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Integrated nutrient management in maize

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The literature on integrated nutrient management in maize crop has been well documented. In this article efforts have been made to review the literature available on integrated nutrient management in corn. The effect of integrated nutrient management on growth character, yield attributes, yield, nutrients uptake, quality characters and economics were presented here.

Today, for the country of India's dimension, with no scope for horizontal expansion and complexity of problems and challenges, there is no alternative but continue to improve productivity without further degrading its natural resources that too in a sustainable manner (Narayanswamy *et al.*, 1994). In this contest we will have to adopt a rationalist organic farming approach to have an 'Evergreen Revolution'. This has led to the concept of integrated nutrient management (INM) gain momentum in recent years to improve and maintain the soil health. Besides this, with escalating cost of energy based fertilizer material, limited fossil fuels, INM approach combines the use of organic sources along with fertilizers, which would be remunerative for getting higher yields with considerable fertilizer economy (Subbian and Palaniappan, 1992)

Growth character:

Madhavi *et al*. (1995) conducted a trial on integrated nutrient management for maize and observed that maximum plant height was recorded with the combination of 4.5 t poultry manure and 100% RDF, which was at par with 3.0 t poultry manure and 100% RDF combination, both these treatment combinations were significantly superior over rest of the treatment combinations.

Kumar *et al*. (2002) observed that application of 150% RDF and 100% RDF + 10 t FYM/ha showed nearly equal plant height, which was higher than 50% RDF +10 t FYM and RDF alone treatments.

Wagh (2002) from a field trial conducted at College of Agriculture, Pune on sweet corn reported that all the growth characters *viz.*, plant height, number of functional leaves, leaf area and total dry matter production were found significantly more with application of 100 per cent RDF(225:50:50 Kg NPK per ha) + 5 tone FYM per ha + Azatobactor + PSB than other fertilizer and FYM levels.

Luikham *et al*. (2003) conducted a trial on baby corn to study the effect of organic and inorganic nitrogen at Coimbatore and the data showed that maximum plant height was recorded with 100% dose of N + 10 t FYM/ ha, which was at par with 75% dose of N + 10 t FYM/ha and both these treatments were significantly superior over control. The maximum dry matter production (g/m^2) was recorded with 100% N + FYM 10 t/ha, which was significantly superior over rest of the treatments, which included FYM.

Rana and Shivran (2003) reported from a field trial carried out on maize at Indian Agriculture Research Institute, New Delhi that dry matter production and leaf area index significantly improved under FYM @ 5 tone per ha with dust mulch or straw mulch as compared to no mulch, FYM @ 5 tone per ha, Dust mulch, straw mulch, kavoline + dust mulch and straw mulch alone.

Karki *et al*. (2005) conducted an experiment at Indian Agricultural Research Institute, New Delhi on maize and reported that application of 120 kg N + 10 t FYM per ha produced significantly higher plant height and dry matter production per plant over rest of treatment combination.

Kumar *et al*. (2005) conducted an experiment at Indian Agricultural Research Institute, New Delhi on maize and reported that application of 120 kg N + 26.2 kg P_2O_5 + 33.2 kg K_2O per ha combining with 10 t FYM per ha yielded significantly higher plant height and leaf area index over rest of treatment combination.

Gosavi (2006) after conducting the field trial at Aspee foundation, Thane on sweet corn reported that the plant height and growth at all the growth stages was influenced significantly due to polythene mulches with the combination of 20 t FYM ha^{-1} over rest of the treatment combination.

Gosavi (2006) after conducting the field trial at Aspee

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foundation, Thane on sweet corn reported that the plant height was significantly higher under the combination of RDF and 20 t FYM ha^{-1}. Further, higher number of functional leaves under RDF and 20 t FYM combination was in position to produce more photosynthates per plant and hence, the dry matter production was significantly higher under this combination.

Pinjari (2007) undertaken the field experiment during 2055-06 and 2006-07 to find out the effect integrated nutrient management on sweet corn and revealed that the plant height increased significantly with the application of 75 % RDN + 25 % N through PM as compared to all the remaining nutrient sources during 2005-06, 2006-07 and in the mean of two years at all the crop growth stages.

The number of leaves was significantly superior with 100% RDN over rest of the nutrient sources except 75 % RDN + 25 % N as PM at all the crop growth stages during both the years and in the mean of two years.

The total dry matter accumulation ($plant^{-1}$) at 30 DAS, the dry matter accumulation ($plant^{-1}$) in leaves, stem and total dry matter at 60 DAS, in the leaves, stem, cob and total dry matter ($plant^{-1}$) at 90 DAS and in the leaves, stem, grains, cob sheath, cob axis and total dry matter ($plant^{-1}$) at harvest were significantly higher with the application of 75 % RDN + 25 % N as PM during both the years of study and in the mean of two years than the remaining nutrient sources.

Yield attributes:

Chandrashekara *et al.* (2000) conducted the field experiment in Arabhavi, Karnataka during the *kharif* season of 1996 and reported that the application of poultry manure (10 t/ha) with recommended rate of fertilizers(RRF 150 kg N/ha in three split doses) produced taller plants (187.5 cm) longer cobs (14.35 cm) with bigger diameter (15.6 cm) and heavier cob weight (170.5 g/cob) than application with control. The per cent increase in cob length, cob girth, and grain weight per plant with the application of poultry manures was 13.1, 23.8 and 53.2 %, respectively, compared with control.

Nanjappa *et al.* (2001) conducted an experiment on maize to study effect of integrated nutrient management at Bangalore, Karnataka. The grains per row were recorded maximum with 75% RDF + FYM 6 t/ha, which was at par with RDF (150 : 75 : 40 kg NPK/ha) alone and significantly superior over 50% RDF + 12 t FYM/ha and FYM 24 t/ha treatments. The grain weight per plant was recorded maximum with 75% RDF + FYM 6 t/ha, which was at par with RDF alone and both these treatments were significantly superior over rest of the treatments.

Wagh (2002) concluded after a field trial conducted at College of Agriculture, Pune on sweet corn that number of cobs, length of cob, girth of cob, weight of cob, number of grains per cob and test weight (g) were significantly more with application of 100 per cent RDF (225:50:50 Kg NPK per ha) + 5 t FYM per ha + Azatobactor + PSB than other fertilizer and FYM levels.

Rana and Shivran (2003) conducted a field trial at Indian Agriculture Research Institute, New Delhi on maize and reported that cob per plant, cob length, grains per cob, grains weight per cob, weight of cobs per plot were significantly higher under FYM @ 5 t per ha and dust mulch or straw mulch as compared to no mulch, FYM @ 5 t per ha, dust mulch, straw mulch and kavoline + dust mulch or straw mulch.

Tripathi *et al.* (2004) carried out a field trial at Raipur (Chhatthisagad) during summer season on maize and reported that diameter of cob, length of cob, grains per cob and grains weight per cob were significantly higher under 60 Kg N per ha + 30 Kg P_2O_5 along with 12 t FYM per ha than the remaining treatment combinations.

Waheeduzzama (2004) reported that the treatment combination of Panchagavya 4 per cent + 50 per cent RDF favourably influenced the plant height (32.40cm), number of leaves per plant (6.20), total leaf area (336.96cm), suckers per plants (4.20) and flower yield per plant (5.90) in anthurium.

Yadav and Christopher Louduary (2006) conducted experiment at Tamilnadu Agricultural University, Coimbatore during 2004 of organically raised rice crop and reported that recommended NPK through fertilizers along with 3 % panchagavya spray registered maximum productive tillers $hill^{-1}$(12.03), panicle length (20.78 cm), filled grains $panicle^{-1}$ (110.07) and seed test weight (17.30 g) compared to without panchagavya spray (9.97, 19.39 cm, 91.53 and 16.19 g, respectively).

Khadtare *et al.* (2006) carried out the research work at college farm of Anand Agricultural University, Anand during *rabi* season of 2005-06 and reported that significantly higher values were recorded in respect of cob girth, cob length and green cob weight in treatment T_{10} (RDF 150:50:0 NPK/ha) followed by T_4 (75 % RDN + 25 % N through VC prepared from *Parthenium hysterophorous* L.) and T_6 (21.7 %) (75 % RDN + 25 % N through VC prepared from *Amaranthus spinosus* Linn.).

Gosavi (2006) after conducting the field trial at Aspee foundation, Thane on sweet corn reported that yield attributes were influenced significantly due to polythene mulch with the combination of 20 t FYM ha^{-1} over rest of the treatment combination.

Pinjari (2007) undertaken the field experiment during 2005-06 and 2006-07 to find out the effect of integrated nutrient management on sweet corn and revealed that the cob length, cob girth, number of grain rows per cob, number of grain per cob were significantly superior with the application of 75 % RDN + 25 % N as PM over rest of the nutrient sources during both the years of study and in the mean of two years.

Yield:

Kachapur and Duragannavar (1991) carried out an experiment during 1990 at Dharwad under rainfed conditions. They revealed that an application of 80:40:40 Kg NPK per ha along with FYM @ 1 ton per ha gave the highest grain yield (2.95 ton per ha) and biomass yield (4.49 ton per ha) than other combinations.

Suri *et al.* (1995) conducted a trial on maize to evaluate effect of FYM and fertilizers at Akrat, Himachal Pradesh, during 1991-92 and 1992-93 and reported that the grain yield was significantly superior with FYM @ 10 t/ha + 90 : 45 : 20 kg NPK/ha over rest of the treatment combinations, during both the years.

Kamalakumari and Singaram (1996a) reported from a field trial on maize conducted at Coimbatore, in *kharif* season that grain yield (t/ha) were significantly higher under 100 kg N : 40 kg P_2O_5 : 40 kg K_2O along with 10 t FYM per ha than rest of the treatment combinations.

Chandrashekara *et al.* (2000) conducted the field experiment in Arabhavi, Karnataka during the *kharif* season of 1996 and reported that the application of poultry manure (10 t/ha) with recommended rate of fertilizers(RRF 150 kg N/ha in three split doses) gave higher grain (50.8 q/ha) and fodder (74.4 q/ha) yields than vermicompost with RRF, FYM with RRF and control treatment(only RRF). The per cent increase in grain yield with application of poultry manure, vermicompost and FYM was 33, 16 and 14 %, respectively compared to control.

Sahoo and Panda (2000) revealed from a field trial conducted at Jashipur, Orissa on maize for two consecutive years 1996 and 1997 in *kharif* season that application of 80 kg N + 40kgP_2O_5 + 40kg K_2O along with 5 t FYM per ha increased grain yield to the tune of 3269 kg per ha in 1996 and 3661 kg per ha in 1997 which were significantly higher than application of chemical fertilizers alone and control.

Vasanthi and Kumaraswamy (2000) conducted the field experiment during 1993-94 in Tamilnadu on a clay loam soil and reported that the green and dry fodder yields of the cereal fodders were significantly higher in the treatments that received poultry manure or sheep-goat manure at 10 t/ha with 50 % of the recommended NPK schedule than the yields in the treatment that had received NPK alone.

Brar *et al.* (2001) reported from a field trial on maize conducted at Ludhiana in *kharif* season that grain yield and stover yield (t per ha) were significantly higher under 150 Kg N + 41.3 Kg P_2O_5 along with 10 t FYM per ha than rest of the treatment combinations.

Nanjappa *et al.* (2001) conducted an experiment on maize to study effect of integrated nutrient management on maize at Bangalore, Karnataka. The grain and straw yield of maize were maximum with 75% RDF + FYM 6 t/ha, which was at par with RDF alone and 50% RDF + FYM 12 t/ha treatments and all these treatments were significantly superior over FYM 24 t/ha alone, during 1998.

Channabasavanna *et al.* (2002) conducted field experiment in Karnataka, India, in 2000 and revealed that the production potential of maize was enhanced by using organic manures in conjunction with chemical fertilizers compared to the use of only inorganic fertilizers. Poultry manure at 4 t/ha with 75 % NPK recorded the highest seed yield (5583 kg/ha), followed by poultry manure at 1 t/ha and 100 % NPK (5573 kg/ha).

The treatment combinations of poultry manure + neem cake + Panchagavya along with increased dose of fertilizers increased pod yield of moringa (Beaulah *et al*., 2002).

Wagh (2002) stated after a field trial conducted at College of Agriculture, Pune on sweet corn that green cob yield and green stover yield (q per ha) were significantly more with application of 100 per cent RDF (225:50:50 Kg NPK per ha) + 5 t FYM per ha + Azatobactor + PSB than other fertilizer and FYM levels.

Yadav and Christopher Loudurag (2006) conducted experiment at Tamilnadu Agricultural University, Coimbatore during 2004 of organically raised rice crop and reported that recommended NPK through fertilizers along with 3 % panchagavya spray registered significantly maximum grain yield (5946 kg/ha) and straw yield (8215 kg/ha) compared to without panchagavya spray (5591 and 7409 kg/ha, respectively).

Khadtare *et al.* (2006) carried out the research work at college farm of Anand Agricultural University, Anand during *rabi* season of 2005-06 and reported that significantly higher values were recorded in respect of green cob yield and green fodder yield in treatment T_{10} (112.5 q/ha and 246.3 q/ha, respectively) (RDF 150:50:0 NPK/ha) followed by T_4 (108.1 and 235.6 q/ha, respectively) (75 % RDN + 25 % N through VC prepared from *Parthenium hysterophorous* L.) and T_6 (107.3 and 229.6 q/ha, respectively) (75 % RDN + 25 % N through

VC prepared from *Amaranthus spinosus* Linn.).

Gosavi (2006) after conducting the field trial at Aspee foundation, Thane on sweet corn reported that green cob and stover yield increased significantly due to polythene mulches with the combination of 20 t FYM ha^{-1} over rest of the treatment combinations.

Gosavi (2006) after conducting the field trial at Aspee foundation, Thane on sweet corn reported that significantly higher cob yield and stover yield under the combination of RDF and 20 t FYM ha^{-1} than the other combinations.

Pinjari (2007) undertaken the field experiment during 2005-06 and 2006-07 to find out the effect of integrated nutrient management on sweet corn and revealed that the number of cobs per hectare, cob yield, straw yield and biological yield during both the years were significantly superior with the application of 75 % RDN + 25 % N as PM over rest of the nutrient sources. While harvest index was higher with the application of 50 % RDN + 50 % N as PM over rest of the nutrient sources.

Uptake of nutrients:

Kamalakumari and Singaram (1996) found that application of FYM (10 t ha^{-1}) along with recommended dose of NPK fertilizers to maize has significantly increased the N uptake to 93.1 kg ha^{-1} and 77.2 kg ha^{-1}, P uptake to 19.0 and 14.9 kg ha^{-1} and K uptake to 233.8 and 186 kg ha^{-1}, respectively, in grain and straw of maize.

Parmar and Sharma (1998) reported after conducting a field experiment at Palampur on wheat that among the combination of levels of phosphorus (0,26,52,78 kg/ha) and mulches (no mulch, pine needles, ghaneri and polythene mulch), significantly higher total uptake of phosphorus was recorded under the combination of 75kg P_2O_5 along with transparent polythene mulch.

Vasanthi and Kumaraswamy (2000) conducted the field experiment during 1993-94 in Tamilnadu on a clay loam soil and reported that the content and uptake of N, P and K were significantly higher in the treatments that received poultry manure or sheep-goat manure at 10 t/ha with 50 % of the recommended NPK schedule than the yield in the treatment that had received NPK alone.

Brar *et al*. (2001) from a field trial conducted at Ludhiana in *kharif* season on maize reported that of NPK uptake was significantly higher under 150 Kg N + 41.3 Kg P_2O_5 along with 10 t FYM per ha than rest of the treatment combinations.

Nanjappa *et al*. (2001) conducted a trial on maize to study effect of integrated nutrient management at Hebbal, Karnataka on sandy loam soil, low in available N and K_2O and medium in available P_2O_5. The uptake data on N, P and K showed that nutrient uptake of N, P and K were recorded significantly superior with 75 % RDF + FYM @ 6 t/ha over 100 % RDF (150 : 75 : 40 kg NPK/ ha), 50 % RDF + FYM @ 12 t/ha, FYM @ 24 t/ha treatments of fertility management, during 1998.

Parmar and Sharma (2001) conducted a field experiment at Regional Research Station, Bajaura on hybrid maize. Results indicated that the total uptake of N by hybrid maize increased with increase in nitrogen level and FYM, due to better proliferation of root system resulting in better absorption of water and nutrients.

Wagh (2002) concluded from a field trial conducted at College of Agriculture, Pune on sweet corn that uptake of nutrients (NPK Kg per ha) were found significantly more with application of 100 per cent RDF (225:50:50 Kg NPK per ha) + 5 t FYM per ha + Azatobactor + PSB than other fertilizer and FYM levels.

Raje Mahadik (2003) after conducting a field trial at Dapoli on groundnut reported that total nitrogen, phosphorus and potassium were significantly higher under the combinations of polythene mulch along with 10 t FYM per ha and recommended dose of nitrogen 50 kg/ha, phosphorus 10 kg/ha and 50 kg/ha potassium than no mulch treatment.

Reddy *et al*. (2005) conducted a trial on maize at Bangalore, during *rabi* seasons of 2001-02 and 2002-03. The data on protein yield revealed that maximum protein yield was recorded with FYM @ equivalent to recommended N (25 kg) + 75 : 40 kg P_2O_5 : K_2O/ha, which was at par with FYM @ recommended N alone, 25 : 45 : 40 kg N : P_2O_5 : K_2O/ha + 10 t FYM/ha and all these treatments were significantly superior over control, during both the years of study. The same trend was observed in case of pooled mean.

Karki *et al*. (2005) conducted an experiment of Indian Agricultural Research Institute, New Delhi on maize and reported that application of 120 kg N + 10 t FYM per ha recorded significantly higher nutrient uptake of 111.54 kg nitrogen, 37.35 kg phosphorus and 87.51 kg potassium per ha than other treatment combination.

Application of FYM @ 15 t/ha + NPK @ 75:75:50 kg/ha + panchagavya @ 3 per cent foliar application (T_{10}) recorded the highest nutrient content of 2.88, 0.32 and 3.12 per cent N, P and K, respectively and uptake of 80.47, 8.94 and 87.18 kg/ha of N, P and K, respectively (Sanjutha *et al.*, 2006).

Gosavi (2006) after conducting the field trial at Aspee foundation, Thane on sweet corn reported that significantly higher uptake of N, P and K by the crop in kernel, stem and leaves under the combination of polythene mulches and RDF than the remaining treatment

combinations.

Gosavi (2006) after conducting the field trial at Aspee foundation, Thane on sweet corn reported that the combination of RDF and 20 t FYM ha^{-1} the uptake of nutrients *i.e.* N, P and K was significantly higher under this combination than the other combinations.

Quality characters:

Kamalakumari and Singaram (1996) reported after a field trial conducted at Coimbatore on maize that reducing sugar, total sugars, crude protein, starch, total carbohydrates and phenol percentage improved under application of 100 kg N : 40 kg P_2O_5 : 40 kg K_2O along with 10 t FYM per ha than rest of the treatment combinations.

Wagh (2002) reported after a field trial conducted at College of Agriculture, Pune on sweet corn that protein content in grain and green fodder, sucrose content in grain and Brix reading of grain were though not affected significantly but slightly improved under application of 100 per cent RDF (225:50:50 Kg NPK per ha) + 5 t FYM per ha + Azatobactor + PSB than other fertilizer and FYM levels.

Application of FYM @ 15 t/ha + NPK @ 75:75:50 kg/ha + panchagavya @ 3 per cent foliar application (T_{10}) recorded the highest andrographolide content 1.31 per cent and yield 8.11 kg/ha followed by FYM @ 15 t/ha + panchagavya @ 3 per cent foliar application (Sanjutha *et al.,* 2006).

Pinjari (2007) undertaken the field experiment during 2005-06 and 2006-07 to find out the effect of integrated nutrient management on sweet corn and revealed that protein content (%) was maximum with 75 % RDN + 25 % N as PM, which was significantly superior over rest of the nutrient sources.

Economics

Chandrashekara *et al.* (2000) conducted the field experiment in Arabhavi, Karnataka during the *kharif* season of 1996 and reported that the application of poultry manure (10 t/ha) with recommended rate of fertilizers (RRF 150 kg N/ha in three split doses) resulted in higher net returrns (Rs. 8875/ha) and benefit cost ratio (11.51). The net returns and benefits obtained were lowest in vermicompost due to the high cost of vermicompost (Rs. 2000/t).

Sahoo and Panda (2000) conducted trials on farmers' field for two consecutive years 1996 and 1997 at Joshipur, Orissa. The results showed that net returns of Rs.10100 per ha was recorded maximum with FYM @ 5 t/ha + 80 : 40 : 40 kg NPK/ha over 80 : 40 : 40 kg NPK/ha alone and control, during both the years of study.

Khadtare *et al.* (2006) carried out the research work at college farm of Anand Agricultural University, Anand during *rabi* season of 2005-06 and reported that significantly higher values were recorded in respect of green cob and green fodder yield, indicated the maximum net return in treatment T_{10} (Rs. 68,565 /ha) (RDF 150:50:0 NPK/ha) followed by T_4 (Rs. 65,833 /ha) (75 % RDN + 25 % N through VC prepared from *Parthenium hysterophorous* L.) and T_6 (Rs. 63,310 /ha) (75 % RDN + 25 % N through VC prepared from *Amaranthus spinosus* Linn.).

Pinjari (2007) undertaken the field experiment during 2005-06 and 2006-07 to find out the effect of integrated nutrient management on sweet corn and revealed that The cost of cultivation, gross returns, net returns were maximum with the 75 % RDN + 25 % N as PM as compared to other nutrient sources during both the years. However, B : C ratio was maximum with RDN as compared to the other nutrient sources.

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