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Zinc nutrition in fodder cowpea (*Vigna unguiculata* L.) - A review

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ABSTRACT

Fodder cowpea (*Vigna unguiculata* L.) is an important leguminous forage crop, valued for its rapid growth, high biomass production, and superior nutritive quality, particularly under dryland and semi-arid conditions. Among the essential micronutrients, zinc plays a crucial role in enhancing crop growth, yield, and quality through its involvement in enzyme activation, energy transfer, root development, nodulation, and various metabolic processes. A comprehensive review of research findings across diverse agro-ecological regions indicates that zinc application significantly improves growth attributes such as plant height, number of branches and leaves, leaf area index, leaf-to-stem ratio, and dry matter accumulation. Optimum zinc application levels, generally in the range of 20–25 kg $ZnSO_4$ ha^{-1}, consistently resulted in higher green and dry fodder yields across different seasons and soil types, while higher doses often produced marginal or statistically at-par responses. Zinc nutrition also influenced phenological development, frequently leading to -lesser number of days to flowering and maturity. Furthermore, adequate zinc supply significantly enhanced fodder quality parameters, including crude protein, crude fibre, and ash contents. Overall, the reviewed studies highlight the importance of balanced zinc fertilization in maximizing productivity and improving the nutritive value of fodder cowpea, thereby contributing to sustainable fodder production and efficient soil fertility management.

Keywords: Cowpea, fodder yield, crude protein, sustainable fodder production and soil fertility management.

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Introduction

Fodder cowpea (*Vigna unguiculata* L.) is a widely cultivated, drought-tolerant leguminous forage crop known for its rapid growth, high green biomass production, and rich protein content. It plays a crucial role in supporting livestock nutrition, particularly in arid and semi-arid regions, due to its adaptability to dryland farming systems and its ability to fix atmospheric nitrogen, thereby improving soil health. Among the essential nutrients required for optimal fodder cowpea growth, phosphorus (P) and zinc (Zn) stand out due to their key physiological roles. Zinc influences the synthesis of growth hormones and supports reproductive processes in certain plants (Prasad, 2007). Zinc plays an important role in chlorophyll formation, carbohydrate metabolism and protein biosynthesis. Zinc is necessary to activate many enzymes like tryptophan synthetase, superoxide dismutase and dehydrogenases.

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Zinc deficiency impairs RNA and protein biosynthesis leading to a reduction in plant protein content (Singh *et al.,* 2018). Zinc fertilizer application causes root and shoot growth during the growing season and therefore leading to an increased seed yield. Zinc fertilization is considered as productive and profitable approach for attaining quality fodder (Rengel, 2001).

Effect of Zinc Application

I. Growth Parameters Plant height

Muhammad *et al*. (2024) concluded that application of 6 kg Zn as soil application + 0.5% $ZnSO_4$ as foliar application recorded maximum plant height in oat fodder during the winter season on loam soils at Sargodha, Pakistan. Ramakrishna *et al*. (2022) stated that plant height was higher with RDF (recommended dose of fertilizers) + foliar spray of 1 % $ZnSO_4$ at 20, 45 and 60 days which differed significantly over soil and foliar application of Zn at various stages compared to recommended dose of fertilizer + no Zn application in fodder maize. Manisha (2021) found that application of 20 kg ha^{-1} $ZnSO_4$

significantly increased plant height in fodder cowpea. It was also found that application of zinc at 20 kg ha^{-1} significantly increased the plant height of fodder maize (Arvind *et al.,* 2020). Mohammad (2019) reported that maximum plant height was recorded with the application of 40 kg K_2O + 25 kg $ZnSO_4$ ha^{-1} and this was on par with soil application of 25 kg $ZnSO_4$ ha^{-1} along with RDF in greengram. Debnath *et al*. (2018) observed maximum plant height when Zn was applied @ 5.0 kg and significantly differed from all other treatments in cowpea. Teja *et al.* (2018) reported that plant height recorded was maximum with RDF + soil application of 50 kg $ZnSO_4$ ha^{-1} along with foliar application of 0.2% $ZnSO_4$ at 30 and 45 DAS in fodder maize.

Number of branches plant^{-1}

Manisha (2021) noticed that application of 20 kg ha^{-1} $ZnSO_4$ significantly recorded maximum number of branches $plant^{-1}$ in fodder cowpea.Mohammad (2019) reported that maximum number of branches $plant^{-1}$ were recorded with the application of 40 kg K_2O + 25 kg $ZnSO_4$ ha^{-1} on par with soil application of 25 kg $ZnSO_4$ ha^{-1} along with RDF in greengram.Debnath *et al*. (2018) found that number of branches were maximum when Zn was applied @ 5 kg ha^{-1} in cowpea on sandy loam soils. Kumar *et al*. (2016) observed that improved number of branches with application of 20 kg $ZnSO_4$ ha^{-1} in cowpea at Haryana, Karnal. Mohan and Singh (2014) noticed that application of 30 kg Zinc ha^{-1} significantly increased the number of branches per plant, over control in fodder teosinte during rainy season on clay loam soils at NDRI, Karnal.

Number of leaves plant^{-1}

Manisha (2021) observed that application of 20 kg ha^{-1} $ZnSO_4$ resulted in maximum number of leaves $plant^{-1}$ in fodder cowpea during *kharif* on clay loam soils at ICAR-NDRI, Karnal. Pandey *et al*. (2019) concluded that zinc application significantly influenced the number of leaves up to 20 kg $ZnSO_4$ as basal application in cluster bean during *kharif* on sandy clay loam soils of Karnal, Haryana. Application of $ZnSO_4$ @ 25 kg ha^{-1} at the time of 1^{st} cutting significantly increased number of leaves per plant in finger millet atAjmer (Rajasthan), during *kharif* on sandy loam soils (Gajendra *et al.,* 2016). Kumar and Bohra (2014) reported that the application of 10 kg Zn ha^{-1} registered significantly higher number of green leaves.

Leaf to stem ratio

Martin *et al*. (2024**)** observed that higher leaf: stem ratio with 25:60:30 kg N: P_2O_5: K_2O ha^{-1}+ zinc @ 0.25% significantly recorded in fodder cowpea. According to Ramakrishna *et al.* (2022) stated that leaf to stem ratio was higher with RDF + foliar spray of 1 % $ZnSO_4$ at 20, 45 and 60 days which differed significantly over soil and foliar application of Zn at various stages. Application of $ZnSO_4$ @ 20 kg ha^{-1} significantly increased the leaf: stem ratio of over control and 10 kg $ZnSO_4$ per ha^{-1} in cluster bean during *kharif* season on sandy clay loam soils of Karnal, Haryana (Pandey *et al*., 2019). Teja *et al*. (2018) reported maximum leaf to stem ratio with RDF + soil application of 50 kg $ZnSO_4$ ha^{-1} along with foliar application of 0.2 % $ZnSO_4$ at 30 and 45 DAS in fodder maize.

Leaf area index

Muhammad *et al.* (2024) observed with Zn at 6 kg ha^{-1}soil application + 0.5 % zinc sulphate as foliar applicationin oats fodder. Arvind *et al*. (2020) noticed higher LAI with 20 kg$ZnSO_4$ ha^{-1} in fodder maize Sabour, Bhagalpur (Bihar) during *Kharif* season. Mohammad (2019) reported maximum LAI with the application of 40 kg K_2O + 25 kg $ZnSO_4$ ha^{-1} which was on par with soil application of 25 kg $ZnSO_4$ ha^{-1} along with RDF in greengram crop. Teja *et al*. (2018) reported higher leaf area index with RDF + soil application of 50 kg $ZnSO_4$ ha^{-1} along with foliar application of 0.2 % $ZnSO_4$ at 30 and 45 DAS in fodder maize. Prasanna *et al.* (2013) noticed maximum leaf area index in clusterbean with foliar application of 0.5 % zinc sulphate at 20 and 45 days after.

Dry matter production

Debnath *et al*. (2018) observed higher dry matter $plant^{-1}$ under the treatment Zn @ 5.0 kg ha^{-1} in cowpea. Teja *et al*. (2018) reported that higher dry matter production at harvest was noticed with RDF + soil application of 50 kg $ZnSO_4$ ha^{-1} along with foliar application of 0.2 % $ZnSO_4$ at 30 and 45 DAS in fodder maize.According to Puniya *et al.* (2013), maximum dry matter accumulation $plant^{-1}$ was observed with soil application of 5 kg zinc ha^{-1} along with foliar application of zinc @ 0.5 % at 25 and 45 days after sowing in mothbean on loamy sand soils of Jobner, Rajasthan.

Days to 50 % flowering

Kiran *et al.* (2018) observed maximum number of days to 50 % flowering with zinc 10 kg ha^{-1}, while the minimum number of days taken to 50 %

flowering was recorded in cowpea during spring-summer on sandy loam soils at Hisar.

II. Yield Green fodder yield

According to Muhammad *et al*. (2024) revealed higher fodder yield with Zn at 6 kg ha^{-1}soil application along with 0.5 % zinc sulphate foliar application in oat fodder. Ramakrishna *et al.* (2022) stated that green fodder yield was highest with RDF + foliar spray of 1 % $ZnSO_4$ in fodder maize during *rabi* season on sandy clay loam soils of PJTAU, Hyderabad. Manisha (2021) concluded that application of 20 kg $ZnSO_4$ produced significantly maximum green fodder yield in fodder cowpea during *kharif* season on clay loam soils at ICAR-NDRI, Karnal. Application of zinc @ 20 kg ha^{-1} significantly improved the green fodder yield in fodder maize (Arvind *et al.,* 2020). Zinc application up to 20 kg ha^{-1} significantly increased the green fodder yield over 0 and 10 kg $ZnSO_4$ ha^{-1} and at 0.5 % zinc spray in cluster bean (Pandey *et al*., 2019). Sandeep and Singh (2017) found that maximum green foliage was recorded with 6 kg Zn ha^{-1} in maize (*Zea mays* L.). A field experiment conducted during *kharif* in sandy loam soils at Ajmer, (Rajasthan), revealed that application of 50 kg $ZnSO_4$ ha^{-1} at the time of first cutting stage significantly increased total green fodder yield in pearl millet (Gajendra *et al*., 2016). Teja *et al.* (2018) noticed higher green fodder yield of maize with soil application of $ZnSO_4$ @ 50 kg ha^{-1} + foliar application of $ZnSO_4$ @ 0.2 % twice at 30 and 45 DAS along with RDF in fodder maize.

Dry fodder yield

Muhammad *et al*. (2024) observed maximum dry matter yield in the treatment combination of Zn at 6 kg ha^{-1} soil application + 0.5 % zinc sulphate foliar application in oat fodder. Ramakrishna *et al*. (2022) stated that dry matter yield was highest with RDF + foliar spray of 1% Zn SO_4 at 20, 45 and 60 days after sowing in fodder maize. Arvind *et al*. (2020) stated that application of zinc 20 kg ha^{-1} significantly improved the dry fodder yield in fodder maize. Zinc application up to 20 kg $ZnSO_4$ ha^{-1} has significantly increased of dry matter yield in cluster bean during *kharif* season on sandy clay loam soils of Karnal, Haryana (Pandey *et al*. 2019). Kumar *et al*. (2017) stated that green and dry fodder yield of maize was higher with the soil application @ 20 kg $ZnSO_4$. Sandeep and Singh (2017) obtained higher dry matter yield with 6 kg Zn ha^{-1} in fodder maize (*Zea mays* L.) during *kharif* season onsandy loam soils at Agra, Uttar Pradesh.Patel *et al.* (2017) reported that application of Zinc @ 25 kg ha^{-1} as soil application along with 0.5 % $ZnSO_4$ at 20 and 40 DAS as foliar application recorded significantly higher dry fodder yield in forage maize.Dry fodder yield of pearl millet was significantly higher with the application of $ZnSO_4$ @ 50 kg ha^{-1} at first and second (Gajendra *et al*., 2016). Application of zinc @ 4 kg Zn ha^{-1} was significantly superior and produced higher dry matter yield (Mitesh *et al*., 2013).

III. Quality Parameters Crude protein content (%)

Raju *et al*. (2024) revealedcrude protein was maximum with application of RDF + 10 kg ha^{-1} $ZnSO_4$ as soil application + foliar application of zinc @ 0.3 % at 45 in fodder maize. Maximum crude protein was obtained with a combination of soil application of Zn @ 6 kg ha^{-1} + 0.5 % zinc sulphate as foliar application in oat fodder. (Muhammad *et al*., 2024) Ramakrishna *et al*. (2022) stated that higher crude protein in fodder maize due to application of RDF + foliar spray of 1 % Zn SO_4 at 20, 45 and 60 days. Kumar *et al*. (2017) found maximum crude protein with soil application of $ZnSO_4$ @ 20 kg ha^{-1} in fodder maize during *kharif* season on sandy clay loam soils at Karnal, Haryana. Application of 8 kg zinc ha^{-1} recorded significantly more crude protein than control in maize(Sandeep and Singh, 2017). The maximum crude protein was noted with the highest level of $ZnSO_4$ (50 kg ha^{-1}) in fodder pearl millet during (Gajendra *et al*., 2016).

Crude fibre content (%)

Application of RDF along with 10 kg ha^{-1} $ZnSO_4$ as soil application + foliar application of zinc @ 0.3% at 45 DAS recorded maximum crude fibre yield in fodder maize (Raju *et al*., 2024). Muhammad *et al*. (2024) opined that soil application of Zn @ 6 kg ha^{-1} + 0.5 % zinc sulphate foliar application recorded maximum crude fibre in oat fodder. A field experiment conducted by Ramakrishna *et al*. (2022) recorded significantly crude fibre content in fodder maize with RDF + foliar spray of 1 % $ZnSO_4$ at 20, 45 and 60 days. Sandeep and Singh, (2017) obtained that application of zinc 8 kg ha^{-1} recorded maximum crude fiber in maize during. Application of zinc @ 4 kg Zn ha^{-1} significantly enhanced the crude fibre content in fodder sorghum (Mithesh *et al*., 2013).

Ash content (%)

RDF + 10 kg ha^{-1} $ZnSO_4$ as soil application + foliar application of zinc @ 0.3% at 45 DAS in fodder maize recorded maximum ash content

(Raju *et al*., 2024).The combination of Zn at 6 kg ha^{-1}soil application + 0.5% zinc sulphate foliar application recorded significantly higher ash content infodder oat (Muhammad *et al*., 2024).Increased ash content of fodder maize was noticed with RDF + foliar spray of 1% $ZnSO_4$ at 20, 45 and 60 days over recommended dose of fertilizer + no Zn (Ramakrishna *et al*., 2022).Kumar *et al*. (2017) inferred that soil application of $ZnSO_4$ @ 20 kg ha^{-1} improved the ash content of fodder maize.

Zinc content

Muhammad *et al*. (2024) noticed that maximum Zn content with soil application (6 kg Zn ha^{-1}) + foliar application (0.5 % zinc sulphate) of fodder oat. Nalini *et al*. (2013) reported that foliar application of zinc @ 0.1 per cent at pre-flowering stages minimized the severity of zinc deficiency and enhanced the seed nutritional status by enhancing zinc content in the seed of black gram. Foliar application of 0.1 % $ZnSO_4$ at flowering enhanced the zinc content in the chickpea seed (Girish *et al*., 2012). Application of zinc 4 kg Zn ha^{-1} found maximum nitrogen and zinc content in fodder sorghum (Mithesh *et al*., 2013). Zinc content in seed significantly increased with the soil application of nitrogen @ 300 kg ha^{-1} and potassium @120 kg ha^{-1} along with foliar application of zinc @ 0.6 per cent in *Phaseolus vulgaris* (Nasri *et al*., 2011).

Conclusions

The reviewed literature conclusively establishes zinc as a critical micronutrient for optimizing growth, productivity, and forage quality of fodder cowpea. Evidence indicates that zinc application in the range of 20–25 kg $ZnSO_4$ ha^{-1} is generally optimal, offering yield benefits comparable to higher doses while ensuring efficient nutrient use. Adequate zinc nutrition also positively influenced crop phenology by promoting early flowering and maturity, thereby improving overall crop performance. Furthermore, enhancements in quality parameters underscore the role of zinc in improving the nutritive value of fodder cowpea. In light of these findings, judicious zinc management emerges as a key strategy for achieving higher fodder productivity, superior forage quality, and sustainable soil health in fodder-based cropping systems.

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