RESPONSE OF FORAGE MAIZE (*Zea mays* L.) TO NUTRIENT MANAGEMENT DURING SUMMER SEASON

by

Mr. Thimmaraja
(Reg.No.019/014)

A thesis submitted to the

MAHATMA PHULE KRISHI VIDYAPEETH,
RAHURI – 413722, DIST. AHMEDNAGAR,
MAHARASHTRA, INDIA

in partial fulfillment of the requirement for the degree

of

MASTER OF SCIENCE (AGRICULTURE)

in

AGRONOMY

DEPARTMENT OF AGRONOMY

POST GRADUATE INSTITUTE
MAHATMA PHULE KRISHI VIDYAPEETH,
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2021

CANDIDATE'S DECLARATION

I hereby declare that this thesis or part
there of has not been submitted
by me or other person to any
other University or Institute
for a Degree or
Diploma

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This is to certify that the thesis entitled, **"RESPONSE OF FORAGE MAIZE (*Zea mays* L.) TO NUTRIENT MANAGEMENT DURING SUMMER SEASON"** submitted to the Faculty of Agriculture, Mahatma Phule Krishi Vidyapeeth, Rahuri, Dist. Ahmednagar (Maharashtra) in partial fulfillment of the requirement for the award of the degree of **MASTER OF SCIENCE (AGRICULTURE)** in **AGRONOMY**, embodies the results of a bonafide research work carried out by **Mr. THIMMARAJA**, under my guidance and supervision and that no part of thesis has been submitted for any other degree or diploma.

The assistance and help received during the course of this investigation have been duly acknowledged.

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Last but not the least, I thank almighty whose countless blessings made me to finally accomplish this thesis.

Place: M. P. K. V., Rahuri **_Thimmaraja_**
Date: / /2021

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LIST OF ABBREVATIONS AND SYMBOLS

@	: At the rate of
ADF	: Acid detergent fiber
ATP	: Adinosine tri Phosphate
B	: Boron
C.D.	: Critical difference
CP	: Crude protein
CPY	: Crude protein yield
CF	: Crude fiber
CFY	: Crude fiber Yield
Cm	: Centi meter
Cu	: Copper
DAS	: Day after sowing
dm^2	: deci meter square
^{O}C	: degree celcius
et al.	: etalli (and others)
etc.	: et cetera (and so on)
FYM	: Farm Yard Manure
Fe	: Iron
Fig.	: Figure
g	: gram (s)
GRDF	: General recommended dose of fertilizer
GFY	: Green forage yield
ha	: hectare (s)
ha^{-1}	: Per hectare
hr	: hour (s)
i.e.	: id est (that is)
K	: Potassium
K_2O	: Potassium oxide
kg	: Kilogram (s)
L :S ratio	: Leaf to stem ratio
L^{-1}	: Per Litre
M	: Meter (S)
m^{-2}	: Per meter square
Mn	: Manganese

Max.	: Maximum
Min.	: Minimum
mg	: Milligram (s)
mm	: Millimeter (s)
Mo	: Molybdenum
N	: Nitrogen
NDF	: Neutral detergent fiber
N.S.	: Non-significant
%	: Per cent
P	: Phosphorous
P_2O_5	: Phosphorous pentoxide
ppm	: Part Per Million
q	: Quintals
RBD	: Randomized block design
RDF	: Recommended dose of fertilizer
RH	: Relative humidity
Rs.	: Rupees
₹	: Rupees
S.Em ±	: Standard error of mean
t	: Tonnes
viz.,	: Videlicet (namely)
Zn	: Zinc

ABSTRACT

"RESPONSE OF FORAGE MAIZE (*Zea mays* L.)TO NUTRIENT MANAGEMENT DURING SUMMER SEASON"

By

Mr. THIMMARAJA

A candidate of the degree of

MASTER OF SCIENCE (AGRICULTURE)

in

AGRONOMY

MAHATMA PHULE KRISHI VIDYAPEETH

RAHURI – 413722

2021

Research Guide	:	**Dr. N. J. Danawale**
Department	:	**Agronomy**

A field investigation on "Response of forage maize (*Zea mays* L.) to nutrient management during summer season" year of 2020 at AICRP on forage crops and research project, M.P.K.V., Rahuri.

The soil of experimental field was low in available nitrogen (244.57 kg ha^{-1}), moderately high in phosphorus (24.31 kg ha^{-1}) and moderately high in potassium (438.68 kg ha^{-1}). The field experiment was laid out in randomized block design with four replications. There were six treatments *viz*. T_1: absolute control, T_2: RDF (100:50:50 N :P_2O_5 :K_2O Kg ha^{-1}), T_3: GRDF (100:50:50 N :P_2O_5 :K_2O Kg ha^{-1} + 5 t ha^{-1} FYM), T_4: GRDF + Soil application of Government notified multi- micronutrient Grade I @ 25 kg ha^{-1}, T_5: GRDF + Two foliar spray of Phule micronutrient grade II @ 1% at 30 and 45 DAS, T_6: GRDF + Soil application of Government notified multi- micronutrient Grade I @ 25kg ha^{-1} + Two foliar spray of Phule micronutrient grade II @ 1% at 30 and 45 DAS.

Among the different treatments forage maize crop fertilized with GRDF in association with soil application of Government notified multi- micronutrient Grade I @ 25 kg ha^{-1} along with two foliar spray of Phule micronutrient grade II @ 1% at 30 and 45 DAS exhibited significantly higher plant height (171.55 cm), number of leaves plant^{-1} (13.78), leaf area plant^{-1} (40.48 dm^2) and stem girth (7.46 cm) at harvest as compared to rest of nutrient management treatments during summer 2020-21. Forage maize crop fertilized with GRDF in association with soil application of Government notified multi- micronutrient Grade I @ 25 kg ha^{-1} along with two foliar spray of Phule micronutrient grade II @ 1% at 30 and 45 DAS exhibited significantly higher dry matter plant^{-1} (76.01 g) and L: S ratio (0.50) as compared to rest of nutrient management treatments and also forage maize crop fertilized with GRDF in association with soil application of Government notified multi- micronutrient Grade I @ 25 kg ha^{-1} along with two foliar spray of Phule micronutrient grade II @ 1% at 30 and 45 DAS exhibited significantly higher green forage yield (587.5 q ha^{-1}) and dry matter yield (119.1 q ha^{-1}) as compared to rest of nutrient management treatments during investigation. However, it was at par with GRDF in association with soil application of Government notified multi- micronutrient Grade I @ 25 kg ha$^{-1.}$

Forage maize crop fertilized with soil application of Government notified multi-micronutrient Grade I @ 25 kg ha^{-1} along with two foliar spray of Phule micronutrient grade II @ 1% at 30 and 45 DAS which recorded numerically higher crude protein content (8.08 %) and also crude protein yield (9.62 q ha^{-1}) than the rest of the nutrient management treatments during investigation. Forage maize crop fertilized with GRDF in association with soil application of

Government notified multi- micronutrient Grade I@ 25 kg ha^{-1} along with two foliar spray of Phule micronutrient grade II @ 1% at 30 and 45 DAS exhibited significantly lower fiber contents such as crude fiber (18.76 %), ADF (25.00 %) and NDF (54.64 %), Whereas, higher crude fiber yield (22.34 q ha^{-1}) than the rest of the nutrient management treatments during investigation. Forage maize crop fertilized with GRDF in association with soil application of Government notified multi- micronutrient Grade I @ 25 kg ha^{-1} along with two foliar spray of Phule micronutrient grade II @ 1% at 30 and 45 DAS exhibited significantly higher nitrogen uptake (158.35 kg ha^{-1}), phosphorus uptake (21.10 kg ha^{-1}) and potassium uptake (130.46 kg ha^{-1}) in forage and also exhibited higher contents of micronutrients such as iron content (51.89 ppm), zinc content (44.69 ppm), copper content (24.33 ppm), manganese (37.44 ppm), boron content (30.86 ppm) and molybdenum content (14.57 ppm) in forage. However it was at par with GRDF in association with soil application of Government notified multi-micronutrient Grade I @ 25 kg ha^{-1}.

Forage maize crop fertilized with GRDF in association with soil application of Government notified multi- micronutrient Grade I @ 25 kg ha^{-1} along with two foliar spray of Phule micronutrient grade II @ 1% at 30 and 45 DAS observed significantly lower available nitrogen (165.30 kg ha^{-1}), available phosphorus (17.13 kg ha^{-1}) and available potassium (347.93 kg ha^{-1}). forage maize crop fertilized with GRDF in association with soil application of Government notified multi- micronutrient Grade I @ 25 kg ha^{-1} along with two foliar spray of Phule micronutrient grade II @ 1% at 30 and 45 DAS observed significantly higher values of iron (5.04 ppm), zinc (0.69 ppm), copper (0.70 ppm), manganese (5.39 ppm), boron (1.08 ppm) and molybdenum (0.97 ppm) in soil after harvest of forage maize crop. However it was at par with GRDF in association with soil application of Government notified multi- micronutrient Grade I @ 25 kg ha^{-1}.

Forage maize crop fertilized with GRDF in association with soil application of Government notified multi- micronutrient Grade I @ 25 kg ha^{-1} along with two foliar spray of Phule micronutrient grade II @ 1% at 30 and 45 DAS exhibited significantly higher gross monetary returns (₹ 88125 ha^{-1}), net monetary returns (₹ 50841 ha^{-1}) and benefit cost ratio (2.36) as compared to rest of the treatments during study. However it was at par with GRDF in association with soil application of Government notified multi- micronutrient Grade I @ 25 kg ha^{-1}.

It can be concluded that, the forage maize crop fertilized with GRDF (100:50:50 N: P_2O_5: K_2O Kg ha^{-1} + FYM 5 t ha^{-1}) in association with soil application of Government notified multi-micronutrient Grade I @ 25 kg ha^{-1} (Zn 5.0 %, Fe 2.0 %, Mn 1 %, B 1 %, Cu 0.5 %) registered better growth, yield, quality and economic returns from forage maize during summer season.

1. INTRODUCTION

Maize is one of the most important and popular cereal fodder crops in the world agricultural economy both as a food for man and feed for animals. It is a miracle crop among all the forage cereal crops due to its excellent growing habit, very high yield potential and better nutritive value and quick growth and there is no cereal on earth with immense potential and that is why it is called "King of forage crops".

Agriculture is the key sector of the Indian economy and allied sector contributes nearly 17% of GDP (Ministry of statistics 2020-2021) and about around 58% of the population dependent on agriculture and allied sectors such as livestock, poultry and fishery etc. for their livelihood. Livestock is the backbone of Indian agriculture contributing nearly 4.11% to the national GDP. This sector generates employment for around 20 million rural population. Indian agriculture is mainly subsistence type and livestock are valuable asset of this group and helps in maintaining the sustainability and intensification of agricultural productivity. Indian dairy industry has exhibited fabulous growth since last three decades. In the modern era where global village concept is driving fast across the globe, India being the largest milk producer of the world has specific benefit in providing food security, nutritional security and economic returns to the world's population. According to the latest report by International market analysis research and consulting group dairy market in India reached a value of 144.55 $ billion in 2020 which produces around 22% share in total milk production in the world with 536 million livestock. Today India emerged as the milk producer in the world with 198.4 million tonnes (NDDB 2019-20). Annual growth rate of this sector is around 4.1% (IGFRI vision 2050). White revolution caused the remarkable change with five times increase in milk production of India. On the other hand low productivity of livestock is distressful situation, which is mainly due to the poor quality of feed and fodder availability. The supply of good quality forage is prerequisite for the success of dairy industry. Due to the urbanization and increasing incomes of ever increasing population resulting in changes of dietary habits are causing the demand for animal origin food.

At present country is facing a net deficit of 35.6% of green fodder, 10.95% of dry crop residue and 44% of concentrate feed ingredients (IGFRI vision 2050). In our country total area under cultivated forage crops is nearly 4.5% and area of 8.6 million hectares. The area of green fodder in Maharasthra is 63520.6 hectares and the production of green fodder is 69700 tonnes and the production of dry fodder is 22783.8 tonnes (Roy *et al.* 2019)

Among the *kharif* forage crops sorghum, maize, pearlmillet, cowpea are popular and in *rabi* cultivated forages are oat, rye, lucerne and berseem and in Summer season crops are sorghum (multicut), pearlmillet (multicut), teosinte (multicut), cowpea and maize (single cut). To meet the requirement of livestock and their annual population growth, strategies are needed to improve the availability of energy rich quality fodder. As feed alone constitutes 65-70% of milk production cost and green fodder can reduce the cost. Therefore it is essential for farmers to cultivate those fodder crops which have short duration, quick growing habit, higher yielder as well as rich in protein, vitamins and minerals.

Maize (*Zea mays* L.) is a annual plant belongs to the family graminae and genus Zea. It is tall annual plant which usually grown to height of one to three meter or more in some cases. The root system of maize crop is fibrous and deep. It is usually well developed. It consists of seminal roots, crown or coronal roots and brace and aerial roots. Seed rate for hybrid maize 20-25 kg ha^{-1}, composite about 18-20 kg ha^{-1} for grain and 70-75 kg ha^{-1} for fodder and being one of the most popular dual crops grown widely in *kharif* season for grain as well as for fodder and during summer season also grown only for fodder on condition of availability of water in India have an advantage over other cultivated crops due to its high production potential capacity, wider adaptability, quick growing habit, succulency, palatability, excellent fodder quality, free from anti nutritional factors and it can be safely fed to the livestock at any growth stage.

Fodder maize is one of the most important *kharif* forage crop next to sorghum in India. It is grown in more than 130 countries. It is great importance for both human and animal feeding. Maize fodder has high digestability and palatability. On an average, it contains 9-11% CP, 60-64% NDF, 38-41% ADF, 28-30% cellulose and 23-25% hemicellulose at milk to early dough stage. It can be fed as a green or dry and used to make excellent silage. Maize grain is also used as a concentrate feed for poultry as well as milch animals. Fodder maize producers require more information on how fertilizer levels and varying plant density affect the fodder yield and quality of different cultivars during summer season. Compared to other cereal forages, maize is characterized by high amount of non-structural carbohydrates. This attribute makes maize as the most popular in making silage since sugars and water soluble carbohydrates are more important for silage preservation which indicates that there is no need of any external carbohydrate sources such as molasses and jaggery for silage making. The higher energy available from maize for the improvement of milk composition and cattle condition make it a better choice (FAO 2000).

African tall forage maize cultivar is a composite of 7 genotypes and it was bred at MPKV, Kolhapur, released for cultivation throughout the country in 1983. The average height of cultivar is 260 cm, has more number of leaves per plant and more leaf area. It has more dry matter (17.65%), crude protein (11-13%) and resistant to stem borer. Yield potential of cultivar is 60-70 t ha^{-1} of green fodder, 1.5 t ha^{-1} of dry fodder and 30-50 q ha^{-1} of grain yield.

Production potential of forage maize can be altered with changes in agronomic practices such as nutrient management. Forage may responds in a different ways under different levels of nutrient under different environmental condition and cultural practices which influences the yield and quality. An adequate supply of nutrients at each growth stage is highly essential for good yield and quality of fodder maize. The essential plant nutrients (N, P, K and micronutrients) are important for plant growth, yield and quality.

Nitrogen being an essential element plays a pivotal role in crop development (Tisdale *et al.*, 1990). It is important nutrient for plant growth and is the most limiting nutrient in our soils. Nitrogen fertilization influences the dry matter yield by influencing growth and photosynthetic efficiency (Yadav *et al.*, 2017). Nitrogen is an also essential element for for both quality and quantity as its component of protein and chlorophyll. It is thus essential for photosynthesis, vegetative and reproductive growth and is often determines the yield of forage maize and it helps in increasing green forage and dry matter yield with higher crude protein and crude fiber content. It also increases chlorophyll content, succulent and vigorous growth, better palatability, improving leaf: stem ratio (Yadvendra *et al.*, 2003)

Phosphorus plays a vital role in crop production as it is involved in CO_2 fixation, synthesis of glucose *i.e.* sugar metabolism, energy storage and transfer (Taiz and Zeiger, 2006). Phosphorus has been reported to increase the strength of cereal straw, stimulate root development, promotes flowering, fruit production, and formation of seeds and is hasten maturity of the crops (Gupta, 2003). Phosphorus is one of the major essential plant nutrients after nitrogen and is the second most deficient plant nutrient. The optimum rate of phosphorus application is important in improving yields of most crops (Cisar *et al.*, 1992). Similarly, potassium play an important role in translocation of sugar from source to sink and it also regulates the opening and closing of stomata and there regulates CO_2 uptake, Potassium triggers activation of enzymes and essential for production of ATP.

Deficiencies of micronutrients in plants have gained more importance worldwide because of the increasing concerns over the effects of low levels of micronutrients especially Zn in fodder crops (Chakmak, 2002). Zn deficiency in soils is common in arid and semi-arid regions. Little or no use Zn fertilizers along with imbalanced fertilization further aggravated Zn deficiency in soils resulting lower Zn contents in grains (Rashid and Ryan, 2004).

Fe serves as an essential micronutrient for almost all living organisms because of its critical role in metabolic processes such as DNA synthesis, respiration, and photosynthesis. Further many metabolic pathways are activated by Fe and it is a prosthetic group constituent of many enzymes. An imbalance between the solubility of iron in soil and the demand for iron by the plant are the primary causes of iron chlorosis. Similarly, in plants Mn plays major role in many oxidation and reduction processes, activation of enzymes, photosynthesis, metabolism of carbohydrates and lipids and synthesis of pigments. It is especially important for the fixation atmospheric nitrogen and its metabolism. However, boron plays a important role in the plant growth and as an essential micronutrient, it helps in transfer of sugars and nutrients from leaves to reproduction site that supports in the development of organs, increase in pollination as well as development of seed. The strengthening of cell wall, cell division, development of seed and sugar are the functions nutrients.

The importance of Mo for plant growth is disproportionate with respect to the absolute amounts required by most plants. Apart from Cu, Mo is the least abundant essential micronutrient found in most plant tissues. Mo is used by selected enzymes to carry out redox reactions. Enzymes that require Mo include nitrate reductase, xanthine dehydrogenase, aldehyde oxidase and sulfite oxidase. Whereas, copper activates some enzymes in plants which are involved in lignin synthesis and it is essential in several enzyme systems. It is also required in process of photosynthesis, is essential in plant respiration and assist in plant metabolism of carbohydrates and proteins. Copper also serves to intensify flavor and color in vegetables and color in flowers.

Keeping in view the above facts the present research was conducted to study the "Response of forage maize (*Zea mays* L.) to nutrient management during summer season." with the following objectives:

1) To study the effect of nutrient management on growth and yield of forage maize.
2) To assess the quality of forage maize as influenced by nutrient management.
3) To assess the economics of forage maize as influenced by nutrient management.

2. REVIEW OF LITERATURE

An experiment entitled "Response of forage maize (*Zea mays* L.) to nutrient management during summer season" has been conducted at AICRP on forage crops Research project, Mahatma Phule Krishi Vidyapeeth, Rahuri during March 2020 to May 2020. The reason for low productivity of milk in India is non availability of good quality feed. The acute shortage of green fodder will observed during summer months. In rural areas the farmers are unaware about use of micronutrinets through foliar spray specially for fodder so, an attempt has been made in this chapter to review the work done to study the response of forage maize to nutrient management during summer season.

2.1 Response of nutrient management on growth of forage maize

Carpici *et al.* (2008) field studies were conducted during 2006 and 2007 growing seasons on agronomic managements such as plant density and nitrogen fertilization on forage maize at agricultural research and experiment center of Uludag University, near Bursa in Turkey and treatment combinations consists of five densities of 60 000, 100 000, 140 000, 180 000 and 220 000 plants ha^{-1} and five rates of 0, 100, 200, 300 and 400 kg N ha^{-1} and results revealed that the effect of plant density increased dry matter yield, stem percentage, leaf number plant^{-1} and stem diameter.

Patel and singh (2009) tested the efficacy of multi-micronutrient mixture grades at micro nutrient research project Anand, Gujrat for Zn-deficiency (grade-II : Fe-2.0%, Mn-0.5%, Zn-8.0%, Cu-0.5%, B-0.5%), Fe-deficiency (grade-III: Fe-6.0%, Mn-1.0%, Zn-4.0%, Cu-0.3%, B-0.5%) and Zn+Fe-deficiency (grade–IV : Fe-4.0%, Mn-1.0%, Zn-6.0%, Cu-0.5%, B-0.5%) besides normal grade for foliar application (grade-I : Fe-2.0%, Mn-0.5%, Zn-4.0%, Cu-0.3%, B-0.5%) at 1% and soil application grade –V (Fe-2.0%, Mn-0.5%, Zn-5.0%, Cu-0.2%, B-0.5%) at 20 kg/ha were prepared. Amongst the foliar grades, Grade-III (for Fe deficient soil) and Grades-IV (For Zn and Fe deficient soils) were found more effective in most of the crops of various groups *viz*., cereals (maize, sorghum, pearlmillet and wheat).

Nadim *et al.* (2010) evaluated use of different levels of Zn, Cu, Fe, Mn and B alone and in different combinations in sorghum at Gomal University, Pakistan. The results revealed that application of boron @ 2 kg ha^{-1} produced higher leaf area index (0.33 and 3.49) and leaf area duration (2.30 and 48.90) at 49 and 98 days after sowing. The same treatment also enhanced crop growth rate (33.40 g m^{-2} day^{-1}), number of grains (46.50 spike^{-1}) and the use of copper @ 8 kg ha^{-1} produced the maximum number of tillers (249 m^{-2}) and similar to that of boron application.

Roy and Khandaker (2010) studied the effect of phosphorus fertilizer on yield and nutritional value in forage sorghum at Bangaldesh Agricultural Univesity, Bangladesh reported that application of phosphorus @ 80 kg TSP ha^{-1} has significant effect on plant height of sorghum at 60 DAS as compared to control and 40 kg TSP ha^{-1}.

Sachin *et al.* (2010) conducted field experiment to study the effect of integrated nutrient management on fodder maize at CCS Haryana Agricultural University, Hisar, Haryana and reported that growth indices leaf area index and crop growth rate were observed significantly higher with 100 per cent RDF followed by 75 per cent RDF+25 per cent N through FYM+Azotobacter.

Valadabadi and Farahani (2012) conducted experiment to evaluate the beneficial impact of planting density and pattern on induced maize at ishmael abad station in Qazvin at Iran and reported that application of nitrogen fertilizer significantly affected the total dry weight (TDW), leaf area index (LAI), relative growth rate (RGR) and crop growth rate (CGR) of maize crop. The highest total dry weight (TDW) (1910 $g.m^{-2}$), LAI (4.2), RGR (0.08 $g.g.day^{-1}$) and CGR (31.2 $g.g.m^{-2}.day^{-1}$) were obtained with application of 520 kg urea ha^{-1}, respectively.

Ghaffari *et al.* (2011) conducted a field experiment to evaluate the integrated nutrients effect on growth, yield and quality of maize (*Zea mays* L.) during spring, 2009, at the Agronomic Research Area, University of Agriculture, Faisalabad. The recommended dose of NPK in addition with single spray of multi micronutrients (a solution mixture of micronutrients *i.e*, Zn=2%, Fe=1%, B=1%, Mn=1%, Cu=0.2% and macronutrients N=1%, K_20=2%, S=2%) substationally improved all growth parameters, ear characteristics and also enhanced macronutrients use efficiency up to 11.5% which induced significant increase in grain yield as compared to control and also in the treatment where recommended dose of NPK was applied alone.

Soomro *et al.* (2011) performed experiment on comparative effects of foliar and soil applied boron on growth and fodder yield of maize at Pakistan agricultural research council, Karachi, Pakistan and revealed that the foliar application of 0.5% boron as a boric acid at early, mid and late whorl stages resulted in taller plants (195.05 cm), thicker stem girth (5.21), more number of green leaves (8.00) $plant^{-1}$, less number of dry leaves (3.00) $plant^{-1}$.

Karfoma *et al.* (2012) conducted experiment the instructional farm of Ramshai Krishi Vigyan Kendra, West Bengal University of Animal and Fishery Sciences, Ramshai, Jalpaiguri, West Bengal during the *kharif* season of 2007 and 2008 under rainfed condition to study the effect of different nutrient management practices on growth, productivity, quality and economics of rainfed fodder maize. The maximum increase in growth attributes, forage yield and economics were obtained from the crop receiving 50% RDN through FYM + 50% RDF (30 kg N, 15 kg P_2O_5 and 15 kg K_2O ha^{-1}) through chemical fertilizers + *Azotobacter* and were closely followed by the crop receiving 50% RDN through MC + 50% RDF through chemical fertilizers + *Azotobacter*, 50% RDN through FYM + 50% RDF through chemical fertilizers and 50% RDN through MC + 50% RDF through chemical fertilizers; but were significantly superior to other fertility treatments.

Prajapati and Kewalanand (2013) conducted a field experiment to evaluate response of micronutrient on growth and yield of sweet sorghum at Instructional Dairy Farm, G.B.P.U.A. & T., Pantnagar, U.S.Nagar, Uttarakhand during *Kharif* seasons of 2012 and 2013 and found that with the application of RDF (NPK 120:60:40 kg/ha) in combination with $ZnSO_4$ 15 kg ha^{-1} + $FeSO_4$ 15 kg ha^{-1} as soil application showed maximum growth attributes characters (plant height, L: S, stem diameter), dry matter content.

Wailare and Amit (2013) studied the influence of integrated nutrient management on growth and yield parameters of maize (*Zea mays* L.) as well as soil physico-chemical properties at research field of the school of Agriculture Lovely Professional University, Phagwara, Punjab and results revealed that the growth parameters (plant height and leaf area) were found to be highest under INM (Integrated Nutrient Management) of poultry manure (PM) or farm yard manure (FYM) and recommended dose of fertilizers (RDF) which are statistically on par but comparatively higher than (100% RDF).

Amanullaha *et al.* (2014) field experiment was conducted to study the response of dryland maize (*Zea mays* L., cv. Azam) to foliar phosphorus (1, 2 and 3% P) and zinc levels (0.1, 0.2, and 0.3% Zn) and their application time (T_1 =at boot stage and T_2 =at silking stage) at the agronomy research farm of the University of Agriculture Peshawar, Pakistan during summer 2014. The results revealed that foliar treated plots had significantly ($P<0.05$) better growth than control (no foliar spray).

Manasa and Devaranavadagi (2015) conducted the experiment on effect foliar application of micronutrients on yield and uptake of nutrients in maize at UAS, Dharwad, Karnataka and found that the growth attributes were significantly higher with soil application of recommended dose of N, P_2O_5, K_2O along with foliar application of $ZnSO_4$ @ 1.0 per cent during grand growth stage such as like cob length, cob girth, number of grains per row, total number of grains per cob, grain weight per cob and 100 grain weight.

Mona and Al- Azad (2015) studied the effect of foliar zinc applications on growth, mineral content and yield of corn plants under field conditions as well as its quality at soil and water department, national research center, Dokki, Egypt and found that maize with combined application of Zn (1.5%) and NPK fertilizer significantly improved plant height, 1000-grain weight, grain yield and harvest index as compared to the treatment fertilized only with NPK.

Rakesh *et al.* (2015) conducted a study to evaluate the fortification through soil and foliar application of zinc could be viable option to improve the productivity and quality of fodder maize at forage research and management centre, ICAR-NDRI, Karnal and the study consisting of varieties (African tall and J-1006) and six sub-plot treatments of zinc fertilization (Zn_0-No zinc sulphate; Zn_1-10 kg ha^{-1} $ZnSO_4$ as basal dose ; Zn_2 -20 kg ha^{-1} $ZnSO_4$ as basal dose ; Zn_3 - 0.5% one foliar spray of $ZnSO_4$ at 30 DAS ; Zn_4 -0.5% two foliar spray of $ZnSO_4$ at 30 and 45 DAS and Zn_5 -10 kg ha^{-1} $ZnSO_4$ as basal dose +0.5% one foliar spray at 30 DAS). Results shows that both the varieties tested were found statistically at par for all the tested parameters, the highest green and dry fodder yield were recorded with Zn_2 (60.16 and 14.15 tonnes ha^{-1}) which was on par to Zn_5 and Zn_4 while lowest with Zn_0 (46.69 and 10.25 tonnes ha^{-1}).

Digvijay *et al.* (2016) conducted a test to evaluate the fodder productivity, silage quality and nutrients uptake potential in 11 maize cultivars at fodder demonstration unit (FDU) of national dairy development board, Anand, Gujrat and study indicated superiority of fodder composite African Tall in terms of higher plant height (265.13 cm), stem-girth (16.58 cm), number of leaves $plant^{-1}$ (13.87).

Jadav *et al.* (2016) carried out an experiment to study the effect of integrated nutrient management on growth and yield of *rabi* forage maize at Jorapura farm of livestock research station, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar, Jorapura, Gujarat and he found that application of 15 t FYM ha^{-1} performed better by recording higher plant height (165.9 cm), number of leaves per plant (12.6), stem girth of 3rd internode (7.96 cm), leaf area per plant (3624 cm^2), leaf: stem ratio (0.34) and length of internodes (12.1 cm) respectively over application of 10 t FYM ha^{-1}. Combined application of 100 % RDF + Azotobacter + PSB recorded higher values of plant height (175.8 cm), number of leaves per plant (13.5), stem girth of 3rd internode (9.28 cm), leaf area per plant (4000 cm^2), leaf: stem ratio (0.37) and length of internodes (12.7 cm) over other combinations.

Lalitha *et al.* (2016) conducted a field experiment to study the effect foliar application of macro and micro nutrients on growth and yield attributes of baby corn (*Zea mays* L.) at GKVK, Benagluru, Karnataka and found that application of 75% RDF + 1.5% 19:19:19 spray + 0.5% $ZnSO_4$ + 0.1% $FeSO_4$ significantly enhanced the growth parameters *viz*., plant height (144.91 cm), total dry matter (152.28 g $plant^{-1}$), Absolute growth rate (1.79 g day^{-1}), Crop growth rate (1.77 g day^{-1}), Net assimilation rate (5.56 g dm^{-2} day^{-1}), Leaf area index (6.84).

Chamegowda *et al.* (2017) conducted experiment to study the effect of soil and foliar application of micronutrient mixtures on growth of greengram at GKVK, Bengaluru and the experiment comprises of RDF + FYM, foliar application of MM at 20 DAS (MMF_1 and MMF_2), 40 DAS (MMF_1 and MMF_2) along with RDF+FYM, Foliar spray at 20 and 40 DAS along with FYM+RDF and soil application of MMS_1, MMS_2, MMS_3 and MMS_4 along with RDF+FYM. Micronutreints mixture comprising Fe (20.10 g), Mn (18.20 g), Zn (160 g), Cu (12.73 g), with B (43.70 g) without B, Mo (2.33 g) was prepared using appropriate micronutrients salts for foliar application acre^{-1} and Fe (80.4g), Mn (72.8g), Zn (640 g), Cu (50.92 g), with B (174.8 g) without B, Mo (9.32 g) for MMS_1 and two, three and four times that of MMS_1 for other mixture (MMS_2, MMS_3 and MMS_4, respectively) acre^{-1} for soil application. Results revealed that foliar application of MMF_1 at 20 days after sowing and MMF_2 at 40 days after sowing along + RDF+FYM recorded significantly higher plant height (28.35 cm), number of leaves per plant (6.87) number of branches per plant (4.13), number of pods per plant (26.42), number of seeds per pod (13.15) and dry matter (15.61 g plant^{-1}) of greengram and was observed with MMS_2 + RDF+FYM.

Mahapatra *et al.* (2017) carried out experiment on integrated nutrient management in baby corn during *kharif* and *rabi* seasons of 2012 and 2013 at agronomic main research station of Orissa University of Agriculture and Technology, Bhubaneswar, Odisha, and experiment consisting of four fertility levels and five secondary and micronutrient levels. Integrated nutrient management exhibited significant effect on growth, application of 75 % RDF+vermicompost @ 2.5 t ha^{-1}+mixed bio-fertilizers recorded the highest plant height, number of leaves plant^{-1}, LAI , dry matter accumulation of baby corn at harvest.

Chaudary *et al.* (2018) tested the efficacy of integrated nitrogen management and spacing on growth and yield of fodder maize at crop research farm, department of agronomy, Naini Agricultural Institute, Allahabad (U.P.). The experiment comprised of three planting geometry *viz* 40 ×10 cm, 50× 10 cm, 60×10 cm and 2 nitrogen levels *i.e.* 90 kg N ha^{-1} and 120 kg N ha^{-1} respectively and the result revealed that treatment [120 kg N ha^{-1} + (50% N through vermicompost + 50%N through urea) + Seed inoculated with Azotobacter + 50x10cm] recorded higher plant height (93.19 cm), dry weight (67.72 g).

Gupta *et al.* (2018) conducted experiment to test the effect of plant population and nitrogen levels on growth and yield of fodder maize (*Zea mays* L.) at the research farm, Bihar Agricultural University, Sabour, Bhagalpur, Bihar. Among the different plant spacing, 30cm x 20cm spacing produced significantly higher plant height, leaf area index and dry matter accumulation at different growth stages of fodder maize, whereas, the number of leaves per plant, leaf-stem ratio and SPAD reading were found significantly higher with a spacing of 45cm x 20 cm.

Roy *et al.* (2018) field experiment performed to study the effect of nitrogen and zinc on growth and yield of baby corn at crop research farm, department of agronomy, SHUATS, Prayagraj, (U.P.). The experiment consists of 3 levels of nitrogen (80 kg ha^{-1}, 100 kg ha^{-1}, 120 kg ha^{-1}) and 3 concentration of zinc applied as foliar spray (0.5%, 1.0%, 1.5%) and reported that the application of 120 kg N ha^{-1} in combination with 1.5% zinc conc. recorded maximum plant height and number of cobs and this combination has also recorded maximum cob weight with husk (81.46 g).

Prasad *et al.* (2019) carried out an experiment to study the performance of different sources of livestock and poultry waste as organic manures on growth and yield of fodder maize at Veterinary College Bidar, Bidar, Karnataka and the results revealed that treatment (Poultry Manure 12 t ha^{-1}) has performed significantly better than all other treatments namely, plant height (206.47 cm), number of leaves $plant^{-1}$ (12.00), dry weight (28.82 g).

Sharma *et al.* (2019) an experiment was conducted to study the response of fodder maize (*Zea mays* L.) varieties to different doses of nitrogen at Lovely Professional University Phagwara, Punjab and the varieties were J1006 and African tall and the results showed that plant height and stem girth of the plant were recorded at 30, 45 and 70 DAS and the treatment (50% RDN+13.7 ton FYM ha^{-1}) showed progressive results at all growth parameter stages. The treatment of having a combination of organic and inorganic fertilizer showed a better result as compared to control.

Thakur *et al.* (2019) study was conducted to evaluate the effect of phosphorus, zinc and iron levels on growth and yield of *kharif* maize (Zea mays L.) at SHUATS, Prayagraj, UP and found that application of Phosphorous 60 kg ha^{-1} + zinc 25 kg ha^{-1} + Fe 25 kg ha^{-1} given maximum plant height (199.03cm), No. of leaves (12.73), Plant dry weight (176.23 g), No. of cob $plant^{-1}$ (1.84), Cob length (20.14cm), No. of Grains row cob^{-1} (17.10), No. of grains row^{-1} (24.13), No. of grains cob^{-1} (412.73) and Test weight (318.0g).

Bharathi *et al.* (2020) conducted experiment on suitable plant geometry, levels of fertilizers and foliar spray of micronutrients (Zn and Fe) at 15, 30 and 45 DAS to improve the growth and yield of sorghum at Agricultural Research Station, Kovilpatti, Tamil Nadu and the experiment consists of two plant geometry, three different dose of fertilizer and foliar spray of micronutrients *viz*., 0.5% $ZnSO_4$ + 0.2% $FeSO_4$ at 15, 30 and 45 DAS. The experimental results shows that reduced plant spacing of 30 × 15 cm together with enhanced application of 50:25:25 kg NPK ha^{-1} + foliar spray of 0.5% $ZnSO_4$ + 0.2% $FeSO_4$ at 15, 30 and 45 DAS significantly increased the growth parameters *viz*., plant height, stem girth, days to flowering and dry matter production.

2.2 Response of Nutrient Management on yield of forage maize.

Reddy *et al.* (2004) conducted an experiment to study the influence of different nitrogen levels on growth and yield of forage maize at dairy experimental station, livestock research institute, Rajendranagar, Hyderabad found that highest green fodder yield (24.9 t ha^{-1}) with the application of 240 kg ha^{-1} of nitrogen.

Aslam *et al.* (2006) study the effect of different nitrogen levels and seed rates on fodder yield of maize (*Zea mays* L.) at agronomic research area, University of Agriculture, Faisalabad, Pakistan and recorded the highest yield of fodder that is 52.21 t ha^{-1} with the treatment combination of 125 kg ha^{-1} of seed rate and the nitrogen level up to 150 kg ha^{-1}.

Patil *et al.* (2006) observed that application of $ZnSO_4$ and $FeSO_4$ significantly increased yield of maize on Vertisols of Malaprabha Command (Karnataka). The highest mean yield of 66.74 q ha^{-1} was obtained in treatment receiving $ZnSO_4$ (25 kg ha^{-1}) + $FeSO_4$ (25 kg ha^{-1}) followed by $ZnSO_4$ (10 kg ha^{-1}) + $FeSO_4$ (10 kg ha^{-1}) application (63.08 q ha^{-1}).

Rahman *et al.* (2007) carried out an experiment to study the effect of cattle slurry on production of fodder maize (*Zea mays* L.) at Bangladesh Agricultural University, Bangladesh recorded that the highest biomass yield that is green fodder (44 t ha^{-1}) with the application of 12 t ha^{-1} cattle dung.

Lone *et al.* (2008) conducted an experiment to study the response of baby corn to integrated nutrient management at Sher-e-Kashmir Agricultural University, Kashmir and recorded enhanced green fodder yield (26.39 t ha^{-1}) was observed with application of 6 t ha^{-1} FYM + 150% of RDF).

Ahmad *et al.* (2009) conducted an experiment to study influence of different sowing methods on the growth, yield and quality of different cultivars of forage maize (*Zea mays* L.) at University of Agriculture, Faisalabad, Pakistan. The growth, yield and quality parameters differed significantly among the different cultivars and sowing methods the variety Pak Afgoi recorded highest green forage yield (56.65 t ha^{-1}), dry matter yield (10.90 t ha^{-1}).

Gillani *et al.* (2011) conducted an experiment to study the interactive effect of both macronutrients and micronutrients on the yield of forage maize at agronomic research area, University of Agriculture, Faisalabad, Pakistan and found that the application of two foliar sprays of micronutrients at 15 and 30 DAS along with NP applied in soil significantly increased the green forage yield (58.63 t ha^{-1}) in Pak Afghoi variety.

Suthar *et al.* (2011) conducted an experiment to test the efficacy of different fertility levels on growth and yield of sweet corn at instructional farm, Rajasthan College of Agriculture, Udaipur, Rajasthan and recorded the highest green fodder (26.54 t ha^{-1}) yield with the application of 90 kg N + 40 kg P_2O_5 ha^{-1}.

Dar *et al.* (2012) conducted a study on planting geometry and nitrogen application in dual purpose baby corn (*Zea mays* L.) at National Dairy Research Institute, Karnal, Haryana and reported that the total green fodder yield (30.8 t ha^{-1}) as well as dry fodder yield (6.52 t ha^{-1}) were higher in 50 cm × 15 cm planting geometry than all other planting geometry, most of the growth and yield attributes of baby corn were significantly improved by nitrogen application up to 120 kg N ha^{-1}. However, green (32.3 t ha^{-1}) as well as dry fodder yield (6.66 t ha^{-1}) increased significantly with increase in the level of nitrogen application up to 180 kg ha^{-1}.

Damame *et al.* (2013) an experiment to study on three maize varieties each of baby corn, green cob, seed type and four forage type were grown together under field at research farm of AICRP on forage crops and utilization, Mahatma Phule Krishi Vidyapeeth, Rahuri, Maharashtra and observed that the mean green forage yield obtained from maize forage type was approximately 1.70 times higher than baby corn and seed type cultivars and 2 times than those of green cob type cultivars. Forage type maize cultivar 'African Tall' gave significantly highest green forage yield.

Prajapati and Kewalanand (2013) field experiment was conducted to evaluate response of micronutrient on growth and yield of sweet sorghum at Instructional Dairy Farm, G.B.P.U.A. & T., Pantnagar, U.S.Nagar, Uttarakhand during *Kharif* seasons of 2012 and 2013 and found that with the application of RDF (NPK 120:60:40 kg ha^{-1}) in combination with $ZnSO_4$ 15 kg ha^{-1} + $FeSO_4$ 15 kg ha^{-1} as soil application showed maximum yield attributes such as green fodder yield of 613.36 and 624.63 q ha^{-1}, dry fodder yield of 170.39, 177.21 q ha^{-1}

Bochare (2014) study was conducted the response of forage maize (African Tall) to nitrogen management at M.P.K.V., Rahuri, Maharashtra reported that the application of GRDF along with foliar application of 2% urea at 30 days after sowing recorded the highest yield and yield contributing attributes such as green fodder yield (57.125 t ha^{-1}) and dry matter yield (12.356 t ha^{-1}).

Vyas *et al.* (2014) an experiment was conducted find out the response of *rabi* maize (*Zea mays* L.) varieties to different levels of nitrogen for green forage yield under middle Gujarat conditions during *rabi* season of 2012-13 at Anand Agricultural University, Anand, Gujarat and results revealed that the highest green forage (543.62 q ha^{-1}) and dry matter (125.29 q ha^{-1}) yields of forage maize were recorded by African tall variety over the variety GM-3 and GM-4 and the application of nitrogen at 140 kg ha^{-1} produced significantly higher green forage (543.40 q ha^{-1}) and dry matter (113.53 q ha^{-1}) yields.

Borase *et al.* (2015) conducted field an experiment to study the response of *kharif* maize to micronutrients at national agricultural research project, Aurangabad, Maharasthra and results revealed that the highest grain yield was recorded by T_8-RDF + $ZnSO_4$ + $FeSO_4$ + Borax (4890 kg ha^{-1}) followed by T_9-RDF + Foliar application of Micronutrient (4791 kg ha^{-1}). Thus, for securing maximum grain yield maize crop should be sown by supplying recommended dose of NPK (150:75:75 kg ha^{-1}) along with $ZnSO_4$ 20 kg ha^{-1}, $FeSO_4$ 20 kg ha^{-1} and borax 5 kg ha^{-1}.

Manasa and Devaranavadagi (2015) conducted the experiment on effect foliar application of micronutrients on yield and uptake of nutrients in maize at UAS, Dharwad, Karnataka and found that the yield attributes were significantly higher with soil application of recommended dose of N, P_2O_5, K_2O along with foliar application of $ZnSO_4$ @ 1.0 per cent during grand growth stage like cob length, cob girth, number of grains per row, total number of grains per cob, grain weight per cob and 100 grain weight and grain yield (89.73 q ha^{-1}).

Chand *et al.* (2016) an experiment was laid out to find effect of zinc fertilization on yiled of baby corn (*Zea mays* L.) at College of Agriculture, Rajendranagar, Hyderabad, reported a dry forage yield (10855 kg ha^{-1}) and green fodder yield (27.76 t ha^{-1}).

Jadhav *et al.* (2016) carried out an experiment to study the effect of integrated nutrient management on growth and yield of *rabi* forage maize at Jorapura farm of livestock research station, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar, Jorapura, Gujarat and the results revealed that 15 t FYM ha^{-1} performed better by recording 5.67 and 5 per cent higher green forage (503 q ha^{-1}) and dry fodder (105 q ha^{-1}) yield, respectively over 10 t FYM ha^{-1}. Combined application of 100 % RDF + Azotobacter + PSB performed better by recording 58.23 and 52.63 per cent higher green forage (557 q ha^{-1}) and dry fodder (116 q ha^{-1}) yield over other treatments.

Kanduri *et al.* (2016) carried out an experiment on effect of different combination of nitrogen phosphorus levels was studied in a field experiment particularly on the fodder yield of African tall maize fodder at College of Veterinary and Animal Sciences, Udgir, Latur, Maharashtra and nitrogen-phosphorus fertilizers at the rate of 0-0, 100-30, 120-40 and 160-50 kg ha^{-1} were applied. Maximum green fodder yield (44.97 t ha^{-1}) was obtained at nitrogen-phosphorus level of 160-50 kg ha^{-1}.

Lalitha *et al.* (2016) conducted a field experiment to study the effect foliar application of macro and micro nutrients on growth and yield attributes of baby corn (*Zea mays* L.) at GKVK, Benagluru, Karnataka and found that application of 75% RDF + 1.5% 19:19:19 spray + 0.5% $ZnSO_4$ + 0.1% $FeSO_4$, recorded significantly higher corn yield and fodder yield (212.37 q ha^{-1} and 76.82 t ha^{-1}, respectively).

Mahapatra *et al.* (2017) performed experiment on integrated nutrient management in baby corn during *kharif* and *rabi* seasons of 2012 and 2013 at agronomic main research station of Orissa University of Agriculture and Technology, Bhubaneswar, Odisha and reported that application of 75% RDF+vermicompost @ 2.5 t ha^{-1}+mixed bio-fertilizers recorded the highest green forage (26.03 t ha^{-1}) yield and application of 40 kg S ha^{-1}+5 kg Zn ha^{-1}+2.5 kg B ha^{-1} has resulted in significant increase in yield components and also green forage (26.17 t ha^{-1}) yield.

Tahira *et al.* (2017) a field experiment was laid out on effect of different levels of seed rate, nitrogen and zinc on yield and quality of fodder maize (*Zea mays* L.) was conducted at UAS, GKVK, Bengaluru during *kharif* 2017 and study revealed that, seed rate of 75 kg ha^{-1} recorded significantly higher dry matter accumulation (104.32 g $plant^{-1}$) and green fodder yield of 34.29 t ha^{-1} when compared to seed rate of 50 kg ha^{-1} (98.60 g $plant^{-1}$ and 29.58 t ha^{-1} of dry matter accumulation and green fodder yield respectively), and was on par with seed rate 100 kg ha^{-1} (102.75 g $plant^{-1}$ and 32.50 t ha^{-1} of dry matter accumulation and green fodder yield respectively). Application of 150 kg nitrogen ha^{-1} resulted significantly higher dry matter accumulation of 107.87 g $plant^{-1}$ and green fodder yield (34.56 t ha^{-1}) over nitrogen at 100 kg ha^{-1} and 125 nitrogen ha^{-1}. Application of 10 kg zinc ha^{-1} recorded significantly higher dry matter accumulation of 103.69 g $plant^{-1}$ and green fodder yield (33.07 t ha^{-1}) over no zinc application (30.78 t ha^{-1}).

Choudary *et al.* (2018) tested the efficacy of integrated nitrogen management and spacing on growth and yield of fodder maize at crop research farm, department of agronomy, Naini Agricultural Institute, Allahabad (U.P.) and reported that treatment [120 kg N ha^{-1} + (50% N through vermicompost + 50%N through urea) + seed inoculated with Azotobacter + 50x10cm] recorded higher green fodder yield (44.56 t ha^{-1}).

Lagad *et al.* (2018) an experiment was conducted to study the effect of foliar nutrient management on yield of summer forage sorghum at M.P.K.V., Rahuri, Maharashtra found that application of GRDF (Gross Recommended Dose of Fertilizers) along with foliar application of 2% urea at 40 days after sowing recorded higher green fodder yield (589.83 q ha^{-1}) and dry matter yield (120.50 q ha^{-1}).

Prasad *et al.* (2019) carried out an experiment to study the performance of different sources of livestock and poultry waste as organic manures on growth and yield of fodder maize at Veterinary College Bidar, Bidar, Karnataka, found that higher green fodder yield $plant^{-1}$ (195.75 g), green fodder yield per m^2 (3132.05 g), green fodder yield ha^{-1} (31.32 t),dry fodder yield $plant^{-1}$ (41.22 g), dry fodder yield per m^2 (659.57 g) and dry fodder yield ha^{-1} (6.60 t).

Thakur *et al.* (2019) study was conducted to evaluate the effect of phosphorus, zinc and iron levels on growth and yield of *kharif* maize (Zea mays L.) at SHUATS, Prayagraj, UP and found that application of Phosphorous 60 kg ha^{-1} + zinc 25 kg ha^{-1} + Fe 25 kg ha^{-1} given maximum grain yield (2.77t ha^{-1}), straw yield (5.23 t ha^{-1}), Harvest index (34.66%).

2.3 Response of nutrient management on quality of forage maize

Ayub *et al.* (2000) tested the efficacy of different combinations of nitrogen and phosphorus levels on quality of maize (*Zea mays* L.) at University of Agriculture, Fasilabad, Pakistan and test results showed that NP levels of 200 and 60kg ha^{-1} respectively recorded higher crude protein and crude fiber yields.

Mohamed El-Murtada Hassan Amin (2006) conducted experiment to investigate the effect of different nitrogen sources on growth, yield and quality of fodder maize (*Zea mays* L.) at Omdurman Islamic University, Sudan and in the investigation the sources of nitrogen used were urea, nitrophoska (NPK), ammonium sulphate nitrate (ASN) and ammonium sulphate (AS) and results indicated that ASN resulted highest crude protein (9.18%) and control recorded highest crude fiber (29.37%) contents.

Ahmad *et al.* (2009) conducted an experiment to study the influence of different sowing methods on the growth, yield and quality of different cultivars of forage maize (*Zea mays* L.) at University of Agriculture, Faisalabad, Pakistan and observed that one of forage maize cultivar (pak afgoi) recorded the highest crude protein (8.76%) and crude fiber (30.93%).

Sahoo *et al.* (2009) carried out an experiment to study the effect of intercropping on forage yield and quality of forage maize (*Zea mays* L.) at Pachhunga University College, Mizoram University, Aizawl, Mizoram and experiment comprises of intercropping maize (*Zea mays* L.) with common bean (*Phaseolus vulgaris* L.), turmeric (*Curcuma longa* L.) and roselle (*Hibiscus sabdariffa* L.) and they obtained that the average acid detergent fibre (ADF) and neutral detergent fibre (NDF) contents in maize significantly decreased in intercrops than the sole maize crop in both years increasing digestibility of forage, the crude protein (CP) in maize was highest (88 g kg^{-1}) when intercropped with bean and lowest (64 g kg^{-1}) with turmeric. The chemical properties such organic carbon and nitrogen content in soil increased with the intercropping.

Gillani *et al.* (2011) conducted an experiment to test the interactive effect of both macronutrients and micronutrients on the yield of forage maize at agronomic research area, University of Agriculture, Faisalabad, Pakistan and observed that highest crude protein (9.55%) in Pakafgoi variety of fodder maize with the application of two foliar sprays of micronutrients and along with NP as soil nutrition.

Choudary *et al.* (2012) study was conducted on fodder potentiality of different types of maize such as baby corn (HM-4), sweet corn (HSC-1), forage type maize (J-1006), normal maize (DHM-117) and quality protein maize (HQPM-5) were analyzed for forage quality at regional research station and seed production centre, Begusarai, Bihar during *kharif* 2012 and study indicated that forage maize (J-1006) exhibited highest crude protein (CP) and lowest in fiber contents (CF,ADF,NDF).

Dar *et al.* (2012) study was conducted on planting geometry and nitrogen application in dual purpose baby corn (*Zea mays* L.) at National Dairy Research Institute, Karnal, Haryana and found that application of nitrogen at higher levels resulted in significant increase in content of CP (11.69%), however ADF (34.79%) and NDF (66.36%) were decreased with increase in level of nitrogen application and also increased the uptake of nitrogen with increased application of nitrogen at higher levels.

Daur and Ahmed (2012) study was conducted to examine the fodder maize response to humic acid at King Abdul Aziz University, Saudi Arabia and found that 25 kg ha^{-1} resulted in highest and crude protein (11.50%), lowest NDF (55.14%) and highest mineral contents (N, P, K, Ca, Mg, S) and also increased residual soil nutrients such as both macro and micro nuteints.

Iqbal *et al.* (2012) a research trial was conducted to test the efficacy of organic and inorganic sources of nitrogen fertilizers alone and in different combinations on the yield and quality contributing parameters of forage maize (*Zea mays* L.) at University of Agriculture, Faisalabad, Pakistan found that application of 100% recommended dose of nitrogen through urea recorded highest crude protein (8.63%) content in forage maize.

Damame *et al.* (2013) an experiment to study on three maize varieties each of baby corn, green cob, seed type and four forage type were grown together under field at research farm of AICRP on forage crops and utilization, Mahatma Phule Krishi Vidyapeeth, Rahuri, Maharashtra and found that forage type maize cultivar African Tall gave significantly highest green forage yield, dry matter yield and crude protein yield. The highest mean per cent crude protein (8.5%), crude protein yield (7.38 q ha^{-1}) and with the lowest mean crude fibre content (22.0%), acid detergent fibre (43.0%) and the lowest mean neutral detergent fibre (62.7%).

Prajapati and Kewalanand (2013) field experiment was conducted to evaluate response of micronutrient on growth and yield of sweet sorghum at Instructional Dairy Farm, G.B.P.U.A. & T., Pantnagar, U.S.Nagar, Uttarakhand during *Kharif* seasons of 2012 and 2013 and found that with the application of RDF (NPK 120:60:40 kg/ha) in combination with $ZnSO_4$ 15 kg ha^{-1} + $FeSO_4$ 15 kg ha^{-1} as soil application showed maximum crude protein yields 16.65 and 17.44 q ha^{-1}.

Gohil *et al.* (2015) conducted an experiment to study the effect of potassium, zinc and FYM on content and uptake of micronutrients by forage maize (*Zea mays* L.) grown on loamy sand soil at B. A. College of Agriculture, Anand, Gujrat and found that application of K_2O @ 60 kg ha^{-1}, Zn @ 20 kg ha^{-1} and FYM @ 10 t ha^{-1} recorded significantly the highest uptake of Fe, Mn, Zn and Cu by crop at harvest.

Manasa and Devaranavadagi (2015) conducted the experiment on effect foliar application of micronutrients on yield and uptake of nutrients in maize at UAS, Dharwad, Karnataka and found that the yield attributes were significantly higher with soil application of recommended dose of N, P_2O_5, K_2O along with foliar application of $ZnSO_4$ @ 1.0 per cent during grand growth stage recorded a higher uptake of Zn, Fe and B.

Meenakshi *et al.* (2015) conducted experiment to test the production potential of forage maize varieties under varying intercropping systems with cowpea at Sher-e-Kashmir University of Agricultural Sciences and Technology of Jammu, Jammu and experiment consisting of three fodder maize cultivars 'African tall, J-1006 and local variety' and cowpea 'CL367' were sown as sole crop as well as in intercropping systems, results revealed that highest crude protein yield was observed with African tall intercropped in 1:1 ratio, the highest crude fibre and NDF yields were recorded in local variety intercropped with cowpea in 2:1 row ratio whereas significantly the highest ADF was recorded with local variety intercropped with cowpea in 1:1 mix.

Kumar *et al.* (2015) conducted an experiment to study the effect of seedling density and nutrient levels on quality of fodder maize (*Zea mays* L.) at ICAR-NDRI, Karnal and results revealed that neutral detergent fiber (NDF) and acid detergent fiber (ADF) content, in which 60 kg ha^{-1} seed rate accumulated significantly lower fiber contents, however the results showed that use of 150% RDF improved CP content by 20.2% and the maize fodder supplied with 150% RDF attributed minimum level of fiber fractions and magnitude of reduction in NDF was 3.49%, ADF was 3.54% and also revealed that the combination of 60 kg ha^{-1} seed rate and 125% RDF obtained significant maximum CP (1542.1 kg ha^{-1}).

Ramanjineyulu *et al.* (2015) conducted an experiment response of maize (*Zea mays* L.) in uptake of micronutrients at developmental stages by foliar application of secondary micronutrients and found that Application of recommended dose of fertilizers with 0.1 per cent $ZnSO_4$ showed the significant effect on uptake of micronutrients by maize crop. Response of maize to micronutrients was consistent, where amount of N, P, and K were adequate in the leaf samples.

Subrhamanya *et al.* (2016) tested the efficacy of varying plant densities and nutrient management on quality of fodder maize (*Zea mays* L.) and reported that application of 60 Kg ha^{-1} of seed rate and 125% RDF recorded a highest crude protein and lowest ADF and NDF content.

Sharifi *et al.* (2016) tested the efficacy of seed priming and foliar application with micronutrients on quality of forage corn (*Zea mays* L.) at Islamic Azad University of Sanandaj, Iran and test results showed that application of nano forms of fertilizers and seed priming compared chemical fertilizers yielded higher crude protein and lower crude fiber yield.

Mohammadi *et al.* (2016) an experiment was carried to study the effect of biological and chemical nitrogen fertilizers and iron micronutrient on forge quality and yield of maize (*Zea mays* L.) at University of Kurdistan, Sanandaj, Iran and found that application of supernitroplus + 300 kg ha^{-1} urea and iron application recorded highest crude protein yield and control treatment recorded highest ADF and NDF contents in forage maize.

Nabooji *et al.* (2016) tested the effect of seed rates and nitrogen levels on growth and fodder yield of sweet sorghum at V.C. farm, Mandya, Karnataka and reported that seed rate of 40 kg ha^{-1} recorded significantly higher crude protein yield (0.54 t ha^{-1}) and crude fiber yield (1.90 t ha^{-1}), among nitrogen levels, application of 125% RDN ha^{-1} recorded significantly crude protein yield (0.63 t ha^{-1}) and crude fibre yield (1.91 t ha^{-1}).

Mishra *et al.* (2017) conducted experiment on response of forage maize to integrated nutrient management Chandra Shekhar Azad University of Agriculture and Technology, Kanpur,UP and reported that effect of integrated nutrient management in maize (*Zea mays* L.) results indicated that application of 100% RDN + 25% N FYM + S_{30} + Zn_5 yielded higher crude protein content (8.99%).

Lagad *et al.* (2018) an experiment was conducted to study the effect of foliar nutrient management on yield of summer forage sorghum at M.P.K.V., Rahuri, Maharashtra and recorded that application of GRDF (Gross Recommended Dose of Fertilizers) along with foliar application of 2% urea at 40 days after sowing yielded highest crude protein yield (10.07 q ha^{-1}) and crude fiber yield (35.19 q ha^{-1}) in summer forage sorghum and also increased the nuteient uptake such as N, P, and K.

Baljeet *et al.* (2019) carried out an experiment on yield and qualitative evaluation of fodder maize (*Zea mays* L.) under potassium and zinc based integrated nutrient management at ICAR-National Dairy Research Institute, Karnal, Haryana and the results revealed that application of 100 % RDK+PGPR+FYM (5 t ha^{-1}) + two-time spray of 0.5% Zn resulted in higher crude protein (CP) content and yield with a concomitant decrease in fibre fractions over other treatments and control.

2.4 Response of nutrient management on economics of forage maize

Rashid *et al.* (2004) conducted an experiment that effect of NPKS fertilization over yield and economics of fodder maize (*Zea mays* L.) at University of Agriculture, Faisalabad, Pakistan reported that the crop fertilized with 250: 150: 100: 15 NPKS kg^{-1} gave the maximum net income of Rs. 48690.5 ha^{-1} with benefit cost ratio of 2.98 in maize.

Reddy *et al.* (2004) conducted and experiment to study the influence of different nitrogen levels on growth and yield of forage maize at dairy experimental station, livestock research institute, Rajendranagar, Hyderabad and found that GDG maize grown by applying 240 kg N ha^{-1} in three splits (0, 30 and 70 DAS) gave significantly higher net returns (INR 24,509 ha^{-1}).

Singh *et al.* (2004) carried out an experiment to evaluate appropriate fertility levels and N sources for baby corn (*Zea mays* L.) at Banaras Hindu University, Varanasi, UP and recorded net returns increased significantly with each successive increase in fertility level upto highest fertility levels *i.e.* 180 + 38.7 + 74.7 kg N+P+K ha^{-1}. Application of N through fertilizer alone recorded significantly higher baby corn yield (2.30 t ha^{-1} mean) and net returns (Rs. 1,10,983 ha^{-1}) over 50% fertilizer N + 50% N through FYM.

Shashidhar *et al.* (2007) conducted a field experiment at Zonal Agricultural Research Station, Navile, Shivamogga, India during *kharif* 2007 Shivamogga, Karnataka to study the effect of different nutrient management practices on yield, economics and nutrient uptake in maize. The results indicated that higher net returns (Rs. 31667 ha^{-1}), B: C ratio (2.6) were recorded with application of 125% of the recommended amount of NPK+ poultry manure on N equivalent basis.. Significantly net returns (Rs. 21467 ha^{-1}), B:C ratio (2.1) were recorded with application of only the recommended amount of NPK through inorganic fertilizers.

Lone *et al.* (2008) an experiment conducted to study the response of baby corn to integrated nutrient management at Sher-e-Kashmir Agricultural University, Kashmir revealed that Cultivation of baby corn (*Zea mays* L.) variety VL-78 under temperate conditions with an application of N:P:K at 90N:60P:40K, kg ha^{-1} in combination with 6 t ha^{-1} FYM revealed a maximum B:C ratio of 1:1.59. With 703 \$ ha^{-1} as cost of cultivation, the estimated gross returns from the cultivation practice were to the tune of 1825 \$ giving a benefit of 1123 \$ ha^{-1}.

Meena and Samrath (2008) carried out an experiment study the effect of cultivars, nitrogen levels and farmyard manure on performance of fodder sorghum at Central Sheep and Wool Research Institute, Avikanagar, Rajasthan reported that net return and benefit: cost ratio were accrued highest with the application of 120 kg N ha^{-1} (Rs. 32,070 ha^{-1} and 2.61) in Sorghum.

Dadarwal *et al.* (2009) experiment was laid out study the integrated nutrient management on yield economics of baby corn (*Zea mays* L.) at Rajasthan College of Agriculture, Udaipur, Rajasthan and observed an increase in net returns and B: C ratio with increasing dose of fertilizer application in baby corn.

Kalhapure *et al.* (2010) experiment was conducted to find out most efficient and economic combination of different organic and inorganic sources of nutrients to increase the productivity of hybrid maize (*Zea mays* L.) at M.P.K.V., Rahuri, Maharashtra found that application of 100% RDF with combined use of organic and inorganic fertilizers which was 7.4 t ha^{-1} with highest gross return ($95.9x10^3$ ha^{-1}) and net return ($54.2x10^3$ ha^{-1}). Maximum B: C ratio (1.30) was also observed in jointly use of 25% RDF, compost, biofertilizers and green manuring and it was followed by application of 100% RDF (1.26).

Shanti *et al.* (2010) study was conducted on forage quality of various maize (*Zea mays* L) cultivars under different use patterns Acharya N. G. Ranga Agricultural University, Hyderabad (A.P.) and found that net returns were Rs. 39,750 ha^{-1} from baby corn. The economics through net returns and B: C ratio indicated baby corn > fodder crop > seed crop > green cob.

Suthar *et al.* (2011) experiment was conducted to study the green fodder yield and quality of sweet corn under varying fertility levels at Rajasthan College of Agriculture, Udaipur, Rajasthan found that one of the variety with four fertility levels (70 + 30, 90 + 40, 110 + 50 and 130 + 60 kg N + P2 O5 ha^{-1}) recorded maximum net returns Rs.127817 ha^{-1} and BC ratio 6.0.

Dar *et al.* (2012) study was conducted on planting geometry and nitrogen application in dual purpose baby corn (*Zea mays* L.) at National Dairy Research Institute, Karnal, Haryana and results revealed that application of 180 kg ha^{-1} recorded highest net returns (155.9 × 103 ha^{-1}) and benefit: cost ratio (2.21) in baby corn.

Damame *et al.* (2013) an experiment to study on three maize varieties each of baby corn, green cob, seed type and four forage type were grown together under field at research farm of AICRP on forage crops and utilization, Mahatma Phule Krishi Vidyapeeth, Rahuri, Maharashtra and found that highest mean gross monetary returns, net monetary returns, B: C (3.5) in fodder.

Anees *et al.* (2014) a field experiment was conducted for two years from 2013 to 2014 to study the effect of foliar spray of potassium and zinc on maize crop under rainfed environment at national agriculture research center, Islamabad, Pakistan and found that combined application of foliar zinc sulphur (FZS) and foliar zinc potassium (FKS) recorded maximum gross returns (Rs. 261775), net returns (Rs. 207295) and B: C ratio (3.80).

Bhagat *et al.* (2014) experiment was conducted to study the production potential and economics of fodder maize (*Zea mays*) varieties sown under varying intercropping systems with cowpea (*Vigna unguiculata*), at the research farm of division of agronomy, Sher-e-Kashmir University of Agricultural Sciences and Technology of Jammu, Jammu and Kashmir observed that fodder maize that among the sole varieties significantly highest net returns and B: C ratio was recorded with African tall followed by sole J-1006 whereas among intercropping treatments significantly the highest fodder maize net returns and B: C ratio was recorded with African tall intercropped with cowpea in 2:1 row ratio.

Vyas *et al.* (2014) an experiment was conducted to find out the response of *rabi* maize (*Zea mays* L.) varieties to different levels of nitrogen for green forage yield under middle Gujarat conditions during *rabi* season of 2012-13 at Anand Agricultural University, Anand, Gujarat and experiment comprised of three varieties (African tall, GM-3 and GM-4) and four nitrogen levels (80,100,120 and 140 kg N ha^{-1}) and found that application of 140kg N kg^{-1} recorded higher net realization of 21282 Rs. ha^{-1} and higher B.C.R. value of 1.09 were recorded in variety African tall. Among different nitrogen levels, application of 140 kg N ha^{-1} resulted in higher net realization (Rs. 19129 ha^{-1}) with B.C.R. of 1.05.

Mahapatra *et al.* (2017) carried out an experiment on integrated nutrient management in baby corn during *kharif* and *rabi* seasons of 2012 and 2013 at agronomic main research station of Orissa University of Agriculture and Technology, Bhubaneswar, Odisha and found that application of 40 kg S ha^{-1}+5 kg Zn ha^{-1}+2.5 kg B ha^{-1} resulted in highest net return (81217 ha^{-1}) and B: C ratio of 3.13.

Lagad *et al.* (2018) an experiment was conducted to study the effect of foliar nutrient management on yield of summer forage sorghum at M.P.K.V., Rahuri, Maharashtra and found that application of GRDF (Gross Recommended Dose of Fertilizers) along with foliar application of 2% urea at 40 days after sowing recorded significantly higher gross returns (Rs. 117966 ha^{-1}) and net returns (Rs. 76620 ha^{-1}).

Thakur *et al.* (2019) conducted a study to evaluate the effect of phosphorus, zinc and iron levels on growth and yield of *kharif* maize (Zea mays L.) at SHUATS, Prayagraj, UP and found that application of Phosphorous 60 kg ha^{-1} + zinc 25 kg ha^{-1} + Fe 25 kg ha^{-1} given maximum gross return of Rs. 88330 ha^{-1}, Net return Rs. 38632 ha^{-1} and B: C 1.78.

3. MATERIALS AND METHODS

The field experiment was conducted to study the "Response of forage maize (*Zea mays* L.) to nutrient management during summer season" at AICRP on Forage Crops Research Project, Mahatma Phule Krishi Vidyapeeth, Rahuri. The details of the material and analytical techniques adopted for the investigation are presented in this chapter.

3.1 Details of experimental material

3.1.1 Experimental site

Research farm of AICRP on Forage Crops and Research Project, MPKV, Rahuri.

3.1.2 Soil

The topography of the experimental field was uniform levelled and uniform in depth up to 60 cm. The soil comes under Inceptisol order. The soil of the experimental site was well drained. The representative soil samples were collected for assessing initial soil fertility status. These soil samples were thoroughly mixed and the composite soil sample was prepared and analyzed for physical and chemical properties of soil.

The soil of experimental field was moderately alkaline in nature, pH was 8.53, normal in EC 0.31 (dSm^{-1}) and medium organic carbon 0.48 (%) as well as the initial soil fertility of experimental field was low in available nitrogen 244.57 kg ha^{-1}, moderate in available phosphorus 24.31 kg ha^{-1} and very high in available potassium 438.68 kg ha^{-1}.

3.1.3 Climate

3.1.3.1 General

Geographically, Mahatma Phule Krishi Vidyapeeth, Rahuri is situated between 19^0 47' and 19^0 57' North latitude and 74^0 19' and 74^0 32' East longitude. The altitude above mean sea level is about 495 meters.

This tract is lying on the Eastern side of Western Maharashtra that falls under rain shadow area. The climatic conditions prevailed during the period of present investigation and the meteorological data were recorded on important weather parameters during summer, 2020 and are presented in Table 2 and graphically depicted in Figure 1

The data revealed that during crop growth period, maximum temperature during the crop growth period was ranged between 28.10 to 40.60 ^oC, minimum temperature during crop growth period was ranged between 13.10 to 26.9 ^oC, the maximum relative humidity was ranged between 55.00 to 81.00 % and minimum relative humidity was ranged between 17.00 to 45.00 %, the sunshine hours were recorded from 7.30 to 10.90, wind velocity ranged from 0.8 to 5.8 km hr^{-1}, rainfall of 95.2 mm in five rainy days during the crop growth period.

Table 1. Chemical properties of soil at experimental site and nutrient status of forage maize after harvest.

Sr. No.	Characteristics	Composition	Method Adopted	References
A	**Chemical properties (Soil)**			
1	Soil pH (1:2.5)	8.53	Potentiometric	Jackson (1973)
2	EC (dSm^{-1})	0.31	Conductometer	Jackson (1973)
3	Organic carbon (%)	0.48	Wet oxidation	Nelson and Sommer (1982)
4	Available nitrogen (kg ha^{-1})	244.57	Alkaline permanganate	Subbiah and Asija (1956)
5	Available phosphorus (kg ha^{-1})	24.31	(Ascorbic acid) 0.5 M $NaHCO_3$ (pH 8.5)	Watnabe and Olsen
6	Available potassium (kg ha^{-1})	438.68	(N Ammonium acetate)	Jackson (1973)
7	Available iron (ppm)	4.20	Atomic Absorption Spectophotometer	Lindsay and Norvell, (1978)
8	Available zinc (ppm)	0.60	Atomic Absorption Spectophotometer	Lindsay and Norvell, (1978)
9	Available copper (ppm)	0.20	Atomic Absorption Spectophotometer	Lindsay and Norvell, (1978)
10	Available manganese (ppm)	2.00	Atomic Absorption Spectophotometer	Lindsay and Norvell, (1978)
11	Available boron (ppm)	0.50	Hot Water Soluable	Berger and Troug (1939)
12	Available molybdenum (ppm)	0.05	Ammonium oxalate at pH 3.3	Griggs (1939)
B	**Nutrient Status of forage maize after harvest**			
1	Nitrogen (kg ha^{-1})	140.28	Alkaline permanganate	Subbiah and Asija (1956)
2	Phosphorus (kg ha^{-1})	15.88	(Ascorbic acid) 0.5 M $NaHCO_3$ (pH 8.5)	Watnabe and Olsen
3	Potassium (kg ha^{-1})	120.36	(N Ammonium acetate)	Jackson (1973)
4	Iron (ppm)	46.23	Atomic Absorption Spectophotometer	Lindsay and Norvell, (1978)
5	Zinc (ppm)	39.63	Atomic Absorption Spectophotometer	Lindsay and Norvell, (1978)
6	Copper (ppm)	18.92	Atomic Absorption Spectophotometer	Lindsay and Norvell, (1978)
7	Manganese (ppm)	30.61	Atomic Absorption Spectophotometer	Lindsay and Norvell, (1978)
8	Boron (ppm)	22.69	Hot Water Soluable	Berger and Troug (1939)
9	Molybdenum (ppm)	9.93	Colorimetric method	Johnson and Arkley (1954)

Table 2: Meteorological data during crop growth period

MW	Date	Temp (^0C)		Relative Humidity (%)		Sunshine hours (hrs)	Wind Velocity (km hr $^{-1}$)	Rainfall (mm)	Rainy Days
		Max.	Min.	Morn.	Even.				
February-2020									
6	5-11	28.1	13.1	81	43	7.60	2.2	0	-
7	12-18	30.3	16.3	81	34	7.50	0.8	0	-
8	19-25	33.5	16.9	73	25	9.30	0.9	0	-
9	26-04	33.6	12.9	80	25	9.40	2.6	0	-
March-2020									
10	5-11	31.0	14.7	73	28	8.60	2.4	0	-
11	12-18	32.5	15.9	68	27	8.50	1.6	0	-
12	19-25	34.4	17.4	71	25	8.80	1.3	0	-
13	26-01	34.2	20.2	75	32	7.30	1.4	023.4	2
April-2020									
14	02-08	37.0	19.0	77	19	9.50	1.2	0	-
15	09-15	38.1	21.3	67	18	9.70	1.3	0	-
16	16-22	39.1	21.9	73	20	10.20	2.0	04.0	1
17	23-29	38.1	21.8	70	20	10.80	3.2	0	-
18	30-06	40.1	25.1	61	17	10.60	3.2	0	-
May-2020									
19	07-13	39.9	25.6	55	20	10.90	3.2	0	-
20	14-20	38.8	26.9	63	25	07.90	3.9	0	-
21	21-27	40.6	25.0	64	17	09.10	5.8	0	-
22	28-03	35.8	24.5	79	45	07.90	5.5	067.8	2

Table 3. Cropping history of the experimental field

Year	Seasons		
	Kharif	*Rabi*	Summer
2018-19	Fallow	Fallow	Fallow
2019-20	Forage maize	Fallow	Fallow
2020-21	Fallow	Fallow	Present investigation

3.2 Methods

3.2.1 Experimental details

The experiment was laid out in randomized block design with four replications. Six treatment combinations were formed. The details of treatments along with symbols used are presented below in Table 4.

3.2.2 Preparation of field layout

The plan of experimental layout is given below and depicted in Fig.2.

Table 4: Details of treatment plots and symbols used

Treatment		
T_1	:	Absolute Control.
T_2	:	RDF (100:50:50 N: P_2O_5: K_2O Kg ha^{-1}).
T_3	:	GRDF (100:50:50 N: P_2O_5: K_2O Kg ha^{-1} + FYM 5 t ha^{-1}).
T_4	:	GRDF + Soil application of Government notified multi-micronutrient Grade I @ 25 kg ha^{-1}
T_5	:	GRDF + Two foliar spray of Phule liquid micronutrient grade II @ 1% at 30 and 45 DAS.
T_6	:	GRDF + Soil application of Government notified multi-micronutrient Grade I @ 25 kg ha^{-1} + Two foliar spray of Phule micronutrient grade II @ 1% at 30 and 45 DAS.

3.2.3 Cultural Operations

Date wise schedule of the cultural operations in the experimental field of forage maize during period of experimentation are given in table 5.

3.2.3.1 Preparation of land and planting layout

After completion of preparatory tillage operation the land was ploughed and harrowed and experimental layout was prepared as a flat beds having gross plot size 3.9 m length and 3.00 m width as per number of replications.

3.2.3.2 Seed and sowing

For sowing of forage maize 40 kg ha^{-1} seed rate was used. Before sowing FYM was applied to the research plot.

Table 5. Schedule of cultural operations carried out during the experimental period

Sr. No.	Name of Operation	Frequency	Date
A.	**Preparatory tillage**		
1.	Ploughing	1	10-02-2020
2.	Harrowing	1	20-02-2020
3.	Field layout	1	28-02-2020
B.	**Sowing and fertilizer application**		
1.	Fertilizer application as basal and top dressing	2	04-03-2020 03-04-2020
2.	Sowing and dibbling	1	04-03-2020
C.	**Post sowing operations**		
1.	Gap filling	1	12-3-2020
2.	Thinning	1	20-03-2020
3.	Hand weeding	1	28-03-2020
4	Foliar Application	2	03-04-2020 17-04-2020
5	Irrigations	7	04-03-2020 12-03-2020 29-03-2020 09-04-2020 19-04-2020 02-05-2020 14-05-2020
E.	**Harvesting**	1	19-5-2020

3.2.3.3 Gap filling

The thinning was carried out 10 days after sowing on 20.03.2020 to maintain uniform plant population.

3.2.3.4 Hand weeding

One common hand weeding was carried out to all treatment at 24 days after sowing in order to keep the experimental plot weed free.

3.2.3.5 Fertilizer application

The forage maize was fertilized with RDF as 100:50:50 kg NPK ha^{-1}. The 50 kg N and full dose of P and K applied as basal dose and remaining 50 Kg N applied at 30 days after sowing (DAS). The source of nitrogen through urea, the source of phosphorus through single super phosphate, potassium was applied through muriate of potash and Fe, Zn, Cu, Mn, B and Mo was applied through Soil application of Government notified multi-micronutrient Grade-Ⅰ @ 25 kg ha^{-1} and two foliar sprays of Phule liquid micronutrient grade - Ⅱ @ 1 % 30 and 45 DAS.

3.2.3.6 Foliar application of water soluble fertilizers

The foliar two sprays of Phule liquid micronutrient grade - Ⅱ @ 1 % 30 and 45 DAS were applied with Knapsack sprayer as per the treatment on 03-04-2020 and 17-04-2020, respectively.

3.2.3.7 Irrigation

The first irrigation was given on 04.03.2020 to forage maize immediately after sowing and second irrigation was given on 12.03.2020 for assured germination and crop establishment. Thereafter, the five irrigations were applied on 29-03-2020, 09-04-2020, 19-04-2020, 02-05-2020 and 14-05-2020 as per requirement of crop by observing visual symptoms. Total five irrigations were required during the period of experimentation.

3.2.3.8 Harvest

The harvesting of forage maize was done on 19.05.2020 (75 days after sowing) for forage at 50 per cent flowering stage.

3.3 Pre harvest studies

3.3.1 Sampling technique

During the course of investigation, five plants were randomly selected and marked with tags from each net plot for recording different growth observation *viz.,* plant height, number of functional leaves, leaf area and leaf: stem ratio.

3.3.2 Initial soil sampling

The representative composite soil sample was collected from experimental field before start of experiment. The collected sample were brought in to the laboratory and mixed thoroughly. The mixed sample was ponded in a wooden mortar and sieved through 2 mm sieve. The sieved 500 g of soil samples were used for analysis of initial status of soil *viz*., pH, EC, organic carbon and available N, P, K, Fe Zn, Mn, Cu, B and Mo. The standard methods mentioned in table 1 were adopted for determination of various soil properties.

3.4 Biometric studies

3.4.1 Plant count

Number of plants from gross plot has been counted

3.4.2 Plant height

The five plants were randomly selected from each net plot plant and height was measured in cm from ground level of stem to the base of last opened leaf at 15, 30, 45, 60 DAS and at harvest of green fodder.

3.4.3 Number of leaves plant^{-1}

The green and fully opened leaves of randomly selected five plant from each net plot tag plant were counted at 15, 30, 45, 60 DAS and at harvest.

3.4.4 Stem girth

The five plants were randomly selected from each net plot plant and stem girth was measured in cm at 15, 30, 45, 60 DAS and at harvest of green fodder.

3.4.5 Leaf area

The leaves of representative plants from each net plot were cut from base and leaf area measured with the help of Biovis PSM- L-2000 leaf area meter.

3.4.6 Leaf: Stem ratio

The leaves of five representative plants from each net plot were cut with sickle from base and their leaves were separated from stem then leaf: stem ratio was calculated from the corresponding weights of leaf and stem obtained from each treatment.

$$\text{L: S Ratio} = \frac{\text{Leaf weight (g)}}{\text{Stem weight (g)}}$$

3.4.7 Green fodder yield (GFY)

All the plants from net plot were harvested by sharp sickle and recorded fresh weight of green forage yield by spring balance in kilogram. The yield of five selected plants for recording various observations was added to this yield value and total yield per net plot was converted into tonnes per hectare.

3.4.8 Dry matter plant^{-1}

The green plant samples were collected at 15, 30, 45, 60 DAS and harvest randomly from each plot and 250 gm plant samples were dried in sunlight and then in oven dried at 70^0C temperature till the constant weight obtained and from the dry weighed sample per cent dry matter was calculated as per formula given below.

$$\text{Dry matter content} = \frac{\text{(Fresh wt. of sample- oven dry wt. of sample)}}{\text{Fresh wt. of sample}} \times 100\ (\%)$$

3.4.9 Dry matter yield (DMY)

The dry matter yield (q ha^{-1}) was calculated by multiplying green forage yield (q ha^{-1}) with dry matter percentage as per formula given below.

$$\text{DMY (q ha}^{-1}\text{)} = \frac{\text{GFY (q ha}^{-1}\text{) x Dry matter (\%)}}{100}$$

The oven dried samples were ground powdered with the help of Wiley mill and sample powder was utilized for estimation of crude protein, crude fibre and NPK content and uptake of nutrient.

3.5 Plant analysis

3.5.1 Crude protein % (CP) and crude protein yield

The protein content from fodder was calculated by multiplying per cent nitrogen in the fodder by a factor 6.25

$$\text{Crude protein yield (q ha}^{-1}\text{)} = \frac{\text{Dry matter yield (q ha}^{-1}\text{)} \times \text{Crude protein content (\%)}}{100}$$

3.5.2 Crude fiber % (CF) and crude fiber yield

The crude fiber content in fodder was determined by the formula given in A.O.A.C. (2005).

$$\text{Crude fiber \%} = \frac{\text{Weight of dried residue (g) - weight of ash (g)}}{\text{Weight of dried sample (g)}} \times 100\ (\%)$$

$$\text{Crude fiber yield (q ha}^{-1}\text{)} = \frac{\text{Dry matter yield (q ha}^{-1}\text{)} \times \text{Crude fiber content (\%)}}{100}$$

3.5.3 Acid detergent Fiber (ADF)

ADF was determined through use of Pelican make Fibra plus equipment of Van Soest *et al.* (1991).

3.5.4 Neural detergent Fiber (NDF)

NDF was determined through use of Pelican make Fibra plus equipment of Van Soest *et al.* (1991).

3.5.5 Uptake of Nutrient

Uptake of nutrient (kg ha^{-1}) after harvest was determined by using following formula

Uptake of nutrient (kg ha^{-1}) = DMY (q ha^{-1}) x Conc. of nutrient

3.5.6 Chemical analysis of plant samples for nutrient content in forage maize

3.5.6.1 Preparation of plant sample

The five plants sample and composite grain sample for estimating the dry matter production and nutrient uptake from each plot at harvest were thoroughly washed with distilled water and dried in hot air oven at 65°C.

Dried samples were powdered in a Willey mill the considerable fineness before storing them in polythene bags for further analysis.

3.5.6.2 Digestion of plant sample

Powdered plant samples were treated with concentrated HNO_3 overnight for pre digestion. Then, the predigested samples were treated with di-acid mixture (HNO_3:$HClO_4$) (9:4 ratio) and digested on sand bath at low temperature till colorless solution was obtained. This was used for further nutrient analysis.

The following analyses were carried out from the di-acid digested samples of whole plant.

3.5.6.3 Chemical analysis of post harvest forage maize

After harvest of crop grain and straw sample of chickpea were collected from the field and processed and analyzed for nitrogen, phosphorus, potassium, zinc, copper, iron, manganese, boron and molybdenum by using standard procedure as mentioned in Table 1.

3.6 Collection of soil sample after harvesting

The soil samples were collected from three spot of each net plot area (0 to 15 cm depth) after harvesting mixed and then taken half kg of soil sample. The samples were air dried, powdered and passing through 2 mm sieve. The sample were analysed for EC, pH, org. carbon and available status of N, P K and for micronutrients by adopting standard methods described in Table 1.

3.6.1 Methods of soil analysis

3.6.1.1 Soil reaction

Soil pH was determined in 1:2.5 soil-water suspensions by potentiometric method Jackson (1973).

3.6.1.2 Electrical conductivity (dS m^{-1})

Electrical conductivity was determined in 1:2.5 soil-water extract using Conductivity Bridge and expressed as dS m^{-1} Jackson (1973).

3.6.1.3 Organic carbon (%)

The organic carbon content of finely ground (0.2mm) soil sample was determined by Walkley and Blacks wet oxidation method as described by Nelson and Sommer (1982) and expressed in g kg^{-1} soil.

3.6.1.4 Available nitrogen (kg ha^{-1})

Available nitrogen in the soil was estimated by modified alkaline permanganate method Subbiah and Asija (1956).The organic matter present in the soil was oxidized by the nascent oxygen liberated by $KMnO_4$ in the presence of NaOH. Ammonia released was absorbed in boric acid mixed indicator. The quantity of NH_3 distilled was estimated by titration against a standard H_2SO_4 (expressed as kg ha^{-1} and interpreted as, low, medium and high).

3.6.1.5 Available phosphorus (kg ha^{-1})

The available phosphorus in the soil samples was extracted with Olsen's reagent (0.5N $NaHCO_3$). Phosphorus in the extracts was determined by ascorbic acid reductant method using spectrophotometer at 660 nm (Watnabe and Olsen 1965) (expressed as kg ha^{-1} and interpreted as, low, medium and high).

3.6.1.6 Available potassium (kg ha^{-1})

Available potassium in soil was extracted by neutral normal ammonium acetate and subsequent estimation was done by flame photometer Jackson (1973) (Expressed as kg ha^{-1} and interpreted as, low, medium and high).

3.6.1.7 Available boron (ppm)

Available boron was extracted by hot distilled water as an extractant as explained by Berger and Truog (1939). Boron was determined in the extract by Hot Water Soluble method using spectrophotometer at 420 nm Berger and Truog (1939), expressed as ppm soil and interpreted as deficient and sufficient using critical values.

3.6.1.8 Available zinc, copper, iron and magnesium (ppm)

Available zinc, copper, iron and magnesium were extracted by using Atomic Absorption Spectrophotometer as explained by Lindsay and Norvell (1978). The concentration of zinc, copper, iron and manganese in the extract was estimated using Atomic Absorption Spectrophotometer (AAS, Shimadzu model), expressed as ppm soil and interpreted as deficient and sufficient using critical values.

3.6.1.9 Available Molybdenum (ppm)

Available molybdenum was extracted by using spectrophotometer by using Tamms reagent given by Griggs (1939) and expressed in ppm and interpreted as deficient and sufficient using critical values.

3.7 Economic studies

3.7.1 Gross monetary returns

The treatment wise gross monetary returns were worked out by considering the prevailing prices of the produce during the year of experimentation.

3.7.2 Cost of cultivation

The treatment wise cost of cultivation was worked out by considering prevailing prices of input given in Appendix-I.

3.7.3 Net monetary returns

Net monetary returns were worked out by subtracting the cost of cultivation from gross monetary returns.

3.7.4 Benefit: Cost ratio

The benefit: cost ratio was worked out by using the following formula

$$\text{B: C ratio} = \frac{\text{Gross monetary returns (₹ ha}^{-1}\text{)}}{\text{Cost of cultivation (₹ ha}^{-1}\text{)}}$$

Table 6. Schedule of biometric observations recorded during experiment

Sr. No.	Particulars	Frequency	Period (DAP)	Sample Size
A) Growth Attributes:				
1	Plant population	1	15 DAP	All plants from each net plot
2	Plant height(cm)	5	15,30,45,60 and harvest	5 plants from net plot
3	No of leaves plant^{-1}	5	15,30,45,60 and harvest	5 plants from net plot
4	Leaf area (dm^2)	5	15,30,45,60 and harvest	5 plants from net plot
5	Stem girth (cm)	5	15,30,45,60 and harvest	5 plants from net plot
B) Yield Attributes:				
1	Dry matter plant^{-1} (g)	5	15,30,45,60 and harvest	5 plants from net plot
2	Leaf : Stem ratio	1	At harvest	5 plants from net plot
3	Green forage maize yield (q ha^{-1})	1	At harvest	Forage yield from all plots
4	Dry matter yield (q ha^{-1})	1	At harvest	Forage yield from all plots
C) Quality Studies:				
1	Crude protein (%)	1	At harvest	Plant sample from each net plot
2	Crude fiber (%)	1	At harvest	Plant sample from each net plot
3	Acid detergent fiber (ADF) (%)	1	At harvest	Plant sample from each net plot
4	Neutral detergent fiber (NDF) (%)	1	At harvest	Plant sample from each net plot
D) Soil and Plant Studies				
1	Initial soil analysis (N, P, K, Fe, Zn, Cu, Mn, B and Mo before start of experiment)	1	Before sowing	Composite sample
2	Soil analysis (N, P,K, Fe, Zn, Cu, Mn, B and Mo after the experiment)	1	After harvest	Sample from each net plot
3	Plant analysis (Macro and Micro nutrients)	1	After harvest	Sample from each net plot
E) Economic studies				
1	Gross returns (Rs ha^{-1})	1	After harvest	
2	Cost of cultivation (Rs ha^{-1})	1	After harvest	
3	Net returns (Rs ha^{-1})	1	After harvest	
4	B: C ratio	1	After harvest	

3.8 Statistical analysis for interpretation of data

The data on various parameter *viz.,* growth, yield, quality, nutrient uptake and economics were tabulated and statistically analyzed by the technique of analysis of variance. F test significance was carried out as given by Panse and Sukhatme (1995). In the tabular data, Critical differences (CD) values have been given for comparison only in case where F test was significant and figures of C.D. are not reported where F test was not significant, only standard error (S.E) values are given.

4. RESULTS AND DISCUSSION

The present investigation on "Response of forage maize (*Zea mays* L.) to nutrient management during summer season" was conducted during the summer season of 2020-2021 at AICRP on Forage crops and Research Project, MPKV, Rahuri. The details result of investigation are analyzed, presented and discussed in this chapter.

4.1 Biometric observations

4.1.1 Plant population

Table 7. Plant population of forage maize as influenced by different treatments

Tr. No.	Treatment	Initial (ha^{-1})	Percentage (%)	Final (ha^{-1})	Percentage (%)
T_1	Absolute Control	213004	95.8	202800	91.2
T_2	RDF (100:50:50 N : P_2O_5 : K_2O kg ha^{-1})	214351	96.4	204048	91.82
T_3	GRDF (100:50:50 N : P_2O_5 : K_2O kg ha^{-1} + 5 t ha^{-1} FYM)	214701	96.6	204098	91.9
T_4	GRDF + Soil application of government notified multi-micronutrient Grade-I @ 25 kg ha^{-1}	214799	96.7	204790	92.10
T_5	GRDF + Two foliar sprays of Phule liquid micronutrient Grade-II @ 1% at 30 and 45 DAS.	214720	96.63	204618	92.07
T_6	GRDF + Soil application of government notified multi micronutrient Grade-I @ 25 kg ha^{-1} + Two foliar sprays of Phule Micronutrient Grade-II @ 1% at 30 and 45 DAS.	215260	96.87	205257	92.28
	S. Em ±	860.98	8.35	860.90	8.20
	C.D.at 5%	NS	NS	NS	NS
	General Mean	204473	96.50	204268	91.70

The mean initial and final plant populations as influenced by different treatments are presented in table 7. The mean initial and final plant count was 204473 and 204268 ha^{-1}, respectively.

The mean initial and final plant population was not influenced significantly due to different nutrient management treatments tried for forage maize. The uniform initial and final plant population of forage maize was observed due to different nutrient management treatments.

4.1.2 Plant height

The data in respect of plant height of forage maize as influenced periodically by different treatments are presented in Table 8 and graphically depicted in Fig. 3. The mean plant heights were 11.08, 37.54, 61.28, 119.19 and 152.41 cm at 15, 30, 45, 60 DAS and at harvest, respectively.

Table 8. Plant height of forage maize as influenced by different treatments

Tr. No.	Treatment	Plant height (cm)				
		15 DAS	30 DAS	45 DAS	60 DAS	At harvest
T_1	Absolute Control	8.48	28.67	44.18	104.61	131.21
T_2	RDF (100:50:50 N : P_2O_5 : K_2O kg ha^{-1})	9.61	34.87	54.10	111.88	146.62
T_3	GRDF (100:50:50 N : P_2O_5 : K_2O kg ha^{-1} + 5 t ha^{-1} FYM)	10.83	37.73	62.73	115.76	151.26
T_4	GRDF + Soil application of government notified multi-micronutrient Grade-I @ 25 kg ha^{-1}	13.06	42.90	68.39	126.52	158.22
T_5	GRDF + Two foliar sprays of Phule liquid micronutrient Grade-II @ 1% at 30 and 45 DAS.	11.19	37.98	65.97	122.32	155.63
T_6	GRDF + Soil application of government notified multi micronutrient Grade-I @ 25 kg ha^{-1} + Two foliar sprays of Phule liquid micronutrient Grade-II @ 1% at 30 and 45 DAS.	13.33	43.10	72.33	134.09	171.55
	S. Em ±	0.34	1.32	1.81	3.69	4.55
	C.D.at 5%	1.03	3.98	5.44	11.13	13.72
	General Mean	11.08	37.54	61.28	119.19	152.41

The plant height was increased progressively with the advancement of age of the plant due to continuous growth habit of forage maize. Initially, the plant height was at lower magnitude up to 30 DAS. The plant growth rate in terms of plant height was more vigorous during the period of 30 DAS up to harvest. The plant height was significantly influenced due to different nutrient management treatments for forage maize.

The application of GRDF in association with soil application of government notified multi-micronutrient Grade I @ 25 kg ha^{-1} along with two foliar sprays of Phule liquid micronutrient Grade II @ 1% at 30 and 45 DAS exhibited significantly higher (13.33, 43.10, 72.33, 134.09 and 171.55 cm respectively) plant height at all growth stages of forage maize. However, it was at par (13.06, 42.09, 68.39, 126.52 and 158.22 cm respectively) with the treatment GRDF along with soil application of government notified multi-micronutrient Grade I @ 25 kg ha^{-1} at all growth stages of forage maize. Whereas the significantly minimum plant height of forage maize was recorded in the treatment absolute control were in no fertilizer were applied.

The increased plant height of forage maize with the application of government notified multi-micronutrient Grade-I @ 25 kg ha^{-1} along with two foliar sprays of Phule micronutrient Grade-II @ 1% at 30 and 45 DAS was due to most favourable availability of micronutrients as both multi-micronutrient Grade-I and Phule liquid micronutrient Grade-II contains precise amount of iron, zinc, copper, manganese, boron, molybdenum *etc.* it was also associated with 5 t ha^{-1} FYM which increases the availability of micronutrients, with all these combinations sources of nutrients facilitated the luxurious growth of forage maize. Iron plays important role in metabolism of chlorophyll while zinc is involved in carbohydrate metabolism, protein synthesis as well boron regulate transport of sugar through membrane, cell division, cell development *etc.* Copper and manganese are essential for energy transfer and photosynthesis. Copper increases nodulation and nitrogen fixation while manganese is vital for protoplast metabolism. The results are in agreement with Manasa *et al.* (2015) Chamegowda *et al.* (2017), and Roy *et al.* (2018).

4.1.3 Number of leaves $plant^{-1}$

Data regarding number of leaves $plant^{-1}$ of forage maize as influenced by different treatments are presented in Table 9 and graphically in Fig. 4. The mean number of leaves $plant^{-1}$ were 3.89, 6.30, 8.45, 9.36 and 11.49 was recorded at 15, 30, 45, 60 DAS and at harvest, respectively.

The application of GRDF in association with soil application of government notified multi-micronutrient Grade I @ 25 kg ha^{-1} along with two foliar sprays of Phule liquid micronutrient Grade II @ 1% at 30 and 45 DAS recorded significantly higher no leaves $plant^{-1}$ (4.78, 7.55, 10.18, 11.18 and 13.78 respectively) at all growth stages of forage maize. However the treatment GRDF plus soil application of government notified multi-micronutrient Grade I @ 25 kg ha^{-1} was found at par (4.73, 7.43, 9.60, 10.40 and 12.95 respectively) with it at all growth stages of forage maize. Whereas the significantly lower number of leaves $plant^{-1}$ of forage maize was recorded in the treatment absolute control were in no fertilizer were applied.

The higher number of leaves plant^{-1} in forage maize by application of government notified multi-micronutrient Grade-I @ 25 kg ha^{-1} along with two foliar sprays of Phule liquid micronutrient Grade-II @ 1% at 30 and 45 DAS was due to most favourable availability of micronutrients as both multi-micronutrient Grade-I and Phule liquid micronutrient Grade-II contains precise amount of iron, zinc, copper, manganese, boron, molybdenum *etc*. it was also associated with GRDF with the combinations of all these treatment combinations helped the forage maize to attain higher number of leaves. The use of GRDF and multi-micronutrient mixtures increased the beneficial effect of macro and micronutrients on number of leaves plant^{-1} leads to increased meristamatic activities and cell elongation associated with protein synthesis. The beneficial of effect foliar spray of micronutrient mixtures associated with high photosynthetic activity and protein synthesis which promotes cell division and elongation that in turn accelerates vegetative growth and increase in number of leaves with vigorous and succulent growth. The similar trend was also reported by Soomro *et al.* (2011), Digvijay *et al.* (2016) and Jadav *et al.* (2016).

Table 9. Number of leaves plant^{-1} of forage maize as influenced by different treatments

Tr. No.	Treatment	Number of leaves plant^{-1}				
		15 DAS	30 DAS	45 DAS	60 DAS	At harvest
T_1	Absolute Control	2.83	5.05	6.00	7.00	8.28
T_2	RDF (100:50:50 N : P_2O_5 : K_2O kg ha^{-1})	3.30	5.39	7.50	8.50	10.03
T_3	GRDF (100:50:50 N : P_2O_5 : K_2O kg ha^{-1} + 5 t ha^{-1} FYM)	3.80	6.19	8.30	9.00	11.48
T_4	GRDF + Soil application of government Notified multi micronutrient Grade I @ 25 kg ha^{-1}	4.73	7.43	9.60	10.40	12.95
T_5	GRDF + Two foliar sprays of Phule liquid Micronutrient grade II @ 1% at 30 and 45 DAS.	3.90	6.21	9.13	10.08	12.45
T_6	GRDF + Soil application of government Notified multi micronutrient Grade I @ 25 kg ha^{-1} + Two foliar sprays of Phule liquid Micronutrient grade II @ 1% at 30 and 45 DAS.	4.78	7.55	10.18	11.18	13.78
	S. Em ±	0.17	0.28	0.27	0.33	0.42
	C.D.at 5%	0.51	0.84	0.82	0.99	1.27
	General Mean	3.89	6.30	8.45	9.36	11.49

4.1.4 Leaf area plant^{-1}

Data regarding leaf area plant^{-1} of forage maize as influenced by different treatments are presented in Table 10 and graphically in Fig. 5. The mean number of leaves plant^{-1} were 2.72, 6.38, 17.79, 26.08 and 33.74 dm^2 was recorded at 15, 30, 45, 60 DAS and at harvest, respectively.

The application of GRDF in association with soil application of government notified multi-micronutrient Grade I @ 25 kg ha^{-1} along with two foliar sprays of Phule liquid micronutrient Grade II @ 1% at 30 and 45 DAS recorded significantly higher leaf area plant^{-1} (3.16, 7.61, 21.91, 31.82 and 40.48, respectively) at all growth stages of forage maize. However, the treatment GRDF plus soil application of government notified multi-micronutrient Grade I @ 25 kg ha^{-1} was found at par (3.13, 7.60, 19.60, 29.85 and 37.71, respectively) with it at all growth stages of forage maize. Whereas, the significantly minimum leaf area plant^{-1} of forage maize was recorded in the treatment absolute control were in no fertilizer were applied. Forage maize experienced luxurious availability of both macro and micronutrients with GRDF in association with soil application of government notified multi-micronutrient Grade-I @ 25 kg ha^{-1} plus two foliar sprays of Phule liquid micronutrient Grade-II @ 1% at 30 and 45 DAS as leaf area is a measure of size of the assimilatory system of the food in plant and it is the product of leaf length and breadth. The application of macro and micronutrients increases significantly more leaf area by the use of these nutrients increases the beneficial effect of nutrients on number of leaves plant^{-1} to increase meristematic activities and cell elongation associated with protein synthesis which also promotes cell division and cell elongation of leaves that in turn to accelerates vegetative growth of forage maize. Similar trend were also indicated by Jadav *et al.* (2016), Lalitha *et al.* (2016) and Mahapatra *et al.* (2017).

4.1.5 Stem girth

Data regarding stem girth of forage maize as influenced by different treatments are presented in Table 11 and graphically in Fig. 6. The mean stem girth were 2.16, 4.47, 5.46, 6.27 and 6.71 cm was recorded at 15, 30, 45, 60 DAS and at harvest, respectively.

The application of GRDF in association with soil application of government notified multi-micronutrient Grade I @ 25 kg ha^{-1} along with two foliar sprays of Phule liquid micronutrient Grade II @ 1% at 30 and 45 DAS recorded significantly higher stem girth (2.50, 5.09, 6.25, 7.14 and 7.46, respectively) at all growth stages of forage maize. However the treatment GRDF plus soil application of government notified multi-micronutrient Grade-I @ 25 kg ha^{-1} was found at par (2.44, 4.82, 5.77, 6.68 and 7.13, respectively) with it at all growth stages of forage maize. Whereas the significantly minimum stem girth of forage maize was recorded in the treatment absolute control were in no fertilizer were applied.

Table 10. Leaf area plant^{-1} of forage maize as influenced by different treatments

Tr. No.	Treatment	Leaf area plant^{-1} (dm^2)				
		15 DAS	30 DAS	45 DAS	60 DAS	At harvest
T_1	Absolute Control	2.06	4.46	10.84	17.29	21.73
T_2	RDF (100:50:50 N : P_2O_5 : K_2O kg ha^{-1})	2.55	5.81	17.20	24.33	32.21
T_3	GRDF (100:50:50 N : P_2O_5 : K_2O kg ha^{-1} + 5 t ha^{-1} FYM)	2.65	6.41	18.37	25.24	33.65
T_4	GRDF + Soil application of government notified multi micronutrient Grade-I @ 25 kg ha^{-1}	3.13	7.60	19.60	29.85	37.71
T_5	GRDF + Two foliar sprays of Phule liquid micronutrient Grade-II @ 1% at 30 and 45 DAS.	2.81	6.42	18.83	28.00	36.69
T_6	GRDF + Soil application of government notified multi micronutrient Grade-I @ 25 kg ha^{-1} + Two foliar sprays of Phule liquid micronutrient Grade-II @ 1% at 30 and 45 DAS.	3.16	7.61	21.91	31.82	40.48
	S. Em ±	0.08	0.25	0.80	1.09	0.99
	C.D.at 5%	0.24	0.76	2.41	3.29	2.97
	General Mean	2.72	6.38	17.79	26.08	33.74

Application of government notified multi-micronutrient grade I plus Phule liquid micronutrient grade II along with GRDF recorded higher stem girth of forage maize due to increase in beneficial effect of nutrients and also foliar application micronutrients through Phule micronutrient grade increased the absorption of micronutrients as Fe played a role in metabolism such as respiration, photosynthesis, Zn in carbohydrate metabolism, B translocated the sugars , Mn and Cu also played role in metabolism. These results in line with the findings of Soomro *et al.* (2011), Digvijay *et al.* (2016) and Bharathi *et al.* (2020).

Table 11. Stem girth of forage maize as influenced by different treatments

Tr. No.	Treatment	Stem girth (cm)				
		15 DAS	30 DAS	45 DAS	60 DAS	At harvest
T_1	Absolute Control	1.52	3.72	4.38	5.08	5.54
T_2	RDF (100:50:50 N : P_2O_5 : K_2O kg ha^{-1})	2.05	4.29	5.27	6.02	6.59
T_3	GRDF (100:50:50 N : P_2O_5 : K_2O kg ha^{-1} + 5 t ha^{-1} FYM)	2.22	4.48	5.45	6.19	6.76
T_4	GRDF + Soil application of government Notified multi micronutrient Grade-I @ 25 kg ha^{-1}	2.44	4.82	5.77	6.68	7.13
T_5	GRDF + Two foliar sprays of Phule liquid micronutrient Grade-II @ 1% at 30 and 45 DAS.	2.24	4.45	5.67	6.56	6.82
T_6	GRDF + Soil application of government Notified multi micronutrient Grade-I @ 25 kg ha^{-1} + Two foliar sprays of Phule liquid micronutrient Grade-II @ 1% at 30 and 45 DAS.	2.50	5.09	6.25	7.14	7.46
	S. Em ±	0.07	0.17	0.18	0.18	0.20
	C.D.at 5%	0.20	0.53	0.53	0.56	0.60
	General Mean	2.16	4.47	5.46	6.27	6.71

4.1.6 Leaf: stem ratio (L: S ratio)

Data regarding leaf: stem of forage maize as influenced by different treatments are presented in Table 12 and graphically in Fig. 7. The mean L: S ratio was 0.37 recorded at harvest.

The application of GRDF in association with soil application of government notified multi-micronutrient Grade I @ 25 kg ha^{-1} along with two foliar sprays of Phule liquid micronutrient Grade II @ 1% at 30 and 45 DAS recorded significantly higher L: S ratio (0.50) at harvest of forage maize. However the treatment GRDF plus soil application of government notified multi-micronutrient Grade-I @ 25 kg ha^{-1} was found at par (0.44) with it. Whereas the significantly minimum L: S ratio of forage maize was recorded in the treatment absolute control were in no fertilizer were applied.

Table 12. Leaf: stem ratio of forage maize as influenced by different treatments

Tr. No.	Treatment	L:S ratio
		At harvest
T_1	Absolute Control	0.26
T_2	RDF (100:50:50 N : P_2O_5 : K_2O kg ha^{-1})	0.33
T_3	GRDF (100:50:50 N : P_2O_5 : K_2O kg ha^{-1} + 5 t ha^{-1} FYM)	0.35
T_4	GRDF + Soil application of government notified multi micronutrient Grade-I @ 25 kg ha^{-1}	0.44
T_5	GRDF + Two foliar sprays of Phule liquid Micronutrient Grade-II @ 1% at 30 and 45 DAS.	0.37
T_6	GRDF + Soil application of government notified multi micronutrient Grade-I @ 25 kg ha^{-1} + Two foliar sprays of Phule liquid micronutrient Grade-II @ 1% at 30 and 45 DAS.	0.50
	S. Em ±	0.02
	C.D.at 5%	0.07
	General Mean	0.37

The increasing the value of L: S ratio is an indicator of increasing in the quality of forage. The physical quality of forage is judged by its L: S ratio, succulence and palatability. L: S ratio might be associated with high nutritive value of forage, because leaf is generally of higher nutrient value and the performance of animal is also closely related to amount of leaf in a diet and was higher with the soil application of GRDF in association with government notified multi-micronutrient grade-I @ 25 kg ha^{-1} along with foliar application of phule micronutrient grade-II @ 1%. Due to increased availability of both macro and micro nutrients in soil as well as foliar application of micronutrients increased the efficiency of utilization of nutrients, which resulted in higher number of leaves and in turn L: S ratio in that treatment. The same results are also reported by Digvijay *et al.* (2016) and Jadav *et al.* (2016).

4.2 Yield parameters

4.2.1 Green forage yield

Data regarding green forage yield forage maize as influenced by different treatments are presented in Table 13 and graphically in Fig.8. The mean green forage yield 47.40 t ha^{-1} was recorded at harvest.

The application of GRDF in association with soil application of government notified multi-micronutrient Grade I @ 25 kg ha^{-1} along with two foliar sprays of Phule liquid micronutrient Grade II @ 1% at 30 and 45 DAS recorded significantly higher (587.52 q ha^{-1}) green forage yield of forage maize that is 45.78 % increase over RDF. However the treatment GRDF plus soil application of government notified multi-micronutrient Grade-I @ 25 kg ha^{-1} was found at par (541.90 q ha^{-1}) with it at harvest in green forage yield of forage maize. Whereas the significantly minimum green forage yield of forage maize was recorded in the treatment absolute control were in no fertilizer were applied.

Table 13. Green forage yield (GFY q ha^{-1}) of forage maize as influenced by different treatments

Tr. No.	Treatment	Green forage yield (q ha^{-1})	Increase of yield over RDF (%)
T_1	Absolute Control	305.86	-
T_2	RDF (100:50:50 N : P_2O_5 : K_2O kg ha^{-1})	403.05	-
T_3	GRDF (100:50:50 N : P_2O_5 : K_2O kg ha^{-1} + 5 t ha^{-1} FYM)	483.62	20
T_4	GRDF + Soil application of government notified multi micronutrient Grade-I @ 25 kg ha^{-1}	541.90	34.4
T_5	GRDF + Two foliar sprays of Phule liquid Micronutrient Grade-II @ 1% at 30 and 45 DAS.	522.31	29.6
T_6	GRDF + Soil application of government notified multi micronutrient Grade-I @ 25 kg ha^{-1} + Two foliar sprays of Phule liquid Micronutrient Grade-II @ 1% at 30 and 45 DAS.	587.52	45.78
	S. Em ±	16.4	
	C.D.at 5%	49.3	
	General Mean	474.04	

Application of GRDF along with government notified multi-micronutrient Grade I @ 25 kg ha^{-1} along with two foliar spray of Phule liquid micronutrient Grade II @ 1% at 30 and 45 DAS. The macro and micronutrients played role in translocation of photosynthates from source to vegetative part of maize and the overall effect of all nutrients on yield parameter was positive which intern produce higher green forage yield. Yield contributing character such as plant height, number of leaves, stem girth, leaf: stem ratio, dry matter content also increased with application of foliar spray through micronutrients which turns to increase in mean green forage yield of Forage maize. The results are in conformity to the findings of the Reddy *et al.* (2004), Patil *et al.* (2006), Borase *et al.* (2015) and Lagad *et al.* (2018).

4.2.2 Dry matter plant^{-1}

Data regarding dry matter plant^{-1} of forage maize as influenced by different treatments are presented in Table 14 and graphically in Fig. 9. The mean dry matter plant^{-1} were 3.36, 6.48, 20.05, 34.21 and 65.53 g was recorded at 15, 30, 45, 60 DAS and at harvest, respectively.

The application of GRDF in association with soil application of government notified multi-micronutrient Grade I @ 25 kg ha^{-1}along with two foliar sprays of Phule liquid micronutrient Grade II @ 1% at 30 and 45 DAS recorded significantly higher (3.97, 7.44, 24.84, 39.44 and 76.01, respectively) dry matter plant^{-1} at all growth stages of forage maize. However the treatment GRDF plus soil application of government notified multi-micronutrient Grade-I @ 25 kg ha^{-1} was found at par (3.95, 7.19, 22.51, 37.08 and 72.23, respectively) with it at all growth stages of forage maize. Whereas the significantly minimum dry matter plant^{-1} of forage maize was recorded in the treatment absolute control were in no fertilizer were applied.

From table 14 and Fig 9 it was observed that initially dry matter plant^{-1} was lower from 30 DAS and increased up to harvest at an increasing rate. The dry matter of forage maize is the product of luxurious plant growth and assimilation of photosynthates. Forage maize fertilized with GRDF in association with soil application of government notified multi-micronutrient Grade I @ 25 kg ha^{-1} plus two foliar sprays of Phule liquid micronutrient Grade II @ 1% at 30 and 45 DAS. Enrichment of soil with macro and micronutrients along with foliar application of micronutrients resulted efficient utilization of macro and micronutrients. Iron enhanced chlorophyll metabolism, zinc is helpful in carbohydrate and protein synthesis. Boron also regulated transport of sugar through membrane and played quite essential role for cell division and cell development. Copper and manganese played their role for energy transfer and photosynthesis. Copper also helped in photosynthesis.

These results were in agreement with the Lalitha *et al.* (2016), Mahapatra *et al.* (2017) and Thakur *et al.* (2019).

Table 14. Dry matter plant^{-1} of forage maize as influenced by different treatments

Tr. No.	Treatment	Dry matter plant^{-1} (g)				
		15 DAS	30 DAS	45 DAS	60 DAS	At harvest
T_1	Absolute Control	2.33	4.40	11.91	25.03	40.92
T_2	RDF (100:50:50 N : P_2O_5 : K_2O kg ha^{-1})	3.13	6.38	19.09	33.55	65.77
T_3	GRDF (100:50:50 N : P_2O_5 : K_2O kg ha^{-1} + 5 t ha^{-1} FYM)	3.38	6.69	20.26	34.76	68.50
T_4	GRDF + Soil application of government notified multi micronutrient Grade-I @ 25 kg ha^{-1}	3.95	7.19	22.51	37.08	72.23
T_5	GRDF + Two foliar sprays of Phule liquid micronutrient Grade-II @ 1% at 30 and 45 DAS.	3.41	6.82	21.72	35.41	69.80
T_6	GRDF + Soil application of government Notified multi micronutrient Grade-I @ 25 kg ha^{-1} + Two foliar sprays of Phule liquid micronutrient Grade-II @ 1% at 30 and 45 DAS.	3.97	7.44	24.84	39.44	76.01
	S. Em ±	0.11	0.20	0.86	1.22	2.01
	C.D.at 5%	0.34	0.61	2.59	3.68	6.07
	General Mean	3.36	6.48	20.05	34.21	65.53

4.2.3 Dry matter yield

Data regarding dry matter yield of forage maize as influenced by different treatments are presented in Table 15 and graphically in Fig. 10. The mean dry matter yield 8.70 t ha^{-1} was recorded at harvest.

The application of GRDF in association with soil application of government notified multi-micronutrient Grade I @ 25 kg ha^{-1} along with two foliar sprays of Phule liquid micronutrient Grade II @ 1% at 30 and 45 DAS recorded significantly higher (119.12 q ha^{-1}) dry matter yield of forage maize. However the treatment GRDF plus soil application of government notified multi-micronutrient Grade-I @ 25 kg ha^{-1} was found at par (107.53 q ha^{-1}) with it at harvest in dry matter yield of forage maize. Whereas the significantly minimum dry matter yield of forage maize was recorded in the treatment absolute control were in no fertilizer were applied.

Table 15. Dry matter yield (q ha^{-1}) of forage maize as influenced by different treatments

Tr. No.	Treatment	Dry matter yield (q ha^{-1})	Percent increase of dry matter yield over RDF (%)
T_1	Absolute Control	57.93	-
T_2	RDF (100:50:50 N : P_2O_5 : K_2O kg ha^{-1})	69.31	-
T_3	GRDF (100:50:50 N : P_2O_5 : K_2O kg ha^{-1} + 5 t ha^{-1} FYM)	78.62	13.4
T_4	GRDF + Soil application of government notified multi micronutrient Grade-I @ 25 kg ha^{-1}	107.53	55
T_5	GRDF + Two foliar sprays of Phule liquid Micronutrient Grade-II @ 1% at 30 and 45 DAS.	89.44	29
T_6	GRDF + Soil application of government notified multi micronutrient Grade-I @ 25 kg ha^{-1} + Two foliar sprays of Phule liquid Micronutrient Grade-II @ 1% at 30 and 45 DAS.	119.12	71
	S. Em ±	4.5	
	C.D.at 5%	13.6	
	General Mean	86.99	

The treatment T_6 was recorded significantly higher dry matter yield because of superior performance in vegetative growth with respect to plant height, number of leaves, stem girth and leaf: stem ratio result in more accumulation of dry matter. The application of macro and micro nutrients through soil along with foliar application increased the utilization of macro and micro nutrients which in turn increased the plant height, number of leaves, stem girth and leaf: stem ratio and thus resulted in more accumulation of dry matter. The similar results are correlated with those reported by Ahmad *et al.* (2009), Bochare (2014), Vyas *et al.* (2014), and Lagad *et al.* (2018).

4.3 Quality parameters

4.3.1 Crude protein content and yield (q ha^{-1})

Data regarding the crude protein content and crude protein yield as influenced by different treatments are presented in Table 16 and graphically depicted in Fig. 11 The mean crude protein content and crude protein yield 6.78% and 6.03 q ha^{-1} was recorded respectively after harvest.

Table 16. Crude protein content and yield as influenced by different treatments

Tr. No.	Treatment	Crude protein (%)	Crude protein yield (q ha^{-1})
T_1	Absolute Control	5.10	2.94
T_2	RDF (100:50:50 N : P_2O_5 : K_2O kg ha^{-1})	6.39	4.42
T_3	GRDF (100:50:50 N : P_2O_5 : K_2O kg ha^{-1} + 5 t ha^{-1} FYM)	6.91	5.47
T_4	GRDF + Soil application of government notified multi micronutrient Grade-I @ 25 kg ha^{-1}	7.27	7.59
T_5	GRDF + Two foliar sprays of Phule liquid micronutrient Grade-II @ 1% at 30 and 45 DAS.	6.96	6.18
T_6	GRDF + Soil application of government notified multi micronutrient Grade-I @ 25 kg ha^{-1} + Two foliar sprays of Phule liquid micronutrient Grade-II @ 1% at 30 and 45 DAS.	8.08	9.62
	S. Em ±	0.27	0.69
	C.D.at 5%	0.82	2.08
	General Mean	6.78	6.03

The application of GRDF in association with soil application of government notified multi-micronutrient Grade I @ 25 kg ha^{-1} along with two foliar sprays of Phule liquid micronutrient Grade II @ 1% at 30 and 45 DAS recorded significantly higher crude protein content (8.08) and crude protein yield (9.62) of forage maize after harvest and the treatment GRDF plus soil application of government notified multi-micronutrient Grade-I @ 25 kg ha^{-1} was found at par with it in crude protein (7.27) and crude protein yield (7.59) after harvest of forage maize. Whereas the significantly minimum crude protein content and crude protein yield of forage maize after harvest was recorded in the treatment absolute control were in no fertilizer were applied.

Crude protein content is a main constituent of quality of forage which the palatability, succulency and intake of forage by animals with the soil application of government notified multi-micronutrient Grade I @ 25 kg ha^{-1} along with foliar spray of Phule liquid micronutrient Grade II @ 1% and also GRDF which increased the availability more macro and micro nutrients to the forage maize, which in turn increased the crude protein content in forage maize. Nitrogen played important role in increase of protein addition to that Fe played critical role in photosynthesis, Zinc played vital role in protein synthesis. Copper and manganese are essential for energy transfer. Copper increases nodulation and nitrogen fixation which was reflected in the results. These results are in agreement with the Ayub *et al.* (2000), Gillani *et al.* (2011), Chaudary *et al.* (2012) and Dar *et al.* (2012).

4.3.2 Crude fiber content and Crude fiber yield (q ha^{-1})

Data regarding the crude fiber content and crude fiber yield as influenced by different treatments are presented in Table 17 and graphically depicted in Fig. 12. The mean crude fiber content and crude fiber yield 21.68% and 18.52 q ha^{-1} was recorded respectively after harvest.

The crude fiber content revealed that the application of GRDF in association with soil application of government notified multi-micronutrient Grade I @ 25 kg ha^{-1} plus two foliar sprays of Phule liquid micronutrient Grade II @ 1% at 30 and 45 DAS recorded significantly lower crude fiber (18.76). However, the treatment that is absolute control were in no fertilizer were applied recorded a significantly higher crude fiber. Whereas, application of GRDF in association with soil application of government notified multi-micronutrient Grade I @ 25 kg ha^{-1} plus two foliar sprays of Phule liquid micronutrient Grade II @ 1% at 30 and 45 DAS recorded significantly higher crude fiber yield (22.34) and treatment GRDF in association with soil application of government notified multi-micronutrient Grade I @ 25 kg ha^{-1} found at par (22.61) with it. However, the treatment that is absolute control were in no fertilizer were applied recorded a significantly lower crude fiber yield.

The crude fibre content decreased with increase in nutrient application because higher nutrient availability, whereas in absolute where in no fertilizer applied leads to forced maturity within the short lifespan of time due to which fiber content in absolute control increased. The decreased crude fiber content increases the palatability and digestibility *etc.* The results are in line with findings of Chaudary *et al.* (2012), Dar *et al.* (2012), Damame *et al.* (2013) and Kumar *et al.* (2015).

4.3.3 ADF and NDF as influenced by different treatments

Data regarding the ADF and NDF as influenced by different treatments are presented in Table 17 and graphically depicted in Fig. 13. The mean ADF and NDF 28.63% and 60.34 % was recorded respectively after harvest.

The ADF and NDF content revealed that the application of GRDF in association with soil application of government notified multi-micronutrient Grade I @ 25 kg ha^{-1} plus two foliar sprays of Phule liquid micronutrient Grade II @ 1% at 30 and 45 DAS recorded significantly lower ADF and NDF (25 and 54.64 respectively). However, the treatment that is absolute control were in no fertilizer were applied recorded a significantly higher ADF and NDF (32.88 and 67.41 respectively).

ADF is the fibrous, least digestible portion of roughage, consists of highly indigestible parts of the forage, including lignin, cellulose, silica and insoluable forms of nitrogen. With the application of government notified micro grade and Phule micro grade along with GRDF decreased the crude fiber and in turn ADF.

NDF is measure of cellulose, hemicelluose, lignin, silica, tannin and cutin. NDF is negatively correlated with the dry matter. With the application of government notified micro grade and Phule micro grade along with GRDF increased dry matter, decreased crude fiber which in turn decreased the NDF in that treatment. Similar findings were also reported by Chaudary *et al.* (2012), Dar *et al.* (2012), Damame *et al.* (2013) and Kumar *et al.* (2015).

4.3.3 Nitrogen uptake in forage maize

Data regarding the nitrogen uptake in forage maize as influenced by different treatments are represented in Table 18 and graphically in Fig. 14. The mean nitrogen uptake in forage maize was 140.28 kg ha^{-1} recorded during investigation after harvest.

The forage maize crop fertilized with GRDF in association with soil application of government notified multi-micronutrient Grade I @ 25 kg ha^{-1} along with two foliar sprays of Phule liquid micronutrient Grade II @ 1% at 30 and 45 DAS recorded significantly higher nitrogen uptake (158.35 kg ha^{-1}) in forage maize and the treatment GRDF plus soil application of government notified multi-micronutrient Grade-I @ 25 kg ha^{-1} was found at par with it in nitrogen uptake (154.16 kg ha^{-1}) in forage maize. Whereas the significantly minimum nitrogen uptake (119.47 kg ha^{-1}) in forage maize was recorded in the absolute control where no fertilizer were applied.

Table 17. Crude fiber content, crude fiber yield (q ha^{-1}), ADF and NDF as influenced by different treatments

Tr. No.	Treatment	Crude fiber (%)	Crude fiber yield (q ha^{-1})	Acid detergent fiber (%)	Neutral detergent fiber (%)
T_1	Absolute Control	25.65	14.85	32.88	67.41
T_2	RDF (100:50:50 N : P_2O_5 : K_2O kg ha^{-1})	23.28	16.13	29.65	61.86
T_3	GRDF (100:50:50 N : P_2O_5 : K_2O kg ha^{-1} + 5 t ha^{-1} FYM)	21.17	16.64	28.96	61.71
T_4	GRDF + Soil application of government notified multi micronutrient Grade-I @ 25 kg ha^{-1}	20.47	22.61	26.93	55.80
T_5	GRDF + Two foliar sprays of Phule liquid micronutrient Grade-II @ 1% at 30 and 45 DAS.	20.77	18.57	28.36	60.64
T_6	GRDF + Soil application of government notified multi micronutrient Grade-I @ 25 kg ha^{-1} + Two foliar sprays of Phule liquid micronutrient Grade-II @ 1% at 30 and 45 DAS.	18.76	22.34	25.00	54.64
	S. Em ±	0.76	0.56	0.90	1.77
	C.D.at 5%	2.30	1.70	2.70	5.33
	General Mean	21.68	18.52	28.63	60.34

Table 18. Nitrogen, phosphorus and potassium uptake by forage maize as influenced by different treatments

Tr. No.	Treatment	Uptake of nutrients (kg ha^{-1})		
		N (kg ha^{-1})	P (kg ha^{-1})	K (kg ha^{-1})
T_1	Absolute Control	119.47	11.05	103.95
T_2	RDF (100:50:50 N : P_2O_5 : K_2O kg ha^{-1})	130.75	13.56	115.18
T_3	GRDF (100:50:50 N : P_2O_5 : K_2O kg ha^{-1} + 5 t ha^{-1} FYM)	137.86	15.16	120.56
T_4	GRDF + Soil application of government notified multi micronutrient Grade-I @ 25 kg ha^{-1}	154.16	18.21	128.75
T_5	GRDF + Two foliar sprays of Phule Micronutrient Grade-II @ 1% at 30 and 45 DAS.	141.10	16.25	123.26
T_6	GRDF + Soil application of government notified multi micronutrient Grade-I @ 25 kg ha^{-1} +Two foliar sprays of Phule micronutrient Grade-II @ 1% at 30 and 45 DAS.	158.35	21.10	130.46
	S. Em ±	4.31	0.36	2.32
	C.D.at 5%	12.99	1.08	6.98
	General Mean	140.28	15.88	120.36

The forage maize crop fertilized with GRDF in association with soil application of government notified multi-micronutrient Grade I @ 25 kg ha^{-1} along with two foliar sprays of Phule liquid micronutrient Grade II @ 1% at 30 and 45 DAS enjoyed a healthy availability of macro and micro nutrients. The iron and zinc played vital role in nitrogen assimilation and protein synthesis. Copper and manganese are essential for energy transfer and photosynthesis. Copper increases nodulation and nitrogen fixation while manganese is vital for protoplast metabolism which reflected in the results. The similar trend was also reported by the Ramanjineyulu *et al.* (2015) and Lagad *et al.* (2018).

4.3.4 Phosphorus uptake by forage maize

Data regarding the phosphorus uptake in forage maize as influenced by different treatments are represented in Table 18 and graphically in Fig. 14. The mean phosphorus uptake in forage maize was 15.88 kg ha^{-1} during investigation after harvest.

The forage maize crop fertilized with GRDF in association with soil application of government notified multi-micronutrient Grade I @ 25 kg ha^{-1} along with two foliar sprays of Phule liquid micronutrient Grade II @ 1% at 30 and 45 DAS recorded significantly higher phosphorus uptake (21.10 kg ha^{-1}) in forage maize and the treatment GRDF plus soil application of government notified multi-micronutrient Grade-I @ 25 kg ha^{-1} was found at par with it in phosphorus uptake (18.21 kg ha^{-1}) in forage maize. Whereas the significantly minimum phosphorus uptake (11.05 kg ha^{-1}) in forage maize was recorded in the absolute control where no fertilizer were applied.

The forage maize crop fertilized with GRDF in association with soil application of government notified multi-micronutrient Grade I @ 25 kg ha^{-1} along with two foliar sprays of Phule liquid micronutrient Grade II @ 1% at 30 and 45 DAS enriched the phosphorous uptake in forage maize due to efficient availability of phosphorus to forage maize. No application of fertilizer to forage maize produced significantly minimum phosphorus uptake in forage maize. The present are in accordance with those reported by Ramanjineyulu *et al.* (2015) and Lagad *et al.* (2018).

4.3.5 Potassium uptake by forage maize

Data regarding the potassium uptake in forage maize as influenced by different treatments are represented in Table 18 and graphically in Fig. 14. The mean potassium uptake in forage maize was 120.36 kg ha^{-1} recorded during investigation after harvest.

The forage maize crop fertilized with GRDF in association with soil application of government notified multi-micronutrient Grade I @ 25 kg ha^{-1} along with two foliar sprays of Phule liquid micronutrient Grade II @ 1% at 30 and 45 DAS recorded significantly higher potassium uptake (130.46 kg ha^{-1}) in forage maize and the treatment GRDF plus soil application of government notified multi-micronutrient Grade-I @ 25 kg ha^{-1} was found at par with it in potassium uptake (128.75 kg ha^{-1}) in forage maize. Whereas the significantly minimum potassium uptake (103.95 kg ha^{-1}) in forage maize was recorded in the absolute control where no fertilizer were applied.

The forage maize crop fertilized with GRDF in association with soil application of government notified multi-micronutrient Grade I @ 25 kg ha^{-1} along with two foliar sprays of Phule liquid micronutrient Grade II @ 1% at 30 and 45 DAS experienced efficient availability and utilization of potassium which was reflected in enrichment of potassium uptake in forage maize. No application of fertilizer to forage maize produced significantly minimum potassium uptake in forage maize. The similar trend was also indicated by Ramanjineyulu *et al.* (2015) and Lagad *et al.* (2018).

4.3.6 Iron content in forage maize

Data regarding the iron content in forage maize as influenced by different treatments are represented in Table 19 and graphically in Fig. 15. The mean iron content in forage maize was 46.23 ppm recorded during investigation after harvest.

The forage maize crop fertilized with GRDF in association with soil application of government notified multi-micronutrient Grade I @ 25 kg ha^{-1} along with two foliar sprays of Phule liquid micronutrient Grade II @ 1% at 30 and 45 DAS recorded significantly higher iron content (51.89 ppm) in forage maize and the treatment GRDF plus soil application of government notified multi-micronutrient Grade-I @ 25 kg ha^{-1} was found at par with it in iron content (49.35 ppm) in forage maize. Whereas the significantly minimum iron content (36.19 ppm) in forage maize was recorded in the absolute control where no fertilizer was applied.

The forage maize crop fertilized with GRDF in association with soil application of government notified multi-micronutrient Grade I @ 25 kg ha^{-1} along with two foliar sprays of Phule liquid micronutrient Grade II @ 1% at 30 and 45 DAS. Combination of both soil and foliar application of micronutrients in association with macronutrients increased the availability of iron and efficient utilization of iron resulted in higher iron content. No application of fertilizer to forage maize produced significantly minimum iron content in forage maize. The results reported in present investigation are in agreement with those reported by Gohil *et al.* (2015), Manasa *et al.* (2015) and Ramanjineyulu *et al.* (2015).

4.3.7 Zinc content in forage maize

Data regarding the zinc content in forage maize as influenced by different treatments are represented in Table 19 and graphically in Fig. 15. The mean zinc content in forage maize was 39.63 ppm recorded during investigation after harvest.

The forage maize crop fertilized with GRDF in association with soil application of government notified multi-micronutrient Grade I @ 25 kg ha^{-1} along with two foliar sprays of Phule liquid micronutrient Grade II @ 1% at 30 and 45 DAS recorded significantly higher zinc content (44.69 ppm) in forage maize and the treatment GRDF plus soil application of government notified multi-micronutrient Grade-I @ 25 kg ha^{-1} was found at par with treatment in zinc content (42.67 ppm) in forage maize. Whereas the significantly minimum zinc content (31.73ppm) in forage maize was recorded in the absolute control where no fertilizer was applied.

The forage maize crop fertilized with GRDF in association with soil application of government notified multi-micronutrient Grade I @ 25 kg ha^{-1} along with two foliar sprays of Phule liquid micronutrient Grade II @ 1% at 30 and 45 DAS. Combination of both soil and foliar application of micronutrients in association with macronutrients increased the availability and zinc and efficient utilization of zinc resulted in enrichment of zinc content. No application of fertilizer to forage maize produced significantly minimum zinc content in forage maize. The results are in corroboration with those reported by Gohil *et al.* (2015), Manasa *et al.* (2015) and Ramanjineyulu *et al.* (2015).

4.3.8 Copper content in forage maize

Data regarding the copper content in forage maize as influenced by different treatments are represented in Table 19 and graphically in Fig. 15. The mean copper content in forage maize was 18.92 ppm recorded during investigation after harvest.

The forage maize crop fertilized with GRDF in association with soil application of government notified multi-micronutrient Grade I @ 25 kg ha^{-1} along with two foliar sprays of Phule liquid micronutrient Grade II @ 1% at 30 and 45 DAS recorded significantly higher copper content (24.33 ppm) in forage maize and the treatment GRDF plus soil application of government notified multi-micronutrient Grade-I @ 25 kg ha^{-1} was found at par with in copper content (23.74 ppm) in forage maize. Whereas the significantly minimum copper content (10.18 ppm) in forage maize was recorded in the absolute control where no fertilizer was applied.

The forage maize crop fertilized with GRDF in association with soil application of government notified multi-micronutrient Grade I @ 25 kg ha^{-1} along with two foliar sprays of Phule liquid micronutrient Grade II @ 1% at 30 and 45 DAS. Combination of both soil and foliar application of micronutrients in association with macronutrients increased the availability of copper content and efficient utilization of copper resulted in enrichment of copper content. No application of fertilizer to forage maize produced significantly minimum copper content in forage maize. The results are in close vicinity to those reported by Gohil *et al.* (2015), Manasa *et al.* (2015) and Ramanjineyulu *et al.* (2015).

4.3.9 Manganese content in forage maize

Data regarding the manganese content in forage maize as influenced by different treatments are represented in Table 19 and graphically in Fig. 15. The mean manganese content in forage maize was 30.61 ppm recorded during investigation after harvest.

The forage maize crop fertilized with GRDF in association with soil application of government notified multi-micronutrient Grade I @ 25 kg ha^{-1} along with two foliar sprays of Phule liquid micronutrient Grade II @ 1% at 30 and 45 DAS recorded significantly higher manganese content (37.44 ppm) in forage maize and the treatment GRDF plus soil application of government notified multi-micronutrient Grade-I @ 25 kg ha^{-1} was found at par with it in manganese content (36.59 ppm) in forage maize. Whereas the significantly minimum manganese content (14.21 ppm) in forage maize was recorded in the absolute control where no fertilizer was applied.

The forage maize crop fertilized with GRDF in association with soil application of government notified multi-micronutrient Grade I @ 25 kg ha^{-1} along with two foliar sprays of Phule liquid micronutrient Grade II @ 1% at 30 and 45 DAS. Combination of both soil and foliar application of micronutrients in association with macronutrients increased the availability of manganese content and efficient utilization of manganese resulted in enrichment of manganese content. No application of fertilizer to forage maize produced significantly minimum manganese content in forage maize. The similar results was also reported by Gohil *et al.* (2015), Manasa *et al.* (2015) and Ramanjineyulu *et al.* (2015).

4.3.10 Boron content in forage maize

Data regarding the boron content in forage maize as influenced by different treatments are represented in Table 19 and graphically in Fig. 15. The mean boron content in forage maize was 22.69 ppm recorded during investigation after harvest.

The forage maize crop fertilized with GRDF in association with soil application of government notified multi-micronutrient Grade I @ 25 kg ha^{-1} along with two foliar sprays of Phule liquid micronutrient Grade II @ 1% at 30 and 45 DAS recorded significantly higher boron content (30.86 ppm) in forage maize and the treatment GRDF plus soil application of government notified multi-micronutrient Grade-I @ 25 kg ha^{-1} was found at par with it in boron content (28.66 ppm) in forage maize. Whereas the significantly minimum boron content (13.41 ppm) in forage maize was recorded in the absolute control where no fertilizer was applied.

The forage maize crop fertilized with GRDF in association with soil application of government notified multi-micronutrient Grade I @ 25 kg ha^{-1} plus two foliar sprays of Phule liquid micronutrient Grade II @ 1% at 30 and 45 DAS. Combination of both soil and foliar application of micronutrients in association with macronutrients increased the availability of boron content and efficient utilization of boron resulted in enrichment of boron content. No application of fertilizer to forage maize produced significantly minimum boron content in forage maize. The similar trend was reported by Gohil *et al.* (2015), Manasa *et al.* (2015) and Ramanjineyulu *et al.* (2015).

Table 19. Micronutrient contents in forage maize as influenced by different treatments

Tr. No.	Treatment	Micronutrient concentration in ppm					
		Fe (ppm)	Zn (ppm)	Cu (ppm)	Mn (ppm)	B (ppm)	Mo (ppm)
T_1	Absolute Control	36.19	31.73	10.18	14.21	13.41	5.20
T_2	RDF (100:50:50 N : P_2O_5 : K_2O kg ha^{-1})	46.02	38.77	16.30	29.67	17.76	7.81
T_3	GRDF (100:50:50 N : P_2O_5 : K_2O kg ha^{-1} + 5 t ha^{-1} FYM)	46.60	39.10	18.40	32.48	19.65	9.00
T_4	GRDF + Soil application of government notified multi micronutrient Grade-I @ 25 kg ha^{-1}	49.35	42.67	23.74	36.59	28.66	13.26
T_5	GRDF + Two foliar sprays of Phule liquid Micronutrient Grade-II @ 1% at 30 and 45 DAS.	47.36	40.85	20.57	33.28	25.81	10.12
T_6	GRDF + Soil application of government notified multi micronutrient Grade-I @ 25 kg ha^{-1} +Two foliar sprays of Phule liquid micronutrient Grade-II @ 1% at 30 and 45 DAS.	51.89	44.69	24.33	37.44	30.86	14.57
	S. Em ±	1.35	1.21	0.64	0.99	0.95	0.45
	C.D.at 5%	4.08	3.65	1.92	2.98	2.86	1.34
	General Mean	46.23	39.63	18.92	30.61	22.69	9.93

4.3.11 Molybdenum content in forage maize

Data regarding the molybdenum content in forage maize as influenced by different treatments are represented in Table 19 and graphically in Fig. 15. The mean molybdenum content in forage maize was 9.93 ppm recorded during investigation after harvest.

The forage maize crop fertilized with GRDF in association with soil application of government notified multi-micronutrient Grade I @ 25 kg ha^{-1} along with two foliar sprays of Phule liquid micronutrient Grade II @ 1% at 30 and 45 DAS recorded significantly higher molybdenum content (14.57 ppm) in forage maize and the treatment GRDF plus soil application of government notified multi-micronutrient Grade-I @ 25 kg ha^{-1} was found at par with it in molybdenum content (13.26 ppm) in forage maize. Whereas the significantly minimum molybdenum content (5.20 ppm) in forage maize was recorded in the absolute control where no fertilizer was applied.

The forage maize crop fertilized with GRDF in association with soil application of government notified multi-micronutrient Grade I @ 25 kg ha^{-1} plus two foliar sprays of Phule liquid micronutrient Grade II @ 1% at 30 and 45 DAS. Combination of both soil and foliar application of micronutrients in association with macronutrients increased the availability of molybdenum content and efficient utilization of molybednum resulted in enrichment of molybdenum content. No application of fertilizer to forage maize produced significantly minimum molybdenum content in forage maize. The results are in conformity to the Gohil *et al.* (2015), Manasa *et al.* (2015) and Ramanjineyulu *et al.* (2015).

4.4 Soil studies

4.4.1 Soil analysis after harvest

The soil fertility within treated plot after harvest of forage maize are presented in table 20. The pH, electrical conductivity and organic carbon content are not influenced significantly. The available nitrogen and phosphorus in the soil after harvest of forage maize were influenced significantly due to different nutrient management treatments but potassium did not influenced with the treatments. The mean pH, electrical conductivity and organic carbon content in soil after harvest of forage maize were 8.51, 0.30 dSm^{-1} and 0.46 %, respectively. The mean available nitrogen, phosphorus and potassium content in soil after harvest of forage maize crop were 149.22, 20.36 and 354.40 kg ha^{-1}, respectively.

The forage maize crop with no fertilizer recorded significantly minimum nitrogen, phosphorus and potassium 133.00, 15.75 and 312.55 kg ha^{-1}, respectively. Among the other nutrient management treatments forage maize crop fertilized with GRDF in association with soil application of government notified multi-micronutrient Grade I @ 25 kg ha^{-1} along with two foliar sprays of Phule liquid micronutrient Grade II @ 1% at 30 and 45 DAS recorded significantly minimum value of available nitrogen, phosphorus and potassium 165.30, 17.13 and 347.93 kg ha^{-1}, respectively within treatment plots.

The forage maize crop with no fertilizer exhausted soil nutrients for the forage maize production as well as forage maize crop fertilized with GRDF in association with soil application of government notified multi-micronutrient Grade I @ 25 kg ha^{-1} along with two foliar sprays of Phule liquid micronutrient Grade II @ 1% at 30 and 45 DAS also exhausted soil nutrients due to higher biological yield.

Table 20. pH, EC, OC, Nitrogen, phosphorus and potassium content in soil after harvest as influenced by different treatments

Tr. No.	Treatment	pH (1:2.5)	EC (dSm^{-1})	OC (%)	Available nutrients ($kg\ ha^{-1}$)		
					N ($kg\ ha^{-1}$)	P ($kg\ ha^{-1}$)	K ($kg\ ha^{-1}$)
T_1	Absolute Control	8.52	0.32	0.45	133.00	15.75	312.55
T_2	RDF (100:50:50 N : P_2O_5 : K_2O kg ha^{-1})	8.51	0.31	0.46	209.37	22.46	397.73
T_3	GRDF (100:50:50 N : P_2O_5 : K_2O kg ha^{-1} + 5 t ha^{-1} FYM)	8.50	0.30	0.44	204.30	21.60	388.67
T_4	GRDF + Soil application of government notified multi micronutrient Grade-I @ 25 kg ha^{-1}	8.51	0.29	0.47	178.10	18.37	369.28
T_5	GRDF + Two foliar sprays of Phule liquid Micronutrient Grade-II @ 1% at 30 and 45 DAS.	8.49	0.30	0.46	197.77	19.36	380.38
T_6	GRDF + Soil application of government notified multi micronutrient Grade-I @ 25 kg ha^{-1} +Two foliar sprays of Phule liquid micronutrient Grade-II @ 1% at 30 and 45 DAS.	8.53	0.31	0.48	165.30	17.13	347.93
	S. Em ±	0.08	0.02	0.01	7.73	0.96	9.47
	C.D.at 5%	NS	NS	NS	23.31	2.89	28.55
	General Mean	8.51	0.30	0.46	181.30	19.11	366.09
	Initial status	8.53	0.31	0.48	244.57	24.31	438.68

4.4.2 Micronutrient contents in soil after harvest

Data regarding micronutrient content in soil after harvest as influenced by different treatments are presented in Table 21 and graphically depicted in Fig. 16. The mean values of micronutrient content in soil after harvest were iron 4.38 ppm, zinc 0.57 ppm, copper 0.52 ppm, manganese 4.32 ppm boron 0.87 ppm and molybdenum 0.68 ppm. The data in respective micronutrient contents in soil after harvest were influenced significantly due to different nutrient management treatments.

Table 21. Micronutrient contents in soil after harvest of forage maize as influenced by different treatments

Tr. No.	Treatment	Micronutrients content (ppm)					
		Fe (ppm)	Zn (ppm)	Cu (ppm)	Mn (ppm)	B (ppm)	Mo (ppm)
T_1	Absolute Control	3.68	0.40	0.34	2.95	0.54	0.26
T_2	RDF (100:50:50 N : P_2O_5 : K_2O kg ha^{-1})	4.16	0.55	0.40	3.40	0.80	0.50
T_3	GRDF (100:50:50 N : P_2O_5 : K_2O kg ha^{-1} + 5 t ha^{-1} FYM)	4.29	0.58	0.48	4.38	0.89	0.69
T_4	GRDF + Soil application of government notified multi micronutrient Grade-I @ 25 kg ha^{-1}	4.65	0.63	0.65	5.06	1.00	0.90
T_5	GRDF + Two foliar sprays of Phule liquid Micronutrient Grade-II @ 1% at 30 and 45 DAS.	4.46	0.60	0.58	4.79	0.95	0.78
T_6	GRDF + Soil application of government notified multi micronutrient Grade-I @ 25 kg ha^{-1} +Two foliar sprays of Phule liquid micronutrient Grade-II @ 1% at 30 and 45 DAS.	5.04	0.69	0.70	5.39	1.08	0.97
	S. Em ±	0.14	0.02	0.02	0.13	0.03	0.03
	C.D.at 5%	0.42	0.07	0.05	0.41	0.09	0.08
	General Mean	4.38	0.57	0.52	4.32	0.87	0.68
	Initial status	4.20	0.50	0.45	3.20	0.75	0.40
	Critical limit	4.50	0.60	0.2	2.0	0.5	0.05

The forage maize crop fertilized with GRDF in association with soil application of government notified multi-micronutrient Grade I @ 25 kg ha^{-1} along with two foliar sprays of Phule liquid micronutrient Grade II @ 1% at 30 and 45 DAS recorded significantly higher values of iron 5.04 ppm, zinc 0.69 ppm, copper 0.70 ppm, manganese 5.39 ppm boron 1.08 ppm and molybdenum 0.97 ppm in soil after harvest and the treatment GRDF plus soil application of government notified multi-micronutrient Grade-I @ 25 kg ha^{-1} was found at par with it for Fe, Zn, Cu, Mn, B and Mo in soil after harvest. Whereas the significantly minimum iron 3.68 ppm, zinc 0.40 ppm, copper 0.34 ppm, manganese 2.95 ppm boron 0.54 ppm and molybdenum 0.26 ppm in soil was recorded in the absolute control where no fertilizer was applied.

Government notified multi-micronutrient Grade I along with Phule liquid micronutrient Grade II favoured enrichment of micronutrient status in soil which facilitated efficient use of micronutrients by forage maize crop which was reflected in its available status in soil after harvest of crop. The results are in conformity to the Gohil *et al.* (2015), Manasa *et al.* (2015) and Ramanjineyulu *et al.* (2015).

4.5 Economic studies

The economic evaluation of forage maize was assessed in terms of gross monetary returns, cost of cultivation, net monetary returns and benefit cost ratio during summer of 2020-21 are presented in table 22.

Mean gross monetary returns, cost of cultivation, net monetary returns and benefit cost of forage maize obtained during summer 2020-21 were ₹ 71102 ha^{-1}, ₹ 32106.3 ha^{-1}, ₹ 38996.16 ha^{-1} and 2.19, respectively. The gross monetary of forage maize crop were influenced significantly due to different nutrient management treatments. The forage maize crop fertilized with GRDF in association with soil application of government notified multi-micronutrient Grade I @ 25 kg ha^{-1} along with two foliar sprays of Phule micronutrient Grade II @ 1% at 30 and 45 DAS found superior and obtained significantly maximum gross monetary returns of ₹ 88125 ha^{-1}, higher net monetary returns of ₹ 50841 ha^{-1} and benefit cost ratio of 2.36 during summer 2020-21than other treatments. Treatment GRDF plus soil application of government notified multi-micronutrient Grade-I @ 25 kg ha^{-1} was found at par with it. No application of fertilizer to forage maize produced significantly lower values of gross monetary returns ₹ 45870 ha^{-1}, net returns ₹ 23642 ha^{-1} and benefit cost ratio (2.06). Similar findings were recorded by Shashidhar *et al.* (2007), Kalhapure *et al.* (2010), Damame *et al.* (2013).

Table 22. Economics of forage maize as influenced by different treatments

Tr. No.	Treatment	Gross Monetary returns (₹ ha^{-1})	Cost of cultivation (₹ ha^{-1})	Net monetary returns (₹ ha^{-1})	B:C ratio	Incremental B:C ratio over RDF
T_1	Absolute Control	45870	22228	23642	2.06	-
T_2	RDF (100:50:50 N : P_2O_5 : K_2O kg ha^{-1})	60450	28614	31836	2.11	-
T_3	GRDF (100:50:50 N : P_2O_5 : K_2O kg ha^{-1} + 5 t ha^{-1} FYM)	72540	33614	38926	2.15	2.41
T_4	GRDF + Soil application of government notified multi micronutrient Grade-I @ 25 kg ha^{-1}	81285	35114	46171	2.31	2.90
T_5	GRDF + Two foliar sprays of Phule Micronutrient Grade-II @ 1% at 30 and 45 DAS.	78345	35784	42561	2.18	2.49
T_6	GRDF + Soil application of government notified multi micronutrient Grade-I @ 25 kg ha^{-1} +Two foliar sprays of Phule micronutrient Grade-II @ 1% at 30 and 45 DAS.	88125	37284	50841	2.36	3.19
	S. Em ±	2356	-	1813		-
	C.D.at 5%	7103	-	5465		-
	General mean	71102	32106	38996	2.19	-

5. SUMMARY AND CONCLUSION

5.1 Summary

The field experiment entitled, "Response of forage maize (*Zea mays* L.) to nutrient management during summer season" was carried out during summer season of 2020-2021 at AICRP on Forage crops Research project, MPKV, Rahuri, Dist. Ahmednagar (M.S.).

The soil of experimental field was low in available nitrogen (244.57 kg ha^{-1}), moderately high in phosphorus (24.31 kg ha^{-1}) and moderately high in potassium (438.68 kg ha^{-1}) and alkaline in reaction pH (8.53) the electrical conductivity was normal (0.31 dSm^{-1}) at 25 ^{0}C and organic carbon content in soil was medium (0.48 per cent).

The field experiment was laid out in randomized block design with four replications. There were six treatments *viz*. T_1: absolute control, T_2: RDF (100:50:50 N :P_2O_5 :K_2O Kg ha^{-1}), T_3: GRDF (100:50:50 N :P_2O_5 :K_2O Kg ha^{-1} + 5 t ha^{-1} FYM), T_4: GRDF + Soil application of Government notified multi- micronutrient Grade I @ 25 kg ha^{-1}, T_5: GRDF + Two foliar spray of Phule liquid micronutrient grade II @ 1% at 30 and 45 DAS, T_6: GRDF + Soil application of Government notified multi- micronutrient Grade I @ 25kg ha^{-1} + Two foliar spray of Phule liquid micronutrient grade II @ 1% at 30 and 45 DAS.

The gross and net plot size were 3.90 m x 3.00 m and 3.30 m x 2.40 m, respectively. The spacing of 30 cm x 15 cm was adopted by using 40 kg seed ha^{-1}. The recommended dose of fertilizer *i.e*. 100: 50: 50 kg N: P_2O_5: K_2O ha^{-1} was applied uniformly to all the treatments except absolute control. Nitrogen was supplied through urea and phosphorus through single super phosphate and potassium through muriate of potash at time of sowing and other fertilizer combinations were applied according to treatments.

The sowing of forage maize was done by dibbling on the flat bed. Irrigation was given immediately after dibbling to ensure good germination. The uniform plant population of forage maize was noticed in different treatment plots during investigation. Total seven irrigations were given to forage maize crop. Plant protection measures were undertaken to control the pest incidence.

The rainfall (94.4 mm) was received during crop growth period of forage maize (march 2020- may 2020). The climatic parameters, mean maximum temperature (28.10-40.0 ^{o}C), mean minimum temperature (13.10-26.9 ^{o}C), relative humidity during morning hour (55.00-81.00 %), evening hour (17.00-45.00 %) and wind velocity (0.8-5.8 km hr^{-1}) was recorded during investigation. The climate was favourable for the forage maize growth and development. The important findings of field experiment are summarized as below.

5.1.1 Growth attributes

The nutrient management treatments to the forage maize crop significantly influenced the growth attributes, yield attributes and yield of forage maize. The forage maize crop fertilized with GRDF in association with soil application of Government notified multi- micronutrient Grade I @ 25 kg ha^{-1} along with two foliar spray of Phule liquid micronutrient grade II @ 1% at 30 and 45 DAS exhibited significantly higher plant height (171.55 cm), number of leaves $plant^{-1}$ (13.78), leaf area $plant^{-1}$ (40.48 dm^2) and stem girth (7.46 cm) at harvest as compared to rest of nutrient management treatments during summer 2020-21. Forage maize crop with no fertilizer recorded significantly lower plant height (131.21 cm), number of leaves $plant^{-1}$ (8.28), leaf area $plant^{-1}$ (21.73 dm^2) and stem girth (5.54 cm) at harvest as compared to rest of nutrient management treatments.

5.1.2 Yield attributes

The forage maize crop fertilized with GRDF in association with soil application of Government notified multi- micronutrient Grade I @ 25 kg ha^{-1} along with two foliar spray of Phule liquid micronutrient grade II @ 1% at 30 and 45 DAS exhibited significantly higher dry matter $plant^{-1}$ (76.01 g) and L: S ratio (0.50) as compared to rest of nutrient management treatments. Forage maize crop with no fertilizer recorded significantly lower dry matter $plant^{-1}$ (40.92 g) and L: S ratio (0.26) as compared to rest of nutrient management treatments.

5.1.3 Yield

The forage maize crop fertilized with GRDF in association with soil application of Government notified multi- micronutrient Grade I @ 25 kg ha^{-1} along with two foliar spray of Phule liquid micronutrient grade II @ 1% at 30 and 45 DAS exhibited significantly higher green forage yield (587.5 q ha^{-1}) and dry matter yield (119.1 q ha^{-1}) as compared to rest of nutrient management treatments. Forage maize crop with no fertilizer recorded significantly lower green forage yield (305.8 q ha^{-1}) and dry matter yield (57.9 q ha^{-1}) as compared to rest of nutrient management treatments.

5.1.4 Quality studies

Forage quality in respect of crude protein content was significantly higher in forage maize crop fertilized with soil application of Government notified multi- micronutrient Grade I @ 25 kg ha^{-1} along with two foliar spray of Phule liquid micronutrient grade II @ 1% at 30 and 45 DAS which recorded numerically higher crude protein content (8.08 %) and crude protein yield (9.62 q ha^{-1}) than the rest of the nutrient management treatments during investigation. Forage maize crop with no fertilizer recorded significantly lower crude protein content (5.10 %) and crude protein yield (2.94 q ha^{-1}) than the rest of the nutrient management treatments during investigation.

Forage maize crop fertilized with GRDF in association with soil application of Government notified multi- micronutrient Grade I @ 25 kg ha^{-1} along with two foliar spray of Phule liquid micronutrient grade II @ 1% at 30 and 45 DAS exhibited significantly lower fiber contents such as crude fiber (18.76 %), ADF (25.00 %) and NDF (54.64 %) and also higher crude fiber yield (22.34 q ha^{-1}) than the rest of the nutrient management treatments during investigation. Forage maize crop with no fertilizer recorded significantly higher fiber contents such as crude fiber (25.65 %), ADF (32.88 %) and NDF (67.41 %) and also lower crude fiber yield (14.85 q ha^{-1}) than the rest of the nutrient management treatments during investigation.

Forage maize crop fertilized with GRDF in association with soil application of Government notified multi- micronutrient Grade I @ 25 kg ha^{-1} along with two foliar spray of Phule liquid micronutrient grade II @ 1% at 30 and 45 DAS exhibited significantly higher nitrogen uptake (158.35 kg ha^{-1}), phosphorus uptake (21.10 kg ha^{-1}) and potassium uptake (130.46 kg ha^{-1}) in forage. Forage maize crop with no fertilizer recorded significantly lower nitrogen uptake (119.47 kg ha^{-1}), phosphorus uptake (11.05 kg ha^{-1}) and potassium uptake (103.95 kg ha^{-1}) in forage.

Forage maize crop fertilized with GRDF in association with soil application of Government notified multi- micronutrient Grade I @ 25 kg ha^{-1} along with two foliar spray of Phule liquid micronutrient grade II @ 1% at 30 and 45 DAS exhibited significantly higher iron content (51.89 ppm), zinc content (44.69 ppm), copper content (24.33 ppm), manganese (37.44 ppm), boron content (30.86 ppm) and molybdenum content (14.57 ppm) in forage. Forage maize crop with no fertilizer recorded significantly lower iron content (36.19 ppm), zinc content (31.73 ppm), copper content (10.18 ppm), manganese (14.21 ppm), boron content (13.41 ppm) and molybdenum content (5.20 ppm) in forage.

5.1.5 Soil studies

The soil pH, electrical conductivity and organic carbon content after harvest were not influenced during investigation.

Forage maize crop with no fertilizer recorded significantly lower available nitrogen (133.00 kg ha^{-1}), available phosphorus (15.75 kg ha^{-1}) and available potassium (312.55 kg ha^{-1}). While among the rest of the nutrient management treatments forage maize crop fertilized with GRDF in association with soil application of Government notified multi- micronutrient Grade I @ 25 kg ha^{-1} along with two foliar spray of Phule liquid micronutrient grade II @ 1% at 30 and 45 DAS observed significantly lower available nitrogen (165.30 kg ha^{-1}), available phosphorus (17.13 kg ha^{-1}) and available potassium (347.93 kg ha^{-1}).

Forage maize crop with no fertilizer recorded significantly lower values of iron (3.68 ppm), zinc (0.40 ppm), copper (0.34 ppm), manganese (2.95 ppm), boron (0.54 ppm) and molybdenum (0.26 ppm) in soil after harvest of forage maize crop. Among the rest of nutrient management treatments forage maize crop fertilized with GRDF in association with soil application of Government notified multi- micronutrient Grade I @ 25 kg ha^{-1} along with two foliar spray of Phule liquid micronutrient grade II @ 1% at 30 and 45 DAS observed significantly higher values of iron (5.04 ppm), zinc (0.69 ppm), copper (0.70 ppm), manganese (5.39 ppm), boron (1.08 ppm) and molybdenum (0.97 ppm) in soil after harvest of forage maize crop.

5.1.6 Economics

Forage maize crop fertilized with GRDF in association with soil application of Government notified multi- micronutrient Grade I @ 25 kg ha^{-1} along with two foliar spray of Phule liquid micronutrient grade II @ 1% at 30 and 45 DAS exhibited significantly higher gross monetary returns (₹ 88125 ha^{-1}), net monetary returns (₹ 50841 ha^{-1}) and benefit cost ratio (2.36) as compared to rest of the treatments during study. Forage maize crop with no fertilizer recorded significantly lower gross monetary returns (₹ 45870 ha^{-1}), net monetary returns (₹ 22228 ha^{-1}) and benefit cost ratio (2.06) as compared to rest of the treatments during study.

5.2 Conclusions

1. Forage maize crop fertilized with GRDF in association with soil application of Government notified multi- micronutrient Grade I @ 25 kg ha^{-1} along with two foliar spray of Phule liquid micronutrient grade II @ 1% at 30 and 45 DAS recorded significantly higher values for growth and yield attributes and yield of forage maize *viz*., plant height (171.55 cm), number of leaves $plant^{-1}$ (13.78), leaf area $plant^{-1}$ (40.48 dm^2) and stem girth (7.46 cm), dry matter $plant^{-1}$ (76.01 g), L: S ratio (0.50), dry matter $plant^{-1}$ (76.01 g) and L: S ratio (0.50), green forage yield (587.5 q ha^{-1}) and dry matter yield (119.1 q ha^{-1}). However, it was at par with GRDF in association with soil application of Government notified multi- micronutrient Grade I @ 25 kg ha^{-1}.

2. Forage maize crop fertilized with GRDF in association with soil application of Government notified multi- micronutrient Grade I @ 25 kg ha^{-1} along with two foliar spray of Phule liquid micronutrient grade II @ 1% at 30 and 45 DAS recorded significantly higher values crude protein content (8.08%) and it recorded significantly lower values for fiber contents *viz*., crude fiber (18.76 %), ADF (25.00 %) and NDF (54.64 %) and it also recorded significantly higher values macro and micro nutrients *viz*., nitrogen uptake (158.35 kg ha^{-1}), phosphorus uptake (21.10 kg ha^{-1}) and potassium uptake (130.46 kg ha^{-1}), iron content (51.89 ppm), zinc content (44.69 ppm), copper content (24.33 ppm), manganese (37.44 ppm), boron content

(30.86 ppm) and molybdenum content (14.57 ppm) in forage than other treatments under study. However, it was at par with GRDF in association with soil application of Government notified multi- micronutrient Grade I @ 25 kg ha^{-1}.

3. Forage maize crop fertilized with GRDF in association with soil application of Government notified multi- micronutrient Grade I @ 25 kg ha^{-1} along with two foliar spray of Phule liquid micronutrient grade II @ 1% at 30 and 45 DAS recorded significantly lower available nitrogen, available phosphorus and available potassium in soil after harvest of forage maize crop except forage maize without fertilizer. The values of micronutrients *viz*., iron (5.04 ppm), zinc (0.69 ppm), copper (0.70 ppm), manganese (5.39 ppm), boron (1.08 ppm) and molybdenum (0.97 ppm) were at significantly higher level in soil wherein forage maize crop fertilized with GRDF in association with soil application of Government notified multi- micronutrient Grade I @ 25 kg ha^{-1} along with two foliar spray of Phule liquid micronutrient grade II @ 1% at 30 and 45 DAS. However, it was at par with GRDF in association with soil application of Government notified multi- micronutrient Grade I @ 25 kg ha^{-1}.

4. Forage maize crop fertilized with GRDF in association with soil application of Government notified multi- micronutrient Grade I @ 25 kg ha^{-1} along with two foliar spray of Phule liquid micronutrient grade II @ 1% at 30 and 45 DAS recorded significantly higher gross monetary returns (₹ 88125 ha^{-1}), net monetary returns (₹ 50841 ha^{-1}) and benefit cost ratio (2.36) and it also recorded highest incremental benefit coat ratio (3.19) as compared to recommended dose of fertilizer. However, it was at par with GRDF in association with soil application of Government notified multi- micronutrient Grade I @ 25 kg ha^{-1}.

Conclusion

It can be concluded that, the forage maize crop fertilized with GRDF (100:50:50 N: P_2O_5: K_2O Kg ha^{-1} + FYM 5 t ha^{-1}) in association with soil application of Government notified multi-micronutrient Grade I @ 25 kg ha^{-1} (Zn 5.0 %, Fe 2.0 %, Mn 1 %, B 1 %, Cu 0.5 %) registered better growth, yield, quality and economic returns from forage maize during summer season.

The above conclusion however based on year's investigation. For confirmation of results the investigation needs to be repeated.

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7. APPENDICES

Appendix – I Price of inputs and outputs per unit

Sr. No	**Particulars**		**Unit price**
1	Hired human Labour (₹ $unit^{-1}$)	Male	328
		Female	328
2	Land Preparation		
i.	Ploughing (Tractor) (₹ ha^{-1})		2500
ii.	Harrowing (Tractor) (₹ ha^{-1})		1400
3	Fertilizers		
i.	FYM (₹ $tonne^{-1}$)		1000
ii.	Urea (₹ kg^{-1})		6
iii.	SSP (₹ kg^{-1})		7
iv.	MOP (₹ kg^{-1})		19
v.	Government notified multi-micro nutrient Grade – I (soil application) (₹ kg^{-1})		60
vi.	Phule liquid micronutrient Grade-II (Foliar application) (₹ lit^{-1})		380
4	Seed (₹ kg^{-1})		40
5	Inter cultivation operation		
i.	Gap filling (₹ $unit^{-1}$)		328
ii.	Thinning (₹ $unit^{-1}$)		328
iii.	Spray charges (₹ $unit^{-1}$)		328
iv.	Weeding (₹ $unit^{-1}$)		328
6	Harvesting		328
7	Output		

i.	Green forage (₹ $tonne^{-1}$)	1500

Appendix –II: Details of cost of cultivation of forage maize crop with application GRDF + Soil application of government notified multi micronutrient Grade-I @ 25 kg ha^{-1} +Two foliar sprays of Phule liquid micronutrient Grade-II @ 1% at 30 and 45 DAS (₹ ha^{-1})

Sr. No.	Particulars	Quantity / Frequency	Cost (₹ ha^{-1})
1	Total labour required	53	17384
2	Land Preparation		
i.	Ploughing	1	2500
ii.	Harrowing	1	1400
3	Fertilizers		
i.	FYM	5	5000
ii.	Urea	217.39	1304
iii.	SSP	312.5	2187
iv.	MOP	83.3	1583
v.	Government notified multi-micro nutrient Grade – I (soil application)	25	1500
vi.	Phule liquid micronutrient Grade-II (Foliar application)	7	2170
4	Seed (kg)	40	1600
5	Cost of spraying	2	656
6	Total cost of cultivation		37284

Appendix – III: Details of micronutrients content in multi micronutrient Grade I (soil application) and Phule liquid micronutrient Grade II (foliar application)

Grade I (soil application)

Nutrient	Content (%)
Zinc	5.0
Iron	2.0
Manganese	1.0
Boron	1.0
Copper	0.5

Phule liquid Micronutrient Grade II (foliar application)

Nutrient	Content (%)
Zinc	3.0
Iron	2.5
Manganese	1.0
Boron	0.5
Copper	1.0
Molybdenum	0.1

VITAE

Mr.THIMMARAJA

MASTER OF SCINCE (AGRICULTURE)

IN

AGRONOMY

2021

Title of thesis		:	Response of Forage Maize (*Zea mays* L.) to Nutrient Management During Summer Season
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N

R-1	R-2	R-3	R-4
T_1	T_6	T_2	T_3
T_3	T_2	T_6	T_4
T_4	T_3	T_1	T_5
T_5	T_4	T_3	T_1
T_6	T_5	T_4	T_2
T_2	T_1	T_5	T_3

Fig. 2 Plan of Experimental layout

Name of the Crop	: Forage Maize (*Zea mays* L.)
Variety	: African Tall
Design	: Randomized Block Design
Replications	: 4
Number of treatments	: 6
Plot Size	: Gross Plot 3.9 m x 3.0 m
	: Net Plot 3.30m x 2.40 m
Spacing	: 30 cm X 15 cm
Sowing layout	: Flat bed

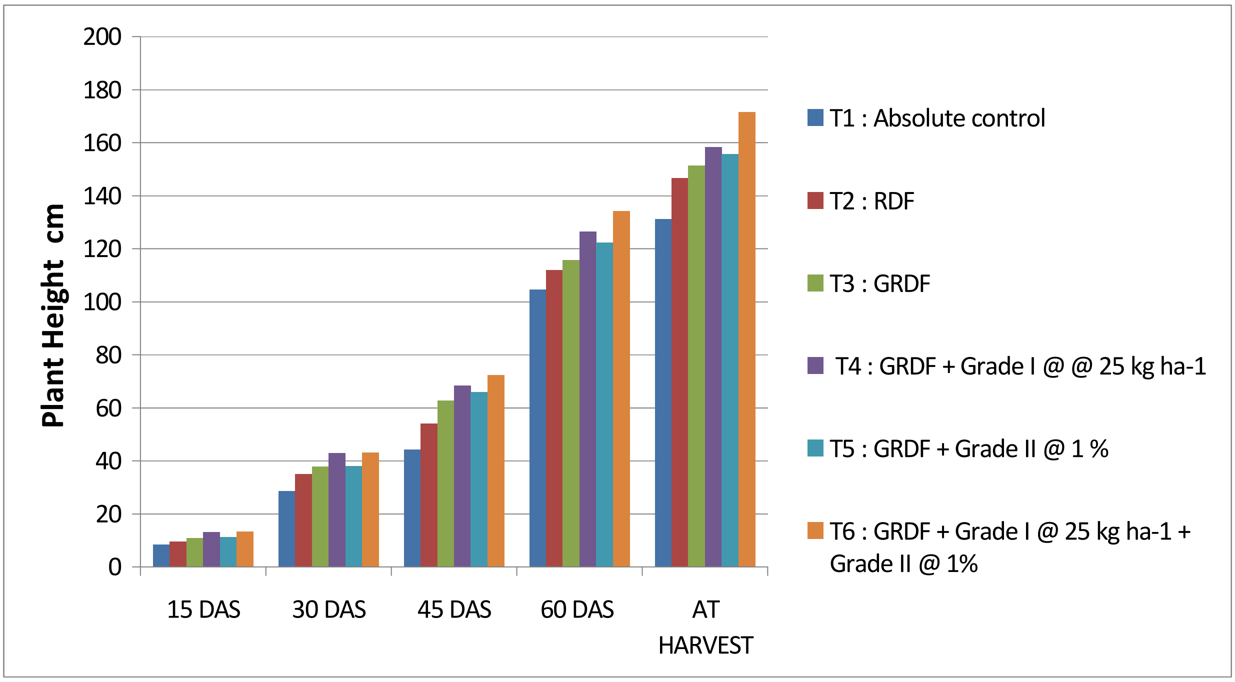

Figure 3 Plant height of forage maize as influenced by different treatments

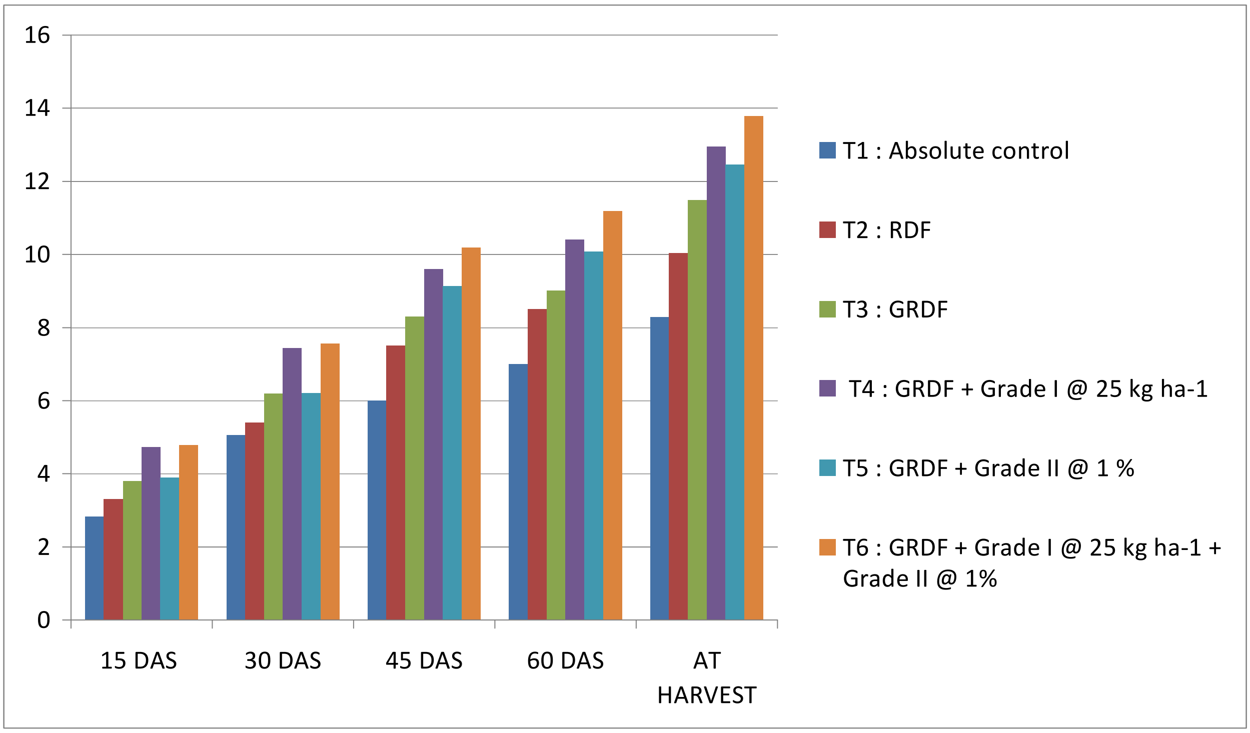

Figure 4 Number of leaves plant^{-1} of forage maize as influenced by different treatments

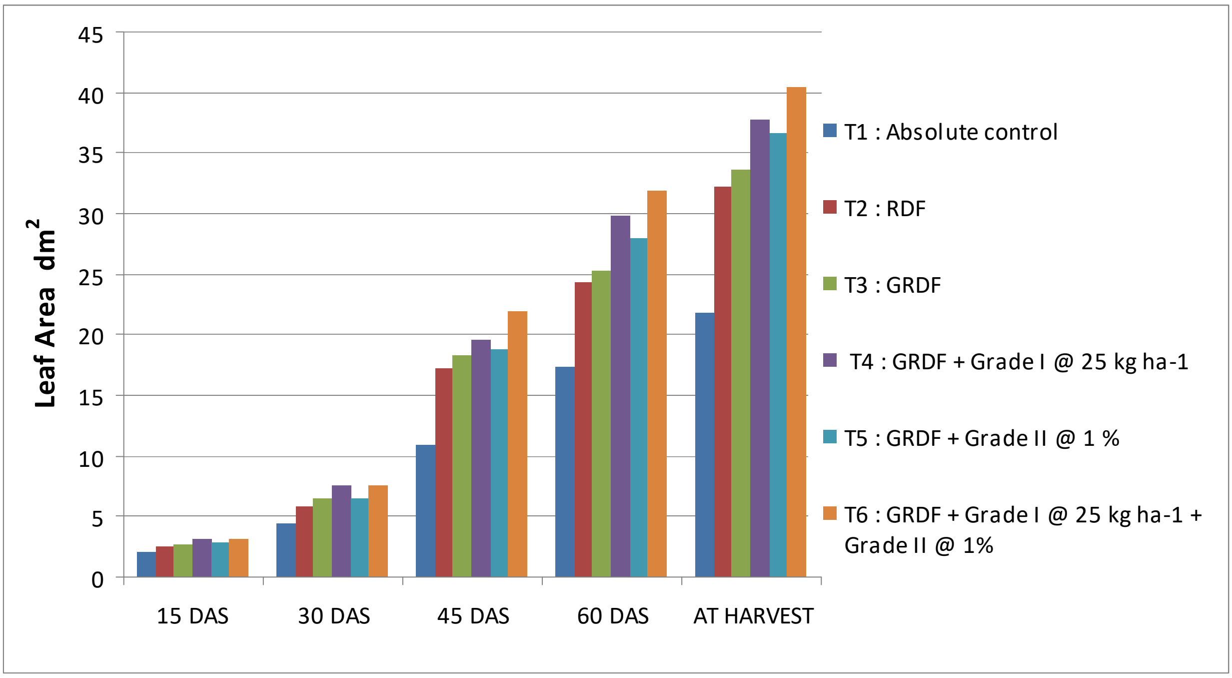

Figure 5 Leaf area plant^{-1} of forage maize as influenced by different treatments

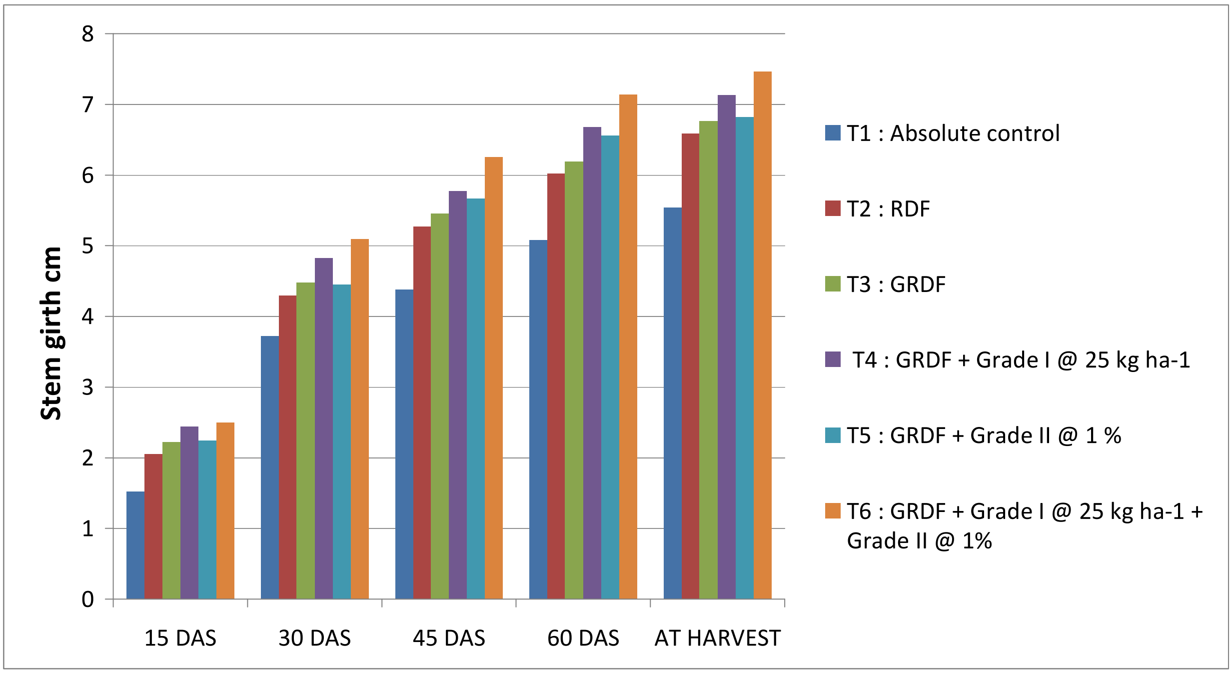

Figure 6 Stem girth of forage maize as influenced by different treatments

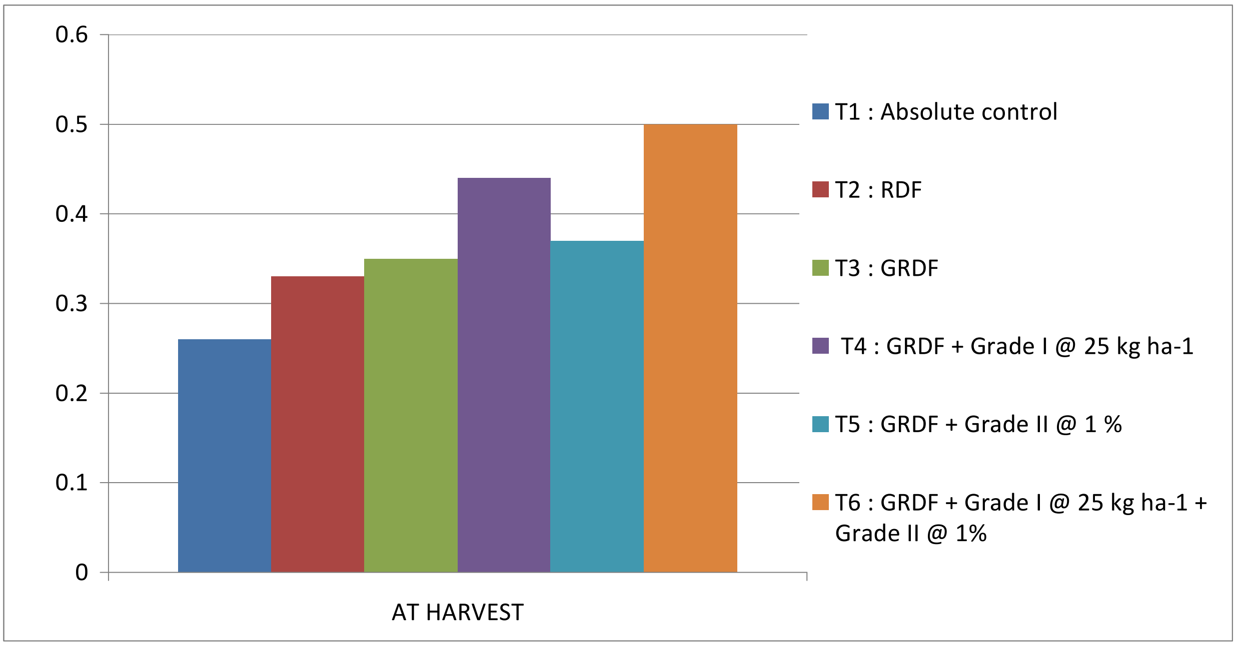

Figure 7 Leaf: Stem ratio of forage maize as influenced by different treatments

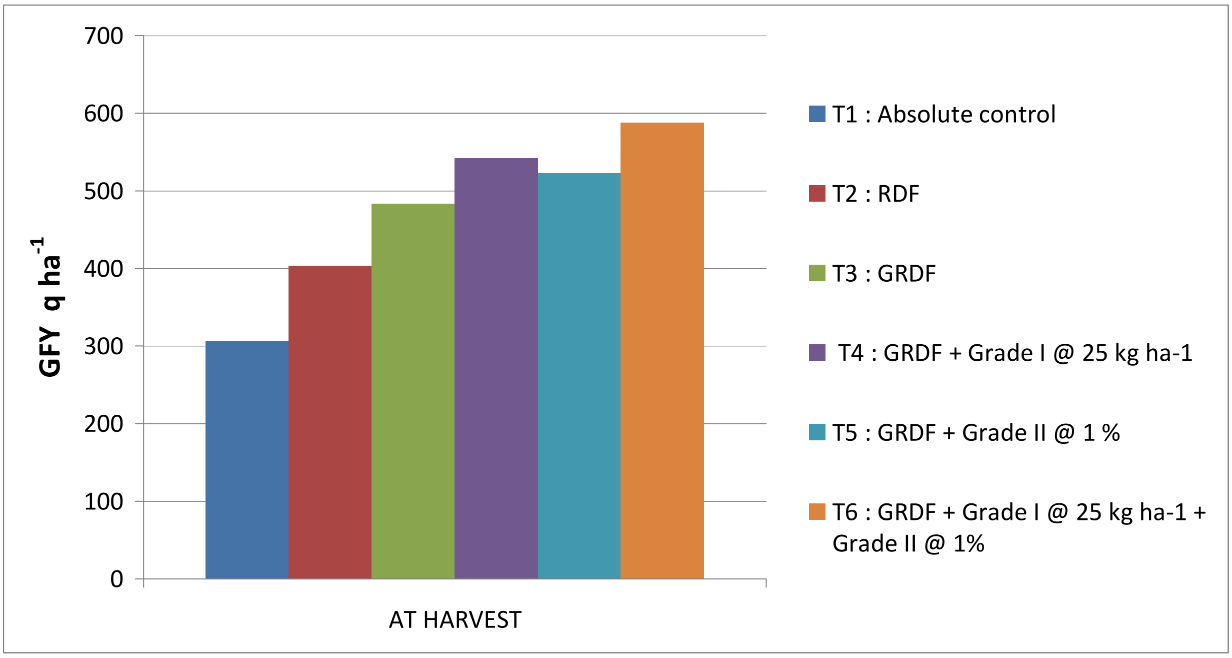

Figure 8 Green forage yield (GFY) of forage maize as influenced by different treatments

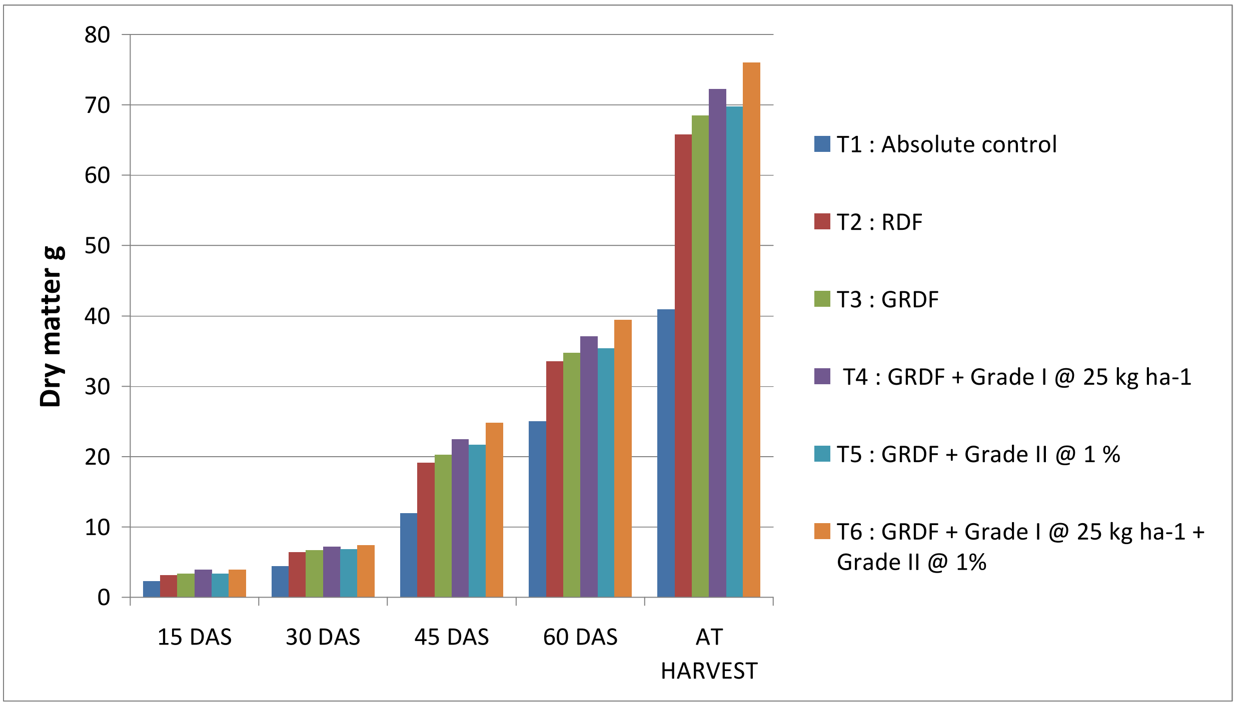

Figure 9 Dry matter plant^{-1} of forage maize as influenced by different treatments

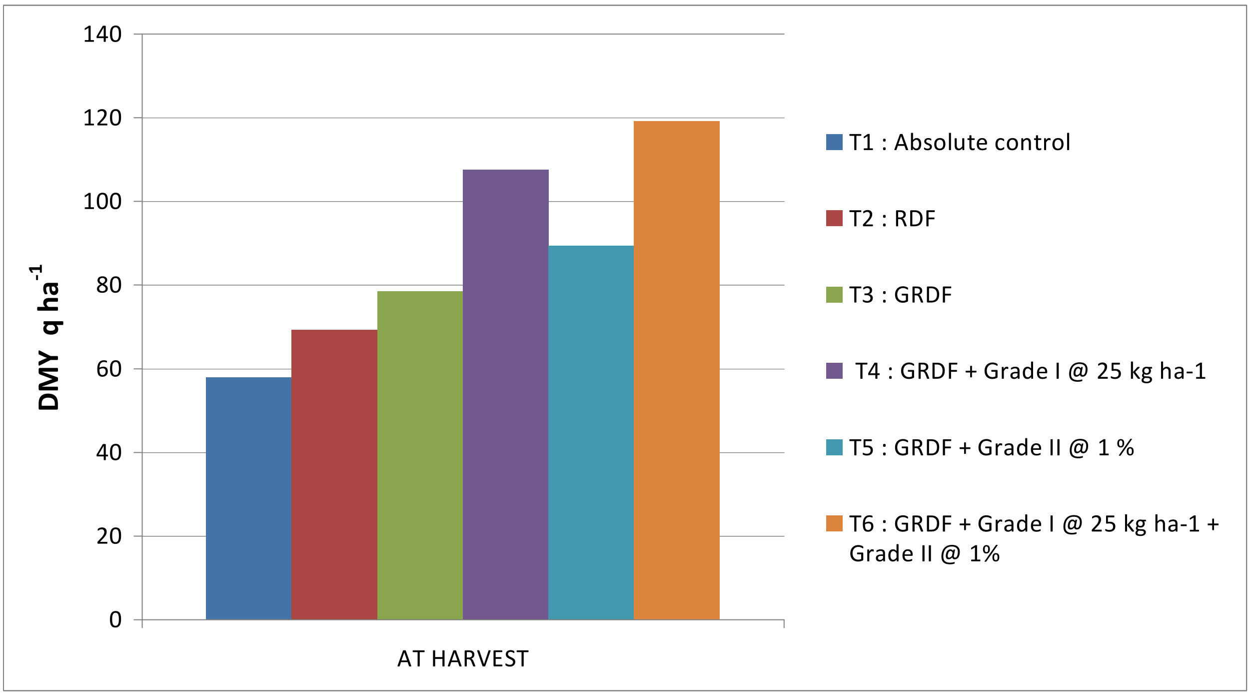

Figure 10 Dry matter yield (DMY) of forage maize as influenced by different treatments

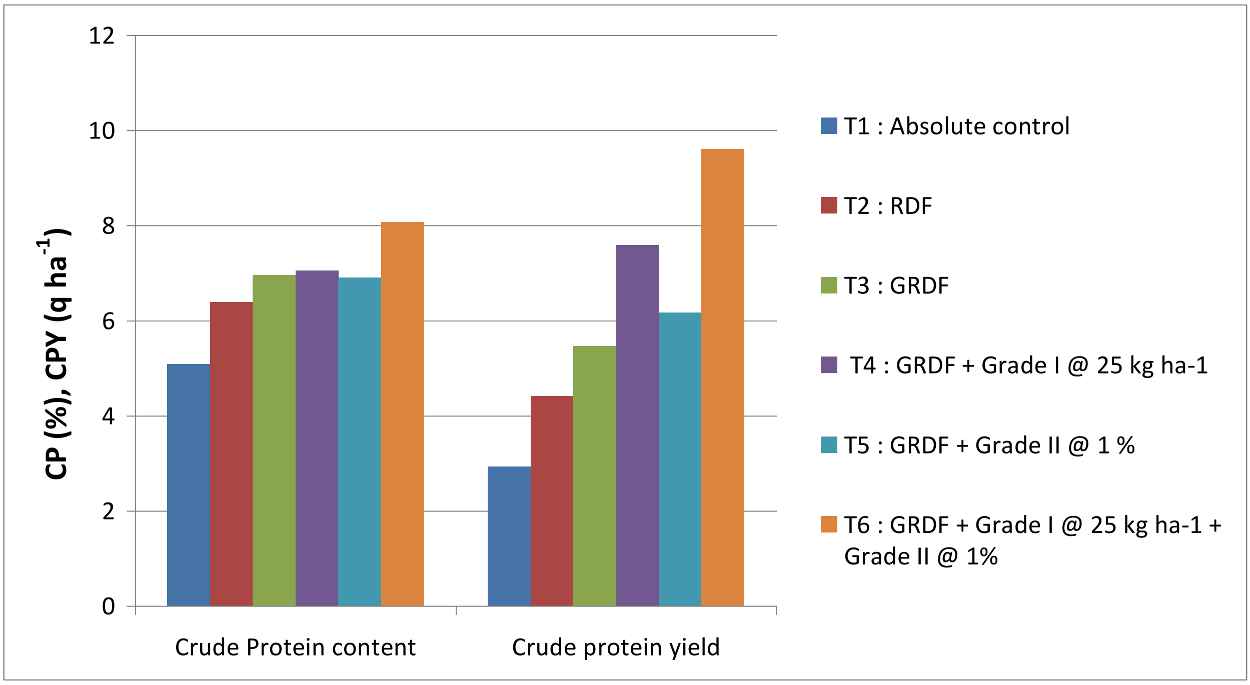

Figure 11. Crude protein content (CP) and yield (CPY) as influenced by different treatments

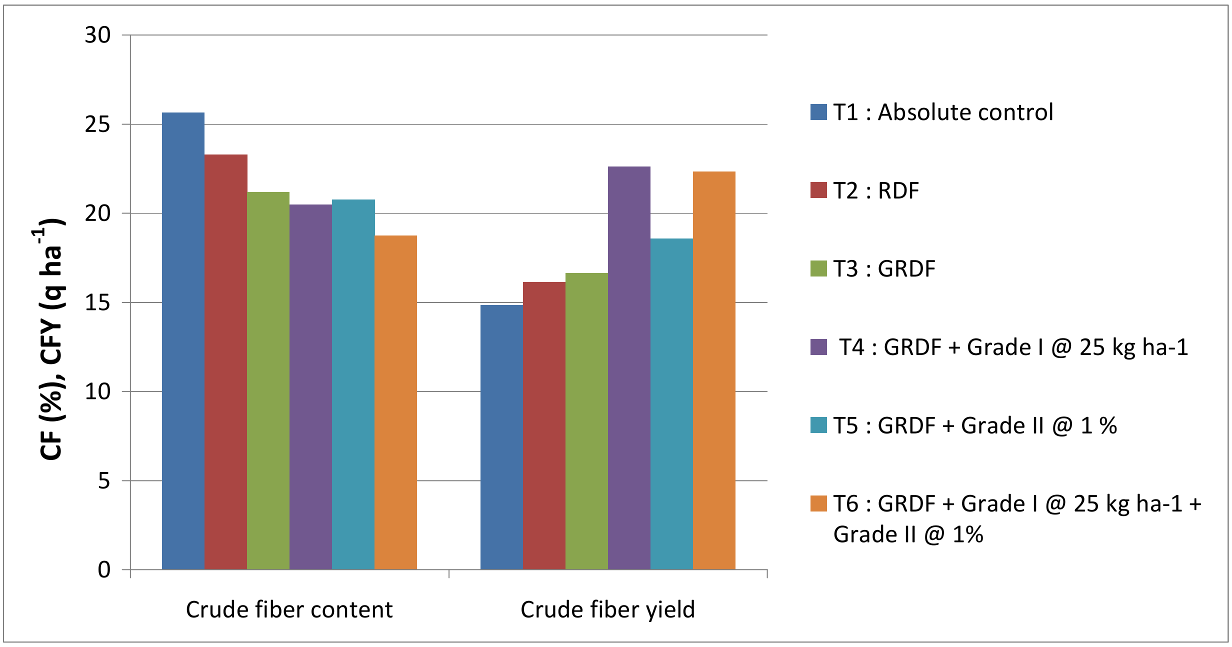

Figure 12 Crude fiber content (CF) and Yield (CFY) as influenced by different treatments

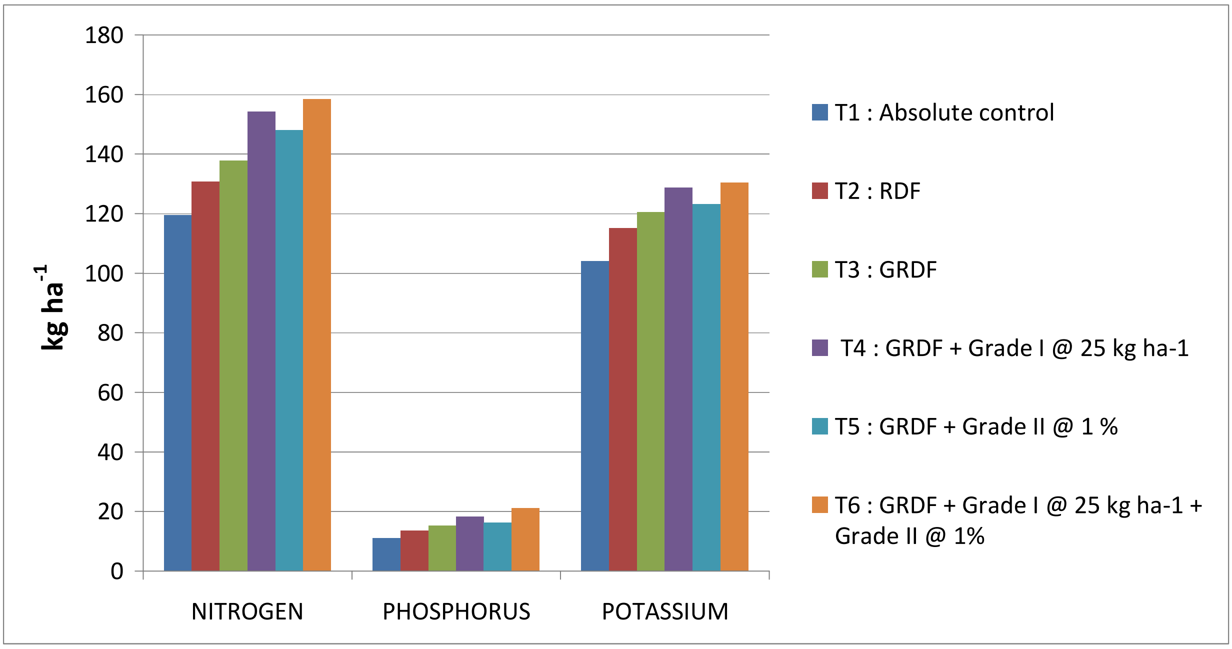

Figure 13 ADF and NDF as influenced by different treatments

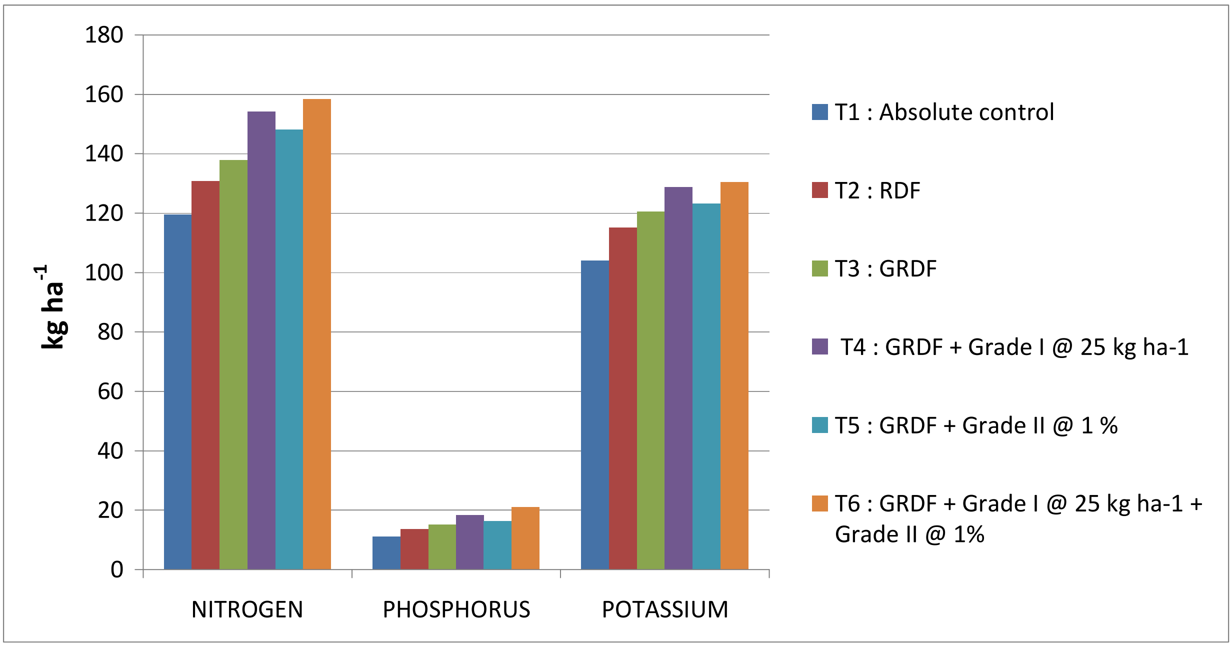

Fig. 14 Nitrogen, phosphorus and potassium uptake by forage maize as influenced by different treatments

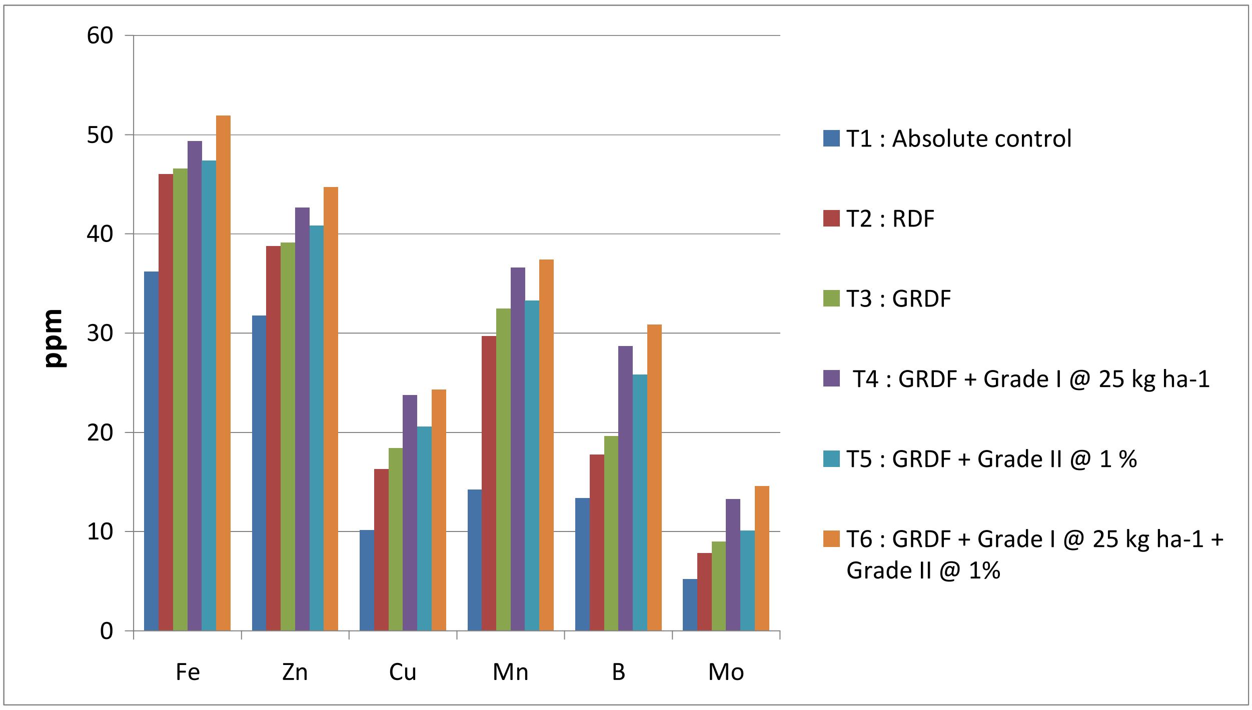

Figure 15 Micronutrient contents of forage maize as influenced by different treatments

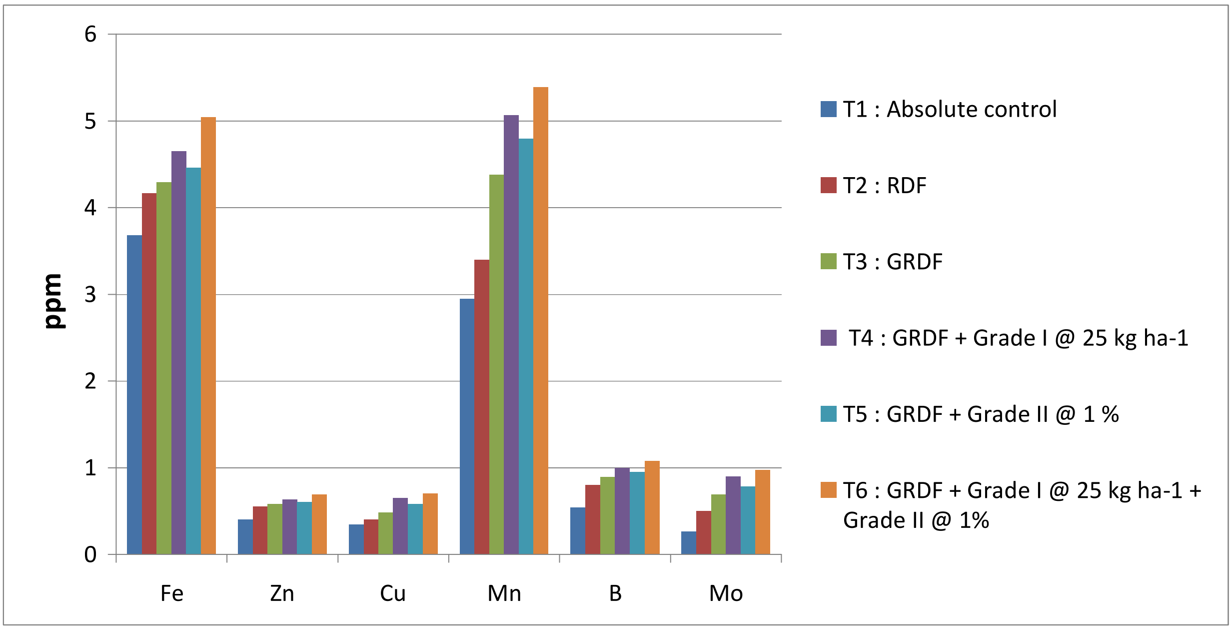

Figure 16 Micronutrient contents in soil after harvest of forage maize as influenced by different treatments

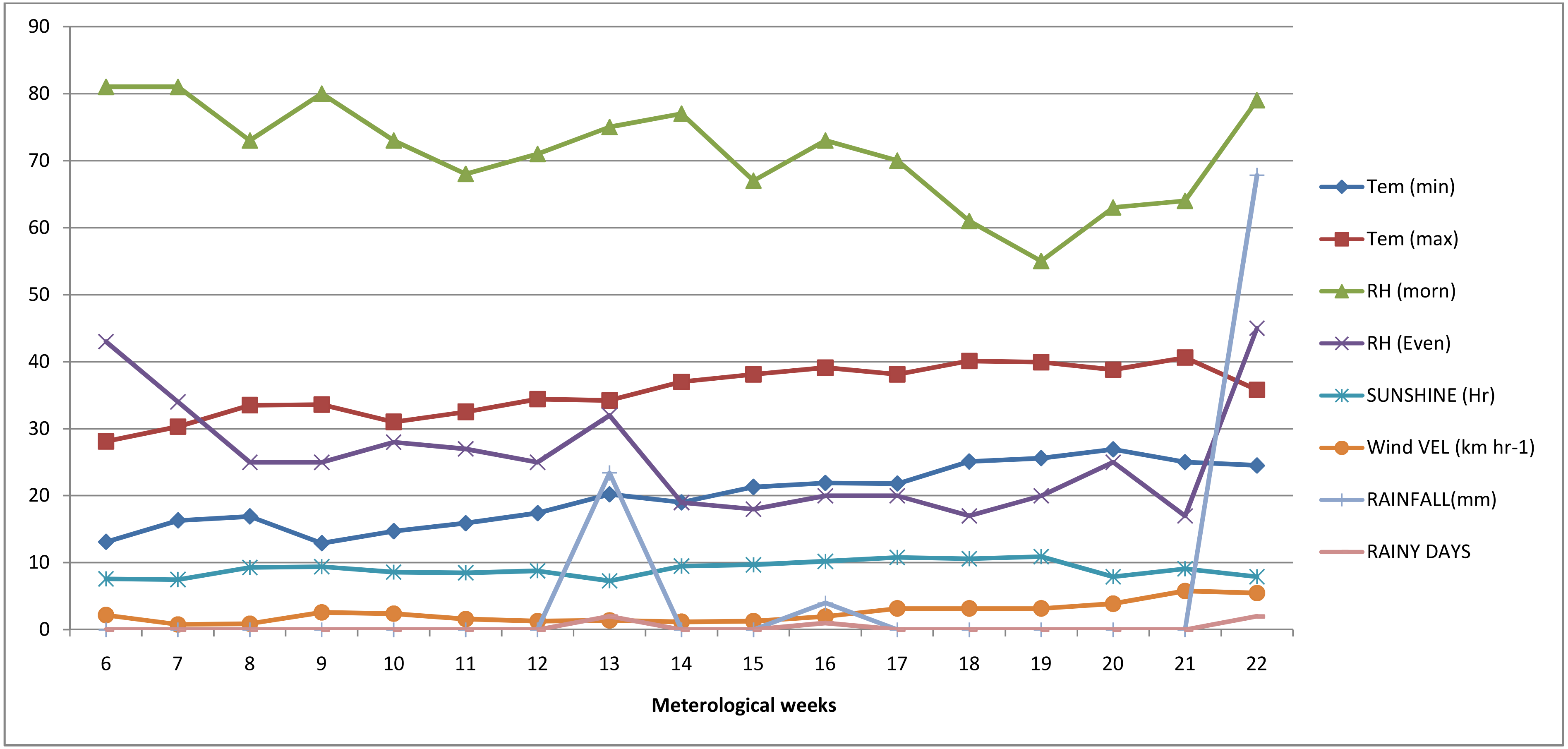

Figure 1 Weekly meteorological data on important weather parameters during crop growth period (March 2020- May 2020).

Sowing of the Research Plot

Fertilizer application

Gap filling

Harvesting of the plot

Plate 1: Various field activities of research plot

T_1: Absolute Control

T_2: RDF

T_3: GRDF

Plate 2 Vegetative growth of forage maize as influenced by different treatments

T_4: Soil application of Grade I

T_5: Foliar application Phule Micro Grade II

T_6: Soil application of Grade I and Phule Micro Grade II

Plate 3: Vegetative growth of forage maize as influnecd by different treatments

Plate 4 General view of the experimental plot

Plate 5: Analysis of soil and plant Sample