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Assessment Of Role Of Zinc (Zn) In Flowering And Seed Production In Legumes

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Abstract

The effects of foliar zinc (Zn) application on seed concentration and subsequent seedling development have been investigated in this study. Plants given different amounts of zinc had the maximum growth and dry matter yield. Pollen formation, Chlorophyll production, fertilization, cell elongation, nodule formation, protein synthesis, and other physiological processes all include Zn. Therefore, Zn nutrition has a positive impact on pulse development, yield, physiological parameters, and nodule formation. Despite its essential function in development, photosynthesis, cell division, and tryptophan formation, which is involved in auxin (IAA) synthesis, little is known about the effects of zinc on flower and grain yield in traditional medicines. Zn deficit, which has been recorded in many areas of the world, not only lowers yields but also lowers the standard of produce. Higher Zn production in crops could be accomplished by introducing effective steps such as careful soil and fertilizer management, productive use of traditional/modified modern. The yield, boldness, vigor, and viability of seeds were all enhanced by foliar Zn application. When Zn-deficient plants were given foliar Zn, seed Zn increased dramatically. Bio-fortification, also known as foliar fertilization, is an effective crop management technique for optimizing crop yield and quality. ***Keyword:-*** *Black gram, Deficiency, Foliar spray, Legumes, Zinc.*

INTRODUCTION

According to World Health Organization reports, a shortage of micronutrients is a big danger to the worldwide people.[1]the term "bio fortification" comes from the Greek word "bios," which means "existence," and the Latin word "fortificare," which means "to make solid". It's a method of the bioavailability of edible parts of plants.[2]

Lack of Zn is a big concern all over the world, impacting soils of all forms, including loam, sandy, peat, and calcareous. Deficiency of zinc is often anticipated in soils with high silicon and phosphorus content. Zinc deficiency can negatively affect plants by lowering the quality of harvested products, stopping the tillering phase, extending the crop maturity time, stunting development, causing spikelet sterility, and causing smaller leaves and chlorosis.[3]

Zinc

Zinc is the micronutrient that western crops most commonly need. Foliar zinc treatments are usually applied to citrus crops once or twice a year. Zinc fertilization is also needed for other tree crops such as cotton, corn, beans, onions, grapes, and tomatoes. Zn is a divalent cation (Zn^{++}) that does not undergo valence shifts and therefore does not have redox action in plants, unlike other metal ions like manganese, copper, and iron.

Zinc absorption is somewhat inhibited by high concentrations of other divalent cations including Ca^{++}. A significant number of enzymes use zinc as a metal part or as a mechanical, structural, or regulatory co-factor. There have been reports of over 80 zinccontains proteins. Zinc-deficient plants have a slightly decreased rate of protein synthesis and a lower protein quality.

The presence of amides and amino acids in these plants shows how essential zinc is for protein synthesis. Zinc is a critical part of RNA polymerase, and extracting it allows the enzyme to become inactive. Zinc is also found in ribosomes and is needed for their structural stability. Increased rates of RNA degradation contribute to the decline in protein content of zinc-deficient plants. Increased RNase activity is a general sign of zinc deficient.

Zinc is a micronutrient that is needed by both animals and plants.

It is a component of many essential enzymes that play a role in the plant's growth process and anabolic process. Its absence not only results in low yields, but also in a decrease in the efficiency of the produced. Zn deficiency is a common micronutrient disorder that affects food output in a few countries, including India, United states, Australia and Turkey.[4] Strong calcareousness in soil, rough soil texture, poor soil organic carbon content, Alkaline soil pH and intense phosphatic fertilizer application are some of the factors that reduce the supply of natural and added Zn fertilizers in soil. Under both submerged environments and aerobic, zinc deficiency is normal.

Sources of zinc

Zinc is found of abundance in minerals. The sum of zinc in the soil is calculated by the soil's parent materials. The available zinc is usually poor in sandy and heavily leached acid soils. Zinc deficiency may also be observed in mineral soils with poor soil organic matter. Soils produced from igneous rocks, on the other side, have a higher zinc content. Zinc is taken up by plants in two forms: divalent ionic form (Zn^{2+}) and chelated zinc. Walnuts, lentils, tofu, chia seeds, cashew nuts, ground linseed hemp seeds, chickpeas, pumpkin seeds, fish, and quinoa are also good sources of zinc. Such foods are also high in protein and iron. The zinc content of certain foods, such as whole meal bread, is mentioned in the table.1 below.[5-6]

Table 1. Enumerates the zinc obtained from various sources

Quantity of food	Quantity of zinc (mg)
150g cooked quinoa	1.57
30g pumpkin seeds	2.0
30g china seeds	1.38
30g Walnut	0.78
80g cooked kidney beans	0.58
100g uncooked firm calcium-set tofu	1.57
30g cashew seeds	1.68
2 slices medium whole meal bread	1.18
30g hulled hemp seeds	3.0
80g reheated canned chickpeas	0.58
30g ground linseed	1.26

RELATION OF ZINC FERTILIZATION IN A SEEDS PRODUCTION

Soil applications

Zinc from the soil or growing medium may be successfully used by nursery plants. With age, this capacity deteriorates. It is ineffective to apply to the dirt. On a neutral (pH water = 6.92) sandy soil (14 percent clay), mature trees needed 75kg zinc sulphate or 2,50 kg Zn-EDTA to significantly enhance the Zn status of the leaf.

Fertigation with microjets

Fertilization can only help young plants, but it is not a smart decision to do it.

Fertigation with drippers

Zinc fertilization by drippers is feasible and effective with young trees. The Zn condition in the leaves and soil, on the other side, must be controlled. The Zinc status of the plants and the productivity of the applications would require higher applications due to weak Zn transportation from the roots to the leaves.

This could result in Zn collecting as zinc phosphate on the roots or as carbonate in the wetted zone's perimeter. It is believed that if all micronutrients are supplied via the water, the roots can grow properly even below the drippers. As a result, water can have at least some of the Zn necessity. Foliar sprays can be used to have the remaining mass.

Foliar sprays

For foliar sprays, zinc nitrate is a popular source of Zn. It comes with a variety of strengths. A substance comprising 5, 5 percent Zn may be added at a rate of 150ml per 100 liters of water with reasonable performance. Every other formulation should be used if the Zn content in the spray solution is less than 82 mg / l. The transformation of foliar Zn in the plant is determined by the Zn status at the time of use.

Zn cannot transfer from the treated leaf to surrounding tissue if the status is poor. Small movement may only be predicted while the status is strong. The sprays must be timed precisely due to the slow flow of Zn. Zinc sprays can be used where a lack of zinc has the greatest effect on demand.

This can happen through fruit set as well as flowering. It can be used at any time while you are under stress. Where Zn deficiency is present, applications should be made as well as possible before the flowering period.

ZINC'S FUNCTION IN PLANT ENZYMES RELATED TO SEED DEVELOPMENT AND FLOWERING

Zinc serves three roles in enzymes: structural, catalytic, and co-catalytic (coactive).In enzymes that catalyze zinc reactions, Zn atom is coordinated to four ligands (e.g., carboxypeptidase and carbonic anhydrase), the most common of which are amino acids glutamine (Glu), asparagine (Asp) and histidine (His), d a a water molecule is the fourth ligand at both catalytical locations.[7]

In enzymes with structured Zn roles (e.g., alcohol dehydrogenase and protein involved in gene expression and DNA replication), the structural zinc atoms are arranged to the S-groups of four cysteine residues, forming a tertiary structure with high stability. In enzymes with structured Zn roles (e.g., alcohol dehydrogenase and protein involved in gene expression and DNA replication), the structural zinc atoms are arranged to the S-groups of four cysteine residues, forming a tertiary structure with high stability.

The functional zinc atoms are arranged to the S-groups of four cysteine residues, creating a tertiary arrangement of strong stability in enzymes with organized Zn functions (e.g., Protein and alcohol dehydrogenase involved in gene expression and DNA replication). Many zinc-enzymes have just one zinc atom per molecule, such as alcohol dehydrogenase.

Protein synthesis

In zinc appropriate Euglena cell, the zinc content of ribosomal RNA is 650-1280 µg g^1 RNA, while it is 300-380 µg g^{-1} RNA in zinc deficient cells. Zinc availability and RNase activity, as well as RNase activity and protein quality, have a direct inverse connection. In the absence of zinc ribosomes are disintegrate, but they may be reconstituted until zinc is restored.[8] Zinc is an essential structural feature of ribosomes.

Reduced translation and transcription, as well as increased rates of RNA degradation, are the causes of high amino acid and low protein content in Zn- deficiency plant. Zinc deficiency is correlated with higher RNase activity concentrations.

Alcohol dehydrogenase

Alcohol dehydrogenase function declines in zinc-deficient plants, but the effects for plant metabolism remain uncertain. Plants grown in underwater or buried fields have a distinct condition. This enzyme has two zinc atoms in each molecule, one for catalysis and the other for structural purposes.[9]

The enzyme catalyzes the conversion of acetaldehyde to ethanol. Ethanol is primarily formed in meristematic tissues, such as root apices, in higher plants growing under aerobic conditions. In low - lying rice flooding increases the function of root alcohol dehydrogenase twice as much in zinc-sufficient plants relative to zinc-deficiency plants, and the low function of this key enzyme in anaerobic metabolism will greatly impair root functions.

Carbonic anhydrase

The hydration of CO is catalyzed by this enzyme, which produces a single zinc atom.

$$CO_2 + H_2O \leftrightarrow HCO_3^- + H^+$$

Carbonic anhydrasehas six subunits, a M.W. of 180 k Da, and six zinc atoms per particle. The enzyme can be present in both the cytoplasm and the chloroplast.

Biochemical functions of Zn in seed production

Plants require zinc (Zn) as a micronutrient. While some soils in Minnesota may have enough zinc for crop development, others need the addition of zinc fertilizers. In fertilizer services for edible beans, corn, and sweet corn, zinc is a preferred micronutrient. The clear propensity of Zn to shape tetrahedral complexes with S-, O- and N-don ligands is responsible for its metabolic functions.

Free ions, storage metalloproteins, low molecular weight clusters and insoluble cell wall frameworks are the most common types of zinc. Zn is inactivated at the intracellular stage by organic ligand complexes or phosphorus complexation.[10] Zinc tends to influence plant water absorption and transport capability as well as minimize the detrimental impact of brief periods of heat stress or salt stress.[11]

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Since Zn is necessary for the synthesis of tryptophan, which is a precursor of Indole acetic acid, this metal also plays a role in the development of auxin, an important growth hormone.[12] Documented their involvement in signal transduction through mitogen-activated protein kinases.[13]

Zinc's function in flower and seed production

Zinc is a micronutrient that plays a role in a variety of physiological functions; its deficiency may have a negative impact on crop growth and yield. Zinc shortage is a big concern all over the world, impacting soils of all forms, including calcareous, sandy, loam, and peat. Under various nitrogen amounts, the effects of bio-fortification of forage sorghum with zinc will be investigated.

Zinc content, leaf field, dry matter, plant height, protein content percent, and fresh forage yield increased with zinc and nitrogen biofortification, but neutral detergent fiber, acid detergent fiber, and ash percentage decreased. Green fodder yield increased by 7.28 and 18.56 percentage, respectively, when 10kg ha-1 zinc and 120kg ha-1 nitrogen were added, while dry matter yield increased by 12.08 and 15.76%.

Similarly, there was a 6.1 to 7.5 percent improvement in crude protein relative to the control sample. Finally, in terms of forage sorghum consistency and yield, Zn and N had the strongest outcomes.[14]

ROLE OF ZINC IN FLOWERING

Zinc in Sugarcane Production

Even though zinc's value is generally known, there has been no study on this micronutrient in sugarcane. Zinc application has been shown in many experiments to increase sugarcane production. Zinc treatments of up to 25 kg ha^{-1} in the plantation furrow resulted in gains of up to 40 t ha^{-1} in the Northeastern Brazilian coastal tableland soils, according to an analysis.

The study's authors started recommending that this zinc dosage be applied to soils with usable Zn levels of less than 0.5 mg dm^{-3}. In a subsequent analysis, sugarcane crops in an Oxisol with lower usable zinc content showed positive responses to zinc application. They observed that when zinc doses of about 10 kg ha^{-1} were added as sulphate in the plantation furrow, the maximum degree of output was achieved.[15]

Zinc as a foliar spray has a significant impact on Marigold development and flower quality (Tagetes erecta L.)

The experiment was set up using a Completely Randomized Design (CRD) process, with one element being replicated 3 times. Tagetes erect were spray with five separate amounts of $ZnSO_4$ in this analysis (0, 0.3, 0.5, 0.7 and 0.9 percent). The results indicated that zinc had a substantial impact on most of the characteristics, although leaf region showed no notable variations.

At 0.5 percent Zinc sulphate application, fresh flower weight (4.67 gm), maximum height of the plant (24.82 cm), stem diameter (0.07cm), number of flower plant-1 (14.66), number of branches per plant (23.21), and number of leaves per branches(40.34) were reported. As a result, it is concluded that 0.5 percent Zn shall be sprayed for high quality Marigold flower production and is therefore recommended for farmers in Peshawar's agroclimatic conditions.[16]

Table 2. Effect of zinc level on marigold plant

Zinc levels	Parameter			
	Height of the plant(cm)	Diameter of stem	Number of Branches per Plant	Number of leaves per branch
0%	17.72	0.019	12.32	30.64
0.3%	22.48	0.029	17.32	33.64
0.5%	24.82	0.07	23.21	40.34
0.7%	22.40	0.03	17.10	33.10
0.9%	22.65	0.04	18.21	35.64

Role of Iron and Zinc on Growth and Flowering of Rosa hybrida Cv. "Dallas"

The impact of foliar spraying or/and soil application (with irrigation water) four times of four concentrations of chelated iron (0, 30, 60, and 120 ppm) and three concentrations of chelated zinc (0, 75, and 150 ppm) singly or in combinations (24 treatments) on the development, flowering, and chemical composition of Rosa hybrida cv. "Dallas."

The analysis of seasons showed that foliar spraying the two nutrient elements (iron and/or zinc) individually or in combination had a positive significant impact on all the tested parameters as opposed to applying them to the soil. As opposed to the other therapies, spraying iron at 30-60 ppm alone or in combination with zinc at 75 ppm resulted in substantial changes in the most tested rose plant parameters.

The most researched parameters of Rosa hybrida cv. "Dallas" decreased when the two nutrient elements were used at their maximum concentrations (120 ppm iron or 150 ppm zinc) individually or in combination, relative to their lower concentrations.[17]

Role of foliar application of Zinc and Iron on the Flowering And essential oil of Chamomile at greenhouse condition

The impact of foliar micronutrient (Zinc and Iron) treatment chamomile yield and essential oil. These studies were set up as factorials of four replications using a randomized full block template (RCBD). Application of micro-nutrients (Zinc, Iron and Zinc + Iron by $ZnSO_4$ + $FeSO_4$ at 0.35 percent concentrations) and duration of treatment (flowering, stem elongation and all stage) were compared to regulation (without foliar application).

Foliar application of Fe and Zn improved flowers production, volatile oil percentage, and essential oil yield as compared to power (untreated). Fe + Zn spray care generated the Higher yield of flower (1962.2 kgha-1), Volatile oil (1.061percent), and yield of volatile oil (20.835 kgha-1), with 46.4, 24.64, and 81.77 percent gains over control, respectively.

Essential oil yield, Crop dry yield, and essential oil percentage were all affected by the time of the foliar use. In comparison to spraying at just one level of stem elongation and flowering, foliar application at both phases has more beneficial results on these characters.[18]

Zinc foliar spray has a beneficial impact on sunflower growth and yield (Helianthus annuus L.)

The better foliate Zn substitute for the HO-1 sunflower range. Under 2.00 percent Zn, seeds index (60.12 g), Amount of seeds head-1 (1298.0), the maximum plant height (203.33 cm), stem girth (10.65 cm), seeds weight head-1 (62.74 g), seed yield (1926.7 kg ha-1), head diameter (19.69 cm), and oil contented (41.92%) were noticed, whereas the stem girth (6.19 cm), head diameter (11.98 cm), minimum plant height (142.66 cm) Amount of (no foliar spray of Zn).

When the maximum concentration of Zn was applied, the Head diameter, plant height, number of seed per head and stem grith improved by 41.45 percent, 88.5 percent, 55.8 percent, and 81.7 percent, respectively. As opposed to the control, seed index, seed production, seed weight per head, and oil content increased by 76.61 percent, 37.2 percent, 81.4 percent, and 43.2 percent, respectively.

On the observation it was determined that foliar application of Zn at a concentration of 2.0 percent may be used to improve Helianthus yield and oil quality. To the findings indicate that Zinc can be used to improve Helianthus yields and quality, especially in areas wherever soils are deficiency in Zn. Such methods can aid in the optimization of current fertilization strategies as well as the improvement of sunflower output.[19]

ROLE OF ZINC IN SEED PRODUCTION IN LEGUMES

The influence on Lens culinaris (late-sown lentil) seed yield and growth

Zinc is more important during the reproductive process, especially during fertilization. the reaction of lentils to varying concentrations of $ZnSO_4$.7H2O. A foliar application of zinc was added during the podding and reflowering stages. All the zinc applications have been found to yield better results than the power. Among the various therapies, zinc concentrations of 0.04 percent and 0.08 percent generated the best results.

Zinc (Zn) deficiency is a well-known global health problem that affecting over half of the globe's peoples. Crop Zn amount increase the highest in the 0.08 percent Zn procedure, but seed yield increased the most in the 0.04 percent Zn treatment. Therefore, it's concluded that foliar zinc application enhances lentil productivity and yield.[20]

Role of zinc nutrition in Chickpea

The chickpea is a commonly cultivated and eaten grain legume. Chickpeas are primarily produced in marginal soils and rainfed areas with low available zinc (Zn); furthermore, micro - nutrient deficiency in soil, especially Zn deficient, have an impact on their productivity. Zinc is an enzyme co-factor that functions both structurally and as a regulator that are active in a number of crops bio-chemical processes.

As a result, Zn deficiency hinders plant growth and production by lowering enzyme function, disrupting ribosomal balance, and slowing protein synthesis rates. In addition, Zn deficiency triggers ovule infertility and flower abortion, resulting in lower yields and ovule infertility.

To increase grain yield and grain Zn concentration in chickpeas, multiple Zincapplication techniques soil treatment, Soil and Foliate—that are simple, efficient, and costeffective for farmers are discussed. Breeding programs for developing Zn-effective chickpea genotypes should provide identifying effective genetic constitution for root Zn absorption and grain variation.[21]

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Green gram, its effect of zinc at early reproduction phase

The impact of foliar Zn treatments on pollen-stigma interaction, fertilization, seed Zn, and seed yield were investigated. The viability of pollen grains, pollen producing capability, and size and size of anthers were all reduced in plants with low levels of (ZnD). SEM analysis of pollen grains revealed morphological variations in pollen form and size as exon elaboration changed.

The pollen receptive region of ZnD plants flowers was decreased, and there was a persistent cuticle over the stigmatic surface, impacting pollen grain germinability. The above results were partly reversed when Zn was applied foliar to Zn-deficient plants. The boldness, vigor, yield and viability of seeds were all enhanced by foliar Zn application. As Zn-deficient plants were given foliar Zn, seed Zn increased significantly.[22]

Under integrated soil fertility control, zinc fertilization improves cowpea (Vigna unguiculata [L.] Walp.) production and grain nutritional content.

The effect of soil type on Zn uptake in cowpeas produced on sand soils versus Laterite soil under Zn fertilization is shown by a larger rise in cereal zinc of Vigna unguiculatagrow up on sandy soils under Zn fertilization, which should be discussed further in agronomic biofortification programs.

It is a considerable yet unstudied grain legume that can help increase nutritional zinc (Zn) consumption in Sub-Saharan Africa. Ground experimentations were performed to examine the effect of Zn fertilizer on cowpea production and efficiency under integrated soil fertility control, driven by the surveys (ISFM).[23]

INFLUENCE OF ZINC IN IMPROVING MUNGBEAN YIELD

Mungbean are an essential part of viable crop development since they not only have a decent origin of nutritional protein, while also helping to increase soil nutrient level by biological N2 fixation. It is a commonly cultivated grain legume. Zinc (Zn) is an important micronutrient for both crop plants like mungbean and humans.

The aim of this research was to find the best Zinc soil uses for mungbean flower development, crop, and bio-fortification. Zinc was added to the soil at concentrations of 0, 2.5, 5.0, 7.5, and 10 mg Zn kg^{-1}. The analysis indicates that applying Zn to the soil significantly enhanced seedling development, yield parameters and morphology, grain yield, and Zn concentration in the grain of mung bean.

However, seedling development, yield parameters and morphological grain yield and grain biofortification where significantly improved Zn was added to the soil at a rate of 10 mg Zinc per kg. To tackle Zn malnutrition, it is proposed that Zn be added to the earth at a rate of 10 mg Zn per kilogram.[24]

Zinc Fortification in Groundnut

Groundnuts are a strong source of zinc, and the seeds are consumed after roasting, baking, salting, or boiling, as well as in several dishes and confectionery. Groundnut availability per capita is lower in India owing to lower production. Increased Zn concentrations in seed by fortification and collection of high Zinc density genotypes can be a way to ensure sufficient levels of Zn intake.

As a result, foliar Zinc application was used to increase the seed Zn content in several groundnut cultivars. Groundnut (Arachishypogaea L) is an essential food legume grown on around 25 million hectares (ha) of land in African (10 million ha), Asian (13.4 million ha), and American (1.2 million ha) countries, predominantly in the United States, China, Nigeria, Myanmar, Sudan, Indonesia, Senegal, India, Argentina, and Vietnam.

It is grown on over 7 million hectares in India alone. Even though the world's average groundnut production is about 1500 kg ha1, it is less than 1000 kg ha1 in more than half of the world's groundnut-growing countries due to weather conditions and low soil fertility. However, because of its high energy, protein, and mineral content at a low price, groundnut is becoming a more popular food plant around the globe.[25]

Table 3. Zinc fortification in groundnut during dry 2010.

Seed Zn content of Groundnut in control plots	**Cultivar's response (% increase in seed Zn control) to Foliar spray of Zn**		
	>20%	**10-20%**	**<10%**
Cultivars with 50mg kg^{-1} and above in seed	GG 2, CO 1, MH 1	RS 1, JL 220, HNG 10, K 134, CSMG 884	TG 26, M 145, ALR 3, Chitra, DRG 12, GG 20, RS 138
Cultivars having below 50 mg Zn kg^{-1} in seed	SG 99, S 206, Tirupati 3, Gangapuri, TG 37, DEG 17, Kadiri3, UF 70-103, VRI 2	ICGV 86031, DSG 1, Girnar 2, M 197	GG 12, ALR 2, ICGS 76, CSMG 84-1

Zinc application and crop performance

The effects of varying levels of soil zinc application on the production of various pulse crops have been studied extensively for quite some time. In terms of yield attributes, yield, nutritional quality, and growth parameters, the responses of various plants to applied zinc through various modes, either alone or in combination, has been examined. chlorophyll content, leaf area, primary and secondary divisions, Plant height, biomass accumulation, yield, and other factors are all used to evaluate the crop's performance.

Plant height

One of its most significant morphological growth parameters affected by nutrients and growth regulators is plant height. Chickpea plant height was slightly higher when 15 kg ZnSO4 ha-1 and 20 kg ZnSO4 ha-1 were applied, respectively, than when no zinc was applied.[26]

Examined the impact of zinc application on summer cluster bean yield and quality in light ridged soil and discovered that a 5.0 kg Zn ha-1 application resulted in substantially higher plant height.[27] Plant height was greatly affected by the application of 10 kg Zn ha-1 (47.76 cm and 47.88 cm in summer mung bean).[28]

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Branching

The number of main branches and sub-branches play a significant role in deciding the crop's production. It has been recognized that application of zinc in soil (ZnSO4 @ 20 kg ha1) has a positive impact on chickpea branching.[29] Similar results were recorded for branching in chickpea, cluster bean, mung bean, and pigeon pea when zinc was applied at concentrations of 15 kg Zn ha-1, 5 kg Zn ha-1, 10 kg Zn ha-1, and 5 mg kg-1.[30]

Leaf area and chlorophyll content

Zinc application of 20 kg ZnSO4 ha-1 had a significant impact on the leaf area index and seed growth rate of pigeon pea. The effect of graded zinc levels on pigeon pea leaf area and growth parameters revealed that 15 kg ZnSO4 plus RDF resulted in significantly higher leaf area.[31] The impact of foliar zinc application (0.1 percent) on mungbean leaf area was investigated, and it was noticed that plant-1 (497 cm2) was substantially higher than regulation.

Nodulation

In terms of nodulation, chickpea, mungbean, soybean, cluster bean, and pigeon pea all reacted positively to applied zinc. In consecutive years of research, there was a 91 percent increase in soybean nodulation when Zn @ 5 kg ha-1 was applied. With the application of Zinc sulphate @ 20 kg ha^{-1}, a positive response to root nodulation was observed in chickpea.[32]

Seed and pod

Zinc treatment by soil and/or foliar application, either alone or in conjunction with FYM, increases the number of seeds pod-1, number of pods plant-1, and test weight in several crops. In chickpea tests, applying 15 kg Zn ha-1 resulted in a substantial increase in the amount of pods plant-1 and 1000 grain weight relative to the control.

Cluster beans, like chickpea, reacted to the application of Zn @ 5 kg ha-1 by generating considerably more pods plant-1 and seeds pod-1. With a zinc application of 20 ppm in the mungbean crop, comparable findings were obtained.

Table 4. Yield response to mode of zinc application

Crop	Mode of Zn	Rate of Zn Application	Yield response	References
	application			
Soybean	Foliar	1.0% $ZnSO_4$	29% higher yield	Gowthaniet al. 2014 [34]
Mungbean	Foliar	$500 mgL^{-1} Zn$	23% higher yield	Ali et al. 2013 [35]
Cluster bean	Soil	Zn@ 5kg ha^{-1}	40% higher yield	Kuniyaet al. 2018[36]
Cowpea	Foliar	0.5% $ZnSO_4$	43% higher yield	Anitha S. et al. 2005 [37]
Chickpea	Soil	Zn@ 15kg ha^{-1}	35% higher yield	Sangamet al. 2004[38]
Black gram	Foliar	0.5% $ZnSO_4$	18%higher yield	Pandey et al. 2012 [39]
Green gram	Soil	Zn@ 5kg ha^{-1}	18-44 % higher yield	Srinivadsaraoet al. 2012 [40]

Pigeon pea	Soil	Zn@ 5kg ha^{-1}	67% higher yield	Mali et al. 2003 [41]
Mungbean	Soil	Zn@ 10kg ha^{-1}	31% higher yield	Ram et al. 2013[42]
Cowpea	Foliar	0.1%Zn	15% higher yield	Salehim et al. 2012 [43]
chickpea	Soil+Foliar	(25kg+0.5) $ZnSO_4$	24% higher yield	Sharafi et al. 2015[44]
Soyabean	Soil	Zn@ 5kg ha^{-1}	33-43% higher yield	Chauhan et al. 2013[45]
Pigeon pea	Soil+FYM	$ZnSO_4$@15kg ha^{-1}+FYM@5t ha_{-1}	25% higher yield	Sharma et al. 2009[46]

Yield and biomass

Grain yield is the crop's final economic product, and is measured by grain weight, number of grains per unit of land area as controlled by management methods, and its genetic capacity. Zn fertilization has a beneficial impact on seed production, according to reports. The maximum grain yield was achieved with Zn at 5 kg ha-1 and S at 60 kg ha-1, which was 66.98% higher than the regulation.[33]

CONCLUSION

Results of physiological zinc (Zn) application is primarily for plant nutrition, with the goal of supplying plants with the optimal dose of Zn-fertilizer to boost growth, quantity, and efficiency of inflorescence and production parameters. Zinc supplementation enhances physiological, development, and yield parameters, as well as flowering and seed yield. The composition of the soil, the type and quantity of clay present, soil organic matter, soil moisture, and the interaction with the other nutrient elements present in the soil all affect the abundance of these nutrients. Many of the applications (soil, foliar, and seed) have yielded promising results.

The application strategies under sufficient and deficient Zn can also be used to improve Zinc density in legume seed to improve human dietary consumption. There is need of hour to work extensive research on zinc in different laboratories and information and results must be shared with extension workers, farmers and Government officials related with agriculture sectors to create awareness among peoples related with farming.

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