Journal of Pharmacognosy and Phytochemistry

Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
www.phytojournal.com
JPP 2020; 9(3): 2213-2219
Received: 16-03-2020
Accepted: 18-04-2020

Subhankar Purohit
Assistant Professor, Department of Agronomy, M S Swaminathan School of Agriculture, Centurion University of Technology and Management, Paralakhemundi, Odisha, India

Gayatree Mishra
Assistant Professor, Institute of Agricultural Sciences, SOA, Bhubaneswar, Odisha, India

Kiran Kumar Mohapatra
PhD Scholar, Department of Soil Science and Agricultural Chemistry, College of Agriculture, Odisha University of Agriculture and Technology, Bhubaneswar, Odisha, India

GC Mishra
Professor, Department of Agronomy, M S Swaminathan School of Agriculture, Centurion University of Technology and Management, Paralakhemundi, Odisha

Corresponding Author:
Subhankar Purohit
Assistant Professor, Department of Agronomy, M S Swaminathan School of Agriculture, Centurion University of Technology and Management, Paralakhemundi, Odisha, India

A critical review on Integrated Nutrient Management (INM) in sweet corn

Subhankar Purohit, Gayatree Mishra, Kiran Kumar Mohapatra and GC Mishra

DOI: https://doi.org/10.22271/phyto.2020.v9.i3aj.11647

Abstract
The continuous use of inorganic fertilizers increases the cost of production, deteriorates soil health and pollutes the environment. Optimum use of organic manures like FYM, vermicompost and bio fertilizer provides all essential nutrients to plant and improves physical, chemical and biological properties of soil. The approach on integrated nutrient management (INM) with judicious use of organic and inorganic nutrient is indispensable for intensification of research. INM helps in the balanced fertilization of crops, where the right amount of plant nutrient from an appropriate source is applied at proper growth stage of a specific crop plant. It is a step towards sustainable agriculture as it reduces the stress of pollution on the nature and the judicious use of resources optimises the productivity. The recent years research work carried out on the integrated nutrient management in India and abroad with respect to growth, yield, nutrient uptake, quality parameters and economics of sweet corn has been critically reviewed in this chapter.

Keywords: judicious use, productivity, balanced fertilization, INM

Introduction
Maize (*Zea mays*) is the third most important cereal crop in the world after wheat and rice. It is an important food, feed, fodder and industrial raw material throughout the world. The poor nutrient management practices in maize is the main reason of lower productivity of the crop. Therefore, in order to achieve optimum crop yield, proper nutrient management through application of chemical fertilizers in addition with organic manures and bio-fertilizers is necessary. The farmers are mainly concentrating on the primary nutrients during fertilization, so micro-nutrient deficiency has become an emerging problem in many crops, which can be corrected through application of organic manures because the organic manures contain the essential micro-nutrients, vitamins, growth regulators etc. along with the primary and secondary nutrients. In maize nutrient management is one of the most important factor affecting the growth and yield as it is considered as an exhaustive crop and requires both macro and micro nutrients for higher growth and yield. Therefore balance fertilization of maize through both organic manures and synthetic fertilizers is required for sustainable crop production. In maize integrated nurtrient management have multipurpose role on the improvement of soil fertility and crop productivity in a sustainable manner (Sindhi *et al*., 2018) [50]. Sweet corn (*Zea mays saccharata*) is one of the important sub-type of maize, which is very popular due to its sweetness and also highly nutritious. In this chapter the main focus is on the INM of sweet corn.

Effect of inorganic fertilizers on growth parameters
In loamy soils of Ranchi (Jharkhand), application of 100% recommended NPK @ 100:50:25 kg ha^{-1} significantly enhanced the plant height, dry matter accumulation, leaf area index and crop growth rate in maize over control (Pathak *et al*., 2002) [40]. A conducted field trial at College of Agriculture, Pune, Maharashtra on sweet corn observed that LAI and CGR were increased significantly with application of 100% RDF (225:50:50 kg of N, P_2O_5 and K_2O ha^{-1}, respectively) (Wagh, 2002) [60]. Application of 150% recommended dose of fertilizer gave the highest values of growth and yield parameters of maize closely followed by 125% recommended dose (Mundra *et al*., 2003) [36]. Experiment conducted at Catede, Argentina by on sweet corn indicated that plant height, total leaf number, leaf area, stem diameter and shoot dry matter were remarkably augmented with 200 kg N ha^{-1} along with 80 kg P_2O_5 ha^{-1} than rest

of the treatment combinations (De Grazia *et al.*, 2003) [14]. The result of experiment conducted during winter in sandy loam soil at Varanasi (Uttar Pradesh) revealed that application of NPK at 180:90:60 kg ha-1 had positive effect on plant height, crop growth rate and net assimilation rate of maize over lower doses (Sutaliya & Singh, 2005) [54]. Significant increase in plant height, dry matter production, LAI and CGR at all the growth stages of maize was observed with application of NPK at 90, 30 and 15 kg ha^{-1} over control (Verma *et al.*, 2006) [59]. The plant height, number of functional leaves and dry matter accumulation were increased with 150% RDF trough out the crop growth stages (Nilesh Bajirao Zende, 2006) [62]. Significant increase in plant height, dry matter production, LAI and CGR at all the growth stages of maize was observed with application of NPK at 90, 30 and 15 kg ha^{-1} over control (Verma *et al.*, 2006) [59]. Recommended dose of fertilizer applied in medium black soil at Thane, Maharashtra during *rabi* season had significant effect on plant height, number of functional leaves and dry matter production at different growth stages of sweet corn (Gosavi *et al*., 2006). Significant increase in plant height, dry matter production and LAI of maize was recorded with the application of 90:17.5 kg N and P_2O_5 ha^{-1} over 75% of RDF. Further increase in fertilizer dosage though enhanced this character but failed to exhibit significant effect (Yadav, n.d.) [61]. During an experiment at the Indian Agricultural Research Institute, New Delhi, it was observed that taller plant height and dry weight $plant^{-1}$ of corn were increased with NPK levels of 187.5: 26.2: 62.5 kg ha^{-1} (R. Shobana *et al*., 2008) [48]. The growth parameters of sweet corn like leaf area index and total dry matter production were influenced favourably with 100% recommended dose of N and P and 125% recommended dose of K, was found in an experiment at Dharwad, Karnataka (Arun Kumar *et al*., 2010) [25]. Application of RDF (100 kg N, 26 kg P_2O_5 and 32 kg K_2O ha^{-1}) gave the highest dry matter production and LAI of maize over control and 50% RDF (Ashok *et al*., 2010) [3].

Effect of inorganic fertilizers on yield attributes

Maximum cob length (18.2 cm), cob diameter (15.6 cm) and 100-seed weight (28.3 g), seeds cob^{-1} (389) and seed weight cob^{-1} (111.3 g) was recorded with the application of 100% recommended dose of NPK (Channabasavanna *et al*., 2002) [9]. During an experiment at College of Agriculture, Dapoli, Maharashtra on sweet corn it was observed that weight of cob, number of grains cob^{-1} and weight of grains cob^{-1} were significantly increased with RDF @ 225 kg N ha^{-1} over rest of the nitrogen levels (Kunjir, 2004) [32]. With increase in fertility levels up to 180:90:60 kg NPK ha^{-1} the cob weight of maize was increased significantly (Sutaliya & Singh, 2005) [54]. The cob length, cob girth, number of seeds cob^{-1}, weight of seeds cob^{-1} and number of $cobsplant^{-1}$ were remarkably higher with 150% RDF than rest of the fertilizer levels (Nilesh Bajirao Zende, 2006) [62]. It was reported from an experiment at Anand Agriculture University, Anand, Gujurat that significantly higher values in respect of cob girth, cob length and green cob weight were obtained in RDF (150:50:0 kg NPK/ha) treatment than other inorganic treatments (Khadtare *et al*., 2006) [22]. Recommended dose of fertilizer applied in medium black soil at Thane, Maharashtra during *rabi* had positive effect on cob weight and length of cob, number of kernel rows/cob, number of kernels /cob, number of cobs $plant^{-1}$ and kernels weight cob^{-1} of sweet corn (Gosavi *et al*., 2009) [18]. A field experiment conducted at Latur. Maharashtra during *kharif* season revealed that application of 100:50:50 kg NPK ha^{-1} significantly enhanced the cob length and girth followed by FYM + *Azospirillium* (Thakur *et al*., 2009) [56]. During an experiment in vertisols at Main Agricultural Research Station, Agriculture College, Dharwad. Karnataka on sweet corn, significant improvement in number of cobs $plant^{-1}$, cob length, number of grains cob^{-1} and fresh cob weight was observed with the application of 100 and 125% recommended NPK levels compared to rest of fertilizer levels (Arun Kumar *et al*., 2010) [25]. Application of 120-60 kg N-P_2O_5 ha^{-1} improved the growth and yield attributes in sweet corn (Mathukia *et al*., 2014) [33].

Effect of inorganic fertilizers on yield

During an experiment at Catede Horticulture and Agriculture, Argentina on sweet corn, the yield and total biomass production, Stover yield and harvest index were significantly enhanced with 200kg N and 80 kg P_2O_5 ha^{-1} over rest of the treatments (De Grazia *et al*., 2003) [14]. Two years of field experimentation conducted at Dapoli, Maharashtra, revealed that cob, stover and biological yield were significantly superior with 150% RDF over rest of the fertilizer levels (Nilesh Bajirao Zende, 2006) [62]. Green cob yield of sweet corn was significantly higher at 120:26.5:50 kg NPK ha^{-1} than control and rest of fertilizer levels (Sahoo & Mahapatra, 2007) [45]. The green cob yield, stover yield and total biomass yield of sweet corn were significantly higher in RDF of 225:60: 60 kg NPK ha^{-1} than control as revealed from the field trial on medium black soil at Thane. Maharashtra (Gosavi *et al*., 2009) [18]. In maize 100% recommended dose of fertilizer produced maximum grain yield (4.92 t ha^{-1}) closely followed by 75 and 50% recommended dose of fertilizer which produced 4.47 and 4.20 t ha^{-1}, respectively (Kataraki *et al*., 2010) [20]. The green cob (15.91 t ha^{-1}) and fodder yield (20.34 t ha^{-1}) of sweet corn was highest with application of 150kg N, 70kg P_2O_5 and 50kg K_2O ha^{-1} in a field trial in sandy loam soil during *rabi* season at Tirupati, Andhra Pradesh (Sunitha *et al*., 2012) [53]. The significant enhancement of green cob and fodder yield was obtained with application of 90 kg N + 40 kg P_2O_5 ha^{-1} over all other treatments from a field trial conducted in clay loam soil during *kharif* season at Udaipur, Rajasthan (Priyanka et a2]. The highest green cob (8.0 t ha^{-1}) and fodder (36.66 t ha^{-1}) yield was obtained with supply of N: P_2O_5 @120:60 kg ha^{-1} in sweet corn crop on clayey soil during an experiment at Junagadh, Gujurat (Mathukia *et al*., 2014) [33].

Effect of inorganic fertilizers on quality

The sugar and protein content were significantly increased with the increasing dose of fertilizers with 150% RDF over 100% RDF (Nilesh Bajirao Zende, 2006) [62]. Significant increase in protein content was observed with increase in fertilizer level from 60 kg N + 30 kg P_2O_5 ha^{-1} to 90 kg N + 35 kg P_2O_5 ha^{-1} in baby corn (Chaudhary, n.d.) [10]. The quality parameters like protein and sugar content in the sweet corn were significantly improved with recommended dose of fertilizer over no fertilizer (Gosavi *et al*., 2009) [18]. The seed inoculation with *Azotobacter* did not significantly influence the sugar content of sweet corn (Hybrid sugar 75). However, application of 150% RDF level significantly increased sugar content in sweet corn (Hybrid sugar 75) over control, 50% and 100% RDF (N B Zende *et al*., 2009) [63]. A significant improvement on quality parameters like non-reducing sugar, total sugar and protein content was recorded with 112.5 kg N, 75.5 kg P_2O_5 and 37.5 kg K_2O/ha (Arun Kumar *et al*., 2010) [25].

Effect of inorganic fertilizers on economics:

Highest net profit was obtained with 100% RDF followed by integration of 75% RDN + 25% RDN through vermi-compost (Khadtare *et al*., 2006) [22]. After conducting a field trial in well drained sandy loam soil at Jashipur, Orissa during *rabi* season, the maximum net profit (Rs 45,952 ha^{-1}) and B:C ratio (3.89) were recorded with 120 kg N, 26.2 kg P_2O_5 and 50 kg K_2O ha^{-1} over control and all other fertilizer levels (Sahoo & Mahapatra, 2007) [45]. Maximum net return (Rs. 20898 ha^{-1}) was obtained with recommended dose of fertilizer over 50% RDF (Rs. 14089 ha^{-1}) and 75% RDF (Rs. 18861 ha^{-1}) (Prasanna Kumar *et al*., 2007) [27]. Highest benefit cost ratio of 6.0 was recorded with the treatment combination of 90 kg N + 40 kg P_2O_5 ha^{-1} while experimenting with sweet corn hybrid sugar -75 at Udaipur, Rajasthan (Suthar *et al*., 2014). Significantly the maximum net return (Rs. 203987/ha) was recorded with 100% RDF with B: C of 7.61 followed by 75% RDF (Rs. 177326/ha) with B:C of 6.91 (khan Mohammadi *et al*., 2017) [23].

Effect of synthetic fertilizers with organic manures on growth parameters:

Plant height of maize was found to be at par with 150% RDF and 100% RDF + 10 t FYM ha^{-1} which was superior over 50% RDF+10t FYM and 100% RDF treatment (Pursushottam Kumar & Puri, 2001) [28]. The application of 75% recommended NPK + 25% RDN through FYM significantly increased the plant height, dry matter production, leaf area index, crop growth rate, net assimilation rate and cob yield of maize over control (Pathak *et al*., 2002) [40]. Maximum plant height of maize was recorded with 100% RDN through FYM which was at par with 100% RDF of N and P through fertilizer and significantly superior over other treatments through fertilizers and organic manures (Kumpawat, 2004) [29]. During an experiment in Indian Agricultural Research Institute, New Delhi application of 120- 26.2- 33.2kg NPK ha^{-1} combined with 10t FYM ha^{-1} significantly enhanced the growth parameters of maize over rest of treatment combinations (Ashok Kumar *et al*., 2005) [26]. Application of 100% NPK (90:30:15 kg /ha) + FYM 10 t ha^{-1} gave higher plant growth rate of maize over control (Verma *et al*., 2006) [59].

Application of nitrogen fortified poultry manure @ 2.5 t ha^{-1} + 100 kg urea ha^{-1} over fortified pacesetter fertilizer (2.5 t ha^{-1} + 100 kg urea ha^{-1}) resulted in significantly higher plant height and leaf area index in maize crop (Ayoola & Makinde, 2009) [5]. Application of 100% RDN + 7.5t FYM ha^{-1} recorded maximum dry matter accumulation and plant height in comparison to rest of the treatments (Shilpashree *et al*., 2012) [47]. Integrated use of 180-75-60 kg NPK /ha + vermiwash in sweet corn gave the highest growth parameters of sweet corn being at par with 180-75-60 kg N-P_2O_5-K_2O/ha + vermicompost as reported from Naira, Andhra Pradesh (Keerthi *et al*., 2013) [21].

Effect of synthetic fertilizers with organic manures on yield attributes:

Application of 75% RDF of NPK through inorganic form and the balance 25% RDN supplied through FYM gave the highest cobs $plant^{-1}$, cob length, cob girth and 1000-grain weight in maize (Pathak *et al*., 2002) [40]. The diameter of cob, length of cob, grains/cob and grain weight /cob were significantly increased with 60 kg N + 30 kg P_2O_5 /ha along with 12 t FYM/ha over the remaining treatment combinations (Tripathi *et al*., 2004) [58]. Application of 100% RDF along with FYM @ 10t /ha reported significant increase in cobs/plant of maize (Mehta *et al*., 2005) [34]. From an experiment at Anand Agriculture University, Anand, Gujurat, significantly higher values of cob girth, cob length and green cob weight were obtained with RDF (150:50:0 kg NPK/ha) treatment followed by 75% RDF + 25% RDN through VC prepared from *Parthenium hysterophorous* L. and 75% RDF + 25% RDN through VC prepared from *Amaranthus sipnosus* L. which were also significantly superior over the remaining treatments (Khadtare *et al*., 2006) [22].

Application of FYM along with fertilizers significantly increased cob length and grains cob^{-1} of maize over application of organic manures and fertilizer alone (Panwar, 2008) [39]. Application of sunhemp green manure + poultry manure + 100% RDN gave the highest 100 grain weight and grain yield $plant^{-1}$ of maize crop (Sujatha *et al*., 2008) [52]. A field trial conducted during kharif season at Research Farm of Uttar Banga Krishi Viswavidyalaya, West Bengal observed the highest cob length (18.19 cm) in 25% RDF (inorganic) + vermicompost @ 5t ha^{-1} (Patra *et al*., 2009) [41].

Application of 120 kg N ha^{-1} combined with 10 t ha^{-1} FYM reduced the cost of production of maize through minimizing the use of fertilizers, which in turn help to sustain the soil health and productivity. FYM along with fertilizers significantly increased cob length and grains cob^{-1} of maize over application of organic manures and fertilizer alone (Kundu *et al*., 2009) [30]. From the field experiment conducted during *kharif* and *rabi* seasons at Tamil Nadu Agricultural University, Coimbatore, Tamilnadu in sandy clay loam soil, it is reported that combined application of 50% RDN through vermicompost and 50% RDF through inorganic NPK remarkably augmented the cob length, girth and number of grain rows/cob due to the synergistic effect (Nagavani *et al*., 2014) [38].

Effect of synthetic fertilizers with organic manures on yield:

Application of 100: 50:50 kg NPK in addition to 10t FYM ha^{-1} significantly increased the grain and straw yield (Brar *et al*., 2001). Application of 75% RDF and 25% RDN through FYM significantly increased the cob weight and cob yield over application of RDF alone (Pathak *et al*., 2002) [40]. Maximum baby corn and green fodder yields was recorded with good quality at 150:75:40 NPK kg / ha+ 10 t FYM/ ha (Ramachandrappa *et al*., 2004) [43]. Application of recommended fertilizer dose + 10 t FYM ha^{-1} and 150% RDF increased the yield by 4.96 and 8.03%, respectively over the recommended fertilizer dose (Anil Kumar & Thakur, 2004) [24]. Maximum grain and stover yield of maize was recorded with the application of 100% recommended NPK + 10 t FYM ha^{-1} followed by 150% recommended NPK (Selvi *et al*., 2004) [46]. Application of NPK (54:25:25 kg ha^{-1}) through inorganic fertilizers + poultry manure significantly increased dry matter production and cob yield over control (Amujoyegbe *et al*., 2007) [2].

Maize crop with nitrogen fortified poultry manure @ 2.5 t ha^{-1} + 100 kg urea ha^{-1} recorded significant enhancement of cob yield $plant^{-1}$ over fortified pacesetter fertilizer (2.5 t ha^{-1} + 100 kg urea ha^{-1}) (Ayoola & Makinde, 2009) [5]. Maximum grain yield (9.50 t ha^{-1}) and stover yield (11.00 t ha^{-1}) were obtained with 100% RDN + FYM @7.5 t ha^{-1} (Shilpashree *et al*., 2012) [47]. Maximum grain yield (4.11 t ha^{-1}) was obtained with 100% RDF + vermicompost (Kannan *et al*., 2013) [19]. During a field experiment at Agriculture College Farm, Naira in

sandy loam soil indicated that maximum green cob yield was recorded with application of 180-75-60 kg N, P_2O_5 and K_2O ha^{-1} + 30 kg RDN through vermicompost (Keerthi *et al*., 2013) [21]. Application of FYM @ 4t ha^{-1} incorporated with 75 kg of N and 60 kg of P_2O_5 ha^{-1} significantly increased the yield of hybrid maize (BH-140) and sustained the productivity over years (Bekeko, 2014) [6].

Application of 100% RDF and vermicompost @ 4.00 t/ha produced maximum green cob yield, green fodder yield, net return and B:C ratio compared with all other treatments (khan Mohammadi *et al*., 2017) [23]. The application of full recommended rate of inorganic fertilizer alone and the combination of the recommended rate of inorganic fertilizer with vermicompost @ 1t ha^{-1} remarkably enhanced the dry matter grain and forage yield in sweet corn (Canatoy, 2018) [8].

Effect of synthetic fertilizers with organic manures on quality parameters

An experiment carried out at the College Farm of Anand Agricultural University, Anand, Gujarat during rabi season of 2005-06 and reported that 75% RDN + 25% RDN through VC prepared from *Parthenium hysterophorous* L. had prominent effect on the content of total soluble sugar of sweet corn (22.0%) which was statistically at par with 75% RDN + 25% RDN through VC prepared from *Amaranthus sipnosus* L. and both these treatments were significantly superior over control (Khadtare *et al*., 2006) [22]. A significant increase in protein content (1.95 g100 g^{-1}) of baby corn was observed in the treatment receiving pelleted form of organic matter (Biomax) along with 75% RDF (150: 60: 40 kg N, P_2O_5 and K_2O ha^{-1}) in sandy clay loam soil of Kalyani, West Bengal (Saha & Mondal, 2006) [44]. Combined application of FYM @ 20t ha^{-1} with 150 percent RDF recorded significantly higher sugar content in the grain of sweet corn than the FYM @ 10 t ha^{-1} with 150% RDF and control (Nilesh Bajirao Zende, 2006) [62]. At Siruguppa (Karnataka), application of poultry manure at 1.0 t ha^{-1} with 100% NPK (150: 75: 75 kg ha^{-1}) gave significantly higher protein yield in maize over lower levels (Nagappa & Biradar, 2007) [37]. The reducing sugar, non-reducing sugar and total sugars increased by supply of nitrogen either through inorganic fertilizers alone or in combination with FYM or vermicompost in the proportion of 50% because of more availability of nitrogen (Dalavi *et al*., 2009) [13].

Effect of synthetic fertilizers with organic manures on economics

Maximum net return was recorded with 100% RDF followed by (75% RDN + 25% RD N through vermicompost prepared from *Parthenium hysterophorous* L.) (Khadtare *et al*., 2006) [22]. Application of RDF (150:75:40 kg N, P_2O_5 and K_2O /ha) + 35 kg vermicompost ha^{-1} registered the highest gross return (Rs. 96838/ha), net return (Rs 76889/ha) and B: C ratio (3.85) (Ashoka *et al*., 2008) [4]. A field experiment conducted on sandy loam soil at Research Farm of Uttar Banga Krishi Viswavidyalaya, West Bengal during *kharif* season showed that 75% RDF + FYM @ 2.5 t ha^{-1} fetched maximum B: C ratio (1.40) followed by 75% RDF+1.0 t VC ha^{-1}. The treatment (25% RDF + Vermi compost @ 5 t ha^{-1}) recorded the lowest B: C ratio (0.57) though it produced higher grain yield due to higher per unit cost of vermicompost than FYM (Patra *et al*., 2009) [41].

The application of vermicompost significantly influenced the uptake of N, P_2O_5 and K_2O and available nutrient content in soil along with the net return (Rs. 202755/ha) and B:C ratio(5.85) (Farnia & Torkaman, 2015) [17].

Effect of synthetic fertilizers with organic manures and bio-fertilizer on growth parameters

During a field experiment at Pune, Maharashtra on sweet corn, all the growth characters like plant height, number of functional leaves, LAI and total dry matter production were markedly increased with supply of 100% RDF (225:50:50 kg NPK /ha) + FYM 5 t ha^{-1} + *Azotobacter* + PSB over other fertilizer and FYM levels (Wagh, 2002) [60]. Application of NPK alone and in combination with *Azotobacter nigricans* and *Rhodotorula glutinis* either alone or in combination with or without 50% or 75% of the recommended dose of NPK had remarkable effect on growth and yield of maize crop over control and the responses were comparable to full dose of NPK (Afifi *et al*., 2003) [1]. During an experiment at Cairo (Egypt), the 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 stover yield of maize over 100% NPK alone (El-Kholy *et al*., 2005) [16]. In a field experiment at Coimbatore, Tamilnadu, integrated nutrient management practices of 50% NPK with poultry manure and bio fertilizers (*Azospirillum* + phosphobacteria) had shown significant effect on growth characters like plant height (183.1cm), LAI (3.47) and plant dry matter (7543 kg/ha) in baby corn (Thavaprakaash & Velayudham, 2007) [57].

On silty clay loam soils at Wadura (Jammu Kashmir), application of 40 kg N + 30 kg P_2O_5 + 10 t FYM ha^{-1}+ *Azotobacter* + VAM significantly enhanced plant height and dry matter production of maize over other treatments (S. Shobana *et al*., 2007) [49]. Application of 75% recommended NPK + VC @ 2.25 t / ha + bio fertilizer increased the plant height and dry matter accumulation over rest of the treatments (Dadarwal *et al*., 2009) [12]. Application of biofertilizer m – star @ 15 kg/ha combined with inorganic NPK fertilizer could increase the soil nutrients and sweet corn growth. This bio fertilizer had also increased the efficiency of in organic fertilizer by 50% (Mukhlis & Lestari, 2014) [35]. Highest plant growth (plant height and stem girth) with the application of 100% RDF + PSB as compared to other treatments (Singh *et al*., 2018) [51].

Effect of synthetic fertilizers with organic manures and bio-fertilizer on yield attributes:

The number of cobs/ plant, length of cob, girth of cob, weight of cob, number of grains / cob and test weight of sweet corn were significantly enhanced with application of 100% RDF(225:50:50 kg NPK/ha) + FYM @ 5t / ha + *Azotobacter* + PSB than other treatments (Wagh, 2002) [60]. Application of *Azospirillum* brasilense and soil yeast Rhodotorula glutinis in the presence of 100% NPK resulted significant increases in number of cobs $plant^{-1}$, cob length, grains cob^{-1}, and cob weight of maize over 100% NPK alone (El-Kholy *et al*., 2005) [16]. An experiment conducted at Wadura (Jammu and Kashmir) on silty clay-loam soil showed that an application of 40 kg N + 30 kg P_2O_5 + 10 t FYM ha^{-1} + *Azotobacter* + vesicular arbuscular mycorrhiza significantly increased number of cobs $plant^{-1}$, cob length, cob girth, grains cob^{-1}, and cob weight of maize over control (Yadav, n.d.) [61]. Highest cob length and cob diameter were recorded with application of 50% recommended dose of NPK + enriched FYM @ 750 kg ha^{-1} + *Azospirillum* (R. Shobana *et al*., 2008) [48]. Application of sunhemp green manure + poultry manure +

100% RDN gave the highest 100 grain weight and grain yield plant^{-1} of maize crop (Sujatha *et al*., 2008) [52]. Application of 75% NPK + 100% FYM +100% Zn + PSB significantly improved the yield attributes of maize (Dinesh *et al*., 2011) [15]. The favourable effect of 100% RDF + PSB on yield attributes of sweet corn was noticed (Singh *et al*., 2018) [51].

Effect of synthetic fertilizers with organic manures and bio-fertilizer on yield

Significantly higher grain and stover yield of maize was observed with 75% NPK + 100% FYM +100% Zn + PSB as evidenced from a field experiment conducted in sandy clay loam soil at experimental farm of Sheila Dhār Institute of Soil Science, Allahabad (Dinesh *et al*., 2011) [15]. The combined application of 100% NPK with A*zospirillum*, phosphorus solubilizing bacteria and vermi compost @ 5t ha^{-1} significantly produced the maximum grain yield of hybrid maize as well as maintained the soil quality (Kuniyal *et al*., 2012) [31]. 50% increase in recommended dose of NPK + enriched FYM @ 750 kg ha^{-1} + bio fertilizer *Azospirillum*) recorded the maximum grain yield of maize (6.56 t ha^{-1}) (R. Shobana *et al*., 2008) [48]. The combined application of N and P bio fertilizers through nitroxin and bio super phosphate treatment had the highest grain yield (12.91 t/ha) and biomass yield (56.55 t/ha) along with increase in the yield components of maize (Farnia & Torkaman, 2015) [17]. The green fodder yield was maximum with application of 150% RDF + PSB while, yield attributes, green cob yield was maximum with the application of 100% RDF + PSB (Singh *et al*., 2018) [51].

Effect of synthetic fertilizers with organic manures and bio-fertilizer on quality parameters

During a field trial on sweet corn at College of Agriculture, Pune, Maharashtra the protein content in grain and green fodder, sucrose content in grain and brix reading of grain though not affected significantly but slightly improved with application of 100% RDF (225:50:50 kg NPK/ ha) + 5 t FYM ha^{-1} + *Azotobacter* + PSB than other fertilizer and FYM combinations (Wagh, 2002) [60]. Significant increase in protein content of maize was obtained with 75% recommended NPK + FYM +Zn + PSB over other treatments (Dinesh *et al*., 2011) [15].

Effect of synthetic fertilizers with organic manures and bio-fertilizer on economics

The application of 120 kg N ha^{-1} through urea along with FYM @10 t ha^{-1} reduced the cost of production of maize by reducing the use of fertilizers (Kundu *et al*., 2009) [30]. During a field experiment on sandy loam soil at Agronomy Farm, College of Agriculture, Anand, Gujrat during *kharif* season, the net return obtained from sweet corn was favourably increased with application of 10 t FYM ha^{-1} + 120 kg N ha^{-1} + 50 kg P_2O_5 ha^{-1} along with seed inoculation with *Pseudomonas* sp. (Chauhan, 2010) [11].

Effect of INM on Soil fertility after crop harvest:

The application of 120 kg N ha^{-1} through urea with combination of FYM @10 t ha^{-1} reduced the cost of production of maize through minimizing the use of fertilizers which in turn help to sustain the soil health and productivity (Kundu *et al*., 2009) [30]. The combined application of 100% NPK with zinc, *Azospirillum*, PSB and vermicompost @5t ha^{-1} had produced the maximum grain yield of maize as well as maintained the soil quality (Kuniyal *et al*., 2012) [31]. During an experiment conducted in sandy loam soils of Agriculture College Farm, Naira, Andhra Pradesh that significant enhancement of postharvest soil available N, P_2O_5 and K_2O were recorded with the application of the highest dose of 180-75-60 kg NPK ha^{-1} + 30 kg N ha^{-1} through vermi compost (Keerthi *et al*., 2013) [21]. The maximum N, P_2O_5 and K_2O were recorded in 100% RDF which was found significantly different from the 75% RDF treatment (khan Mohammadi *et al*., 2017) [23].

Conclusion

From the above discussion, it can be concluded that balanced fertilization of the sweet corn from both organic and inorganic sources is necessary for better yield. The integrated application of synthetic fertilizers, organic manures and bio-fertilizers improves both the growth and yield of sweet corn and results in higher net return in a sustainable way. INM is the best practice for yield optimization by maintaining the soil health with judicious resource utilization in sweet corn. INM also improves the use efficiency of fertilizers, there by reduces the cost of production.

References

1. Afifi MH, Manal FM, Gomaa AM. Effect of biofertilizer under different levels of chemical fertilizers on maize (Zea mays L). Annals of Agricultural Science Moshtonor, 2003; 41:1411-1420.
2. Amujoyegbe BJ, Opabode JT, Olayinka A. Effect of organic and inorganic fertilizer on yield and chlorophyll content of maize (Zea mays L.) and sorghum Sorghum bicolour (L.) Moench. African Journal of Biotechnology. 2007; 6(16).
3. Ashok K, Shiva D. Evaluation of organic and inorganic sources of nutrients in maize (Zea mays) and their residual effect on wheat (Triticum aestivum) under different fertility levels. Indian Journal of Agricultural Sciences. 2010; 80(5):364-371.
4. Ashoka P, Pujari BT, Hugar PS, Desai BK. Effect of micronutrients with or without organic manures on yield of baby corn (Zea mays L.--chickpea (Cicer artietinum L.) sequence. Karnataka Journal of Agricultural Sciences. 2008; 21(4):485-487.
5. Ayoola OT, Makinde E. Maize growth, yield and soil nutrient changes with N-enriched organic fertilizers. African Journal of Food, Agriculture, Nutrition and Development. 2009; 9(1):580-592.
6. Bekeko Z. Effect of enriched farmyard manure and inorganic fertilizers on grain yield and harvest index of hybrid maize (bh-140) at Chiro, eastern Ethiopia. African Journal of Agricultural Research. 2014; 9(7):663-669.
7. Brar BS, Dhillon NS, Chhina HS. Integrated use of farmyard manure and inorganic fertilizers in maize (Zea mays). The Indian Journal of Agricultural Sciences. 2001; 71(9).
8. Canatoy RC. Dry Matter Yield and NPK Uptake of Sweet Corn as Influenced by Fertilizer Application. Asian Journal of Soil Science and Plant Nutrition, 2018, 1-10.
9. Channabasavanna AS, Biradar DP, Yelamali SG. Effect of poultry manure and NPK on growth and yield of maize. Karnataka Journal of Agricultural Sciences. 2002; 15(2):353-355.
10. Chaudhary R. (n.d.). Effect of Plant Population and Fertility Levels on Yield and Quality of Baby corn (Zea mays L.). MPUAT, Udaipur.

11. Chauhan NM. Effect of integrated nutrient management on growth, yield and economics of sweet corn (Zea mays L). Journal of Progressive Agriculture. 2010; 1(1):8-10.
12. Dadarwal RS, Jain NK, Singh D. Integrated nutrient management in baby corn (Zea mays). Indian Journal of Agricultural Sciences. 2009; 79(12):1023-1025.
13. Dalavi PN, Bhondave TS, Jawale SM, Shaikh AA, Dalavi ND. Effect of sources of organic manures in integrated nutrient management on yield and quality of sweet corn. Journal of Maharashtra Agricultural Universities. 2009; 34(2):222-223.
14. De Grazia J, Tittonell PA, Germinara D, Chiesa A. Phosphorus and nitrogen fertilisation in sweet corn (Zea mays L. var. saccharata Bailey). Spanish Journal of Agricultural Research. 2003; 1(2):103-107.
15. Dinesh M, Upadhyay SK, Chitranjan K, Shiv B, Neeraj P. Effect of integrated nutrient management system on nutrient uptake and yield of maize (Zea mays). New Agriculturist. 2011; 22(1):5-14.
16. El-Kholy MA, El-Ashry S, Gomaa AM. Biofertilization of maize crop and its impact on yield and grains nutrient content under low rates of mineral fertilizers. Journal of Applied Sciences Research. 2005; 1(2):117-121.
17. Farnia A, Torkaman H. Effect of different biofertilizers on yield and yield components of maize (Zea mays L.). Bull. Env. Pharmacol. Life Sci. (BEPLS). 2015; 4(4):75-79.
18. Gosavi SP, Chavan SA, Bhagat SB. Effect of mulches, fertilizer and levels of FYM on yield, quality and nutrient uptake of rabi sweet corn (Zea mays saccharata). Journal of Soils and Crops. 2009; 19(1):92-96.
19. Kannan RL, Dhivya M, Abinaya D, Krishna RL, Krishnakumar S. Effect of integrated nutrient management on soil fertility and productivity in maize. Bulletin of Environment, Pharmacology and Life Sciences. 2013; 2(8):61-67.
20. Kataraki NG, Desai BK, Pujari BT. Integrated nutrient management in irrigated maize. Karnataka Journal of Agricultural Sciences. 2010; 17(1).
21. Keerthi S, UpendraRao A, Ramana AV, Tejeswara Rao K. Effect of nutrient management practices on cob yield, protein content, npk uptake by sweet corn and post harvest N, P2O5 and K2O. International Journal of Advanced Biological Research. 2013; 3(4):553-555.
22. Khadtare SV, Patel MV, Mokashi DD, Jadhav JD. Influence of vermicompost on quality parameters and soil fertility status of sweet corn. Journal of Soils and Crops. 2006; 16(2):384-389.
23. Khan Mohammadi N, Pankhaniya RM, Joshi MP, Patel KM. Influence of inorganic fertilizer, vermicompost and biofertilizer on yield & economic of sweet corn and nutrient status in soil. IJAR. 2017; 3(5):183-186.
24. Kumar Anil, Thakur KS. Effect of integrated nutrient management on promising composite maize (Zea mays) varieties under rainfed mid-hill conditions of Himachal Pradesh. Indian Journal of Agricultural Science. 2004; 74(1):40-42.
25. Kumar Arun, Gali SK, Hebsur NS. Effect of different levels of NPK on growth and yield parameters of sweet corn. Karnataka Journal of Agricultural Sciences. 2010; 20(1).
26. Kumar Ashok, Gautam RC, Singh R, Rana KS. Growth, yield and economics of maize (Zea mays)-wheat (Triticum aestivum) cropping sequence as influenced by integrated nutrient management. Indian Journal of Agricultural Science. 2005; 75(11):709-711.
27. Kumar Prasanna, Halepyati AS, Pujari BT, Desai BK. Effect of integrated nutrient management on productivity, nutrient uptake and economics of maize (Zea mays L.) under rainfed condition. Karnataka Journal of Agricultural Sciences. 2007; 20(3):462-465.
28. Kumar Pursushottam, Puri UK. Effect of nitrogen and farmyard manure application on maize (Zea mays) varieties. Indian Journal of Agronomy. 2001; 46(2):255-259.
29. Kumpawat BS. Integrated nutrient management for maize (Zea mays)-Indian mustard (Brassicajuncea) cropping system. Indian Journal of Agronomy. 2004; 49(1):18-21.
30. Kundu S, Gajbhiye PN, Srinivasarao C, Bheemaiah G. Effect of integrated nutrient management on yield attributes, yield, nutrient uptake and economics of growing maize in tamarind-based cropping system. Indian Journal of Dryland Agricultural Research and Development. 2009; 24(1):81-86.
31. Kuniyal HC, Singh V, Ram S, Bhatnagar A. Nutrient management on soil health, nutrient uptake and yield of maize under temporary submerged condition in mollisol. Madras Agricultural Journal. 2012; 99(7-9):548-552.
32. Kunjir SS. Effect of planting geometry, nitrogen levels and micronutrients on the performance of sweet corn (Zea mays L. saccharata) under lateritic soils. M. Sc. (Agri.) Thesis.
33. Mathukia RK, Choudhary RP, Shivran A, Bhosale N. Response of Rabi sweet corn to plant geometry and fertilizer. Journal of Crop and Weed. 2014; 10(1):189-192.
34. Mehta YK, Shaktawat MS, Singhi SM. Influence of sulphur, phosphorus and farmyard manure on yield attributes and yield of maize (Zea mays) in southern Rajasthan conditions. Indian Journal of Agronomy. 2005; 50(3):203-205.
35. Mukhlis M, Lestari Y. Effects of Biofertilizer "M-star" On Land Productivity And Growth Of Sweet Corn In Acid Sulphate Soil Of Swampland. AGRIVITA, Journal of Agricultural Science. 2014; 35(3):242-248.
36. Mundra SL, Vyas AK, Maliwal PL. Effect of weed and nutrient management on weed growth and productivity of maize (Zea mays L.). Indian Journal of Weed Science. 2003; 35(1-2):57-61.
37. Nagappa CAS, Biradar DP. Effect of integrated nutrient management on productivity, profitability and sustainability of irrigated maize. Karnataka Journal of Agricultural Sciences. 2007; 20(4):837-839.
38. Nagavani AV, Subbian P. Productivity and economics of hybrid maize as influenced by integrated nutrient management. Current Biotica. 2014; 7(4):283-293.
39. Panwar AS. Effect of integrated nutrient management in maize (Zea mays)-mustard (Brassica compestris var toria) cropping system in mid hills altitude. The Indian Journal of Agricultural Sciences. 2008; 78(1).
40. Pathak SK, Singh SB, Singh SN. Effect of integrated nutrient management on growth, yield and economics in maize (Zea mays)-wheat (Triticum aestivum) cropping system. Indian Journal of Agronomy. 2002; 47(3):325-332.
41. Patra PS, Biswas S. Integrated nutrient management on growth, yield and economics of maize (Zea mays L.) under terai region. Journal of Crop and Weed. 2009; 5(1):136-139.

42. Priyanka K, Kaushik MK, Dilip S, Kiran K. Yield, nutrient content, uptake and quality of sweet corn varieties as influenced by nitrogen and phosphorus fertilization under Southern Rajasthan condition. Annals of Agri Bio Research. 2014; 19(1):67-69.
43. Ramachandrappa BK, Nanjappa HV, Shivakumar HV. Yield and quality of baby corn (Zea mays L.) as influenced by spacing and fertilization levels. Acta Agronomica Hungarica. 2004; 52(3):237-243.
44. Saha M, Mondal SS. Influence of integrated plant nutrient supply on growth, productivity and quality of baby corn (Zea mays) in Indo-Gangetic plains. Indian Journal of Agronomy. 2006; 51(3):202-205.
45. Sahoo SC, Mahapatra PK. Yield and economics of sweet corn (Zea mays) as affected by plant population and fertility levels. Indian Journal of Agronomy. 2007; 52(3):239-242.
46. Selvi D, Santhy P, Dhakshinamoorthy M, Maheshwari M. Microbial population and biomass in rhizosphere as influenced by continuous intensive cultivation and fertilization in an Inceptisol. Journal of the Indian Society of Soil Science. 2004; 52(3):254-257.
47. Shilpashree VM, Chidanandappa HM, Jayaprakash R, Punitha BC. Influence of integrated nutrient management practices on productivity of maize crop. Indian Journal of Fundamental and Applied Life Sciences. 2012; 2(1):45-50.
48. Shobana R, Imyavaramban V. Integrated nutrient management in hybrid maize (Zea mays L.) cv. Pionner 30V 92. Plant Archives. 2008; 8(1):433-434.
49. Shobana S, Usha Kumari SR, Malleshi NG, Ali SZ. Glycemic response of rice, wheat and finger millet based diabetic food formulations in normoglycemic subjects. International Journal of Food Sciences and Nutrition. 2007; 58(5):363-372.
50. Sindhi SJ, Thanki JD, Desai LJ. A review on integrated nutrient management (INM) approach for maize. Journal of Pharmacognosy and Phytochemistry. 2018; 7(4):3266-3269.
51. Singh S, Singh V, Shukla RD, Singh K. Effect of fertilizer levels and Bio-fertilizer on green cob yield of corn (Zea mays L.). IJCS. 2018; 6(2):2188-2190.
52. Sujatha MG, Lingaraju BS, Palled YB, Ashalatha KV. Importance of integrated nutrient management practices in maize under rainfed condition. Karnataka Journal of Agricultural Sciences. 2008; 21(3):334-338.
53. Sunitha N, Reddy PM. Effect of graded nutrient levels and timing nitrogen application on yield and quality of sweet corn (Zea mays L.). Madras Agricultural Journal. 2012; 99(4-6):240-243.
54. Sutaliya R, Singh RN. Effect of planting time, fertility level and phosphate-solubilizing bacteria on growth, yield and yield attributes of winter maize (Zea mays) under rice (Oryza sativa)-maize cropping system. Indian Journal of Agronomy. 2005; 50(3):173-175.
55. Suthar M, Singh D, Nepalia V, Singh AK. Performance of sweet corn (Zea mays) varieties under varying fertility levels. Indian Journal of Agronomy. 2014; 59(1):168-170.
56. Thakur GD, Karanjikar PN, Kasbe AB, Dhamak AL, Barkule SR. Effect of fertilizer levels on yield and yield contributing characters of sweet corn. Asian Journal of Soil Science. 2009; 4(2):280-282.
57. Thavaprakaash, N, Velayudham K. Effect of crop geometry, intercropping systems and INM practices on cob yield and nutrient uptake of baby corn. Asian Journal of Agricultural Research. 2007; 1(1):10-16.
58. Tripathi RS, Srivastava GK, Malaiya S. Effect of variety, sowing time and integrated nutrient management on growth, yield attributes and yield of summer maize (Zea mays L.). Annual Agrcultural Research New Series, 2004, 155–158.
59. Verma A, Nepalia V, Kanthaliya PC. Effect of integrated nutrient supply on growth, yield and nutrient uptake by maize (Zea mays)--wheat (Triticum aestivum) cropping system. Indian Journal of Agronomy. 2006; 51(1):3-6.
60. Wagh DS. Effect of spacing and integrated nutrient management on growth and yield of sweet corn (Zea mays L. saccharata). M. Sc. Thesis, 2002.
61. Yadav LR. (n.d.). Effect of Organic Manures, Chemical Fertilizers and Phosphorus Sources on Quality Protein Maize (Zea mays L.). MPUAT, Udaipur, 2002.
62. Zende NB, Pinjari SS, Suryawanshi JS, Bhondve TS. Effect of nutrient management on growth, yield, quality, economics and nutrient partitioning of sweet corn. BIOINFOLET-A Quarterly Journal of Life Sciences. 2009; 6(1):16-21.
63. Zende Nilesh Bajirao. Effect of Integrated Nutrient Management on The Performance Of Sweet Corn (Zea Mays Saccharata). Dr Balasaheb Sawant Konkan Krishi Vidyapeeth; Dapoli.