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Impact of INM on Growth and Yield of Maize (*Zea mays*) Crop in Central Plain Zone of Uttar Pradesh, India

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A B S T R A C T

A field experiment was conducted at field no. 6 Student's Instructural Farm at Chandra Shekhar Azad University of Agriculture and Technology, Kanpur during the *Kharif* season 2017 to find out integrated nutrient management effect on maize with ten treatments i.e. T_1 (125% RDN), T_2 (100% RDN), T_3 (100% RDN + 25% N FYM), T_4 (100% RDN + 25% N FYM + S_{30}), T_5 (100% RDN + 25% N FYM + S_{30} + Zn_5), T_6 (75% RDN), T_7 (75% RDN + 25% N FYM), T_8 (75% RDN + 25% N FYM + S_{30}), T_9 (75% RDN + FYM + S_{30} + Zn_5), T_{10} (Control) in RBD with 3 replications. Maize variety Azad Uttam was taken for study. The results revealed that the grain and stalk yield of maize respond significantly with the different treatment combination. The result showed highest grain yield (35.25 q ha^{-1}) and stalk yield (97.99 q ha^{-1}) with the application of 100% RDN + 25% N FYM + S_{30} + Zn_5 ha^{-1}, which was 88 % and 63.31 % higher to lowest grain yield (18.75 q ha^{-1}) and stalk yield (60 q ha^{-1}) at control. The maximum growth and yield in case of all treatments was found in T_5 (100% RDN + 25% N FYM + S_{30} + Zn_5) and lowest in T_{10} (Control).

Introduction

Maize (*Zea mays L.)* is one of the most important cereal crop, next to rice and wheat and is used as a food for human and feed for animals. This crop has been developed into a multi dollar business in countries *viz*. Thiland, Tiwan, Singapore, Malaysia, USA, Canada and Germany, because of its potential as a value added product for export and a good food substitute. Maize is gaining immense importance on account of its potential uses in manufacturing starch, plastics, rayon, adhesive, dye, resins, boot polish etc. and due to this large uses it is rightly called a Miracle crop and also known as 'Queen of cereals' due to its high potential yield. In India, maize is grown in an area of 9.76 million hectares with production of 26.14 million tonnes and productivity of 2629.28 kg ha^{-1} (Government of India, 2017). Maize yield is generally higher in high solar intensities, lower night temperature and lower pest infestation. Optimum plant density leads to better utilization of solar radiation resulting into corn dry matter accumulation and biomass production. Uttar Pradesh is the major producing state contributes 60 percent area and 70 percent of maize production in India. Abbasi *et al.,* (2010) reported that application of the highest rate of N (150 kg ha^{-1}) recorded the highest grain yields (3763 kg ha^{-1}) of maize. The proportional increase in maize yield for Nitrogen (90 kg N ha^{-1}) + poultry manure (30 kg N ha^{-1}) and Nitrogen (60 kg N ha^{-1}) + poultry manure (60 kg N ha^{-1}) was 85 and 83%, respectively.

Baral and Adhikari (2013) reported that 15% yield increased when 10 t $ha^{–1}$ FYM applied with azotobacter.

Bindhani *et al.,* (2007) reported that the application of 120 kg N ha^{-1} resulted in tallest plant with maximum dry matter yield and leaf area index which is significantly higher t5han 80 kg N ha^{-1}. They also reported a significant increase in makeable baby corn $plant^{-1}$ fresh weight, length and girth with the application of 120kg N ha^{-1}.

Bindhani *et al.,* (2008) reported that application of 120 kg N ha^{-1} increase significantly higher plant height, dry matter production and leaf area index over other treatment including control.

Dilshad *et al.,* (2010) observed that application of RDF (120 kg N+ 90 kg P_2O_5 + 60 kg K_2O ha^{-1}) or 50 per cent of RDF + FYM 10 t ha^{-1} + bio powder resulted in significantly greater plant height of maize over other treatments including control.

El-Kholy *et al.,* (2005) noted that application of *Azospirillum brasilense* and soil yeast *Rhodotorula glutinis* in the presence of 100% NPK gave significant increases in plant height, leaf area index, grain and straw yield of maize over 100 % NPK alone.

Kar *et al.,* (2006) reported significantly higher number of cobs $plant^{-1}$, length of cob, girth of cob, grains cob^{-1} and weight of cob of sweet corn with application of 80 kg N ha^{-1} over control.

Kumar *et al.,* (2017) observed that application of S and Zn has resulted in significant improvement for crude protein, Ca, ash in baby corn. Application of 125% RDF (187.5-93.7-75 kg ha^{-1}) and 50 kg S ha^{-1} along with 10 kg Zn ha^{-1} has great impact on corn production in maximum corn yield, fodder yield, nutrient content and monetary returns to the growers.

Kumar *et al.,* (2017) revealed that treatment T_3 (150% RDF) recorded significantly higher growth parameters and yield attributes *viz.* plant height (201.90 cm), number of grains cob^{-1} (393.20), test weight (223.25 g) and grain yield (52.05 q ha ha^{-1}) which was closely followed by treatment T_5 (RDF+5 tons FYM $ha^{–1}$ and recorded plant height (200.30 cm), number of grains cob^{-1} (391.95), test weight (223.15 g) and grain yield (51.70 q ha ha^{-1}) and was found to be at par to treatment T_3.

Mehta *et al.,* (2011) noted the maximum dry matter accumulation, leaf area index and crop growth rate in maize with application of 275 kg ha^{-1} N which was statistically at par with 250 kg nitrogen ha^{-1} but significantly higher over control.

Mehta *et al.,* (2005) reported significant increase in cobs $plant^{-1}$ of maize with application of 100 % RDF along with FYM at 10 t ha^{-1} over control.

Sahoo and Mahapatra (2005) reported significant increase in cobs $plant^{-1}$ and weight of cob of maize were noted with application of increasing levels of nitrogen fertilizers.

Satish *et al.,* (2011) reported higher grain (4402 kg $ha^{-1)}$ and straw (5888 kg $ha^{-1)}$ yield in summer maize in treatments with both organic and inorganic fertilizers in *kharif* followed by 100 percent NPK in summer season, thus showing the beneficial effect of organic sources of nutrients on the succeeding crop and also improving the soil fertility levels.

Sepat and Kumar (2007) observed significant increases in plant height and dry matter accumulation of maize crop with application of increasing levels of nitrogen up to 120 kg ha^{-1}.

Shabnam *et al.,* (2011) state that application of FYM @ 5 t $ha^{-1}$and lime @ 0.3 t ha^{-1} recorded maximum dry matter accumulation, leaf area index and crop growth rate and produced higher grain (4.162 t ha^{-1}) and stover (9.823 t ha^{-1}) yields of maize under red and lateritic soils of Ranchi.

Shrivas *et al.,* (2007) reported that application of 33.33% (RN) through non- edible oil cakes, 33.33 % (RN) through cow dung manure and 33.33 % (RN) through enriched compost recorded higher plant growth of maize over rest of treatments.

Singh and Yadav (2007) found that application of 100 % RDF (90 kg N + 17.5 kg P ha^{-1}) significantly improved plant height, dry matter production and leaf area index of maize over 75 per cent of RDF.

Singh *et al.,* (2007) reported that application of 40 kg N+ 30 kg P2O5 + 10 t FYM ha^{-1}+ Azotobacter +VAM significantly enhanced plant height and dry matter production of maize over other treatments.

Sujatha *et al.,* (2008) reported that application of sunhemp green manure + poultry manure + 100 % RDN gave significantly higher total dry matter accumulation $plant^{-1}$, leaf area index and cob yield $plant^{-1}$ in maize over rest of treatment combinations.

Thirupathi *et al.,* (2016) reported that applicatio0n of N and S @ 225 and 60 kg ha^{-1} recorded highest grain yield, stover yield, crude protein content and B:C ratio than other N and S contribution but it was on par with N and S @ 225 and 80 kg $ha^{-1.}$

Verma *et al.,* (2006) found significant increase in plant height, dry matter production, leaf area index, crop growth rate and net assimilation rate at 30, 60 and 90 DAS of maize crop with application of NPK at 90, 30 and 15 kg $ha^{-1,}$ respectively over control.

Yadhav and Christopher Lourduraj (2006) reported that the application of organic manures, FYM, poultry manure, green leaf manure and panchagavya spray resulted in significant increase yield attributes of sweet corn such as cob length, cob diameter and number of grains per cob.

Materials and Methods

The experiment was conducted on Maize during *kharif* season of 2017 under natural condition at field no. 6 Student's Instructural Farm at Chandra Shekhar Azad University of Agriculture and Technology, Kanpur. The soil of the experimental field was alluvial in origin. Soil sample (0-15cm) depths were initially drawn from randomly selected parts of the field before sowing. The quantity of soil sample was reduced to about 500 gm through quartering technique. The soil sample was then subjected to mechanical and chemical analysis in order to determine the textural class and fertility status the soils were sampled to a depth of 0-30 cm of the soil, air-dried and sieved (2 mm) for soil analyses. Some physical and chemical properties of soils are given in Table 1.

Maize variety Azad Uttam was taken for study. In the present experiment 10 treatments

T_1 (125% RDN), T_2 (100% RDN), T_3 (100% RDN + 25% N FYM), T_4 (100% RDN + 25% N FYM + S_{30}), T_5 (100% RDN + 25% N FYM + S_{30} + Zn_5), T_6 (75% RDN), T_7 (75% RDN + 25% N FYM), T_8 (75% RDN + 25% N FYM + S_{30}), T_9 (75% RDN + FYM + S_{30} + Zn_5), T_{10} (Control)were laid out in Randomized Block Design(RBD) with three replications having plot size 5 x 4 meter square. Doses of fertilizers are applied @ 120 Kg N, 60 Kg P_2O_5, 40 Kg K_2O/ha 30 Kg S/ha, 5 Kg Zn/ha and Organic manure 60 tonne/ha through Urea, D.A.P and Murate of Potash, Elemental sulphur, Zinc oxide and Farm Yard Manure. Sowing is done @ 20 kg seed ha^{-1} maize variety Azad Uttam was used and sown on 22 June 2017. Row to row and plant to plant distance remain 60 and 20 respectively. Seed were sown about 5-6 cm depth

Field preparation

The experimental field was ploughed once with soil turning plough fallowed by two cross harrowing. After each operation, planking was done to level the field and to obtain the fine tilth. Finally layout was done and plots were demarked with small sticks and rope with the help of manual labour in each block. Application of fertilizers: The crop was fertilized as per treatment. The recommended dose of nutrient i.e. N, P, and K was applied @ 120: 60: 40 kg ha^{-1} respectively. Time and method of fertilizer: Half does N_2 and total phosphorus, potash, zinc and sulphur were applied as basal dressing. Remaining dose of nitrogen was applied through top dressing after knee-high stage. Well decompose FYM applied @ 60 t ha^{-1} 15 day after sowing. Seed Treatment: To ensure the seeds free from seed borne diseases, seeds were treated with thiram 75% WDP (1.5g/kg of seed). Seed and sowing: 20 kg seed ha^{-1} maize variety Azad Uttam was used and sown on 22 June 2017. Row to row and plant to plant distance remain 60 and 20 respectively. Seed were sown about 5-6 cm depth. Intercultural operations: Weeding and hoeing were done with khurpi and hand hoe after germination. Irrigation: Tube-well was the source of irrigation. Irrigation was provided in the crop as and when required. Harvesting: The crop was harvested at proper stage of maturity as determined by visual observations. Half meter length on either end of each plot and two border rose from each side as border were first removed from the field to avoid error. The crop in net plot was harvested for calculation on yield data. Produce was tied in bundles and weighted for biomass yield. Threshing of produce of each net crop was done by manually.

Yield of crop

Grain yield

The clean and dried grains from each plot weighed with the help of electronic balance in kg/ha and converted into q/ha. Stalk Yield:- Stalk yield can be obtained by subtracting grain yield from the biological yield.

Observations recorded

The observations were recorded as per the procedure described below. For this purpose 5 plants were selected randomly in each net plot and were tagged with a level for recording various observations on growth and yield parameters. Biometric observation: Biometric observation such as plant population, average plant height at maturity, number of cobs, length of cobs, test weight of 1000 grain, cob girth, number of grain, number of row were recorded treatment wise grain and stalk yields were recorded per plot and converted into quintal ha^{-1}.

Soil analysis

Mechanical separates:- Soil separates analyzed by International pipette method as described by the Piper (1966). pH:- pH of the soil determined by using soil water suspension (1:2.5) with the help of digital pH meter. EC:- EC also determined using soil water suspension (1:2.5) with help of conductivity meter (Jackson, 1967). Organic carbon:- Organic Carbon was determined by Walkley and Black's rapid titration method as described by Jackson (1967). Available Nitrogen:- It was determined by Alkaline Potassium Permagnate Method described by Subbiah and Asija (1956). Available Phosphorus:- It is determined by Olsen's method using 0.5 M $NaHCO_3$ (Olsen *et al.,* 1954). Available Potassium:- Potassium is determined by using Neutral Normal Ammonium Acetate (pH 7.0) by Flame Photometer. Available Sulphur:- Available Sulphur was determined by turbidimetric method (Chesnin and Yien,1950) after extraction with 0.15%$CaCl_2$ solution. Available Zinc:- Available Zn is determined by Atomic Absorption Spectrophotometer with the help of DTPA extractant (Lindsey and Norvell, 1978).

Statistical analysis

The data on various characters studied during the course of investigation were statistically analyzed for randomized block design. Wherever treatment differences were significant ("F" test), critical differences were worked out at five per cent probability level. The data obtained during the study were subjected to statistical analysis using the methods advocated by Chandel (1990).

Results and Discussion

Impact of INM on growth and yield attributes of maize

Growth attributes

Plant population plot^{-1}

Data in regard with plant population plot^{-1} was recorded at the time of crop harvest are depicted in table 4.1 and figure 1 showed non-significant variation in plant population within all the treatments. Maximum number of plant plot^{-1} ha^{-1} (246) was recorded with 100% RDN + 25% N FYM + 30 kg + 5kg Zn ha^{-1} followed by (244) with 75% RDN +25 % N FYM + 30 kg S + 5 kg Zn ha^{-1} and minimum (232) at control (T_{10}). Integration of FYM, sulphur and zinc showed non-significant variation in plant population when applied with 75 % RDN and 100 % RDN.

Plant height

Data pertaining to plant height given in table 4.1 and figure 1 showed linear variation in all the treatments. Maximum plant height 195 cm was recorded with T_5 (100% RDN + 25% N FYM + 30 kg S + 5 kg Zn ha^{-1}) followed by 244 cm with T_9 (75% RDN + 25% N FYM + 30 kg S + 5 kg Zn ha^{-1}) and minimum 179 cm at control (T_{10}). It is also obvious from the data that plant height increased in all the treatments in comparison to control but the increase in plant height was recorded non-significant. Integration of sulpher, zinc and FYM with 100% RDN and 75% RDN also influenced plant height but the increase was plant height recorded non-significant.

Yield attributes

Number of cob plant $^{-1}$

It is visualized from the data given in table 4.2 and figure 2 showed that number of cob plant^{-1} influenced significantly in all the treatment over to control. Maximum number of cob (1.6 plant^{-1}) was recorded with T_5 (100 % RDN + 25% N FYM + 30 kg S + 5 kg Zn ha $^{-1}$) followed by (1.48 cob plant^{-1}) T_9 (75 % RDN + 25 % N FYM + 30 kg S + 5 kg Zn ha^{-1}) and minimum (1.02 cob plant^{-1}) at control (T_{10}). Integration of S, Zn and FYM showed slight increase in number of cob plant^{-1} when applied with 100% RDN and 75% RDN treatments. Variation in number of cobs plant^{-1} within 75% RDN and 100 % RDN and 125% RDN was found non-significant.

Girth of cob

Girth of cob as effected by different treatment are given in table 4.2 And figure 2 showed linear and non-significant variation within all the treatments. Maximum cob girth 11.7 cm was recorded with T_5 (100 % RDN + 25% N FYM + 30 kg S + 5 kg Zn ha^{-1}) followed by 11.56 with T_9 (75 % RDN + 25 % N FYM + 30 kg S + 5 kg Zn ha^{-1}) and minimum 10.20 at control (T_{10}). It was also observed that cob girth cm^{-1} increased significantly in all the treatment in comparison to control. Integration of S, FYM and Zn showed non-significant increase in cob girth when applied with 100% RDN and 75% RDN treatment.

Cob length cm

Data in respect cob length was given in table 4.3 and illustrated in figure 3 showed significant variation in all the treatment. Maximum cob length (14.40 cm) was recorded with T_5 (100 % RDN + 25% N FYM + 30 kg S + 5 kg Zn ha^{-1}) followed by (14.20 cm) T_9 (75% RDN + 25% N FYM + 30 kg S + 5 kg Zn ha^{-1}) and minimum (12.5 cm) at control (T_{10}). It was also observed that cob length increased significantly in all the treatment in comparison to control (T_{10}). Integration of S, FYM and Zn influenced cob length significantly when applied with 100% RDN and 75% RDN treatments. Variation in cob length within 75% RDN, 100 RDN% and 125% RDN was also found significant.

Number of rows cob^{-1}

Number of rows cob^{-1} varied from 7.66 to 11.33 and variation in number of rows cob $^{-1}$ within all the treatments was found non-significant. It is also obvious from the data given in table 4.3 and figure 3 showed no. of rows cob^{-1} increase significantly in all the treatment over to control. Integration of S, Zn, and FYM showed slight increase in number of rows cob^{-1} but the increase was found non-significant. Variation in number of rows cob^{-1} within 75 % RDN, 100 % RDN and 125 % RDN was also found non-significant.

Number of grains row cob^{-1}

Data in regard to Number of grains row cob^{-1} given in table 4.4 and figure 4 showed significant increase in all the treatment over control. Maximum number of grain (19.6 cob^{-1}) was recorded with T_5 (100 % RDN + 25% N FYM + 30 kg S + 5 kg Zn ha^{-1}) followed by (19.0 cob^{-1}) T_9 (75% RDN + 25% N FYM + 30 kg S + 5 kg Zn ha^{-1}) and minimum (16.0 cob^{-1}) at control (T_{10}). Integration of S, Zn and FYM showed significant increased in number of grains row cob^{-1} when applied with 100 % RDN and 75% RDN treatments. Variation in number of grain row cob^{-1} within 75 % RDN, 100% RDN and 125 % RDN was also found significant.

Test weight (1000 grain)

Test weight as expressed by weight 1000 grains in gram is given in table 4.4 and figure 4. The results revealed that test weight was non-significantly influenced by the different treatments. Maximum increase in test weight was recorded (220.50 gm) with T_5 (100% RDN + 25% N FYM + 30 kg S + 5 kg Zn ha^{-1}) followed by (218.40 gm) T_9 (75% RDN + 25 % N FYM + 30 kg S + 5 kg Zn ha^{-1}) and minimum (214.60 gm) at control (T_{10}). It was also observed that all the treatments showed significant increase in test weight over control. Integration of S, FYM and Zn showed positive effects when applied with 100% RDN and 75% RDN treatments but the increase was found non- significant. Variation in test weight within 75% RDN, 100% RDN and 125% RDN was recorded significant.

Yield

Biological yield

It is apparent from the data given in table 4.5 and figure 5 that biological yield of maize increase significantly in all the treatments in comparison to control (T_{10}) maximum biological yield (133.24 q ha^{-1}) was recorded with T_5 (100 % RDN + 25% N FYM + 30 kg S + 5 kg Zn ha^{-1}) followed by (123.88 q ha^{-1}) with T_9 (75 % RDN + 25 % N FYM + 30 kg S + 5 kg Zn ha^{-1}) and minimum (78.75 q ha^{-1}) at control (T_{10}). Variation in biological yield within 75% RDN, 100% RDN and 125% RDN was found significant. Integration of S, FYM and Zn also showed significance increase in biological yield when applied with 75% RDN and 100% RDN treatments.

Grain yield

It is apparent from the data depicted in table 4.5 and illustrated in figure 5 showed that all the treatment significantly influenced the grain yield over control. Higher grain yield (35.25 q ha^{-1}) was recorded with T_5 (100 % RDN + 25% N FYM + 30 kg S + 5 kg Zn ha^{-1}) which was (88%) higher to the lowest grain yield (18.75 q ha^{-1}) of control (T_{10}) and (31.04 %) higher to 100 % RDN (T_2). Integration of 30 kg sulphur ha^{-1} with 100 % RDN + 25% N FYM produced (11.87%) more grain yield in comparison to 100 % RDN + 25% N FYM (T_3). Likewise integration of 5 kg zinc with 100% + 25% N FYM + 30 kg sulphur ha^{-1} influenced (8.46%) higher grain yield in comparison to 100% RDN + 25 % N FYM + 30 kg sulphur ha^{-1}. Super imposition of 25% N through FYM with 100% RDN (T_3) produced (7.99 %) higher grain yield over 100 % RDN (T_2). Variation in grain yield within 75% RDN and 100% RDN was found significant. It was also observed that treatment receiving 125% (T_1) inorganic fertilizer produced higher grain yield in comparison to 100% RDN and 25% N FYM (T_3) but the increase was found non-significant. Substitution of 25 % N FYM with 75 % RDN produced lower grain yield than 100% RDN but yield difference within these treatment was found comparable and at par. It is interesting to show that integration of FYM, sulphur and Zn showed higher increase in grain yield when applied with 75% RDN in comparison to 100% RDN treatment.

Stalk yield

Data in regard to stalk yield given in table 4.5 and figure 5 showed significant increase in all the treatments in comparison to control. Maximum stalk yield (97.99 q ha^{-1}) was recorded with T_5 (100% RDN + 25% N FYM + 30 kg S + 5 kg Zn ha^{-1}) which was (63.31%) higher than control. Integration of FYM, sulphur and zinc produced 85.69 q ha^{-1}, 91.65 q ha^{-1} and 97.99 q ha^{-1} over yield when applied with 100% RDN and 6.02 %, 7.30% and 7.35% more when applied with 75 % RDN treatment respectively. Variation in stalk yield within 75% RDN, 100% RDN and 125% RDN was found significant. It was also observed that substitution of 25% N FYM produced stalk yield at par to 100% RDN. Super imposition of 25% N through FYM with 100% RDN also produced stalk yield at par to 125% RDN.

Impact of INM on growth attributes, yield attributes and yield

The study encompasses observations on growth parameters and yield attributing characters were taken. The characters included in study were plant population $plot^{-1}$, plant height (cm.) at harvest stage of the crop, no. of cob $plant^{-1}$, girth of cob (cm.), no. of rows cob^{-1}, no. of grain cob^{-1} and test weight

(1000 grain) gm. At the harvest the data were recorded on biological yield, grain yield and stalk yield.

Growth attributes

Plant population

Plant population varied from 234 to 246 in all the treatment and variation in plant population within all the treatment was noted non-significant.

This indicated that nutrient treatment was affected in plant population. Plant population could be affected due to seeding, germination percentage etc. These findings are related to the findings of Verma *et al.*, (2006), Jena *et al.*, (2013) and Shrivas *et al.*, (2007)

Plant height

Plant height was measured at harvest stage. Perusal of the data given in table 4.1 and figure 1 showed that plant height increase significantly in all the treatment over control. Plant height varied from 174 to 195 cm plant^{-1} within all the treatments. Addition of FYM, S, Zn influenced plant height when applied with 100% RDN and 75 % RDN. Significant variation in plant height was noted within 75% RDN, 100% RDN and 125% RDN.

Maximum plant height 195 cm. was recorded with T_5 (100% RDN + 25% N FYM + 30 kg S + 5 kg Zn ha^{-1}) which were 35.71% higher than control. This indicates that the nutrient application resulted in augmented photosynthetic activity due to combined and balance effect of nutrients in maize.

Significant increase in cell division and growth was also manifested in terms of plant height. Increase in plant height due to integration of S and Zn and organic manure with 100% inorganic fertilizers. Similar results have been reported by Bindhani *et al.*, (2007), El-Kholy *et al.*, (2005), Mehta *et al.*, (2011), Kumar (2008) and Singh and Yadav (2007).

Yield attributes

Yield attributes parameter that has been given in table 4.2 to table 4.4 and figure 2 to 4 showed that significant increase in yield attributing parameter in all the treatments over control. Maximum yield attributing parameter was recorded with T_5 (100 % RDN + 25 % N FYM + 30 kg S + 5 kg Zn ha^{-1}) followed by T_9 (75% RDN + 25% N FYM + 30 kg S + 5 kg Zn ha^{-1}) and minimum at control (T_{10}). Addition of S, Zn and FYM with 100% RDN and 75% RDN also accelerate yield attributing parameters but the increase in yield attributing parameters in general was found non-significant. Increase in yield attributing parameters within 75% RDN, 100% RDN and 125% RDN were noted in general significant. Increase in yield attributing parameters might be attributed to increase cell expansion and various metabolic processes in the presence of adequate available nutrient. Results in this study are agreement with those of following workers Sahoo and Mahapatra (2005), Kar *et al.*, (2006), Mehta *et al.*, (2011) and Kumar (2008).

Impact of INM on grain and stalk yield

A perusal of the data presented in table 4.5 and illustrated in figure clearly revealed that all the treatment significantly influenced the grain and stalk yield over control. The highest grain yield 35.25 q ha^{-1} and stalk yield 97.99 q ha^{-1}were recorded with T_5 (100% RDN + 25 % N FYM + 30 kg S + 5 kg Zn ha^{-1}) which was 88% and 63.31% higher than yield of control (T_{10}). Integration of 30 kg S ha^{-1} produced 11.87% and 13.01% higher grain and 6.95% and 5.67% stalk yield with 100%

and 75% RDN. Like-wise S integration of 5 kg Zn also produces 8.46% and 8.84% higher grain and 6.91% and 6.87% stalk yield with 100% and 75% RDN. Super imposition of FYM with 100% RDN and substitution of 25% N through FYM with 75% RDN also influenced 7.99% 8.82% higher grain and 5.49% and 7.07% higher stalk yield. It is also obvious from the data that 100% RDN produced 10.47% more grain and 7.61% higher stalk yield over 75% RDN. Application 125% RDN also produced 8.55% higher grain and 5.31% higher stalk over 100% RDN. It is interesting to report here that integration of 25% N through FYM with 100% RDN produced grain and stalk yield on par to 125% RDN.

Table.1 Some properties of the <2mm fraction of the top 30 cm of soil used for the site

S.No.	Particulars	Values
A.	**Mechanical separates**	
1.	Sand (%)	59.6
2.	Silt (%)	17.4
3.	Clay (%)	23.00
4.	Textural Class	Sandy loam
B.	**Physico-chemical properties**	
5.	pH (1:2.5)	8.2
6.	EC (1:2.5) (dS/m at 25^0C)	0.20
7.	Organic Carbon (%)	0.36
8.	Available Nitrogen (kg/ha)	190.00
9.	Available Phosphorus (kg/ha)	13.50
10.	Available Potassium (kg/ha)	182
11.	Available Sulphur (kg/ha)	15.80
12.	Available Zinc (ppm)	0.56
13.	Particle Density (Mg/m^3)	2.54
14.	Bulk Density (Mg/m^3)	1.30
15.	Pore Space (%)	46.0

Table.2 Impact of integrated nutrient management on growth attributes of maize

S.No.	Treatment	Plant Population plot^{-1}	Plant Height (cm)
1.	T_1 = 125% RDN	240	191
2.	T_2 = 100% RDN	238	189
3.	T_3 = 100% RDN + 25% N FYM	239	190
4.	T_4 = 100% RDN + 25% N FYM + S_{30}	243	193
5.	T_5 = 100% RDN + 25% N FYM + S_{30} + Zn_5	246	195
6.	T_6 = 75% RDN	235	186
7.	T_7 = 75% RDN + 25% N FYM	237	188
8.	T_8 = 75% RDN + 25% N FYM + S_{30}	241	192
9.	T_9 = 75% RDN + FYM + S_{30} + Zn_5	244	194
10.	T_{10} = Control	232	170
S. E.±		5.59	0.325
C. D. (at 5 %)		16.93	0.973

Table.3 Impact of integrated nutrient management on yield attributes of maize

S.NO.	Treatments	No of cob plant^{-1}	Girth of cob (cm.)
1.	T_1	1.35	11.10
2.	T_2	1.15	10.76
3.	T_3	1.25	10.85
4.	T_4	1.45	11.50
5.	T_5	1.60	11.70
6.	T_6	1.08	10.40
7.	T_7	1.12	10.58
8.	T_8	1.38	11.30
9.	T_9	1.48	11.56
10.	T_{10}	1.02	10.20
S.E.±		0.019	0.027
C.D. (at 5 %)		0.058	0.082

Table.4 Impact of integrated nutrient management on yield attributes of maize

S.No.	Treatments	Cob length (cm)	No of rows cob^{-1}
1.	T_1	13.75	10
2.	T_2	13.20	9.67
3.	T_3	13.50	9.67
4.	T_4	14.05	10.67
5.	T_5	14.40	11.33
6.	T_6	12.80	8
7.	T_7	13.05	9.67
8.	T_8	13.85	10.00
9.	T_9	14.20	10.67
10.	T_{10}	12.5	7.66
S. E.±		0.033	0.325
C. D. (at 5 %)		0.100	0.974

Table.5 Effect of integrated nutrient management on yield attributes of maize

S.No.	Treatments	No of grains row cob^{-1}	Test weight (1000 grain) (gm)
1.	T_1	17.8	217.20
2.	T_2	17.20	216.80
3.	T_3	17.60	217.05
4.	T_4	18.08	218.10
5.	T_5	19.60	220.50
6.	T_6	16.80	215.50
7.	T_7	17.00	216.30
8.	T_8	18.20	217.50
9.	T_9	19.00	218.40
10.	T_{10}	16.00	214.60
S. E. ±		0.217	0.811
C. D. (at 5 %)		0.649	2.429

Table.6 Impact of integrated nutrient management on yield of maize

S.No.	Treatments	Grain yield (q ha^{-1})	Stalk yield (q ha^{-1})	Biological yield (q ha^{-1})
1.	T_1	29.20	85.55	114.75
2.	T_2	26.90	81.23	108.13
3.	T_3	29.05	85.69	114.74
4.	T_4	32.50	91.65	124.15
5.	T_5	35.25	97.99	133.24
6.	T_6	24.35	75.48	99.83
7.	T_7	26.50	80.82	107.32
8.	T_8	29.95	85.41	115.36
9.	T_9	32.60	91.28	123.88
10.	T_{10}	18.75	60.00	78.75
S. E. ±		0.876	0.559	1.435
C. D. (at 5 %)		2.622	1.674	4.296

It was also observed that substitution of 25% N through FYM with 75% RDN produces grain yield at par to 100% RDN. Increase in grain and stalk yield might be due to increasing in growth and yield attributes of maize and due to integration of S, Zn and organic manure with inorganic fertilizer. Organics besides release their own nutrient might have increase in the nutrient use efficiency of applied inorganic fertilizer in maize crop. The result of the present study is in agreement with those of several investigators Sujatha *et al.,* (2008), Karasu (2012) and Kumar *et al.,* (2017).

Biological yield

Impact of INM on biological yield of maize presented in table 4.5 and fig. 4.5 showed significant increase in biological yield in all the treatments over control. Maximum biological yield was 133.24 q ha^{-1} was noted with T_5 (100% RDN + 25% N FYM + 30 kg S + 5 kg Zn ha^{-1}) which was found 69.19% higher over the yield 78.75 q ha^{-1} of control. Addition of S, Zn and FYM also influenced biological yield when applied with 100% RDN and 75% RDN. Variation in biological yield within 75% RDN, 100% RDN and 125% RDN was noted significant. Increase in biological yield with graded dosed of RDN and integration of S, Zn and FYM may be due to that all the nutrient element is associated with the metabolism of nutrient in plant life cycle. These results are in the line of the findings of Abbasi *et al.,* (2010) and Choudhary *et al.,* (2007).

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