Overviewing Forage Maize Yield and Quality Attributes Enhancement with Plant Nutrition Management

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Abstract: Forages are the most palatable animal feed resource and highly relished by dairy animals. Forage maize is a high yielder of green forage but confronts under nourishment. Plant nutrition is one of the most important and vital factor which determines forage yield and plays an important role in ensuring considerably high forage yield for ruminants. Nitrogen and phosphorous are the most important plant nutrients which affect forage yield, as well as quality attributes of green forage. As inorganic fertilizers prices are skyrocketing with each passing year, small farmers in developing countries like Pakistan and India can ill-afford to supply required plant nutrients particularly nitrogen and phosphorous through inorganic means at appropriate time and in balanced quantities and resultantly forage yield suffers a serious setback. An optimum combination of organic, as well as inorganic fertilizers has the potential to increase the forage yield of maize along with quality parameters particularly protein content. Plant nutrition management by combining farm yard manure and poultry manure with inorganic fertilizers not only ensures increased forage yield but forage quality is also improved. However, need of hour is to make rigorous and in-depth investigations to find out the most appropriate combinations of inorganic fertilizers and organic sources to ensure the sustainability of agriculture and to increase the productivity of dairy animals along with increasing the income of cash striving small land holders as a part of poverty alleviation strategies in developing countries.

Key words: Crude protein · Dairy animals · Fodders · Farm yard manure · Poultry manure

INTRODUCTION

Livestock are an integral and vital constituent of farming systems in Pakistan. Pakistan has been endowed with over 39 million cattle and 34 million buffalos which are referred to as large ruminants [1]. The annual milk production is just over 51 million tons which makes Pakistan third biggest milk producing country in the world. But matter of grave concern is that despite greater number of milch animals and their high known potential, their productivity is seriously underutilized [2, 3, 4]. A variety of factors are responsible for lower productivity of dairy animals, but under-nourishment constitutes the biggest factor which hampers the performance of dairy animals in terms of milk production [5]. Conventional (dry and green roughages and concentrates) and to a small extent non-conventional feed resources are provided to dairy animals. Fodders and forages in combination with crop residues provide 51% of total digestible nutrients in Pakistan, while the share of rangelands and post-harvest grazing is 38% and 3%, respectively. Cereals by-products and oil cakes provide 6% and 2% of the total digestible nutrients, respectively [6]. Currently, milch animals are facing a deficit of 29% in total digestible nutrients (TDN) and 33% in crude protein (CP) [7]. Forages are considered to be the most palatable animal feed resource which is highly relished by dairy animals. The term forage is applied to all plant materials that are fed to animals in green succulent farm, while the term fodder implies to dried forages such as hay and silage. Cereals forages such as maize, sorghum, oat, barley and millets give higher forage yield but are deficient in protein contents. Forage legumes such as soybean, cowpea, cluster bean etc. are rich source of crude protein but these forage legumes yield only half in comparison with cereal forages. Berseem, alfalfa and oat constitute as...
major autumn forages, while spring season forages include sorghum and maize. The matter of concern is that area under forage crops is decreasing rapidly and has achieved a reduction pace of 2% per decade [8, 9]. In addition, there is June-July and again November-December, two periods of severe forage shortage and dearth during which performance and productivity of animals is deplorably poor in term of milk production. Among cereals, maize crop is of special attraction because of its multi-dimensional uses [10, 11]. It finds its use as a forage crop for dairy animals, feed for poultry birds and variety of industrial and food products for human beings. Forage maize can be harvested at any stage and fed to animals as there is little or negligible risk of oxalic acid, cyanide and prussic acid presence as that of forage sorghum. But unfortunately, the full potential of this crop to fill the nutritional gap has not been properly exploited in Pakistan. A score of soil, climatic and agronomic factors (seed, irrigation, insect-pest management etc.) significantly reduce forage maize yield and also result in poor quality forage. But poor nutrition is one the biggest hurdle in achieving the full potential yield of forage maize. Inorganic fertilizers provide an instant source of nutrients to plants as compared to organic sources. Most of Pakistani soils are deficient in nitrogen and phosphorous, while majority of soils are responding to potash application as well. But nitrogen is the most important plant nutrient as it is required for robust vegetative growth. Nitrogen is required by plants in greatest quantities than any other plant nutrient. Nitrogen even takes more important and vital role in forages yield and quality attributes. However, skyrocketing prices of inorganic fertilizers often result in their suboptimal use and resultantly forge maize yield suffers a serious setback. The use of organic sources of plant nutrition in combination with inorganic fertilizers holds the key to fulfill crops nutrition requirement.

This study provides a comprehensive and critical review of plant nutrition management particularly nitrogen management in order to increase the forage maize yield and quality parameters particularly the crude protein content in perspectives of small land holders.

**Nutritional Profile of Forage Maize:** Maize is a cereal crop belonging to Gramineae or Poaceae family and tribe Andropogoneae. In some English speaking countries, it is known as corn and locally as Makye in Urdu and Gacha in Punjabi. Forage maize contains crude protein in the range of 7.5-8.5%, crude fiber 32-34%, while the fat content is usually 1-2.5%. The dry matter is in the range of 32-34%, ash 7-9% and nitrogen free extract 50-50% [7]. It is evident from the nutritional profile of forage maize that it does not contains sufficient quantity of crude protein which is the most important quality parameter of forages as compared to forage legumes which contain crude protein in the range of 20-24% [11]. But it a matter of great interest that on per hectare basis, forage maize provides more crude protein than forage legumes. It is because of the fact that forage maize gives a fairly high forage yield as compared to forage legumes on per hectare basis. On the other hand, forage maize nutritional profile varies depending on many factors such as variety, climatic conditions, agronomic practices and particularly plant nutrition management practices. Appropriate plant nutrition management not only ensures higher biomass production but also improves quality parameters of forage maize.

**Influence of Nutrition Management on Forage Maize Growth and Yield:** Plant nutrition has a significant effect on forage maize yield, particularly nitrogen supplied either through inorganic or organic means. Iqbal et al. [12] conducted a field trial on forage maize and treatments included different combinations of organic and inorganic sources. Results revealed that the maximum green forage yield of 47 t ha⁻¹ and dry matter yield of over 10 t ha⁻¹ was achieved when recommended dose of nitrogen was supplied through inorganic means in the form of urea fertilizer. However, they also found that 75% of recommended nitrogen dose through urea and 25% through poultry manure were also effective in increasing fresh forage yield. Thus they concluded that combining organic and inorganic sources have similar potential to increase the fresh forage yield of maize. Almodares et al. [13] concluded that nitrogen was effective in increasing forage maize and sorghum yield as well as quality parameters such as protein content as compared to control treatment. They concluded that nitrogen applied in the form of urea was instrumental in increasing the forage maize yield up to 72 t ha⁻¹ and protein content to 7.8%. Oad et al. [14] also concluded that significantly higher forage maize yield was obtained when 120 kg ha⁻¹ nitrogen from urea was applied in combination with 3000 kg ha⁻¹ of farm yard manure (FYM). They suggested that though inorganic nitrogen application is the common practice for forage maize but a combination of organic and inorganic sources had a fairly significant effect on the growth and green forage yield of maize. Integrated nitrogen management was an effective tool to increase the maize production and that too in an economical way as
inorganic fertilizers are a costlier source of nitrogen as compared to inorganic sources. Ibrahim et al. [15] reported that forage maize yield was increased when it was intercropped with forage legumes and it was mainly due to more nitrogen availability for maize forage maize. Legumes start to meet their nitrogen needs and serves as nitrogen savers though are not nitrogen contributors. Ayub et al. [16] concluded that forage maize yield can be reasonably increased by managing plant nutrition as forage maize yield was significantly increased with optimization of nitrogen and it was quite evident in both forage varieties that were used in experiment. Dahmardeh [17] reported that effective nitrogen management resulted in more vigorous vegetative growth of maize and resultantly there was more absorption of photo synthetically active radiation (PAR) by forage maize and ultimately there was a significantly higher forage yield as compared to treatment that was not subjected to any plant nutrition management. Obi and Ebo [18] found that integrated nitrogen management strategies by combining organic and inorganic sources had a positive effect on soil properties and maize yield was also increased to a great extent. Ayub et al. [19] reported that both nitrogen and phosphorous had positive effects on forage maize growth and ultimately higher forage yield was recorded due to robust vegetative growth. They were of the view that optimum plant nutrition management ensures the efficient utilization of all resources related to soil and environment. Ahmad [20] observed that nitrogen management and adjusting its dose keeping in view the fertility status of soil and crop requirement was an efficient technique to give a healthy boot to forage maize yield. Who also reported that under-nourishment, particularly of nitrogen caused a significant reduction on forage maize yield. Cheema [21] also observed that optimizing nitrogen and phosphorous was effective in increasing maize growth and yield, while optimum plant nutrient management reduced the wasteful use of inorganic fertilizers and thus reducing the incurred costs. Adenyan and Ojeniye [22] reported that by combining different organic sources such as poultry manure and other poultry litter with inorganic fertilizers of nitrogen, phosphorous and potassium was proved to be a good plant nutrition management strategy. They concluded that by combining different organic and inorganic sources to maintain soil fertility was more effective, economical and sustainable technique as compared to sole use of inorganic fertilizers. Vasanthi and Kumaraswamy [23] reported that different manure-fertilizers schedule had a more pronounced effect on the cereal forages yield. They concluded that manure-fertilizers schedules increased the uptake of nutrients like nitrogen and phosphorous because manures released nutrient slowly and thus nutrient supply remained continue for a longer period of time. They concluded that this combination reduced the wastage of nitrogen as volatilization or leaching and more phosphorous was available for longer time. Rasheed et al. [24] reported that maize yield was improved with nitrogen management and there was a significant increase in maize yield as compared to control treatment. Appropriate nitrogen management resulted in significant improvement in leaf area index, crop growth rate and photosynthetic efficiency [25, 26, 27, 28]. Oleary and Rehm [29] reported that there was a linear relationship between nitrogen application rate and forage maize yield. Gonzalez et al. [30] reported that by combining organic and inorganic sources to supply essential nutrients had a positive effect on the soil properties. They also concluded that crops yield were increased because inorganic sources provided quick and instant supply of nutrients and organic sources provided a continuous supply of nutrients for a longer period of time because organic sources always tend to release nutrients slowly and thus nutrients become available to plants at latter stages as well. Thus by combining inorganic and organic sources have a positive and ameliorative effect on soil properties. Cereal forages yield potential can be achieved by including organic manures such as farm yard manure (FYM), poultry manure and litter and other organic resources. This plant nutrition management strategy is more sustainable and economical because inorganic fertilizers prices are skyrocketing and small farmers can ill-afford to purchase and apply fertilizers in optimum quantities and resultantly full potential yield of cereal forage particularly of forage maize cannot be exploited.

**Boosting Quality Attributes of Forage Maize with Plant Nutrition Management:** Though cereal forages are high yielders of green forage but matter of concern is that these are poor in term of quality parameters such as protein content which is the most important quality parameter. Livestock particularly milch animals are unable to meet their dietary needs if only cereal forages are fed to them and ultimately milk production suffers a serious setback. The quality parameters can be increased to some extent with optimum plant nutrient management as reported various researchers. Iqbal et al. [12] reported that when nitrogen was supplied from both inorganic and manures, it improved the quality attributes of forage maize as protein content were increased to 8.43% which was
higher than control treatment (Fig. 2). Iqbal [31] also reported that forage maize quality was improved in an intercropping system of forage maize with legumes because of better nutrient management and nitrogen saving by legumes. Plant nutrition management particularly of nitrogen management had a significant effect on different quality attributes of forage maize. Various researches concluded that protein content of forage maize was improved with nitrogen management and it was also reported by them that there was a linear correlation between protein content of fresh green forage and protein content [32-37]. Optimum plant nutrition management improved all quality attributes of forage maize such as crude protein (CP) and ash and crude fiber content were decreased. Sahar et al. [38] reported that nitrogen application in optimum quantities were effective in increasing the quality aspects of forage maize. Hamid and Nasab [39] reported that there was a linear relationship between nitrogen application rate and quality attributes of forage maize. More nitrogen was effective in increasing the crude protein contents and decreasing the crude fiber contents.

**Future Research Trends:** Plant nutrition management is one of the most important strategies in the hands of agronomists and researchers to increase the forages yield and same is true for forage maize [40]. Combining organic sources of plant nutrition such as farm yard manure and poultry manure with inorganic sources has the potential to increase the forages yield. It will not only ensure plant nutrient sources diversification but will contribute to enhanced farm productivity along with increasing the farmer’s returns. Thus there is a dire need to make more research for successful integration of organic as well inorganic sources of plant nutrients. As organic sources are known to release nutrients much slowly than inorganic fertilizers, their time of application is the most critical factor that needs to be thoroughly investigated with

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**Fig. 1:** Forage maize yield (t ha$^{-1}$) as influenced by application of organic and inorganic fertilizers adapted from Iqbal *et al.* [12]

**Fig. 2:** Protein content (%) of forage maize as influenced by application of organic and inorganic fertilizers adapted from Iqbal *et al.* [12]
Plant nutrition management is a valuable tool to increase the productivity and quality of cereal forages. Integration of organic and inorganic sources for plant nutrients ensure higher production of forage maize and that too in an economical way because of higher prices of inorganic fertilizers as compared to organic sources. Organic and inorganic fertilizers combinations are vital step towards sustainable agriculture while productivity of milch animals can be increased because of more biomass production of nutritious forage maize. However there is a dire need to investigate the optimum combinations of organic and inorganic sources so that full potential yield of forages can be ensured to support livestock and trigger white revolution.

**REFERENCES**


