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Impact of Nutrients on the Development and Yield of Fodder Maize (*Zea mays* L.): A Review

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ABSTRACT

Maize (*Zea mays* L.), is one of the most important and multipurpose crops, different environmental condition is suitable for maize crop growing and has miscellaneous uses as animal feed and human food. Maize not only provided energy but also provided protein, crude protein, crude fibre, *etc*. All macro and micronutrients affect different growth stages of fodder maize crops. Different doses of different nutrients affect differently over the plant enhancement and yield into fodder maize crops. Green fodder plays an important role as a feed of animal husbandry. Nutritious fodders are directly and primarily involved in the growth and production of the dairy department. As a nutritious and non-leguminous feed, fodder maize is the more significant green fodder. The growing time of maize is quick, with high dry matter accumulating, power and is a highly dainty fodder crop. Fodder maize holds adequate quantities of protein, minerals and annexes high digestibility as compared to legume and non-legume fodder crops. Fodder maize is use as silage for preservation due to the presence of high availability of soluble sugars in the early green stage. So, adopt proper macro and micronutrients with the proper dose which help the crop grow quickly and produce good quality fodder crops for animals.

Key words: Fodder maize, Nitrogen, Phosphorus, Potassium, Quality and Production, Zinc.

After wheat and rice, the 3rd most momentous crop as food grain is maize. It is use as a food grain crop side by side it is used as a vegetable and forage crop. India is considering as a 2nd largest producer of cereals after China. Animal husbandry and agriculture are economically, religiously and culturally involved with the interwind raggery in the society of humans and play a vital element in rural life with mixed farming and raring of livestock (Dagar, 2017). Manure, drought power, meat, fuel, rural transport and milk gets as a sources of existence for farmers and as insurance scheme against crop failure which gets from livestock (Downing *et al*., 2017). In the region of 70 per cent of household trust on agriculture and livestock division for their profession (Ghosh *et al.,* 2016). In accordance with 20th livestock enumerating 2019, the completed livestock production in India is 535.82 million, above from 4.6 percent from the form remunerating in 2012. India acts as a higher milk producer country in the world but the animal productivity is lower (1538 kg per annual) in comparison to the world wide mean (2238 kg per annual) due to a lack of animal feed supply or less fodder crop production (Vijay *et al*., 2018). India annexes a large number of livestock with head count is million and with colossal demography of livestock and as a result, producesa huge amount of milk. But present day, we are endurance from the everlasting poverty of milk side by side with wool and meat because of lower sprouting of livestock products due to lack of forage. The availability of forage is 488 million tonnes in contrast to the estimated requirements from 822 million tonnes (Sharma 2009). Only 4.4 per cent area of gross cultivated area is under the cultivation of fodder crops in India. If, we want to reduce the crisis of fodder crops, the alternative way is enhancing the yield of forage in aspecific area ina specific time. Before getting a higher yield, we should maintain the proper soil fertility status by applying the proper nutrients with optimum doses. Plants required 17 essential nutrients among them 14 mineral essential plant nutrient together with nitrogen, phosphorus, potash, magnesium, calcium, sulphur, boron, chlorine, nickel, iron, molybdenum, copper, zinc and manganese are supplied by inorganic and organic fertilizer (Van Maarschalkerweerd and Husted, 2015). And other 3 non-mineral essential plant elements including hydrogen, oxygen and carbon are attained from soil water and the atmosphere. The different nutrient has different functions during the period of growth and development of the crop.

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Nitrogen effect

Nitrogen is a more significant nutrient owing to any crop enhancement as well as fodder crop production. The vital role plays by nitrogen for consisting of different structural components like molecules, proteins, amino acids, chlorophyll and other different constituents. A deficient and excessive supply of nitrogen affects the enhancement and yield of crops adversely and also determined the crop yield in intensive agriculture. Crop yields have improved in a dramatic manner from the previous 50 years because of the usage of nitrogen fertilizer (Jiao *et al.,* 2016). Approximate, rate of nitrogen recovery in the crop is 30-40% during the season of growing. Optimizing the use of nitrogen fertilizer inputting technology which elevated the nitrogen utilization rate. In addition to breeding also try to improve new cultivars whose yielding power is high in the application of low nitrogen (Van Bueren *et al.,* 2017), which see the pathway of sustainable agricultural development (Lynch, 2019).

Growth and growth components

Different components affect the growth of crops like the number of leaves, plant height, stem diameter and leaf area of forage maize significantly affected with the use of nitrogen fertilizer (Boltro *et al*., 2022). Different growth analyses like leaf area index, leaf length, leaf width and growth rate increase by the application of nitrogen (Namakka *et al*., 2012). Improvement of photosynthesis pigments in maize crops by the application of nitrogen but, decreased in the chlorophyll a:b ratio in maize crops (Akram 2014). El-Mekser *et al*. (2015) proposed that maize yield improved by the application of optimum nitrogen supply. Paul *et al*. (2019) directed a field trial on fodder maize crop and concluded that different levels of nitrogen affect the growth parameter of fodder maize crops. The tallest height of the plant (204.9 cm) and higher leaves number in the unit of the plant (12.22) were obtained by applying of 200 kg nitrogen ha^{-1}as compared to lower plant height (155.4 cm) and lower leaves number in unit plant (10.56) in the application of 100 kg nitrogen ha^{-1}. Ahmed *et al*., (2017) described that applying of urea in higher concentrations had a negative impact on the growth of the plant. Khanna *et al*. (2019) compared with applying of azotobacter showed the best results and even the mixed application of FYM showed favourable crop enhancement and yield. Significantly increase number of plant leaves by the application of nitrogen in optimum dose (Khan *et al*., 2014). From Iran, Valdabadi and Farahani (2012) concluded that applying of nitrogen substance affects outstandingly the total dry weight (TDW), relative growth rate (RGR), leaf area index (LAI) and crop growth rate(CGR) of maize crop. The highest LAI (4.2), TDW (1910 g m^{-2}), CGR (31.2 $g.g^{-1}.\ m^{-2}\ day^{-1}$) and RGR (0.08 $g.g.\ day^{-1}$) were gained by the application of 520 kg urea ha^{-1}. Jena *et al*. (2015) proposed that the larger height of the plant (212.75 cm) and a higher leaf area index (3.89) were obtained from the application of 240 kg nitrogen ha^{-1} as compared to control treatments. Rihab *et al*., 2015 conducted a field experiment and explained about the effect of different levels of nitrogen in maize field under plant density (Table 1).

Yields and yield attributes

The yield of forage crops are significantly affected by nitrogen fertilization. The higher forage yield (70.38 ton ha^{-1}) of fodder maize was gained in applying of 200 kg nitrogen ha^{-1}as comparison with 150 kg nitrogen ha^{-1} and the lower forage yield (46.72 ton ha^{-1}) of fodder maize was gained with applying of 100 kg nitrogen ha^{-1} (Paul *et al.,* 2019). The same result was proposed by Khan *et al*. (2014) who concluded that highest yield was received by the application of nitrogen substance properly with the proper dose. Jena *et al*. (2015) from Andhra Pradesh, conducted an experiment on maize crop and proposed that the highest amount of dry matter produced (13432 kg ha^{-1}) by the petition of 240 kg nitrogen ha^{-1} respectively, while the lowest dry matter production (4022 kg ha^{-1}) was observed in the control condition. Kar *et al*. (2016) reported that higher dry matter (21.66%) and higher yield of dry matter (83.77 q ha^{-1}) were executed by the application of the proper recommended dose of fertilizer. From Andhra Pradesh, Reddy and Bhanumurthy (2010) proposed that fodder maize not only produces green forage yield but also it produces dry fodder and grain yield. And get higher stover yield (8.3 ton ha^{-1}) and grain yield (3.9 ton ha^{-1}) with the application of 240 kg nitrogen ha^{-1} in the three split doses (0,30 and 70 DAS). Kalra and Sharma (2015) conducted an experiment depending on the agro-climatic indices of fodder maize in Punjab and after completing their experiment they proposed that higher heat use efficiency (6.46 kg/ha °C day) and photo-thermal index (22.76°C days/ day) in the presence of higher nitrogen (120 kg ha^{-1}) application condition as compared to control condition, due to increasing the photosynthesis rate, as a result, increase the dry matter accumulation. At the same time, they concluded that lower accumulated photo-thermal units (19531°C days) and lower accumulated growing degree days (1427°C days) in the application of a higher dose of nitrogen (120 kg ha^{-1}) as compared to the control situation. As a result, increase the vegetative growth of the fodder maize crop and increase the green fodder yield. Rihab *et al.,* 2015 conducted a field experiment and explained about the effect of different levels of nitrogen in fresh-weight of maize plant (Table 2).

Table 1: Effect of several levels of nitrogen over plant density (plant ha^{-1}) of maize.

Treatment	45 DAS	60 DAS	75 DAS
0 kg N ha^{-1}	350584	317349	329109
54.7 kg N ha^{-1}	351985	349146	337427
109.5 kg N ha^{-1}	358868	342299	322516

(Rihab *et al*., 2015)

Table 2: Effect of several doses of nitrogen over fresh weight per plant (g) of maize.

Treatment	45 DAS	60 DAS	75 DAS
0 kg N ha^{-1}	30.465	62.88	79.18
54.7 kg N ha^{-1}	35.944	71.21	91.30
109.5 kg N ha^{-1}	41.674	75.06	116.16

(Rihab *et al*. 2015)

Qualities and quality attributes

Qualities and quality attributes are the most important factor for fodder maize crops. If animal feed shigh-quality'sfeed then they give a higher amount of output. So, produce high-quality fodder crops. Reddy and Bhanumurthy (2010) proposed that fodder maize consisted of high crude protein (1695 kg ha^{-1}) and uptake high amount of nitrogen (273.4 kg ha^{-1}) with applying of 240 kg nitrogen per hector in the three split doses (0, 30 and 70 DAS). Kar *et al.* (2016) proposed that the highest amount of carbohydrate (83.30%) present in fodder maize crop in the application of 100% recommended dose of nitrogen as compared to sugarcane (78.55%) and sorghum (73.18%). The highest carbohydrate present in maize crops means it has a high energy value as agreen fodder crop. Iqbal *et al.* (2014) indicated that when nitrogen was applied in organic and inorganic forms, it increases the qualities and quality attributes of fodder maize like protein content were improved to 8.43% which was higher as comparison with control treat ments. Htet *et al*. (2016) demonstrated the trialon forage maize and they concluded that higher percentage of crude protein and nitrogen-free extract in 70 DAS as compared to 90 DAS. Baghdadi *et al*. (2017) introduced to study the nitrogen and pre-sowing effects over the fodder attribute of corn and in that experiment, they saw that a higher percentage of crude protein (7.04), acid detergent fiber (27.64), total ash (6.02) and dry matter digestibility (58.41) was received in the applying of 360 kg nitrogen ha^{-1} as compared to the lower rate of nitrogen application (120 kg ha^{-1}). Meena *et al*. (2019) were assessed an experiment and concluded that an important effect over yield and crude fibre content depending on the different levels of nitrogen (Table 3). And also proposed that a highest percent of crude protein content (7.04%), crude fibre content (25.21%), crude protein yield (866 kg ha^{-1}), crude fibre yield (3143 kg ha^{-1}) and nitrogen content (1.17%) was obtained in the applying of 120 kg nitrogen per hector as compared to control condition.

Phosphorus effect

Phosphorus is deliberated as an indispensable nutrient for the development and growth of plants. Phosphorus as anintegrated portion of nucleic acid, metabolic activity and is necessary for respiration of cellular. Also it is engaged in moreenergy storages, sugar metabolism, CO_2 fixation, enzymatic reaction and transformation. Usages of unobtrusive phosphorus will help on the improving the yield ha^{-1}. Deficiency of phosphorus takes place into the animals when folders full of 0.10-0.12% phosphorusin feed (Black *et al*., 1949). Phosphorus is the most important plant growth supporting element after nitrogen and it is also an important second needy plant element as well as a nutrient.

Growth and growth components

Issa Piri (2012) proposed that application of a proper dose of phosphorus fertilizer along with a foliar spray of micronutrients significantly affects enhancement and development of plant. Bouras *et al.* (2021) studied that phosphorus fertilizer enhances the productivity of fodder maize irrigated with saline water and they suggested that in saline conditions increasing the phosphorus fertilization which helps the increasing all parameters of plant growth; the higher rate of all growth parameters were gained during the applying of 150 kg $P_2O_5$$ha^{-1}$. Jena *et al*. (2015) proposed that larger height of the plant (185.95 cm) and higher leaf area index (3.17) were obtained from applying of 100 kg phosphorus ha^{-1} namely compared to the control condition. Raskar *et al*. (2012) suggested that the height of maize plant increases with the increased rate of phosphorus fertilizer applications up to 80 kg ha^{-1}.

Yields and yield attributes

Jena *et al.* (2015) proposed that higher dry matter production (10572 kg ha^{-1}) was gained by the appealing of 100 kg phosphorus per hector pursued by the control condition. Masowa *et al*. (2021) were assessed the affects of the supplementary application of different nutrient on maize and they proposed that the combined application of ammonium ion and phosphorus in the soil increases the yield of maize. Raskar *et al.* (2012) proposed that application with 60 and 80 kg phosphorus ha^{-1} in equality and largerst over yield of maize as compared to 40 kg phosphorus ha^{-1}. Shivran *et al*. (2013) suggested that significantly larger yield of stover in maize crops with the application of improving levels till 40 kg Phosphorus ha^{-1} as compared to 20 kg Phosphorusha^{-1}.

Qualities and quality attributes

Ghodpage *et al.* (2008) suggested that content of crude protein in maize increased with applying of 80 kg phosphorus ha^{-1} but adversely starch content in maize decreased.

Table 3: Effect of nitrogen levels on Quality attribute of maize.

Treatments	CP content (%)	CF content (%)	CPY (kg ha^{-1})	CFY (kg ha^{-1})	N content (%)	N uptake (kg ha^{-1})
N1 (0 kg N ha^{-1})	5.28	23.02	479	2117	0.88	80.6
N2 (80 kg N ha^{-1})	6.12	23.87	654	2563	1.00	107.5
N3 (100 kg N ha^{-1})	6.72	24.72	800	2935	1.09	130.1
N4 (120 kg N ha^{-1})	7.04	25.21	866	3143	1.17	145.3
S.Em	0.11	0.33	20.04	89.98	0.02	3.76
C.D. at 5%	0.33	0.95	58.14	261.10	0.05	10.92

(Meena *et al.,* 2019)

Rashid and Iqbal (2012) exposed that fodder maize yield increased by appealing with a higher rate of phosphorus till 53 kg phosphorus ha^{-1}. Side by side it also increased the quality parameter of fodder maize crop and showed the non-significant effects of acid detergent fiber (ADF) and neutral detergent fiber (NDF).

Potassium effect

Potassium is one of the major primary macronutrient. It works as an activator of the number of enzymes related to the resistance to different environmental stress, diseases and also related to the synthesis of carbohydrates. Osmotic potential in cells and tissue also maintain by potassium as potassium is the cation in charge. Potassium mainly works for increasing the immunity power in the plant (Medici *et al.,* 2019). It is systematically for protein implication, photosynthesis, stomatal movement and maintaining cation-anion balance.

Effect of potassium on growth, yield and quality

By the application of 2% potassium as a foliar spray, enhanced the height of plant, index of leaf area and mean single area of the leaf which were proposed by Amanullah *et al.* 2016). Mastoi *et al*. (2013) conduct atrialon hybrid maize for grain purpose and explained that increase some characteristics of maize such as height of plant (2 to 15%) and yield of grain (22 to 83%) with the application of 60 kg ha^{-1} potassium fertilizers either organic or inorganic as compared to the application of 30 kg ha^{-1} organic or inorganic potassium fertilizer. Ijaz *et al*. (2014) shown that the application of several doses of potassium fertilizer significantly differs in the improvement, quality and yield of maize plants. It also proposed that crop gave higher plant height (273.72 cm) with applying of 175 kg potash ha^{-1}. Rehman *et al*. (2014) proposed that applying of various levels of potash fertiliser significantly affects the growth and yield of maize crops. Ibni *et al.* (2015) exposed that due to drought stress conditions, maize plant improvement and yield also increased with the application of potassium fertilizer and also proposed that the water scarcity of maize be reduced by the application of potassium fertilizer. Different growth and yield parameter were seen in applying of various levels of potassium fertiliser (30, 60 and 90 kg ha^{-1}) and higher height of plant, maximum number of leaves per plant and maximum leaf area was obtained with the applying of 90 kg potassium ha^{-1} as compared to other levels of fertilizers application due to this 90 kg ha^{-1} potassium apply in two split dose (50% at sowing time and other 50% at V9 stage: when ear shoots are visible clearly) which reported by Iqbal and Amanullah (2015). Ali *et al.* (2020) proposed that a higher number of crude protein (7.66%) and crude oil (3.66%) were obtained by applying of potassium @ 160 kg ha^{-1}. Aslam *et al.* (2013) reported that potassium, more helpful to reduce the scarcity of water in maize, produced a good quality yield of maize in form of potassium element.

Effect of zinc

Zinc, the most significant micronutrients during production of crop, plays an significant role in different metabolic processes during crop growth and development, for this reason, it is called anessential trace element (Kopriva *et al*., 2015; Courbet *et al*., 2019). Also it plays important role in enzyme activation, metabolism of carbohydrates, oxidation, synthesis of protein and revival reactions. Different fertilizers are used during crop production, from which the crop get zinc and another micronutrient, quality and performance of the crop improved and deficiencies of those elements inhibit the amount of soluble carbohydrate, destroys RNA, decline photosynthesis and reduced the conjugation of protein and decrease the quality and performance of crop (Efe and Yarpuz, 2011). In the biological process, zinc act an active element and there are biological and chemical connection within it and some other elements such as iron, nitrogen and phosphorus and also an antagonistic impact with phosphorus and copper on zinc (Aboyeji *et al*., 2020).

Growth components

Adesh *et al.* (2021) observed that higher height of plant (130.90 cm), number of leaves (18.80) and leaf area index (3.14) were obtained by the applied of 20 kg $ZnSO_4$ ha^{-1} + 20 kg $FeSO_4$ ha^{-1} as basal stage + 0.5% $ZnSO_4$ + 0.5% $FeSO_4$ asa spray on foliar at 45days after sowing as comparison with control condition. Rama Krishna *et al*. (2022) proposed that higher height of plant (297.6 cm), number of leaves (13.98) and leaf to stem ratio (0.218) and stem girth (8.10 cm) was obtained by the application of foliar spray of 1% $ZnSO_4$ in a different time (20, 45 and 60 days). Sulthana *et al*. (2015) reported that different growth parameter increase and the highest plant height (362 cm), leaf-to-stem ratio (0.304) and leaf area index (4.972) were obtained with applied of 50 kg $ZnSO_4$ as a soil application and 0.2% $ZnSO_4$ along with a recommended dose of fertilizer as comparison with control treatment. Sewhag *et al.* (2022) favoured that applying of zinc, increases the different crop growth parameters. Higher plant height (166 cm) and leaf length (97.66 cm), number of leaves (13.02) and leaf breadth (7.56 cm) was obtained by applying of 25 kg ha^{-1} $ZnSO_4$ as basal dose + 1% spray on foliar at 45 days after sowing followed by control treatment condition. The deficiency of zinc in the crop during crop production decrease several metabolic activities and biological process in plant (Sadeghzadeh 2013). Zinc has an essential physiologic function for controlling the cellular membrane's functions and integrity which was reported by Mousavi, Galavi and Rezaei in 2013.

Yield and quality of fodder

Chabb *et al.* (2011) observed the enhanced content of chlorophyll significantly, shoot dry weight and zinc uptake by the application of zinc. Azab (2015) indicated that the mixing applied of a consulted dose of fertiliser including zinc (1.5%) improved the yield of stover in maize crops. Adesh

Table 4: Fodder yield of baby corn as followed with several doses of zinc applications.

Treatment	Green fodder yield (ton ha^{-1})	Dry fodder yield (ton ha^{-1})	Fodder productivity (kg ha^{-1} day^{-1})
Zn (0 kg ha^{-1})	27.37	5.94	423.87
Zn (5 kg ha^{-1})	29.51	6.41	453.33
Zn (10 kg ha^{-1})	30.87	6.71	466.21
S.Em	0.62	0.13	5.97
C.D. at 5%	1.82	0.37	17.41

(Kumar *et al.,* 2015)

et al. (2021) declared that parameter of yield and characteristics offorage crops vary on the different levels of zinc applications. Upper yield of green fodder (519.20 q ha^{-1}), yield of dry fodder (137.90 q ha^{-1}), yield of crude protein (7.40 q ha^{-1}), content of protein (10.27%)and crude fiber (58.33%) were achieved with the applying of 20 Kg $ZnSO_4$ ha^{-1} at the basal stage with 0.5% $ZnSO_4$ as a foliar application at 45 DAS the comparison with control conditions. Ramakrishna *et al*. (2022) indicated that the highest production of dry matter (104 q ha^{-1}), yield of green fodder (419 q ha^{-1}), crude protein (9.3%), ether extract (2.4%) and total ash (7.1%) were achieved by the application of 1% $ZnSO_4$ at 20, 45 and 60 DAS as compared to control treatment. Sulthana *et al.* (2015) indicated that yield parameter of green fodder increased and the higher yield of green fodder (424 q ha^{-1}) and production of dry matter (6695 Kg ha^{-1}) were received by applying of 50 Kg $ZnSO_4$ as a soil application and 0.2% $ZnSO_4$ along with a recommended dose of fertilizer as comparison with control conditions. Choudhary *et al*. (2017) documented that the combined applying of zinc in form of $ZnSO_4$in soil and foliar both, increased the yield of stover and biological yield. Sewhag *et al.* (2022) opined that the zinc application increases crop yield parameters and quality. Highest yield of green fodder (463.08 q ha^{-1}), yield of dry fodder (118.75 q ha^{-1}), crude protein (9.90 %) were obtained with applying of 25 kg $ZnSO_4$ ha^{-1} as basal dose + 1% spray on leaves at 45 DAS followed by control treatment condition. Kumar *et al.* 2015 explained that green fodder yield and dry fodder yield are affected by different doses of zinc which is explained in Table 4.

CONCLUSION

It is terminated that the sensible use of nitrogen, phosphorus, potassium and zinc enhanced the growth, yield and quality of fodder maize. The right input of nutrients, right amount and right place and right time increased the yield of fodder and multiplications of fodder products side by side increase the economic status of producers. If use fodder maize as intercropping with the leguminous crop so, less amount of nitrogen is required for the production this fodder crop as well as advantageous to the grower.

Conflict of interest: None.

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