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

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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 exhaustible 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 nutrient management have multipurpose role on the improvement of soil fertility and crop productivity in a sustainable manner (Sindh 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 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 exhaustible 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 nutrient management have multipurpose role on the improvement of soil fertility and crop productivity in a sustainable manner (Sindh 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.

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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$_2$O$_5$ 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. Shobhana 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 Dhawad, Karnataka (Arun Kumar et al., 2010) [25]. Application of RDF (100 kg N, 26 kg P$_2$O$_5$ and 32 kg K$_2$O 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 cobs plant$^{-1}$ 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, Gujarat 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 (Khadur 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 + Azospirillum (Thakur et al., 2009) [60]. 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) [22]. Application of 120-60 kg N-P$_2$O$_5$ 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$_2$O$_5$ 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 120:25:5:50 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$_2$O$_5$ and 50kg K$_2$O ha$^{-1}$ in a field trial in sandy loam soil during rabi season at Tirupati, Andhra Pradesh (Sunitsa et al., 2012) [53]. The significant enhancement of green cob and fodder yield was obtained with application of 90 kg N + 40 kg P$_2$O$_5$ ha$^{-1}$ over all other treatments from a field trial conducted in clay loam soil during kharif season at Udaipur, Rajasthan (Priyanka et al, 2014). The highest green cob (8.0 t ha$^{-1}$) and fodder (36.66 t ha$^{-1}$) yield was obtained with supply of N: P$_2$O$_5$ @120:60 kg ha$^{-1}$ in sweet corn crop on clayey soil during an experiment at Junagadh, Gujarat (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$_2$O$_5$ ha$^{-1}$ to 90 kg N + 35 kg P$_2$O$_5$ 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$_2$O$_5$ and 37.5 kg K$_2$O/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) [21]. After conducting a field trial in well drained sandy loam soil at Jaspur, 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 P₂O₅ and 50 kg K₂O ha⁻¹ over control and all other fertilizer levels (Sahoo & Mahapatra, 2007) [49]. 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 P₂O₅ 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 120-26.2-33.2 kg 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 (Ayoolla & 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-P₂O₅-K₂O/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 P₂O₅/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% RDN + 25% RDN through VC prepared from Parthenium hysterophorus L. and 75% RDN + 25% RDN through VC prepared from Aamaranthus 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 sun hemp 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% RDN (inorganic) + vermicompost @ 5 t 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, Tamilnudu in sandy clay loam soil, it is reported that combined application of 50% RDN through vermicompost and 50% RDN 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% RDN and 25% RDN through FYM significantly increased the cob weight and cob yield over application of RDN 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 (Amujoyebge 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) (Ayoolla & 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, P₂O₅ and K₂O ha⁻¹ + 30 kg RDN through vermicompost (Keerthi et al., 2013) [23]. Application of FYM @ 4t ha⁻¹ incorporated with 75 kg of N and 60 kg of P₂O₅ ha⁻¹ significantly increased the yield of hybrid maize (BH-140) and sustained the productivity over years (Bekoko, 2014) [40]. 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 hysterophorus 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 Amanthus spinosus 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, P₂O₅ and K₂O 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 Siriguppa (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 hysterophorus L.) (Khadtare et al., 2006) [22]. Application of RDF (150:75:40 kg N, P₂O₅ and K₂O/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) [8]. 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 + Vermicompost @ 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, P₂O₅ and K₂O 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 P₂O₅ + 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% (Mukhis & Lestari, 2014) [55]. 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 P₂O₅ + 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)\(^{[32]}\). 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 Azospirillum, phosphorus solubilizing bacteria and vermi compost @ 5 t 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. Shobhana 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, Gujarat 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\(_2\)O\(_5\) 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\(_2\)O\(_5\) and K\(_2\)O 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\(_2\)O\(_5\) and K\(_2\)O 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.

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