EFFECT OF SOIL AND FOLIAR SUPPLEMENTATION OF NITROGEN, BORON AND SALICYLIC ACID ON QUALITY, YIELD, NUTRIENT CONTENT OF CUCUMBER (*Cucumis sativus* L.) AND ON NUTRIENT STATUS OF ALFISOLS OF KONKAN

By

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B.Sc. (Agri.)

DEPARTMENT OF SOIL SCIENCE AND AGRICULTURAL CHEMISTRY,

FACULTY OF AGRICULTURE,

DR. BALASAHEB SAWANT KONKAN KRISHI VIDYAPEETH,

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MAY, 2019

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A thesis submitted to the

DR. BALASAHEB SAWANT KONKAN KRISHI VIDYAPEETH, DAPOLI
(Agricultural University)
Dist. Ratnagiri (Maharashtra State), India

in partial fulfillment of the requirements for the degree of

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C E R T I F I C A T E

This is to certify that the thesis entitled **"Effect of soil and foliar supplementation of nitrogen, boron and salicylic acid on quality, yield and nutrient content of cucumber (*Cucumis sativus* L.) and on nutrient status of alfisols of Konkan"** submitted to the Faculty of Agriculture, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli, Dist. Ratnagiri, Maharashtra State, in the partial fulfilment of the requirements for the degree of **MASTER OF SCIENCE (AGRICULTURE)** in **SOIL SCIENCE AND AGRICULTURAL CHEMISTRY**, embodies the results of a piece of *bona-fide* research carried out by **Miss. ASAWARI PRAKASH JADHAV** under my guidance and supervision and that no part of the thesis has been submitted for any other degree or diploma or published in other form. All the assistance and help received during the course of investigation and the sources of literature have been duly acknowledged by her.

Place: Dapoli

Date:

(N. H. KHOBRAGADE)
Chairman,
Advisory Committee and
Research Guide

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In context of completion of this manuscript, the most important and humble part for me to write this note. While living in this the materialistic world we are subject to analyse the things, finding reasons, and expertise truth and in such interaction we meet many peoples get connected them emotionally for many reasons and part of such emotional bonding's we will understand the real part of life more accurately.

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I wish to end this note by saying a simple sentence "Everyone is special just believe in yourself and become reason for the people happiness and happiness is the biggest success of life."

Place: Dapoli.

Date: / /2019 **(ASAWARI PRAKASH JADHAV)**

DEPARTMENT OF SOIL SCIENCE AND AGRIL. CHEMISTRY

COLLEGE OF AGRICULTURE, DAPOLI

DIST. RATNAGIRI, MAHARASHTRA

Title of Thesis	**:**	**Effect of soil and foliar supplementation of nitrogen, boron and salicylic acid on quality, yield, nutrient content of cucumber (*Cucumis sativus* L.) and nutrient status of alfisols of Konkan**
Name of student	**:**	**Miss. Asawari Prakash Jadhav**
Regd. No.	**:**	ADPM/17/2568
Name and Designation of Research Guide	**:**	Prof. N. H. Khobragade Assistant Professor, Department of Soil Science and Agril. Chemistry, College of Agriculture, Dapoli

ABSTRACT

A field experiment was conducted to study the, "Effect of soil and foliar supplementation of nitrogen, boron and salicylic acid on quality, yield and nutrient content of Cucumber *(Cucumis sativus* L.) and on nutrient status of Alfisols of Konkan" was undertaken at Education and Research Farm of Department of Agril. Botany, Dr.B.S. Konkan Krishi Vidyapeeth, Dapoli during Summer, 2018 with Randomized Block Design comprising ten treatments and three growth stages (30 DAS, 60 DAS and at harvest of the crop) with three replications, where the effect of soil and foliar supplementation of nitrogen, boron and salicylic acid either alone or in combinations with the recommended dose of fertilizers (135:60:30 NPK kg ha^{-1}) along with 15 t ha^{-1} FYM and an absolute control (to judge the fate of native nutrients) were studied.

The results revealed that the growth parameters *viz*., vine length and number of branches; yield parameters *viz*., number fruits $vine^{-1}$ and weight fruit vine, fruit yield of cucumber of variety Sheetal; quality parameters of cucumber *viz*., TSS, reducing sugar, total sugar and titratable acidity; nitrogen, phosphorus, potassium and boron content in plants as well as available nitrogen, available phosphorus, available potassium and hot water soluble boron content in soils significantly increased due to the application of recommended dose of fertilizer (135:60:30 kg ha^{-1}) + foliar spray of nitrogen through urea (1%) + soil application of boron through borax @ 2 kg ha^{-1}+ foliar spray of salicylic acid (0.2%) along with 15 t ha^{-1} FYM. Thus, recommended dose of fertilizer (135:60:30 NPK kg ha^{-1}) + foliar supplementation of nitrogen, boron and salicylic acid along with FYM maximized growth, yield, quality of fruits and improved the soil fertility in the lateritic soils of Konkan.

APPENDIX

ABBREVIATIONS USED

@	:	at the rate
^0C	:	Degree Celsius
%	:	Per cent
B		Boron
Ca		Calcium
CD	:	Critical Difference
cm	:	Centimeter(s)
Cu	:	Copper
cv.	:	Cultivar
DAS	:	Days After Sowing
DAT		Days After Transplanting
dS m^{-1}	:	Deci-Siemen per meter
EC	:	Electrical conductivity
ES		Elemental Sulphur
et al.	:	and others
Fe	:	Iron
Fig.	:	Figure(s)
FYM	:	Farm Yard Manure
g kg^{-1}	:	gram per kilogram
ha	:	Hectare (s)
hrs.	:	Hours
i.e.	:	That is
K	:	Potassium
KAB	:	Konkan Annapurna Briquettes
kg	:	Kilogram
kg ha^{-1}	:	Kilogram per hectare
Mg	:	Magnesium
mg kg^{-1}	:	Milligram per kg
MT	:	Metric tonnes
MOP	:	Muriate of Potash

M.S.	:	Maharashtra state
NS	:	Non-significant
N	:	Nitrogen
P	:	Phosphorus
pH	:	Pussaince De Hydrometer
PM	:	Poultry manure
pp	:	particular page
ppm	:	parts per millions
TSS	:	Total Soluble Solids
q	:	quintal (s)
RDN	:	Recommended Dose of Nitrogen
RDF	:	Recommended Dose of Fertilizers
S	:	Sulphur
SA	:	Salicylic Acid
SEm	:	Standard error of mean
SSP	:	Single Super Phosphate
$Vine^{-1}$	:	Per vine
t	:	Tonnes (s)
var.	:	Variety
VC	:	Vermicompost
viz.	:	Namely
Zn	:	Zinc

CHAPTER I

INTRODUCTION

Cucumber (*Cucumis sativus L.*), a native of Asia and Africa, is popular vegetable among cucurbitaceous family. It is grown for its edible tender fruits in almost all often world under tropical and subtropical conditions and in all parts of India for last three thousand years. It is said to be the native of northern India (Pursglove, 1969).

"Cucumbers are naturally low in calories, carbohydrates, sodium, fat and cholesterol" said Megan Wax, a registered dietician and nutritionist in Orlando Florida. Cucumbers contain unique polyphenols and other compounds that may help to reduce your risk of chronic diseases. They are good sources of phytonutrient such as flavonoids, lignin and triterpenses which have antioxidant and anti-inflammatory and anti-cancer benefit according to world healthiest food. The fruits of cucumbers possesses various medicinal properties e.g. cooling effect, prevents constipation, checks jaundice and indigestion (Nandkarni, 1927). Nutritionally 100g of edible portion of cucumber contains 96.3 g moisture, 2.5 g carbohydrates, 0.4 g protein, 0.1 g fat, 0.3 g minerals, 10 mg calcium, 0.4 g fiber and traces of vitamin C and iron.

India is the second largest producer of vegetables in the world, next to China, by producing around 162 million tonnes of vegetables annually from an area around 9 million hectares. Maharashtra ranks sixth in vegetable production with an annual production of 80.08 lakh from an area 4.74 lakh. The present area under cucumber cultivation in Konkan region is about 460 ha with the annual production of 5,163 tonnes.

Nitrogen being a major food for plants is an essential constituent of protein (build from amino acids that involves in catalization of chemical responses and transportation of electrons) and chlorophyll (enable the process of photosynthesis) present in many major portions of the plant body. Nitrogen plays a most important role in various physiological processes. It imparts dark-green colour in plants, promotes leaves, stem and other vegetative part's growth and development. Moreover, it also stimulates root growth. It encourages the uptake and utilization of other nutrients including potassium, phosphorous and controls overall growth of plant (Bloom, 2015 and Hemerly, 2016). Deficiency of nitrogen causes reduced growth, appearances of chlorosis (changing of the green color into yellow color of leaves), and appearances of red and purple spots on the leaves, restrict lateral bud growth (from which leaves, stem and branches develop).

Boron content in lateritic soil varied from 0.03 to 0.29 mg kg^{-1} with the mean values of 0.154 mg kg^{-1}. The bench terraced lateritic soils are reported to be deficient in available in boron (Patil *et al*., 1987).

Boron (B) is a unique non-metal micronutrient required for normal growth and development of plants. In 1923, it was first time reported that B is essential for cell structure of plants (Warington, 1923). The possible roles of B include sugar transport, cell wall synthesis, lignification, cell wall structure integrity, carbohydrate metabolism, ribose nucleic acid (RNA) metabolism, respiration, indole acetic acid (IAA) metabolism, phenol metabolism, and as part of the cell membranes (Parr and Loughman, 1983; Ahmad *et al.*,2009). B in anthers, stigmas and ovaries may be twice as high as in stems of plants (Sywortokin, 1958), suggesting its role in pollen formation and quality of flowers and fruits.

Salicylic acid (SA; 2-hydroxybenzoic acid) is an endogenous growth regulator of phenolic nature, which is normally produced in plants in very small quantities (Raskin, 1992) and participates in the regulation of physiological processes in plants (Shakirova *et al.*, 2003). For example, SA is postulated to play a role as a natural inductor of thermogenesis, to induce flowering in a range of plants, to control ion uptake by roots and stomatal conductivity (Raskin, 1992). Exogenous application of SA may influence a range of diverse processes in plants, including stomatal closure, ion uptake and transport (Gunes *et al*., 2005), membrane permeability (Barkoskyand Einhellig, 1993), as well as photosynthetic and growth rates (Khan *et al*., 2003). In addition to facilitating plant growth, SA has been shown as an important signal molecule which can induce particular enzyme catalyzing biosynthetic reactions. In recent years, application of exogenous SA at non-toxic concentrations to plants has been shown to be effective in the regulation number of processes, such as biotic and abiotic stresses (Ananieva *et al.*, 2004; Eraslan *et al*., 2007; Janda *et al*., 2007; Xu and Tian, 2008).

The study on leaching loss of nitrogen in lateritic soils from the applied fertilizers revealed the higher loss of native as well as applied nitrogen (Anonymous, 1990). Boron content in lateritic soils varied from 0.03 to 0.29 ppm with mean value of 0.154 ppm. The bench terraced lateritic soils are reported to be deficient in available boron (Patil *et al*, 1986).

The foliar spray of nutrients and plant growth regulators enhance the nutrient uptake (Kuttimani and Velayutham, 2011). Among the methods of fertilizer application, foliar nutrition is recognized as an important method of fertilization, since foliar nutrients usually penetrate the leaf cuticle or stomata and enters the cells facilitating easy and rapid utilization of nutrients (Latha and Nadanassababady, 2003). Use of the foliar spray to get thin membranes which will give a large surface friction, it will be useful under the condition in which the absorption of nutrients through the soil difficult (AL-Naeime *et al*., 2000).

A high penetration rate is one of the pre-requisites for efficient foliar nutrition. Urea, due to its intrinsic characteristics such as small molecular size, non-ionic nature and high solubility, is usually taken up rapidly through the leaf cuticle. 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). The beneficial effects of foliar urea applications, expressed as an increase in yield and an improvement of crop quality were reported in many vegetable species such as cabbage, onion, cucumber, squash (Padem and Yildirim 1996, Kolota and Osinska 2001).

As cucumber is one of the important summer sown economic crop of Konkan and foliar fertilization may provide a new approach to improve cucumber quality and productivity and such no work on foliar application has been done on summer grown cucumber in lateritic soils of Konkan, the present study on "Effect of foliar supplementation of nitrogen, boron and salicylic acid on growth, yield and uptake of nutrients by cucumber (*Cucumis sativus* L.) and nutrient status of alfisols of Konkan" is proposed to undertake with the following objectives **:**

1. Effect of soil and foliar supplementation of nitrogen, boron and salicylic acid on growth and yield of cucumber
2. Effect of soil and foliar supplementation of nitrogen, boron and salicylic acid on quality parameters of cucumber
3. Effect of soil and foliar supplementation of nitrogen, boron and salicylic acid on nutrient content of cucumber
4. Effect of soil and foliar supplementation of nitrogen, boron and salicylic acid on nutrient status of soil

CHAPTER III

MATERIALS AND METHODS

The present investigation pertaining to the studies on the "Effect of soil and foliar supplementation of nitrogen, boron and salicylic acid on quality, yield, nutrient content of Cucumber (*Cucumis sativus* L.) and on nutrient status of alfisols of Konkan" was conducted during Summer, 2018 at Department of Agricultural Botany, College of Agriculture, Dapoli. The analytical work was carried out in the research laboratory of the Department of Soil Science and Agricultural Chemistry, College of Agriculture, Dapoli. The details regarding material used and methods followed during course of investigation are presented in this chapter.

3.1 Materials

3.1.1 Experimental site:

The field trial was conducted at Research and Education Farm, Department of Agricultural Botany, College of Agriculture, Dapoli, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli during Summer season of 2018.

3.1.2 Soil:

The experiment was conducted on lateritic soil. This soil is classed into Gimhavane Series, which is a member of fine, mixed, isohyperthermic family of Fluventic Ustropepts (Bhattacharjee *et al,* 1978). Representative surface soil sample (up to 22.5 cm) was collected prior to raising the crop on the experimental field by following the standard method of soil sample collection to know the initial fertility status of the soil. The soil after necessary laboratory processing was analyzed for different physico-chemical properties (Table 1).

It is revealed from the data that the soil was moderately acidic in reaction and having normal electrical conductivity, moderately high in organic carbon, low in available nitrogen and very low and very high in available phosphorus and available potassium, respectively.

3.1.3 Climatic conditions:

Department of agricultural Botany, College of Agriculture, Dapoli is situated in the tropical region on 17^{o} $45^{'}$ N latitude and 73^{o} 11' E longitude. The town is located at altitude of 800 ft. (240m) and 8 km from Arabian sea having hot and humid climate with well-expressed three seasons *viz.*, Summer (March to May), Rainy (June to October) and Winter (November to February). The region receives very high rainfall (above 3000 mm, annually). The weather parameter recorded at the Meteorological Observatory of Department of Agronomy Meteorological Observatory of Department of Agronomy, College of Agriculture, Dapoli during the experimental period are presented in Table 2.

Table 1. Physico-chemical properties of the experimental field

Sr. No.	Property		Content
1.	**Physico-chemical properties**		
	I)	Bulk density (mg m^{-3})	1.15
	II)	Particle density (mg m^{-3})	2.34
2.	**Chemical Properties**		
	I)	pH (1:2.5)	5.51
	II)	Electrical conductivity (dS m^{-1})	0.013
	III)	Organic Carbon (g kg^{-1})	11.4
	IV)	Available N (kg ha^{-1})	179.0
	V)	Available P_2O_5 (kg ha^{-1})	8.54
	VI)	Available K_2O (kg ha^{-1})	383.0
	VII)	Available B (mg kg^{-1})	0.26
	VIII)	Available Fe (mg kg^{-1})	33.86
	IX)	Available Mn (mg kg^{-1})	61.61
	X)	Available Zn (mg kg^{-1})	0.23
	XI)	Available Cu (mg kg^{-1})	3.44

Table 2. Meteorological data recorded at Meteorological Observatory of Department of Agronomy during crop growth period Summer, 2018

Met. Week	Period	Temp (°C)		Relative Humidity (%)		Sun-shine (hrs/day)	Rain-fall (mm)
		Max.	Min.	Morn.	Even.		
11	12.03.18 - 18.03.18	34.6	18.9	92	64	6.4	0
12	19.03.18- 25.03.18	31.8	15.3	91	69	1.3	0
13	26.03.18 - 01.04.18	33.6	19.9	96	88	8.0	0
14	02.04.18 - 08.04.18	32.5	19.7	92	87	3.9	0
15	09.04.18 - 15.04.18	34.7	20.0	91	69	8.7	0
16	16.04.18 - 22.04.18	33.7	20.9	90	69	8.9	0
17	23.04.18 - 29.04.18	34.1	19.5	90	67	10.6	0
18	30.04.18 - 06.05.18	33.0	21.0	91	69	10.5	0
19	07.05.18 - 13.05.18	34.0	24.0	89	71	9.4	0
20	14.05.18 - 20.05.18	34.2	23.4	91	73	8.2	1
21	21.05.18 - 27.05.18	33.7	24.5	90	71	7.4	0
22	28.05.18 - 03.06.18	33.9	25.4	89	76	6.8	1
23	4.06.18 - 11.06.18	34.2	25.2	90	76	8.9	1

3.1.4 Crop:

The Cucumber cv. Sheetal released by Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli in 1984; was grown as a test crop. The variety is, quickest maturing, high yielding vine with dark green coloured foliage, early bearing type crops having fruit weight 200-250 g, medium, long, cylindrical, green coloured with good keeping quality. The duration of variety is about 95-105 days. The crop was sown by dibbling method.

3.1.5 Preparation of Spraying Solution:

The nitrogen through urea @ 1%, boron through boric acid @ 0.5%, salicylic acid @ 0.2% and Amrashakti @ 0.2% solutions for foliar application were prepared by dissolving the respective weight of chemical in respective quantity of water by continuous stirring and were applied during early morning using a Knapsack Sprayer in the pertinent treatments at 30 and 60 Days after sowing (DAS).

3.1.6 Application of Manures and Fertilizers:

In order to supply various major nutrients to cucumber, various fertilizers were used. The information regarding the nutrient composition of the fertilizer and manures used are mentioned in Table 3.

Table 3. Nutrient composition of various inorganic fertilizers and FYM used in the study

Sr. No.	Source	Nutrient Content (%)			
		N	P_2O_5	K_2O	B
A)	Manures				
1.	Farm Yard Manure	0.59	0.27	0.58	-
B)	Fertilizers				
1.	Urea	45.68	-	-	-
2.	Single Super Phosphate	-	15.86	-	-
3.	Muriate of Potash	-	-	59.82	-
4.	Borax	-	-	-	10.55
5.	Boric acid	4.60	0.70	4.00	
6.	Amrashakti	4.60	0.70	4.00	2.00

After the preparation of plots, FYM was added @ 15 t ha^{-1} as common to all treatments except control. Nitrogen @ 135 kg ha^{-1} was applied in two splits *viz.,* first dose of 50 per cent N before sowing and second dose of 50 per cent at 30 days after sowing in the pertinent treatments. Phosphorus @ 60 and potassium @ 30 kg ha^{-1} were applied in a single dose before the time of sowing in the pertinent treatments.

3.1.7 Details of the experiment:

1)	Soil type	:	Lateritic soil
2)	Year and season	:	Summer, 2018
3)	Test Crop	:	Cucumber
4)	Variety	:	Sheetal
5)	Number of treatments	:	Ten
6)	Number of replications	:	Three
7)	Design of experiment	:	Randomized Block Design
8)	Spacing	:	4.0 m x 3.0 m

9)	Plot size	:	0.6 m X 3.0 m Ridges and furrows
10)	Recommended dose of fertilizer	:	135:60:30 kg ha^{-1} $N:P_2O_5:K_2O$
11)	Seed rate	:	2.4 kg ha^{-1}

Layout of the experiment:

The plan of field experiment layout is shown in Fig.1.

3.1.8.1 Details of treatments:

There were ten treatment combinations replicated thrice. The details are presented in Table 4.

Table 4. Details of the treatments

Tr.No.	Description of Treatment
T_1	Absolute control (No Fertilizers)
T_2	RDF 135:60:30 kg $N:P_2O_5:K_2O$ kg ha^{-1} only
T_3	RDF+ Foliar spray of nitrogen through urea @ 1%
T_4	RDF + Foliar spray of boron through boric acid @ 0.5%
T_5	RDF+ Soil application of boron through borax @ 2 kg ha^{-1}
T_6	RDF + Foliar spray of salicylic acid @ 0.2%
T_7	RDF + Foliar spray of boron @ 0.5% + Foliar spray of salicylic acid @ 0.2%
T_8	RDF + Foliar spray of nitrogen @1% + Foliar apray of boron @ 0.5% + Foliar spray of salicylic acid @ 0.2%
T_9	RDF + Foliar spray of nitrogen through urea @ 0.1% + Soil application of borax @ 2 kg ha^{-1} + Foliar Spray of salicylic acid @ 0.2%
T_{10}	RDF + Foliar boron through Amrashakti @ 2%

Note: FYM was applied @ 15 t ha^{-1} to all treatment except treatment T_1 is absolute control.

3.1.8.2 Other cultivation details:

The various pre and post cultural operations were carried out as per the recommended package of practices for cucumber. The details regarding the cultural operations followed are given in Table 5.

i) Land preparation:

The experimental plot was ploughed, clod crushed and ridges and furrows were made as per experimental layout. Then bunds were prepared around each treatment plot so as to avoid mixing of fertilizers from one treatment to other.

ii) Seed rate and sowing:

Healthy and well developed seeds of cucumber (Variety Sheetal) were obtained from Central Experiment Station, Wakawali and used for sowing. Sowing was done by dibbling the seeds at a spacing of 0.6 m x 3.0 m.

iii) Gap filling:

Gap filling was done 10 days after sowing to maintain the plant population.

iv) Earthing up:

After hand weeding, earthing up was done for proper support to the plants.

v) Weed control:

Hand weeding was done for 3 times to remove the weeds from ridges and furrows of plots.

vi) Harvesting:

The experimental crop was harvested when the fruits are tender. The plants from border rows of all the four sides were harvested separately to eliminate the border effect. For harvesting the fruits were harvested manually.

Table 5. The details of cultural operations followed during the course of investigation

Sr. No.	Operation	Date
1	Ploughing	05/03/2018
2	Clod crushing	06/03/2018
3	Layout of experiment	10/03/2018
4	Preparation of beds	14/03/2018
5	Application of FYM	14/03/2018
6	Application of fertilizers	14/03/2018
7	Sowing (dibbling of seeds)	15/03/2018
8	Gap filling	25/03/2018
9	Weeding by manually	10/04/2018
10	Earthing up	10/04/2018
11	Irrigation	As per requirement
	15/03/2018, 17/03/2018, 19/03/2018, 22/03/2018, 26/03/2018, 31/03/2018, 09/04/2018, 15/04/2018, 21/04/2018, 28/04/2018, 02/05/2018, 10/05/2018, 15/05/2018, 20/05/2018	
12	Plant protection	
	➢ Spraying of insecticides Lamda Cyhlothrin	2/4/2018
	➢ Spraying of Redomil +Rogor	12/4/2018
13	Harvesting	
	1st picking of fruits	24/04/2018
	2 nd picking of fruits	26/04/2018
	3rd picking of fruits	28/04/2018
	4th picking of fruits	02/05/2018
	5th picking of fruits	04/05/2018
	6th picking of fruits	07/05/2018
	7th picking of fruits	10/05/2018
	8th picking of fruits	12/05/2018
	9th picking of fruits	14/05/2018
	10th picking of fruits	19/05/2018
	11th picking of fruits	21/05/2018
14	Soil Sampling	
	i)Initial representative soil sample collection	05/03/2018
	ii)Soil sample collection at 30 DAS	14/04/2018
	ii)Soil sample collection 60 DAS	14/05/2018
	ii)Soil sample collection after harvesting of crop	10/06/2018
15	Plant Sampling	
	i) Plant sample collection at 30 DAS	14/04/2018
	ii) Plant sample collection at 60 DAS	14/05/2018
	iii)Plant sample collection at after harvesting of crop	10/06/2018

3.1.9 Biometric observations

Biometric observations to assess the effect of treatment on the growth and development of crop were recorded at an interval of 30 DAS, 60 DAS and at harvest stage.

i) Sampling Technique

For recording biometric observations five plants from each net plot were randomly selected. The selected plants were labeled with proper notations.

ii) Growth studies

The details in respect of various biometric and other observations recorded during the course of study are presented in Table 6.

Table 6. Biometric and other observations recorded

Sr. No.	Particular	Frequency	Stages
A.	Growth attributing characters		
i)	Vine length (cm)	3	At 30DAS, 60 DAS and at harvest
ii)	Number of branches vine^{-1}	3	At 30 DAS, 60 DAS and at harvest
B.	Yield attributing characters		
i)	Number of fruits vine^{-1}	1	At harvest
ii)	Weight of fruits vine^{-1} (kg)	1	At harvest
iii)	Fruit yield (q ha^{-1})	1	At harvest
C.	Plant Nutrient Content		
	Nutrient content of N, P, K and B	3	At 30 DAS, 60 DAS and at harvest
D.	Soil Parameters		
	Soil reaction, EC, organic carbon and changes in available N, P, K and B	3	At 30 DAS, 60 DAS and at harvest
E.	Quality Parameters		
	Moisture per cent, TSS, Reducing sugar, Total sugar and Titratable acidity	1	At harvest

3.1.9.1 Pre-harvest studies

1. Vine length (cm)

The height of the plant was measured in cm from ground level up to the base of last fully opened leaf of the plant with the help of measuring tape.

2. Number of branches vine^{-1}

Number of branches per plant was recorded by counting the main and the lateral branches collectively of the five observational plants and the average number of branches vine^{-1} were worked out.

3.1.9.2 Post harvest study

1) Number of fruits vine^{-1}

Treatment wise five observation plants were harvested separately and the number of fruits vine^{-1} was counted and the mean of these five plants was recorded.

2) Weight of fruits vine^{-1} (kg)

The weight of individual fruit of each observational plant measured on mono pan electronic balance and average weight of fruit was worked out.

3) Total fruit yield (q ha^{-1})

The fruits collected from each net plot were weighed and fruit yield per plot was recorded which was subsequently expressed on hectare basis.

3.2 Methods

3.2.1 Plant analysis

The treatment-wise plant samples were collected at 30DAS, 60DAS and at harvest of crop and dried at 60^{0}C was used for this purpose. After recording the dry weight, the samples were grinded in Willey type grinding mill and stored in plastic bags for digestion.

Plant sample digestion:

3.2.1.1 Total Nitrogen (%)

The plant samples were digested with (1:1) conc. H_2SO_4 + H_2O_2 (30%) and the total nitrogen content was determined by Micro-Kjeldhal method (Tandon, 1993).

3.2.1.2 Total Phosphorus and Potassium

For determination of P and K, 1.0 g plant sample was digested with nitric and perchloric acid (9:4), the final volume was made to 100 ml with distilled water and P and K in extract was determined (Tondon, 1993).

3.2.1.3 Total Boron

For determination of B, 0.5 g oven dry and finally ground plant sample was ignited gently to a white or gray ash in a porcelain evaporating dish in a muffle furnace at 550 ^{0}C. The dish and content were allowed to cool and extracted with 5 mL of 0.1N HCl and then by taking 1 mL of filtered aliquot, B in extract was determined by using spectrophotometer (Jackson, 1973).

Plant analysis

3.2.1.4 Total nitrogen (%)

The plant samples collected at 30 DAS, 60 DAS and at harvest of crop were digested with conc. H_2SO_4 using H_2O_2 and the total nitrogen content was determined by Kjelplus apparatus (Tandon, 1993).

3.2.1.5 Phosphorus (%)

It was determined by using known quantity of di-acid extract as mentioned above and the yellow colour was developed with combined HNO_3 vanadomolybdate reagent. Phosphorus was determined colorimetrically by using spectrophotometer at 420 nm wave lengths (Tondon, 1993).

3.2.1.6 Potassium (%)

It was estimated flame photometrically by feeding diluted di-acid digested solution duly diluted 10 times (Tondon, 1993).

3.2.1.7 Total Boron (mg kg^{-1})

Boron was estimated from plant samples colorimetrically by using 1 mL of Azomethine-H reagent with 1 mL of Buffer solution to the 1 mL of aliquot prepared for B estimation and made final volume 25 ml on 430 nm (Berger and Troug 1939).

3.2.2 Soil analysis

The treatment wise representative surface soil samples (up to 22.5 cm) were collected at 30 DAS, 60 DAS and at harvest of the crop with the help of screw auger. Then the treatment wise composite samples were prepared by mixing the soil and following the principle of quartering. These samples were air dried in shade, pounded in wooden mortar and pestle, sieved through 2 mm sieve and 0.5 mm sieve (for organic carbon) and stored in plastic bags in corrugated boxes for physical and chemical analysis. The following methods were used for soil analysis.

3.2.2.1 Soil physical properties

i) Particle density (Mg m^{-3})

Particle density of the field soil samples collected was determined by Pycnometer method (Black, 1965).

ii) Bulk density (Mg m^{-3})

Bulk density of the field soil samples collected was determined using clod coating method described by Black (1965).

3.2.2.2 Soil chemical properties

i) Soil reaction (pH)

The pH of soil samples (initial and at peg initiation and harvest of the crop) was determined using Systronic pH meter model 361 having combined electrode using 1:2.5 soil:water suspension ratio (Jackson 1967).

ii) Electrical conductivity (EC) (dSm^{-1})

Electrical conductivity of soil samples (initial and at 30 DAS, 60 DAS and at harvest of the crop) was determined with the help of Systronic Conductivity Meter-308 using 1:2.5 soils:water suspension ratio (Jackson, 1973).

iii) Organic carbon ($g\ kg^{-1}$)

It was determined by following Walkley and Black wet oxidation method (Black 1965).

iv) Available nitrogen ($kg\ ha^{-1}$)

Available nitrogen was determined by alkaline permanganate (0.32% $KMnO_4$) method (Subbiah and Asija 1956).

v) Available phosphorus ($kg\ ha^{-1}$)

Available phosphorus in initial and treatment wise soil samples collected at 30 DAS, 60 DAS and harvest of the crop was determined by Bray II method by developing blue colour with ammonium molybdate and stannous chloride. Phosphorus in the extract was determined colorimetrically by using Spectrophotometer model ELICO SL-164 Double Beam at 660 nm wavelength as outlined by Black (1965).

vi) Available potassium ($kg\ ha^{-1}$)

It was estimated on ELICO Flame Photometer model CL 361 using neutral-normal-ammonium acetate (NH_4OAc, pH 7.0) as per procedure given by Jackson (1973).

vii) Hot water extractable boron ($mg\ kg^{-1}$)

It was determined by hot water extractable method of Berger and Troug (1939) using Azomethine-H reagent. Air dried soil was extracted with $CaCl_2$ by using water cooled reflux condenser. The filtrate was evaporated with $Ca(OH)_2$ in silica crucible on hot water bath upto dryness and HCl diluted aliquot was taken for determination of boron by using Azomethine-H and B was estimated by colorimetrically at 420 nm.

3.2.3 Analysis of quality parameters

The treatment wise plant fresh samples were collected and used for analysis of quality parameters like total soluble solids, reducing sugar, total sugar, titratable acidity and moisture % by the methods given below.

3.2.3.1 Moisture (%)

The fresh samples were taken from the plots moisture content was determined by drying a known quantity of the sample at 55-60 ^{0}C to a constant weight. Moisture percentage was calculated on oven dry basis (Ranganna, 1977).

3.2.3.2 Total Soluble Solids (^{0}Brix)

The total soluble solids were determined with the help of hand refractometer and the value was correlated at room temperature (28 ^{0}C).

3.2.3.3 Reducing sugar (%)

The reducing sugars were determined by the method of Lane and Eynon (1923) as modifications suggested by Ranganna (1986). 25 g pulp was taken in 259 ml volumetric flask. To this, 100 ml distilled water was added and the contents were neutralized by 1 N sodium hydroxide. Then 2 ml of 45 percent lead acetate was added to it. The contents were mixed well and kept for 10 minutes. Then exact quantity of 22 percent potassium oxalate was added to precipitate the excess of lead acetate. The volume was made to 250 ml with distilled water and solutions were filtered through Whatman No.4 filter paper. This filterate was used for determination of reducing sugars by titrating it against the boiling mixture of Fehling A and Fehling B (5 ml each) using methylene blue as an indicator. The results were expressed in percent basis.

Calculated by formula:

$$\text{Reducing sugar (\%)} = \frac{100 \text{ x Volume made x } 250}{\text{Burette reading x Wt. of sample}} \text{ x } 0.05$$

3.2.3.4 Total sugar (%)

The total sugars were estimated by Lane and Eynon method (1923) as described by Ranganna (1986). For inversion at room temperature, 50 ml aliquot clarified deleaded solution prepared for reducing solution estimation was transferred to 250 ml flask, to which 10 ml of 50 per cent HCl was added and then allowed to stand at room temperature for 24 hrs. It was then neutralized with NaOH solution. The volume was neutralized aliquot was made to 250 ml with distilled water. This aliquot was used for determination of total sugars by titrating it against the boiling mixture of Fehling A and Fehling B (5 ml each) using methylene blue as an indicator. The results were expressed in percent basis.

Calculated by formula:

$$\text{Total sugars (\%)} = \frac{100 \times \text{Volume made} \times 250}{\text{Burette reading} \times \text{Wt. of sample} \times 50} \times 0.05$$

3.2.3.5 Titratable Acidity (%)

Acidity was determined by using titratable acidity method which was suggested by Ranganna (1985).

3.3.3 Statistical analysis

The data obtained were subjected to statistical analysis by following procedure pertinent to “Randomized Block Design” as given by Panse and Sukhatme (1967).

Chapter II

REVIEW OF LITERATURE

Cucumber is one of the most important summer vine vegetable crop, used extensively for very early production to capture best prices. Fertilizer management practices need to assure that plant requirements are satisfied to achieve good yields of high-quality fruit. Applying foliar nutrients is one tool to maintain or enhance plant nutritional status. Often quick effects are seen and deficiencies can be corrected before yield or quality losses occur.

An attempt is made to review the literature regarding research work done on the effect of soil and foliar supplementation of nitrogen, boron and salicylic acid on quality, yield, and nutrient content of cucumber (*Cucumis sativus* L.) and on nutrient status of soil. The pertinent information reported has been reviewed under the following heads:

2.1 : Effect of soil and foliar supplementation of nitrogen, boron and salicylic acid on growth and yield of cucumber

2.2 : Effect of soil and foliar supplementation of nitrogen, boron and salicylic acid on quality parameters of cucumber

2.3 : Effect of soil and foliar supplementation of nitrogen, boron and salicylic acid on nutrient content of cucumber

2.4 : Effect of soil and foliar supplementation of nitrogen, boron and salicylic acid on nutrient status of soil

2.1 Effect of soil and foliar supplementation of nitrogen, boron and salicylic acid on growth and yield of cucumber

Karuppaiah (2005) found the foliar application of borax (0.5%) at 35, 50 and 65 days after transplanting to be the best in terms of number of flowers per plant, number of fruits per plant, individual fruit per plant, individual fruit weight and yield (32.15 tonnes ha^{-1}) followed by copper sulphate (0.5%) and zinc sulphate (0.5%) sprayed at 35, 50 and 65 days after transplanting in brinjal.

Sathya (2006) revealed that the highest fruit yield of tomato var.PKM1 of 33 t ha^{-1} was recorded in treatment that received borax @ 20 kg ha^{-1} and was found to be significantly superior to rest of the treatments (0, 5, 10, 15 and 25 kg ha^{-1}) where the yield increase was about 33.6 per cent over control.

Dipti *et al*. (2008) studied the effect of application of boron through solubor and borax as foliar spray and soil application of borax on boron deficient alkaline calcareous soil by conducting a field experiment on tomato. It was observed that foliar application of boron through both solubor and borax @ 140 mg kg^{-1} recorded significant increase in yield over control. The soil application of borax was also found equally beneficial. However, application of boron through solubor and borax @ 280 mg kg^{-1} was found to significantly improve the quality of tomato suggesting that foliar application of solubor or borax @ 280 mg kg^{-1} is beneficial for increasing yield as well as enhancing quality of tomato grown on alkaline calcareous soils.

Yildirim *et al.* (2008) evaluated that the effect of foliar salicylic acid application on growth, chlorophyll and mineral content of cucumber grown under salt stress. The study was conducted in pot experiment under greenhouse conditions. Cucumber seedlings were treated with foliar SA applications at different concentrations (0.0, 0.25, 0.50 and 1.00µM). Salinity treatments were established by adding 0, 60, and 120 mM of sodium chloride (NaCl) to a base complete nutrient solution. The SA was applied with spraying two times as before and after transplanting. Salt stress negatively affected the growth, chlorophyll content and mineral uptake of cucumber plants. However, foliar applications of SA resulted in greater shoot fresh weight, shoot dry weight, root fresh weight and dry root weight as well as higher plants under salt stress. Shoot diameter and leaf number per plant increased with SA treatment under salt stress.

An experiment was conducted by Jilani *et al.* (2009) to check the effect of different levels of NPK on the growth and yield of hybrid cucumber. Application of NPK fertilizer (100-50-50) showed the best performance in almost all the parameters studied, as it took least days to flowering (39.33), fruit setting (11.55), maximum fruit per plant (35.5), maximum fruit weight (136.03 g) and yield ha^{-1} (60.02) tonnes. Application of NPK fertilizers @ 120-60-60 kg ha^{-1} also showed some beneficial effect on some parameters including fruit weight (150.69 g) and vine length (3.85 m). Control plots showed un-satisfactory results regarding all the parameters.

Faten *et al*. (2010) conducted two field experiments during the seasons of 2006 and 2007 at the experimental station of Ministry of Agriculture at Baramoon Farm, Dakalhlia Governorate, Egypt, to study the response of squash plant to the foliar application by some chemical materials (urea at the rate of 1% and 2%) as an antioxidants. Generally in the foliar application by urea as antioxidant resulted in vigour squash plant as expressed by plant length, average leaves and/or shoots number per plant as well as the fresh and dry weight of whole plant and its leaves and shoot compared with foliar application by other antioxidant materials. Moreover, the significant heaviest tons and best fruit properties of total and early yield were recorded with urea application. Applied antioxidants gave more vigour plant growth and yield of squash in comparison with the control treatment.

Mostafa Heidari and Mobasri Moghadam Mohammad (2012) evaluated the effect of rate and time of nitrogen application on *Momordica charantia* (bitter gourd), a field experiment was conducted at the University of Zabol in Iran during 2011. The experiment was laid out as split plot based on randomized block design with three replications. Three levels of nitrogen rates consisting of N_1 = 75, N_2 =150, and N_3=225 kg ha^{-1} as main plot and three time application including: T_1=1/2 at 3 and 4 leaves and ½ before flowering, T_2=1/2 at 3 and 4 leaves and ½ after fruit start were used as sub plot. The results revealed that both rate and time of nitrogen application had a significant effect on fruit yield. The highest fruit yield was recorded at the rate of N_3 and time of nitrogen application in T_3 treatment. In this study, by increasing nitrogen levels from 75 to 225 kg N ha^{-1}, the values of nitrogen, phosphorus and potassium content in fruit increased.

Kumari (2012) suggested that foliar application of boron, iron and manganese each at 100 ppm at 30 days after transplanting at an interval of 10 days resulted in maximum seed yield and seed germination (95, 92 and 88%, respectively) in tomato. The maximum plant height and number of photosynthetic leaves per plant were registered with the application of boric acid, zinc sulphate and copper sulphate each at 250 ppm in tomato.

In an investigation on effect of foliar spraying of salicylic acid on growth, yield and quality of cold stored strawberry plants, Metwally *et al*. (2013) point out that salicylic acid increased vegetative growth characteristics, i.e. plant length, number of leaves/plant, leaf area and root and vegetative growth fresh weights. The most effective treatment in enhancing growth, fruit quality and yield of cold stored strawberry cv. Sweet Charlie was found to be salicylic acid at 2.0 mM three times.

Effect of NPK fertilizer on fruit yield and yield components of pumpkin (*Cucurbita pepo*) examined by Oloyede *et al.* (2013). This study was carried out for the purpose of evaluating the influence of NPK fertilizer on fruit yield and fruit yield parameters of pumpkin. The experiment was carried out under field condition in 2010 for two seasons at the Teaching and Research Farm, Obafemi Awolowo University, Ile-Ife, Nigeria. The farm is located on latitude 07^{0}28’N and longitude 04^{0}33’ above sea level. NPK 15:15:15 compound fertilizer was applied as ring/side dressing at the rates of (0, 50, 100, 150, 200, 250 kg ha^{-1}). The experiment as randomized blocks design and was replicated six times. Each plot size was 10m×12m and consisted of 7 rows. Alley was 3 m, while the plants were spaced 2m×2m. Data were taken on yield and yield parameters such as; fruit height, fruit circumstance, fruit fresh weight, fruit dry weight, fruit dry matter, fruit yield, seed number and seed weight. The fresh fruit yield was 21 t ha^{-1} and 7 t ha^{-1} for early and late seasons, respectively. Fruits number/ha significantly (p=0.05) increased from 7000 in control to over 10,000 ha^{-1} at fertilizer rates between 100 and 250 kg ha^{-1}. Fruit weight also increased from 9 to 17 t ha^{-1} between control and higher fertilizer rates. Seed yield from application at 100 to 250 kg ha^{-1} were similar and significantly better than control and 50 kg ha^{-1} NPK application. Mean seed yield between 100-250 kg NPK was 460 kg ha^{-1}. The value was 37% higher than at 50kg NPK and 57% higher than in control. Increasing fertilizer above 100 kg NPK ha^{-1} did not significantly (p=0.05) increase the fruit yield nor the seed yield.

In a study on requirement of N,P,K and S for yield maximization of Bitter gourd (var. BARI Karola) conducted at the research field of Horticulture Research Centre, BARI, Joydebpur during *kharif* seasons of 2010 and 2011 comprising four levels each of N (0, 90, 120,150 kg ha^{-1}), P (0, 20, 40, 60 kg ha^{-1}), K (0, 40, 80, 120 kg ha^{-1}) and S (0, 20, 30, 40 kg ha^{-1}) along with a blanket dose of 2 kg B, 4 kg Zn, and 5 ton cowdung ha^{-1}, Shamima Nasreen *et al.* (2013) revealed that application of N120 P40 K80 S30 kg ha^{-1}along with a blanket dose of 2 kg B, 4 kg Zn and 5 ton cowdung ha^{-1} appears to be the best treatment for maximizing the yield of bitter gourd in Grey Terrace Soil (AEZ-28) of Joydebpur.

An experiment effect of prilled urea, urea and NPK briquette on the yield of bitter gourd in two upzillas of Jessore district was conducted by H. Akter *et al.* (2015) to evaluate the performance of deep placement of urea and NPK briquettes compared to broadcast application of prilled urea for bitter gourd production during *kharif* season of 2013. The experiments were conducted in two locations in Jessore district, Chowgacha and Jessore sadar. Seven treatments were designed to evaluate crops response. T_1: Control, T_2: Farmer’s practice, T_3: Recommended dose of all fertilizers except N, T_4: Recommended dose of all fertilizers except cowdung, T_5: Urea briquette + other fertilizers, T_6: NPK briquette + other fertilizes and T_7: NPK briquette + other fertilizers except cowdung. The rate of urea and NPK briquette was 10 per cent less than the rate of recommended prilled urea. The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. The recommended fertilizer doses were used to supply N, P, K, S, Zn and B from urea, TSP, MOP, gypsum, zinc sulphate (hepta) and boric acid respectively. The results showed that deep placement of NPK briquette gave significantly the highest yield of bitter gourd (31.16 tha^{-1}) followed by urea briquette (30.75 tha^{-1}) which were 12.34 and 7.41 per cent higher over recommended dose of all fertilizers. The highest N recovery (77.4%) was found when 72 kg N ha^{-1} was applied as NPK briquette.

Baqer Challab Hadi AL-Rubaye and Emad Abd Atia (2016) studied the influence of foliar sprays on the growth and yield of summer squashat the spring season 2014 where the highest vegetative growth was found at 5 mM concentration of salicylic acid compared with the other concentration. It was observed, plant height (64.04 cm), plant yield (1.211 kg $plant^{-1}$), total yield (23.071 t ha^{-1}) and the total soluble solids of carbohydrates, N, P, K and Zn, in the fruit (14.93, 1.73, 0.61, 1.74 and 2.66 per cent).

Bommesh *et al*. (2016) examined the effect of soil and foliar application of boron levels on cucumber productivity in sandy loam black soils (pH 7.95) of Coimbatore, Tamil Nadu. The results revealed that the soil application of boron at the rate of 1.5 kg ha^{-1} along with foliar spray of boric acid (0.5%) in an interval of 30 and 45 days after sowing (DAS) found to be best for highest vine length, maximum number of leaves and nodes. However, the soil application of 1.5 kg ha^{-1} of boron with foliar spray of boric acid at the rate of 0.25% on 30 and 45 DAS revealed to be better for flowering and yield attributing characters like days to first flowering, nodes to first flowering, fruit length, fruit weight (154.74g), fruits per plant, yield per plant, yield per hectare (115.54 t), marketable fruits (97.5%).

Patidar *et al.* (2016) reported that foliar application of boron (40 ppm + zinc 40 ppm + iron 80 ppm) resulted in the production of first female flower minimum node number (3.47), maximum number of branches per plant at 90 DAS (24.40), vine length at final harvest 120 DAS (568.33cm), minimum number of aborted flowers (68.24%), maximum fruit length (14.10cm), fruit diameter (3.40cm), number of fruits per plant (43.13) and days to maturity (38.83) in cucumber.

Sadia *et al.* (2016) carried out a field experiment for two consecutive years to study the effectiveness of soil and foliar application of micronutrients on the yield of tomato (*Lycopersicon esculentum* Mill.) at the Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur. The micronutrients zinc (Zn) in the form of zinc sulphate ($ZnSO_4.7H_2O$) at the rate of 0.05 % and boron (B) in the form of boric acid (H_3BO_3) at the rate of 0.03% were applied as foliar spray at three different stages of plant growth i.e (i) before flower initiation; (ii) after fruit set when it becomes approximately marble sized; and (iii) at 20 days interval of second spray. The tomato yield and its contributing yield traits were significantly affected by foliar fertilizer treatments as against soil application of B and Zn fertilizers. Among various treatments, foliar application of Zn (0.05 %) + B (0.03%) produced maximum fruit yield (85.5 and 81.7 t ha^{-1} in 2013 and 2014, respectively) while the control no application of Zn (0.0) and B (0.0) produced 66.8 and 60.7 t ha^{-1} in 2013 and 2014, respectively and it was statistically identical with soil application of B and Zn @ 2 and 6 kg ha^{-1} (T_5), respectively. The increment of yield was 19.2 to 31.1% and 7.57 to 18.3%, respectively, over control and soil application. The integrated use of foliar application of micronutrients and soil application of macronutrients are recommended to enhance tomato yield.

Chatterjee and Bandyopadhyay (2017) was conducted two year field experiment to assess the effect of boron, molybdenum and biofertilizers on growth, nodulation and pod yield of vegetable cowpea in acid soil of eastern Himalayan region. Treatments consisted of four levels of seed treatment with molybdenum and biofertilizers (Rhizobium + PSB) and four levels of foliar spray of boron, laid out in split plot design. The result revealed that combined use of seed treatment with molybdenum (0.5 g kg^{-1} seed) and biofertilizers along with foliar spray of boron at 4 weeks of planting significantly enhanced the growth and yield attributes of cowpea and registered 42% and 54% improvement in number of pod and pod yield per plant respectively over control, whereas seed treatment with molybdenum (0.5 g kg^{-1} seed) and biofertilizers alone recorded 76% and foliar spray of boron at 4 weeks of planting alone produced 39% higher pod yield per plant over control.

In lateritic soils of Konkan, Kadam *et al.* (2017) carried out an experiment to study the effect of boron and Konkan Annapurna briquettes on yield, nitrogen use efficiency and nutrient uptake by okra (*Abelmoshus esculentus* L.) and observed that the split application of 75% RDN through tar coated Konkan Annapurna Briquettes (KAB) fortified with boron @ 4 kg ha^{-1} which was applied in two times i.e. 1/2 quantity of briquettes at 2-3 leaf emergence stage of okra plant and 1/2 quantity of briquettes at 30 DAS @ 2 briquettes per plant which found promising to enhance the okra green pod yield. The placement of boron fortified tar coated Konkan Annapurna Briquettes can reduce the recommended dose of fertilizer to the extent of 25% during *Kharif* season in Konkan region.

Effect of boron and sulphur application on plant morphology and yield of potato investigated by Mohammad Ali Muthanna *et al.* (2017) during the month of October in 2015-16 and 2016-17. The experiment was laid out in randomized block design with three replications and thirteen treatments. Out of thirteen treatments one control, one recommended dose of fertilizers (N:P:K-150:80:120 kg ha^{-1}) and eleven treatment combinations along with recommended dose of fertilizers (RDF) including 3 doses of boron (1 kg, 2 kg and 3 kg); 2 doses of sulphur (30 kg and 40 kg) and their combinations (1 kg boron + 30 kg sulphur, 2 kg boron + 30 kg sulphur, 3 kg boron + 30 kg sulphur, 1 kg boron + 40 kg sulphur, 2 kg boron + 40 kg sulphur and 3 kg boron + 40 kg sulphur) were applied. The study indicated that plant morphology and yield of potato plant were significantly influenced by boron and sulphur application. The maximum plant height and yield of marketable tubers (17.99 t ha^{-1} and 27.00 t ha^{-1}) were recorded in the plants treated with RDF + 2 kg B + 40 kg S during both year of investigation. RDF + 2 kg B + 40 kg S was also found statistically at par with the maximum values under characters viz., number of sprouts per tuber, stem diameter and number of marketable tubers $hill^{-1}$.

Patil *et al.* (2017) conducted a field experiment during 2010-11 to 2014-15 at Zonal Agricultural Research Station, Igatpuri, Dist. Nasik (Maharashtra) to study the effect of soil application of boron on growth, yield and soil properties of lowland paddy laid out in randomized block design with five treatment replicated four times. The doses of borax were 0 kg, 2.5 kg, 5.0 kg, 7.5 kg and 10 kg per hectare, respectively. The soils of the site were shallow laterite having pH 6.7, low in soil available N and K_2O and moderate in available P_2O_5. The soil available B (hot water soluble) was ranges between 0.292 to 0.412 ppm. The pooled data revealed that treatment T_5 (Soil application of borax @10 kg ha^{-1}) produced significantly higher grain (43.45 q ha^{-1}) and straw yield (51.91 q ha^{-1}), however it was at par with treatment T_3 (Soil application of borax @ 5 kg ha^{-1}) and T_4 (Soil application of borax @ 7.5 kg ha^{-1}). It was recommended to apply 5 kg borax ha^{-1} in boron deficient soils at the time of transplanting for higher yield and returns of paddy.

Raquel Sobral da Silva (2018) studied the effect of boron (b) and lime on production of watermelon in dystrophic yellow latosol soil. The experiment was carried out in a dystrophic yellow latosol soil, in a randomized block design in subdivide plots: plots (i) liming or without liming and subplots: (ii) boron (0, 2, 4 and 5 kg ha^{-1}), with 8 treatments and 5 replicates. The use of boron provided positive effects on the analyzed variables viz., weight, number of commercial fruits, total soluble solids and productivity.

2.2 Effect of soil and foliar supplementation of nitrogen, boron and salicylic acid on quality parameters of cucumber

Govindan (1952) observed the influence of B on the carbohydrate balance in tomato crop and reported that increasing levels of B increased the reducing sugar and non- reducing sugar content of tomato.

To comprehend the response of boron on vegetative growth, fruit yield and quality of tomato var. Pusa Ruby during 1998-99 and 1999-2000 at ICAR Research complex for NEH region, Jharnapani, Nagaland, Naresh Babu (2002) conducted an experiment and showed that in a field experiment with tomato (cv. Pusa Ruby); boron had profound positive response on yield and quality parameters. Response of applied boron was more pronounced at higher concentrations and significantly improved total soluble solids (TSS), reducing sugar. Acidity of fruits showed marked increase with increased levels of boron up to 250 ppm levels.

Application of 0.3 per cent borax as foliar spray improved the fruit size, ascorbic acid and also reduced fruit cracking (Paithankar *et al.*, 2004).

Mady (2009) conducted two field experiments to study effect of foliar application with 50 and 100 ppm salicylic acid (SA) and 100 and 200 ppm of vitamin E (VE) on growth and productivity of tomato, where the results revealed that chemical composition of minerals and some bio-constituents such as carbohydrates, vitamin C, total soluble solids in tomato fruits were increased. Therefore, the study strongly admit the use of salicylic acid and vitamin E as foliar application not only increased early and total yields but also getting a good fruit quality as well.

Singh *et al*. (2010) conducted an experiment to determine that the effects of salicylic acid (10-500µM) on seedling growth, development and nitrogen use efficiency in cucumber (*Cucumis sativus* L.) plants with or without nitrogen nutrient. Salicylic acid increased contents of chlorophyll, total non-structural carbohydrates and total nitrogen, as well as nitrate assimilation through the induction of nitrate reductase activity in isolated cucumber cotyledons. Accumulation of salicylic acid was two-fold higher in cotyledons without nitrate supply in comparison to that with nitrate supply. Further 50 µM of SA induced enhancement inn seed germination and growth characteristics. However higher salicylic acid concentrations inhibited above physiological characteristics. Results show that, field application of salicylic acid need optimum physiological concentration (e.g. 50 µM) to increase nitrogen use efficiency particularly during germination and seedling growth.

Kuttimani and Velayutham (2011) evaluated the effect of foliar application of nutrients on the yield and nutrient uptake of greengram. Foliar spray of nutrients (urea, DAP and sodium molybdate) and growth regulator (Salicylic acid) were sprayed as individual and in combination at vegetative and flowering stages. Combined application of 2%DAP+100 ppm salicylic acid+0.05% sodium molybdate increased the yield attributes and grain yield 928 kg ha^{-1}, haulm yield 1230 kg ha^{-1} followed by 2% urea+100 ppm salicylic acid + 0.05 sodium molybdate treatment. Similar trend was observed in nutrient uptake (N, P and K) also.

Amra *et al.* (2014) observed the effect of fluoride and salicylic cid on seedling growth and biochemical parameters of watermelon (*Citrullus lanatus*) in *in vitro* grown seedlings. Results revealed that SA (Salicylic acid) treated seedlings showed higher levels of sugars and these were further increased by 7 % and 14 % with NaF (Sodium Fluoride) treatment in doses of 1mM and 10 mM respectively, SA-induced accumulation of sugars under stress has also been reported on *Okra* seedlings.

Talang *et al.* (2017) carried an investigation to study the effect of foliar spray of micronutrients, *viz*,, calcium and boron and sorbitol on fruit-set, yield and fruit quality in mango (*Mangifera indica* L). cv. Himsagar, at Bidhan Chandra Krishi Viswavidyalaya, Regional Research Station, Gayeshpur. Results of the experiment revealed that boric acid (0.02%) + sorbitol (2.0%) were the most effective for enhancing fruit-set (1.58%), yield (48.51 kg $tree^{-1}$), fruit weight (165.6 g), TSS (18.59°Brix), total sugars (14.92%) and ascorbic acid content (20.32 mg 100 g^{-1}).

Haldavnekar *et al.* (2018) conducted the field experiment entitled "Effect of micronutrient on yield and physico-chemical composition of Alphonso mango under Konkan agro-climatic conditions" was conducted at Regional Fruit Research Station, Vengurle to determine the effect of micronutrients (RDF with combination of zinc sulphate, boric acid, copper sulphate, borax) on the yield and quality of mango cv. Alphonso. Results revealed that the treatment T_5 (RDF + foliar spray of 0.4% zinc sulphate + copper sulphate (0.2%) + Borax (0.2%), spraying at just before flowering and marble stage of fruit growth recorded the highest number of fruits/tree (240.67) and fruit yield (6.41 t. ha^{-1}). Further, the treatment T_4 (RDF + foliar spray of 0.4% zinc sulphate + boric acid (0.2%) spraying at just before flowering and marble stage of fruit growth recorded the highest T.S.S (19.35 ^{0}B) and lowest acidity (0.13%).

Kadu *et al.* (2018) conducted an experiment on the lateritic soil of *Konkan* region to study the "Effect of soil application of potassium and foliar spray of zinc and boron on yield and quality of watermelon [*Citrullus lanatus* (Thunb)]. The field experiment was comprised sixteen treatment combinations replicated thrice was laid out in factorial randomized block design. The treatments included basal application of FYM @15 t ha^{-1}, nitrogen @ 150 kg ha^{-1} and phosphorus @ 50 kg ha^{-1} with different levels of potassium i.e. K_0, K_1, K_2 and K_3 @ 0, 25, 50 and 75 kg ha^{-1}, respectively and foliar application of micronutrients i.e. M_0, M_1, M_2, M_3 @ 0, 0.5% Zn, 0.1 % B and 0.5% Zn + 0.1 % B at flowering, respectively. Result showed that the application of 75 kg K_2O ha^{-1} through soil along with 0.5% Zn and 0.1% B through foliar application found effective to increased yield and yield attributing characters as well as quality of watermelon in terms of TSS and anthocyanin content in *lateritic* soils of Konkan.

Shelke *et al*. (2018) carried out an experiment on the influence of salicylic acid on the growth and yield in onion Cv. (Akola safed) during *rabi* season of year 2016-2017, at Chilli and Vegetable Research Unit, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola in Factorial Randomized Block Design having main factor being stages of application with 3 levels viz. 30 DAT, 60 DAT, 30 and 60 DAT and another sub factor was concentration of salicylic acid with 4 levels viz. 50, 100, 150, 200 mg L^{1}, with three replications and 13 treatment combinations with control treatment. The results of present investigation indicated that, the growth characters like plant height (cm), number of leaves per plant were showed significant influence due to a treatment combination consisting of two applications of spray of salicylic acid at 30 and 60 DAT with an application of salicylic acid @ 100 mg L^{-1} (A_3C_2). Considering to the cured bulb yield, A, B, C grade bulbs and total marketable yield were recorded maximum, where in the treatment combination consisting of two applications of salicylic acid at 30 and 60 DAT along with salicylic acid @ 100 mg L^{-1} (A_3C_2).

Singh *et al*. (2018) observed the influence of foliar application of urea, potassium sulphate and borax on the fruit quality of guava during of two successive years i.e. 2014 and 2015 on guava c.v. G–27 where the results revealed that TSS, reducing sugar, non-reducing sugar and total sugar exhibited with the foliar application of urea at 2%, Potassium sulphate at 0.8% and Borax at 0.75% concentration.

2.3 Effect of soil and foliar supplementation of nitrogen, boron and salicylic acid on nutrient content of cucumber

A field experiment was conducted by Kotur (1997) on a B – deficient red sandy loam soil (Ultic Haplustalf) having pH 5.2 with cauliflower where the foliar application of boron at the concentration of 0.0125% and 0.125%

boric acid significantly increased the boron content of leaf tissue (12.5 and 19.4 mg kg^{-1}, respectively) compared to 'no – B' control (10.5 mg kg^{-1}).

Chander *et al*. (2007) evaluated that in a laboratory incubation and greenhouse experiments on two boron (B) - deficient soils of Bajaura (loam) and Junga (sandy loam), the application of B maintained significantly higher amounts of available B throughout the study period and the application of B at the rate of 1, 2 and 3 mg kg^{-1} resulted in a significant and consistent increase in B uptake by leaves and curd parts of cauliflower in both the experimental soils. An increase in B removal in plant tissues is obvious in B application had significantly increased available B in the soils.

Yildirim *et al.* (2007) studied the effect of foliar urea application on quality, growth, mineral uptake and yield of broccoli (*Brassica oleracea* L., var. *italica)* under field conditions in 2003, 2004 and 2005. Broccoli cultivars AG 3317 and AG 3324 were treated with foliar urea applications at different concentrations (0.0, 0.4, 0.8 and 1.0%). In regard to the nutrient content, it can be interfered that soil nitrogen fertilization and foliar urea applications increased the content of almost all nutrients in leaves and heads of both broccoli cultivars in three experiment years. Generally, the greatest values were obtained from 1.0% urea application for both cultivars.

Effect of lime, zinc and boron application on yield, nutrient uptake of quality of soybean in nearly terraced lateritic soils of Konkan was studied by Rathod (2008) during *kharif* 2007 and the study revealed that the application of ½ lime requirement + Zn + B along with RDF favourably increased uptake of NPK,Ca and Mg as well as micronutrients.

Atilla Dursun *et al.* (2010) conducted a two-year greenhouse experiment to study the yield and quality response of three vegetables to B addition (0, 1, 2, 3, and 4 kg B ha^{-1}). The optimum economic B rates (OEBR) were 2.3, 2.6, 2.4 kg B ha^{-1}, resulting in soil B concentrations of 0.33, 0.34 and 0.42 mg kg^{-1}. Independent of plant species, B application decreased tissue nitrogen (N), calcium (Ca), and magnesium (Mg) but increased tissue phosphorus (P), potassium (K), iron (Fe), manganese (Mn), zinc (Zn), and copper (Cu) concentrations. The B addition of 2.5 kg ha^{-1} is sufficient to elevate soil B levels to non-deficient levels.

Hossain *et al.*(2011) conducted an experiment for three years from 2003-04 to 2005-06 to find out the optimum rate of B application for maximizing nutrient uptake and yield of mustard in calcareous soil of Jessore, Bangladesh. Boron was applied at 0, 1, and 2 kg ha^{-1}. The mustard variety BARI Sarisha-8, *(B. napus* group) was selected for the experiment. Boron and N concentrations of grain and stover were significantly increased with increased rate of B application indicating that B had positive role on protein synthesis. In case of P, S, and Zn, the concentrations were significantly increased but in case of K, it remained unchanged in stover. The grain B concentration increased from 19.96 µg g^{-1} in B control to 45.99 µg g^{-1} and 51.29 µg g^{-1} due to application of 1 kg and 2 kg B ha^{-1}, respectively. Concerning the effect of B on the nutrient uptake, six elements followed the order K> N> S> P> B> Zn and these were significantly influenced by B application.

Mostafa Heidari and Mobasri Moghadam Mohammad (2012) evaluated the effect of rate and time of nitrogen application on *Momordica charantia* (bitter gourd at the University of Zabol in Iran during 2011 where three levels of nitrogen rates consisting of N_1 = 75, N_2 =150, and N_3=225 kg ha^{-1} as main plot and three time application including: T_1=1/2 at 3 and 4 leaves and ½ before flowering, T_2=1/2 at 3 and 4 leaves and ½ after fruit start were used as sub plot under the split plot design. The results revealed that both rate and time of nitrogen application had a significant effect on fruit yield. The highest fruit yield was recorded at the rate of N_3 and time of nitrogen application in T3 =1/3 at 3 and 4 leaves, 1/3 before flowering, and 1/3 after fruit to start treatment. In this study, by increasing nitrogen levels from 75 to 225 kg N ha^{-1}, the values of nitrogen, phosphorus and potassium content in fruit increased.

El-Hedek (2013) investigated the effect of foliar applications of salicylic acid (SA) and potassium silicate on tolerance of wheat plants to soil salinity (S) on wheat plants. Foliar spray of salicylic acid with rates of 0, 50, 100 and 150 mg L^{-1} were applied. Plants treated with salicylic acid showed remarkable increase in potassium (%), calcium (%) and phosphorus (%) of grains and straw.

In lateritic soils of Konkan, Kadu (2015) conducted an experiment on effect of soil application of potassium and foliar spray of zinc and boron on yield and quality of watermelon and revealed that the nutrient content in the leaves at various growth stages influenced significantly due to application of 75 kg K_2O ha^{-1} through soil along with 0.5% Zn and 0.1% B through foliar application.

Seyyed Reza Jafari *et al*. (2015) studied that response of cucumber (*Cucumis sativus* L.) seedlings to exogeneous silicon and salicylic acid under osmotic stress and investigated that the role of 1.5 mM silicon (Si) and 10 µM salicylic acid (SA) singly or combination, inducing cucumber seedlings tolerance to osmotic stress (15% PEG). Osmotic stress reduced shoot fresh and dry mass (SFM, SDM) ,shoot K^+ uptake and leaf area(LA) and increased malondialdehyde (MDA), hydrogen peroxide,(H_2O_2) , and ion leakage(IL). Under osmotic stress, Si,SA and Si+SA, increased LA, SFM, SDM, relative water content, total phenolic compounds, anthocyanin, flavonoids, shoot K^+ and phenylanine ammonia lyase (PAL) activity. In all cases the effect of Si + SA was more pronounced. Moreover, Si, SA and Si or SA reduced MDA, H_2O_2, ion leakage, proline and other aldehydes under osmotic stress. Meanwhile, under osmotic stress, or Si or SA improves seedling performance by enhancing antioxidant enzyme activity, but the better performance of the seedlings under osmotic stress treated with Si + SA was not associated with further enhancement of antioxidant enzymes activity. However, Si + SA treatment significantly increased non-enzymatic antioxidants, total phenolic compounds, anthocyanin, flavonoids, and Si, K^+,

Ca^{2+} content in shoot and also PAL activity that might have contributed to higher tolerance of seedling to osmotic stress.

In lateritic soils of Konkan, Kadam *et al.* (2017) carried out an experiment to study the effect of boron and Konkan Annapurna briquettes on yield, nitrogen use efficiency and nutrient uptake by okra (*Abelmoshus esculentus* L.) It was observed that the split application of 75% RDN through tar coated Konkan Annapurna Briquettes (KAB) fortified with boron @ 4 kg ha^{-1} which was applied in two times i.e. 1/2 quantity of briquettes at 2-3 leaf emergence stage of okra plant and 1/2 quantity of briquettes at 30 DAS @ 2 briquettes per plant which found promising to enhance the higher uptake in respect to N, P, K and B content found to be improved. The placement of boron fortified tar coated Konkan Annapurna Briquettes can reduce the recommended dose of fertilizer to the extent of 25% during *Kharif* season in Konkan region.

2.4 Effect of soil and foliar supplementation of nitrogen, boron and salicylic acid on nutrient status of soil

Tariq and Mott (2006) studied the influence of applied calcium-boron ratio on the solubility of nutrient-elements in soil. The study was based on the hypothesis that the concentration of certain nutrients in soil solution can be used as a mirror for plant nutrients, with regard to the effect of applied Ca/B ratios in soil. Results revealed that the concentrations of phosphorus, sodium, copper and iron in soil solution were not significantly altered, while rest of the nutrient-elements significantly changed due to applied Ca/B ratios in soil. Results also indicate that almost all nutrient-elements correlated to Ca/B ratios in soil solution as well as in applied terms, though with a variable statistical significance. For example, phosphorus, iron, boron and molybdenum showed negative and rest of the nutrient-elements such as nitrogen ($NH^{4+}NO^{3}$), potassium, calcium, magnesium, sodium, zinc, manganese and copper showed positive correlation. Moreover, Soil pH showed a significantly negative correlation to Ca/B ratios in soil solution.

The present study suggests that both Ca/B ratios either in soil solution or in applied terms are significant, in determining the nutrients response in soil-plant system and linking the plant nutrition to soil fertility.

In a laboratory incubation and greenhouse experiments on two *b*oron (B) - deficient soils of Bajaura (loam) and Junga (sandy loam), Chander *et al*. (2007) noted that, the application of B maintained significantly higher amounts of available B throughout the study period with the application of B at the rate of 1, 2 and 3 mg kg^{-1}.

A field experiment was conducted in the lateritic soils of Bhubaneswar to study the effect of lime and boron on yield and nutrient content of cabbage (Jena *et al*, 2009). The results revealed with application of lime the pH of the post-harvest soil increased. On the other hand with application of B the pH was decreased as compared to no B treatment. The available B content in post-harvest soil was decreased in B_0 treatments in an investigation on the foliar application of 1, 2 and 3 % urea and potassium nitrate to cashewnut, a significant increase in available N, P, K and S was obtained, but non-significant effect was observed on pH and EC of soil.

In a long term experiment continued since 1971-72, soil and wheat plant samples were collected during 2009-10 on a Typic Haplustept at Indian Agricultural Research Institute, New Delhi, to study the distribution of native soil boron (B) in different fractions and their contributions towards B availability and uptake by wheat. Treatments included N alone, NP, NPK, 150% of recommended NPK, NPK + farmyard manure (FYM) and an unfertilized control. Five soil B fractions were determined along with hot CaCl2- extractable (available) B. Readily soluble, specifically adsorbed and organically bound B fractions were significantly greater under continuous use of NPK+FYM compared with other treatments, resulting in higher values of available B in NPK+FYM treatment. Soil organic C and cation exchange capacity were the important soil characteristics that governed the distribution of soil B in different fractions. Organically bound and specifically adsorbed B appeared pivotal regarding the availability of native B for plant uptake (Dey *et al.,* 2014).

In lateritic soils of Konkan, Kadu (2015) found that the available primary nutrients as well as micronutrients (Zn and B) in soil at various growth stages influenced significantly due to application of 75 kg K_2O ha^{-1} through soil along with 0.5% Zn and 0.1% B through foliar application. But the effect of foliar application of Zn and B found to be non-significant on soil pH and EC.

Alessandra Aparecida de Sá and Paulo Roberto Ernani (2016) studied the effect of liming and rates of B applied to the soil on B leaching. The experiment was carried out in the laboratory in 2012, and treatments consisted of a factorial combination of two rates of liming (without and with lime to raise the soil pH to 6.0) and five rates of B (0, 10, 20, 50 and 100 mg kg^{-1}, as boric acid). A Typic Rhodudalf was used, containing 790 g kg^{-1} clay and 23 g kg^{-1} organic matter; the pH (H_2O) was 4.6. Experimental units were composed of PVC leaching columns (0.10 m in diameter) containing 1.42 kg of soil (dry base). Boron was manually mixed with the top 0.15 m of the soil. After that, every seven days for 15 weeks, 300 mL of distilled water were added to the top of each column. In the percolated solution, both the volume and concentration of B were measured. Leaching of B decreased with increased soil pH and, averaged across the B rates applied, was 58 % higher from unlimed (pH 4.6) than from limed (pH 6.6) samples as a result of the increase in B sorption with higher soil pH. In spite of its high vertical mobility, the residual effect of B was high in this oxisol, mainly in the limed samples where 80 % of B applied at the two highest rates remained in the soil, even after 15 water percolations. Total recovery of applied B, including leached B plus B extracted from the soil after all percolations, was less than 50 %, showing that not all sorbed B was quantified by the hot water extraction method.

Patil *et al.* (2017) conducted a field experiment during 2010-11 to 2014-15 at Zonal Agricultural Research Station, Igatpuri, Dist. Nasik (Maharashtra) to study the effect of soil application of boron on growth, yield and soil properties of lowland paddy. The experiment was laid out in randomized block design with five treatment replicated four times. The doses of borax were 0 kg, 2.5 kg, 5.0 kg, 7.5 kg and 10 kg per hectare respectively. The soils of the site were shallow laterite having pH 6.7, low in soil available N and K_2O and moderate in available P_2O_5. The soil available B (hot water soluble) was ranges between 0.292 to 0.412 ppm. The pooled data revealed that treatment T_5 (Soil application of borax @10 kg ha^{-1}) produced significantly higher grain (43.45 q ha^{-1}) and straw yield (51.91 q ha^{-1}), however it was at par with treatment T_3 (Soil application of borax @ 5 kg ha^{-1}) and T_4 (Soil application of borax @ 7.5 kg ha^{-1}). It was recommended to apply 5 kg borax ha^{-1} in boron deficient soils at the time of transplanting for higher yield and returns of paddy.

Pravin Singh *et al.* (2017) reviewed that proper plant nutrition is essential for successful production of vegetable crops in open and also under protected conditions. Integrated supply of micronutrients with macronutrients in adequate amount and suitable proportions is one of the most important factors that also control the plant growth in vegetable crops. Micronutrients are involved in all metabolic and cellular functions. Plants differ in their need for micronutrients. Major functions in vegetable production of mineral micronutrients zinc (Zn), boron (B) and Iron (Fe) that are generally accepted as essential for all higher plants are reviewed in the paper.

CHAPTER IV

RESULTS AND DISCUSSION

In the present investigation an attempt has been made to study the effect of soil and foliar supplementation of nitrogen, boron and salicylic acid on quality, yield and nutrient content of Cucumber *(Cucumis sativus* L.) and on nutrient status of alfisols of Konkan during summer 2018, where the effect of different treatments on yield and quality of cucumber as well as periodical soil and plant samples collected at 30 DAS, 60 DAS and at harvest of the crop were studied. The observations and analytical values obtained during course of study were analysed statistically, described and contemplated to discuss the variations observed with an attempt to establish the 'effect and cause' relationship in the light of available evidences and literature. For brevity, the entire results and discussion has been divided into the following heads**:**

4.1 : Effect of soil and foliar supplementation of nitrogen, boron and salicylic acid on growth and yield of cucumber

4.2 : Effect of soil and foliar supplementation of nitrogen, boron and salicylic acid on quality parameters of cucumber

4.3 : Effect of soil and foliar supplementation of nitrogen, boron and salicylic acid on nutrient content of cucumber

4.4 : Effect of soil and foliar supplementation of nitrogen, boron and salicylic acid on physico-chemical properties and nutrient status of soil

4.1 : Effect of soil and foliar supplementation of nitrogen, boron and salicylic acid on growth and yield of cucumber

4.1.1 : Effect of soil and foliar supplementation of nitrogen, boron and salicylic acid on growth parameters of cucumber

4.1.1.1 Vine length (cm)

The vine length of cucumber significantly affected due to the soil and foliar supplementation of nitrogen, boron and salicylic acid and varied from

29.27 to 93.23 cm at 30 DAS, 73.53 to 274.80 cm at 60 DAS and 131.33 to 407.00 cm at harvest (Table 7) and indicated that the vine length increased over the periods of observations from 30 DAS to harvest of the crop. The range value of vine length of cucumber variety Sheetal reported here are in agreement with Naik (2016), Torane (2014) and Ghayal (2016).

Table 7. Effect of soil and foliar application of nitrogen, boron and salicylic acid on vine length of cucumber

Treat code	Treatments	Vine length (cm)		
		30 DAS	60 DAS	At Harvest
T_1	Control (No Fertilizer)	29.27	73.53	131.33
T_2	Recommended Dose of Fertilizer 135:60:30 NPK kg ha^{-1}	73.67	102.67	281.68
T_3	RDF+ Foliar spray of Urea (1%)	81.39	231.53	303.88
T_4	RDF+ Foliar spray of Boric acid (0.5%)	85.71	242.80	307.67
T_5	RDF+ Soil application of Borax @ 2 kg ha^{-1}	75.24	195.00	295.07
T_6	RDF+ Foliar spray of Salicylic acid (0.2%)	86.93	246.67	339.33
T_7	RDF+ Foliar spray of Boric acid (0.5%) + Foliar spray of Salicylic acid (0.2%)	87.33	256.00	350.67
T_8	RDF+ Foliar spray of Urea (1%) + Foliar spray of Boric acid (0.5%) + Foliar spray of Salicylic acid (0.2%)	90.40	265.37	399.67
T_9	RDF+ Foliar spray of Urea (1%) + Soil application of Borax @ 2 kg ha^{-1}+ Foliar spray of Salicylic acid (0.2%)	93.23	274.80	407.00
T_{10}	RDF+ Amrashakti @ 2%	74.08	103.00	285.47
	S.E. $\pm$	**3.39**	**3.25**	**2.79**
	C.D. (P=0.05)	**10.07**	**9.66**	**6.93**

Application of recommended dose of fertilizer (135:60:30 kg ha^{-1}) + foliar spray of nitrogen through urea (1%) + soil application of boron through borax @ 2 kg ha^{-1}+ foliar spray of salicylic acid 0.2% (i.e. treatment T_9) recorded the highest vine length at different growth stages (i.e. 93.23 cm at 30 DAS, 274.80 cm at 60 DAS and 407.00 cm at harvest) which signifies the efficacy of combined application of soil and foliar application of nitrogen, boron and salicylic acid. The Treatment T_9 was found at par with the treatments T_4, T_6, T_7 and T_8 at 30 DAS, while it was found at par with T_8 at 60 DAS and at harvest.

In general, application of recommended dose of fertilizer (135:60:30 kg ha^{-1}) (T_2) significantly increased the vine length at all growth stages of cucumber over control (T_1). The enhancement in growth parameters could be due to the better and proper nourishment of the crop when fertilized. There was further increase in vine length with the foliar application of nitrogen through urea 1% along with application of recommended dose of fertilizer (T_3) over the application of recommended dose of fertilizer alone (T_2). The treatment T_2 i.e. application of recommended dose of fertilizer and treatment T_{10} i.e. RDF+ Amrashakti @ 2% were at par with each other at all the growth stages. The application of fertilizers helped to fulfil the requirement of the crop which resulted in increase of vine length.

In case boron application, the foliar spray of boric acid (0.5%) (T_4) recorded the significant higher values compared with the soil application of borax @ 2 kg ha^{-1} (T_5) indicating thereby the superiority of foliar spray over the soil application.

Increase in vine length with the foliar application of nitrogen through urea were also reported by Jilani (2009), Eifediyi and Remison (2010) and Shinde (2014) in cucumber and Umamaheswarappa *et al*. (2005), Leghari *et al.* (2014) and Baloch (2012) in bottle gourd and Bhosale (2016) in watermelon. Significantly highest vine length in cucumber with mean of 456.56 cm due to foliar application of urea was also reported by Nasrollahzadeh-asl *et al.* (2015).

Moreover, increase in vine length with the application of boron was also reported by Meena *et al.* (2017) and Patidar *et al.* (2017) in cucumber.

In case of boron, Bommesh *et al.*(2017) found the significantly highest mean vine length (406.95 cm) with the soil application of boron @ 1.5 kg ha^{-1} + foliar spray of boric acid @ 0.50 % on 30 and 45 DAS at harvest (100 DAS) of the crop. Verma *et al.* (2012) also found significant effect of B application for plant height in mustard and the maximum plant height was observed with 1.0 kg B ha^{-1} compared to control (no boron application). This may be due to role of boron in cell elongation, photosynthesis and translocation of photosynthates (Brown and Hu, 1996).

The increase in vine length due to foliar application of salicylic acid may be due to the effect of salicylic acid in increased cell division in the apical meristem so increasing plant height, in addition to its ability to improve the effectiveness of the immune of antioxidant in plants, salicylic acid has a mechanism to prevent the crash of chlorophyll as well as the revitalization of the effectiveness of enzyme active (RuBISCO) (Sure *et al*., 2011).

Gharib (2006) observed that the application of salicylic acid (SA) at low concentration increased photosynthetic activity in basil and marjoram which enhanced their plant height, number of inter-nodes, number of branches and leaves as well as leaf area, fresh and dry weights.

4.1.1.2 Number of branches vine^{-1}

The number of branches of cucumber significantly affected due to the soil and foliar supplementation of nitrogen, boron and salicylic acid and varied from 0.73 to 2.73 at 30 DAS, 4.24 to 13.17 at 60 DAS and 5.99 to 14.22 at harvest stage (Table 8) and indicated that the number of branches were increased over the periods of observations from 30 DAS to harvest of the crop. The range value of number of branches of cucumber reported here are in agreement with Meena *et al*. (2017).

The combined application of recommended dose of fertilizer (135:60:30 kg ha^{-1}) + foliar spray of nitrogen through urea (1%) + soil application of boron through borax @ 2 kg ha^{-1}+ foliar spray of salicylic acid (0.2%) (i.e. treatment T_9) recorded the maximum number of branches at all the growth stages of cucumber (i.e. 2.73 at 30 DAS, 4.24 at 60 DAS and 5.99 at harvest).The treatment T_9 was found to be at par with the treatments T_2, T_3, T_4, T_5, T_6, T_7, T_8, T_9 and T_{10} at 30 DAS also at par with the treatments T_3, T_4, T_5, T_6, T_7, T_8 at 60 DAS and at harvest stage.

Rather than the soil application of borax @ 2 kg ha^{-1} (T_5), the foliar spray of boric acid 0.5% (T_4) recorded the higher values of number of branches, indicating thereby the superiority of foliar over the soil application.

Application of Amrashakti @ 2% along with RDF (T_{10}) noted the increase in number of branches $vine^{-1}$ over the application of RDF alone (T_2), but these two treatment were at par with each other. The enhancement in growth parameters could be due to the better and proper nourishment of the crop when fertilized.

Table 8. Effect of soil and foliar application of nutrients on number of branches $vine^{-1}$ of cucumber

Tr. code	Treatments	No. of Branches $vine^{-1}$		
		30 DAS	60 DAS	At Harvest
T_1	Control (No Fertilizer)	0.73	4.24	5.99
T_2	Recommended Dose of Fertilizer 135:60:30 NPK kg ha^{-1}	1.87	8.59	9.43
T_3	RDF+ Foliar spray of Urea (1%)	2.27	10.79	11.73
T_4	RDF+ Foliar spray of Boric acid (0.5%)	2.27	11.39	11.83
T_5	RDF+ Soil application of Borax @ 2 kg ha^{-1}	2.20	10.04	10.91
T_6	RDF+ Foliar spray of Salicylic acid (0.2%)	2.33	11.76	12.57
T_7	RDF+ Foliar spray of Boric acid (0.5%) + Foliar spray of Salicylic acid (0.2%)	2.60	12.57	13.40
T_8	RDF+ Foliar spray of Urea (1%) + Foliar spray of Boric acid (0.5%) + Foliar spray of Salicylic acid (0.2%)	2.60	12.69	13.68
T_9	RDF+ Foliar spray of Urea (1%) + Soil application of Borax @ 2 kg ha^{-1} + Foliar spray of Salicylic acid (0.2%)	2.73	13.17	14.22
T_{10}	RDF+ Amrashakti @ 2%	1.90	8.98	9.85
	S.E. $\pm$	**0.34**	**1.13**	**1.21**
	C.D. (P=0.05)	**1.03**	**3.36**	**3.60**

In general, application of RDF (T_2) increased phosphorus content in plant over control (T_1), which further increased with the combined application of RDF + foliar spray of Urea @ 1% (T_3). N is necessary for photosynthesis and affects vegetative and reproductive growth of the plants.

Kaisher *et al.* (2010) observed that application of boron at the rate of 5 kg B ha^{-1} had significant effect on number of branches plant^{-1} on mung bean in sandy loamy textured boron-deficient soil in Bangladesh. Basavarajeswari *et al.* (2008) reported that out of nine different foliar treatments the application of boric acid at 100 ppm resulted in maximum plant height, maximum number of primary branches (18.30), plant length and fruit yield (30.50 tonnes ha^{-1}) of tomato than control.

The salicylic acid plays an important role in physiological activity of the plant like photosynthesis through its effect on the function of stomata and the rate of transpiration and breathing passages in cucumber (Orabi *et al.*, 2010). Salicylic acids have a role in increasing the chlorophyll pigment and carotene and accelerate the photosynthesis process and increase the activity of some important enzymes, in addition to increasing the plant hormone levels like auxins and cytokinins because of treatment with salicylic acid so it will lead to increased vegetative growth (Abdulwahed *et al.*, 2012).

4.1.2 : Effect of soil and foliar supplementation of nitrogen, boron and salicylic acid on yield attributing characters of cucumber

4.1.2.1 Number of fruits vine^{-1}

The number of fruits per vine of cucumber significantly affected due to the soil and foliar supplementation of nitrogen, boron and salicylic acid and ranges from 1.29 to 7.00 (Table 9). The range value of number of fruits per vine of cucumber variety of Sheetal was reported here are in agreement with Torane (2014).

Treatment T_9 where there was application of recommended dose of fertilizer (135:60:30 kg ha^{-1}) + foliar spray of nitrogen through urea (1%) + soil application of boron through borax @ 2 kg ha^{-1}+ foliar spray of salicylic acid (0.2%) recorded significantly higher number of fruits (7.0) and it was on par with T_3 to T_8 treatments.

Table 9. Effect of soil and foliar application of nutrients on number of fruits per vine of cucumber

Tr. code	Treatments	No. of fruits vine^{-1}
T_1	Control (No Fertilizer)	1.29
T_2	Recommended Dose of Fertilizer 135:60:30 NPK kg ha^{-1}	3.74
T_3	RDF+ Foliar spray of Urea (1%)	4.38
T_4	RDF+ Foliar spray of Boric acid (0.5%)	4.64
T_5	RDF+ Soil application of Borax @ 2 kg ha^{-1}	4.36
T_6	RDF+ Foliar spray of Salicylic acid (0.2%)	5.14
T_7	RDF+ Foliar spray of Boric acid (0.5%) + Foliar spray of Salicylic acid (0.2%)	5.38
T_8	RDF+ Foliar spray of Urea (1%) + Foliar spray of Boric acid (0.5%) + Foliar spray of Salicylic acid (0.2%)	5.95
T_9	RDF+ Foliar spray of Urea (1%) + Soil application of Borax @ 2 kg ha^{-1}+ Foliar spray of Salicylic acid (0.2%)	7.00
T_{10}	RDF+ Amrashakti @ 2%	4.29
	S.E. $\pm$	**0.91**
	C.D. (P=0.05)	**2.70**

In case boron application, the foliar spray of boric acid 0.5% (T_4) recorded the significant higher values compared with the soil application of borax @ 2 kg ha^{-1} (T_5) indicating thereby the superiority of foliar over the soil application. The treatment T_2 (RDF) and treatment T_{10} (RDF + Amrashakti @ 2%) were found at par with each other at all observations.

The number of fruits per vine is closely associated with growth parameters like length of vine etc. which can be contributed to nutrient availability and its uptake; this might have favourable effect of nitrogen in increasing, chlorophyll content in leaves resulting in better synthesis of carbohydrates and build up for more new cells which might have increased the number of fruits per plant (Maynard, 1962) in peppers. Similarly, the application of boron takes part in active photosynthesis, which ultimately helps towards increase in number of cucumber fruits.

Similarly, increase in number of fruits per vine due to nitrogen application was reported by Leghari *et al.* (2014) in bottle gourd and that of due to foliar application of boron by Kadu (2015) in watermelon. Gedam *et al*. (1998) studied the effect of plant growth regulators and boron on flowering, fruiting and seed yield of bitter gourd and concluded that 11.73 fruits vine^{-1} obtained by application of 4 ppm boron.

Foliar application of salicylic acid have a pronounced enhancement of yields of many plant species as mentioned by Yildirim *et al.* (2006) on cucumber, Elwan and El-Hamahmy (2009) on pepper, Karlidag *et al.* (2009) on strawberry, and Mady (2009) and Javaheri *et al.* (2012) on tomato. These increases in yields may be closely linked to the increase in vegetative growth characteristics, i.e. plant length, number of leaves plant^{-1}, leaf area, and fresh and dry weights of root and vegetative growth and may be also linked to the increase in the crown carbohydrate content. According to Shakirova *et al.* (2003), the positive effect of salicylic acid on yield can be due to its influence on other plant hormones. Salicylic acid altered the auxin, cytokinin and ABA balances in wheat and increased the growth and yield under both normal and saline conditions. Increasing of yield under foliar application of salicylic acid could be ascribed to the well-known roles of salicylic acid on photosynthetic parameters and plant water relations. Fariduddin *et al.* (2003) reported that exogenous application of salicylic acid enhanced the net photosynthetic rate, internal CO_2 concentration and water use efficiency in *Brassica juncea*.

4.1.2.2 Weight of fruit vine^{-1} (kg)

The data regarding weight of fruit per vine as influenced soil and foliar supplementation of nitrogen, boron and salicylic acid and ranges from 0.49 to 1.98 kg (Table 10). The range value of weight of fruit per vine (kg) of cucumber variety Sheetal was reported here are in agreement with Torane (2014), Naik (2016) and Lajurkar (2014).

Table 10. Effect of soil and foliar application of nutrients on weight of fruit per vine of cucumber

Tr. code	Treatments	Wt. of fruit (kg) vine^{-1}
T_1	Control (No Fertilizer)	0.49
T_2	Recommended Dose of Fertilizer 135:60:30 NPK kg ha^{-1}	0.70
T_3	RDF+ Foliar spray of Urea (1%)	1.28
T_4	RDF+ Foliar spray of Boric acid (0.5%)	1.44
T_5	RDF+ Soil application of Borax @ 2 kg ha^{-1}	1.27
T_6	RDF+ Foliar spray of Salicylic acid (0.2%)	1.51
T_7	RDF+ Foliar spray of Boric acid (0.5%) + Foliar spray of Salicylic acid (0.2%)	1.82
T_8	RDF+ Foliar spray of Urea (1%) + Foliar spray of Boric acid (0.5%) + Foliar spray of Salicylic acid (0.2%)	1.88
T_9	RDF+ Foliar spray of Urea (1%) + Soil application of Borax @ 2 kg ha^{-1}+ Foliar spray of Salicylic acid (0.2%)	1.98
T_{10}	RDF+ Amrashakti @ 2%	1.00
	S.E. ±	**0.30**
	C.D. (P=0.05)	**0.90**

The lowest value of weight of fruit per vine (kg) of cucumber was recorded by the absolute control (T_1) i.e. no fertilizer application. While, there was significant increase in weight of fruit per vine (kg) with the application of RDF either alone or in combination with soil and foliar supplementation of nitrogen, boron and salicylic acid (Table 10). The applied fertilizers beneficial to fulfil the requirement of the crop which resulted in to the increase in the height of the plant.

Application of recommended dose of fertilizer (135:60:30 kg ha^{-1}) + foliar spray of nitrogen through urea (1%) + soil application of boron through borax @ 2 kg ha^{-1}+ Foliar spray of salicylic acid (0.2%) (i.e. treatment T_9) recorded the maximum weight of fruit per vine (1.98 kg) which was at par with the treatment T_3, T_4, T_5, T_6, T_7 and T_8.

In case boron application, the foliar spray of boric acid 0.5% (T_4) recorded the significant higher values compared with the soil application of borax @ 2 kg ha^{-1} (T_5) indicating thereby the superiority of foliar over the soil application method.

The treatment T_2 i.e. application of recommended dose of fertilizer and treatment T_{10} i.e. RDF+ Amrashakti @ 2% were at par with each other in respect of fruit weight per vine.

In lateritic soils of Konkan, Kadam (2016) found graded increase in increase in weight of fruit per plant of okra with the graded doses of boron applied through Konkan Annapurna briquette. Pandav *et al.* (2016) reported that the supply of borax led to absorption of water, synthesis and translocation of more metabolites, which resulted in increased fruit length, fruit diameter and ultimately average fruit weight in brinjal and Tomato crop (Haque *et al.,* 2011*).*

4.1.2.3 Fruit yield q ha^{-1}

The data regarding fruit yield as influenced soil and foliar supplementation of nitrogen, boron and salicylic acid and varied from 58.53 to 231.22 q ha^{-1} under summer season (Table 11). The yield of Sheetal variety of cucumber 200 q ha^{-1} to 250 q ha^{-1} were reported in Diary of Dr. B.S. Konkan Krishi Vidyapeeth, but variation in fruit yield of Sheetal variety of cucumber with different locations and season were reported earlier. Ghayal (2016) reported 103 to 165 q ha^{-1} fruit yield of Sheetal variety of cucumber during *Kharif* season, while 17 to 23 q ha^{-1} fruit yield of Sheetal variety of cucumber during *Kharif* season was reported by Torane (2014) in lateritic soils under Konkan conditions. Monisha Rawat (2013) reported 82.13 q ha^{-1} fruit yield of Sheetal variety of cucumber during *Rabi* season and 318.19 q ha^{-1} fruit yield of Sheetal variety of cucumber in summer season at G.B. Pantnagar, Uttarakhand.

Soil and foliar application of nitrogen, boron and salicylic acid on cucumber significantly increased the fruit yield over the absolute control i.e. no fertilizer application. Since foliar nutrients usually penetrate the leaf cuticle or stomata and enters the cells facilitating easy and rapid utilization of nutrients (Latha and Nadanassababady, 2003).

Application of recommended dose of fertilizer (135:60:30 kg ha^{-1}) + Foliar spray of nitrogen through urea 1% + Soil application of boron through borax @ 2 kg ha^{-1}+ Foliar spray of salicylic acid 0.2% (i.e. treatment T_9) recorded the maximum fruit yield (231.22 q ha^{-1}), which was at par with the treatment T_7 and $T_{8.}$ The combined effect of application of nitrogen, boron and SA performed better than alone application for influencing most of growth and yield attributes. These combinations influenced all the growth and yield characters.

Table 11. Effect of soil and foliar application of nutrients on fruit yield of cucumber

Tr. code	Treatments	Fruit yield (q ha^{-1})
T_1	Control (No Fertilizer)	58.53
T_2	Recommended Dose of Fertilizer 135:60:30 NPK kg ha^{-1}	85.21
T_3	RDF+ Foliar spray of Urea (1%)	153.41
T_4	RDF+ Foliar spray of Boric acid (0.5%)	170.73
T_5	RDF+ Soil application of Borax @ 2 kg ha^{-1}	144.95
T_6	RDF+ Foliar spray of Salicylic acid (0.2%)	175.31
T_7	RDF+ Foliar spray of Boric acid (0.5%) + Foliar spray of Salicylic acid (0.2%)	206.16
T_8	RDF+ Foliar spray of Urea (1%) + Foliar spray of Boric acid (0.5%) + Foliar spray of Salicylic acid (0.2%)	216.87
T_9	RDF+ Foliar spray of Urea (1%) + Soil application of Borax @ 2 kg ha^{-1}+ Foliar spray of Salicylic acid (0.2%)	231.22
T_{10}	RDF+ Amrashakti @ 2%	129.96
	S.E. ±	**17.20**
	C.D. (P=0.05)	**51.10**

In case boron application, the foliar spray of boric acid 0.5% (T_4) recorded the significant higher values compared with the soil application of borax @ 2 kg ha^{-1} (T_5) indicating thereby the superiority of foliar over the soil application method.

Application of Amrashakti @ 2% along with RDF (T_{10}) increased the fruit yield over the sole application of RDF (T_2), but the treatment T_2 and T_{10} were at par with each other at all the growth stages of cucumber. Several workers have also suggested that foliar feeding of nutrients directly to the site of metabolism as a substitute for or supplement to soil application noticeably improved fruit yield and quality attributes (Samra *et al*., 1997; Singh *et al*., 1994). Moreover, Singh (2002) reported that in case of mango, the leaves of mango absorb most of the nutrients within 24-72 hours after spray and, thereafter, depletion of leaf nutrient content is seen owing to translocation of N, P, and K to actively developing organs within the plant system. Potassium is macronutrient attributed to the invigorating effect of K on phloem loading, photosynthesis and translocation and large molecular weight synthesis in the developing fruits (Rabeh and Sweelam, 1990). Singh *et al.* (2008) opined that potassium is an important nutrient for fruit filling in terms of size and weight of mandarin fruits. They also stated that, potassium is required for production and transport of plant sugars that increases the weight of mango fruits. Potassium helps in energy transformation and activation of enzymes in carbohydrate metabolism which subsequently partitioning of photosynthates to the developing fruits.

Nitrogen being the component of amino acid, nucleotide, and nucleic acid, number of co-enzyme, auxins and cytokinins can induce cell elongation, cell enlargement and development and thereby improved the nut production. Nitrogen also helps to synthesis of carbohydrate, protein and other metabolism (Raheja, 1971).

Maurya (1987) reported that 80 kg N ha^{-1} + spraying of 0.25 per cent boron showed 242.26 q ha^{-1} fruits yield along with 45 kg P_2O_5 ha^{-1} and 85 kg K_2O ha^{-1} in cucumber. Bommesh *et al.* (2016) investigated that soil application of boron at the rate of 1.5 kg ha^{-1} along with the foliar spray of boric acid at 0.25% in an interval of 30 and 45 days after sowing recorded highest yield in greenhouse cucumber.

The response of crops to B not only varies with plant species, soil type and environmental conditions, but also its excess/deficiency may affect the availability and uptake of the other plant nutrients (Tariq and Mott, 2007). Gluntsov *et al.* (1989) reported that incorporation of 0.52 or 0.80 mg boric acid kg^{-1} in the greenhouse soil increased the yield of cucumber from 1723 to 1787 g per plant. Phookan *et al*. (1991) reported that boron influences greatly the flowering, fruit set and seed development in tomato. Maintaining high B levels in reproductive parts in a vital component of efficient B management for horticultural crops (Edward Raja, 2009).

Increase in yield of plant might be due to foliar application of boron which is involved in development of cell wall, cell differentiation and root and shoot elongation. It is also involved in ovary developments, seed development and maturity of crop plant. This may be attributed to greater photosynthetic activity, resulting the increased production and accumulation of carbohydrates and favourable effect on retention of flowers and fruits, which might have increased number and weight of fruits (Patidar *et al*., 2017 and Brown, 1979).

In this context, Patidar *et al.* (2017), Heidarian *et al.* (2001) and Babaeian *et al.* (2010) further explained the synergistic relationship between boron and iron where boron application causes higher uptake of iron. The combination plays an important role in the development and growth of new cells in plant meristem. It also acts as regulator of K/Ca ratio in plants and necessary for the translocation of sugar, starch, phosphorus and synthesis of amino acid and including chlorophyll synthesis, thylakoid synthesis, chloroplast, plant growth and development.

In case of salicylic acid, Monalisa (2014) found significant influence of SA on production of marketable bulb of onion than untreated control. This better efficacy of application of SA might be due to better effect on higher vegetative growth, bulb yield attributing parameters, relatively less pests and diseases attack with higher uptake of NPKS nutrient by plants receiving foliar spray of SA in general and at higher rate of spraying.

The increase in fruit yield with the application of salicylic acid may be due to the stimulatory effect of SA on flowering regulation which has been well known for a long time (Raskin, 1992; Rivas-San Vicente and Plasencia,, 2011) would eventually affect total number of fruits (Ondrašek *et al*., 2007) and enhance efficiency in fruit production. Previously, increased yield of strawberry (Aghaeifard *et al*., 2015) and tomato (Javaheri *et al*., 2012) has been related to promoted cell division and cell enlargement due to SA (Hayat *et al*., 2010) through its influence on other plant hormones such as auxin, cytokinin and ABA balances (Shakirova, 2007) and enhanced net photosynthetic rate, internal CO_2 concentration and water use efficiency (Fariduddin *et al*., 2003).

The beneficial response of organic manures in relation to crop yield might be attributed to the availability of sufficient amount of plant nutrients throughout the growth period of crops, improvement of soil environment resulting in higher root proliferation leading to better absorption of moisture and nutrient, plant vigour and superior yield attributes and ultimately higher yield. After proper decomposition and mineralization, the manures supplied available nutrients directly to the plants and also had solubilizing effect on fixed forms of nutrients in soil (Sinha,1981).

Moreover, Kuttimani and Velayutham (2011) observed that increase in pod yield in greengram due to individual and combined use of urea, DAP, salicylic acid and sodium molybdate, which might be due to nutrient supply through foliage and supply of all nutrients at vegetative and flowering stages of crop growth. This might have caused more number of pods and efficient translocation of photosynthates from source to sink.

4.2 : Effect of soil and foliar supplementation of nitrogen, boron and salicylic acid on quality parameters of cucumber

4.2.1 Moisture (%)

The data regarding moisture percentage of fruit as influenced by soil and foliar supplementation of nitrogen, boron and salicylic acid varied from 95.75 to 98.64 per cent (Table 12). The similar ranges of moisture per cent in cucumber fruit was also found by Ghayal (2016) and Naik (2016).

Application of RDF alone or in combination with soil and foliar application of nitrogen, boron and salicylic acid (from treatment T_2 to T_{10}) numerically increased the moisture per cent over the control treatment (T_1), but did not reach the level of significance.

Table 12. Effect of soil and foliar application of nutrients on moisture of cucumber fruit

Treat code	Treatments	Moisture (%)
T_1	Control (No Fertilizer)	92.75
T_2	Recommended Dose of Fertilizer 135:60:30 NPK kg ha^{-1}	94.65
T_3	RDF+ Foliar spray of Urea (1%)	95.43
T_4	RDF+ Foliar spray of Boric acid (0.5%)	95.31
T_5	RDF+ Soil application of Borax @ 2 kg ha^{-1}	95.06
T_6	RDF+ Foliar spray of Salicylic acid (0.2%)	95.32
T_7	RDF+ Foliar spray of Boric acid (0.5%) + Foliar spray of Salicylic acid (0.2%)	95.21
T_8	RDF+ Foliar spray of Urea (1%) + Foliar spray of Boric acid (0.5%) + Foliar spray of Salicylic acid (0.2%)	95.62
T_9	RDF+ Foliar spray of Urea (1%) + Soil application of Borax @ 2 kg ha^{-1}+ Foliar spray of Salicylic acid (0.2%)	95.64
T_{10}	RDF+ Amrashakti @ 2%	94.48
	S.E. $\pm$	**0.6**
	C.D. (P=0.05)	**NS**

Numerically the highest moisture per cent was recorded with the application of recommended dose of fertilizer (135:60:30 kg ha^{-1}) + Foliar spray of nitrogen through urea (1%) + Soil application of boron through borax @ 2 kg ha^{-1}+ foliar spray of salicylic acid (0.2%) (i.e. treatment T_9) followed by T_8.

By and large, the soil application of nutrients alone or in combination with the foliar application urea, boric acid, and salicylic acid increased the moisture content, which might be due to causing the chemical changes within the fruits so that the fruits could retain more water against the force of evaporation and possibly they may also alter some of the proteinaceous constituents of the cell so as to increase the affinity for water (Rydahl *et al*., 2018).

4.2.2 Total soluble solids (T.S.S) ^{0}Brix

The data regarding total soluble solids of fruit as influenced by soil and foliar supplementation of nitrogen, boron and salicylic acid and varied from 1.66 to 2.16 ^{0}Brix (Table 13). The similar ranges of total soluble solids of fruit also reported by Ghayal (2016) in cucumber.

Soil and foliar application of nitrogen, boron and salicylic acid on cucumber significantly increased the total soluble solids over the absolute control i.e. no fertilizer application.

Application of recommended dose of fertilizer (135:60:30 kg ha^{-1}) + foliar spray of nitrogen through urea (1%) + soil application of boron through borax @ 2 kg ha^{-1}+ foliar spray of salicylic acid 0.2% (i.e. treatment T_9) recorded the maximum total soluble solids (2.16 ^{0}Brix) which was at par with the treatment $T_{6,}$ T_7 and $T_{8.}$ Similarly, treatments T_3, T_4, T_5 and T_{10} were at par with each other. Higher amount of available soil nutrients increased the absorption of plant nutrients; hence the value of total soluble solids in fruit juice was increased (Bhosale, 2016).

In case boron application, the foliar spray of boric acid 0.5% (T_4) recorded the significant higher values compared with the soil application of borax @ 2 kg ha^{-1} (T_5) indicating thereby the superiority of foliar over the soil application of boron.

Application of Amrashakti @ 2% along with RDF (T_{10}) increased the TSS over the sole application of RDF (T_2), but the treatment T_2 and T_{10} were at par with each other. Several workers have also suggested that foliar feeding of nutrients directly to the site of metabolism as a substitute for or supplement to soil application noticeably improved fruit quality attributes (Samra *et al*., 1997; Singh *et al*., 1994).

Table 13. Effect of soil and foliar application of nutrients on total soluble solids of cucumber fruit

Treat code	Treatments	T.S.S ^{0}Brix
T_1	Control (No Fertilizer)	1.66
T_2	Recommended Dose of Fertilizer 135:60:30 NPK kg ha^{-1}	1.70
T_3	RDF+ Foliar spray of Urea (1%)	1.90
T_4	RDF+ Foliar spray of Boric acid (0.5%)	1.93
T_5	RDF+ Soil application of Borax @ 2 kg ha^{-1}	1.83
T_6	RDF+ Foliar spray of Salicylic acid (0.2%)	2.00
T_7	RDF+ Foliar spray of Boric acid (0.5%) + Foliar spray of Salicylic acid (0.2%)	2.06
T_8	RDF+ Foliar spray of Urea (1%) + Foliar spray of Boric acid (0.5%) + Foliar spray of Salicylic acid (0.2%)	2.10
T_9	RDF+ Foliar spray of Urea (1%) + Soil application of Borax @ 2 kg ha^{-1}+ Foliar spray of Salicylic acid (0.2%)	2.16
T_{10}	RDF+ Amrashakti @ 2%	1.73
	S.E. $\pm$	**0.07**
	C.D. (P=0.05)	**0.21**

The increase in TSS may be due to combination of nutrients that enhanced the conversion of complex polysaccharides into simple sugar through translocation of sugars from leaves to developing fruits reported by Jadhav (2018). Further, in this connection Combrink *et al.*, (1995) explained that TSS increased with the application of boron might be due to increased translocation of sugars and growth modifying substances in plants of muskmelon.

Dabas and Jindal (1985) observed higher TSS due to application of boron as boric acid @ 0.3 % to the grape. Bommesh *et al.* (2017) recorded the significantly highest total soluble solids (TSS) in cucumber (3 ^{o}Brix) with the soil application of 1 kg ha^{-1} boron with foliar spray of 0.5% boric acid.

Increase in TSS might be due to spray of urea which helps in sugar transport ultimate accumulation of more sugars in fruits. Its action on converting complex substances into simple ones, which enhances the metabolic activity in fruits. Increasing total sugar is due to either speedily converted into sugars and their derivatives by reactions involving reverse glycolytic pathways or might have been used in respiration or both. The present results are in conformity with the findings of Meena *et al*. (2005), Dutta and Banik (2007), Kundu *et al*. (2007), Jat and Kacha (2014), Parmar *et al*. (2014) and Jatav *et al*. (2016).

There was increase in TSS due to foliar application of salicylic acid. Data obtained from the present study agree with other studies which indicated that salicylic acid maintained higher concentrations of total soluble solids of cowpea (Chandra *et al.*, 2007), tomato (Mady, 2009; Javaheri *et al.*, 2012), pepper (Elwan and El-Hamahmy, 2009), strawberry (Karlidag *et al.*, 2009) and kiwifruits (Bal and Celik, 2010) than the control. This enhancement of fruit soluble solids content can be attributed to the role of salicylic acid in improving membrane permeability, absorption and tilization of mineral nutrients. Some researches indicated that salicylic acid increased membrane permeability which would facilitate absorption and utilization of mineral nutrients and transport of assimilates (Barkosky and Einhellig, 1993, Gunes *et al.*, 2005). This would also contribute towards enhancing the capacity of the treated plants for biomass production as is reflected in the increase in fresh and dry weights of plants.

4.2.3 Titratable Acidity (%)

The data regarding titratable acidity of fruit as influenced soil and foliar supplementation of nitrogen, boron and salicylic acid and varied from

0.08 to 0.31% (Table 14). The similar ranges of titratable acidity of fruit also found by Ghayal (2016) and Cimpeanu *et al.* (2013) in cucumber.

Application of recommended dose of fertilizer (135:60:30 kg ha^{-1}) + foliar spray of nitrogen through urea (1%) + soil application of boron through borax @ 2 kg ha^{-1}+ foliar spray of salicylic acid (0.2%) (i.e. treatment T_9) recorded the highest titratable acidity (0.309 %) which was found significantly superior over rest of the treatments.

Table 14. Effect of soil and foliar application of nutrients on titratable acidity of cucumber fruit

Treat code	Treatments	Acidity %
T_1	Control (No Fertilizer)	0.082
T_2	Recommended Dose of Fertilizer 135:60:30 NPK kg ha^{-1}	0.111
T_3	RDF+ Foliar spray of Urea (1%)	0.129
T_4	RDF+ Foliar spray of Boric acid (0.5%)	0.132
T_5	RDF+ Soil application of Borax @ 2 kg ha^{-1}	0.128
T_6	RDF+ Foliar spray of Salicylic acid (0.2%)	0.169
T_7	RDF+ Foliar spray of Boric acid (0.5%) + Foliar spray of Salicylic acid (0.2%)	0.218
T_8	RDF+ Foliar spray of Urea (1%) + Foliar spray of Boric acid (0.5%) + Foliar spray of Salicylic acid (0.2%)	0.226
T_9	RDF+ Foliar spray of Urea (1%) + Soil application of Borax @ 2 kg ha^{-1}+ Foliar spray of Salicylic acid (0.2%)	0.309
T_{10}	RDF+ Amrashakti @ 2%	0.120
	S.E. $\pm$	**0.015**
	C.D. (P=0.05)	**0.047**

In case boron application, the foliar spray of boric acid 0.5% (T_4) recorded the significant higher values compared with the soil application of borax @ 2 kg ha^{-1} (T_5) indicating thereby the superiority of foliar over the soil application.

The treatment T_2 i.e. application of recommended dose of fertilizer and treatment T_{10} i.e. RDF+ Amrashakti @ 2% were at par with each other. Several workers have also suggested that foliar feeding of nutrients directly to the site of metabolism as a substitute for or supplement to soil application noticeably improved fruit yield and quality attributes (Samra *et al*., 1977; Singh *et al*., 1994).

Similar results of increase in titratable acidity due to foliar application of urea and Amrashakti were also found by Jadhav (2018) and Patil *et al.* (2010) in Alphonso mango and Naresh Babu (2002) in tomato.

4.2.4 Reducing sugar (%)

The data regarding reducing sugar of fruit as influenced by the soil and foliar supplementation of nitrogen, boron and salicylic acid varied from 0.724 to 1.053 per cent (Table 15). The similar ranges of reducing sugar fruit also reported by Ghayal (2016) in cucumber and Kameshwari *et al.* (2011) in ridge gourd.

Table 15. Effect of soil and foliar application of nutrients on reducing sugar of cucumber fruit

Treat code	Treatments	Reducing sugar (%)
T_1	Control (No Fertilizer)	0.724
T_2	Recommended Dose of Fertilizer 135:60:30 NPK kg ha^{-1}	0.741
T_3	RDF+ Foliar spray of Urea (1%)	0.763
T_4	RDF+ Foliar spray of Boric acid (0.5%)	0.781
T_5	RDF+ Soil application of Borax @ 2 kg $ha+^{-1}$	0.756
T_6	RDF+ Foliar spray of Salicylic acid (0.2%)	0.810
T_7	RDF+ Foliar spray of Boric acid (0.5%) + Foliar spray of Salicylic acid (0.2%)	0.890
T_8	RDF+ Foliar spray of Urea (1%) + Foliar spray of Boric acid (0.5%) + Foliar spray of Salicylic acid (0.2%)	0.925
T_9	RDF+ Foliar spray of Urea (1%) + Soil application of Borax @ 2 kg ha^{-1}+ Foliar spray of Salicylic acid (0.2%)	1.053
T_{10}	RDF+ Amrashakti @ 2%	0.747
	S.E. $\pm$	**0.030**
	C.D. (P=0.05)	**0.091**

Application of recommended dose of fertilizer (135:60:30 kg ha^{-1}) + foliar spray of nitrogen through urea (1%) + soil application of boron through borax @ 2 kg ha^{-1}+ foliar spray of salicylic acid (0.2%) (i.e.

treatment T_9) recorded the maximum reducing sugar (1.053 %) which was significantly superior over all treatments.

In case boron application, the foliar spray of boric acid 0.5% (T_4) recorded the significant higher values compared with the soil application of borax @ 2 kg ha^{-1} (T_5) indicating thereby the superiority of foliar over the soil application.

The treatment T_2 i.e. application of recommended dose of fertilizer and treatment T_{10} i.e. RDF+ Amrashakti @ 2% were at par with each other. Several workers have also suggested that foliar feeding of nutrients directly to the site of metabolism as a substitute for or supplement to soil application noticeably improved fruit yield and quality attributes (Samra *et al*., 1977; Singh *et al*., 1994).

Dabas and Jindal (1985) observed higher reducing sugar due to application of boron as boric acid @ 0.3 % to the grape. With increase in reducing sugar content in cucumber which enhanced better quality fruits as observed by Kameshwari *et al*. (2011) in ridge gourd.

4.2.5 Total sugar (%)

The data regarding total sugar of fruit as influenced soil and foliar supplementation of nitrogen, boron and salicylic acid and varied from 2.42 to 5.54 per cent (Table 16). The similar ranges of total sugar of fruit also found by Anuja and Poovizhi (2010) and Ghayal (2016) in cucumber.

Application of recommended dose of fertilizer (135:60:30 kg ha^{-1}) + foliar spray of nitrogen through urea (1%) + soil application of boron through borax @ 2 kg ha^{-1}+ foliar spray of salicylic acid (0.2%) (i.e. treatment T_9) recorded the maximum total sugar (5.54 %) which was significantly superior over rest of the treatments.

In case boron application, the foliar spray of boric acid 0.5% (T_4) recorded the significant higher values compared with the soil application of borax @ 2 kg ha^{-1} (T_5) indicating thereby the superiority of foliar over the soil application.

The treatment T_2 i.e. application of recommended dose of fertilizer and treatment T_{10} i.e. RDF+ Amrashakti @ 2% were at par with each other at harvest. Several workers have also suggested that foliar feeding of nutrients directly to the site of metabolism as a substitute for or supplement to soil application noticeably improved fruit yield and quality attributes (Samra and Arora, 1977; Singh *et al.*, 1994).

Table 16. Effect of soil and foliar application of nutrients on total sugar

Treat code	Treatments	Total sugar (%)
T_1	Control (No Fertilizer)	2.41
T_2	Recommended Dose of Fertilizer 135:60:30 NPK kg ha^{-1}	2.62
T_3	RDF+ Foliar spray of Urea (1%)	3.35
T_4	RDF+ Foliar spray of Boric acid (0.5%)	3.64
T_5	RDF+ Soil application of Borax @ 2 kg ha^{-1}	3.25
T_6	RDF+ Foliar spray of Salicylic acid (0.2%)	3.65
T_7	RDF+ Foliar spray of Boric acid (0.5%) + Foliar spray of Salicylic acid (0.2%)	4.55
T_8	RDF+ Foliar spray of Urea (1%) + Foliar spray of Boric acid (0.5%) + Foliar spray of Salicylic acid (0.2%)	4.79
T_9	RDF+ Foliar spray of Urea (1%) + Soil application of Borax @ 2 kg ha^{-1}+ Foliar spray of Salicylic acid (0.2%)	5.54
T_{10}	RDF+ Amrashakti @ 2%	2.96
	S.E. $\pm$	**0.169**
	C.D. (P=0.05)	**0.502**

Jadhav (2018) reported that the increase in sugars and different fractions of sugars might be due to nutrient combination augmented the conversion of starch to sugar and it has also been increases transportation of sugars, synthesis of metabolites and rapid translocation of photosynthates and minerals from other parts of the plant to developing fruits.

4.3 : Effect of soil and foliar supplementation of nitrogen, boron and salicylic acid on nutrient content of cucumber

4.3.1 Total nitrogen (%)

The nitrogen content of leaf significantly affected due to the soil and foliar supplementation of nitrogen, boron and salicylic acid and varied from 0.72 to 1.13 per cent at 30 DAS, 0.51 per cent to 0.89 at 60 DAS and 0.39 to 0.71 per cent at harvest stage (Table 17) and indicated that the nitrogen content in plant were declined over advance growth stages from 30 DAS to harvest of the crop. The range value of nitrogen content in plant reported here are in agreement with Ghayal (2016) and Torane (2014) in cucumber.

Soil and foliar application of nitrogen, boron and salicylic acid on cucumber significantly increased the total nitrogen over the absolute control i.e. no fertilizer application. The soil and climatic conditions play a significant role in uptake and utilization of N.

Application of recommended dose of fertilizer (135:60:30 kg ha^{-1}) + foliar spray of nitrogen through urea (1%) + soil application of boron through borax @ 2 kg ha^{-1}+ foliar spray of salicylic acid (0.2%) (i.e. treatment T_9) recorded the highest nitrogen content at all growth stages (i.e. 1.13 % at 30 DAS, 0.89 % at 60 DAS and 0.71 % at harvest stage) was significantly superior over all treatments at 30 DAS while it was found to be at par with the treatment T_8 at 60 DAS and at harvest.

In case boron application, the foliar spray of boric acid 0.5% (T_4) recorded the significant higher values compared with the soil application of borax @ 2 kg ha^{-1} (T_5) indicating thereby the superiority of foliar over the soil application.

In general, application of RDF (T_2) increased phosphorus content in plant over control (T_1), which further increased with the combined application of RDF + foliar spray of Urea @ (1%) (T_3). The treatment T_2 i.e. application of recommended dose of fertilizer and treatment T_{10} i.e. RDF+ Amrashakti @ 2% were at par with each other at growth stages Fritz (1978) pointed out that a repeated application of small units of foliar fertilizers stimulates plant metabolism and an increased nutrient uptake via the roots can be observed. It was concluded that the absorption of urea by the leaves of most crops is greater and faster than that of inorganic nitrogen forms. This phenomenon is related to the fact that the cuticular membrane is 10 to 20 times more permeable to urea than to inorganic ions (Wojcik, 2004).

Table 17. Effect of soil and foliar application of nutrients on total nitrogen content in plant of cucumber

Treat code	Treatments	Total Nitrogen (%)		
		30 DAS	60 DAS	At Harvest
T_1	Control (No Fertilizer)	0.72	0.51	0.39
T_2	Recommended Dose of Fertilizer 135:60:30 NPK kg ha^{-1}	0.80	0.55	0.47
T_3	RDF+ Foliar spray of Urea (1%)	0.97	0.80	0.61
T_4	RDF+ Foliar spray of Boric acid (0.5%)	0.96	0.65	0.57
T_5	RDF+ Soil application of Borax @ 2 kg ha^{-1}	0.94	0.65	0.56
T_6	RDF+ Foliar spray of Salicylic acid (0.2%)	0.89	0.65	0.56
T_7	RDF+ Foliar spray of Boric acid (0.5%) + Foliar spray of Salicylic acid (0.2%)	0.96	0.78	0.58
T_8	RDF+ Foliar spray of Urea (1%) + Foliar spray of Boric acid (0.5%) + Foliar spray of Salicylic acid (0.2%)	1.03	0.84	0.67
T_9	RDF+ Foliar spray of Urea (1%) + Soil application of Borax @ 2 kg ha^{-1}+ Foliar spray of Salicylic acid (0.2%)	1.13	0.89	0.71
T_{10}	RDF+ Amrashakti @ 2%	0.84	0.56	0.52
	S.E. $\pm$	**0.025**	**0.021**	**0.019**
	C.D. (P=0.05)	**0.076**	**0.065**	**0.057**

It can be seen from the data that N content in leaf gradually decrease with fruit development irrespective of the different foliar spray, which could be consequence of ion translocation to the developing fruit (Bezerra *et al.,* 2007 and Harishukumar *et al.,* 1980).

In general, it was observed that total nitrogen content in leaves was increased at 30 DAS; later on it was declined at 60 DAS and harvest stage. This might be due to the use of N content by plant for flowering and fruiting of cucumber.

Plants consist of three principal organs, roots, stem and leaves. Nitrogen is primarily absorbed from roots and leaves. Further, process of photosynthesis also occurs in leaves. They also involve in nitrogen (N) assimilation by reduction of NO_3 and NH_4 into amino acids which are building block of proteins. Third major organ of plants is stem that connects roots and leaves and encourages shoot. Plant has two physiological pathways for transportation of energy, xylem (vessels) and the phloem (tubes). Soil applied N (nutrient) are move from the roots to leaves in the process of xylem (drink to up) after absorption of roots, while foliar applied N are transported from leaves to roots by the process of phloem (living cells) (Shah Jahan Leghari *et al.*, 2016).

Increase in N content in watermelon with increase in the dose of nitrogen has been reported earlier by number of workers (Bhosale 2016, Hegde (1989), Reuter and Robinson (1986), Bergmann, 1988 and Sevimli, 1996). Similar pattern of increase in nitrogen content in watermelon due to foliar spray of B was reported by Kadu (2015). Kuttimani and Velayutham (2011) observed increase in nitrogen uptake by green gram with the foliar spray of urea and salicylic acid.

Bonilla *et al.* (1980) observed that B deficiency and toxicity resulted in more NO^{3-}N accumulation in the sap of sugar beet due to the decrease in the activity of the N-Rase enzyme, suggesting a specific effect of B on N-Rase activity. Similarly, Shen *et al*. (1993) reported the N-Rase activity in rape plants was markedly increased with increasing N with B than without added B.

Study of Singh *et al*. (2010) indicated that a positive correlation between chlorophyll content and total N in cucumber cotyledons. Moreover, they reported that the effect of SA was more significant in absence of NO3- than in presence of nitrate. Increases in N-content, and chlorophyll content at lower concentration of SA, indicates that the acid plays a regulatory role during the biosynthesis of active photosynthetic pigments.

SA might be involved in mobilization of internal tissue NO^{3-} and chlorophyll biosynthesis to increase the functional state of the photosynthetic machinery in plants (Shi *et al*. 2006), or it may induce accumulation of α-amino levulinic acid (α-ALA) in cotyledons. Ananiev *et al*. (2004) reported increases in chlorophyll biosynthesis in excised cotyledons of *Cucurbita pepo* L. (zucchini), cv. Cocozelle in response to growth regulator. This induction may be due to the interaction of PAs with light (McClure, 1997; Hemm *et al*., 2004) producing higher rates of carbohydrate synthesis through photosynthetic activity. This is possibly due to changes in membrane organization at higher SA level or to chelation of some important elements of cellular and organelle membrane (Uzunova and Popova, 2000).

In an experiment conducted by Singh *et al.* (2010), N-content increased, when NO^{3-} was not applied. However; internal nitrate may provide an inductive concentration to NR activity at lower concentrations of SA and/or SA induced modulation of nitrogen use efficiency (NUE) in cucumber cotyledons (Singh and Singh 2008). It may be that increase in NO^{3-} assimilation was dependent on the physiological concentration (e.g. 50 μM) of SA when NO^{3-} was absent.

The significant increase in N content in plant with the application of FYM @ 15 t ha^{-1} along with RDF (from treatment T_2 to T_{10}) could be attributed to increasing availability of nutrients from manures that the organic manures after decomposition release macro and micro-nutrients to soil solution, which becomes available to the plants, resulting in higher uptake.

4.3.2 Total Phosphorus (%)

The phosphorus content of plant significantly affected due to the soil and foliar supplementation of nitrogen, boron and salicylic acid and varied from 0.159 to 0.356 per cent at 30 DAS, 0.147 per cent to 0.298 per cent at

60 DAS and 0.087 to 0.294 per cent at harvest stage (Table 18). The variations were associated with leaf age and the phonological changes of the plant over the period of fruit development (Bezzera *et al*., 2007). The data also indicated that the phosphorus content was declined with advance age of crop from 30 DAS to harvest of the crop, as the need for phosphorus is greater in the early part of growth cycle than in the latter part (Black, 1968).

Table 18. Effect of soil and foliar application of nutrients on total phosphorus content in plant of cucumber

Treat code	Treatments	Total Phosphorus (%)		
		30 DAS	60 DAS	At Harvest
T_1	Control (No Fertilizer)	0.159	0.147	0.087
T_2	Recommended Dose of Fertilizer 135:60:30 NPK kg ha^{-1}	0.232	0.148	0.176
T_3	RDF+ Foliar spray of Urea (1%)	0.261	0.171	0.195
T_4	RDF+ Foliar spray of Boric acid (0.5%)	0.284	0.220	0.204
T_5	RDF+ Soil application of Borax @ 2 kg ha^{-1}	0.272	0.217	0.201
T_6	RDF+ Foliar spray of Salicylic acid (0.2%)	0.289	0.234	0.229
T_7	RDF+ Foliar spray of Boric acid (0.5%) + Foliar spray of Salicylic acid (0.2%)	0.310	0.261	0.232
T_8	RDF+ Foliar spray of Urea (1%) + Foliar spray of Boric acid (0.5%) + Foliar spray of Salicylic acid (0.2%)	0.328	0.284	0.278
T_9	RDF+ Foliar spray of Urea (1%) + Soil application of Borax @ 2 kg ha^{-1}+ Foliar spray of Salicylic acid (0.2%)	0.356	0.298	0.294
T_{10}	RDF+ Amrashakti @ 2%	0.245	0.171	0.190
	S.E. $\pm$	**0.011**	**0.006**	**0.008**
	C.D. (P=0.05)	**0.034**	**0.020**	**0.025**

In general, application of RDF (T_2) increased phosphorus content in plant over control (T_1), which further increased with the combined application of RDF + foliar spray of urea @ 1% (T_3). The data obtained in this study concur with those of Yildirim *et al*. (2007) who showed that foliar urea applications increased P concentration in leaves of broccoli under field conditions. In addition, it was observed that foliar urea applications elevated the N and K content in lettuce (Padem and Alan, 1995), and N, K and Fe content in tomato (Alan and Padem, 1994).

Application of recommended dose of fertilizer (135:60:30 kg ha^{-1}) + foliar spray of nitrogen through urea (1%) + soil application of boron through borax @ 2 kg ha^{-1} + foliar spray of salicylic acid (0.2%) (i.e. treatment T_9) recorded the highest phosphorus content at all the growth stages (i.e. 0.356 at 30 DAS, 0.294 at 60 DAS and 0.896 at harvest stage) was found to be at par with the treatment.

In case boron application, the foliar spray of boric acid 0.5 per cent (T_4) recorded the significant higher values compared with the soil application of borax @ 2 kg ha^{-1} (T_5) indicating thereby the superiority of foliar over the soil application. The treatment T_2 i.e. application of recommended dose of fertilizer and treatment T_{10} i.e. RDF+ Amrashakti @ 2 per cent were at par with each other at 30 DAS and at harvest stage.

In general, the total phosphorus content in leaves appear to decrease with the advancement of crop growth from 30 DAS to harvest of the crop. This decrease may be due to uptake of native phosphorus translocated for metabolic activities.

Kuttimani and Velayutham (2011) observed increase in phosphorus uptake by green gram with the foliar spray of urea and salicylic acid.

In this context, Tariq and Mott (2007) noted a positive effect of B on P uptake, which altered the permeability of plasmalemma at the root surface, resulted in increased P absorption.

Pollard *et al.* (1977) found that B deficiency in corn and broad beans reduced the capacity for the absorption of phosphate, due to the reduced ATPase activity, which could be rapidly restored by the addition of B. The evidence suggested that B functions in the regulation of plant membranes and that the ATPase is a possible component of transport processes. The possible mechanisms, whereby this control is exercised, include direct interaction of B with polyhydroxy components of the membrane and the elevation of endogenous levels of auxins. Chatterjee *et al.* (1990) observed that P deficiency (i.e., soluble protein, DNA, activity of ribonuclease and increase activities of peroxidase, acid phosphatase and polyphenol oxidase) were intensified by a combined deficiency of B and P. On the other hand, decrease in (starch, sugar content, DNA, RNA and activity of ribonuclease) were aggravated by a combined excess of B and P.

There was increase in NPK content in plant due to application of salicylic acid. This may be attributed to the role of salicylic acid to stimulate plant growth, the absorption and transport of nutrients, membrane permeability, the rate of growth and photosynthesis (Basra *et al*., 2007). Add to that the salicylic acid is internal growth regulator involved in regulating physiological processes in plants, contribute to modifying activity of enzymes antioxidant, improves the process of photosynthesis, nutrient uptake, activity of phenolic antioxidants and many vital metabolic compounds (Khandaker *et al.*, 2011). Where it works as an antidote oxidative contributes to scavenge of free roots and thus protect cell membranes and thus gets the absorption and transport of nutrients better (Mady 2009), As well as the important functions in protecting the nucleic acids and protein to prevent crashes (Amanullah *et al.*, 2010).

Our results of increase in phosphorus content in plant due to foliar spray of salicylic acid coincide with those reported by Karlidag *et al*. (2009) on strawberry, Mady (2009) on tomato and Metwally *et al*. (2013) on strawberry who stated that foliar spraying of salicylic acid increased phosphorus leaf content.

The range value of phosphorus content from plant reported here are in agreement with Ghayal (2016) in cucumber variety Sheetal. Similar results were reported by Cikili *et al.* (2013) in cucumber plant in which shoot accumulation ranged from 0.11 to 0.31 per cent with application of K and B.

4.3.3 Total Potassium (%)

The potassium content of plant significantly affected due to the soil and foliar supplementation of nitrogen, boron and salicylic acid and varied from 0.188 to 0.421 per cent at 30 DAS, 0.124 to 0.189 per cent at 60 DAS and 0.081 to 0.173 per cent at harvest stage (Table 19) and indicated that the potassium content were decreased over advancement age of crop from 30 DAS to harvest of the crop. The range value of potassium content in plant reported here are in agreement with Ghayal (2016) and Cikili *et al.* (2013) in cucumber. In general, application of RDF (T_2) increased potassium content in plant over control (T_1), which further increased with the combined application of RDF + foliar spray of urea @ 1% (T_3). The data obtained in this study concur with those of Yildirim *et al*. (2007) who showed that foliar urea applications increased K concentration in leaves of broccoli under field conditions. In addition, it was observed that foliar urea applications elevated the K content in lettuce (Padem and Alan, 1995) and in tomato (Alan and Padem, 1994).

Table 19. Effect of soil and foliar application of nutrients on potassium content in plant of cucumber

Treat code	Treatments	Total Potassium (%)		
		30 DAS	60 DAS	At Harvest
T_1	Control (No Fertilizer)	0.188	0.124	0.081
T_2	Recommended Dose of Fertilizer 135:60:30 NPK kg ha^{-1}	0.236	0.128	0.117
T_3	RDF+ Foliar spray of Urea (1%)	0.303	0.147	0.138
T_4	RDF+ Foliar spray of Boric acid (0.5%)	0.343	0.147	0.145
T_5	RDF+ Soil application of Borax @ 2 kg ha^{-1}	0.244	0.140	0.134
T_6	RDF+ Foliar spray of Salicylic acid (0.2%)	0.354	0.156	0.145
T_7	RDF+ Foliar spray of Boric acid (0.5%) + Foliar spray of Salicylic acid (0.2%)	0.362	0.172	0.154
T_8	RDF+ Foliar spray of Urea (1%) + Foliar spray of Boric acid (0.5%) + Foliar spray of Salicylic acid (0.2%)	0.394	0.173	0.170
T_9	RDF+ Foliar spray of Urea (1%) + Soil application of Borax @ 2 kg ha^{-1}+ Foliar spray of Salicylic acid (0.2%)	0.421	0.189	0.173

T_{10}	RDF+ Amrashakti @ 2%	0.237	0.136	0.126
	S.E. ±	**0.009**	**0.006**	**0.005**
	C.D. (P=0.05)	**0.029**	**0.019**	**0.017**

Application of recommended dose of fertilizer (135:60:30 kg ha^{-1}) + foliar spray of nitrogen through urea (1%) + soil application of boron through borax @ 2 kg ha^{-1}+ foliar spray of salicylic acid (0.2%) (i.e. treatment T_9) recorded the highest potassium content at all growth stages (i.e. 0.421 % at 30 DAS, 0.189 % at 60 DAS and 0.173 % at harvest stage) was found to be at par with the treatments at T_8 at 30 DAS and at harvest stage while also at par with T_7 and T_8 at 60 DAS.

In case boron application, the foliar spray of boric acid 0.5% (T_4) recorded the significant higher values compared with the soil application of borax @ 2 kg ha^{-1} (T_5) indicating thereby the superiority of foliar over the soil application.

The treatment T_2 i.e. application of recommended dose of fertilizer and treatment T_{10} i.e. RDF+ Amrashakti @ 2% were at par with each other at all the periods of observations.

The decrease in K content over periods of observations might be due to uptake of potassium by the crop for metabolic activities. This trend of decrease K content from 30 DAS to harvest of the crop indicated the depletion of nutrients due to consequence mobility of potassium ions to developing fruit (Sathi *et al.*, 2010).

In this context, Tariq and Mott (2007) noted uptake of K increased with boron because of their mutual synergistic relationship. Shorrocks (1990) reported that effects of B and membrane permeability could lead to association between B and K. The stimulation of K accumulation by the ATPase proton pumps which may account for positive correlations between K and B.

Kuttimani and Velayutham (2011) observed increase in phosphorus uptake by green gram with the foliar spray of urea and salicylic acid.

Similarly; Cikili *et al.* (2013) reported that increased potassium content in leaves as increasing the application of boron along with potassium in cucumber. Tolgyesi and Kozma (1974) reported that K contents showed a highly significant positive correlation with B contents of 98 grasses at the flowering stage.

4.3.4 Total boron (mg kg^{-1})

The boron content in plant significantly affected due to the soil and foliar supplementation of nitrogen, boron and salicylic acid and varied from 26.87 to 47.72 mg kg^{-1} at 30 DAS, 27.78 to 44.48 mg kg^{-1} at 60 DAS and 20.29 to 41.27 mg kg^{-1} at harvest stage (Table 20) and indicated that the boron content were decreased with advance stage of crop from 30 DAS to harvest of the crop, which may be attributed to the dilution effect of dry matter production. Boron is relatively immobile in plants and frequently the B content increase from the lower to the upper plant parts (Wilkinson, 1957).

Table 20. Effect of soil and foliar application of nutrients on Boron content in plant of cucumber

Treat code	Treatments	Total Boron (mg kg^{-1})		
		30 DAS	60 DAS	At Harvest
T_1	Control (No Fertilizer)	26.87	27.78	20.29
T_2	Recommended Dose of Fertilizer 135:60:30 NPK kg ha^{-1}	31.34	28.47	25.10
T_3	RDF+ Foliar spray of Urea (1%)	37.68	31.62	28.13
T_4	RDF+ Foliar spray of Boric acid (0.5%)	38.33	34.66	32.10
T_5	RDF+ Soil application of Borax @ 2 kg ha^{-1}	33.09	31.25	28.02
T_6	RDF+ Foliar spray of Salicylic acid (0.2%)	32.78	29.59	26.39
T_7	RDF+ Foliar spray of Boric acid (0.5%) + Foliar spray of Salicylic acid (0.2%)	38.84	35.63	33.03
T_8	RDF+ Foliar spray of Urea (1%) + Foliar spray of Boric acid (0.5%) + Foliar spray of Salicylic acid (0.2%)	39.25	41.24	40.97
T_9	RDF+ Foliar spray of Urea (1%) + Soil application of Borax @ 2 kg ha^{-1}+ Foliar spray of Salicylic acid (0.2%)	47.72	44.48	41.27

T_{10}	RDF+ Amrashakti @ 2%	32.99	30.35	26.59
	S.E. ±	**0.94**	**1.13**	**3.07**
	C.D. (P=0.05)	**2.80**	**3.35**	**9.14**

The lowest values of boron content in plant were observed in control treatment (T_1), where there was no addition of RDF as well as FYM. Further the close scrutiny of the data indicated that there was increase in boron content in plant in the treatment T_2, T_3, T_4, T_5, T_6 ,T_7 ,T_8, and T_{10} where there was no application of boron through soil and only the RDF along with FYM @ 15 t ha^{-1} was applied. This signifies the role of organic matter in the availability of boron content in soil. In this connection, Das (2007) explained that in addition to the effect that organic matter can have on complexing boron, it is one of the main sources of boron in acid soils. Application of organic materials to soils can raise substantially the concentration of boron in plants.

Application of recommended dose of fertilizer (135:60:30 kg ha^{-1}) + foliar spray of nitrogen through urea (1%) + soil application of boron through borax @ 2 kg ha^{-1}+ foliar spray of salicylic acid (0.2%) (i.e. treatment T_9) recorded the highest boron content at all growth stages (i.e. 0.421 at 30 DAS, 0.189 at 60 DAS and 0.175 at harvest stage) where treatment T_9 was found significantly superior over all treatment at 30 DAS and was found to be at par with the treatments T_8 at 60 DAS and with T_7 and T_8 at harvest.

In case boron application, the foliar spray of boric acid 0.5% (T_4) recorded the significant higher values compared with the soil application of borax @ 2 kg ha^{-1} (T_5) indicating thereby the superiority of foliar over the soil application method. In fact, it was determined that foliar fertilization does not replace soil-applied fertilizer completely, but it does increase the uptake and hence the efficiency of the nutrients applied to the soil (Yildirim *et al*., 2007).

The treatment T_2 i.e. application of recommended dose of fertilizer and treatment T_{10} i.e. RDF+ Amrashakti @ 2% were at par with each other at all the periods of observations.

The increase in boron content at pre-flowering stage in cucumber leaves may be due to foliar spray of nutrients and due to translocation of boron from soil to leaves through absorption by plant. While, it steadily decreased up to harvest stage might be due to requirement of boron in larger amount by plant during reproductive stages for germination of pollen grains and elongation of tubes and hormone movement during flowering, fruiting, fruit setting, sugar translocation and fruit quality.

Devi *et al.* (2012) reported that boron uptake by soybean was influenced by boron application, which may be due to the increase in level of boron. In lateritic soils of Konkan, Kadam (2016) also observed that increasing level of boron increased the boron content in the okra fruits. Savkare (2018) determined the critical limit of boron with the help of threshold yield (Yield at 0 kg B ha^{-1} application), plateau yield (Yield at 6 kg B ha^{-1} application) and Bray's per cent yield (threshold yield plateau $yield^{-1}$ x100) and found 68 mg kg^{-1} as the critical limit of boron for okra grown in soils of Konkan region.

4.4 : Effect of soil and foliar supplementation of nitrogen, boron and salicylic acid on physico-chemical properties and nutrient status of soil

Physico-chemical properties of soil :

4.4.1 Soil pH

The soil pH at various observational periods ranged from 4.68 to 5.21 at 30 DAS, 5.18 to 5.44 at 60 DAS and 5.13 to 5.70 at harvest stage (Table 21). The pH of lateritic soils of Konkan region ranged from 4.75 to 6.50 (Anonymous 1990). The data indicated that the soils are acidic in nature. The acidic nature of soils might be attributed to leaching of soluble salts due to heavy precipitation.

The data further indicated that the application of soil and foliar application of nitrogen, boron and salicylic acid did not influence significantly on pH of the soil at various growth stages. Numerically the highest soil pH (5.21) was noted in treatment T_9 (i.e. RDF + foliar spray of nitrogen through urea @ 1% + soil application of boron through borax @ 2 kg ha^{-1}+ Foliar spray of salicylic acid @ 0.2%) at 30 DAS; while at 60 DAS and at harvest treatment T_7 (RDF+ foliar spray of boric acid (0.5%) + foliar spray of salicylic acid (0.2%) recorded the highest pH value 5.44 and 5.70, respectively.

In general, the soil pH appears to increase with the advancement of crop from 30 to 60 DAS irrespective of the treatment without any specific trend of increase or decrease was observed at harvest.

Table 21. Effect of soil and foliar application of nutrients on pH of soil

Treat code	Treatments	pH		
		30 DAS	60 DAS	At Harvest
T_1	Control (No Fertilizer)	5.05	5.41	5.13
T_2	Recommended Dose of Fertilizer 135:60:30 NPK kg ha^{-1}	5.11	5.18	5.09
T_3	RDF+ Foliar spray of Urea (1%)	4.68	5.28	5.34
T_4	RDF+ Foliar spray of Boric acid (0.5%)	4.92	5.07	5.26
T_5	RDF+ Soil application of Borax @ 2 kg ha^{-1}	4.98	5.29	5.09
T_6	RDF+ Foliar spray of Salicylic acid (0.2%)	4.80	5.12	5.42
T_7	RDF+ Foliar spray of Boric acid (0.5%) + Foliar spray of Salicylic acid (0.2%)	5.08	5.44	5.70
T_8	RDF+ Foliar spray of Urea (1%) + Foliar spray of Boric acid (0.5%) + Foliar spray of Salicylic acid (0.2%)	4.88	5.17	5.39
T_9	RDF+ Foliar spray of Urea (1%) + Soil application of Borax @ 2 kg ha^{-1}+ Foliar spray of Salicylic acid (0.2%)	5.21	5.32	5.15
T_{10}	RDF+ Amrashakti @ 2%	4.92	5.17	5.39
	S.E. $\pm$	**0.156**	**0.124**	**0.139**
	C.D. (P=0.05)	**NS**	**NS**	**NS**

In lateritic soils of Konkan, Kadu (2015) also reported non-significant effect of foliar spray of boron on soil pH applied to water melon. Kadam (2016) observed non-significant effect of boron on soil pH applied through fortified briquettes to okra. Similarly, Savkare (2018) noted non-significant effect of different levels of boron (i.e.0, 2, 4 and 6 kg B ha^{-1}) applied to three different types of soils i.e. low, medium and high in boron content on soil pH. Further, non-significant effect of foliar application of Urea and Amrashakti on soil pH was stated by Jadhav (2018) and Palsande (2011).In lateritic soils of Konkan, Kadu (2015) also reported non-significant effect of foliar spray of boron on soil pH applied to water melon. Kadam (2016) observed non-significant effect of boron on soil pH applied through fortified briquettes to okra. Similarly, Savkare (2018) noted non-significant effect of different levels of boron (i.e.0, 2, 4 and 6 kg B ha^{-1}) applied to three different types of soils i.e. low, medium and high in boron content on soil pH. Further, non-significant effect of foliar application of Urea and Amrashakti on soil pH was stated by Jadhav (2018) and Palsande (2011).

The mechanism responsible for this increased in soil pH was due to ion exchange reactions which occur when terminal OH- of Al or Fe^{2+} hydroxyl oxides are replaced by organic anions, which are decomposed products of the manure such as malate, citrate and tartarate (Eshoo and Bell, 1992; Pocknee and Summer, 1997 and Hue and Amiens, 1989).

The increase in pH of acid soil due to addition of organic manures is attributed to the deactivation of Fe^{3+} and concomitant release of basic cations during their decomposition (Lal and Mathur 1988).

4.4.2 Electrical conductivity (EC) (dS m^{-1})

The data pertaining to electrical conductivity of the soil as affected by soil and foliar application of nitrogen, boron and salicylic acid ranged from 0.13 to 0.29 dS m^{-1} at 30 DAS, 0.08 to 0.26 dS m^{-1} at 60 DAS and 0.06 to

0.14 dS m^{-1} at harvest stage (Table 21). In general, lateritic soils are free from soluble salt due to high rainfall (Anonymous, 1990).

The data further indicated that the application of soil and foliar application of nitrogen, boron and salicylic acid did not influence significantly on EC of the soil at various observational periods. Numerically the highest soil EC (0.29 dS m^{-1}) was noted in treatment T_5 (i.e. RDF+ Soil application of Borax @ 2 kg ha^{-1}) at 30 DAS; while at 60 DAS and at harvest treatment T_9 (RDF + foliar spray of nitrogen through urea @ 1% + soil application of boron through borax @ 2 kg ha^{-1}+ foliar spray of salicylic acid @ 0.2% recorded the highest EC value 0.26 dS m^{-1} and 0.14 dS m^{-1}, respectively.

Table 22. Effect of soil and foliar application of nutrients on electrical conductivity of soil

Treat. code	Treatments	EC (dS m^{-1})		
		30 DAS	60 DAS	At Harvest
T_1	Control (No Fertilizer)	0.14	0.15	0.06
T_2	Recommended Dose of Fertilizer 135:60:30 NPK kg ha^{-1}	0.13	0.14	0.12
T_3	RDF+ Foliar spray of Urea (1%)	0.15	0.21	0.10
T_4	RDF+ Foliar spray of Boric acid (0.5%)	0.17	0.08	0.12
T_5	RDF+ Soil application of Borax @ 2 kg ha^{-1}	0.29	0.10	0.09
T_6	RDF+ Foliar spray of Salicylic acid (0.2%)	0.20	0.20	0.06
T_7	RDF+ Foliar spray of Boric acid (0.5%) + Foliar spray of Salicylic acid (0.2%)	0.15	0.17	0.07
T_8	RDF+ Foliar spray of Urea (1%) + Foliar spray of Boric acid (0.5%) + Foliar spray of Salicylic acid (0.2%)	0.17	0.25	0.07
T_9	RDF+ Foliar spray of Urea (1%) + Soil application of Borax @ 2 kg ha^{-1}+ Foliar spray of Salicylic acid (0.2%)	0.28	0.26	0.14
T_{10}	RDF+ Amrashakti @ 2%	0.26	0.21	0.08
	S.E. ±	**0.14**	**0.15**	**0.06**
	C.D. (P=0.05)	**NS**	**NS**	**NS**

No specific trend of increase or decrease in EC due to soil and foliar application of nitrogen, boron and salicylic acid were observed at various observational periods. In general, the electrical conductivity of the soil decreased at harvest of the crop over to 30 DAS irrespective of the treatments. This decrease may, probably, be due to partial washing away of the salts from the surface soil, besides uptake of the minerals by the plants.

In the present investigation, the soils showed slight increase due to the application of FYM @ 15 t ha^{-1} along with RDF during the period of study with the exception of T_2 at 30 DAS and T_2, T_4 and T_5 at 60 DAS which might be due to the possible built up of the soluble nutrient drawn from manures on mineralization.

In lateritic soils of Konkan, Kadu (2015) also reported non-significant effect of foliar spray of boron applied to water melon on EC of soil. Kadam (2016) observed non-significant effect of boron on EC applied through fortified briquettes to okra. Similarly, Savkare (2018) noted non-significant effect of different levels of boron (i.e.0, 2, 4 and 6 kg B ha^{-1}) applied to three different types of soils i.e. low, medium and high in boron content on EC. Further, non-significant effect of foliar application of Urea and Amrashakti on EC was stated by Jadhav (2018) and Palsande (2011). Mondal *et al*. (1991) and De *et al*. (1994) studied the relationship of B with various soil properties and found negative correlation with EC of the soil.

4.4.3 Organic Carbon (g kg^{-1})

The data pertaining to organic carbon of the soil as affected by soil and foliar application of nitrogen, boron and salicylic acid ranged from 17.41 to 19.26 g kg^{-1} at 30 DAS, 16.93 to 18.72 g kg^{-1} at 60 DAS and 15.21 to 18.07 g kg^{-1} at harvest stage (Table 23). The ranges indicated that the organic carbon in the soil was in “very high range” as per the ranges proposed by Bangar and Zende (1978). These figures are in conformity with reported earlier (Anonymous, 1990 and Diwale, 1994). In general, the data indicated that the organic carbon content of the soil decreased from 30 DAS to 60 DAS (except T_4 at 60 DAS) and from 60 DAS to harvest of the crop (except T_8 at harvest). This is probably due to the decomposition of applied and native organic matter.

The data further indicated that the application of soil and foliar application of nitrogen, boron and salicylic acid did not influence significantly on organic carbon of the soil at various growth stages of crop. But, the application of FYM @ 15 t ha^{-1} (from treatment T_2 to T_{10}) numerically increased the organic carbon in the soil. Numerically the highest organic carbon of soil (19.26 g kg^{-1}) was noted in treatment T_9 (i.e. RDF+ Foliar spray of urea @ (1%) + Soil application of borax @ 2 kg ha^{-1}+ Foliar spray of salicylic acid @ (0.2%) at 30 DAS; while in treatment T_2 (i.e. Recommended Dose of Fertilizer 135:60:30 NPK kg ha^{-1}) at 60 DAS and at harvest treatment. No specific trend of increase or decrease in organic carbon due to soil and foliar application of nitrogen, boron and salicylic acid were observed at various growth stages of crop. In general, lower values of organic carbon were noted at harvest compared to 30 DAS.

Table 23. Effect of soil and foliar application of nutrients on organic carbon content of soil

Treat code	Treatments	Organic carbon (g kg^{-1})		
		30 DAS	60 DAS	At Harvest
T_1	Control (No Fertilizer)	17.41	16.93	15.21
T_2	Recommended Dose of Fertilizer 135:60:30 NPK kg ha^{-1}	18.98	18.72	18.07
T_3	RDF+ Foliar spray of Urea (1%)	18.59	18.20	16.37
T_4	RDF+ Foliar spray of Boric acid (0.5%)	17.67	17.68	17.16
T_5	RDF+ Soil application of Borax @ 2 kg ha^{-1}	18.59	17.28	17.02
T_6	RDF+ Foliar spray of Salicylic acid (0.2%)	18.85	17.75	16.01
T_7	RDF+ Foliar spray of Boric acid (0.5%) + Foliar spray of Salicylic acid (0.2%)	17.54	17.03	16.88
T_8	RDF+ Foliar spray of Urea (1%) + Foliar spray of Boric acid (0.5%) + Foliar spray of Salicylic acid (0.2%)	17.81	17.19	17.60

T_9	RDF+ Foliar spray of Urea (1%) + Soil application of Borax @ 2 kg ha^{-1}+ Foliar spray of Salicylic acid (0.2%)	19.26	18.59	17.16
T_{10}	RDF+ Amrashakti @ 2%	17.42	18.46	16.38
	S.E. $\pm$	**0.77**	**0.62**	**0.84**
	C.D. (P=0.05)	**NS**	**NS**	**NS**

In lateritic soils of Konkan, Kadu (2015) also reported non-significant effect of foliar spray of boron on organic carbon applied to water melon. Kadam (2016) observed non-significant effect of boron on organic carbon applied through fortified briquettes to okra. Similarly, Savkare (2018) noted non-significant effect of different levels of boron (i.e.0, 2, 4 and 6 kg B ha^{-1}) applied to three different types of soils i.e. low, medium and high in boron content on organic carbon. Mondal *et al*. (1991) and De *et al*. (1994) studied the relationship of B with various soil properties and found negative correlation with organic carbon of the soil.

Nutrient status of soil :

4.4.4 Available Nitrogen (kg ha^{-1})

Available nitrogen content in soil was significantly affected due to the soil and foliar supplementation of nitrogen, boron and salicylic acid and varied from 229.42 to 371.20 kg ha^{-1} at 30 DAS, 246.03 to 357.64 kg ha^{-1} at 60 DAS and 189.17 to 293.74 kg ha^{-1} at harvest stage (Table 21) indicating fertility rating from ‘low’ to ‘medium’ (Bangar and Zende, 1978). The range value of available nitrogen from soil reported here are in agreement with Ghayal (2016), Gite (2018), Kadu (2015) and Bhosale (2016) in lateritic soils. The content of available nitrogen in lateritic soil ranges from low to moderately high and the values vary between 149.0 to 674.0 kg ha^{-1} (Anonymous, 1990).

Application of N through RDF along with the addition of FYM @ 15 t ha^{-1} either alone or in combination with the soil and foliar application of nitrogen, boron and salicylic acid (from treatment T_2 to T_{10}) significantly increased available nitrogen over the absolute control i.e. no fertilizer application (T_1). Significantly highest available nitrogen i.e. 371.20 kg ha^{-1} at 30 DAS, 357.64 at 60 DAS and 293.74 kg ha^{-1} at harvest stage was recorded in treatment T_9 with the application of recommended dose of fertilizer (135:60:30 kg ha^{-1}) + foliar spray of nitrogen through urea (1%) + Soil application of boron through Borax @ 2 kg ha^{-1}+ foliar spray of salicylic acid (0.2%) which was found to be at par with the treatments T_5 at all growth stages of crop.

Thus, the soil application of borax @ 2 kg ha^{-1} in the treatments T_9 and T_5 recorded the significant higher values of available nitrogen in the soil indicating thereby the role of boron in increasing the available nitrogen in soil.

Table 21. Effect of soil and foliar application of nutrients on available nitrogen of soil

Treat code	Treatments	Available Nitrogen (kg ha^{-1})		
		30 DAS	60 DAS	At Harvest
T_1	Control (No Fertilizer)	229.42	246.03	189.17
T_2	Recommended Dose of Fertilizer 135:60:30 NPK kg ha^{-1}	328.81	344.54	277.54
T_3	RDF+ Foliar spray of Urea (1%)	324.38	300.71	264.02
T_4	RDF+ Foliar spray of Boric acid (0.5%)	314.41	274.56	250.51
T_5	RDF+ Soil application of Borax @ 2 kg ha^{-1}	361.42	348.06	287.39
T_6	RDF+ Foliar spray of Salicylic acid (0.2%)	319.35	281.24	263.72
T_7	RDF+ Foliar spray of Boric acid (0.5%) + Foliar spray of Salicylic acid (0.2%)	265.40	250.36	221.76
T_8	RDF+ Foliar spray of Urea (1%) + Foliar spray of Boric acid (0.5%) + Foliar spray of Salicylic acid (0.2%)	305.64	260.21	256.51
T_9	RDF+ Foliar spray of Urea (1%) + Soil application of Borax @ 2 kg ha^{-1}+ Foliar spray of Salicylic acid (0.2%)	371.20	357.64	293.74
T_{10}	RDF+ Amrashakti @ 2%	255.38	253.82	209.27
	S.E. ±	**4.26**	**3.97**	**4.11**
	C.D. (P=0.05)	**12.67**	**11.80**	**12.22**

Further data indicated that the available nitrogen from soil was decreased with advancement of crop growth from 30 DAS to harvest of the crop (except T_1 and T_2 at 60 DAS). This decrease may be attributed to the fact that lateritic soils are percolative in nature and there are probable N losses due to leaching and denitrification under field conditions, besides uptake by plants. The similar trend of decrease of N in lateritic soil was also reported by Thorbole (2002) and Shinde (2008).

In general, the data indicated that the soil having high organic matter content showed high available N. The increase in organic matter may be due to accumulation of leaf litter fall during the period of fruit development as the numbers of leaves were enhanced with foliar spray over the control. Organic matter mineralization provides a continuous, although limited, supply of plant available N, in addition to P and S (Tisdale *et al*., 1995).

4.4.5 Available Phosphorus (P_2O_5) (kg ha^{-1})

Available phosphorus from soil was significantly affected due to the soil and foliar supplementation of nitrogen, boron and salicylic acid and varied from 11.15 to 19.97 kg ha^{-1} at 30 DAS, 10.72 to 18.39 kg ha^{-1} at 60 DAS and 9.92to 15.12 kg ha^{-1} at harvest stage (Table 25). The available P_2O_5 content in lateritic soils ranges from 0.35 to 74.14 kg ha^{-1} with an average of 14.14 kg ha^{-1} (Anonymous, 1990).

The preponderance of less active (reductant phosphorus and occluded phosphorus) and inactive (residual phosphorus) phosphorus fractions over active phosphorus fractions, dominance of iron phosphorus over aluminum phosphorus, low concentration of solid phosphorus and high phosphorus fixing capacity of soils are some of the important reasons for low phosphorus availability in lateritic soils of Konkan (Dongale, 1989 and Anonymous, 1990). Phonde (1987) reported that the average phosphorus fixing capacity of lateritic soil was higher (94.99 %) than that of medium black soils (77.05 %).

Further, data indicated that the available phosphorus from soil was decreased over the periods of observations from 30 DAS to harvest of the crop. The range value of available phosphorus from soil reported here are in agreement with Gite (2018), Kadu (2015) and Bhosale (2016).

Application of phosphorus through RDF along with the addition of FYM @ 15 t ha^{-1} either alone or in combination with the soil and foliar application of nitrogen, boron and salicylic acid (from treatment T_2 to T_{10}) significantly increased available phosphorus over the absolute control i.e. no fertilizer application (T_1). The increased in phosphorous availability might be also due to synergistic effect of N with phosphorus which increased the availability of P in the soil (Shrivastava, 2002).

Table 25. Effect of soil and foliar application of nutrients on available phosphorus (P_2O_5) in soil

Treat code	Treatments	Available Phosphorus (kg ha^{-1})		
		30 DAS	60 DAS	At Harvest
T_1	Control (No Fertilizer)	11.15	10.72	9.92
T_2	Recommended Dose of Fertilizer 135:60:30 NPK kg ha^{-1}	17.03	16.01	13.36
T_3	RDF+ Foliar spray of Urea (1%)	17.05	15.22	12.75
T_4	RDF+ Foliar spray of Boric acid (0.5%)	14.47	12.82	11.29
T_5	RDF+ Soil application of Borax @ 2 kg ha^{-1}	18.24	16.28	14.44
T_6	RDF+ Foliar spray of Salicylic acid (0.2%)	16.50	13.49	10.41
T_7	RDF+ Foliar spray of Boric acid (0.5%) + Foliar spray of Salicylic acid (0.2%)	13.23	11.05	10.05
T_8	RDF+ Foliar spray of Urea (1%) + Foliar spray of Boric acid (0.5%) + Foliar spray of Salicylic acid (0.2%)	13.72	12.10	10.49
T_9	RDF+ Foliar spray of Urea (1%) + Soil application of Borax @ 2 kg ha^{-1}+ Foliar spray of Salicylic acid (0.2%)	19.97	18.39	15.12
T_{10}	RDF+ Amrashakti @ 2%	13.12	11.17	9.92
	S.E. ±	**0.73**	**0.65**	**0.50**
	C.D. (P=0.05)	**2.17**	**1.93**	**1.49**

Significantly highest available phosphorus i.e. 19.97 kg ha^{-1} at 30 DAS, 18.39 kg ha^{-1} at 60 DAS and 15.12 kg ha^{-1} at harvest stage was recorded in treatment T_9 application of recommended dose of fertilizer (135:60:30 kg ha^{-1}) + foliar spray of nitrogen through urea (1%) + Soil application of boron through borax @ 2 kg ha^{-1}+ foliar spray of salicylic acid (0.2%) which was significantly superior over rest of all treatments at 60 DAS; while was at par with T_5 at 30 DAS and at harvest. Among other treatments, T_2 and T_3 were at par with each other at 30 DAS and at harvest; while T_2, T_3 and T_5 were at par with each other at 60 DAS.

Thus, the soil application of borax @ 2 kg ha^{-1} in the treatments T_9 and T_5 recorded the significant higher values of available phosphorus in the soil indicating thereby the role of boron in increasing the available phosphorus in soil. Graded increase in available P_2O_5 content of soil with the graded doses of boron applied through briquettes in lateritic soil of Konkan was also reported by Kadam (2016). Mondal *et al*. (1991) and De *et al*. (1994) studied the relationship of B with various soil properties and found positive correlation with available phosphorus in the soil.

Further, the available P_2O_5 content of soil irrespective of treatments gradually declined in all the treatment at crop maturity, it may be due to the uptake of P_2O_5 by plants which usually takes place intensively after flowering (Barbatzkii, 1959). Singh and Singh (1975) reported that phosphorous availability decreased with time during incubation due to fixation. Further, organic matter mineralization provides a continuous, although limited, supply of plant available P (Tisdale *et al*., 1995).

4.4.7 Available Potassium (K_2O) (kg ha^{-1})

Available potassium from soil was significantly affected due to the soil and foliar supplementation of nitrogen, boron and salicylic acid and varied from 233.22 to 356.89 kg ha^{-1} at 30 DAS, 225.91 to 341.11 kg ha^{-1} at 60 DAS and 120.85 to 310.30 kg ha^{-1} at harvest stage (Table 26) indicating fertility rating from ‘low’ to ‘high’ (Bangar and Zende, 1978). The data also indicated that the available potassium from soil was decreased over the periods of observations from 30 DAS to harvest of the crop. The range value of available potassium from soil reported here are in agreement with Savkare (2018), Gite (2018), Kadu (2015) and Bhosale (2016). The available K_2O content in lateritic soils ranges from 11 to 1152 kg ha^{-1} with an average of 226 kg ha^{-1} (Anonymous, 1990).

Application of potassium through RDF along with the addition of FYM @ 15 t ha^{-1} either alone or in combination with the soil and foliar application of nitrogen, boron and salicylic acid (from treatment T_2 to T_{10}) significantly increased available potassium over the absolute control i.e. no fertilizer application (T_1). The increased in potassium availability might be also due to synergistic effect of N with potassium which increased the availability of K in the soil (Shrivastava, 2002).

Table 26. Effect of soil and foliar application of nutrients on available potassium (K_2O) in soil

Treat code	Treatments	Available Potassium (kg ha^{-1})		
		30 DAS	60 DAS	At Harvest
T_1	Control (No Fertilizer)	233.22	225.91	120.85
T_2	Recommended Dose of Fertilizer 135:60:30 NPK kg ha^{-1}	336.77	273.86	264.70
T_3	RDF+ Foliar spray of Urea (1%)	258.24	251.64	219.17
T_4	RDF+ Foliar spray of Boric acid (0.5%)	267.77	252.44	256.82
T_5	RDF+ Soil application of Borax @ 2 kg ha^{-1}	348.30	322.50	299.09
T_6	RDF+ Foliar spray of Salicylic acid (0.2%)	284.53	275.47	261.43
T_7	RDF+ Foliar spray of Boric acid (0.5%) + Foliar spray of Salicylic acid (0.2%)	254.48	244.78	197.34
T_8	RDF+ Foliar spray of Urea (1%) + Foliar spray of Boric acid (0.5%) + Foliar spray of Salicylic acid (0.2%)	325.73	292.63	286.92
T_9	RDF+ Foliar spray of Urea (1%) + Soil application of Borax @ 2 kg ha^{-1}+ Foliar spray of Salicylic acid (0.2%)	356.89	341.11	310.30

T_{10}	RDF+ Amrashakti @ 2%	250.44	233.46	159.01
	S.E. ±	**3.90**	**8.85**	**4.04**
	C.D. (P=0.05)	**11.59**	**26.29**	**12.02**

Significantly highest available potassium i.e. 356.89 kg ha^{-1} at 30 DAS, 341.11 kg ha^{-1} at 60 DAS and 310.30 kg ha^{-1} at harvest stage was recorded in treatment T_9 application of recommended dose of fertilizer (135:60:30 kg ha^{-1}) + foliar spray of nitrogen through urea (1%) + Soil application of boron through borax @ 2 kg ha^{-1}+ Foliar spray of salicylic acid (0.2%) which was found to be at par with the treatments T_5 at 30 DAS, 60 DAS and at harvest stage.

Thus, the higher values of available potassium in soil were noted with the soil application of borax @ 2 kg ha^{-1} in treatments T_9 and T_5 thereby indicating the role of boron in increasing the available potassium in soil. Graded increase in available K_2O content of soil with the graded doses of boron applied through briquettes in lateritic soils of Konkan was also reported by Kadam (2016); Mondal *et al*. (1991) and De *et al*. (1994) studied the relationship of B with various soil properties and found positive correlation with available potassium in the soil.

In addition, available K tended to decline with time irrespective of different treatments. This decrease in K_2O content may probably attributed to leaching of soluble K fractions and removal of solutions K^+ by crop (Tisdale *et al*., 1995).

4.4.6 Hot water extractable Boron (mg kg^{-1})

Hot water extractable boron in soil was significantly affected due to the soil and foliar supplementation of nitrogen, boron and salicylic acid and varied from 0.231 to 0.426 mg kg^{-1} at 30 DAS, 0.204 to 0.400 mg kg^{-1} 60 DAS and 0.197 to 0.378 mg kg^{-1} at harvest stage (Table 27). The range value of hot water extractable boron reported here are in agreement with Kadu (2015) and Savkare (2018).

Das (2007) reported that the ability of clay minerals to adsorb boron has been found to be highest in micaceous type illite clay minerals closely followed by montmorillonite clay minerals, whereas kaolinite has the lowest boron adsorption capacity. The laterite and lateritic soils of Ratnagiri and Sindhudurg district of Konkan are dominant in kaolinite clay (Anonymous, 1990).

Qertli and Grgurevic (1975) explained that boric acid is the form of boron that plant roots absorb most efficiently. Because of its non-ionic nature once boron is released from soil minerals it can be leached from the soil fairly rapidly. This explains why soil in high rainfall areas is often deficient in boron (Gupta, 1979).

Further, Das (2007) also reported that boron availability is decreased under dry soil conditions. So boron deficiency is often associated with dry weather and low soil moisture condition and this behaviour may be related to restricted release of boron from organic complexes and to impaired ability of plants to extract boron from soil due to lack of moisture in root zone. Although boron levels in soil may be high, low soil moisture impairs transport of boron to absorbing root surfaces.

Table 27. Effect of soil and foliar application of nutrients on available boron in soil

Treat code	Treatments	Hot water extractable Boron (mg kg^{-1})		
		30 DAS	60 DAS	At Harvest
T_1	Control (No Fertilizer)	0.231	0.204	0.197
T_2	Recommended Dose of Fertilizer 135:60:30 NPK kg ha^{-1}	0.269	0.242	0.238
T_3	RDF+ Foliar spray of Urea (1%)	0.287	0.260	0.240
T_4	RDF+ Foliar spray of Boric acid (0.5%)	0.238	0.211	0.202
T_5	RDF+ Soil application of Borax @ 2 kg ha^{-1}	0.394	0.367	0.355
T_6	RDF+ Foliar spray of Salicylic acid (0.2%)	0.247	0.227	0.237
T_7	RDF+ Foliar spray of Boric acid (0.5%) + Foliar spray of Salicylic acid (0.2%)	0.290	0.263	0.244

T_8	RDF+ Foliar spray of Urea (1%) + Foliar spray of Boric acid (0.5%) + Foliar spray of Salicylic acid (0.2%)	0.335	0.308	0.288
T_9	RDF+ Foliar spray of Urea (1%) + Soil application of Borax @ 2 kg ha^{-1}+ Foliar spray of Salicylic acid (0.2%)	0.426	0.400	0.378
T_{10}	RDF+ Amrashakti @ 2%	0.242	0.220	0.219
	S.E. $\pm$	**0.03**	**0.03**	**0.03**
	C.D. (P=0.05)	**0.11**	**0.11**	**0.10**

Application of RDF along with the soil and foliar application of nitrogen, boron and salicylic acid on cucumber (from treatment T_2 to T_{10}) significantly increased available boron over the absolute control i.e. no fertilizer application (treatment T_1). Significantly highest available boron i.e.0.426 mg kg^{-1} at 30 DAS, 0.400 mg kg^{-1} at 60 DAS and 0.378 mg kg^{-1} at harvest stage was recorded in treatment T_9 application of recommended dose of fertilizer (135:60:30 kg ha^{-1}) + foliar spray of nitrogen through urea (1%) + Soil application of boron through borax @ 2 kg ha^{-1}+ Foliar spray of salicylic acid (0.2%) which was at par with T_5 and T_8 at all observational periods.

The treatment T_2 i.e. application of recommended dose of fertilizer and treatment T_{10} i.e. RDF+ Amrashakti @ 2% were at par with each other at all the periods of observations.

The data also indicated that the hot water extractable boron was decreased over the periods of crop growth from 30 DAS to harvest of the crop. The decrease boron content in plant may be attributed to the dilution effect of dry matter production. The availability of boron decrease sharply under drought conditions, possible because of both a decrease in B mobility by mass flow to the roots and polymerization of boric acid (Das, 2007).

The lowest values of hot water soluble boron was observed in control treatment ($T_{1)}$ where there was no addition of RDF as well as FYM. Further the close scrutiny of the data indicated that there was increase in boron content of soil in the treatment $T_{2,}$ $T_{3,}$ T_4, $T_{5,}$ T_6 ,T_7 ,$T_{8,}$ and T_{10} where there was no application of boron through soil application, but the RDF along with FYM @ 10 t ha^{-1} was only applied. This signifies the role of organic matter in the availability of boron content in soil. In this connection, Das (2007) explained that in addition to the effect that organic matter can have on complexing boron, it is one of the main sources of boron in acid soils. Application of organic materials to soils can raise substantially the concentration of boron in plants. Berger and Pratt (1963) reported that a large part of the total boron in soils was associated with organic matter in tightly bound form. However this boron can be released to soil solution in forms available to plants by microbial activities. Olsen and Berger (1946) also found that oxidation of soil organic matter resulted in a significant release of boron in forms available to plants by microbial activities.

Boron concentration in the soil solution is controlled by B adsorption reactions. These reactions restrict the amount of water-soluble B available for plant uptake, because plants respond directly to the B concentration in soil solution and only indirectly to the amount of B attached to soil surfaces. Thus, the soil adsorption complex acts as both a source and a sink for dissolved B (Keren and Bingham, 1985).

In the present investigation, the soil application of boron recorded the higher values of hot water extractable boron content in soil with the soil application of borax @ 2 kg ha^{-1} in treatments T_9 and T_5. Graded increase in hot water extractable boron in soil with the graded doses of boron applied through briquettes in lateritic soils of Konkan was also reported by Kadam (2016). Savkare (2018) also observed increase in hot water extractable boron content in soil with the increasing levels of boron (i.e.0, 2, 4 and 6 kg B ha^{-1}) applied to three different types of soils i.e. low, medium and high in boron content.

In this context, Lal and Rao (1954) reported that B serves to regulate the accumulation of ions even from nutrient solutions. Similarly, Santra *et al*. (1989) reported that B not only functions within the plant but also in the nutrient medium, thereby affecting the intake of nutrients. These results suggest that B may also serve to regulate or retard the availability of ions from soils. Bartlett and Picarelli (1973) observed that applied B along with lime lowered the Al and Mn concentration to a greater extent than with lime alone of acid soil. Moreover, Belvins (1995) reported that higher than normal levels of B would alleviate Al toxicity, specifically by increasing the root growth of plants. These studies show that B may help in the amelioration of soil acidity and counteract the Al toxicity in acid soils. In the literature, there is considerable disagreement between those who have worked with plants grown in soils and those who used sand or solution culture techniques. In sand culture studies, Mozafar (1989) reported that with increasing B levels the concentration of plant nutrients were changed in the leaves as well as in the roots of maize plants. While, in soil studies, Miller and Smith (1977) reported that applied B did not consistently affect the concentration of elements in tips, upper and lower leaves, upper and lower stem of alfalfa plants. It is clear from the reported conflicting statements of the investigators, that B effects on the behavior of nutrients vary depending on crop species or genotypes, plant part analyzed, various growth stages and the use of different types of growth media.

Mills and Jones (1996) studied on cucumber and suggested that a critical value of boron for optimum cucumber growth was 25-85 mg kg^{-1}. Jena *et al.* (2009) observed that the available B content in post-harvest soil decreased from 0.63 ppm (initial value) to 0.47 ppm in B_0 treatments. With application of B @ 1-2 kg ha^{-1}, the available B content remained between 0.61 to 0.62 ppm which was lower than the initial available B content. Savkare (2018) determined the critical limit of boron with the help of threshold yield (Yield at 0 kg B ha^{-1} application), plateau yield (Yield at 6 kg B ha^{-1} application) and Bray's per cent yield (threshold yield plateau yield^{-1} x100) and found 0.52 mg kg^{-1} of available boron as the critical limit for okra grown in soil in Konkan region.

CHAPTER V

SUMMARY AND CONCLUSION

A field study, namely, "Effect of soil and foliar supplementation of nitrogen, boron and salicylic acid on quality, yield and nutrient content of cucumber *(Cucumis sativus* L.) and on nutrient status of alfisols of Konkan" was undertaken at Education and Research Farm of Department of Agril. Botany, Dr. B.S Konkan Krishi Vidyapeeth, Dapoli during summer 2018, where the effect of different treatments on yield and quality of cucumber as well as periodical soil and plant samples collected at 30 DAS, 60 DAS and at harvest of the crop were studied. The field experiment was laid out in Randomized Block Design where the effect of soil and foliar supplementation of nitrogen, boron and salicylic acid either alone or in combinations applied along with the recommended dose of fertilizers (135:60:30 NPK kg ha^{-1}) and an absolute control (to judge the fate of native nutrients) comprising ten treatments and three periods of observations (30 DAS, 60 DAS and at harvest of the crop) with three replications.

The important findings evolved from the present investigation are summarized below:

5.1 : Effect of soil and foliar supplementation of nitrogen, boron and salicylic acid on growth parameters of cucumber

5.1.1.1 Vine length

The vine length of cucumber varied from 29.27 cm to 93.23 cm at 30 DAS, 73.53 cm to 274.80 cm at 60 DAS and 131.33 cm to 407.00 cm at harvest and indicated that the vine length increased over the periods of observations from 30 DAS to harvest of the crop.

Application of recommended dose of fertilizer (135:60:30 kg ha^{-1}) + foliar spray of nitrogen through urea (1%) + soil application of boron through borax @ 2 kg ha^{-1}+ foliar spray of salicylic acid (0.2%) (i.e. treatment T_9) recorded the highest vine length at all growth stages of crop (i.e. 93.23 cm at 30 DAS, 274.80 cm at 60 DAS and 407.00 cm at harvest) and was found to be at par with the treatments T_2, T_6, T_7 and T_8 at 30 DAS, while it was at par with T_8 at 60 DAS and at harvest.

5.1.1.2 Number of branches Vine^{-1}

The number of branches of cucumber varied from 1.00 to 2.73 at 30 DAS, 4.24 to 13.17 at 60 DAS and 5.99 to 14.22 at harvest stage and indicated that the vine length increased over the periods of observations from 30 DAS to harvest of the crop.

Application of recommended dose of fertilizer (135:60:30 kg ha^{-1}) + foliar spray of nitrogen through urea (1%) + soil application of boron through borax @ 2 kg ha^{-1}+ foliar spray of salicylic acid (0.2%) (i.e. treatment T_9) recorded the maximum number of branches at all growth stages (i.e. 2.73 at 30 DAS, 4.24 at 60 DAS and 5.99 at harvest stage). Treatment T_9 was found to be at par with the treatments T_2, T_3, T_4, T_5, T_6, T_7, T_8, T_9 and T_{10} at 30 DAS also at par with the treatments T_3, T_4, T_5, T_6, T_7, T_8 at 60 DAS and at harvest stage

5.1.2.1 Number of fruits vine^{-1}

The number of fruits per vine of ranges from 1.29 to 7.00 and indicated that the number of fruits per vine increased over the periods of observations from 30 DAS to harvest of the crop.

Application of recommended dose of fertilizer (135:60:30 kg ha^{-1}) + foliar spray of nitrogen through urea (1%) + soil application of boron through borax @ 2 kg ha^{-1}+ foliar spray of salicylic acid (0.2%) (i.e. treatment T_9) recorded the highest number of fruits per vine (7.00). Treatment T_9 was found to be at par with the treatments T_3, T_4, T_5, T_6, T_7 and T_8.

5.1.2.2 Weight of fruit vine^{-1} (kg)

The weight of fruit per vine ranges from 0.49 to 1.98. Application of recommended dose of fertilizer (135:60:30 kg ha^{-1}) + foliar spray of nitrogen through urea (1%) + soil application of boron through borax @ 2 kg ha^{-1}+ foliar spray of salicylic acid (0.2%) (i.e. treatment T_9) recorded the maximum weight of fruit per vine (1.98 kg) which was at par with the treatment T_3, T_4, T_5, T_6, T_7 and T_8.

5.1.2.3 Fruit yield q ha^{-1}

The fruit yield varied from 58.53 to 231.22 q ha^{-1} under summer season. Application of recommended dose of fertilizer (135:60:30 kg ha^{-1}) + foliar spray of nitrogen through urea (1%) + soil application of boron through borax @ 2 kg ha^{-1}+ foliar spray of salicylic acid (0.2%) (i.e. treatment T_9) recorded the maximum fruit yield (231.22 q ha^{-1}), which was at par with the treatment T_7 and T_8.

5.2 : Effect of soil and foliar supplementation of nitrogen, boron and salicylic acid on quality parameters of cucumber

5.2.1 Moisture (%)

The moisture percentage of fruit varied from 95.75 to 98.64 per cent. Moisture percentage of fruit showed non-significant results.

5.2.2 Total soluble solids (T.S.S) ^{0}Brix

The total soluble solids of varied from 1.667 to 2.167 ^{0}Brix. Application of recommended dose of fertilizer (135:60:30 kg ha^{-1}) + foliar spray of nitrogen through urea (1%) + soil application of boron through borax @ 2 kg ha^{-1}+ foliar spray of salicylic acid (0.2%) (i.e. treatment T_9) recorded the maximum total soluble solids (2.16 ^{0}Brix) which was at par with the treatment T_6, T_7 and T_8.

5.2.3 Titratable Acidity (%)

The titratable acidity of fruit varied from 0.08 to 0.31 per cent. Application of recommended dose of fertilizer (135:60:30 kg ha^{-1}) + foliar spray of nitrogen through urea (1%) + soil application of boron through borax @ 2 kg ha^{-1}+ foliar spray of salicylic acid (0.2%) (i.e. treatment T_9) recorded the highest titratable acidity (0.309 %) which was at par with the treatment $T_{6,}$ T_7 and $T_{8.}$

5.2.4 Reducing sugar (%)

The reducing sugar of fruit varied from 0.724 to 1.053 per cent. Application of recommended dose of fertilizer (135:60:30 kg ha^{-1}) + foliar spray of nitrogen through urea (1%) + soil application of boron through borax @ 2 kg ha^{-1}+ foliar spray of salicylic acid (0.2%) (i.e. treatment T_9) recorded the maximum reducing sugar (1.053 %) which was significantly superior over all treatments.

5.2.5 Total sugar (%)

The total sugar of fruit varied from 2.42 to 5.54 per cent. Application of recommended dose of fertilizer (135:60:30 kg ha^{-1}) + foliar spray of nitrogen through urea (1%) + soil application of boron through borax @ 2 kg ha^{-1}+ foliar spray of salicylic acid (0.2%) (i.e. treatment T_9) recorded the maximum total sugar (5.54 %) which was significantly superior over all treatments.

5.3 : Effect of soil and foliar supplementation of nitrogen, boron and salicylic acid on nutrient content of cucumber

5.3.1 Total Nitrogen (%)

The nitrogen content of plant ranges from 0.72 to 1.13 per cent at 30 DAS, 0.51 per cent to 0.89 at 60 DAS and 0.39 to 0.71 per cent at harvest stage. The nitrogen content in plant was declined over the periods of observations from 30 DAS to harvest of the crop.

Application of recommended dose of fertilizer (135:60:30 kg ha^{-1}) + foliar spray of nitrogen through urea (1%) + soil application of boron through borax @ 2 kg ha^{-1}+ foliar spray of salicylic acid (0.2%) (i.e. treatment T_9) recorded the highest nitrogen content at all the periods of observations (i.e. 1.13 % at 30 DAS, 0.89 % at 60 DAS and 0.71 % at harvest stage) was significantly superior over all treatments at 30 DAS while it was found to be at par with the treatment T_8 at 60 DAS and at harvest.

5.3.2 Total Phosphorus (%)

The phosphorus content of plant varied from 0.159 to 0.356 per cent at 30 DAS, 0.147 per cent to 0.298 per cent at 60 DAS and 0.087 to 0.294 per cent at harvest stage. The phosphorus content in plant was declined over the periods of observations from 30 DAS to harvest of the crop.

Application of recommended dose of fertilizer (135:60:30 kg ha^{-1}) + foliar spray of nitrogen through urea (1%) + soil application of boron through borax @ 2 kg ha^{-1}+ foliar spray of salicylic acid (0.2%) (i.e. treatment T_9) recorded the highest phosphorus content at all the periods of observations (i.e. 0.356 at 30 DAS, 0.294 at 60 DAS and 0.896 at harvest stage) was found to be at par with the treatments at T_8 at all periods of observation.

5.3.3 Total Potassium (%)

The potassium content of plant varied from 0.188 to 0.421 per cent at 30 DAS, 0.124 to 0.189 per cent at 60 DAS and 0.081 to 0.173 per cent at harvest stage. The potassium content in plant was declined over the periods of observations from 30 DAS to harvest of the crop.

Application of recommended dose of fertilizer (135:60:30 kg ha^{-1}) + foliar spray of nitrogen through urea (1%) + soil application of boron through borax @ 2 kg ha^{-1}+ foliar spray of salicylic acid (0.2%) (i.e. treatment T_9) recorded the highest potassium content at all the periods of observations (i.e. 0.421 % at 30 DAS, 0.189 % at 60 DAS and 0.173 % at harvest stage) was found to be at par with the treatments at T_8 at 30 DAS and at harvest stage while also at par with T_7 and T_8 at 60 DAS.

5.3.4 Total Boron (mg kg^{-1})

The boron content in plant varied from 26.87 to 47.72 mg kg^{-1} at 30 DAS, 27.78 to 44.48 mg kg^{-1} at 60 DAS and 20.29 to 41.27 mg kg^{-1} at harvest stage. The boron content in plant was declined over the periods of observations from 30 DAS to harvest of the crop.

Application of recommended dose of fertilizer (135:60:30 kg ha^{-1}) + foliar spray of nitrogen through urea (1%) + soil application of boron through borax @ 2 kg ha^{-1}+ foliar spray of salicylic acid (0.2%) (i.e. treatment T_9) recorded the highest boron content at all the periods of observations (i.e. 0.421 at 30 DAS, 0.189 at 60 DAS and 0.175 at harvest stage) where treatment T_9 was found significantly superior over all treatment at 30 DAS and was found to be at par with the treatments T_8 at 60 DAS and with T_7 and T_8 at harvest.

5.4 : Effect of soil and foliar supplementation of nitrogen, boron and salicylic acid on nutrient status of soil

5.4.1 Soil pH

The soil pH at various observational periods ranged from 4.68 to 5.21 at 30 DAS, 5.18 to 5.44 at 60 DAS and 5.13 to 5.70 at harvest stage, but the pH of soil did not influence significantly due to different treatments at all growth stages of crop.

5.4.2 Electrical conductivity (EC) (dS m^{-1})

The electrical conductivity of the soil showed non-significant effect of soil and foliar application of nitrogen, boron and salicylic acid which ranged from 0.13 to 0.29 dS m^{-1} at 30 DAS, 0.08 to 0.26 dS m^{-1} at 60 DAS and 0.06 to 0.14 dS m^{-1} at harvest stage.

5.4.3 Organic carbon (%)

The organic carbon content in soil showed non-significant effect of soil and foliar application of nitrogen, boron and salicylic acid which ranged from 17.41 to 19.26 g kg^{-1} at 30 DAS, 16.93 to 18.72 g kg^{-1} at 60 DAS and 15.21 to 18.07 g kg^{-1} at harvest stage.

5.4.4 Available Nitrogen (kg ha^{-1})

Available nitrogen content in soil varied from 229.42 to 371.20 kg ha^{-1} at 30 DAS, 246.03 to 357.64 kg ha^{-1} at 60 DAS and 189.17 to 293.74 kg ha^{-1} at harvest stage. The available nitrogen from soil was decreased over the periods of observations from 30 DAS to harvest of the crop.

Significantly highest available nitrogen i.e. 371.20 kg ha^{-1} at 30 DAS, 357.64 at 60 DAS and 293.74 kg ha^{-1} at harvest stage was recorded in treatment T_9 with the application of recommended dose of fertilizer (135:60:30 kg ha^{-1}) + foliar spray of nitrogen through urea (1%) + soil application of boron through borax @ 2 kg ha^{-1}+ foliar spray of salicylic acid (0.2%) which was found to be at par with the treatments T_5 at all observational periods.

5.4.5 Available Phosphorus (P_2O_5) (kg ha^{-1})

Available nitrogen from soil was significantly affected due to the soil and foliar supplementation of nitrogen, boron and salicylic acid and varied from 11.15 to 19.97 kg ha^{-1} at 30 DAS, 10.72 to 18.39 kg ha^{-1} at 60 DAS and 9.92to 15.12 kg ha^{-1} at harvest stage. The available phosphorus from soil was decreased over the periods of observations from 30 DAS to harvest of the crop.

Significantly highest available phosphorus i.e. 19.97 kg ha^{-1} at 30 DAS, 18.39 kg ha^{-1} at 60 DAS and 9.92 to 15.12 kg ha^{-1} at harvest stage was recorded in treatment T_9 application of recommended dose of fertilizer (135:60:30 kg ha^{-1}) + foliar spray of nitrogen through urea (1%) + Soil application of boron through borax @ 2 kg ha^{-1}+ foliar spray of salicylic acid (0.2%) which was significantly superior over rest of all treatments at 60 DAS; while was at par with T_5 at 30 DAS and at harvest. Among other treatments, T_2 and T_3 were at par with each other at 30 DAS and at harvest; while T_2, T_3 and T_5 were at par with each other at 60 DAS.

5.4.6 Available Potassium (K_2O) (kg ha^{-1})

Available potassium from soil varied from 233.22 to 356.89 kg ha^{-1} at 30 DAS, 225.91 to 341.11 kg ha^{-1} at 60 DAS and 120.85 to 310.30 kg ha^{-1} at harvest stage. The available potassium from soil was decreased over the periods of observations from 30 DAS to harvest of the crop.

Significantly highest available potassium i.e. 356.89 kg ha^{-1} at 30 DAS, 341.11 kg ha^{-1} at 60 DAS and 310.30 kg ha^{-1} at harvest stage was recorded in treatment T_9 application of recommended dose of fertilizer (135:60:30 kg ha^{-1}) + foliar spray of nitrogen through urea (1%) + Soil application of boron through borax @ 2 kg ha^{-1}+ Foliar spray of salicylic acid (0.2%) which was found to be at par with the treatments T_5 at 30 DAS, 60 DAS and at harvest stage.

5.4.7 Hot water extractable boron (mg kg^{-1})

Hot water extractable boron in soil was significantly affected due to the soil and foliar supplementation of nitrogen, boron and salicylic acid and varied from 0.231 to 0.426 mg kg^{-1} at 30 DAS, 0.204 to 0.400 mg kg^{-1} 60 DAS and 0.197 to 0.378 mg kg^{-1} at harvest stage. The Hot water extractable boron from soil was decreased over the periods of observations from 30 DAS to harvest of the crop.

Significantly highest available boron i.e.0.426 mg kg^{-1} at 30 DAS, 0.400 mg kg^{-1} at 60 DAS and 0.378 mg kg^{-1} at harvest stage was recorded in treatment T_9 application of recommended dose of fertilizer (135:60:30 kg ha^{-1}) + foliar spray of nitrogen through urea (1%) + Soil application of boron through borax @ 2 kg ha^{-1}+ Foliar spray of salicylic acid (0.2%) which was at par with T_5 and T_8 at all observational periods.

CONCLUSIONS :

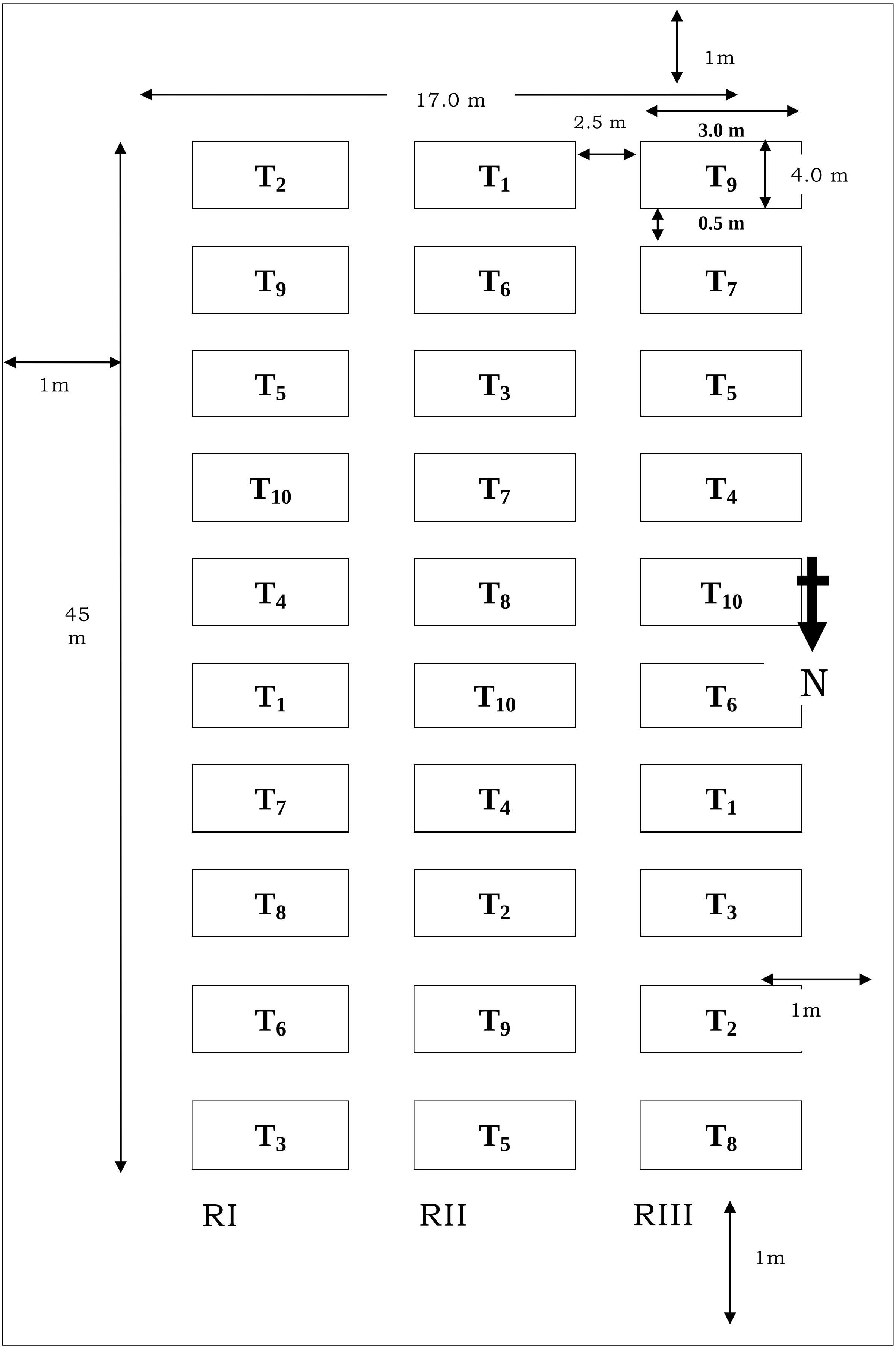
On the basis of data obtained from the present investigation, the following conclusions may be drawn:

- The growth parameters *viz.*, vine length and number of branches; yield parameters *viz.*, number fruits vine^{-1} and weight fruit vine, fruit yield of cucumber of variety Sheetal; quality parameters of cucumber *viz.*, TSS, reducing sugar, total sugar and titratable acidity as well as nitrogen, phosphorus, potassium and boron content in plants, the application of recommended dose of fertilizer (135:60:30 kg ha^{-1}) + foliar spray of nitrogen through urea (1%) + soil application of boron through borax @ 2 kg ha^{-1}+ foliar spray of salicylic acid (0.2%) had recorded the highest favourable parameters, which was at par with the treatment of RDF+ foliar spray of urea (1%) + foliar spray of boric acid (0.5%) + foliar spray of salicylic acid (0.2%) in most of the parameters.
- Application of recommended dose of fertilizer (135:60:30 kg ha^{-1}) + foliar spray of Nitrogen through urea (1%) + soil application of boron through borax @ 2 kg ha^{-1}+ foliar spray of salicylic acid (0.2%) resulted in significant increase in available nitrogen, available phosphorus, available potassium and hot water soluble boron content in soils indicating buildup of soil fertility.

Thus, considering growth and yield of cucumber, quality of fruit, nutrient content in plant and soil available nutrient status, application of recommended dose of fertilizer (135:60:30 kg ha^{-1}) + foliar spray of nitrogen through urea (1%) + soil application of boron through borax @ 2 kg ha^{-1}+ foliar spray of salicylic acid (0.2%) was found to be superior and beneficial in lateritic soils of Konkan from the view point of getting higher fruit yields and maintaining the soil fertility.

The data being preliminary in nature, needs further confirmation.

Fig. 1. Layout plan of the field experiment



LITERATURE CITED

Abdulwahed M. S., Aqeel H. A. and Rawaa H. H. (2012). Effect of spray by ascorbic and salicylic acid on some physiological properties of the local sour orange seedling *Citrus aurantium* L., *J. of Thi Qar Univ. for Agric. Research,* **1**(2): 43 – 55, (In Arabic)

Aghaeifard F., Babalar M., Fallahi E., Ahmadi A., (2015). Influence of humic acid and salicylic acid on yield, fruit quality, and leaf mineral elements of strawberry (*Fragaria ananassa duch*.) cv. Camarosa. - *J. Plant Nutr*., 39(13): 1821-1829.

Ahmad, S., R. Ahmad, M.Y. Ashraf, M. Ashraf and E.A. Waraich, (2009). Sunflower (*Helianthus annuus*L.) response to drought stress at germination and seedling growth stages. *Pak. J. Botany*, **41**(2): 647-654.

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.

Alessandra Aparecida de Sá and Paulo Roberto Ernani (2016) Boron Leaching Decreases with Increases on Soil pH. *Rev Bras Cienc Solo*; v**40**:e0150008

AL-Naeime S. N. A., Principles of plant nutrition, AL-Mousel Univ., Iraq, 2000. (In Arabic)

Amanullah M. M., S. Sekar and S. Vincent (2010). Plant growth substances in crop production, A Review. *Asian J. of Plant Sci.,* **9** (4):215-222,

Amra Ram, Verma Pooja, BR Gadi (2014). Effect of Fluoride and Salicylic Acid on seedling growth and Biochemical Parameters of Watermelon *(Citrullus lanatus).Research report Fluoride* **47(1):**49-55

Ananieva, E.A., K.N. Christov and L.P. Popova (2004). Exogenous treatment with salicylic acid leads to increased antioxidant capacity in leaves of barley plants exposed to paraquat. *J. Plant Physiol***.,** **161**: 319-328.

Anonymous (1990) *Soils* Research bulletin-2, Published by Directorate of Research, Konkan Krishi Vidyapeeth, Dapoli (M.S.).

Anuja S. and K Kalai Poovizhi (2010) Effect of soil and foliar application of organic nutrients on yield and quality of cucumber cv. Long green.*Veg Sci* **37**(1): 91-93

Atilla Dursun Metin Turan, Melek Ekinci, Adem Gunes, nizamettin Ataoglu, Aslihan Esringü, and Ertan Yildirim (2010). Effects of Boron fertilizer on Tomato, Pepper, and Cucumber yields and chemical composition. *Communications in Soil Science and Plant Analysis*, **41**:1576–1593

Babaeian, M., M. Heidari and Ghanbari, A. (2010). Effect of water stress and foliar micronutrient application on physiological characteristics and nutrient uptake in sunflower *(Helianthus annus* L.), *Iranian J. Crop Sciences* **12**(4): 377-391

Bal, E. and S. Celik (2010). The effects of postharvest treatments of salicylic acid and potassium permanganate on the storage of kiwifruit. *Bulgarian J. Agric. Sci*., **16** (5): 576-584

Baloch GS. (2012). Effect of nitrogen and phosphorus on the growth and productivity of bottle gourd, *Lagenaria siceraria* Mal. M.Sc. Thesis submitted to Sindh Agriculture University Tandojam.

Banger, A.R. and Zende, G.K. (1978). Soil Testing: A new basis for efficient fertilizer use. *Journal of Maharashtra Agricultural University* **3**(2): 81-84.

Baqer Challab Hadi AL-Rubaye and Emad Abd Atia (2016). The influence of foliar sprays on the growth and yield of summer squash. International Journal of Scientific & Engineering Research, Volume **7**, Issue 6

Barbatzkii, S (1959). Lupin, "Izdatel' Stvo Literaturi" Publishers, MoscowCited from Turkov N. S. (1970). Ed. "Fiziologia cel' skokhozaistvennykh" Rastenii, Vol. **VI**, Moscow State University Publication, Moscow (In Russian), pp. 183

Barkosky, R.R. and F.A. Einhellig (1993). Effects of salicylic acid on plant water relationship. *J. Chem. Ecol*., **19:** 237-247.

Bartlett, R.J. and C.J. Picarelli, (1973). Availability of boron and phosphorus as affected by liming an acid potato soil. *Soil Sci*., **116:** 77-83.

Basavarajeswari CP, Hosamni RM, Ajjappalavara PS, Naik BH, Smitha RP and Ukkund (2008). Effect of foliar application of micronutrients on growth, yield components of tomato (*Lycopersicon esculentum* Mill). *Karnataka Journal of Agricultural Sciences* **21(3):** 428-430.

Basra S. M. A., M. Farooq, H. Rehman and B. A. Saleem, (2007). Improving the germination and early seedling growth in melon (*Cucumis melo* L.) by pre-sowing Salicylic acid treatments. *International J. of Agric. and Biology,* **09(**4):550 – 554

Belvins, D.G., (1995). Boron and Soil Acidity: Aluminium Toxicity and Boron Deficiency. In: Boron in Agriculture, Shorrocks, V.M. (Ed.). Borax Consolidated Ltd., London, SW., 1P. 1HT. pp: 2-3.

Berger, K. C. and P. F. Pratt (1963). In: Fertilizer Technology and Usage (M.H. McVickar, G. L Bridger and L.B. Nelson, eds.) pp. 287-340. *Soil sci. Soc. Am., Madison,* Wisconsin. USA.

Berger, K.C. and Troug, E. (1939) Boron determination in soils and plants. *Indian Eng. Anal. Ed.* **11**: 540-545.

Bergmann (1988). Entstehung Visuelle and Analytische Diagnose, *Gustav Fischer Verlag.* Stuttgart, 378

Bezerra, M. A., Claudivan, F. de Lacerda, Eneas Gomes Filho., Carlos E.B. de Abreu and Josh, T.Prisco. (2007). Physiology plant grown under Adverse condition. *Beaz.J. plant physiol***., 19** (4): 449-461.

Bhattacharjee, J. C., Deshmukh, P.L., Kalbande, A. R. and Vaidya, G.S. (1978). Report on detailed survey of Konkan Krishi Vidyapeeth. Dapoli, District-Ratnagiri, Maharashtra. Report No. 409 (ICAR). N.B.S.S. and L.U.P., ICAR, New Delhi.

Bhosale, A.R. (2016) Effect of graded levels of nitrogen and potassium on yield and quality of watermelon in lateritic soils of Konkan. M.Sc. (Agri.) *Thesis* submitted to Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli.

Black, C.A (1965) *Method of Soil Analysis* Part – II. Am. Agron. Inc. Madison Wisconsin, U.S.A.pp. 1040- 41, 1374-75.

Black, C.A (1968) *Soil-Plant relationship.* Second Edition. Pp 633

Bloom, A.J., 2015. The increasing importance of distinguishing among plant nitrogen sources. Current opinion in plant biology, 25: 10-16.

Bommesh J.C., P.Iren Vethmoni, K.S.Subramanian, Kattula Nagarju, Sunil Kumar M.K. (2016) Effect of Boron levels on Growth, Flowering and yield of greenhouse cucumber. *Res.Environ.Life Sci*. **9**(8):1033-1036.

Bommesh J.C., P.Iren Vethmoni, Sunil Kumar, Kattula Nagaraju, Goudar Revati and Pandav Ajay Kumar (2017) Effect of boron levels on physiology and quality characters of greenhouse parthenocarpic Cucumber (*Cucumis sativus* L.). *Environment and Ecology* **35**(2):676-680

Bonilla, I. O. Cadahia, O. Carpena and V. Hernando, (1980). Effects of boron on nitrogen metabolism and sugar levels of sugar beet. *Plant Soil,* **57**: 3-9.

Brown, J.C., (1979). Effects of boron stress on copper enzyme activity in tomato. *J. Plant Nutr*., **1**: 39-53.

Brown, P.H., and Hu, (1996). Phloem mobility of boron in species dependent: Evidence for phloem mobility in sorbitol-rich species. *Annals of Botany* **77**: 497-505.

Chander Girish, Verma T.S and Sandeep Sharma (2007). Influence of boron and farmyard manure on available boron and exchangeable calcium and their removal by cauliflower in the boron-deficient soils of Himachal Pradesh. *Journal of the Indian society of soil science* **Vol. 55** No.1, pp 62-66

Chandra, A.,A. Anand, and A. Dubey. (2007). Effect of salicylic acid on morphological and biochemical attributes in cowpea. *J. Environ. Biol.* **28**:193-196.

Chatterjee Ranjit and Subhendu Bandyopadhyay (2017). Effect of boron, molybdenum and biofertilizers on growth and yield of cowpea (*Vigna unguiculata* L. Walp.) in acid soil of eastern Himalayan region. *Journal of the Saudi Society of Agricultural Sciences* **16**, 332–336

Chatterjee, C., P. Sinha and S.C. Agarwal (1990). Interactive effect of boron and phosphorus on growth and metabolism of maize grown in refined sand. *Can. J. Plant Sci*., **70**: 455-460.

Cikili yakup., Halil Samet., SevdaDursun.(2013). Effect of potassium content on alleviation of boron toxicity in cucumber plant (*Cucumis sativus*.L) . *Soil water journal*, **2**(1).

Cimpeanu, G., Neata, G., Teodorescu, R., Cimpeanu, C and Folea, I. (2013). Influence of fertilization system on the quality of cucumbers. Notulae Botanicae, *Horti Agro botanici*, Cluj-Napoca. **41** (1): 226-230.

Combrink NJJ, Jacobs G, Maree PCJ (1995). The effect of calcium and boron on the quality of muskmelon (*Cucumis melo* L.). *J South Afr Soc Hort Sci* **5:** 33—38.

Dabas, A.S. and P.C. Jindal (1985). *Indian J. Agric. Res.,* **19**: 40-44

Das, D.K. (2007). Micronutrients: Their Behaviour in Soils and Plants. Kalyani Publishers, New Delhi

De, B., De, S. K. and Das, D. K. (1994). *Indian Agric.* **38**: 201-205.

Dey Abir, B.S. Dwivedi, M.C. Meena, S.P. Datta and Ashok Kumar (2014). Soil Boron Fractions and Their Contribution towards Boron Availability and Uptake by Wheat on a Typic Haplustept under Long-term Fertilization. *Journal of the Indian Society of Soil Science,* Vol. 62, No**. 4**, pp 384-390

Devi K N, Singh LNK, Singh MS, Singh SB, Singh KK, (2012) Influence of sulphur and boron fertilization on yield, quality, nutrient uptake and economics of soybean (*Glycine max*) under upland conditions. *J Agricultural Science* **4**(4): 1-10.

Dipti S. Waghdhare, V.K. Kharche, Kajal A. Jadhav ,Pushpalata C. Bhosale (2008). Effect of boron application on yield and quality of tomato grown on alkaline calcareous soils. *An Asian Journal of Soil Science,* (**3**)1: 49-52

Diwale S.R. (1994). Distribution of different forms of zinc in rice soil profiles of Konkan. M.Sc. (Agri.) *Thesis* submitted to Dr. Balasaheb Sawant Konkan Krish Vidyapeeth, Dapoli.

Dongale, J.H. (1989). Phosphorus fractions in relation to P availability and the response of crops to fertilizer phosphorus in lateritic soil of Konkan. Ph.D. *Thesis* submitted to Dr. B. S. K. K. V. Dapoli, Dist. Ratnagiri (MS).

Dutta, P. and Banik, A.K. (2007). Effect of foliar feeding of nutrients and plant growth regulators on physico-chemical quality of sardar guava grown in red and lateritic tract of West Bengal. *Acta Hort*. 735: 407-411.

Edward Raja M. 2009. Importance of micronutrients in the changing horticultural scenario in India'. *J. Hortl.Sci*.**4** (1): 1-27.

Eifediyi, E.K and S.U Remison (2010). Growth and yield of cucumber (*Cucumis sativu*s L.) as influenced by farmyard manure and inorganic fertilizer. *J. of plantBreeding and crop Sci*., **2** (7):216:220.

El-Hedek, K.S (2013). Effect of foliar application of salicylic acid and potassium silicate on tolerance of wheat plants to soil salinity. *J. Soil sci. and Agric. Eng.*, Mansoura Univ., 4(3): 335-357

Elwan, M.W.M. and M.A.M. El-Hamahmy (2009). Improved productivity and quality associated with salicylic acid application in greenhouse pepper. *Scientia Horticulture*, **122:** 521-526.

Eraslan, F., A. Inal, A. Gunes and M. Alpaslan (2007). Impact of exogenous salicylic acid on the growth, antioxidant activity and physiology of carrot plants subjected to combined salinity and boron toxicity. *Sci. Hortic*., **113**: 120-128.

Eshoo, T. and Bell, L.C. (1992). Soil and solution phase changes and mungbean response during amelioration of aluminum toxicity organic matter. *Plant and Soil* **140**: 183-196.

Faten S.Abd-El-Aal, A.M. Shaheen, A.A. Ahmed and Asmaa R, Mahmoud (2010). Effect of Foliar Application of Urea And Amino acids mixtures as antioxidants on Growth, Yield and Characteristics of Squash. *Research journal of Agric. And Biological Sci.*,**6**(5):583-588.

Fritz A. (1978). Foliar fertilization-a technique for improved crop production. V. Africa Symp. *Hort. Crops. Acta Hort*., **84**: 150–161

Gedam,V. M., Patil, R. B., Suryawanshi, Y. B. and Mate, S. N. (1998). Effect of plant growth regulators and boron on flowering, fruiting and seed yield in bittergourd. *Seed Research*. **26** (1) 97-100.

Gharib, F.A. (2006). Effect of salicylic acid on the growth, metabolic activities and oil content of basil and marjoram. *International J. Agric. Biology,* **4**: 485-492.

Ghayal (2016). Effect of different organic and inorganic fertilizers on yield and quality of cucumber *(Cucumis sativus* L.) and some soil properties. M.Sc. (Agri.) *Thesis* submitted to Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli, Dist. Ratnagiri, Maharashtra (Unpublished).

Gite Varsha (2018). Effect of Integrated Nutrient Management on Yield of Bottle gourd (*Lagenaria siceraria* L.) and Soil properties in Lateritic soil of Konkan

(M.S.) M.Sc. (Agri.) *Thesis* submitted to Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli, Dist. Ratnagiri, Maharashtra (Unpublished).

Gluntsov N.M., Zabolotnova L.A., Skortsova N. K., Utkina T.N. Puzanova O.A(1989). Effect of boron on the yield of cucumber and tomato fruits. *Agrokhimiya*. **8** 75-80

Govindan, R. (1952). *Curr. Sci*., **19:** 319.

Gunes, A., A. Inal, M. Alpaslan, N. Cicek, E.G. Bagci, F. Eraslan and T. Guzelordu (2005). Effects of exogenously applied salicylic acid on the induction of multiple stress tolerance and mineral nutrition in maize (*Zea mays* L.). *Arch. Agron. Soil Sci*., **51**: 687-695.

Gupta, U. C. (1979). *Can. J, Soil sci.,* **59**: 241-247

H. Akter., Tarafder S. K, Huda A and Mahmud A. A. (2015). effect of prilled urea, urea and npk briquettes on the yield of bitter gourd in two upazillas of jessore district. *J. Environ. Sci. & Natural Resources*, **8**(1): 157-160

Haldavnekar PC, Baviskar SB, Raut RA, Munj AY, Shedge MS and Sanas MP (2018). Effect of micronutrient on yield and physico-chemical composition of alphonso mango under Konkan agro-climatic conditions. *Journal of Pharmacognosy and Phytochemistry*; **7**(5): 2447-2449

Haque, M. E.; Paul, A. K. and Sarkar, J. R. (2011). Effect of nitrogen and boron on the growth and yield of tomato *(Lycopersicon esculentum* M.) *EJBSM*, **2**: 277-282.

Harishukumar, P. H. and Nair, B. P. (1980). Seasonal fluctuation in the major nutrients component of cashew leaf tissue (*Anacafdium occidentale* L.). *Indian Cashew J*.**, 13**: 32-35.

Hayat Q., Hayat S., Irfan M., Ahmad A., (2010). - Effect of exogenous salicylic acid under changing environment: a review. - Environ*. Exper. Bot.,* **68**: 14-25.

Hegde D. M. (1989). Response of watermelon to irrigation and nitrogen *J. Maharashtra agric. Univ.*, **14**(1) 70-74

Heidarian, R., Kord, H., Khodadad, M., Amir P. L. and Mashhadi, F.b A. (2001). Investigating Fe and Zn foliar application on yield and its components of soybean (Glycine max) at different growth stages, *J. Agricultural Biotechnology and Sustainable.* **3**(9): 189 -197.

Hemerly, A., (2016). Genetic controls of biomass increase in sugarcane by association with beneficial nitrogen-fixing bacteria, In Plant and Animal Genome XXIV Conference. Plant and Animal Genome, during month of January

Hemm, M.R., Rider, S.D., Ogas, J., Murry, D.J. and Chapple, C. (2004). Light induces phenylpropanoid metabolism in Arabidopsis roots. *The Plant J.* **38**(5), 765-778.

Hossain M.A., M. jahiruddin and F. Khatun (2011). Effect of boron on yield and mineral nutrition of MUSTARD (*Brassica napus*). *Bangladesh J. Agril. Res.* 36(1): 63-73

Hue, N.V. and Amiens, I. (1989). Aluminum detoxification with green manures). Communications in Soil Science

Jackson, M.L. (1967). *Soil Chemical Analysis*, Wisconsin Prentice Hall of India Pvt. Ltd., New Delhi. pp. 46, 128, 152, 206, 283.

Jackson, M.L. (1973). *Soil chemical analysis.* Prentice Hall of India Pvt. Ltd., New Delhi.

Jadhav Sayali (2018). Effect of foliar application of nutrients on induction of vegetative flush, soil properties, nutrient concentration, yield and quality of Alphonso mango (*Mangifera indica* L.) during 2016-17. M.Sc. (Agri.) *Thesis* submitted to Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli, Dist. Ratnagiri, Maharashtra (Unpublished).

Janda, T., E. Horváth, G. Szalai and E. Páldi (2007). Role of salicylic acid in the induction of abiotic stress tolerance. In: Hayat, S., Ahmad, A. (Eds.), Salicylic Acid: A Plant Hormone. Springer. Dordrecht. Netherlands, pp. 91-150

Jat, Giriraj and Kacha, HL (2014). Response of guava to foliar application of urea and zinc on fruit set, yield and quality. *Journal of Agri Search* **1**(2): 86-91

Jatav Rajesh, Kanpure R.N. And Tiwari Rajesh (2016). Effect of foliar spray of urea and zinc sulphate on morphological, yield and quality attributes of guava (*Psidium guajava* L.) Cv. apple colour *International J. of Agri. Sci.* **8**, (58,): 3263-3268.

Javaheri, M., K. Mashayekhi, A. Dadkhah and F.Z. Tavallaee (2012). Effects of salicylic acid on yield and quality characters of tomato fruit (*Lycopersicum esculentum* Mill.). *Intl. J. Agric. Crop Sci.,* **4** (16): 1184-1187.

Jena, D., Dash, A. K., Mohanty B., Jena B. and Mukhi S. K. (2009). Interaction effect of lime and boron on cabbage-okra cropping system in boron deficient acidic laterite soils of Bhuvneshwar. *Asian J.Soil Sci.,* **4** (1):74-80

Jilani Muhammad Saleem, Abu Bakar, Kashif Waseem and Mehwish Kiran (2009). Effect of different levels of NPK on the growth and yield of Cucumber (*Cucumis sativus*) under the plastic tunnel. *Journal of Agriculture and Social Sciences* **5**:99-101

Kadam D B, Kasture M C, Dodake S B, Dhopavkar R V and Dademal A A (2017). Effect of boron and Konkan Annapurna briquettes on yield, nitrogen use efficiency and Nutrient uptake by okra (*Abelmoschus esculentus* L.) International *Journal of Chemical Studies*; **5**(3): 214-217

Kadam D. B (2016). Effect of boron and Konkan Annapurna Briquttes on yield, nitrogen use efficiency and nutrient uptake by okra (Abelmoschus esculentus (L.) M. Sc. (Ag.) *Thesis* submitted to Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli. (unpublished) (M.S) India

Kadu J B, Kasture MC, Tapkeer PB, Dhopavkar RV and MVVI Annapurna (2018). Effect of soil application of potassium and foliar spray of zinc and boron on yield, yield contributing character and quality of watermelon [*Citrullus lanatus* (thunb.)] in lateritic soils of Konkan. *International Journal of Chemical Studies*; **6**(3): 07-12

Kadu, J.B. (2015). Effect of soil application of potassium and foliar spray of zinc and boron on yield and quality of watermelon [*Citrullus lanatus* (Thunb.)]. M.Sc. (Agri.) *Thesis* submitted to Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli, Dist. Ratnagiri, Maharashtra (Unpublished).

Kaisher, M.S., Rahman, M.A., Amin, M.H.A., Amanullah, A.S.M., and Ahsanullah, A.S.M. (2010). Effects of sulphur and boron on the seed yield and protein content of mungbean. *Bangladesh Research Publications Journal*. **3:** 1181-1186.

Kameshwari, L.P., Narayanamma, M., S. Riazuddin Ahmed and Chaturvedi, A. (2011). Influence of integrated nutrient management in ridge gourd *[Luffa acutangula* (Roxb.) L.]. *Vegetable Science* **38**(2): 209-211.

Karlidag, H., E. Yildirim and M. Turan (2009). Exogenous applications of salicylic acid affect quality and yield of strawberry grown under antifrost heated greenhouse conditions. *J. Plant Nutr. Soil Sci*., **172**: 270-276

Karuppaiah P (2005). Foliar application of micronutrients on growth, flowering and yield characters of brinjal cv Annamalai. Plant Archives **5**(2): 605-608.

Keren, R. and Bingharn, F. T. (1985). Boron in water, soil and plants. *Advance in soil sci.* **1:** 229-276.

Khade V.N., Patil P.B., Jadhav S.N., Khanvilkar S.A. and Bhosale S.S. (1995). Effect of irrigation, mulch, nitrogen and potassium on fruit yield and economics of watermelon. *J. Maharashtra agric Univ*. **20**(1) 40-43.

Khan, W., B. Prithviraj and D.L. Smith (2003). Photosynthetic responses of corn and soybean to foliar application of salicylates. *J. Plant Physiol*., **160:** 485-492.

Khandaker L., A.S.M.G.M. Akond and S. Oba, (2011). Foliar application of salicylic acid improved the growth, yield and leafs bioactive compounds in red Amaranthus *(Amaranthus tricolor* L.) vegetative crops, Res. *Bulletin*, **74**: 77 – 86

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.

Kotur Shivputra C. (1997). Nitrogen – Boron interaction in Cauliflower (*Brassica oleracea* var. botrytis.) on an Alfisols. *Journal of Indian society of soil science* **45:** 519-522

Kumari S. (2012). Effect of micronutrients on quality of fruit and seed in tomato (*Solanum lycopersicum* L). *International Journal of Farm Sciences* **2**(1): 43-46.

Kundu, S.; Ghosh, B.; Mitra, S.K. and Mazumdar, D. (2007). Effect of Foliar Spraying of Nitrogen Phosphorus and Potassium on yield and fruit quality of guava (*Psidium guajava*). *Acta hort*. 735. pp. 433-440

Kuttimani R. and Velayutham A.(2011). Foliar application of nutrients enhances the yield attributes and nutrient uptake of greengram. *Agric. Sci. Digest*., **31** (3): 202 - 205

Lajurkar Vaibhav (2014). Evaluation of F_1 hybrid of cucumber (*Cucumis sativus* L) undernaturally ventilated polyhouse. MSc (Hort.) *Thesis* submitted to Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli, Dist. Ratnagiri, Maharashtra (Unpublished).

Lal, K.N. and M.S. Rao, (1954). Microelement Nutrition of Plants. 1st Edn., Plant Physiology Laboratory College of Agriculture, Banarus Hindu University, Banaras 5, India.

Lal, S. and Mathur, B.S. (1988). Effect of long term manuring fertilization and liming on crop yield and some physical properties of acid soil. *Journal of the Indian Society of Soil* Science **36**, 113-119

Lane and Eynon (1923). Determination of reducing sugar by Fehling′s solution with methylene blue as internal indicator. *J. Soc. Chem, India* **39**(3):16-20.

Latha, M.R. and Nadanassababady T. (2003). Foliar nutrition in crops. *Agric.Rev***., 24 (**3): 229-234

Leghari M.H. Mugheri A.A, Sheikh S.A., Wahocho N.A (2014). Response of nitrogen levels on the growth and yield of bottle gourd varieties. *International Journal of Agronomy and Agricultural Research* (IJAAR) Vol**. 5**, No. 6, p. 86-92

Mady, M.A. (2009). Effect of foliar application with salicylic acid and vitamin E on growth and productivity of tomato (*Lycopersicon esculentum* Mill.) plant. *J. agric. Sci. Mansoura Univ*., **34** (6): 6735-6746.

Maurya, K. R. (1987). Effect of nitrogen and boron on sex ratio, yield protein and ascorbic acid content of cucumber. *Indian J. of Horti.*,vol – **44**

Maynard, D. N. (1962). Influence of nitrogen levels on flowering and fruit set of peppers.*Amer.Soc.Hort. Sci.***10**:385-389

McClure, J.M. (1997). The physiology of phenolic compounds. *Recent Adv. Phytochem.* **12**, 525- 556.

Meena Somendra, K.D. Ameta, R.A. Kaushik, Shankar Lal Meena and Madhu Singh. (2017). Performance of Cucumber (*Cucucmis sativus* L.) as Influenced by Humic Acid and Micro Nutrients Application under Polyhouse Condition. *Int.J.Curr. Microbiol.App.Sci*. **6**(3): 1763-1767.

Meena, R. P.; Mohammed, S.and Lakhawat, S. S. (2005). Effect of foliar application of urea and zinc sulphate on fruit quality and yield of density planting system. *J. Horti. Sci.* **11** (2): 90-93.

Metwally, A.A., S.M. Youssef, S.M. El-Miniawy and M.E. Ragab (2013). effect of foliar spraying of salicylic acid on growth, yield and quality of cold stored strawberry plants. *J. Biol. Chem. Environ. Sci.,* **8** (1): 1-17

Milford G.F.J., Armstrong M.J., Jarvis P.J., Houghton B.J, Bellett-Travers D.M., Jones J., Leigh R.A. (2000). Effects of potassium fertilizer on the yield, quality and potassium off take of sugar beet crops grown on soils of different potassium status. *Journal of Agricultural Sciences*, **135**, 1-10.

Miller, R.D. and R.K. Smith, (1977). Influence of boron on other chemical elements in alfalfa. Commun. *Soil Sci. Plant Anal*., **8**: 465-478

Mills, H. A. and Jones, J.B. (1996). Plant analysis handbook II: A practical sampling, preparation, analysis and interpretation guide. Micro-macro publication. Athens.

Mohammad Ali Muthanna, Anil K. Singh, A. Tiwari, V.K. Jain and M. Padhi (2017). Effect of Boron and Sulphur Application on Plant Growth and Yield Attributes of Potato (*Solanum tuberosum* L.). *International Journal of Current Microbiology and Applied Sciences* 2319-7706 Volume **6** Number 10 pp. 399-404

Mohite K. R. (2007). Evaluation of illite types of snapmelon (*Cucumis melo.* var. momordica) under konkan region of Maharashtra. M. Sc. (Agri.) *Thesis* submitted to Dr. Balasaheb Sawant Konkan Krishi vidyapeeth, Dapoli.

Monalisa (2014). Effect of salicylic acid on growth, yield, disease pest reaction and quality of onion (*Allium cepa* l.) Msc. *thesis* submitted to Orissa university of Agriculture and Technology, Bhubaneswar.

Mondal, A.K. (1991). Ph.D thesis Department of Agricultural Chemistry and Soil Science, BCKV, Mohanpur.

Monisha Rawat (2013). Evaluation of F_1 hyrids of cucumber (*Cucumis sativus* L) for early fruit yield in polyhouse under tarai conditions of Uttarakhand. M.Sc.

Thesis submitted to Govind Ballabh Pant University of Agriculture and Technology, Pantnagar

Mostafa Heidari and Mobasri Moghadam Mohammad (2012). Effect of rate and time of nitrogen application on fruit yield and accumulation of nutrient elements in *Momordica charantia. Journal of the Saudi Society of Agricultural Sciences* **11,** 129–133

Mozafar, A., (1989). Boron effect on mineral nutrients of maize. *Agron. J*., **81**: 285-290.

Nadkarni, K. M. (1927). Indian materia medica. Nadkarni and co. Bombay, Newslett., **12**(4): 40

Naik Vaibhav (2016). Effect of different levels of fertilizer on cucumber and yield of F_1 hybrids of cucumber (*Cucumis Sativus*. L) under Konkan agroclimatic conditions. M. Sc. (Horti.) *Thesis* submitted to Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli.

Naresh Babu (2002). Response of foliar application of boron on vegetative growth, fruit yield and quality of tomato var. pusa ruby. *Indian journal of Hill Farmg* **15**(1): 109-112

Nasrollahzadeh-asl N, M. Delshad and A.K. Kashi (2015). The effects of foliar application of urea, calcium nitrate and boric acid on growth and yield of greenhouse cucumber (cv. Khassib) Biological Forum – *An International Journal* **7**(1): 712-720

Oloyede FM, Agbaje GO and IO Obisesan (2013). Effect of npk fertilizer on fruit yield and yield components of pumpkin (*Cucurbita pepo* Linn.). *African j. food nutrition and development* Volume **13**

Olsen RV, Berger KC (1946). Boron fixation as influenced by PH, organic matter content and other factors. *Soil Science Society of America Proceedings* **11:** 216-220.

Ondrašek G., Romić D., Romić M., Duralija B.,Mustač I., (2007). Strawberry growth and fruit yield in a saline environment. - *Agriculturae Conspectus Scientificus,* **71**: 155-158.

Orabi S. A., S. R. Salman, and M. A. F. Shalabya (2010). Increasing resistance to oxidative damage in cucumber (*Cucumis sativus* L.) Plants by exogenous application of Salicylic acid and Paclobutrazol, *World J. of Agric. Sci,* **6** (3): 252-259.

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

Padem H., Yildirim E. (1996). Effect of foliar fertilizer on yield and yield components of summer squash (*Cucurbita pepo* L.). 1st Egypt.-Hung. Hort. Abstr.Conf. Kafr El-Sheikh, Egypt.

Paithankar, D.H.; Sadawarte, K.T.; Mahorkar, V.K.; Dipali Deo. (2004). Effect of foliar application of boron and DAP fertilization on quality of tomato (*Lycopersicon esculentum,* Mill) *J. Soils and Crops*, **14** (1): 46-49.

Palsande Vijaykumar Narayan (2011). Effect of Urea and Potassium nitrate through foliar application along with insecticidal spray on yield, quality and nutrient content in leaves of Cashewnut var. Vengurla-4. M.Sc thesis submitted to Dr.B.S. Konkan Krishi Vidyapeeth, Dapoli.

Pandav A. K., Manoj Kumar Nalla, Aslam T., Rana, M. K. Bommesh J. C (2016). Effect of Foliar Application of Micronutrients on Growth and Yield Parameters in Eggplant cv HLB 12. *Environment & Ecology* **35** (3): 1745—1748

Panse V.G. and Sukhatme P.V. (1967). Statistical methods for Agricultural workers, ICAR, New Delhi.

Parmar, J.M., Karetha, K.M. and Rathod, P.J. (2014). Effect of foliar spray of urea and zinc on growth and flowering attributes of guava (*Psidium guajava*) cv. Bhavnagar red. *Adv. Res. J. Crop Improv,* **5** (2): 140-143.

Parr, A. J. and Loughman, B. C. (1983). Boron and membrane function in plants. In: Metals and micronutrients: Uptake and utilization by plants, 87-107, D. A. Robb & W. S. Pierpoint (Eds.), Academic Press, New York, NY, U.S.A.

Patidar D.K., Maurya I.B., Arvindakshan K., Singh P. and Meena B. (2016). Influence of boron, zinc and iron on growth and yield of cucumber under polyhouse condition. *The Ecoscan* **9** (Special Issue): 895-899.

Patidar Dharmendra Kumar, Maurya I. B, Jitendra Singh, Pravin Singh and Vikash Kumar Khatik (2017). Effect of boron, zinc, iron and their treatment combinations on growth and yield of gynoecious cucumber under polyhouse condition. 12(1): 619-618

Patil C.H., Diwan P.M., Chavan A.S. and Dongale J.H (1987). *J.Maharashtra agric. Univ*. **24**(2):130-132.

Patil YJ, Patil HM, Bodake PS, Lende NS and Patil VS (2017) Effect of soil application of boron on growth, yield and soil properties of lowland paddy. *International Journal of Chemical Studies*; **5**(5): 972-975

Patil, G.D., Patil, M.D., Adsule, R.N. and Patil, N.D. (1986). Influence of superphosphate, borax and boronated superphosphate on nutrient concentration and uptake by groundnut. *Journal of Maharashtra Agricultural Universities* **11**, 321-324.

Patil, K.D. Chavan S.A. and Gokhale N. B (2010). Present status of micronutrient research and future strategies for research in Konkan region. 9th National Symposium of ICAR, Goa. 27-30.

Phonde, D.B. (1987). Phosphorous fixation capacity as influenced by soil properties of rice soils of Konkan. M.Sc. (Agri.) *Thesis* submitted to Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli, Dist. Ratnagiri, Maharashtra (Unpublished).

Phookan, D.B., Shadeque, A. and Barukah, P. J. (1991). Effect of plant growth regulators on seed yield and quality of tomato.Veg.Sci.**18**: 93-95.

Pocknee, S. and Summer, A. (1997). Cation and nitrogen contents of each of organic matter determines its liming potential. *Soil Science Society of America Journal* **61**: 86-96.

Pollard, A.S., A.J. Parr and B.C. Loughman, (1977). Boron in relation to membrane function in higher plants. *J. Exp. Bot*., **28**: 831-841

Pravin Singh, Dharmendra Kumar, Patidar and Om Prakash Rajpat (2017). Role of foliar application of micronutrients (B, Zn and Fe) in vegetables. *International journal of farm science* **7(2):** 15-21

Pursglove, J.W. (1969). Tropical crops dicotyledons I. longamans. Green & co. Ltd. London & Harlow.

Qertli, J.J. and E. Grgurevic (1975). *Agron J*., **67:** 278-280

Rabeh, M.R. and Sweelam, M. (1990). Efficiency of potassium, nematicide and their combination in relation to absorption of potassium, population of citrus nematode (*Tylenchulus semipenetrans*) and yield of Mandarin (*Citrus reticulate*). *Indian J. Agri. Sci*., **60**(4):52-55.

Raheja, P.C., (1971). Hand Book of Manures and fertilizer. ICAR, New Delhi, pp**. 11**-13

Ranganna, S. (1977). *Manual of analysis of fruit and vegetables products*. Tata Mc Graw Hill publishing Co. Ltd. New Delhi pp.**9**-82.

Ranganna, S. (1985). *manual of analysis of fruit and vegetables products.* Tata Mc Graw Hill publishing Co. Ltd. New Delhi pp.**9**-82.

Ranganna, S. (1986).Manual analysis of fruit and vegetable products. Tata Mc. Graw Hill Publishing Company Ltd., New Delhi.

Raquel Sobral da Silva, Marileia Barros Furtado, Nítalo André Farias Machado, Hosana Aguiar Freitas de Andrade, Analya Roberta Fernandes Oliveira, Maryzélia Furtado de Farias, Luisa Julieth Parra-Serrano, Jomar do Livramento Barros Furtado, Raissa Rachel Salustriano Silva-Matos, Marcos Renan Lima Leite (2018). Effect of Boron (B) and lime on production of watermelon in dystrophic yellow latosol soil. *Australian Journal of Crop Science* **12**(12):1975-1982

Raskin I. (1992). Role of salicylic acid in plants. *Ann. Rev. Plant Physiol. Plant Mol. Biol.*; **43**:439-63.

Rathod Keval Daryasing (2008). Effect of boron application on yield nutrient uptake and quality of soybean [*Glycine max* (L) Merill] in newly terraced lateritic soils of Konkan. M.Sc. *thesis* submitted to Dr. B.S.Konkan Krishi Vidyapeeth, Dapoli.

Reuter, D.J. and Robinson, J.B. (1986). .*Plant analysis*. Inkata Pres, Melbourne, Sydney, 165-184

Rivas-San Vicente M., Plasencia J., (2011). Salicylic acid beyond defence: its role in plant growth and development. - *J. Exper. Bot.,* **62**: 3321-3338.

Rydahl, M.G., Hansen Aleksander R., Kračun Stjepan K., Mravec Jozef. (2018). Report on the Current Inventory of the Toolbox for Plant Cell Wall Analysis: Proteinaceous and Small Molecular Probes. *Frontiers in Plant Sci***, 9**: 581.

Sadia S., Naser H. M.,Akter S and. Begum R. A (2016). Effectiveness of soil and foliar applications of zinc and boron on the yield of tomato. *Bangladesh J. Agril. Res*. **41**(3): 411-418

Samadia D.K., Pareek O.P. and Vashishtha B.B. (2006). AHS-10 and AHS- 82: new snapmelon *Ind. Hort.* Pp 10-11

Samra, J.S. and Arora Y.K. (1997). *Mineral Nutrition*. In: R.E. Litz. The Mango, botany, production and uses. Cab International, New York.

Santra, G. H. (1989). Relationship of boron with iron, manganese, copper, and zinc with respect to their availability in rice soil. *Environment and Ecology* **7:**874–877.

Sathi Babu, N.; Hari Prasad, P. and Venketeswara Rao.(2010). Leaf nutrients (NPK) status of cashew garden in costal districts of Andrapradesh.*The Andra Agric. J.,* **57** (1): 91-98.

Sathya, S. (2006). M.Sc. (Ag.) *Thesis*, Agricultural College and Research Institute, Madurai.

Sathya, S., Mahendran, P.P. and Arulmozhiselvan, K. (2013). Availability of nutrients as influenced by boron application in boron deficient soil of Typic Haplustalf, *Agril. Sci. Digest* **33**: 317-320.

Savkare Hemangi (2018). Critical limit of Boron for Okra [*Abelmoschus esculentus* (L.)] in Konkan region (M.S.) M.Sc. (Agri.) *Thesis* submitted to Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli, Dist. Ratnagiri, Maharashtra (Unpublished).

Sevimli, E. (1996). Damla Sulama Sistemi Kuruluve Malcli Alanda Karpuzve Tursuluk Hiyar Bitkisine Azot, Fosforve Potasyumlu Gubre Dozlarinin Uygulanmasin in Verim Uzerine Etkileri.E.U. Fen Bilimleri Enstitusu (DoktoraTezi).İzmir-Turkey.

Seyyed Reza Jafari, Seyyed Mohammad Javed Arvin, Khosrow Manoochehri Kalantari (2015). Response of cucumber (*Cucumis sativus*.L) seedlings to exogenous silicon and Salicylic acid under osmotic stress. *Acta biologica Szeged* **59**(1):25-33

Shah Jahan Leghari,Niaz Ahmed Wahocho, Ghulam Mustafa Laghari,Abdul Hafeezb Laghari, Ghulam Mustafa Bhabhan, Khalid Hussain Talpur,Tofique Ahmed Bhutto, Safdar Ali Wahocho, Ayaz Ahmed Lashari (2016). Role of Nitrogen for Plant Growth and Development: *A review*. *Environmental Biology,* **10**(9) Pages: 209-218

Shakirova, F. M. (2007). Role of hormonal system in the manisfestation of growth promoting and anti-stress action of salicylic acid. In: Hayat, S., Ahmad, A. (Eds). Salicylic Acid. A PlantHormone. Springer. Dordrecht. Netherlands, pp. 69-89.

Shakirova, F.M., A.R. Sakhabutdinova, M.V. Bezrukova, R.A. Fatkhutdinova and D.R. Fatkhutdinova (2003). Changes in the hormonal status of wheat seedlings induced by salicylic acid and salinity. *Plant Sci*., **164**: 317-322.

Shamima Nasreen, R. Ahmed and M. Nazim Uddin (2013). Requirement of N, P, K, and S for yield maximization of bitter gourd (*Momordica charantia*) Bangladesh *J. Agril. Res*. **38**(2): 355-361

Shelke PV, Ghawade SM and Bhavar SV (2018). Influence of salicylic acid on the growth and yield in onion Cv. (Akola safed) International *Journal of Chemical Studies* ; **6**(6): 562-566

Shen, Singh Z., Y. Liang and K. Shen, (1993). Effect of boron on the nitrate reductase activity in oilseed rape plants. *J. Plant Nutr*., **16**: 1229-1239.

Shi, Q., Bao, Z., Zhu, Z., Ying, Q., Qian, Q. (2006). Effects of different treatments of salicylic acid on heat tolerance, chlorophyll fluorescence and antioxidant enzyme activity in seedlings of *Cucumis sativa* L. *Plant Growth Reg*. **48**(2), 127-135.

Shinde M.G. (2008). Effect of integrated nutrient management on soil properties, yield and quality of okra (*Abelmoschus esculentus* L.) grown in *kharif* season in lateritic soil of Konkan region. M.Sc. (Agri.) Thesis submitted to Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli, Dist. Ratnagiri, Maharashtra

Shinde, S.J. (2014). Evaluation of F_1 hybrids of cucumber and their nutrition management under Konkan agroclimatic condition. M.Sc. (Agri.) *Thesis* submitted to Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli, Dist. Ratnagiri, Maharashtra (Unpublished).

Shorrocks, V.M., (1990). Behavior, function and significance of boron in agriculture. Report on an International Workshop at St. John's College, Oxford, England. 23-25 July, 1990. Published by Borax Consolidated Limited, London. SW 1P 1H T.

Shrivastava, O. P. (2002). Efficacy of biofertilizers in relation to its integrated use with fertilizers and manures. *Indian Journal of agriculture chemistry* **35**, 122-134.

Singh Balkrishan, Rohatash Singh Bhadauria,. Barholia A. K and Singh K. V. (2018). Influence of Foliar Application of Urea, Potassium sulphate and Borax on the Fruit Quality of Guava. *Int.J.Curr.Microbiol.App.Sci Special* Issue-6: 2791-2796

Singh, A., Singh and P.K. (2008). Salicylic acid induced biochemical changes in cucumber cotyledons. *I. J. Agri. Biochem*. **21**(1-2), 35-38.

Singh, B. and Singh M. (1975). Sulphur status of Hissar soils and availability of sulphur and phosphorus affected by fertilizer application. Haryana *Agriculture University Journal Research* **5**, 222-230.

Singh, D.P., Dabbas, M.R. and Prakash, H.G. (2010). Effect of micronutrients on growth, yield attributes and pod yield of okra in semi-arid zone of Uttar Pradesh. *Asian J. Hort.* **4**(2):488-490.

Singh, J.N., D.K. Singh, and D. Chakravarthy (1994). Effect of urea and NAA on fruit retention and physicochemical composition of mango (*Mangifera indica* L.) cv. Langra. *Orissa J. Hort*., **22**:26-30.

Singh, M.V. (2008). Micronutrient Deficiencies in Crops and Soils in India In: Micronutrient deficiencies in Global Crop Production (Ed.) B. *J. Alloway. Springer, Netherlands*, Pp. 93-125.

Singh, P.C. (2002). Effect of different levels of nitrogen and phosphorus on yield, yield components and oil content of mustard (*Brassica juncea*) cv. Varuna. *J. Living World*. **9**(1): 1-4.

Singh, Pramod Kumar; Chaturvedi, Varun Kumar and Bose, Bandana (2010). Effects of Salicylic acid on seedling growth and Nitrogen Metabolism in Cucumber (*Cucumis sativus.* L). *Journal of stress physiology and microbiology* **6:** 102-113.

Sinha (1981). Effect of continuous use of fertilizers on yield and nutrient in wheat in wheat-soybean-potato cropping system. *Journal of the Indian society of soil science* **29**, 537-542

Subbaiah, B.V. and G.I. Asija (1965). A rapid procedure for the estimates available nitrogen in soil. *Curr.Sci.* **25(8)**:259- 260.

Sure S., H. Arooie and R. D. Moghadam, (2011). Influence of drought stress and its interaction with Salicylic acid on medicinal pumpkin (*Cucurbita pepo* L.) seedling growth. *Botany Research J.,* **4** (4-6): 35 – 40.

Sywortokin, G.S. (1958). The B content of plants with a latex system. *Supplement der Landwirtscaft, Akademie-Verlag,* Berlin. pp.283–88.

Talang H.D., P. Dutta, C. Mukhim and S. Patil (2017). Effect of calcium, boron and sorbitol on fruit-set, yield and quality in mango cv. Himsagar. J. *Hortl. Sci.*Vol. **11**(2): 166-169

Tandon, H.L.S.(Ed.). (1993). *Methods of Analysis of soils, Plants, Waters and Fertilizers.* FDCO, New Delhi, India

Tariq M and Mott C. J. B (2007). Effect of Boron on the Behavior of Nutrients in Soil-Plant Systems- A Review. *Asian Journal of Plant Sciences Volume* **6** (1): 195-202, 2007

Tariq M. and C. J. B. Mott (2006) Influence of applied calciumVol. 5, No. 6, p. 86-92, -boron ratio on the solubility of nutrient-elements in soil .*Journal of Agricultural and Biological Science* VOL. **1**, NO. 3

Thorbole, S.B. (2002). Impact of integrated use of fertilizers on growth, yield, quality and nutrient uptake by okra (Abelmoschus esculentus (L.) Monech) and changes in nutrient availability in lateritic soil. M.Sc. (Agri) Thesis submitted to Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli, Dist. Ratnagiri, Maharashtra (Unpublished).

Tisdale, L. Samuel, Werner L. Nelson, James D. Beaton and John L. Havlin (1995) *Soil fertility and fertilizers* published by Prentice, Hall of India Private Limited, New Delhi. pp.316,321,325,335 and 336.

Tolgyesi, G. and A. Kozma, (1974). Investigation on factors affecting boron uptake by grasses. *Agrokemia-es-Talajatan*, **23**: 83-98.

Tondon, HLS (1993) Fertiliser recommendations for oilseed crops - a guidebook (2nd edition), Fertiliser Development and Consultation Organisation, New Delhi.

Torane H.B (2014). Efficacy of Konkan Annapurna briquettes (KAB) with different coating materials on yield and quality of cucumber (*Cucumis sativus* L.) .M.Sc *thesis* submitted to Dr. B.S.Konkan Krishi Vidypeeth, Dapoli.

Tripathy P, Maharana T, Nandi T, Dora D K**(** 1993). Effect of cutting node number and fertilizer on spine gourd (*Momordica dioica*). Indian Journal of Agricultural Sciences, **63 (7),** 432-435.

Umamaheshwarappa, P., V. Nachegowda, and P.V. Murthy (2005). Uptake of nitrogen, Phosphorus, potassium and fruit size of cucumber cv. *Poinsett* as influenced by different level of NPK fertilizers.Karnataka. *J.Hort*. **1**(3):76- 80.

Uzunova, A.N. and Popova, L.P. (2000). Effect of salicylic acid on leaf anatomy and chloroplast ultra-structure of barley plants. *Photosynthetica* **38**(2), 243-250.

Verma C.K., Prasad K., Yadav D.D. (2012). Studies on response of sulphur, zinc and boron levels on yield, economics and nutrients uptake of mustard [*Brassica juncea* (L.) Czern & Coss] *Crop Res* **44**(1&2): 75-78.

Warington, K. (1923). The effect of boric acid and borax on the broad bean and certain other plants. *Annal. Botany* **37:** 629–672.

Wilkinson, B. (1957). Boron in the glasshouse tomato plant. *Nature* 180: 666.

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 15N after foliar urea application in wild-type and urease-antisense transgenics. *Plant Physiol.*, **128**: 1129–1136.

Wojcik P. (2004). Uptake of mineral nutrients from foliar fertilization. *J. Fruit Orn. Plant Res. Spec. ed*., **12:** 201–218

Xu, X. and S. Tian (2008). Salicylic acid alleviated pathogen-induced oxidative stress in harvested sweet cherry fruit. *Postharvest Biol. Technol*., **49**: 379-385

Yildirim E, Guvenc I., Turan M,. Karatas A. (2007). Effect of foliar urea application on quality, growth, mineral uptake and yield of broccoli (*Brassica oleracea* L., *var. italica*) *Plant Soil Environ*., **53**, (3): 120–128

Yildirim Ertan, Metin Turan, and Ismail Guvenc (2008). Effect of Foliar Salicylic Acid Applications on Growth, Chlorophyll, and Mineral Content of Cucumber Grown Under Salt Stress. *Journal of Plant Nutrition*, **31**: 593–612

Yildirim, E., I. Guvenc and A. Karatas (2006). Effect of different number foliar salicylic acid applications on plant growth and yield of cucumber. VI. Turkey National Vegetable Symposium. September 19–22, Kahramanmaras, Turkey.

Material & Methods

Appendix

Review of Literature

Literature cited

Introduction

Results & Discussion

Summary & Conclusions