



# Nutrient Management in Organic Baby Corn Production: A Review

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## ABSTRACT

The concept of organic agriculture is receiving increased attention and organic food markets are also expanding quite fast in many parts of the world including India. Development of production technology particularly appropriate nutrient management strategy for organic baby corn is necessary for realizing higher yield and economic returns as well as soil health aspect. Most of the organic manures are low in nutrient contents, which are not sufficient to meet the nutritional requirement of the crops with smaller quantities, especially when inorganic fertilizers are not applied. Under such circumstances, enrichment of organic manures and composts with permitted additives like rock phosphate and beneficial microbial cultures is a feasible option for nutrient supplementation in organic food production. Microbial enrichment technique with bio-inoculants to composting material had been shown to improve the quality of compost. The enrichment of the organic manures with beneficial microbial cultures will further contribute to the enhancement of N and P contents through nitrogen fixation and phosphate solubilization. Hence, the enriched organic manures and their combination provide an ideal nutrition strategy for the crop. There is the possibility of increasing the nitrogen content of compost by inoculation with nitrogen-fixing organisms and the phosphorus content by the inoculation with phosphate solubilizing bacteria. Improved manures will play a major role in organic farming since the method of production is simple and easy.

**Key words:** Baby corn, Enriched compost, Fortification, Organic farming, Yield.

Maize (*Zea mays* L.) is the third most important cereal crop next to rice and wheat and has the highest production potential among the cereals grown in the country. Maize cobs harvested before fertilization within 3 to 5 days of silk emergence are referred to as baby corn. It is a dual purpose crop which provides green cobs for human consumption and fodder for livestock which is ready within a period of 65-75 days after sowing. Baby corn is cultivated on a commercial scale in many parts of the world. Of late, attention is being paid to explore its potential in India. Maize, being an exhaustive crop, much attention is required in its nutrient management especially while growing under organic cultivation. The literature available on nutrient management under organic mode in baby corn cultivation is quite limited and technology generation in this line has started now only. This is very true in the North Eastern region, because cultivation of the crop is relatively new.

Organic manures are the natural materials that decompose into the soil and enrich by providing energy for growth of microorganisms. These are the valuable by-products of farming and allied industries derived from plants and animal resources. The intensive cropping systems were posing a serious threat to sustainable agriculture due to depletion of soil nutrients at the same time polluting the soil and water due to injudicious use. At the same time, supply of all the essential nutrients through chemical fertilizers is not always affordable for the small farmers.

The concept of organic agriculture is receiving increased attention and organic food markets are also expanding quite fast in many parts of the world including India (Garibay and Jyoti, 2003). Expansion of the organic market makes it possible for farmers to reap the benefit of a trade with higher price premiums (Ummyiah *et al.*, 2017).

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Growing awareness of the health and environmental issues associated with the intensive use of chemical inputs has lead to interest in alternate forms of agriculture globally. In contrast to this, organic agriculture is a good management system for ensuring a healthy agro-ecosystem, including concerns on biological cycles, biodiversity and soil biological activity (Srinivasan, 2014).

The use of chemical fertilizer may be helpful in achieving maximum yield of baby corn but keeping present scenario of sustainability, soil and public health in mind, the need was felt to standardize green technology for production of safe baby corn production through supplementation of the nutrient requirement through biofertilizers and organic manures. Continuous application of chemical fertilizers pose health hazards and reduces a microbial population in soil, besides being quite expensive and thereby making the cost of production high. Under such circumstances, biofertilizers and organic manures may play a major role. Development of production technology, particularly appropriate nutrient management strategy for organic baby corn is necessary for realizing higher yield and economic returns (Saha *et al.*, 2007).

Most of the organic manures are very low in nutrient contents, which are not sufficient to meet the nutritional requirement of the crops, especially when inorganic fertilizers are not applied (Manna *et al.*, 2001). Under such circumstances, fortification of organic manures and composts with permitted additives like rock phosphate and beneficial microbial cultures is a feasible option for nutrient supplementation in organic food production.

Balanced use of nutrients through organic sources like farmyard manure, poultry manure, vermicompost and biofertilizers are prerequisites for sustaining soil fertility and producing maximal crop yields with optimal input levels (Kumar *et al.*, 2017). Composting organic residues with rock phosphate and bio-fertilizers may help to solubilize phosphorus and to increase phosphorus availability to plants. Nitrogen-fixing bacteria, besides fixing N, solubilize P due to the production of enzymes (Kumar and Narula, 1999).

Microbial enrichment technique with bio-inoculants to composting material had been shown to improve the quality of compost (Borah *et al.*, 2014). The enrichment of the organic manures with beneficial microbial cultures will further contribute to the enhancement of N and P contents through nitrogen fixation and phosphate solubilization. Hence, the enriched organic manures and their combination provide an ideal nutrition strategy for the crop. There is the possibility of increasing the nitrogen content of compost by inoculation with nitrogen-fixing organisms and the phosphorus content by the inoculation with phosphate solubilizing bacteria, (Kaushik *et al.*, 2008).

#### Effect of Bio-fertilizers on quality compost preparation

Bio-fertilizer is a gift to our modern agricultural science. Bio-fertilizers are applied in the agricultural field as they make unavailable nutrients into available form. Conventional manures contain compost, household wastes and green manure. Those are not as effective as chemical fertilizers. So, chemical fertilizers are mostly used by the farmers for crop development. But obviously, the chemical fertilizers are not environment-friendly and they destroy the fertility of the soil in a long run. Scientists have developed bio-fertilizers to make this world healthy for everybody in a natural way. Quality compost making is possible by simply mixing and incubating with compost before application to the soil. It helps in early release of plant nutrients for use by crops.

Bio-fertilizers are nothing but mass of living or inactive strains of phosphate solubilizing, nitrogen-fixing microorganisms treat to soil, seed or composting areas with the objective of increasing number of such micro-organisms and accelerate those microbial processes which augment the availability of nutrients that can be easily assimilated by plants (Mazid *et al.*, 2011). Bio-fertilizers play a very significant role in improving soil fertility by fixing atmospheric nitrogen, both, in association with plant roots and without it, solubilize insoluble soil phosphates and produces plant growth substances in the soil. The role and importance of bio-fertilizers in sustainable crop production have been reviewed by several authors.

#### Importance of biofertilizers in maize cultivation

Synthetic fertilizers cause hazardous effects like contamination and pollution of the soil, water basins and harm micro-organisms and beneficial insects, making the crop more susceptible to diseases and degrade soil fertility. It is predicted that by 2020, to attain the projected production of 321 million tons of food grain, the necessity of nutrient will be 28.8 million tons, while their availability will be only 21.6 million tons with a deficit of about 7.2 million tonnes (Panpatte *et al.*, 2018). On the other hand, the long-term usage of bio-fertilizers is eco-friendly, economical, productive, more efficient and accessible to marginal and small farmers over chemical fertilizers (Mahdi *et al.*, 2010).

Bio-fertilizers offer a safe option to utilize renewable inputs to improve the fertility of land using biological wastes with those beneficial micro-organisms which supply organic nutrients to the farm produces. Ebrahimipour *et al.* (2011) reported that significant increase of soil nutrients was observed due to use of bio-fertilizer and they concluded that non-chemical sources of crop nutrition provide a reliable alternative to chemical fertilization in organic crop production. Meena *et al.* (2013) identified that the integrated use of bio-fertilizers offers a cheaper low capital intensive and eco-friendly route to boosting farm productivity.

*Azotobacter* is a free-living aerobic diazotrophic (with the ability to use N<sub>2</sub> as the sole nitrogen source) microorganism commonly occurring in soil. *Azotobacter chroococcum* among various species is the most commonly occurring species in Indian soil (Sudhaker *et al.*, 2000). In India, about 33% of the trials were conducted on the use of *azotobacter* inoculation on crops. The beneficial effect of the microorganism in different crops was established in all these studies.

The occurrence of the organism has been reported from the rhizosphere of a number of crop plants such as rice (*Oryza sativa* L.), maize (*Zea mays* L.), sugarcane (*Saccharum officinarum* L.), bajra (*Pennisetum glaucum* L.), vegetables and plantation crops (Mazid *et al.*, 2011). They do not, however, produce any visible nodules or outgrowth on root tissues. These are non-symbiotic free-living aerobic bacteria possessing the highest respiratory rate and can fix N up to 25 kg ha<sup>-1</sup> under optimum conditions and increase yield up to 50%. These fertilizers have been successfully used in wheat (*Triticum aestivum* L.), maize, cotton (*Gossypium arboreum* L.), pearl millet (*Pennisetum glaucum* L.) and paddy, though their response depends upon the amount of organic matter available in the soil.

Most of the Indian soils are low to medium in P status and the efficiency of phosphate fertilizers is also low due to fixation of a large fraction of applied P into sparingly soluble inorganic phosphates. Such soluble phosphorus is taken up easily by plants resulting in 10-20% increase in the yield of almost all the crops. Several reports have examined the ability of different bacterial species to solubilize insoluble inorganic phosphate compounds, such as tricalcium phosphate, dicalcium phosphate, hydroxyapatite and rock

phosphate. Among the bacterial genera with this capacity are *pseudomonas*, *bacillus*, *rhizobium*, *burkholderia*, *achromobacter*, *agrobacterium*, *flavobacterium* and *erwinia*. P is both native in soil and when applied in inorganic fertilizers, becomes mostly unavailable to crops because of its low levels of mobility and solubility and its tendency to become fixed in the soil. The phosphate solubilizing bacteria are life forms that can help in improving phosphate uptake of plants in different ways. The soil bacteria belonging to the genera *Pseudomonas* and *Bacillus* and Fungi are more common.

#### Effect of organic manures in baby corn production

The application of organic manure on soil not only improve the crop productivity but also sustain and maintain the productivity and some of the beneficial importance of organic manure are reduction in the cost of cultivation, production of highly nutritious food without residual toxicity which can deteriorate human health and also maintain ecological balance. Moreover, the number of micronutrients present in organic manures may be sufficient to meet the requirement of crop production (Lalith *et al.*, 2013). The release of available N and other nutrients from organic sources is slow and difficult to predict. Furthermore, there ought to be temporary variation due to nutrient cycling in microorganisms or plant roots (Jacoby *et al.*, 2017). Organic manure have long residual effect which slowly released and stored for a longer time in the soil (Baghdadi *et al.*, 2018). Wailare (2012) has revealed that the use of organic manure (FYM, poultry manure) on sweet corn field resulted in a significant increase in yield.

Further, Ghosh *et al.* (2013) reported that upon inoculation with effective microorganism and organic fertilizer application, sweet corn showed better growth, grain yield as well as an increase in root growth and activity. Nitrogen being the major constituent of chlorophyll, therefore, increase in nitrogen availability leads to an increase in chlorophyll content. Besides the supply of major nutrients, organic manures also stimulate plant growth by producing growth stimulating substances (enzymes, antibiotics and growth hormones) available in vermicompost.

#### Effect of FYM in baby corn production

Application of FYM is always beneficial for improving nutrient use efficiency along with improvement in the water holding capacity of soil, especially under rainfed ecosystem. FYM which is organic in nature plays a great role in improving the crop yield and soil productivity (Tisdale *et al.*, 1990) and has a significant influence on the physical and chemical properties of soil. Their beneficial effects are ultimately reflected in the grain yield of the crop. Brar *et al.* (2001) while working at Punjab, reported that growth characters and yield increased significantly from 10 t ha<sup>-1</sup> to 30 t ha<sup>-1</sup>. Sankhyan *et al.* (2001) in a field experiment at Himachal Pradesh reported that dry matter accumulation; LAI and plant height of maize recorded a significant increase with application of 10 t FYM ha<sup>-1</sup> over no FYM application. Plant

height and dry matter content of maize were found to be significantly higher in a field experiment conducted at Salooni and Bangalore through the application of 10 t ha<sup>-1</sup> FYM more than 5 t ha<sup>-1</sup> FYM as well as control treatment (Karki *et al.*, 2005). Application of FYM to maize showed positive influence on leaf area index, dry matter production and various yield components on silty loam soil at Palampur, Himachal Pradesh. Jayaprakash *et al.* (2004) reported that the highest grain and straw yield was obtained with organic treatments compared to no organic treatment. Application of 20 t ha<sup>-1</sup> FYM resulted in significantly higher maize number of leave as well as dry matter production over 10 t ha<sup>-1</sup> as well as control (Joshi and Chilwal, 2018).

Bhat *et al.* (2013) reported that the organic material increased maize growth with the best responses @ 20 t ha<sup>-1</sup>. In a field trial conducted at University of Agricultural Sciences, Dharwad main research field on maize revealed that application of FYM resulted in significantly higher grains and stover yield than vermicompost as well as control (Pattanashetti *et al.*, 2002). Srinivasan (1992) reported that application of FYM 10 t ha<sup>-1</sup> increased the cob length from 11.6 cm (control) to 19.9 cm at Vamban, Tamil Nadu. Khanday *et al.* (1991) reported that FYM significantly increased the yield attributes of maize. Kumar and Puri (2001) reported that application of 15 t ha<sup>-1</sup> in maize resulted in maximum cob length. Verma *et al.* (2003) reported that FYM increased all yield attributes significantly over control. The above findings reveal that various yield attributing characters show significant improvement with increasing rates of FYM application (15-20 t ha<sup>-1</sup>) in maize.

#### Effect of vermicompost on baby corn production

Vermicomposts are organic materials broken down by interactions between micro-organism and earthworms in a mesophilic process, to produce fully stabilized organic soil amendments with low C:N ratios (Ramasamy *et al.*, 2011). In organic farming the application of organic manure especially vermicompost is recommended. It is eco-friendly, non-toxic, consumes low energy input for composting and is a recycled biological product (Lourduraj and Yadav, 2005). Vermicompost is a good substitute for commercial fertilizers and has more N, P and K than normal heap manure (Nasab *et al.*, 2015). The favourable effect of vermicompost on growth might be attributed to the presence of relatively readily available plant nutrients, growth-enhancing substances and number of beneficial organisms like nitrogen-fixing, phosphate solubilizing, cellulose decomposing and other beneficial microbes as well as antibiotics, vitamins and hormones, etc. (Nehra *et al.*, 2001). The higher availability of nutrients especially nitrogen and phosphate in vermicompost and improved soil physical, chemical and biological properties might have contributed to higher yields (More, 1994). The use of vermicompost helps in maintaining soil fertility since the mineral elements contained in it were changed to forms more that could be readily taken up by plants such as nitrates, exchangeable phosphorous, soluble potassium, calcium, manganese etc.

On the other hand, the increase in growth parameters may be attributed to the presence of growth hormones, enzymes and other secretions of earthworms which could stimulate the growth and development of the crop. It has been demonstrated that vermicompost contains many humic acids which improve morphological traits of the crop and thus increases the leaf number, leaf area index, stem diameter, plant height and reduces the period of slow growth (Atarzadeh *et al.*, 2013).

Jayprakash *et al.* (2004) observed that among different sources of organics, application of vermicompost @ 2 t ha<sup>-1</sup> resulted in significantly higher plant height (181.23 cm), number of leaves (6.95), higher dry matter production in maize compared to no organics and was on par with the application of FYM @ 10 t ha<sup>-1</sup> (179.21 cm) on clay loam soils of RARS, Raichur. Channabasanagowda *et al.* (2008) have also shown that the differential action of vermicompost may be because of the fact that the vermicompost has a slow release of nitrogen due to slow mineralization which helps in the availability of nutrients to the plants throughout the growth of the plant and thus resulting in higher growth. Field studies conducted by Jayprakash *et al.* (2004) on clay loam soils of Raichur revealed that grain yield of maize increased significantly in treatment which received vermicompost (67.47 q ha<sup>-1</sup>) and was found on par with the treatment which received FYM (65.22 q ha<sup>-1</sup>).

The enrichment of vermicompost with PSM and FNF significantly increased N, P and K contents (Padmavathiamma *et al.*, 2008). Math (2013) reported that population of FNF and PSB were highest in FNF, PSB and rock phosphate enriched vermicompost. The nutrient status of enriched organic manures has supported the better establishment of a population of PSB and FNF in enriched vermicompost. The population of inoculated organisms (PSB and FNF) was highest in microbially enriched organic manures due to microbial and rock phosphate enrichments as reported by Rao *et al.* (2013).

#### Effect of poultry manure in baby corn production

Poultry manure is solid and liquid excreta consists most abundant nitrogen compound (40-70 % of total N) like uric acid or urate, while urea and ammonium are present in minute amounts (Amanullah *et al.*, 2010). The positive effects of bio-fertilizer and poultry manure on plant growth as observed in this study have also been reported by some workers (Nwangburuka *et al.*, 2012) using various organic amendments. They found that inoculated plants with organic amendments showed higher growth characteristics than uninoculated ones. Several workers have reported the similar effect of fertilizer on crop nutrients availability and yield (Geeta *et al.*, 2013). However, results were better obtained when bio-fertilizers were combined with organic amendments (Babajide *et al.*, 2012). Positive growth response of inoculated plants could be due to the provision of nutrients especially nitrogen and growth promoting hormones by *Azospirillum* and enhanced uptake of

phosphorus and other nutrients due to mycorrhizal colonization (Bama and Ramakrishnan, 2010).

Enujeke (2013) studied the effects of poultry manure on growth and yield of improved maize in Asaba area of Delta state, Nigeria and found the positive response of maize to poultry manure and reported that poultry manure contained basic nutrients required for enhancing growth and yield of crops. Poultry manure had been reported to improve growth and yield of maize (Ezeibekwe *et al.*, 2009). Combined application of bio-fertilizer and poultry manure @ -pp;5 t ha<sup>-1</sup> (bio-organic) significantly produced the plants with desirable growth parameters; plant height, numbers of leaves plant<sup>-1</sup>, leaf area, shoot and root dry biomass, followed by bio-fertilizer and poultry manure.

Amujoyegbe *et al.* (2007) reported that poultry dropping increased root growth of maize and the crop extracted soil water more efficiently for increased grain yield. Poultry manure was identified to be the most concentrated in nutrient content among all the organic sources (Biratu *et al.*, 2018). Ogbonna *et al.* (2012) noted that poultry dropping plays significant roles in enhancing the yield of crops in the southern part of Nigeria. Akinrinde *et al.* (2006) founded that poultry manure enhanced higher leaf area in maize plant over combined application of both poultry manure and bio-fertilizers. Farhad *et al.* (2011) reported that 8 t ha<sup>-1</sup> of poultry manure resulted in significantly higher grain yield, dry matter and increased leaf area of maize.

#### Effect of enriched compost in baby corn production

Natural phosphate rocks (RP) have been recognized as a valuable alternative for P fertilizers. In India, it is estimated that there are almost 260 million tons of phosphate rock deposits and this material will provide a cheap source of phosphate fertilizer for crop production (FAO, 2002). Unfortunately, RP is not readily available to the plants in soils with a pH >5.5–6.0. Because of this, extension services are reluctant to recommend it and farmers are hesitant to utilize RP directly. The direct application of rock phosphate (RP) as a fertilizer is an easy and comparatively cheap way of adding P to the soil. However, RP is an insoluble inorganic form and its solubility is related to many factors, including soil properties, plant species and soil microorganisms. One approach for solubilization of RP in field conditions is the application of phosphate-solubilizing Micro-organisms (PSM). Kaur and Reddy (2014) reported that Inoculation of PSB together with RP fertilization significantly increased the growth parameters such as shoot height and shoots and root dry biomass compared to RP fertilization singly and DAP treatment. Majeed *et al.* (2015) reported that the use of microbial inoculants improves nutrient supply to crops. For instance, RP becomes soluble to plants by microorganism activity in the soil through the production of organic acids (Rashid *et al.*, 2004).

Lime is a good soil amendment to reduce the soil acidity and increase the soil pH and thereby enhances the nutrient availability. However, due to its high rate of application results in increase in the cost of cultivation. So, other option to

reduce the rate of application is essential. One of the suitable options is the combined application of lime with FYM, which is cost effective. Studies on effect of enriched compost with lime and ash on field crops are very limited. Kumar *et al.* (2015) reported that the application of lime @ 1.0 t ha<sup>-1</sup> increased the cob, corn and fodder yield significantly to the tunes of 15, 9.81 and 15.36%, respectively over the control. Hence the liming is an important management practice in acid soil (Kovacevic and Rastija, 2010). Lime, as CaCO<sub>3</sub>, was applied at a rate of 2 t ha<sup>-1</sup>, which was determined as the approximate liming requirement of this soil in a laboratory experiment. This treatment was included to test the effects of increasing soil pH on maize shoot biomass (Opala, 2011). Chandrakar and Jena (2009) studied the effect of fly ash and soil amendments to maize crop on soil reaction, dehydrogenase and urease activities, soil microbial biomass carbon and yield in Alfisols. They reported that the integrated use of lime+fly ash+FYM resulted in 66 % higher dehydrogenase activity, maximum microbial biomass carbon and also maximum grain yield. Considering the huge amount of organic manure requirement in organic farming, possible cheaper sources must be explored to minimize the cost of production in organic baby corn production.

## CONCLUSION

Baby corn is gaining popularity in many states of India because of its shorter duration and demand in food market. In states like Assam, Baby corn is rather a new introduction to the crop production system, so efforts are required to standardize and economize its cultivation. Need was felt to standardize organic production technology for baby corn through supplementation of the nutrient requirement through organic manures and bio-fertilizers. A viable nutrient management is very important for bringing more area under organic baby corn production. Fortification of FYM with lime and ash is one of the good options for organic baby corn cultivation. Lime is a good soil amendment to reduce the soil acidity and increase the soil pH and thereby enhances the nutrient availability. Considering the high cost of enriched compost, the improved manure fortified with low cost materials like lime and ash may be a cheaper option for organic baby corn production. Since the method of production is simple, fortified enriched compost will be a suitable nutrient supplement in organic baby corn production in the small and marginal farmers of the state.

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