REVIEW ARTICLE

INTEGRATED NUTRIENT MANAGEMENT IN MAIZE PRODUCTION – A REVIEW

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ABSTRACT

Maize is one of the main staple crops of Nepalese diet grown throughout the country during summer season as single crop or relayed with millet. This short review article analyses the previous works & studies on impact of INM in maize production. Long-time research which was conducted in different areas has shown that in addition to natural resources deterioration, abiotic-biotic stress, deficiency of several macro & micro nutrients is also an essential factor which influences yield reduction, productivity declination, and shrinkage in net profit. Therefore, Integrated use of chemical and organic fertilizer on yield and yield attributes component of maize is very crucial for assurance of food security & food self-sufficiency. Integrated Nutrient Management (INM) aims at adjustment of soil fertility and plant nutrient supply to an optimum level for sustaining the desired crop productivity through optimization of benefit from all possible sources of plant nutrients. The integrated use of major plant nutrients (nitrogen, phosphorus, and potash) along with different organic carbon sources (animal manures and plant residues) together with bio-fertilizers (beneficial microbes) significantly improves maize growth, yield and yield components together with grower's income.

KEYWORDS

Zea mays L., Organic fertilizer, Inorganic fertilizer, Yield, Nutrient, Quality.

1. INTRODUCTION

Maize (*Zea mays L.*) is a major agronomic crop cultivated worldwide, is cross-pollinated long day plant belongs to the family Poaceae. It is the second highest producing cereal crop after rice in terms of area & production in Nepal. It is the traditional crop cultivated as food, feed & fodder in slopping Bari land (rainfed upland) in the hills of Nepal. It contains 11.1% protein, 3.6% fat, 2.7% fiber, 66.3% carbohydrate and 1.5% minerals (Calcium, phosphorous, Iron) and Vitamins (A, B, E) (Joshi et al., 2017). It is grown in 8, 91,583 hectares of land and is produced 2,231,517 tons of maize grain with the productivity of 2.5 t ha⁻¹. It is cultivated in three distinct agro-climatic regions within Nepal, the terai & inner terai, the mid-hills and the high-hills. The proportion of maize area consists of about 73.78 % in mid-hills, 16.42 % in terai and 9.80 % in high-hills in Nepal. It is one of the major food crops in the hilly regions of Nepal and accounts for 71% maize production of the country (Statistical Information in Nepalese agriculture, MoAD). Maize demand has been constantly increasing by about 5% annually in the last decades (Sapkota and Pokhrel, 2010). The feed business affiliated with NFIA in Nepal requires 1.5 million tons of maize each year, 87% of which is imported from India (Timsina et al., 2016). Per capita maize consumption in Nepal was 98 g/person/day (Ranum et al., 2014). Maize contributes 24.97% to the total cereal production (MoALD, 2020).

Integrated Nutrient Management (INM) - using organic manures with mineral fertilizers is advocated as viable approach not only in maintaining and sustaining proper plant growth, nutrient uptake & productivity, but

also in providing stability to crop production (Hussain et al., 1995; Ahmad et al., 2008). Out of the total maize area in the country, 9.80, 73.78, and 16.42%, respectively belong to the high hills, middle hills, and terai ecological belt (MoALD, 2018). Nepali hill farmers will be benefitted getting 20-25% higher yields through cultivating native hybrids compared to OPVs. In the middle hills of Nepal, the improved OPVs yielded 106.4% higher than local varieties with an average yield of 2.53 t /ha, which is very low (MoALD, 2018). The ratio of human consumption to total production is higher in less accessible areas of Nepal. However, these days, we can see the shift of maize utilization patterns from food to feed even in the hilly areas (Ghimire et al., 2018).

Integrated Nutrient Management is known as a judicious use of organic and inorganic sources of plant nutrient to crop fields for sustaining, adjusting and maintaining soil productivity. Organic fertilizers are mainly essential for ecological balance, low cost of cultivation, clean environment and nutritious food without impacting negative effect on human health (Hedge and Sudhakar, 2001). Among the various nutrients, nitrogen is one of the principal nutrients for better harvest requires approximately 150 N₂O kg ha⁻¹ (Prasad et al., 1987). Integrated Nutrient Management initiate biological and organic environment which helps to increase the production of maize as well as improve the quality of food grains and soil environment. Crop responses to organic and biological nutrient carriers are not as spectacular as fertilizer but the supplementary and complementary use of such sources is known to improve the effective utilization efficiency of fertilizers (Yadav, 1998). The appropriate & conjunctive application of suitable nutrients through organic and

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inorganic way by solely or in combined form can provide the solutions to increase in the price of inorganic fertilizers & deterioration effect of soil fertility and productivity.

2. MATERIALS AND METHODS

This review paper uses secondary data of different literature reviews about Integrated Nutrient Management in Maize production. Our purpose of this review was to study about the different practices for betterment in yield, nutrient content, uptake & status, quality, physiochemical properties of soil and economics of maize. The relevant and important published work of different plant scientists under Integrated Nutrient Management in maize production system had been reviewed in this paper.

3. RESULT AND DISCUSSION

We made to present a brief summary of work carried out in different countries related to our topic Integrated Nutrient Management with different headings are as follows.

3.1 Impacts of Integrated Nutrient Management in Maize

3.1.1 Impact of Inm On Yield and Yield Attributes

Application of FYM @ 10 t ha⁻¹ on 1000 grain weight of maize crop increase the production which is found in kharif season maize in different states of India (Tetarwal et al., 2011). Thousand grain weight will be significantly higher with 100 % (210 g) than 75% (201 g) N of recommended dose during kharif season in India (Singh et al., 2009). Higher number of grains per row was obtained with azotobacter inoculation than no inoculation which assisted to give significantly higher number of grains per cob owing to insignificantly higher number of grains rows per cob. These together with higher thousand grain weight was able to give significantly higher grain yield in the treatment with azotobacter seed inoculation (4.55 t ha⁻¹) in comparison to inoculation (3.95 t ha⁻¹). This all might be due to an improvement in nutrition status of the soil and creation of suitable environment for better root growth through secretion of growth promoting substances (gibberellins, cytokinin and auxin) and availability of nitrogen fixed by microorganisms (Okon and Kapulinh, 1986; Shah and Joshi, 1986).

Higher plant height, cobs/plant, grains/cob, grain and biological yield were recorded with 150% RDF which was at par with RDF + 10 t/ha FYM, further significantly higher dry matter at the time of harvest was recorded with RDF + 10t/ha FYM which was at par with 150% RDF (Tetarwal et al., 2012). A field study in Tamil Nadu during rabi found that application of vermicompost@ 5 t/ha along with 100% RDF (120-60-00 kg N-P-K/ha) showed its superiority with respect to yield parameters like number of grains per cob, 100 seed weight and yield (Kannan et al., 2013). Significantly higher grain yield was recorded with application of 100% RDF + BF + GM (one row of Sunhemp between two rows of maize) over rest of all treatments (Gundlur et al., 2015). When 25% RDF + biofertilizers (Azotobacter + PSB) + green manuring with sunhemp + compost was applied, significantly taller plants and highest total plant dry matter content were recorded (Kalhapure et al., 2013). Highest number of cobs per plant, number of grains per cob and weight of 100 grains were produced with the treatment of 25% RDF + biofertilizers (Azotobacter + PSB) + green manuring with sunhemp +compost whereas number of cobs per plant were in usual or expected amount with the application of biofertilizers (Azotobacter + PSB) + green manuring with sunhemp + compost (Kalhapure et al., 2013).

Maize grain yield and plant height were also increased with the integrated use of Improved Fallow (IF) along with low dose of NP fertilizers or FYM (Negassa et al., 2007). The significantly a greater number of days to maturity was observed in 25 October sowing followed by 15 October and 5 November dates of sowing during both the years and the average number of days to maturity were also more in 25 October sowing as compared to other dates of sowing (Andrew et al., 2006). Das and Bauer observed a declining trend of yield in all cropping systems except for maize under hedgerow systems (Das and Bauer, 2009). The most rapid

decline was observed in the conventional system due to heavy loss of soil nutrients and organic matter caused by the soil erosion which reduced yield by 44% over 30 years. A group researcher also found significant yield decline in maize crops under continuous cropping system in the uplands of Philippines which have the similar topographic condition to that of mid hills of Nepal (Nelson et al., 1997).

3.1.2 Impact of Inm On Nutrient Content, Uptake & Soil Status

The average use of fertilizer in the eastern midhills is 90 kg/ha comprised of 57 kg urea, 30 kg DAP and 3 kg Potash, whereas only 36 kg/ha fertilizer is used in the mid-western and far-western midhills. In the Terai, where adoption of Improved technology is higher than the hills, 84 kg/ha urea, 62 kg/ha DAP and 32 kg/ha potash is used. Despite poor access, farmers in the high-hill reported using 37 kg fertilizer per ha in maize fields on average (Paudyal et al., 2001). The average use of fertilizer in the eastern midhills is 90 kg/ha comprised of 57 kg urea, 30 kg DAP and 3 kg Potash, whereas only 36 kg/ha fertilizer is used in the mid-western and far-western midhills. In the Terai, where adoption of Improved technology is higher than the hills, 84 kg/ha urea, 62 kg/ha DAP and 32 kg/ha potash is used. Despite poor access, farmers in the high-hill reported using 37 kg fertilizer per ha in maize fields on average (Paudyal et al., 2001).

The application of 100% RDF (40-15-00 kg N-P-K/ha) + 10 t/ha FYM registered maximum NPK uptake by maize and available N and P status to the tune of 1.28 and 14.89 % respectively over initial status of soil fertility (Tetarwal et al., 2011). Significantly higher grain yield, straw yield and NPK uptake were recorded with NPK + FYM @ 12.5 t/ha + Biochar @15 t/ha + Azospirillum @ 2 kg/ha which was at par with NPK + FYM @ 12.5 t/ha + Biochar @ 10 t/ha + Azospirillum @ 2 kg/ha (Coumaravel et al., 2015). Significantly higher grain yield, Zn and Fe uptake by grain, straw and total uptake obtained with application of P50-PEC + P50 one foliar spray at silking stage (Paramesh et al., 2014). Significantly higher available NPK status in soil were recorded with sunhemp + poultry manure @ 1t/ha + 100% RDN which was at par with sunhemp + vermicompost @ 3.67 t/ha + 75% RDN (Sujatha et al., 2008).

An experiment during kharif season that reported that application of vermicompost @ 5 t/ha with 100% RDF (90-40 kg N-P/ha) on maize improves organic carbon content, N and P status of soil than control (Singh and Nepalia, 2009). When 25% RDF + biofertilizers (Azotobacter + PSB) + green manuring with sunhemp + compost was applied, significantly lowest pH was observed (Kalhapure et al., 2013). After harvesting the maize crop, the bulk density of soil was found to be lowest i.e. 1.30g/cm³ along with highest infiltration rate i.e. 3.74cm/hr when 25% RDF + biofertilizers (Azotobacter + PSB) + green manuring with sunhemp + compost were applied whereas bulk density of soil was found to be higher i.e. 1.33g/cm³ when 100% RDF, 25% RDF and control treatment were applied (Kalhapure et al., 2013). Uptake of N, P2O5 and K2O was found to be highest when 25% RDF + biofertilizers (Azotobacter + PSB) + green manuring with sunhemp + compost was applied (Kalhapure et al., 2013). The soil pH (H₂O), exchangeable bases (Ca⁺⁺, Mg⁺⁺, and K⁺), organic matter (OM), and the available P were increased when mucuna was used as an improved fallow (IF) (Negassa et al., 2007). In IF, the uptake of N and P was highly improved and it was supplemented when low dose of NP fertilizers were used (Negassa et al., 2007). When FYM or low dose of NP fertilizers were applied in IF, nutrients in the soil were conserved and nutrient uptake efficiency was also increased (Negassa et al., 2007). The response of Maize to K application was noticed more in upland soil in comparison to low land. This may be due to low availability of K in upland soil. (Kumar et al., 2004). The average use of fertilizer in the eastern midhills is 90 kg/ha comprised of 57 kg urea, 30 kg DAP and 3 kg Potash, whereas only 36 kg/ha fertilizer is used in the mid-western and far-western midhills of Nepal. Adoption of Improved technology is higher in terai than the hills, 84 kg/ha urea, 62 kg/ha DAP and 32 kg/ha potash is used there. Despite poor access, farmers in the high-hill reported using 37 kg fertilizer per ha in maize fields on average (Paudyal et al., 2001). kg urea, 30 kg DAP and 3 kg Potash, whereas only 36 kg/ha fertilizer is used in the mid-western and far-western midhills.

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3.1.3 Impact of Inm On Physio-Chemical Properties of Soil

Significantly lowest pH was observed in application of 25% RDF+ biofertilizers (Azotobacter+ PSB) + green manuring with sunhemp + compost. Also, the decrease in pH over initial value is more in treatments which included either sole application of biofertilizers, green manuring and compost or their combination with inorganic nutrient sources. When manures and chemical fertilizers are applied to soil, nitrification and decomposition processes produce various acids. Nitrification process releases hydrogen ion into soil solution. The organic matter added with 198 A.H. Kalhapure et al green manuring and compost application acts as a pH buffer, releasing H⁺ which are responsible for reducing alkalinity of the soil (Antil and Singh, 2007). Application of Azotobacter with phosphate solubilizing bacteria as biofertilizers are also responsible for decreasing soil pH by producing organic acids which has been already reported (Mohammadi and Sohrabi, 2012). The infiltration rate of soil is depending upon the arrangement of soil particles, porosity and stability of soil aggregates. But there is inverse relation between bulk density and infiltration rate of soil. The soils of the treatments in which biofertilizer, green manuring with sunhemp and compost were applied in combination recorded higher infiltration rate which might be due to the better soil particle aggregation & microbial respiration. Decrease of bulk density and increase in infiltration rate as the effect of addition of organic and inorganic fertilizers in soil were reported in no cropped field (Martens and Frankenberger, 1992; Rasoulzadeh and Yaghoubi, 2010).

3.1.4 Impact of Inm On Quality

Significantly higher grain yield, crude protein, crude protein yield, lysine, methionine and tryptophan were recorded with application of P50-PEC + P50 one foliar spray at silking stage (Paramesh et al., 2014). Significantly higher biological yield, grain yield, harvest index and protein (%) were obtained under 5.0 ton of vermicompost + 75% recommended dose of NPK (Yadav et al., 2016). An experiment on sandy clay loam soil to evaluate the effect of integrated nitrogen management in maize during rabi season. Maximum crude protein (%) of maize (8.63%) was attained in 100 RDN from urea which was remained at par with application of 75 % N from urea + 25 % N from poultry manure with crude protein of 8.46% (Iqbal et al, 2014) [2]. Higher grain and protein yield was recorded with 100% RDF + FYM @ 10 t/ha over rest of treatments (Makwana, 2014).

3.1.5 Impact of Inm On Economics

Significantly higher gross return and net return recorded with 5 t/ha VC + 75% recommended dose of NPK which was at par with Azotobacter + 75% N and recommended dose of P and K while significantly highest B:C ratio observed with Azotobacter + PSB + 75 % NP and recommended dose of K

(Yadav et al., 2016). Maize + sunhemp (GM) + poultry manure (25% N) + 100% RDN through inorganic fertilizers recorded significantly higher gross returns, net returns and B:C ratio which was at par with maize + sunhemp (GM) + poultry manure (25% N) + 75% RDN through inorganic fertilizers (Sujatha et al., 2008).

4. CONCLUSION

In conclusion, this review paper emphasizes the management strategies of organic and inorganic nutrients, sources role, and the significances of Integrated Nutrient Management in maize. With the increasing global food insecurity, the haphazard use of chemical fertilizer is leading to soil deterioration, soil acidification, and environmental pollution. The INM is the alternative approach for sustainable, eco-friendly, and cost-effective management for improving soil fertility, soil productivity, quality, nutrient uptake, status and reducing the impact of inorganic fertilizers on the environment. The Integrated Nutrient Management system also significantly increases the availability of nutrient status in the soil as well as microbial activity in the soil. INM enhances the physiochemical status of soil by maintaining pH & increase gross return. Hence, Integrated Nutrient management (INM) can be an option which is a flexible approach to minimize the use of chemical sources of nutrients along with maximization of their efficiency and farmer's economic profit.

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