Review Article

Nutrient Management in Maize and Cowpea Intercropping System : A Review

ABSTRACT

Maize (*Zea mays* L.) is a versatile crop grown for human food, animal feed, fodder and industrial raw materials. Being a widely spaced crop, it provides opportunity to accommodate intercrops for optimum use of agri-inputs and profit maximization. Cowpea (*Vigna unguiculata*) as an intercrop can contribute to income earning and improving soil health through nitrogen fixation and residue incorporation. Additionally, with its vigorous growth and dense canopy, cowpea can help suppress weeds, thereby reducing the need for herbicides. The nutrient management in maize and cowpea intercropping system is vital for ecosystem sustainability, soil health restoration, yield promotion and profit enhancement. In this paper, an attempt has been made to compile research accomplishments on effects of various plant nutrients on crop performance in maize and cowpea intercropping system. Application of plant nutrients at a level above recommended dose performed positively in the intercropping system due to higher nutrient requirement of two crops as compared with a single crop. Suitable management of plant nutrients contribute to overall agricultural sustainability by conserving resources, minimizing environmental impacts and fostering resilience in farming systems. Espousal of integrated nutrient management approaches have the potentiality to augment productivity, resilience and sustainability of maize and cowpea intercropping systems leading to better resource use efficiency and improved crop yield.

KEY WORDS: Maize, Cowpea, Intercropping, Nutrient Management

1. INTRODUCTION

Maize (*Zea mays* L.) is the third most important crop in India after rice and wheat [1]. It is otherwise known as the "golden food" due to high grain yield and nutrition value. Maize is a staple food for millions of people around the world, which is consumed directly as maize on the cob or processed into various food products such as cornmeal, cornflour, corn syrup and corn oil. It is utilized in various industrial applications, such as production of ethanol for biofuels. Ethanol derived from corn is a significant component of renewable energy strategies in many countries. Maize is one of the most versatile emerging crops having wider adaptability under varied agro-climatic conditions. Maize has the highest genetic yield potential among the cereals [2]. Cowpea is a drought tolerant crop with both value for vegetable and fodder. According to the Food and Agriculture Organization, the world production of cowpea in 2021 was estimated to be about 8.99 million metric tons from a harvested area of about 14.91 million ha.

Decrease in per capita land availability compels to go for intercropping systems to augment productivity through development of appropriate technology of growing field crop in association with legumes[3].Pulses can do wonder when intercropped with widely spaced crops like maize, sorghum, pearlmillet, cotton and sugarcane [4]. Pulses improve soil health status through nitrogen fixation and improve soil aeration through the tap root systems. Intercropping is one of the ways to increase the productivity of land under the supply of limited resources, which provides certain insurance against biotic and abiotic stress [1]. Maize (*Zea mays* L.) and cowpea (*Vigna unguiculata*) are important components of traditional mixed cropping system due to the associated benefits like suppression of weeds, maintenance of soil fertility, protection of against soil erosion and insurance against crop failure [5]. Cowpea is well adapted to hot and dry climates, making it a resilient crop in regions with challenging growing conditions. It can thrive in poor soils and contribute to sustainable agriculture by improving soil fertility through nitrogen fixation. Cowpea has the ability to fix atmospheric nitrogen through a symbiotic relationship with rhizobia bacteria in their root nodules. The deep roots of cowpea help to break up compacted soil and improve soil structure. The roots also add organic matter in the soil when crop residues are incorporated after harvest, enhancing soil fertility and water retention capacity. Integrating cowpea as an intercrop in farming system offers numerous advantages that contribute to sustainable agriculture, enhanced productivity and resilience against various challenges faced by farmers. Cowpea keeps the soil productive and alive by bringing qualitative changes in physical, chemical and biological properties. Cowpea is an important source of protein for human. Cowpea is a multipurpose grain legume whose pods can be used as green bean [6]. Maize being a widely spaced crop, can provide adequate opportunity to grow a short duration legume like cowpea as intercrop between two rows of maize [7].

In the traditional cropping system, C_4 cereal crops like maize, jowar and bajra can be intercropped effectively with C_3 legumes like greengram, blackgram, soybean, cowpea, etc.Cereal-legume intercropping plays a vital role in subsistence food production system, especially under handicapped situations [8] as it provides staple food consisting of cereals and pulses and can be grown under difficult growing conditions. Maize is one of the promising cereal crop, which can be intercropped with cowpea to enhance crop yield and income per unit area [9].This system not only provides certain insurance against biotic and abiotic stress, but also helps in the maximization of productivity and profit by efficient utilization of natural resources.

Several studies have corroborated that productivity of maize can be augmented by taking up cowpea as intercrop even in soils with poor fertility status. This is due to addition of nitrogen to the soil through biological nitrogen fixation by cowpea. Maize and legume intercropping was found to be more remunerative and less risky as compared to sole crop of maize [10]. This review is done to minimize the dearth of compiled information on effect of nutrient management on maize and cowpea intercropping system.

2. INTERCROPPING

Cereal and pulses intercropping is one of the vital practices for increasing land use efficiency, thus resulting in enhanced yield and economic return of various agricultural production systems. In view of changing climatic condition, intercropping is considered to be an effective measure to increase the resilience in the cropping system[11]. Under current scenario of decreasing per capita land availability and climatic aberrations, achieving higher crop yield, land use efficiency and economic return are possible through efficient intercropping systems [12].

Appropriate utilization of available resources depends on spatial and temporal arrangement of component crops in an intercropping system. The system can be more productive and profitable if inter row competition for limiting resources like solar radiation, nutrients and water is reduced through proper arrangement of component crops. Thus, maximum resource utilization can be achieved by adoption of appropriate plant architecture and crop geometry in an intercropping system. An ideal spatial arrangement leads to enhanced synergistic effect of the component crops and increase the physiological efficiency of the system in a particular environment. Suitable nutrient management practice is one of the major factors influencing the quantum of nutrient availability to the crops for better growth and development. Disparity in nutrient availability influences yield, crop growth &development and also affects the crop physiology [2].

The intercropping of cereal and legume is widely practiced to develop a sustainable food production system [12, 13]. It has been reported that suitable spatial arrangements play a vital role to establish superiority of intercropping of maize and cowpea over the sole crop of maize [14].

Maize and cowpea intercropping has multiple benefits over sole cropping due to symbiotic associations and complementary interactions between component crops in utilizing limited resources [15]. The wider row space of maize encourages weed infestation, which can be smotheredby inclusion of legume crops, especially cowpea. Cowpea, with its vigorous growth and dense canopy, can help smother weeds, reducing the need for herbicides or manual weeding. It can also supplement the nitrogen requirement of maize through nitrogen fixation[16]. Moreover, there is less competition between maize and cowpea for uptake of nutrients and water as their root architecture and penetration depth are different to obtain these resources from different layer of soil[17]. Intercropping with cowpea enhances the resilience of farming systems to climate variability and extremes like drought or excessive rainfall.

In maize and cowpea intercropping system, maize has a taller canopy and deeperrootsystem than cowpea cropresulting in efficient utilization of resources by both the crops.Higher grain yield of maize in the maize+legume intercropping system because of fast initial growth and better shoot &root growth as compared tothat of the legume taken as intercrop [18, 19]. As maize is the dominant crop in this system, major part of the resources like water and nutrients are utilized by maize although both the crops share the available resourcesfor their growth and development [20]. In this intercropping system, formation of crop canopies at different heights facilitates higher interception of solar radiation. Various intercrop models compete differently for interception of light [21]. However, in intercropping systems, light competition depends on planting geometry, plant densities and date of sowing. Border row effects are also crucial in such systems [22]. Different root depth & spread of maize and cowpea enable the crops to uptake water from different depth of soil, which enhances the overall water-use efficiency of the system [23]. It was reported that maize and cowpea intercropping system was effective in soil moisture conservation, which may reach up to 15.98 per cent during the active crop growth stages and up to 16.70 per cent after crop harvest [13, 24].

3. NUTRIENT MANAGEMENT

Appropriate nutrient management is crucial for achieving both economic and environmental sustainability in agriculture. It maximizes yields, reduces costs, protects natural resources and ensures that agriculture can continue to maintain production without degrading the environment. Effective nutrient management supports sustainable agriculture by balancing productivity with environmental stewardship. Nutrient management plays a crucial role in intercropping systems due to the unique dynamics and interactions between different crops grown together. Application of chemical fertilizer to the soil provides essential elements for plant growth and enhancing crop productivity[25]. Increase in vegetative growth, physiological traits and yield attributes of maize were significantly influenced by application of chemical fertilizers [26].

Maize and cowpea supplied with 125% recommended dose of fertilizer (RDF) recorded significantly highest plant height as compared to application of 75% & 100% RDF [2]. However, the lowest plant heights of maize and cowpea were recorded, when recommended fertilizer dose was reduced to 75% RDF. Similarly, application of plant nutrients through a combination of 75% RDN + 25% farm yard manure (FYM) + bio-fertilizers resulted in maximum plant height of 173.89 cm in maize. However, intercropping of maize and cowpea (1:2) exhibited negative effect on plant height (167.51 cm) of maize with same level of plant nutrient application [1].

Although application of plant nutrients through inorganic sources enhanced crop yield during initial years,it resulted in unsustainable crop productivity subsequently[27, 28].Nutrient management plays a crucial role in maximizing yield in intercropping systems by ensuring efficient nutrient use, reducing competition among crops, enhancing soil fertility, improving crop resilience and promoting overall sustainability. Positive effect of nitrogen on plant growth was observed due to its vital contribution in metabolic processes of the plant[1]. Combined application of RDF and FYM might have helped to increase plant growth resulting in higher seed and stover yield. Higher seed yield of maize was obtained with application of 125% RDF, which may be due to balanced supply of plant nutrients[29]. Increase in cowpea yield under sole crop was because of wider available space and absence of competition for light and nutrients with maize.

An increment of 25 % nutrient over RDF significantly enhanced the green cob yield and straw yield as compared to reduction of RDF by 25% due to inadequate supply of NPK required for achieving proper growth and development of maize[2]. The additional 25 % dose of fertilizers enhanced nutrient uptake, which might have resulted in improvement of growth parameters like dry matter production and yield attributing characters leading to higher yield of cob and straw in maize. They also reported that performance of cowpea was significant in terms of seed yield under different nutrient levels. Significantly higher seed yield was obtained with application of 125% RDF as compared to other nutrient combinations. Application of 75% RDN + 25% FYM + Bio-fertilizers to sole maize recorded maximum seed yield of 6391.63 kg/ha. However, maize + cowpea (1:2) intercropping system with same fertility level resulted in statistically comparable results [1].Various studies reported that application of 100% RDF in conjunction with vermi-compost and bio-fertilizers significantly increased grain and stover yield of maize[30, 31].

Equivalent yield is an important index in assessing the performance of different crops under inter and/or mixed cropping systems. Maize equivalent yield exhibited an increasing trend with increase in nutrient levels from 75% RDF up to 125%RDF[2]. This might owe to better utilization of applied nutrients by the components crops. Maize intercropped with cowpea has higher maize equivalent yield due to additional yield of cowpea[32, 33]. Studies reported that application of 75% RDF + PSB + Azotobacter+ vermicompost @ 5.0 t/ha significantly increased grain yield (3,684 kg/ha), stover yield (6,207kg/ha) and harvest index in sole crop of maize[33]. This was owing to the enhancement of yield attributes of maize, availability and absorption of applied nutrients and improved soil fertility. The same treatment recorded maximum pods per plant, seeds per pod and 1,000-seed weight in sole crop of cowpea.

4. NITROGEN

Nitrogen is the most crucial element to achieve maximum productivity from an intercropping practice. Rate, time and dose of nitrogen fertilizer needs to be carefully adjusted to obtained desired yield level [34]. Nitrogen in maize and cowpea intercropping system primarily revolves around the symbiotic nitrogen fixation capability of cowpea, which benefits both crops by providing a natural and sustainable source of nitrogen in the agro-ecosystem. Effective management of nitrogen in maize and cowpea intercropping system involves optimizing spacing between plants, timing of planting and potentially adjusting fertilizer application rates based on the nitrogen contribution from cowpea.

Maize plant can use a substantial amount of atmospheric nitrogen fixed by root nodules of cowpea, under intercropping system. Non-legume crops can take up nitrogen being excreted by the leguminous root system and are also capable of utilizing the nitrogen released through mineralization of root nodules [35].Experimental details revealed that maize and cowpea intercropping is beneficial to build up available soil nitrogen status in soils with low nitrogen content [36]. Maize and cowpea are complimentary to each other in nitrogen utilization as maize requires higher amount of nitrogenous fertilizer than cowpea [37]. Atmospheric nitrogen fixation by cowpea, thus contributes to reducing the competition of both the crops for soil-applied nitrogen and therefore, allow maize to use more of this [38].

Interaction between maize and cowpea intercropping patterns and N levels revealed that application of 216 kg N ha^{-1} is better than 288 kg N ha^{-1} in the cowpea + maize intercropped in alternating ridges [39]. He also observed declining agronomic efficiency with increase in level of nitrogen in sole maize resulted in the minimum agronomic efficiency with the highest (288 kg ha^{-1}) N level. Application of 216 kg N ha^{-1} either with maize and cowpea alternating ridges or maize and cowpea same ridge showed that the highest agronomic efficiency values of 14.6 and 9.4 kg kg^{-1}, respectively.

5. PHOSPHOROUS

Phosphorus dynamics in maize and cowpea intercropping system involve how phosphorus is managed and utilized within this cropping system. Phosphorus management in maize and cowpea intercropping focuses on leveraging the complementary root systems and biological interactions to optimize phosphorus uptake efficiency and overall crop productivity while minimizing environmental impact. In maize and cowpea intercropping system, the complementary root structures can enhance overall phosphorus uptake efficiency. Deeper roots of maize can access phosphorus from deeper soil layers, while shallower roots of cowpea can scavenge phosphorus from the upper layers. Active nodules usually contain two to three times more phosphorous than inactive ones, which signifies the importance of P for nodulation and symbiotic nitrogen fixation. This is supported by a field observation showing significant and positive correlation between N and P contents in legumes [40].

Phosphorous availability in rhizosphere and P concentration in maize & cowpea under intercropping system increased considerably [41].They also reported that increase in P concentration, higher plant biomass and enhanced grain yield of intercropped maize were due to positive effect of cowpea on P availability. The increase in P availability in the rhizosphere of maize under intercropping system can be attributed to acidification in the legume rhizosphere [42]. In phosphorous deficient soils, acidification of the rhizosphere contributed for enhancement of P availability [43]. Inclusion of cowpea as an intercrop with maize resulted in increased value of phosphorous concentration on the above ground part of the plants [44].

6. POTASSIUM

Potassium is an essential nutrient for plant growth and development, playing roles in enzyme activation, protein synthesis, and water regulation within plants. Potassium is an essential nutrient for plant growth, which decides the interaction between soil and plants [45]. It serves as a co-factor for more than 40 enzymes those are directly related to plant metabolic processes for the growth and development of plants [46]. Potassium regulates stomatal activity, rate of transpiration, rate of photosynthetic and ultimate grain yield [47].Intercropping maize with cowpea can positively influence potassium availability and uptake by both crops through complementary root systems, nitrogen fixation, residue management, and improved overall soil fertility.

Potassium has a multifaceted role in maize and cowpea intercropping system influencing growth, yield, nutrient uptake efficiency, stress tolerance and produce quality. Managing potassium levels effectively in such systems ensures optimal performance of both crops, supporting sustainable and productive agricultural practices. Application of 150 kg potassium fertilizer / ha produced the highest plant height, ear length, ear diameter, no. of kernels per row, no. of rows per ear, ear weight and weight of 100-kernel as compared to 0 and 75 kg/ha [48]. Higher dose of potassium (150 kg/ha) resulted in maximum grain yield of maize. Effect of potassium on higher yield of cowpea can be attributed to role of potassium production of certain growth enzymes, protein synthesis as well as photosynthesis [48].

7. MICRONUTRIENT

Micronutrients are essential for optimizing maize and cowpea intercropping systems by supporting growth, improving nutrient uptake efficiency, enhancing resilience to stress and promoting sustainable agricultural practices. Intercropping maize and cowpea with balanced micronutrient levels promotes ecological sustainability by enhancing nutrient cycling and soil health. Intercropping maize with cowpea can alter nutrient uptake patterns due to differences in root systems and nutrient requirements. Micronutrients ensure that both crops can efficiently absorb and utilize essential nutrients from the soil, thus maximizing overall productivity. Micronutrients such as iron (Fe), zinc (Zn), manganese (Mn), etc. are essential for various biochemical processes in plants. They are involved in enzyme systems, photosynthesis and hormone regulation, which are vital for optimal growth and development of both maize and cowpea plants.

Micronutrient application has substantially influenced the yield parameters of maize crop in maize cowpea intercropping system. The maximum values of thousand grain weight of cowpea (240 g) and maize (272 g) were recorded with application of iron and zinc nano-chelates. Application of micronutrients substantially influenced the biological yield of both maize and cowpea in the intercropping system. The biological yield of maize (28129 kg/ha) and cowpea (19580 kg/ha) have been realized with application of iron and zinc [49]. Various authors have reported effect of iron on plant growth and yield. There was enhancement in biomass yield of capsule bean of cowpea with application of nano-iron chelate @ 5 gram per litre water [50]. Micronutrient supplements enhance overall performance of crop, particularly in soils deficient with those elements. Iron and zinc in particular play a pivotal role in photosynthesis. Foliar application of iron and zinc nano-chelates resulted in increased production of leaf during photosynthesis thereby augmented yield due to quick availability of nutrients in pulses [51]. Application of zinc nano-micronutrients enhanced protein content of cowpea grain to the tune of 26.9 to 27.8 due to suitable concentration of amino acids, which stimulated metabolism of the plant.

8. ORGANIC SOURCES OF NUTRIENT

It was observed that application of 75 % N, P &K along with mycorrhiza inoculation resulted in continuous supply of phosphorous and small quantity of nitrogen and potassium under maize and cowpea intercropping system. This enhances the overall metabolic activities of both the crops, which ultimately was translated to higher system yield [52, 14]. The results indicate that plants treated with maize + cowpea (2:1) + 50% of Recommended Dose of Nitrogen (RDN) through farm yard manure + 50% of RDN through poultry manure + lime (200 kg/ha), resulted in significantly maximum physiological parameters of the crops. Application of Phosphate Solubilising Mycorrhiza (PSM) to maize and cowpea intercropping system resulted in a continuous supply of P as well as little quantity of N and K to both the crops. This could translate to an increase in the metabolism, photosynthesis and yield [52]. In cowpea, availability of more of soil P due to addition of PSM enhanced the nodule activities, which could prove beneficial to the crop in terms of yield [14].

Organic nutrient management of maize and cowpea intercropping through application of 50% RDN through farm yard manure and poultry manure along with 200 kg lime /ha resulted in maximum plant height, number of leaves per plant, leaf area index, dry matter accumulation and crop growth rate [53].Application of organic manure to maize and cowpea intercropping system can be a sustainable practice, which may promote soil health and overall environmental sustainability. It was reported that in maize and cowpea intercropping system, use of Ambrosia weed biomass as green manure partially substituted the requirement of FYM, which produced comparable economic yield of maize provided with inorganic fertilizers[6].

9. CONCLUSION

Nutrient management is vital for the success of maize and cowpea intercropping systems, offering numerous benefits those enhance productivity, profitability and environmental stewardship. Nutrient management in maize and cowpea intercropping systems is crucial for maximizing productivity and ensuring both crops receive adequate nutrition.Efficient nutrient management practices minimize nutrient runoff and leaching, which can reduce negative impact on soil, pollution of water bodies and protect groundwater quality. Sustainable nutrient management practices contribute to overall agricultural sustainability by conserving resources, minimizing environmental impacts and fostering resilience in farming systems. Adoption ofintegrated nutrient management strategies can enhance the productivity, resilience and sustainability of maize and cowpea intercropping systems, ultimately leading to improved crop yields and economic returns.

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