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Enhancing Maize Productivity through Nitrogen Application Methods and Timing in Pakistan

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Abstract

Agriculture sector plays an important role in the economy of Pakistan and is one of the major determinants of the economic growth and well-being. It contributes about 21% to Gross Domestic Product (GDP) and employs 45% of labor force. Majority of the population i.e-62% belongs to rural areas, and their livelihood directly or indirectly depends on agriculture. Poor nutrient management is one of the key factors contributing to decline in the productivity of maize in Pakistan. This review article is mainly focus on role of nitrogen and its application methods in growth, development, and production of the maize. Despite the fact that maize productivity is relatively better than other major cereal crops, its current maize productivity is still far below its potential productivity. The rate, time and method of nitrogen (N) fertilizer application are among the major abiotic factors limiting the productivity of the crop and are strongly related to growth, development, and yield of the crop. Nitrogen affects various physiological and biochemical processes in plant cells that ultimately affect the growth and development of the plant. Crop yield increases up to certain limit and declines if applied in an excess amount of nitrogen. Proper nitrogen application at proper growth stages and sufficient amount are need to be necessary for higher grain yield of maize. This review will serves for maize researchers to enhance maize productivity through nitrogen application timing and methods.

Keywords: Maize; Nitrogen; Timing; Method; Growth and yield

Role of Nitrogen in Maize Production

Poor nutrient management is one of the key factors contributing to decline in the productivity of maize. Nitrogen (N) deficiency is the key constraints in Maize production [1,2]. N is a vital plant nutrient that determines the yield; important for maize production [1]. A sufficient quantity of N throughout the growing season is a must for optimum maize growth. It plays an important role in plant growth as an essential constituent of cell components and require for the synthesis of chloroplast, amino acids, proteins and cell division [3,4]. The maize kernel is composed of approximately 72% starch, 10% protein, 5% oil, 2% sugar, and 1% ash with the remainder being water [5]. Maize is a plant that requires a high quantity of nutrients due to its enormous nutrient utilizing capacity. A higher volume of nitrogen is required for higher yield. Nitrogen is required in a more significant amount than other nutrients. The use of nitrogen fertilizers results in higher biomass and protein yield and increases the concentration of protein in the plant tissue [6]. Maize plants deficient in N will develop poor root system, which reduces their anchorage capacity [7]. When nitrogen deficiency occurs, maize will be stunted, photosynthesis gets reduced and consequently has a profound influence on grain yield. Reduced N is also associated with lower protein content of seeds and vegetative parts [8,9]. Also, low level of N causes early maturity which results in a significant reduction in yield and quality. Further, N deficiency in maize may develop thin and spindly stems which could be prone to lodging by wind. Nitrogen regulates the efficiency of the use of nutrients in the plant. The nitrogen affects various physiological and biochemical processes in plant cells and, ultimately, affects growth and development [10]. Nitrogen uptake by the maize plant increases its concentration in both the plant or in the grain due to the higher total dry matter content.

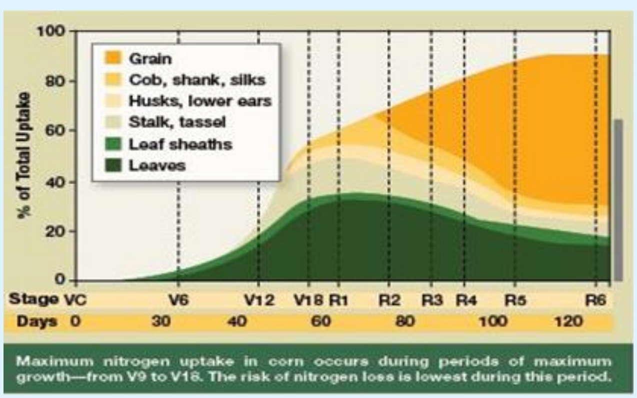

Figure 1: Timing of Nitrogen Uptake in Corn

Maize Response to Foliar Nitrogen Application

Modern technologies for maize production require a soil fertilization to be combined with application of foliar fertilizers [11]. Soil fertilization, and particularly the nitrogen fertilization, may be reduced by means of additional application of foliar biologically active fertilizers [12]. Foliar fertilization is a widely used practice to correct nutritional deficiencies in plants caused by improper supply of nutrients to roots [13]. Hu Y, et al. observed the foliar nitrogen application to determine the effect of foliar N on dry land wheat [14]. A field experiment was conducted during 2010-11 with randomized complete block design using four replications. The application of 80 kg N ha^{-1} applied in urea form, 70 kg N ha^{-1} at sowing time while 10 kg N ha^{-1} in the form of spray having (2 % N). The remaining N was given with different combination at various growth stages (30, 60, 90 and 120 days) after emergence. The yield was enhanced with foliar N over control. The experiment resulted that foliar application of 2 % in a single split or 120 DAE in dry land condition could increase wheat productivity. Bhattarai EM, et al. conducted research to determine the response of foliar fertilization, drought and salinity on the growth of maize [15]. At green house maize were planted in soil with drought and salinity after 23 days of sowing. The expanding leaves, dry weight of the blades, plant height, shot biomass length and fresh weight were investigated at harvest stage with element and minerals like (Na, K, Ca, Mg, P and N) in each leaf were analyzed. The minimization occurred in evapotranspiration, maize growth, shoots fresh and also in dry weight and leaf fresh and dry weight under salinity and drought and the foliar fertilization failed to enhance growth of plant under drought and salinity stress. The saline condition is responsible for plant reduction because of osmotic and no exchange on the concentration of nutrient in leaves.

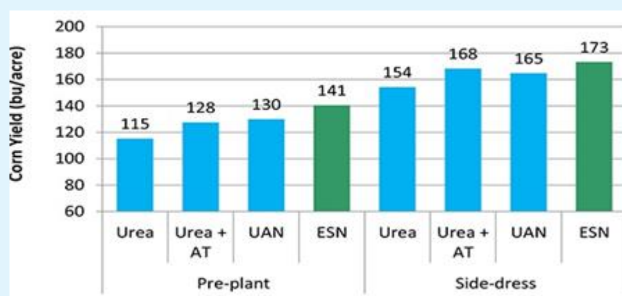

Figure 2: N Source and Timing Comparisons

Time and Methods of Nitrogen Application in Maize

The timing of nitrogen application affects the yield [16]. Use of nitrogen in early plant growth improves yield and improves vegetative growth and development, and when is given in later stages of plant growth, late maturity and maturation cannot adequately promote the final yield. Although the level of nitrogen in the grain increases, it is used in later growth stages [17]. Diallo AO, et al. found that the application of nitrogen fertilizer @ 80 kg N/ha gave higher benefit cost ratio (1.5) [18]. Thakur DR, et al. found that during the sowing, earthing up and silking stages, the nitrogen applied at 3 equal divided doses to 60 kg/ha, maximized the yield of corn grain [19]. Hati N, et al. found that leaf senescence got increased due to smaller leaf area and less photosynthesis due to nitrogen deficiency [20]. Yadav DN, found that increment of amount of Nitrogen applied results more leaf number and thicker stem [21]. Leaf area and leaf number significantly increased by both rate and application of Nitrogen [22].

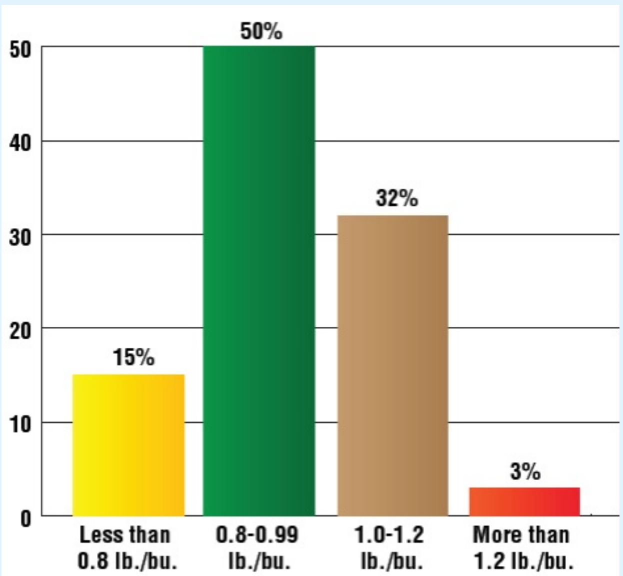

Figure 3: How Much Nitrogen Do you Plan to Apply vs. Your Target Corn Yield?

Growth and Yield of Maize Effected by Nitrogen

Adhikari P, et al. also found earlier silking occurred due to a higher percentage of Nitrogen applied [23]. Sherchan DP, et al. found that the application of higher nitrogen dose (200 kg N/ha) gave the highest number of cobs/plant (1.09), cob length (15.90 cm), cob diameter (5.10), number of grains/grain row (32.54,the number of grain rows/cob (14.11), number of grains/cob (459.9) and the greatest test weight (318.2g) and shelling recovery (72.14%) [24]. Adhikari P and Dawadi DR also reported that response of nitrogen and its application time to maize differs due to genetic characters, growing season (winter, spring, and summer), maturity period (early and full season), and growing domain (mountain/hill and Terai) [23,25]. Muza L, et al. found a higher application rate of Nitrogen effectively increased kernel number per ear and kernel rows number per cob [26]. A higher level of Nitrogen (180 kg N/ha) improved seed yield to 2.85 t/ha of inbred (NML-1) maize [27]. Hati N, et al. found that the commercial maize hybrids require high nitrogen levels and fertile soils and hybrids are more responsive to nitrogen fertilizer [20]. Plant population ranging between 69,000 and 81,000 plants/ha, showed a significantly higher uptake of nitrogen than the 57,000 plant population/ha observed during 12 leaf and tasseling stages [21]. Hanway JJ, founded that use of nitrogen in early plant growth improves yield and improves vegetative growth and development, and when is given in later stages of plant growth, late maturity and maturation cannot adequately promote the final yield [28].

Conclusion

The amount of nitrogen fertilizer varies with soil and environmental condition as well as genetic architecture of plants. The nitrogen uptake in grain increases with application of increased level of nitrogen up to 150 kg N/ha applied in soil. The application of nitrogen up to 200 kg N/ha increased the growth traits, yield and yield attributing traits. This study suggests that recommended nitrogen application as basal dose at planting stage, split doses at critical growth stages namely knee high, and flowering stages should be applied for enhancing maize production. The nitrogen is essential for physiological and biochemical processes that ultimately affects growth and development.

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