Evaluation of timing of nitrogen application in maize (*Zea mays L.*) grown on coarse loamy Typic Haplustepts soil of Punjab: A Review

ABSTRACT

Maize (Zea mays L.) is a species of Z. mays plant in the Poaceae family, the origin of maize is Mexico, where many diverse types of maize are found. The discovery of fossil maize pollen with other archaeological evidence in Mexico indicates Mexico to be the native of maize. Maize is widely grown all over the world. In 2014, the total world production was 1.04 billion tonnes. The maize plant can grow up to 3m (10 ft) In heights. Although some natural strains can reach a height of 13meters, the stem is typically made up of 20 internodes of 18 cm (7 in) length. The leaves sprout from the nodes and grow alternately on opposing sides of the stem, with complete edges. The stem's tip is capped with a tassel, which is an inflorescence of male flowers. When the tassel matures and the circumstances are warm and dry enough, the anthers on the tassel dehisce and release pollen. Maize pollen is anemophilous (dispersed by wind), and because of its high settling velocity, the majority of pollen falls within a few metres of the tassel. Every year, maize reproduces sexually. This randomly picks half of the genes from a particular plant to propagate to the next generation, which means that beneficial crop qualities (such as high yield or good nutrition) may be lost in the following generations unless specific strategies are utilised. In genetically modified (GM), maize was one of 26 GM crops produced commercially. Nano-fertilizer technology is meant to distribute nutrients in a controlled manner in response to crop needs, allowing nutrient usage efficiency to be enhanced without negative consequences. Maize was used as a model system to evaluate Nitrogen Nano-fertilizer formulations. Nanourea treatment consistently outperformed conventional urea in terms of growth, yield, quality, and nutrient absorption.

Keywords: Nano-fertilizer, Nitrogen, Maize pollen. Maize tassel.

Introduction

Maize (Zea mays L.) is the third important cereal crop in India after rice and wheat. It is sensitive to water logging that results in reduced yields of those grown in tropical and subtropical regions (Rathore et al., 1998). Total maize production of over 18% is often affected by floods and water logging problems in South and Southeast Asia (Zaidi et al., 2011), thereby causing substantial production losses (DMR 2001). However, average yield losses of up to 30% are reported each year in maize production in India (DMR 2001). The early growth phase of maize development from the second leaf stage to the seventh leaf stage is the most susceptible phase during water logging condition (Zhang et al., 2015).

Maize (Zea mays L.) belongs to the family Poaceae, the 3rd most important cereal crops in the world after rice and wheat. It originated in Mexico where its oldest known ears could be traced back to about 7000 years ago (Mangeisdorf et al., 1964). The crop has a wider range of uses. These include the following: human food, industrial processed food, production of starch and used as forage to feed animals. Maize with its large number of cultivars and different maturity periods has a wider range of tolerance to different environmental conditions (Purseglove, 1972).

Maize is called ‘queen of cereals’ as it is grown throughout the year due to its photo-thermo-insensitive character and highest genetic yield among the cereals. Being a C4 plant, it is very efficient in converting solar energy into dry matter. Over 85% of the maize produced in the country is consumed as human food. The importance of maize lies in its wide industrial applications besides serving as human food and animal feed. Green cobs are roasted and consumed by people with great interest. Maize seed contains 10% protein, 4% oil, and 2-3% crude fiber. Several food dishes including chapattis are prepared out of maize flours and grains. Green maize plants are used as succulent fodder. Popping corn is a method of starch cookery. Maize is a raw material for a number of products viz., starch, glucose, dextrose, sorbitol, dextrin, high fructose syrup, molto, dextrin, germ oil, germ meal, fiber rand gluten products which have applications in industries such as alcohol, textile, paper, pharmaceuticals, organic chemicals, cosmetics and edible oil. Maize has got very high yield potentiality and wide adaptability under various agro climatic conditions than any other cereal crop (Singh, 2014).

Maize yield is a function of climate, soil variety, and cultural practices. Correlating these functions to produce the highest possible yields with the greatest efficacy has been the aim of research workers ever since maize production began. Since there is a limited scope to increase the area under maize cultivation because of competition from other cereals and commercial crops, the only alternative is through enhancement of productivity by various management factors. Among the factors limiting the yield of maize in many areas is inadequate irrigation and low plant population (Reddy, 2017). In India, maize is grown in diverse environments from the dry area of Chitradurga, Karnataka, to the warm wet plateau of Chindwara (M.P). Since maize is largely grown under rain-fed conditions during the rainy season, the crop is sown with the onset of the monsoon. Sowing window of maize occurs during 1st fortnight of June to the 1st fortnight of July depending upon the onset of the monsoon.

Maize yields during winter are higher than yields during the rainy season. During winter, maize enjoys a favourable environment of cool temperatures, clear sky, and higher solar radiation interception with less infection of insect pests and there by better yields (Joshi et al., 2005). Maize crop possesses great genetic diversity and can be grown across varied agro-ecological zones (Ferdu et al., 2002). The variation in the crop growing environment modifies the microclimate to which the plants are exposed and it is responsible for biomass production and ultimately yield It is necessary to understand the knowledge of plant-environment interaction for increasing the yield of crops. Phonological development of the crop closely followed the changes in weather conditions occurring during the crop growing period. Therefore, a detailed study of crop phonological events in maize would provide a base for understanding different growth and developmental processes as related to weather parameters. The crop growing environment leads to changes in the crop micro climate, which has a direct influence on plant growth and development and resource utilization (Hugar and Halikatti,2015).

The leaf area and canopy structure are important growth parameters for forage production. The optimum leaf area index for grain production is considerably less than that for maximum dry matter production. Goldsworthy et al. (1974). Grain yield was severely reduced due to the low rate of P application. In the case of Nepalese soils, the levels of these nutrients are reported to be continuously declining. Improvement of the yield attributed characters due to higher N levels and split P application stimulated the grain yield. Masood et al., (2011) and Jones et.al, (2003).

The split doses of P had contributed to higher grain yield over the same dose of P applied in the basal dose. Increase in grain yield of maize significantly with increased N levels might be due to the greater contribution of nitrogen for producing healthier, strong and vigorous grains more. Onasanya and Zaman Khan et al. (2009).The application of potassium improves leaf area index, dry matter accumulation, and other algometric parameters. The enhanced growth due to potassium application was due to several roles of K in crop plants that might help in increasing plant height and leaf area index control. The important reasons might be increased root growth (Valadabadi and Farahani, 2009).

The purpose of this review is to learn how nano fertilizers are used in maize crops on the course loamy Typic Haplustept soil of Punjab.

Importance of maize as a staple food

Maize is an important food crop not only because it is consumed worldwide, but also due to its nutritive value. Maize provides more carbohydrates than wheat and sorgham do, and it is a good source of phosphorus (Adeyemo, 1984; Brandes, 1992) and it also contains small amounts of calcium, iron, thiamine, niacin and fat (Adeyemo, 1984). “food security is a state reached when all people at all times have access to adequate amounts of safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life” (FAO, 2008).

Maize breeding is led by the International Maize and Wheat Improvement Centre (CIMMYT) and International Institute of Tropical Agriculture (IITA) in conjunction with NARES in South Africa to make bio-fortified crops. Germ-plasma screening discovered genetic variation for the target level (15 ppm) of pro vitamin A carotenoids in temperate maize, which was then bred into tropical varieties. Recent developments in marker-assisted selection technology have been the increased efficiency and accuracy of identifying genes controlling the traits of interest for enrichment of pro vitamin A in maize. Naqvia et al.(2009).

It is a good source of starch, protein, and fat, accounting for 72% starch, 10% protein, and 4% fat, supplying an energy density of 365 Kcal/100 g compared with rice and wheat (Nuss and Tanumihardjo 2010). Bio-fortified studies in maize began with evaluation in animal models, which all showed very encouraging results. Since traditionally bred, maize did not have high levels of pro vitamin A at the start of the Harvest Plus project (Pixley et al., 2013).

Maize, providing an estimated 15% of the world's protein and 20% of the world's calories (Brown and others 1988), is a dietary staple for more than 200 million people. This number can be expected to grow as the world's population approaches 8 billion in 2025 (Lutz and others, 2001; USDA 2009), indicating maize's status as a paramount crop in the context of global nutrition.

Effectiveness studies after biofortified maize is broadly introduced and disseminated are needed to measure its impact on vitamin A status under normal market conditions as well as the generational effects of feeding β-carotene enhanced staple crops to population groups (Tanumihardjo, 2010). Therefore, maize that has quality protein, enhanced zinc, and increased pro vitamin A carotenoids may supply better nutrition than any single nutrient approach for populations that have high maize takes.

Highest yields are typically found in areas where corn takes 130 to 140 d to mature (Benson and Pearce 1987). Today, maize is grown on 156 million hectares per year in nearly 100 countries within 40◦S to 58◦N latitude and all longitudes (Brown and others, 1988; FAO 2009).

Proteins from cereals including normal maize, has poor nutritional value because of reduced content of essential amino acids such as lysine and tryptophan leading to harmful consequences such as growth retardation, protein energy mal-nutrition, anaemia, pellagra, free radical damage etc. As a consequence, the use of maize as food is decreasing day by day among health-conscious people (Graham,G.Getal1990).

Importance at the international level of maize

Maize is grown over a wider range of altitudes and latitudes than any other food crop, under temperatures ranging from cool to very hot, on wet to semi-arid lands, and in many types of soils. The global area for maize (average for 2008–2010) is about 150 million ha. The corresponding average annual production was over 750 million metric tons.

People across Asia depend on maize, rice, and wheat, but these staple crops do not meet daily dietary requirements and are deficient in essential vitamins (such as Vitamin A) and micro nutrients such as iron and zinc. Nearly 200 million children, younger than five years, are under nourished with protein, which is a major national challenge. In this context, maize could play an important role worldwide. (Graham, G.G.etal1990).

Maize is one of the most important food crops in the world and together with rice and wheat, provides at least 30% of the food calories to more than 4.5 billion people in 94 developing countries. In parts of Africa and Mesoamerica, maize alone contributes over 20% of food calories.(Bekele Shiferaw 2011).

Major maize production areas are located in temperate regions of the globe. The United States, China, Brazil and Mexico account for 70 per cent of global production. India has 5per cent of maize acreage and contributes 2 percent of world production

(Tripathi K. K et al., 2011).

Maize currently covers 25 million ha in sub-Saharan Africa, largely in smallholder systems that produce 38 million metric tons, primarily for food (Smale et al., 2011). Maize had become important in smallholder agriculture in Africa both as a subsistence and as a cash crop. The construction of infrastructure, and especially railways, further encouraged the expansion of smallholder maize cultivation. The nearly complete change in the diets of tens of millions of Africans from traditional sorghum and millet to maize in less than two generations represents an almost unprecedented transformation in food production and consumption patterns (Byerlee and Heisey, 1997).

Importance at national level of maize

Maize (Zea mays L.) is an important cereal crop of india. It is a source of nutrition as well as phyto-chemical compounds. Phyto-chemicals play an important role in preventing chronic diseases. It contains various major phyto chemicals such as carotenoids, phenolic compounds, and phytosterols. (Tajamul Rouf Shah et al. 2016).

Indian Scenario maize is the third most important food grain following wheat and rice. About 28 percent of maize produced is utilized for food purpose but 11 per cent for livestock feed, 48 percent for poultry feed, 12 per cent in wet milling industry (for example, starch and oil production) and 1 per cent as seed goes in India.

Maize is an essential source of various phyto-chemicals that play an important role in our health (Kopsell et al., 2009). There is an inverse correlation between the consumption of phyto-chemicals and the development of chronic diseases. The phyto chemicals in whole grains have received less attention and sometimes been underestimated. The research has suggested that phyto chemicals in grains due to their potent antioxidant activities, demonstrate a significant beneficial contribution in reducing the risk of many diseases (Liu, 2007; Madhujith & Shahidi, 2007; Shahidi, 2009).

Maize grain, especially the yellow variety, contains large quantities of carotenoid pigments and has a vital significance in the diet as human beings are not able to biosynthesize carotenoids. These pigments are also beneficial in preventing cancer (Michaud et al., 2000).

Importance at State Punjab level of maize

The maize production in Punjab in 2012-13 was 4.71lakh metric tonnes, and the total area under the crop was 1.29lakh hectares (Department of Food Processing, Punjab 2013). With an average productivity of 3,650 kg/ha, farmers cultivating maize made substantial profits that year. The strategy of the (Department of Agriculture, Punjab2014).

Maize can be grown over a range of agro-climatic zones and this quality makes it a versatile crop. Maize is suitable to be grown in diverse environmental conditions which is not possible for any other crop. It is grown from58°N to 40°S, from below sea level to altitudes higher than 3000 m, and in areas with 250 mm to more than 5000mm of rainfall per year.(AICRP 2007).

Maize can play an important role in the crop diversification policy of the state. It is used in poultry and animal feed and for the manufacture of starch, glucose, and cornflakes. It is also used as a human food (Makki di roti) in the winter season.

A permanent maize scheme (staff scheme) is also being implemented to enhance maize production in the state. An amount of Rs. 18.67lac was allocated under this scheme and an expenditure of Rs. 17.81lac was incurred to implement the scheme. Maize crop is mainly sown in the districts of Hoshiarpur, Roopnagar, Shaheed Bhagat, Singh Nagar, Amritsar, Gurdaspur, Jalandhar, Kapurthala, Patiala, Ludhiana, SASNagar and Fatehgarh Sahib in the state. Traditionally, maize was grown as kharif crop and now sowing during Rabi season has also been started in some districts with the invention of new varieties. It is now possible to raise spring crops in Hoshiarpur, Shaheed Bhagat, Singh Nagar, Jalandhar, and Kapurthala. Maize production campaign was launched to boost production. Main emphasis was laid on popularization of high-yielding varieties of maize of P.A.U. which are given as under:- Long Term Varieties PMH-1, F-9572-A, Parbhat, Kesari Short Term Varieties PMH-2, JH-3459, Punjab Sathi-1 Fodder Varieties JH-1006 Popcorn Varieties Pearl Popcorn, Punjab Sweet Corn.

Research on Growth curve of maize plants

Growth curve model is very useful for investigating growth problems in a short time, especially in agricultural crops. Growth functions have been used to provide a mathematical summary about time data on the growth of an organism or parts of an organism (Thornley and France, 2007).

Statistical model is often insufficient to know in more detail about the characteristics of the plant growth as it just tests whether there is a different effect of treatment on the plant variable. There were several studies about some non-linear growth models in describing plant growth, for example, describing the leaf growth model of maize. In the case, the result showed that the best fitted growth model such as: Richards, Logistic and Gompertz (Karadavut et al., 2010). And it is also said that plant height is a key indicator of plant growth and is linked to N nutrition during vegetative of corn development (Yin et al., 2011)

Highest growth rate for maize has been registered in the last one decade among all food grains including wheat and rice because of newly emerging food habits, consumer awareness about health as well as enhanced industrial requirements. (Murdia L.K et al., 2016)

Role of major nutrients in the nutrition of maize (N,P,K) :

Maize(Zea mays L.) are the major ones that are considered as stable food across the globe due to their high nutritional significance enriched with abundant amount of macronutrients like starch, fibre, protein and fat along with micronutrients like B-complex vitamins, ß-carotene and essential minerals, i.e. magnesium, zinc, phosphorus, copper, etc. (Shikha Bathla, Manpreet Jaidka, and Ramanjit Kaur, 2019).

In addition to NPK soil application, micronutrients can be used as foliar applications. In this concern, balanced nutrition leads to an efficiency increment of all nutrients applied and, thus decreasing the amount of fertilizers used. Concerning the NPK balanced fertilization and micronutrients to maximize maize yield, the results obtained by El-Fouly (1984) were confirmed the important role of balanced fertilization.

The plant material was digested using an acid mixture consisting of nitric per chlorin and sulphuric acid in the ratio of 8:1:1 (v/v), respectively (Chapman and Pratt, 1978). Nitrogen (N) was determined in the dry plant material using the boric acid modification described by (Ma and Zuazage,1942), and distillation was done using a Buechi 320-N2-distillation unit. Phosphorus was photo-metrically determined using the molybdate vanadate method according to Jackson,1973.

Nitrogen is an essential nutrient for maize and a key determinant of grain yield, particularly through its role in photosynthesis and other biological processes such as absorption of water and minerals, vacuole storage, and xylem transport. (Aziiba Emmanuel Asibi et al. 2019).

Phosphorus is important for stimulating root and shoot growth and promoting vigorous seedling growth. Potassium is important for corn growth because it helps increase disease resistance andwaterstresstolerance. Adequate K increases the ability of cornplantsto efficient uptake other nutrients.

Plants require P for growth throughout their life cycle, especially during the early stages of growth and development. Phosphorus is integral to the conversion of solar energy to chemical energy that plants need to synthesize sugars, starch, and proteins. It is essential for the transfer of energy, produced through photosynthesis, to be used for growth and reproduction.

Iffico nano fertilizer

Maize is an exhaustible crop that demands high nutrition for their growth and development. The productivity of the crop depends on the nutrient management systems. Inorganic fertilizers are most widely used all over the world as it gives higher yield and the end result is also much appreciable. Efficient use of nitrogen is important for maize production as it increases the yield and maximizes economic return and minimizes NO3 leaching to the ground (Mohammadi GR et al.,2009).

Application of IFFCO Nanourea fertilizers and IFFCO sagarika through foliar spray as an alternative to soil application of fertilizers in combination with synthetic fertilizers through soil application for maize was very effective in enhancing the yield and yield attributing parameters as well as recorded maximum BC ratio. One litre IFFCO Nano N replaces 100 kg of urea, hence the use of nano fertilizer reduces economic burden on the government investment for the production of direct fertilizers, enhancing the socio-economic status of the farming community by reducing the cost of production. (K. Ajithkumar et al. 2021). IFFCO Nano Urea is the only Nano fertilizer approved by the Government of India and included in the Fertilizer Control Order (FCO). It is developed and Patented by IFFCO. Application of 1bottle of Nano Urea can effectively replace at least 1 bag of Urea. It has been tested on more than 90 crops across 11,000 locations in collaboration with ICAR- KVKs, Research Institutes, State Agriculture Universities, and progressive farmers of India. When sprayed on leaves, Nano Urea easily enters through the stomata and other openings and is assimilated by the plant cells. It is easily distributed through the phloem from source to sink inside the plant as per its need. Unutilized nitrogen is stored in the plant vacuole and is slowly released for proper growth and development of the plant. Small size (20-50 nm) of Nano Urea increases its availability to the crop by more than 80%.

Integrated nutrient management in maize

INM aims to maintain or adjust soil fertility and supply plant nutrients to an optimal level for sustaining crop productivity through the integration of the benefits of all possible sources of plant nutrients. INM significantly improved the yield and yield traits of maize. (Almaz Meseret Gezahegn 2021).Integrated nutrient management (INM) is a method that helps to sustain agricultural production and protect the environment for future generations. It may be defined as the application of soil fertility management practices that maximize fertilizer and organic resource use efficiency to enhance crop production (N. Sanginga and P. L. Woomer 2009).

This practice includes the judicious use of appropriate types of chemical fertilizers and organic resources; it combines both organic and inorganic nutrient sources to achieve higher crop productivity, prevents soil degradation, and improves soil-water infiltration, thus helping to meet future food supply (C. Chen et al. 2004). The organic sources besides supplying N, P, and K also make unavailable sources of elemental nitrogen, bound phosphates, micronutrients, and decomposed plant residues into an available form to facilitate to the plant to absorb the nutrients. However, it is also the fact that the optimum yield level of maize production can’t be achieved by using only organic manures because of their low nutrient content. Efficacy of organic sources to meet the nutrient requirement of the crop is not as assured as mineral fertilizers, but the joint use of chemical fertilizers along with various organic sources is capable of improving soil quality and higher crop productivity on long-term basis. Highest productivity of crops in a sustainable manner without deteriorating the soil and other natural resources could be achieved only by applying an appropriate combination of different organic manures and inorganic fertilizers (Chandrashekara et al., 2000).

Conclusion

The primary biophysical reason of low agricultural output in developing nations is soil fertility loss. The application of inorganic fertilisers is critical for maintaining soil fertility. Nonetheless, the greatest problem of employing inorganic fertiliser is the high cost of inorganic fertilisers mixed with the low income of resource-poor farmers in developing nations. The application of organic manure can help to preserve soil organic matter, give balanced nutrients to the current crop, and leave a large residual nutrient to succeeding crops in a cropping system. Crop residue retention on farms is also beneficial to soil organic matter and crop productivity. However, because organic sources have a poor nutritional value, a large number of organic sources are necessary. The integration of diverse nutrition sources has been shown to be more successful in different parts of the world than the mere use of chemical fertilisers or organic manures. The technique not only increases crop yield, but it also preserves and sustains soil productivity, and it is a cost-effective strategy for poor nations.

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