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Influence of organic and inorganic sources of nitrogen on nutrient uptake and yield of maize in maize-mustard cropping system in Northren Telangana zone

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Abstract
A field experiment was conducted at Regional Agricultural Research Station, Polasa, Jagtial during *kharif*, 2018 and 2019 to study the effect of integrated nutrient management practices on nutrient uptake and yield of maize in maize-mustard cropping system. The experiment was laid out in a randomized block design for maize during *kharif*, 2018 with nine treatments comprising of T_1-100% RDF, T_2-75% RDN + 25% N through FYM, T_3-75% RDN + 25% N through vermicompost, T_4-75% RDN + 25% N through poultry manure, T_5-75% RDN+ 25% N through sheep manure, T_6-75% RDN + 25% N through neem cake, T_7-75% RDN + *Azotobacter* @ 5 kg ha$^{-1,}$ T_8-75% RDN + *Azospirillum* @ 5 kg ha^{-1} and T_9-75% RDN + *Azotobacter* @ 2.5 kg ha^{-1} + *Azospirillum* @ 2.5 kg ha^{-1} which were replicated thrice. Significantly higher nitrogen, phosphorus and potassium uptake was recorded with 75% RDN + 25% RDN through vermicompost which is on par with 100% RDF and 75% RDN + 25% RDN through FYM, 75% RDN + 25% RDN through sheep manure at harvest during 2018 and 2019. Significantly higher grain yield (6349 and 6514 kg ha^{-1} in 2018 and 2019, respectively) and stover yield (8259 and 8460 kg ha^{-1} in 2018 and 2019, respectively) over 75% RDN + 25% N through poultry manure, 75% RDN + 25% N through neem cake, 75% RDN + *Azotobacter* @ 2.5 kg ha^{-1} + *Azospirillum* @ 2.5 kg ha^{-1}, 75% RDN + *Azospirillum* @ 5 kg ha^{-1}, 75% RDN + *Azotobacter* @ 5 kg ha^{-1}. While, it is comparable with 100% RDF, 75% RDN + 25% N through FYM and 75% RDN + 25% N through sheep manure.

Keywords: organic, inorganic nitrogen, nutrient uptake, maize yield

Introduction
Maize (*Zea mays* L.) is the world's third leading cereal crop after wheat and rice. It accounts to 8% and 25% of the world's total area and production respectively under cereal crops. In India, maize occupies an area of 95.69 lakh hectares with an average production of 287.65 lakh tones with productivity of 3006 kg ha^{-1}, while in Telangana it is grown in an area of 5.61 lakh hectares with production of 29.99 lakh tonnes and productivity of 5347 kg ha^{-1} (CMIE, 2020) [4].
Nutrient management in maize is one of the significant yield influencing character. The organic sources besides supplying N, P and K also make unavailable source of elemental nitrogen, bound phosphorus, micronutrients and decomposed plant residues into available form to facilitate plant to absorb the nutrients. But, the combined use of chemical fertilizers along with various organic sources is capable of improving soil quality and crop productivity on long term basis. Highest productivity of crops in sustainable manner without deteriorating the soil and other natural resources could be achieved only by applying appropriate combination of different organic manures and inorganic fertilizers (Chandrashekara *et al*., 2000) [2]. As cropping system serves as a component of integrated nutrient management (INM) for sustaining the productivity of the system through efficient nutrient cycling, balanced fertilization must be based on the concept of the cropping system to sustain productivity of a system as a whole rather than a single crop. Intensified and multiple cropping systems require judicious application of chemical, organic and bio-fertilizers for yield sustainability and improved soil health. Such integrated application is not only complementary but also has synergistic effects. Therefore, the nutrient needs of crop production systems can be met through integrated nutrient management and sustainable crop productivity, nutrient uptake and soil nutrient status in maize based cropping systems (Kemal and Abera, 2015) [10].

Material and Methods

A field experiment entitled "Direct and residual effects of integrated nutrient management in Maize-Mustard cropping system in Northern Telangana zone" was conducted during *kharif* 2018 and 2019 at Regional Agricultural Research Station, Polasa, Jagtial, Northern Telangana Zone of Telangana state. The soil of experimental site was sandy loam with pH of 7.6, Electrical conductivity 0.23 dSm^{-1}, low in organic carbon (0.28%), low in available nitrogen (180 kg ha^{-1}) and medium in phosphorus (53 kg ha^{-1}) and medium in potassium (315 kg ha^{-1}).The experiment was laid out in a randomized block design for maize during *kharif* 2018 and 2019 with nine treatments consisting of 100% RDF, 75% RDN + 25% N through FYM, 75% RDN + 25% N through vermicompost, 75% RDN + 25% N through poultry manure, 75% RDN + 25% N through sheep manure, 75% RDN + 25% N through neem cake, 75% RDN + *Azotobacter* @ 5 kg ha^{-1}, 75% RDN+ *Azospirillum* @ 5 kg ha^{-1} and 75% RDN + *Azotobacter* @ 2.5 kg ha^{-1} + *Azospirillum*@ 2.5 kg ha^{-1}..Crop was sown at spacing of 60cm × 20cm on 27th June during 2018 and 26th June during 2019. Organic manures were applied (on equal N basis) as per the treatment and incorporated into the soil two weeks before sowing. Crop was fertilized with uniform level of 60 kg P_2O_5 and 50 kg K_2O ha^{-1}. Half of the total N and full P and K fertilizers were applied at the time of sowing. Remaining N was applied at knee high stage by pocketing method and free living *Azotobacter sp*, *Azospirillum sp* were incorporated in soil at the time of sowing. The required amount of N, P and K fertilizers were applied through urea, SSP and Muriate of potash, respectively. Other cultural operations and plant protection measures were followed as per the recommendations. Crop received 603 mm (31 rainy days) and 746 mm (44 rainy days) rainfall during the crop growth period in 2018 and 2019, respectively.

Results and Discussion

Effect of Organic and Inorganic Sources of Nitrogen On Nutrient Uptake Of Maize

Nutrient Uptake

Plants draw nutrients from the soil and translocate to different parts for metabolism the edible parts are the end products as food for man. The surplus nutrients that are left behind in the vegetative part of the plant as crop residue are feed for the animals. Therefore, treatments are designed to exploit the available nutrients to maximize the production both for man and livestock. Therefore, a scientific evaluation of nutrient uptake by the whole plant including roots is the nutrient removal by the plants that excludes the stubble and the roots is very essential. This helps the research worker to elicite a relatively better manipulation of soil for most efficient flow of nutrients from soil to the plants. In this endeavor the influence of substituting 25% nitrogenous fertilizer with different sources of organic manures is examined for the major nutrients NPK. The results shown obtained are present in table 1, 2,3. With appropriate discussions for a clear understanding of farm practices that can be best exploited.

Nitrogen uptake (kg ha^{-1})

Nitrogen is known to enhance the amino acid content and eventually the protein necessary for the health of man and live stock. Farmers can substitute 25% nitrogenous fertilizer with vermicompost, FYM and sheep manure while sustaining the soil health and reducing a quarter of the nitrogenous fertilizer and partly minimized the soil erosion.

In both the years (2018 and 2019), uptake of N recorded by maize at 60, 90 days after sowing and at harvest in seed and stover were significantly influenced by integrated nutrient management treatments (Table1).

At 60 DAS, significantly higher nitrogen uptake was observed under 75% RDN + 25% RDN through vermicompost (90.36 and 94.57 kg N ha^{-1}) which was on par with 100% RDF (86.05 and 91.14 kg N ha^{-1}) and 75% RDN + 25% RDN through FYM (81.39 and 88.17 kg N ha^{-1}) during 2018 and 2019, respectively over 75% RDN + 25% RDN through sheep manure, 75% RDN+ *Azotobacter* @ 2.5 kg ha^{-1}+*Azospirillum* @ 2.5 kg ha^{-1}, 75% RDN+ *Azospirillum* @ 5 kg ha^{-1} and 75% RDN + *Azotobacter* @ 5 kg ha^{-1}. Significantly lower nitrogen uptake was recorded in 75% RDN + *Azotobacter* @ 5 kg ha^{-1} (39.50 and 41.83 kg N ha^{-1} during 2018 and 2019, respectively).

At 90 DAS, significantly higher nitrogen uptake was observed under 75% RDN + 25% RDN through vermicompost (154.68 and 161.15 kg N ha^{-1}) which was on par with 100% RDF (144.89 and 151.9 kg N ha^{-1}) and 75% RDN + 25% RDN through FYM (135.95 and 146.86 kg N ha^{-1}) during 2018 and 2019, respectively over 75% RDN + 25% RDN through sheep manure, 75% RDN+ *Azotobacter* @ 2.5 kg ha^{-1}+*Azospirillum*@ 2.5 kg ha^{-1}, 75% RDN+ *Azospirillum*@ 5 kg ha^{-1} and 75% RDN + *Azotobacter* @ 5 kg ha^{-1}. Significantly lower nitrogen uptake was recorded in 75% RDN + *Azotobacter* @ 5 kg ha^{-1} (66.95 and 71.68 kg N ha^{-1} during 2018 and 2019, respectively).

In the both the years, N uptake of grain was significantly influenced by integrated nutrient management practices. N uptake by maize grain was ranged from 46.53 to 91.68 kg N ha^{-1} during 2018, 51.78 to 92.20 kg N ha^{-1} during 2019. Significantly higher N uptake in maize grain was recorded under 75% RDN + 25% RDN through vermicompost (91.68 and 92.20 kg N ha^{-1} in 2018 and 2019, respectively) which was on par with 100% RDF (87.68 and 89.98 kg N ha^{-1}), 75% RDN + 25% RDN through FYM (83.03 and 87.33 kg N ha^{-1}), 75% RDN + 25% RDN through sheep manure(78.82 and 80.09 kg N ha^{-1}) in 2018 and 2019, respectively over 75% RDN + 25% RDN through poultry manure, 75% RDN+ *Azotobacter* @ 2.5 kg ha^{-1}+*Azospirillum*@ 2.5 kg ha^{-1}, 75% RDN+ *Azospirillum*@ 5 kg ha^{-1} and 75% RDN + *Azotobacter*@ 5 kg ha^{-1}. Significantly lower nitrogen uptake was recorded in 75% RDN + *Azotobacter*@ 5 kg ha^{-1} (46.53 and 51.78 kg N ha^{-1} during 2018 and 2019, respectively).

Nitrogen uptake in stover was significantly influenced by integrated nutrient management practices in both the years. Significantly higher N uptake in maize stover was recorded under 75% RDN + 25% RDN through vermicompost (66.86 and 77.49 kg N ha^{-1} in 2018 and 2019, respectively) which is comparable with application of 100% RDF (65.41 and 69.58 kg N ha^{-1} in 2018 and 2019, respectively) and 75% RDN + 25% RDN through FYM (62.06 and 68.37 kg N ha^{-1} in 2018 and 2019, respectively), 75% RDN + 25% RDN through sheep manure(58.51 and 65.80 kg N ha^{-1} in 2018 and 2019, respectively) over 75% RDN + 25% RDN through poultry manure 75% RDN + 25% RDN through sheep manure, 75% RDN+ *Azotobacter* @ 2.5 kg ha^{-1}+*Azospirillum*@ 2.5 kg ha^{-1}, 75% RDN+ *Azospirillum*@ 5 kg ha^{-1} and 75% RDN + *Azotobacter* @ 5 kg ha^{-1}. Significantly lower nitrogen uptake was recorded in 75% RDN + *Azotobacter* @ 5 kg ha^{-1} (34.37 and 43.30 kg N ha^{-1} during 2018 and 2019, respectively).

The uptake of nitrogen showed significant differences due to different nutrient management strategies from 60 DAS till harvest. The uptake of this nutrient was not altered significantly due to the inorganic or the combined source of inorganic and organic nitrogen initially at 30 DAS. This trend owes to the low requirement of nitrogen in the initial growth phase by the seedlings. As the demand for nitrogen requirement increased during the reproductive phase coinciding with flowering stage of the crop. The uptake increased incessant the availability of nitrogen by substituting 25% nitrogenous fertilizer with poultry manure, neem cake or the bacterial cultures lagged behind to meet the requirement of the essential nutrients unlike the substitution of 25% nitrogenous fertilizer with vermicompost, FYM and sheep manure could probably made available enough nitrogen for the crop metabolism as with the continuous flow of the nutrient through the recommended level of fertilizer.

Conjunct use of organic manures along with mineral fertilizers increased the N uptake over sole mineral fertilizers (RDF) which may be attributed partly to addition of nitrogen from decomposition of FYM and partly to improvement in overall soil environment. It might have resulted in root proliferation, ultimately leading to better absorption of water and nutrients from soil and applied fertilizers. Such beneficial effect of FYM on N uptake has also been reported earlier by different researchers (Sindhi *et al*., 2016; Kumari *et al*., 2017; Gourav *et al*., 2019) [21, 12, 8]. The increase in N uptake due to liming may be ascribed to increase in microbial activity which, in turn, might have enhanced the mineralization of organic N thereby releasing more N in the soil (Meena *et al*., 2017; Otieno *et al*., 2018; Gourav *et al*., 2019) [17, 18, 8].

Phosphorus uptake (kg ha^{-1})

Phosphorous is vital metabolic product in the plant system known for better root growth development, tolerance to pest and diseases, muscle development for man and animal. Therefore, on evaluation of phosphorus uptake by different nutrient management treatments is also imperative.

During 2018 and 2019, uptake of phosphorous recorded by maize at 60, 90 days after sowing and at harvest in grain and stover was significantly influenced by integrated nutrient management treatments (Table 2).

At 60DAS, significantly higher phosphorus uptake was observed under 75% RDN + 25% RDN through vermicompost (36.62 and 38.58 kg P ha^{-1} in 2018 and 2019, respectively) which was on par with 100% RDF (32.35 and 35.03 kg P ha^{-1}), 75% RDN + 25% RDN through FYM (31.19 and 33.16 kg P ha^{-1} in 2018 and 2019, respectively) and 75% RDN + 25% RDN through sheep manure (29.33 and 31.34 kg P ha^{-1} in 2018 and 2019, respectively). Significantly lower phosphorus uptake was recorded in 75% RDN + *Azotobacter* @ 5 kg ha^{-1} (17.80 and 20.77 kg P ha^{-1} during 2018 and 2019, respectively).

At 90 DAS, significantly higher phosphorus uptake was observed under 75% RDN+25% RDN through vermicompost (62.69 and 68.80 kg P ha^{-1} in 2018 and 2019, respectively) which was on par with 100% RDF (57.26 and 62.67 kg P ha^{-1} in 2018 and 2019, respectively), 75% RDN + 25% RDN through FYM (54.19 and 61.64 kg P ha^{-1} in 2018 and 2019, respectively). Significantly lower phosphorous uptake was recorded in 75% RDN + *Azotobacter* @ 5 kg ha^{-1} (26.45 and 29.29 kg P ha^{-1} during 2018 and 2019, respectively).

In the both the years, phosphorous uptake of seed was recorded significantly influenced by integrated nutrient management practices. Phosphorus uptake by maize seed was ranged from 15.82 to 32.75 kg P ha^{-1} during 2018, 18.53 to 35.84 kg P ha^{-1} during 2019. Significantly higher P uptake in maize seed was recorded under 75% RDN + 25% RDN through vermicompost (32.75 and 35.84 kg P ha^{-1} in 2018 and 2019, respectively) which was on par with 100% RDF (32.34 and 33.32 kg P ha^{-1} in 2018 and 2019, respectively), 75% RDN + 25% RDN through FYM (30.86 and 32.27 kg P ha^{-1} in 2018 and 2019, respectively)and 75% RDN + 25% RDN through sheep manure(27.79 and 30.56 kg N ha^{-1} in 2018 and 2019, respectively).Significantly lower nitrogen uptake was recorded in 75% RDN + *Azotobacter* @ 5 kg ha^{-1} (15.82 and 18.53 kg P ha^{-1} during 2018 and 2019, respectively).

Phosphorus uptake in stover was significantly influenced by integrated nutrient management practices in both the years. Significantly higher under P uptake in maize stover was recorded under 75% RDN + 25% RDN through vermicompost (31.53 and 33.75 kg P ha^{-1} in 2018 and 2019, respectively) followed by 100% RDF (30.51 and 32.24 kg P ha^{-1} in 2018 and 2019, respectively), 75% RDN + 25% RDN through FYM (28.72 and 31.97 kg P ha^{-1} in 2018 and 2019, respectively and 75% RDN + 25% RDN through sheep manure (26.29 and 29.88 kg N ha^{-1} in 2018 and 2019, respectively). Significantly lower phosphorus uptake was recorded in 75% RDN + *Azospirillum* @ 5 kg ha^{-1} (14.38 and 18.27 kg P ha^{-1} during 2018 and 2019, respectively).

The data in the present investigation exhibited that all the treatments tested were alike in their response on the uptake of phosphorus at 30 DAS. The reason for this in different response could probably due to the extremely low requirement of this nutrient in the initial phase of crop establishment. The response due to different sources of organic manures that substituted 25 per cent of nitrogenous fertilizer confirmed significant influence on phosphorous uptake as that of nitrogen in the later stages. On the other hand the uptake was significantly low by substituting 25 per cent nitrogenous fertilizer with poultry manure, neem cake or the bacterial cultures. The beneficial effects of phosphorous uptake concurs the trend with nitrogen uptake by three sources of organic manures *viz*., vermicompost, FYM and sheep manure.

The increase in phosphorous uptake with addition of FYM might be due to release of P during mineralization of organic phosphorous and chelating action of organic acids released during decomposition of FYM on Al, Fe and Mn thereby increasing P availability. Similar results have been reported by Sharma *et al.* (2016) [20], Meena *et al.* (2017) [17] and Gourav *et al.* (2019) [8]. The higher P uptake due to application of lime might be ascribed to the reduction in P fixation by decreasing the activity of Al and Fe ions, which are potential P fixers, thereby increasing P availability to the crops (Rajneesh *et al*., 2017; Otieno *et al*., 2018; Verde *et al*., 2018; Gourav *et al*., 2019) [19, 18, 27, 8].

Potassium uptake (kg ha^{-1})

The importance of uptake of potassium is no less emphasize in maintaining cell turgor. It plays key role in activation of > 60 enzymes besides it imparts tolerance for pest and diseases.

In both the years (2018 and 2019), uptake of potassium recorded by maize at 60, 90 days after sowing and at harvest in seed and stover was significantly influenced by integrated nutrient management treatments (Table 3). At 60 DAS, significantly higher potassium uptake was recorded under 75% RDN + 25% RDN through vermicompost (84.25 and

89.61 kg K ha^{-1} in 2018 and 2019, respectively) which was on par with 100% RDF (80.55 and 87.54 kg K ha^{-1} in 2018 and 2019, respectively) and 75% RDN + 25% RDN through FYM (76.36 and 79.45 kg K ha^{-1} in 2018 and 2019, respectively). Significantly lower potassium uptake was recorded in 75% RDN + *Azotobacter* @ 5 kg ha^{-1} (51.42 and 54.41 kg K ha^{-1} during 2018 and 2019, respectively).

At 90 DAS, significantly higher potassium uptake was recorded under 75% RDN + 25% RDN through vermicompost (138.59 and 152.48 kg K ha^{-1} in 2018 and 2019, respectively) which was on par with 100% RDF (134.38 and 143.98 kg K ha^{-1} in 2018 and 2019, respectively), 75% RDN + 25% RDN through FYM (125.52 and 139.7 kg K ha^{-1} in 2018 and 2019, respectively).Significantly lower potassium uptake was recorded in 75% RDN + *Azotobacter* @ 5 kg ha^{-1} (73.0 and 84.76 kg K ha^{-1} during 2018 and 2019, respectively).

In the both the years, potassium uptake of seed was significantly influenced by integrated nutrient management practices. Potassium uptake by maize seed was ranged from 20.17 to 43.33 kg K ha^{-1} during 2018, 22.30 to 49.95 kg K ha^{-1} during 2019. Significantly higher under K uptake in maize seed was recorded under 75% RDN+25% RDN through vermicompost (43.33 and 49.95 kg K ha^{-1}in 2018 and 2019, respectively) which was on par with 100% RDF (43.31 and 48.42 kg K ha^{-1} in 2018 and 2019, respectively), 75% RDN + 25% RDN through FYM (41.59 and 45.49 kg K ha^{-1} in 2018 and 2019, respectively) and 75% RDN + 25% RDN through sheep manure (39.05 and 41.78 kg K ha^{-1} in 2018 and 2019, respectively). Significantly lower potassium uptake was recorded in 75% RDN + *Azotobacter* @ 5 kg ha^{-1} (20.17 and 22.30 kg ha^{-1} during 2018 and 2019, respectively).

Potassium uptake in stover was significantly influenced by integrated nutrient management practices in both the years. It ranged from 60.21 to 97.14 kg K ha^{-1} during 2018, 65.02 to 103.11 kg K ha^{-1} during 2019. Significantly higher under K uptake in maize stover was recorded under 75% RDN + 25% RDN through vermicompost (97.14 and 103.11 kg K ha^{-1} in 2018 and 2019, respectively) followed by 100% RDF (94.51 and 98.17 kg K ha^{-1} in 2018 and 2019, respectively), 75% RDN+25% RDN through FYM (90.25 and 94.49 kg K ha^{-1} in 2018 and 2019, respectively), 75% RDN + 25% RDN through sheep manure (80.98 and 88.26 kg K ha^{-1} in 2018 and 2019, respectively). Significantly lower potassium uptake was recorded in 75% RDN + *Azotobacter* @ 5 kg ha^{-1} (60.21 and 65.02 kg ha^{-1} during 2018 and 2019, respectively).

The substitution of 25 per cent of nitrogenous fertilizer with vermicompost, FYM and sheep manure had similar effect on the uptake of potassium in maize as with the crop nourished with inorganic fertilizers. The uptake was critically low at 60 and 90 DAS in the whole plant or in the seed and the crop ruminant at harvest. The 25 per cent nitrogenous fertilizer was substituted with poultry manure, neem cake or the bacterial cultures. The constant trend of enough uptake of N, P and K by the plant from 60 DAS until harvest by the replacement of 25 per cent nitrogenous fertilizer with vermicompost, FYM or sheep manure during the 2 years of study provide evidence that these organics become regular farm practice to sustain the nutrient uptake on par with the practice of depend only on the fertilizer. This strategy is likely to improve the soil physicochemical properties without impairing biological activity of the microorganism and acting as a soil binding agent to minimize the erosion.

With advancement of crop growth stages nutrient uptake has increased up to harvest. Significantly higher nutrient uptake was observed under 75% RDN + 25% RDN through vermicompost. Vermicompost can produce higher amounts of chlorophyll a, chlorophyll b and carotenoids compared to the plants supplemented with inorganic fertilizers and unfertilized plants (Ayob *et al*., 2014). Besides, vermicompost can retain nutrients for a long time and has high soil porosity (24% higher than unfertilized soil) and high water holding capacity compared to conventional compost due to its humus content, thus reducing the irrigation requirement by 30-40% (Chaudhuri *et al*., 2016) [3]. This could be the reasons for greater nutrient uptake by maize crop. Similar results were recorded by other researches Meena *et al*., 2007. The usage of vermicompost has also been reported to result in the production of healthier plants with better resistance towards pests and diseases (Liu *et al*., 2019 and Sulaiman and Mohamad, 2020) [14, 24]. Nutrient content in 75% RDN+25% RDN through vermicompost was on par with 100% RDF, 75% RDN+25% RDN through FYM, 75% RDN+25% RDN through sheep manure. Under 100% RDF greater nutrient content and dry matter produced might be the reason for higher nutrient uptake (Leela Rani *et al*., 2011) [13]. The results of present investigation is found to be in conformity with that of Anita *et al*. (2007) [1]

The slow mineralization of organics ensures adequate availability at greater level of absorption and translocation to the plant parts during growing period thereby increased quantities of nutrients might observed. Similarly, the organic sources of N made P and K in available forms for longer period in soil which improved N, P and K uptake with integrated nutrient supply. Higher values for the uptake of N P K by maize with integrated nutrient management were also evidenced by earlier researchers (Massey and Gaur, 2006; Singh and Yadav, 2007 and Sunitha and Maheswara Reddy, 2012) [15, 22, 25].

Application of biofertilizers along with inorganic fertilizers recorded lower nutrient uptake. As the experimental soil has lower organic carbon content (0.28%) and there was no supplemental application of carbon might reduced the efficiency of microorganism to fix atmospheric nitrogen. Hence these treatments could not helped the plants to uptake nutrients.

Yield

Grain yield (kg ha^{-1})

The data on grain yield of maize in response to different integrated nitrogen management treatments in relation to the recommended level of inorganic fertilizers is presented in Table 4.

Significantly higher grain yield of maize was recorded with application of 75% RDN + 25% RDN through vermicompost (6349 and 6514 kg ha^{-1} in 2018 and 2019, respectively) which was on par with 100% RDF (6262 and 6342 kg ha^{-1}), 75% RDN + 25% RDN through FYM (6007 and 6211 kg ha^{-1}) and 75% RDN + 25% RDN through sheep manure(5424 and 5630 kg ha^{-1} respectively) during 2018 and 2019, respectively. Significantly lower grain yield was recorded with application of 75% RDN + *Azotobacter* @ 5 kg ha^{-1} (4545 and 4642 kg ha^{-1} during 2018 and 2019, respectively).

Maize fertilized with the recommended level of 200:60:50 kg ha^{-1} NPK produced 6262 kg ha^{-1} grain yield in 2018 and 6342 kg ha^{-1} in 2019. This response was incident on sandy loam soil having a very low organic carbon content of 0.28% in the first year and 0.30% in the second year. The soil available nitrogen was also low. It was 180 kg ha^{-1} N in the first year and 188 kg ha^{-1} in the second year. The other two major nutrients *viz*., phosphorus and potassium were within the range of medium status. The available P_2O_5 was 53 kg ha^{-1} in the first year and 55 kg ha^{-1} in the second year. The available K_2O content was 315 kg ha^{-1} in the first year and 328 kg ha^{-1} in the second year. Obviously, the crop responded to a high level of 200 kg N ha^{-1} since maize is an exhaust crop. A plethora of literature confirmed that the present-day requirement of nitrogen is as high as 200-400 kg ha^{-1}in nitrogen starving soils (Leela Rani *et al*. 2011 and Wang *et al.* 2020) [13]. In his review Shaik Mohammad (2020) prompted that the excess and inappropriate application of fertilizers to improve crop production leads to an uncontrolled release of undesirable substances-nutrients and toxins in the soil, atmosphere, ground and surface waters. This is not safe for health. The soils have become sick and continuously degraded. The massive application of fertilizers and insufficient animal or green manures made the soils dusty and susceptible to erosion washing away the nutrients. Efforts to increase food grain production by the application of high doses of fertilizers with imbalanced nutrient proportions to the new high yielding varieties disrupted the equilibrium of native nutrient fertility. Rehm (2018) pointed that the green revolution varieties have a weakness. They cannot absorb as much nitrogen as the traditional varieties.

The results in the present investigation showed that the substitution of 25% recommended level of nitrogenous fertilizer with Farm Yard Manure, vermicompost, sheep manure or poultry manure are the best options to realize similar yield as with the entire recommended level of nitrogen. This trend was consistent in both the years. But the pooled analysis of variance did not maintain this consistency with the integration of sheep or poultry manure. The effect of other sources of organic complements was not effective. The substitution of 25% nitrogenous fertilizer with neem cake or the addition of *Azotobacter* and *Azospirillum* @ 5 kg ha^{-1} each and their combined application @ 2.5 kg ha^{-1}each significantly reduced the yield of maize both in 2018 and 2019. However concurrent to the present investigation Leela Rani *et al.* (2011) [13] observed that the effect of neem cake was not equal to the 25% level of nitrogenous fertilizer. The response of bacterial cultures *Azotobacter* and *Azospirillum* were highly inconsistent ranging from a positive to no response in previous investigations made by Kannan *et al.* (2019) [9].

Stover yield (kg ha^{-1})

Significantly higher stover yield of maize was recorded with application of 75% RDN + 25% RDN through vermicompost (8259 and 8460 kg ha^{-1} in 2018 and 2019, respectively) which was on par with 100% RDF (8166 and 8340 kg ha^{-1}), 75% RDN + 25% RDN through FYM (8065 and 8270 kg ha^{-1}), 75% RDN + 25% RDN through sheep manure (7321 and 7867 kg ha^{-1} respectively)and 75% RDN + 25% RDN through neem cake(7134 and 7441 kg ha^{-1} respectively) during 2018 and 2019, respectively. Significantly lower grain yield was recorded with application of 75% RDN + *Azotobacter* @ 5 kg ha^{-1} (6395 and 6858 kg ha^{-1} during 2018 and 2019, respectively).

The stover of maize is known for its lactogenic properties. It increases the milk yield of cattle. Therefore, it is valued more than the straw and stover of other cereals and millets. The crop fertilized with 200: 60: 50 kg ha^{-1} NPK produced 8166 and 8340 kg ha^{-1} stover during 2018 and 2019. About 8- 10 kg stover fed @ 2% body weight of the cattle along with other farm waste like grass, weeds, legumes, fallen leaves of trees and vegetable or fruit wastes will meet the requirement of adult cattle for > 600 days. The application of 75% nitrogenous fertilizer and 25% N through vermicompost (8259 and 8460 kg ha^{-1}), Farm yard manure (8065 and 8270 kg ha^{-1}), sheep manure (7321 and 7867 kg ha^{-1}) poultry manure (7282 and 7544 kg ha^{-1}) and neem cake (71341 and 7441 kg ha^{-1}) also produced stover yield on par with the recommended level of fertilizers. This response was consistent during the two years. The bacterial cultures *Azotobacter* and *Azospirillum* could not sustain the nitrogen requirement of the crop. Hence, their additions reduced the stover yield significantly (Table 4.).

Awareness to combine every organic source with fertilizers will improve the soil physical properties, replenish the depleting micronutrients, retain the soil moisture and thereby improve the fertilizer use efficiency for high yield. The long term benefits are more conspicuous.

Table 1: Nitrogen uptake (kg ha^{-1}) of maize as influenced by integrated nutrient management treatments

Treatments	2018					2019				
	30DAS	60DAS	90DAS	Harvest		30DAS	60DAS	90DAS	Harvest	
				Grain	Stover				Grain	Stover
T_1- 100% RDF	35.60	86.05	144.89	87.68	65.41	40.22	91.14	151.90	89.98	69.58
T_2-75% RDN + 25% N through FYM	37.33	81.39	135.95	83.03	62.06	41.28	88.17	146.86	87.33	68.37
T_3-75% RDN + 25% N through vermicompost	36.90	90.36	154.68	91.68	66.86	40.75	94.57	161.15	92.20	77.49
T_4-75% RDN + 25% N through poultry manure	31.76	64.42	106.46	66.61	54.05	35.54	65.77	112.23	75.14	59.75
T_5-75% RDN+ 25% N through sheep manure	36.11	72.24	115.54	78.82	58.51	40.25	73.95	134.95	80.09	65.80
T_6-75% RDN + 25% N through neem cake	29.68	55.75	91.22	58.23	48.79	32.89	63.30	107.88	69.61	58.01
T_7-75% RDN + *Azotobacter* @ 5 kg ha^{-1}	30.61	39.50	66.95	46.53	34.37	32.64	41.83	71.68	51.78	43.30
T_8-75% RDN+ *Azospirillum*@ 5 kg ha^{-1}	30.34	41.50	75.27	51.11	38.76	32.35	46.15	79.45	59.26	48.74
T_9-75% RDN+ *Azotobacter* @ 2.5 kg ha^{-1}+ *Azospirillum*@ 2.5 kg ha^{-1}	27.49	52.10	82.81	52.96	41.92	29.47	59.95	98.87	61.23	52.18
S.Em±	3.97	4.45	11.19	6.26	4.30	4.30	5.37	11.42	5.79	5.71
CD (*p*=0.05)	NS	9.43	23.72	13.27	9.12	NS	11.38	24.21	12.27	12.11

Table 2: Phosphorus uptake (kg ha^{-1}) of maize as influenced by integrated nutrient management treatments

Treatments	2018					2019				
	30DAS	60DAS	90DAS	Harvest		30DAS	60DAS	90DAS	Harvest	
				Grain	Stover				Grain	Stover
T_1- 100% RDF	21.65	32.35	57.26	32.34	30.51	26.20	35.03	62.67	33.32	32.24
T_2-75% RDN + 25% N through FYM	20.45	31.19	54.19	30.86	28.72	23.93	33.16	61.64	32.27	31.97
T_3-75% RDN + 25% N through vermicompost	22.64	36.62	62.69	32.75	31.53	28.79	38.58	68.80	35.84	33.75
T_4-75% RDN + 25% N through poultry manure	17.40	26.18	43.46	25.58	22.54	17.98	27.52	48.32	27.96	27.37
T_5-75% RDN+ 25% N through sheep manure	19.53	29.33	45.39	27.79	26.29	23.54	31.34	52.38	30.56	29.88
T_6-75% RDN + 25% N through neem cake	17.88	23.35	38.40	20.48	19.85	15.74	25.02	41.72	25.01	24.33
T_7-75% RDN + *Azotobacter* @ 5 kg ha^{-1}	18.00	17.80	26.45	15.82	14.38	12.11	20.77	29.29	18.53	18.27
T_8-75% RDN+ *Azospirillum*@ 5 kg ha^{-1}	17.79	19.61	27.65	17.04	15.97	13.49	21.29	32.03	20.25	19.83
T_9-75% RDN+ *Azotobacter* @ 2.5 kg ha^{-1}+ *Azospirillum*@ 2.5 kg ha^{-1}	17.66	20.97	31.42	18.15	17.14	15.82	22.85	36.11	21.56	22.12
S.Em±	1.84	3.84	3.84	2.36	2.61	1.99	3.56	3.58	2.27	1.93
CD (*p*=0.05)	NS	8.14	8.14	5.00	5.53	NS	7.55	7.59	4.81	4.09

Table 3: Potassium uptake (kg ha^{-1}) of maize crop as influenced by integrated nutrient management treatments

Treatments	2018					2019				
	30DAS	60DAS	90DAS	Harvest		30DAS	60DAS	90DAS	Harvest	
				Grain	Stover				Grain	Stover
T_1- 100% RDF	39.61	80.55	134.38	43.31	94.51	45.01	87.54	143.98	48.42	98.17
T_2-75% RDN + 25% N through FYM	38.21	76.36	125.52	41.59	90.25	43.10	79.45	139.70	45.49	94.49
T_3-75% RDN + 25% N through vermicompost	42.25	84.25	138.59	43.33	97.14	47.71	89.61	152.48	49.95	103.11
T_4-75% RDN + 25% N through poultry manure	33.45	61.60	97.26	29.80	76.27	37.58	65.90	114.17	35.53	81.35
T_5-75% RDN+ 25% N through sheep manure	36.52	71.31	113.39	39.05	80.98	40.89	74.55	124.79	41.78	88.26
T_6-75% RDN + 25% N through neem cake	32.70	57.36	96.07	27.83	72.64	36.52	63.02	108.51	33.30	78.39
T_7-75% RDN + *Azotobacter* @ 5 kg ha^{-1}	30.72	51.42	73.00	20.17	60.21	33.15	54.41	84.76	22.30	65.02
T_8-75% RDN+ *Azospirillum*@ 5 kg ha^{-1}	31.52	54.05	79.87	22.12	66.08	33.91	56.63	91.08	26.85	68.19
T_9-75% RDN+ *Azotobacter* @ 2.5 kg ha^{-1}+ *Azospirillum*@ 2.5 kg ha^{-1}	31.41	56.45	92.06	25.78	68.67	34.82	59.93	100.49	30.26	73.41
S.Em±	4.45	9.50	19.37	2.04	7.76	5.23	4.95	6.14	3.99	7.94
CD (*p*=0.05)	NS	20.14	41.06	4.32	16.45	NS	10.49	13.02	8.46	16.83

Table 4: Grain and Stover yield of maize as influenced by integrated nutrient management treatments

Treatment	Grain yield (kg ha^{-1})			Stover yield (kg ha^{-1})		
	2018	2019	Mean	2018	2019	Mean
T_1- 100% RDF	6262	6342	6302	8166	8340	8253
T_2-75% RDN + 25% N through FYM	6007	6211	6109	8065	8270	8168
T_3-75% RDN + 25% N through vermicompost	6349	6514	6431	8259	8460	8359
T_4-75% RDN + 25% N through poultry manure	5369	5557	5463	7282	7544	7413
T_5-75% RDN+ 25% N through sheep manure	5424	5630	5527	7321	7867	7594
T_6-75% RDN + 25% N through neem cake	5151	5326	5239	7134	7441	7287
T_7-75% RDN + *Azotobacter* @ 5 kg ha^{-1}	4545	4642	4594	6395	6858	6627
T_8-75% RDN+ *Azospirillum*@ 5 kg ha^{-1}	4816	4981	4898	6870	6917	6894
T_9-75% RDN+ *Azotobacter* @ 2.5 kg ha^{-1}+ *Azospirillum*@ 2.5 kg ha^{-1}	4973	5067	5020	6968	7141	7055
Mean	5433	5586	5509	7384	7649	7517
S.Em±	440	436		563	533	
CD (*p*=0.05)	934	924		1194	1131	

Conclusion

Based on the research results, it can be concluded that the integrated nitrogen supply system through FYM, vermicompost, sheep manure by replacing 50 kg N ha^{-1} out of the 200 kg recommended dose ha^{-1} resulted in similar nutrient uptake, grain and stover yield as with the application of entire nitrogen through inorganic fertilizer. Hence it is evident that 25% of inorganic nitrogen can be substituting by organic manure manures *viz*., vermicompost, FYM, sheep manure to obtain on par yield in maize crop.

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