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"Integrated Nutrient Management in corn production for food security and enhancing soil fertility under irrigated conditions". A Review

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Abstract: In coming decades, a major issue in designing sustainable agricultural system will be the management of soil organic matter and the rational use of inputs such as animal manures, crop residue, green manures, sewage sludge and food industry wastes. However, since organic manures cannot meet modern agriculture, integrated use of nutrients from the fertilizers and organic sources seems to be a need of the time. The continuous use of high levels of chemical fertilizers is adversely affecting the sustainability of agriculture production and causing environmental pollution. It is ultimately viable to achieve such a target through the wise application of INM approach, which is known as a balanced mixture of organic, inorganic and bio-fertilizers in suitable combinations. The basic concept underlying the integrated management system (INMS), nevertheless, is the maintenance and possible improvement of soil fertility for sustaining crop productivity on long term basis and also to reduce fertilizer input cost. The different components of integrated nutrient management process have great diversity in terms of chemical and physical properties and nutrient release patterns.

Key words: INM, organic manure, bio-fertilizer, sustainable agriculture.

I. INTRODUCTION

Maize (*Zea mays*) is one of the most important cereal crop which is grown for grain, fodder and raw material for industry, in almost all parts of the world as it has good adaptability to environmental conditions. Borlaugh referred maize as "Queen of Cereals" because of its high productivity. In India maize occupies third rank both in area and production after rice and wheat. In India Andhra Pradesh was reported to be the largest producer of maize among the producing state contributing 21 percent (%) of total production , followed by Karnataka 16 %, Rajasthan 10 %, Bihar and Maharashtra 9 % each as well as Uttar Pradesh and Madhya Pradesh each contribute 6 % (P Chennakrishnan and K Raja, 2012). The low productivity is due to the imbalanced application of fertilizers. Since, the future India depends on agricultural growth, agriculture has become eco- friendly production system capable of sustainable growth in agriculture to meet the basic needs of rapidly increasing population. Constraints to bring in more area under cultivation and deficiency of various macro and micronutrients in soils have forced Indian farmers to use more chemical fertilizers to increase yield (Planning commission of India, 2011). The excessive use of chemical fertilizers has also resulted in over extraction of ground water in the area. Further, one sided heavy use of chemical fertilizers, less use of organic resources has made our soils sick and problematic. The continuous use of high levels of chemical fertilizers is adversely affecting the sustainability of agriculture production and causing environmental pollution (Virmani, 1994). Through proper application of INM that is combination of organic, inorganic and biofertilizers can reduce the environmental pollution (B. H. Janssen, 1993). The main concept of underlying INM is to maintain and improve the fertility of soil to have sustainable production of crops for long duration and to reduce cost of chemical fertilizers. The increase in organic carbon status occurred on combined use of organic manure and fertilizer which could be enhanced further by the application of bio- fertilizer. (Baskar, 2003; Singh and Pathak 2003; Tolanur and Badanur, 2003; Mishra and Das, 2000). Hence the application of these combinations can sustain the soil fertility and productivity. The combined application of these combinations can maintain soil fertility and productivity. (Sindhi et.al., 2018). Biofertilizers can prove to be an effective low-cost technology for the Indian farmers. Thus, there is requirement to improve the nutrient supply system in terms of Integrated nutrient management involving the use of fertilizers in conjunction with organic manure and fertilizers (Singh et.al., 2018).

II. MATERIAL AND METHODS:

In October 2020 literature reviews were collected on the different aspects about Integrated nutrient management in maize, the purpose of this review study was to know the different management practices on maize growth, yield quality produce and nutrient uptake. The relevant scientific work published earlier has been reviewed.

III. RESULT AND DISCUSSION:

Attempts are therefore, made to present a summary of work carried out in India and abroad relating to the integrated nutrient management reviewed under given headings:

Effect of Integrated Nutrient on Maize growth:

Organic and inorganic sources of plant nutrients play a significant role in growth of maize plant.

Verma et al. (2012) conducted an experiment in Uttar Pradesh and reported that there was increase in LAI and days taken to maturity when combination of FYM (7.5 t/ha) and N (100 kg/ha) was applied to winter maize.

When 7.5 t of FYM and 100% of NPK was applied to maize crop, it improved the number of leaves/ plant, LAI and total dry matter (Shilpashree et al., 2012).

The maximum plant height and the number of tillers per plant were observed with (120; 60; 40: 25 NPK Zn kg /ha FYM) which was 86.43 cm and 7.33, respectively (Sangma et.al., 2017). The growth parameters (plant height and crop dry matter) were significantly influenced with 100 % NPK + FYM 10 t/ ha (Arvind et.al., 2006).

Joshi et.al., (2013) suggested RDF (120-60-30 kg N_P_K / ha + FYM @ 10 t/ha resulted in maximum plant height, dry matter production and leaf area index, which was 96.5 % higher over control.

(Khadtare et.al., 2006), observed maximum dry matter accumulation, plant height, number of leaves per plant and leaf area index was obtained with the application of 100 % RDF (120-60-00 NPK kg/ha) with different combinations of FYM. Similar results were found by Tetrawal et.al.,2011, Shilpashree et.al., 2012 and Kannan et.al., 2013.

Highest plant height and dry matter produced by maize crop when 10 t/ha FYM was applied along with 100% NPK (Shinde et al., 2014).

Louraduraj (2006) reported that combined application of 100 % RDF (135- 62 -50 NPK kg/ha).

with 5 t/ha vermicompost significantly increased plant height, dry matter accumulation and leaf area index in maize as compared to other treatment combinations.

Kannan et.al., (2013) found that application of vermicompost @ 5 t/ha + RDF (120-60-00 kg NPK/ ha) significantly increased plant height and leaf area index as compared to control.

Mahato et. al., (2020) conducted a field experiment during summer season at instructional farm in West Bengal and revealed that application of vermicompost @ 2 t/ha along with 75 % of RDF and 0.5 % foliar application of Zn SO4 exhibited maximum plant height , leaf area index and dry matter accumulation .

Kalhapure et.al., (2013) revealed the most efficient and suitable combination of different organic and inorganic sources of nutrients to increase the productivity of hybrid maize (Zea mays L.) and further found that application of 25 % RDF (30-15-15 kg NPK /ha) + biofertilizers (Azotobacter + PSB) + green manuring with sun hemp + compost resulted in significantly taller plants and maximum total plant dry matter accumulation.

(Nagavani and Subbaian, 2014), reported that growth parameters viz. plant height and leaf area index were significantly increased with the application of 50 % RDF through poultry manure + 50 % recommended dose of inorganic fertilizer.

Iqbal et.al., (2014) reported that highest plant height and number of leaves per plant observed with the application of 75 % of N (urea) + 25 % N (poultry manure).

Mahmood et al. (2017) found that use of combination of inorganic fertilizer with any of organic fertilizer like FYM, poultry manure or sheep manure improved the growth parameters in maize crop.

Ali et al. (2019) observed that integration of poultry manure and press mud with single super phosphate enhanced the growth parameters like silking and tasseling. Moreover, use of 75 % of poultry manure was found to be more economical in maize crop.

(Maske et.al., 2015), revealed that when field was applied with 100 % RDF (120-60-40) Kg NPK /ha + 10 t FYM/ha, highest growth parameters like, plant height, dry matter accumulation per plant of maize.

Highest plant height and dry matter production was recorded in maize after the application of FYM (10 t/ha) along with 100% NPK (Shinde et al., 2014).

Desai et.al., (2015), reported the increase in number of spikes per meter row length, length of spike and number of grains per spike were significantly higher with the application of (150-75-00 NPK kg/ha + FYM @ 5 t/ha + Azotobacter + PSB + Sulphur @ 40 kg/ha.

Ravi et. al. (2012) observed that the application of 10t/ha of FYM along with recommended doses of NPK significantly improved that plant height and total dry matter in summer maize.

Kumar et al. (2018) found that application of 50% of NPK through farmyard manure greatly reduced the number of days taken by maize crop for tasseling as compared to 100% NPK through inorganic sources.

Afe et al. (2015) reported that days to commencing of tasseling taken by maize crop reduced from 47 to 38 days when poultry manure was applied along with 30 kg N /ha.

Complementary effect of NPK and Farmyard manure was reported by Priya et al. (2014) that plant height was significantly increased with FYM application with maize crop.

Effect of Integrated Nutrient Management on yield attributes and yield of maize:

(Verma et.al.,2011), reported that the application of 7.5 % t /ha FYM and this much quantity of Azospirillum can produce greater yield of winter maize.

Bearal and Adhikari (2013) reported that 15 % yield increased when 10 t /ha FYM applied with azotobacter.

Gundlur et. al. (2015) reported combination of chemical fertilizers with green manure is significantly beneficial in increasing the grain yield in maize.

In 2008, Ashoka et al. found that integrated use of chemical fertilizers, vermicompost and micronutrients helps in increasing the ear length in maize crop. This was later supported by Raman et al. in 2018.

When 5 tons of vermicompost was applied with 75% NPK produced the maximum grain yield in maize (4.4t/ha) and improved the fertility of soil (Kumar, 2014).

Taipodia and Yubbey reported in 2013, that winter maize seeds inoculated with PSB and 5 t/ha FYM produced maximum grain yield and stover yield.

Joshi et.al., (2013) reported that the highest number of cobs per plant, test weight, cob weight and grain weight per cob were obtained with 100 % RDF (120-60-30) Kg NPK /ha + FYM @ 10 t /ha.

El-Gawad et al. (2017) concluded that application of compost and sheep manure @ 10 tons/ha, increase the number of grains per row to 33.97 which was higher than the chemically fertilized maize crop. (Joshi et.al., 2013; Pandey and Avasthi, 2014) suggested that the maximum number of cobs per plant, dry matter production, test weight, grain and straw yield.

Kannan et.al., (2013), suggested that with the application of vermicompost @ 5 t /ha along with 100 % RDF (120-60-00 Kg NPK /ha) resulted in maximum number of grains per cob, 100 seed weight and yield.

(Desai et.al., 2015), suggested the maximum increase in the number of spikes and number of grains per spike were 34.35 %, 28 % and 31 % respectively over the RDF 120-60-00 NPK Kg/ha. Similar results were found by Pandey et.al., (2009), Mubarak and Singh (2011) and Ali et.al., (2012).

Nagavani and Subbian (2014) reported the significant increase in yield components, grain and straw yields of hybrid maize with the application of 50 % RDF through poultry manure + 50 % RDF through inorganic fertilizers.

Maske et.al., (2015) reported that the application of 100 % RDF (120-60-40 Kg NPK /ha) + 10t FYM /ha resulted in highest yield attributes viz. cobs/ plant, test weight, grain and straw yield of maize.

Pandey and Avasthi (2014) reported that grain yield and straw yield were higher in RDF (120-60-40 Kg NPK /ha + FYM 10t/ha.

A study was conducted by Wailare et al.(2017) at Phagwara, Punjab and reported that use of poultry manure or FYM increased the leaf area and plant height to a small extent but the increase in yield parameter was significantly greater than 100% RDF in maize crop. Similar resulted were also reported by Thavaprakaash et al. (2005).

Under rain-fed conditions of Uttar Pradesh, Kumar et al. (2018) reported that integration of FYM, zinc and iron with 75% RDF greatly improved the grain yield of maize as compared to 100% recommended dose alone.

Mahato et al. (2018) conducted an experiment in West Bengal and observed that use of 2t/ha vermicompost + 0.5% Zinc sulphate + 75% RDF produced significant improvement in plant height, leaf area index and higher grain yield of maize crop.

Ghosh et al. (2020) found that use of concentrated Brassicaceous seed meal for consecutive two years increased the yield of maize crop by 19 % in the second year as compared to use of only chemical fertilizers. Neem cake and Farmyard manure were also found to be more useful in increasing yield of maize than common chemical fertilizers.

Reena et.al., (2017) revealed the maximum increase in grain and straw yield due to integrated use of FYM, Sulphur and boron with 75 % NPK may be due to synergistic effect of all inputs when combined with 75 % NPK. Similar results were also reported by Reddy et.al., 2009 and Singh and Kumar (2010).

Sangma et.al., (2017) reported the maximum number of grains per spike, test weight, grain yield and straw yield when applied with the 100 % NPK through inorganic in combination with FYM and Zn.

Yield of maize crop increased to 11.7 t/ha when combination of biofertilizer and vermicompost @ 9t/ha was applied (Zaremanesh et al., 2017).

Lakhwinder Singh et.al.(2017), indicated that increase in yield contributing characters of plots treated with application of 75 % RDF + vermicompost (5 t/ha) + FYM + Azotobacter was due to more available nutrients to crop plants during critical period lead to more growth and higher yield attributes. Zaremanesh et.al., (2017) also reported the higher grain and biological yield with the application of chemical fertilizer in combination with azotobacter.

Joshi et.al. (2013), suggested that maximum values for almost all yield parameters viz. number of cobs per plant, test weight, cob weight and grain weight per cob were obtained with 100 % RDF (120-60-30 kg NPK/ha) + FYM @ 10 t/ha.

The yield attributes viz.number of cobs per plant, dry matter production , 1000 grain weight, grain and straw yields were significantly influenced with 100 % RDF (120-60-40 NPK kg/ha) with 5 t/ha vermicompost (Pawar and Patil, 2007, Joshi et.al., 2013 and Pandey and Awasthi,2014).

Shinde et.al., (2014) and Maske et.al., (2015) reported that the application of 100 % RDF (120-60-40 NPK kg/ha) with 10 t/ha FYM gave higher grain and straw yield of maize.

(Maske et.al., 2015) revealed that application of 100 % RDF (120-60-40 NPK Kg /ha) in combination with 10 t/ha FYM resulted in highest grain and straw yields of maize.

Shinde et.al., 2014, reported with the application of 100% RDF (120-60-40 Kg NPK/ha) + 10 t FYM / ha recorded maximum number of cobs /plant, test weight, grain yield and straw yields of maize.

Solanki et al. (2016) conducted an experiment at Chittorgrah, Rajasthan and reported that use of Zinc (25kg/ha) , PSB (20g/kg seed) and Azotobacter along with seed treatment (*Trichoderma viride* at 5g/kg seed) increased the yield by more than 24 percent as compared to common practices followed by farmers.

A trail was conducted by Tukur et al. in 2017 and he found the use of INM significantly effects the number of grains / cob. Use of FYM and poultry manure produced higher grains than 100% NPK through inorganic sources. Similar finding was reported by Uwah et al. in 2011.

Tej Alben et.al. (2017) found the maximum increase in the yield and yield attributing characters by using INM which might be due to addition of nitrogen as well as other nutrients and growth promoting substances through organic manure.

In 2010, Prasad et. al. conducted an experiment at Jharkhand and reported that substituting 50% of Nitrogen recommended doses for maize with FYM usually increase the grain yield. He also concluded that well decomposed FYM is more effective than green manures in improving soil fertility.

Application of 10 tons of FYM/ ha in maize crop increased the number of grains per cob to 458.5 whereas when chemical fertilizers were used, it was only 290.8 grains per cob (Mahesh et al., 2010).

Bhatt et al. (2020) concluded that use of organic and inorganic fertilizers improved the growth parameters. However, best yield was obtained with application of 50% N through Urea and remaining 50% N through poultry manure.

1000 grain weight was increased by use of sheep manure along with different N levels. Rizwan et al. reported that 1000 grain weight was recorded as 214 grams which was higher as compared to only nitrogen application. Later, Admas et al. in 2015 supported these finding with similar results.

Amanullah et. al. (2018) reported that the yield and yield components were higher when seed treatment of maize was done with Phosphate solubilizing bacteria.

Biological yield of maize crop increased with application of fertilizers in integrated manner. FYM, compost, poultry manure and biofertilizers can be used in different combinations (Dilshad, 2010., Shah et al., 2007., Tomar et al., 2017).

Coumaravel et. al. (2015) reported that using NPK, FYM (12.5t/ha) and *Azospirillium* enhanced maize yield and nutrient uptake as well.

Integration of FYM, Zinc and chemical fertilizers in maize increased the yield of crop by 12 percent than control treatment (Sarwar et al., 2012). He also reported that increasing the dose of zinc above 4kg per ha and more than 25 percent of N supplied through FYM had no effect on yield, so it will be economic loss.

Highest yield of maize crop was recorded with application of FYM, Sulphur and Zinc along with 100%% recommended dose of NPK (Mishra et al., 2019).

According to Pal et al. (2016), application of poultry manure produced maximum increase in growth parameters of maize whereas goat manure produces maximum benefit.

Significant increase in growth and yield of maize crop was recorded by Munda et al. with application FYM and Eupatorium, both @ 2.5 t/ha.

According to Chivenge et al. (2010), yield of maize crop increases with increasing quality of organic manures and quantity of organic manure + N fertilizer.

Opala et al. (2014) reported that use of various organic manures increased the yield of maize crop. However, high quality FYM under green house and goat manure in field conditions produced the best result in an experiment conducted in acid soils of Kenya.

Shah et al. (2009) reported that number of cobs per plant was higher when combination of FYM and urea were applied as compared to sole urea application.

Nutrient Content uptake and soil Status:

Tetarwal et.al.,(2011) reported that with the application of 100 % RDF (40-15-00 kg NPK /ha) + 10t/ha FYM resulted in highest NPK uptake by maize and available N and P status of soil also increased by 1.28% in N and 14.89 % in P.

Singh et.al., (2012) found that the application of 100 % RDF (120-26.21-33.2 kg NPK/ha with FYM @ 10 t/ha gave significantly maximum uptake of nitrogen and phosphorus by grain, straw and total uptake by crop over control plot.

Kalhapure et.al. (2013) reported that with the application of 25 % RDF (30-15-15 Kg NPK /ha) + biofertilizers (Azotobacter + PSB) + green manuring with sun hemp + compost, higher values of organic carbon, available N, P2O5 and K2O content in soil.

Pandey and Avasthi (2014) revealed that organic carbon, CEC, total porosity, available N, P2O5 and Zn in soil recorded highest with the application of RDF (120-60-40 Kg NPK / ha) + FYM 10 t/ha.

Peeyush et al. (2009) found that application of Zinc and 100% NPK enhanced the Zinc concentration in wheat grains. Chauhan et al. (2011) reported that organic carbon content of soil was 9.4g/kg when 15t/ha FYM was added in wheat crop.

Sujatha et. al. (2008) reported that using the combination of sun hemp as green manure, poultry manure and recommended doses of NPK increased the nutrient uptake by maize crop under rainfed conditions. Moreover, it also increased the infiltration rate of the soil.

According to Binoy et al. (2019), nutrient uptake is increased by application of FYM, dry biomass of weeds and poultry manure. Combination of vermicompost and biofertilizers also helps in improving the nutrient uptake by crops.

Enhanced decomposition of crop residues was recorded when FYM was integrated with chemical fertilizers in maize and it also improved the water stable aggregates (Zakaria et. al., 2013).

The physical properties of soil were improved with application of biofertilizers, green manures, FYM and chemical fertilizers and this combination of fertilizers also increased growth and yield attributes of maize crop (Mohammadi, 2017).

According to Selim (2020), use of integrated nutrient management not only reduce the use of chemical fertilizers but it also improves the physical properties of soil and maximize the profitability.

Water stable aggregates and soil porosity was improver with application of FYM and poultry manure. Also, the soil carbon content was increased by FYM application in the maize crop (Meena et al., 2018).

Usman et al. (2015) recommended that application of integrated organic and inorganic fertilizers increase the nutrient use efficiency and reduce leaching losses.

Nottidge et al. (2011) found that use of rice husk ash with chemical fertilizer not only increase the grain yield in maize but also improves the nitrogen level of soil.

Abid et al. (2020) revealed that use of FYM at the rate of 16 t/ha increases the water retention and nutrient availability in soil. Moreover, duration of nutrient availability was also increased with application of organic manures in maize based cropping system.

Application of organic manures in soils which have low productivity, the physical and biological properties of those soils are improved (Selim, 2018; Rahmann et al., 2016; Selim et al, 2017).

Use of biofertilizers, FYM and lime are not only beneficial in improving growth and yield of maize crop but also improves the moisture retention capacity soil and increases the infiltration rate was well (Saha et al., 2009). He concluded that FYM plays major role in improving crop yield because the treatments without FYM showed lesser increase in yield.

Combined use of 25% RDF + biofertilizer (PSB) + green manuring + compost enhanced the soil nutrient status and infiltration rate (Kalhapure et al., 2014).

Sigaye et al. (2020) concluded that 50% NP + 50% vermicompost is best combination for not only increasing the maize yield but it also improved the soil fertility and economically viable for small farmers as well.

Singh et al. (2010) reported that use of inorganic fertilizers and FYM in equal proportion enhanced the availability of nitrogen, phosphorus and potassium in soil after crop harvest.

IV. CONCLUSION:

From the discussion, it can be concluded that higher growth, yield, quality and nutrient uptake can be achieved by using judicious use of organic, inorganic and bio-fertilizers.

Results have proved that integrated nutrient management in maize results in enhancing growth, yield and improves the soil fertility of soil. Hence the application of these combinations can sustain the soil fertility and productivity for a longer time without causing environmental pollution.

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