysore J. Agri. Science*, 107- 109.

Villeneuve, S., Coulombe, J., Belec, C. & Tremblay N. (2002). A comparison of sap nitrate test and chlorophyll meter for nitrogen status diagnosis in broccoli (*Brassica oleracea* L. var. italica). In: Proc. Workshop Eco. Fertil. Veg. *Acta Hort.*, **571**, 171–177.

Westerveld, S. M., McKeown, A. W., McDonald, A. W. & Scott-Dupree C. D. (2003). Chlorophyll and nitrate meters as nitrogen monitoring tools for selected vegetables in southern Ontario. In: Proc. XXVI. IHC. Fertil. Strateg. Field Veg. Prod. *Acta Hort.*, **627,** 259–266.

Witte, C. P., Tiller, S. A., Taylor, M. A. & Davies, H. V. (2002). Leaf urea metabolism in potato. Urease activity profile and patterns of recovery and distribution of ^{15}N after foliar urea application in wild-type and urease-antisense transgenic. *Plant Physiol*., **128**, 1129–1136.

APPENDICES

APPENDIX- I

Cost of cultivation of bidi tobacco nursery and other economical details

[A] Details of operational cost

Sr. No.	Particular	Input	Rate (₹)	Cost (₹ ha^{-1})
A.	**Land preparation**			
1	Tractor cultivation	4 hr	350 hr^{-1}	1,400.00
2	Field layout, channels and preparation of levelled beds	50 L	178 day^{-1}	8900.00
B.	**Sowing and water spraying**			
1.	Sprinkling water over beds	10 L, 30 days	178 day^{-1}	53,400
2.	Seed	5 kg	1000 kg^{-1}	5,000.00
3.	Sowing charges	10 L	178 day^{-1}	1,780.00
4.	Hand weeding	40 L	178 day^{-1}	7120.0
C.	**Manure and fertilizer application rate**			
	a. Application charges	10 L	178 day^{-1}	1,780.00
D.	**After care operations**			
1	Plant protection measures			
	a. Ridomil	3 l ha^{-1}	1560 lit^{-1}	4,680.00
	b. Chloropyriphos	20 l ha^{-1}	240 lit^{-1}	4,800.00
	c. Copper sulphate (0.6%)	2 times, 60 kg	171 kg^{-1}	20,520.00
	d. Lime	2 times, 60 kg	9.24 kg^{-1}	1109
	e. Application charges	40 L	178 day^{-1}	7120.00
E.	**Land revenue**	-	300/ha/ annum	150.00
	Total cost			**1,17,759**

[B] Details of treatment cost

Treat.	Treatment Details	Treatment cost (₹. ha^{-1})				Cost (₹. ha^{-1})
		FYM	C. C	A. S	Foliar spray	
T_1	RDN (180 kg N as Basal)	7200	15960	2835	-	25995
T_2	RDN + Foliar spray Urea (1.0 % at 20 DAS)	7200	15960	2835	35	26030
T_3	RDN + Foliar spray Urea (2.0 % at 20 DAS)	7200	15960	2835	70	26065
T_4	RDN + Foliar spray Urea (1.0 % at 30 DAS)	7200	15960	2835	35	26030
T_5	RDN + Foliar spray Urea (2.0 % at 30 DAS)	7200	15960	2835	70	26065
T_6	75% RDN + Foliar spray Urea (1.0 % at 20 DAS)	5400	11970	2126	35	19531
T_7	75% RDN + Foliar spray Urea (2.0. % at 20 DAS)	5400	11970	2126	70	19566
T_8	75% RDN + Foliar spray Urea (1.0 % at 30 DAS)	5400	11970	2126	35	19531
T_9	75% RDN + Foliar spray Urea (2.0. % at 30 DAS)	5400	11970	2126	70	19566
T_{10}	75% RDN + Foliar spray AS (0.5 % at 30 DAS)	5400	11970	2126	31.5	19528
T_{11}	75% RDN + Foliar spray Cow urine (1 % at 30 DAS)	5400	11970	2126	25	19521
T_{12}	75% RDN + Foliar spray Vermiwash (2.0 % at 30 DAS)	5400	11970	2126	500	19996

	Quantity of Manure and fertilizer and their rate				
				₹.	₹.
1.	FYM		9 t ha^{-1}	800 t^{-1}	7,200.00
2.	Castor cake		2.1 t ha^{-1}	7600 t^{-1}	15,960.00
3.	Ammonium sulphate		225 kg ha^{-1}	12.6 kg^{-1}	2835
5.	Cow urine		5 lit	5 lit $^{-1}$	25.0
6.	Vermiwash		10 lit	50 lit $^{-1}$	500.0
7	Ammonium sulphate		2.5 kg ha^{-1}	12.6 kg^{-1}	31.5
8	Urea	1.0 %	5.0 kg ha^{-1}	6.92 kg^{-1}	35.0
		2.0 %	10.0 kg ha^{-1}	6.92 kg^{-1}	70.0

[C] Total cost of production for various inputs utilized in bidi tobacco nursery

Treatment	Common cost (₹ ha^{-1}) A	Treatment cost (₹ ha^{-1}) B	Total treatment cost (₹ ha^{-1}) C= A+B	Supervision charges @ 10% (for 2 months) D	Interest on working capital @ 12% E	Total cost of cultivation (₹ ha^{-1}) F= C+D+E
T_1	1,17,759	25995	143754	2396	2923	149073
T_2	1,17,759	26030	143789	2396	2924	149109
T_3	1,17,759	26065	143824	2397	2924	149145
T_4	1,17,759	26030	143789	2396	2924	149109
T_5	1,17,759	26065	143824	2397	2924	149145
T_6	1,17,759	19531	137290	2288	2792	142370
T_7	1,17,759	19566	137325	2289	2792	142406
T_8	1,17,759	19531	137290	2288	2792	142370
T_9	1,17,759	19566	137325	2289	2792	142406
T_{10}	1,17,759	19513	137272	2288	2791	142351
T_{11}	1,17,759	19521	137280	2288	2791	142359
T_{12}	1,17,759	19996	137755	2296	2801	142852

APPENDIX II

Appendix I (A) : Analysis of variance for various growth attribute of tobacco seedlings

Source of variation	df	Plant stand at 15 DAS	Mean sum of square								
			Crop growth rate			Relative growth rate			Net assimilation rate		
			30 DAS	45 DAS	55 DAS	30 DAS	45 DAS	55 DAS	30 DAS	45 DAS	55 DAS
		1	2	3	4	5	6	7	8	9	10
Replication	**3**	0.024	0.073	0.43	2.89	0.000000	0.000003	0.000003	0.000002	0.000005	0.000004
Treatment	**11**	0.050	0.068*	11.78*	10.34*	0.000001	0.000013*	0.000004*	0.000003	0.000071*	0.000041*
Error	**33**	0.032	0.071	0.56	0.90	0.000001	0.000003	0.000002	0.000002	0.000007	0.000007
Total	**47**	-	-	-	-	-	-	-	-	-	-

***Significant at 5% level**

Source of variation	df	Mean sum of square							
		Leaf area			Chlorophyll content			Number of damped seedlings	
		30 DAS	45 DAS	55 DAS	30 DAS	45 DAS	55 DAS	45 DAS	55 DAS
		11	12	13	14	15	16	17	18
Replication	**3**	45.6	165.1	172.7	13.73	12.97	11.79	0.68	0.25
Treatment	**11**	260.5*	389.2*	291.3*	18.43*	34.06*	33.60*	2.79*	3.38*
Error	**33**	16.5	38.5	38.0	7.01	4.48	5.18	0.30	0.40
Total	**47**	-	-	-	-	-	-	-	-

***Significant at 5% level**

Source of variation	df	Mean sum of square									
		Fresh weight of seedlings			Dry weight of seedlings			Root length of seedlings		Shoot length of seedlings	
		30 DAS	45 DAS	55 DAS	30 DAS	45 DAS	55 DAS	45 DAS	55 DAS	45 DAS	55 DAS
		19	20	21	22	23	24	25	26	27	28
Replication	3	0.004	0.24	0.26	0.00001	0.00004	0.00088	0.20	0.79	0.078	0.010
Treatment	11	0.010*	1.02*	0.61*	0.0005*	0.005*	0.013*	0.65*	1.21*	0.222*	0.318
Error	33	0.001	0.05	0.04	0.00003	0.00011	0.00013	0.02	0.08	0.007	0.017
Total	47	-	-	-	-	-	-	-	-	-	

*Significant at 5% level

Appendix I (B) : Analysis of variance for various yield attribute of tobacco seedlings

Source of variation	df	Mean sum of square					
		No. of transplantable seedlings		No. of non transplantable seedlings		No. of total seedlings	
		45 DAS	55 DAS	45 DAS	55 DAS	45 DAS	55 DAS
		29	30	31	32	33	34
Replication	3	116725	198754	8157	9322	144061	203518
Treatment	11	124084.7*	1286	40175*	11503*	30760*	7709
Error	33	7556.79	4501	5328	946	10888	4023
Total	47	-	-	-	-	-	-

*Significant at 5% level

Appendix I (c) : Analysis of variance for various chemical analysis of tobacco seedlings

Source of variation	**df**	**Mean sum of square**						
		Plant			**Soil sample**			
		N%	**P%**	**K%**	**N kg ha^{-1}**	**P kg ha^{-1}**	**K kg ha^{-1}**	**O.C%**
		35	**36**	**37**	**38**	**39**	**40**	**41**
Replication	**3**	0.041	0.001	0.04	8.917	4.482	2553.88	0.00007
Treatment	**11**	0.053*	0.018*	0.05*	5.403	3.347	3.61	0.00009
Error	**33**	0.007	0.001	0.01	2.720	3.620	8.34	0.00005
Total	**47**	**-**	**-**	**-**	**-**	**-**	**-**	**-**

***Significant at 5% level**

CERTIFICATE

This is to certify that I have no objection for supplying to any scientist one copy of any part of this thesis for rendering reference service in a library of documentation centre.

Place: Anand

Date: / 07/ 2018 (**Patel Pinalben B.**)