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IMPORTANCE OF NITROGEN APPLICATION IN CROP PRODUCTION – A BRIEF REVIEW

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ABSTRACT
The combined application of different kinds of fertilizers to soils has resulted in steady increase in agricultural crop production and from the times when green revolution took place our grain production has almost doubled. For increased crop production and for the overall maintenance of soil fertility the role of synthetic fertilizers cannot be ignored. Each synthetic fertilizer whether it is nitrogen, phosphorus or potassium has a definite role to play for the physiological improvement of crop produce and the deficiency of any of these is sure to have its deleterious effect not only on soil fertility but for the growing crop as well. In order to maintain the proper ratio of these nutrients particularly N P K in soil, the application of all these at optimum levels is of paramount importance. Inorganic fertilizer plays a critical role in world food security, but it must be recognized that highest yields are in some systems the result of using both organic and inorganic nutrient sources. Adoption of the 4R principles, right nutrient source at the right rate, right time, and right place-help in ensuring appropriate use of nutrient resources and optimized productivity. However it is equally important that these macro nutrients are not applied in abundance as their excessive application damages soil microbial complex thus resulting in depleted availability of other micronutrients and as such stunted growth of crops. The utility of nitrogen in crops is reviewed.

KEY WORDS: Nitrogen, crop production.

INTRODUCTION

Nitrogen is the most indispensable nutrient required by the plants for their luxuriant growth. The importance of nitrogen is underlined by the fact that it is not only the major component of chlorophyll but also the major component of amino acids which are the building blocks of proteins. It is also the significant component of nucleic acids such as DNA, the genetic material that allows cells to grow and reproduce. Healthy plants often contain 3-4% N in their above ground tissues. This is a much higher concentration as compared to other nutrients in plants. Despite N being one of the most abundant elements on earth, N deficiency is probably the most common nutrition problem affecting plants. Plants with roots restricted by soil compaction also show signs of N deficiency even when adequate N is present in soil. Most plants take N from soil continuously throughout their life. N demands usually increases with increase in plant size. A plant applied with adequate N grows rapidly and produces large amount of succulents. The nitrogen deficit plant is generally small and develops slowly because it lacks N necessary to manufacture adequate structural and genetic material. The plant leaves are usually pale green or yellow because of lack of adequate chlorophyll. The older leaves often become necrotic and ultimately they die as plant moves nitrogen from less important older tissue to more important younger one. On the other hand some plants may grow so rapidly when supplied with excessive N that they develop protoplasm faster than they can. Such plants often become weak and may also lead to mechanical injuries. As such the application of nitrogen balance in soil for the maintenance of soil health is of utmost importance for soil fertility management.

Importance of nitrogen in plants

Fixen *et al.* (2005) observed that the global data describing efficiencies of nitrogen (N), phosphorus (P) and potassium (K) for major cereal crops from researcher-managed plots suggest that only 40 to 65% of the N fertilizer applied is utilized in the year of application. The first-year use efficiencies for potassium range from 30 to 50%, while those for phosphorus are lower (15 to 25%), in view of the complex dynamics of phosphorus in soils. Cheng *et al.* (2014) conducted a pot experiment and observed that the total nitrogen concentration in soil and the nitrate concentration in lettuce increased as the amount of nitrogen fertilizer increased. Roberts (2008) observed that applied phosphorus remains available to crops over long periods of time, often for a decade or longer. The common values for nitrogen efficiency on farmer-managed fields are less encouraging. When not properly managed, up to 70 to 80% of the added nitrogen can be lost in rain-fed conditions and 60 to 70% in irrigated fields.

Modern maize hybrids take up more nitrogen from the soil after pollination than older hybrids. Ensuring adequate nitrogen supplies in the later part of the growing season can be important for attainment of full yield potential. In some cases, a benefit to delayed application of nitrogen and use of nitrification inhibitor has been found to increase N uptake, yield and N use efficiency (Burzaco *et al.*, 2014). Nitrogen is an essential element required for successful plant growth. Although inorganic nitrogen compounds (*i.e.*, NH_4^+, NO_2^-, and NO_3^-) account for less than 5% of the total nitrogen in soil (Brady and Weil, 2008).

Once nitrogen fertilizers are applied to agricultural systems, they are absorbed directly by plants or converted into various other forms through the oxidation process. Excess nitrogen is lost in ionic or gaseous form through leaching, volatilization, and denitrification (Tamme *et al*, 2009). The phytoavailability of the nitrogen pool increases when excess nitrogen is applied, and this increase intensifies the potential threat to the surrounding environment (Sharifi, 2011). There are close relationships between the excessive application of nitrogen fertilizers and environmental problems such as eutrophication, the greenhouse effect, and acid rain (Wang *et al.*, 2002). Ikemoto *et al*., 2002 observed that consuming contaminated groundwater or crops with a high concentration of nitrate has negative effects on human health. Rationalizing fertilizer application is an important issue for sustainable agriculture because it can reduce the negative effects of farming on the surrounding environment Zebarth *et al*., 2009).

An agricultural system should include yield and environmental quality during management. Green leafy vegetables contain the highest nitrate levels (Prasad and Chetty, 2008). Because consuming high levels of nitrate may further lead to severe pathologies in humans. Cultivating edible crops with low nitrate content is very important (Mensinga *et al.*, 2003).

The Joint Expert Committee of the Food and Agriculture (JECFA) Organization of the United Nations/World Health Organization and the European Commission (EC) Scientific Committee on Food have also set an acceptable daily intake for nitrate of 0–3.7 $mg \cdot kg^{-1}$ body weight (Santamaria, 2006). Hartwar *et al*. (2003) reported that iron is a component of ferredoxin and is associated with chloroplast. It helps in photosynthesis and results in better vegetative growth. The continuous use of chemical fertilizers and amendments for more than three decades in maize-wheat system in an acid Alfisol of Western Himalayas brought out marked depletion in the pools of all the micronutrient cations compared to uncultivated (buffer) plots (Sambhavi, 2011). The pools of Fe, Mn, Zn and Cu were noticeably higher in the plots dressed with organics and inorganics (100% NPK + FYM) compared to the plots receiving no fertilizers for about 36 years (Sambhavi, S. 2011).

In a study by Dolui and Mondal (2007) on different forms of iron in some Inceptisols, Alfisols and Ultisols of Mizoram and M.P., it was found that mean contents of Fe were found to be in descending order as follows: dithionite> oxalate > pyrophosphate > ammonium acetate > KCl extractable. Behera *et al.*(2009) studied the effect of continuous cropping an on-going long-term experiment in New Delhi, India with maize and wheat on soil characteristics and various forms of micronutrient cations in an Inceptisol over the years and reported a decrease in concentrations of all four metallic cations bound to organic matter, in addition to Fe and Zn associated with carbonates in all the treatments in surface soil.

Different forms of iron in soil under a long term experiment with maize-wheat cropping sequence was studied by Behera and Singh (2010) in the alkaline soils of IARI, New Delhi and reported that DTPA-extractable Fe did not differ significantly among the treatments as a result of continuous cropping for more than three decades. The overall mean total iron (Fe) content varied from 2.36 to2.61% under different treatments. Residual Fe constituted a major portion of total Fe in all the layers of soil. The Fe associated with easily reducible Mn and organic matter contributed directly to DTPA-extractable Fe both in pre-maize and post-wheat soil. Driven by the fast expansion of irrigation and fertilizer consumption and the adoption of improved seeds and best management practices, which triggered a significant increase in the yields of major crops, agricultural production has grown between 2.5 and 3 times since the beginning of the 1960s (FAO, 2011). A gradual increase in CEC due to graded levels of NPK was also recorded probably due to higher content of crop residues (Jeegdeshwaripv *et al.*, 2001). Agbenin (2010) studied the extractability and slow reactions of Cu and Zn in a weathered savanna soil under pastures and revealed that sequential extraction of added copper and zinc indicated that between 26 and 30% of the total Cu and between 19 and 30% of total Zn were associated with organic matter.

The *et al*. (2006) studied the effect of amendments on grain yield of maize and after four years it was found that continuous application of amendments to acid soil resulted in higher grain yield as compared to plots without amendments. Prasad *et al*. (2010) conducted a long-term experiment to study the influence of integrated nutrient management on productivity of maize-wheat cropping system in an acid Alfisol (pH 6.5) of Jharkhand and concluded that grain yield of maize and wheat increased significantly with the increase in NPK levels. Tabassum *et al*. (2010) monitored the changes in organic carbon due to conjoint use of inorganic fertilizers and organic manures under soybean-wheat system in a Typic Haplustert (pH 7.8) of Bhopal and reported that continuous application of chemical fertilizers in conjunction with organic sources maintained initial status of soil organic carbon after 4 years of cropping. An increase in number of grains per spike, 1000 grain weight and number of spikes in wheat with the application of zinc either as basal or foliar was reported by Pahlavan-Rad and Pessarakali (2009) in the soils of Iran.

Dhiman (2007) observed an increase in Zn-III and Zn-IV fractions with the application of fertilizers under Palampur conditions. Singh *et al*. (2010) found that, application of 40 kg N + 40 kg P_2O_5ha-1was optimum for fenugreek as it significantly improved growth, yield attributes, nutrient content and uptake, net returns and benefit :cost ratio over 20kg N + 20kg P_2O_5ha-1and the control. Therefore the soil fertility results in higher available N and P content during harvesting. Sammauria *et al*. (2011) reported that, application of 26.2kg P ha-1and 7.5kg Zn ha-1to fenugreek significantly increased the content and uptake of P and Zn. However, increasing levels of either of these two nutrients was found to have depressive effect on content and uptake of other nutrients by fenugreek. Combined application of 26.2 kg P ha-1+ 7.5 kg Zn ha-1resulted in the highest yield of the crops.

Parte (2013) reported that the highest content and uptake of nutrients like N, P, K and micronutrients Fe, Mn, Zn, Cu and Cl was found in treatment where application of 25% effluent along with organic manures and inorganic fertilizers was applied in case of okra in lateritic soil of Konkan. Jilani *et al*. (2008) conducted field experiment on effect of different nitrogen levels on growth and yield of cucumber, and observed that the application of nitrogen @100 ha-1produced maximum fruit weight and number of fruits per plant (35.5). Waseem (2008) studied the effect of different nitrogen levels on growth and yield of cucumber (*Cucumis sativus* L.) at Pakistan during 2006 and noted that six levels of nitrogen (0, 20, 40, 60, 80 and 100kg/ha) and the application of 100kg N produced maximum fruit weight (152.2 g) and vine length (3.08m) which are ultimately contributing in the yield. However 80 kg N was found to be the most economical dose for obtaining higher number of fruits (15.22) and ultimately higher yield of cucumber (13.9 t/ha).

Jilani (2009) from field experiment on effect of different levels of NPK on the growth an yield of hybrid cucumber reported that application of NPK fertilizer (100-50-50) showed the best performance in almost all the parameters viz. maximum fruit per plant (35.5), maximum fruit weight (136.03 g) and yield per hectare (60.02) tons. Application of NPK fertilizers @ 120-60-60 kg ha–1also showed some beneficial effect on some parameters including fruit weight (150.69g) and vine length (3.85 m), respectively. Parmar *et al.* (2011) studied the response of cucumber to chemical fertilizer and biofertilizer at Navsari agriculture universities in 2007 and observed that application of 75% recommended dose of fertilizer +*Azospirillum* + PSB (T7) recorded the maximum vine length (330.75cm), and also yield of cucumber per plot (18.87 kg/plot) and per hector (23590.31 kg/ha) of cucumber over rest of the treatments. Fadhil Hussein and Ridha (2011) from his field experiment on hybrid cucumber he concluded that recommended dose of fertilizers (T3) (260 kg Urea per ha with 340 kg super phosphate with added 100 kg K per ha K_2O) produced maximum yield of hybrid cucumber. Zhang *et al.*, (2011) studied the effect of irrigation and nitrogen fertilization under subsurface drip irrigation in solar greenhouse on yield and quality response of cucumber and observed that among the different nitrogen fertilization levels (N1300 kg ha-1, N2 450 kg ha-1, and N3600 kg ha-1) recorded maximum weight of cucumber fruits over rest of the treatments.

Zhaopeng Ou Yang *et al.* (2013) conducted field experiment on effect of different nitrogenous fertilizers types and application measures on temporal and spatial variation of soil nitrate-nitrogen in cucumber and observed that application of 300 kg/hm^2 (N2) urea produced the maximum yield (87228.97 kg/hm2) of cucumber as compared to other treatments. Zhaopeng Ou Yang *et al*. (2013) studied the effect of various nitrogenous fertilizers and their levels on Big-arch shelter cucumber yield and water use efficiency at Beijing. The results indicated that the application of 350 and 550 kg/ha urea caused significant increase in yield of cucumber. Arshad *et al.*, (2014) conducted field experiment on effect of different levels of NPK fertilizers on the growth and yield of greenhouse cucumber (*Cucumis sativus*) by using drip irrigation at Abu Dhabi and observed that the application of NPK dose 1000 g fertigation-1was found to be the mos suitable dose to produce the maximum fruit per plant 34.435, maximum fruit weight 134.670 grams and yield per hectare 58.820 tons over rest of the treatments.

Shinde (2014) reported that maximum number of fruit per vine, yield per vine, and yield per hectare were significantly influenced when high dose of 64 fertilizer (250:100:50 NPK/ha) was applied over rest of the treatments in cucumber. Dodake *et al.* (2015) conducted field experiment on the effect of integrated nutrient supply system on nutrient uptake by bitter gourd and changes in soil properties in lateritic soils of coastal region of Dapoli and observed that the treatment receiving 50 per cent recommended dose of fertiliser through inorganic fertilizer + 50 per cent poultry manure registered the higher pH value (6.14). Akther *et al.* (2015) studied the effect of prilled urea, urea and NPK briquettes on the yield of bitter gourd and they observed that the treatment receiving application of urea briquettes registered the highest value of Phosphorus uptake (29.07, kg ha-1) and total nitrogen uptake (139.9kg ha-1). Cimpeanu *et al.* (2013) studied the influence of fertilization system on the quality of cucumber and observed that the application of inorganic fertilization caused variation in acidity from (0.28% to 0.40%.) The soluble chemical fertilizer was found to produce maximum ascorbic acid (19.70 mg/100 g) content.

Zheng *et al.* (2016) studied the long-term effects of controlled-release urea (CRU) on crop yields and soil properties which were investigated in lysimeters under wheat and corn rotation system from 2009 to 2014 in northern China. The CRU included polymer-coated urea (PCU), sulfur-coated urea (SCU), and polymer coating of sulfur-coated urea (PSCU) was applied at 147, 210 kg N ha–1 for wheat and 262.5, 375 kg N ha–1 for corn and the urea was applied at 210 kg N ha–1 for wheat and 375 kg N ha–1 for corn. Results showed that the N release characteristics of three kinds of CRU in field condition were all closely matched to the N requirement of crops. Consequently, the CRU treatments improved wheat and corn yields by 3.2 to 10.1% and 4.9 to 11.1%, increased apparent N use efficiency by 45.9 to 53.8% in wheat, and 36.2 to 45.4% in corn, respectively, compared with urea. Furthermore, the PSCU achieved the highest and the most stable crop yields among CRU. Even reducing CRU rate by 30% produced the same yields as with the 100% rate of urea. In addition, soil total N and organic matter contents in CRU were effectively increased in the topsoil of 0 to 20 cm after 5 yr. Therefore, long-term application of CRU had great potential to increase wheat–corn yields, N use efficiency, reduce application frequency, improve soil fertility, decrease the leaching of soil NO3—N and NH4+–N, and also relieve soil pH decreased.

Satish *et al*. (2011) observed that among various treatments, where ever combination of both organic and inorganic fertilizers are used during Kharif season and 75 to 100% NPK through inorganic fertilizer during summer season has significantly improved the fertility levels when compared to all other treatments. Dash *et al*. (2010) revealed that the treatments were applied to rice crop during kharif season. Incorporation of chemical fertilizer enhanced the contents of micronutrients (Fe, Mn, Cu and Zn) in plants and, obviously, their uptake in plant and grain and straw at harvest in comparison to rest of the N sources**.**

Sohel *et al*. (2016) concluded that the phosphorus in rice grain ranged from 0.208 to 0.289% due to application of chemical fertilizers along with the cow dung or poultry manure. Mean maize yield was increased by 29.7 per cent under application of 20 kg S ha-1as compared to no sulphur application (Srinivasrao *et al*. 2010). Application of 100% recommended dose of nitrogen through chemical fertilizer gave significantly higher maize grain yield compared to 100% application through compost and 50% through chemical fertilizer and 50 per cent through compost (Sheoran *et al*., 2009). Paradkar *et al*. (2010) observed that application of 125 per cent of recommended dose of fertilizers (150 kg N, 26.4kg P and 33.3kg K_2O ha-1) tended to give significantly higher baby corn yield over recommended dose of fertilizer. Application of recommended dose of nutrients (120 +26 + 32kg ha-1ofNPK) gave significantly higher maize grain yield as compared to INM treatments involving curtailment of N (30-60kg ha-1)and subsequent addition of organics like FYM, seed inoculation with *Azotobacter* and green manuring of cowpea over application of 160 and 80 kgNha^{-1} (Kumar and Dhar, 2010).

Kumar (2008) conducted experiment at New Delhi to study nitrogen use efficiency of corn. Results of experiment revealed that application of 40, 80 and 120 kg Nha^{-1}tended to increase nitrogen uptake by 46.5, 78, and 99 per cent by maize crop. Application of 70 kg N, and 13 kg P_2O_5 ha-1through fertilizers resulted in significantly higher NPK uptake by maize crop in comparison to sole application of organics composted waste +stake cow dung (1:1) 10t ha-1or conjoint application of fertilizers and organics at half the sole dose (Makinde and Ayoola, 2010). Dwivedi *et al.* (2007) reported significant build up of available Zn due to zinc sulphate application. Addition of Zn along with 100% NPK significantly raised the level of available Zn content (1.33 mg kg-1) in the soil. Wang (2010) reported that soil potassium deficiency has been increasing over recent decades as a result of higher inputs of N and P fertilizers concomitant with lower inputs of potassium fertilizers in China.

Chun-e He *et al*. (2012) examined the effects of long-term potassium fertilization on crop yields and potassium use efficiency and balance under wheat -maize cropping system in the North China Plain (NCP). The application of potassium alone significantly improved maize yield by 46% but wheat showed no response. Majumdar *et al*., (2012) conduct on-farm potassium response studies in rice, wheat and maize, spread across the Indo-Gangetic Plains, highlighted that grain yield response to fertilizer potassium is highly variable and is influenced by soil, crop and management factors. Average yield losses in rice, wheat and maize in farmers' fields due to K-omission were 622, 715 and 700 kg/ha, respectively. Vinutha *et al.*(2008) also reported that effect of continuous use of chemical fertilizers in finger millet-maize cropping system. They observed that, the pH of soil decreased from initial value 6.2 to 5.2 in 100% NPK under continuous application of chemical fertilizers for 20 years. Maximum decrease was observed in 150% NPK (4.7) treated plots.

Sharma *et al.* (2007) revealed that continuous cropping of rice-wheat-cowpea in Mollisol for 31 years soil has not significant effect on pH under different fertilizer treatments but EC increased slightly from its initial value 0.29 dS m-1to 0.38 dS m-1in 150% NPK treated plot. Bholanathsaha *et al.* (2013) monitored the fate of applied P into its nutrition using a 40 years old long-term fertility experiment started since rabi 1968-69 with pearl millet-wheat cropping system for the present investigation during 2009 and 2010. All the water soluble phosphatic fertilizers (SSP, DAP, UAP) were found significantly superior over partially water soluble nitrophosphate (NP) and mineral acid soluble rock phosphate (RP) sources in terms of nutrients uptake by wheat. On an average, 45 to 55% increase of N, P and K uptake were found upon application of water soluble phosphatic fertilizers over mineral acid soluble sources viz. RP.

Bharmal (2008) revealed that, fertilizer formulation significantly influenced the plant growth, fruit yield and quality parameters. The fertilizer formulation NPK (30:10:10) required minimum days to fifty per cent flowering and recorded maximum number of branches per plant were significantly increased by NPK (30:10:10). Shaymaa *et al.*, (2009) reported that total fruit yield was significantly higher in 75 and 100% NPK fertigation (54.16 and 58.76 t ha-1) respectively than 50% fertigation rate, which accounted to 12and 22% yield increase, respectively. Patil (2008) reported that increasing dose of fertilizers caused increase in uptake of nutrients by banana plant. Recommended dose of fertilizers with 10 tha-1FYM resulted in to optimum nutrient uptake.

Shaymaa *et al.* (2009) reported that the higher uptake of NPK was the result of significantly higher dry matter production at 90 days after transplanting of tomato. Al-Mohammadi and Al Zubi (2011) carried out an experiment in greenhouse during winter season at Experimental Station, Al-Balqa University, Jordan to evaluate irrigation and fertigation levels on yield and quality of tomato crop. The results indicated that content of nitrogen, phosphorus and potassium in tomato leaf significantly increased with increase in levels of fertilizers and quantity of water. Imamsaheb *et al.* (2011) showed that higher uptake of nitrogen, phosphorus and potassium by tomato plant was recorded with 100% recommended NPK as compared with 75 and 50% recommended NPK

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