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Antagonism of Phosphorus and Zinc in Pulse Based Cropping System in Tarai Region of Eastern Uttar Pradesh

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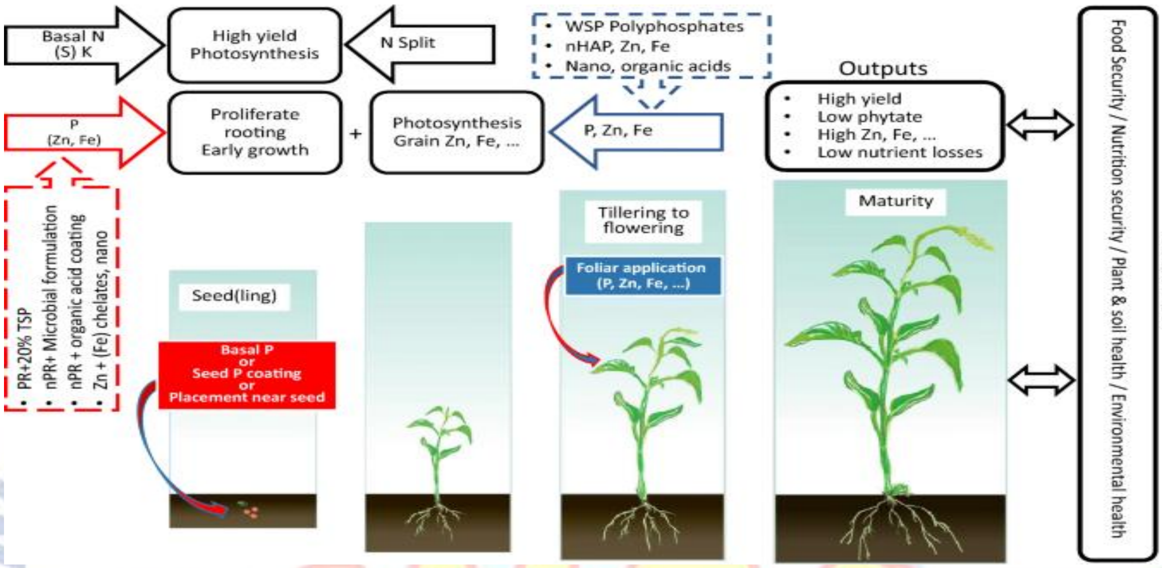
ABSTRACT

Pulses are an integral part of Indian agricultural economy next to cereals and oilseeds in terms of acreage, production and economic value. Pulses are rich source of protein and energy, but in India, these are largely cultivated under energy starved conditions resulting in poor pulse productivity. This is mainly because of unavailability of quality seed at desired time, cultivation on marginal and sub-marginal lands, imbalanced use of fertilizers and non-adoption of crop improved management practices. India is the largest producer and consumer of pulses in the world, accounting for about 25% of global production, 27% of consumption and 34% of food use. To reduce the demand-supply gap, government of India launched various programmes in pulses. Still, prime attention is required to meet the food security challenges, especially in case of pulse sector. In order to enhance and sustain the pulse productivity at high levels, the development and promotion of low–cost pulse production technology need greater attention so that technology is widely adopted by the practizing farmers. The most potential technologies in pulse production include improved crop establishment and management practices, integrated soil fertility and pest management practices, etc. which enhance not only the productivity and profitability but also warrants environmental and social sustainability besides nutritional security. Various agronomic researches have shown that improved cultivation practices, such as seed replacement with improved varieties, raised bed planting method, use of biofertilizers, foliar application of fertilizers at critical stages in rainfed areas, application of secondary and micro-nutrients and adoption of appropriate modules for integrated weed and pest management, etc. have great potential in gearing–up pulses productivity. Thus, there is a great challenge for policy makers, farm scientists and farming community to enhance pulse productivity using improved farm technology to meet–out the national and local pulse requirements. Antagonistic P-Zn interactions can occur when soils receive high P application rates or those that are very low in plant available Zn. Phosphorus (P) fertilizer is often added to cropping systems to increase yield, but growers should not overlook the importance of micronutrients like Zinc (Zn). Understanding some of the nutrient interactions that affect nutrient availability can help with management decisions like fertilizer source. The interaction of P and Zn has been well researched and documented in the fields of soil chemistry and plant nutrition. For example, research shows that high rates of P fertilizer without adequate plant available Zn can reduce Zn uptake by the roots, induce Zn deficiency, and decrease plant growth and yield. When making decisions for a soil fertility program, it is important to consider some of the factors and situations that may cause P-Zn antagonism and how to best avoid or minimize those factors. Hence farming in Tarai region of UP includes P and Zn addition confirmly because of their antagonism.

KEYWORDS : Phosphorus, zinc, tarai, uttar Pradesh, antagonism, soil, fertilizer

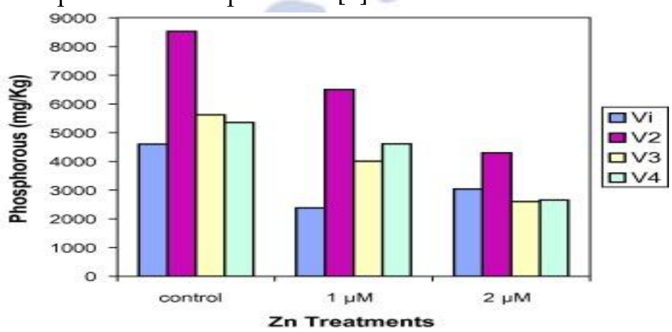
INTRODUCTION

Pulses play a fundamental role as a low fat, high fiber source of protein and carbohydrates, the essential components of traditional food basket. Pulses contributing about 10 per cent in daily protein intake and 5 per cent in energy intake are of particular importance for food security in low income countries, where the major source of protein are non animal products. Pulses also contains thiamin, niacin, calcium, phosphorus, iron etc are also found in sufficient quantity and essential for human per day minimum nutrient requirement. [1]



Phosphorus fertilizers essential for crops

During 1951 the area under pulses cultivation in India was 19.09 million hectares, which increased to 26.47 million hectares in 2015-16. The production of pulses increased from 8.41 million tonnes to 18.45 million tonnes. The production increased by 119.38 per cent where as the population increased by 252.12 per cent, showing more rapid growth for the same period. Due to population explosion, the per capita availability of pulses has declined from 60.72 g/ day to 46.78 g/day against the requirement of 80 g/day. The productivity of pulses has increased from 4.41 q/ha in 1951 to 8.03 q/ha in 2015-16. This shows that there was no significant increase in productivity of pulses as compared to the cereals. [2] The main reason behind it was that the pulses have been regarded as "The crop of the marginal area and crop of poor farmers". Due to this reason very little promotional efforts by the farmers, government and other agencies has been taken. Other reason for low productivity and adaptability of pulse crops are highly susceptible to insects, pests and diseases as compared to pulsesand other crops, insufficient availability of HYV seeds, poor and slow technological dissemination, improper marketing infrastructure. In this context, the minimum research attention towards pulses contributed more gap between its requirement and supply.[3] Growth, variation and forecasting in agriculture production have become a matter of great concern from the view point of long term food security of the country. It is always desirable to maintain high and regular growth in farm production with minimum variability to achieve sustained economic growth. Keeping in mind, the importance of pulses and estimation of its demand and supply and projection, a critical examination of growth, variation, decomposition analysis and constraints related to production, post harvest management and marketing infrastructure among various agro-climatic zones on one hand and the growth of population on other would have paramount importance.[4]



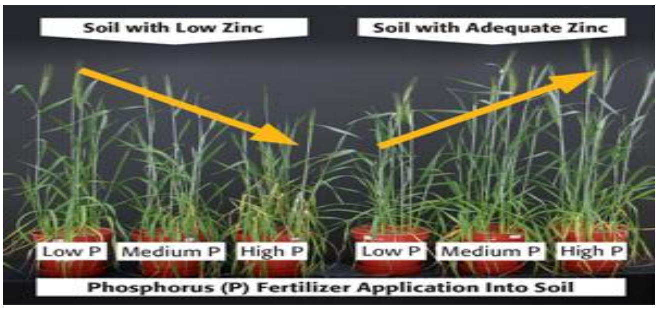
Zn with P effects on growth rate increased

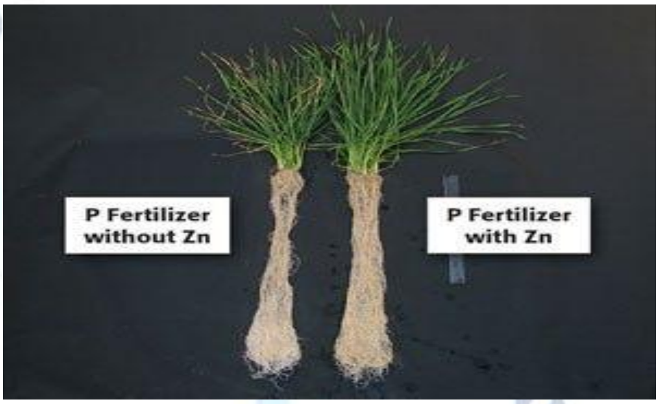
Pulse crops are cultivated in Kharif, Rabi and Zaid seasons of the Agricultural year. Rabi crops require mild cold climate during sowing period, cold climate during vegetative to pod development and warm climate during maturity / harvesting. Similarly, Kharif pulse crops require warm climate throughout their life from sowing to harvesting. Summer pulses are habitants of warm climate in Tarai Areas of Uttar Pradesh. [5]

One of the primary causes of Zn deficiency in soils treated with high amounts of P fertilizer is its reaction with soluble Zn in the soil. This reaction produces insoluble Zn-phosphate complexes which influences the availability of Zn for plant uptake over time . A potential outcome is a reduction of Zn availability leading to Zn deficiency and reduced plant growth. Mycorrhizae are beneficial fungi that form a symbiotic association with roots. Mycorrhizal fungi play an important role in plant nutrient uptake (particularly P and Zn) by extending hyphae (e.g., a fungi produced root-like structure) horizontally and deeper into the soil where plant roots normally can't reach. These fungi allow plant roots to have a greater surface area for increased water and nutrient uptake capacity. In terms of Zn, mycorrhizae may be responsible for up to 50% of the total Zn uptake in crop plants . When high rates of P are applied, hyphae become "lazy" and the overall root footprint is decreased, resulting in a reduction of Zn uptake by the plant. High P application rates may, therefore, reduce Zn uptake mainly due to the reduced mycorrhizae-dependent Zn uptake. [6]

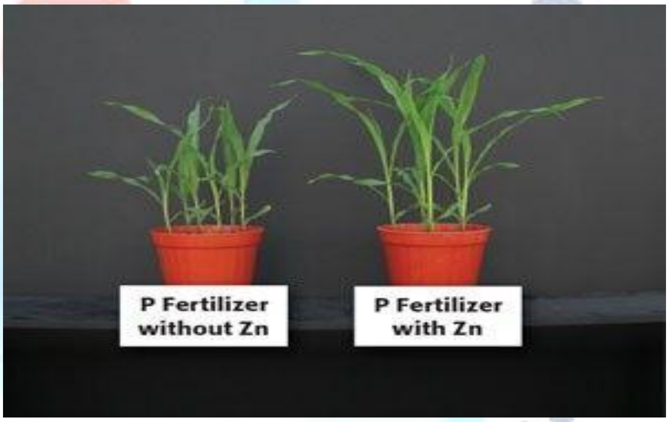
OBSERVATIONS

Antagonistic P-Zn interactions can occur when soils receive high P application rates or those that are very low in plant available Zn. For example, a greenhouse study using a calcareous soil with low plant available Zn discovered that high P application rates induced Zn deficiency and reduced plant growth. In contrast, plants that received adequate Zn did not show any Zn deficiency and responded positively to higher P rates. [7]





P and Zn are antagonistic



P with Zn shows better yield and growth

Due to the negative P-Zn interaction, maintaining proper Zn nutrition is critical, especially when soils receive P fertilizer. It is, therefore, not surprising why pulse crops in Tarai region of UP are treated with P fertilizer co-granulated with Zn resulted in better growth and yield than plants that received P without Zn. Applying Zn-containing P fertilizers not only improved shoot growth, but demonstrated root growth improvements as well.[8]

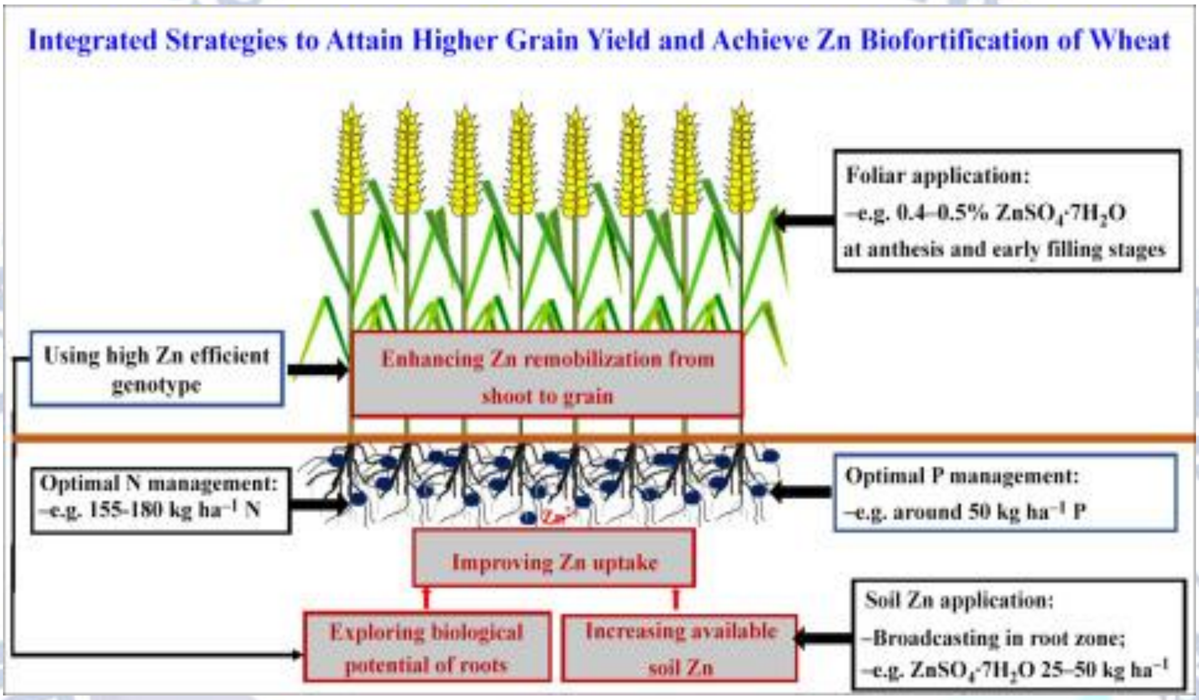
DISCUSSIONS

Urd bean holds good performances in absolute terms among the other pulse crops while the compound growth rate revealed that the moong bean was found to be positive and recorded second highest growth rate among other pulse corps in terms of area of cultivation, production and yield in Uttar Pradesh over the study period. Eventhough, the fact that urd bean, moong bean and pea were found to obtain positive growth performance in production and yield among other pulse crops. The future projection shows that we are lagging behind the production of pulses crops as it decreasing every year which forced to malnutrition for majority of the population in the state[9]

The addition of P fertilizer without adequate Zn can reduce crop growth and yield. Research suggests that two of the key reasons are:

1) Negative P-Zn interaction and the formation of insoluble Zn-Phosphate complexes and

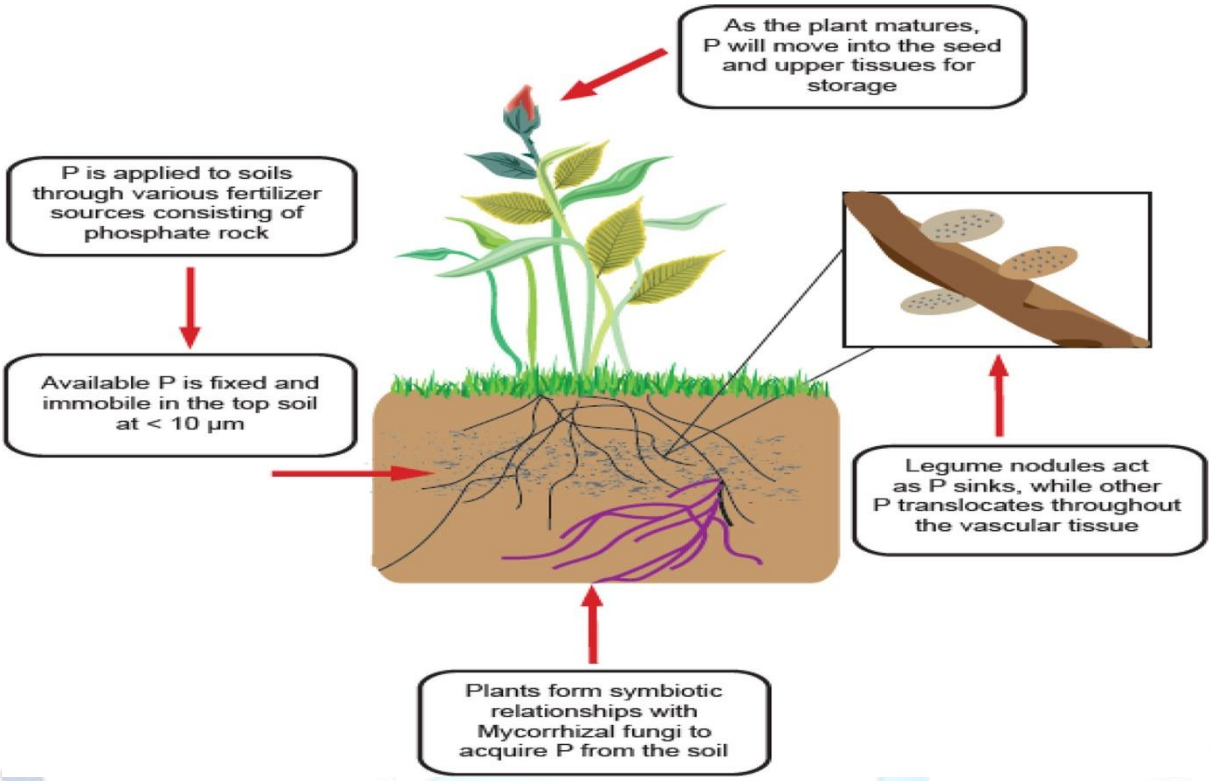
2) Reduced mycorrhizal activity. The negative effect is magnified under conditions where soil Zn supply is very low and P application rates are high. Improved plant growth response to P was realized when the Zn supply was sufficient or when Zn was co-granulated with P fertilizer. Therefore, application of Zn-containing P fertilizers can be successful in reducing or eliminating the Zn deficiency and realize a greater response to applied P.[10]



Zn and P antagonism for cereals and pulses

RESULTS

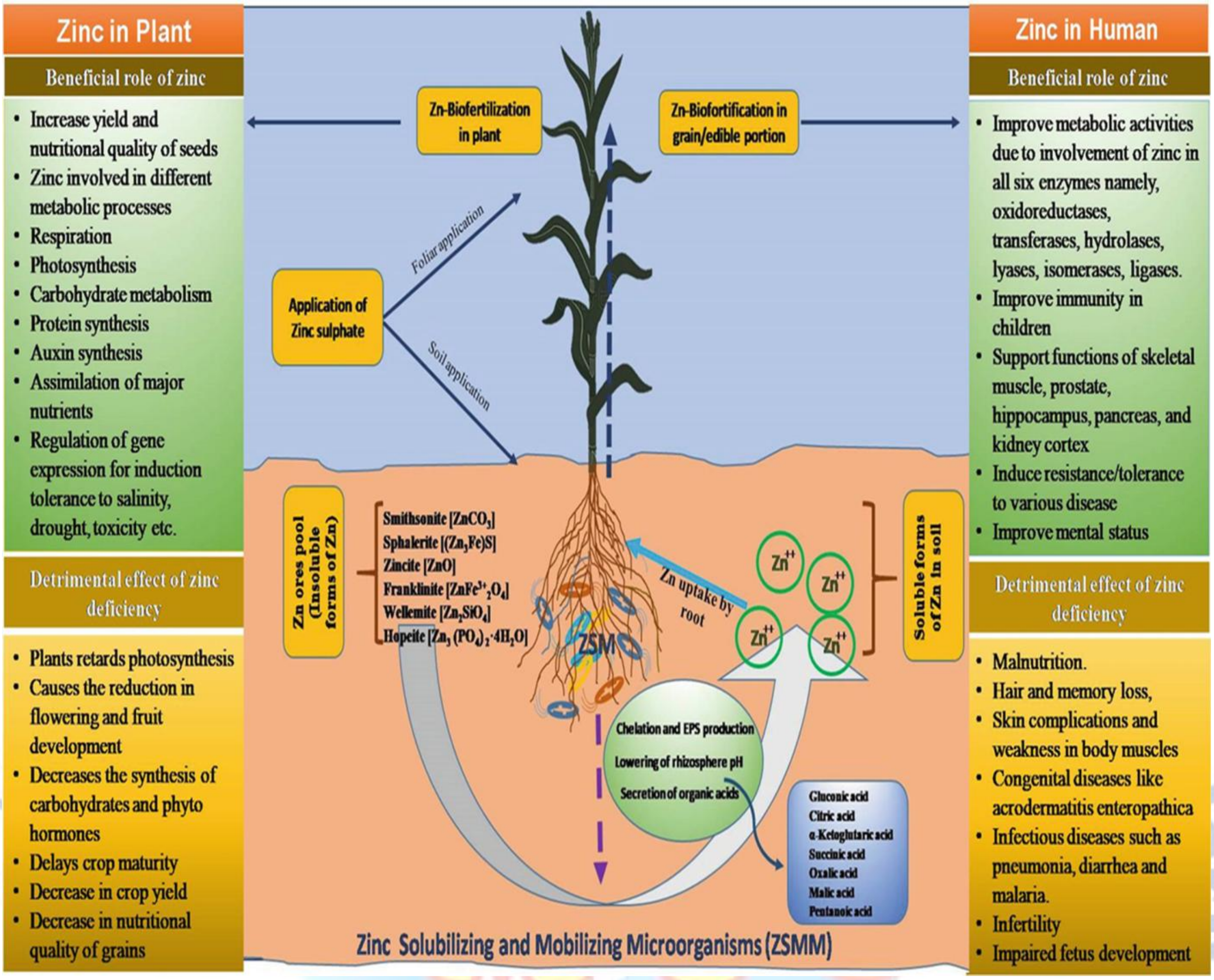
Pulses, long considered "the poor man's meat" because of their protein profile, occupy a unique place in India. India ranks as the country with the world's largest number of malnourished people. Because of this, coupled with the country's high incidence of vegetarianism, the future of pulses is of special significance to India's large poor population. Pulses are also among the crops that have been adversely affected by the dominance of cereals over the past several decades, so it is clear that agricultural policy is implicated in both the nutritional challenges and, as we hope to show, in potential solutions. India is the world's largest producer and consumer of pulses. Major pulses grown in India include chickpea or Bengal gram, pigeon pea or red gram, lentil, black matpe, mung bean or green gram, lablab bean, moth bean, horse gram, pea, grass pea or khesari (*Lathyrus sativus*), cowpea (*Vigna unguiculata*), and broad bean or faba bean (*Vicia faba*). Popular pulses in India are chickpea, pigeon pea, green gram, black matpe, and lentil. Pulses are mostly grown in two seasons: (1) the warmer, rainy season or kharif (June–October), and (2) the cool, dry season or rabi (October–April) Chickpea, lentil, and dry peas are grown in the rabi season, while pigeon pea, black matpe, green gram, and cowpea are grown during kharif.[11]



Phosphorus essential in Pea cultivation

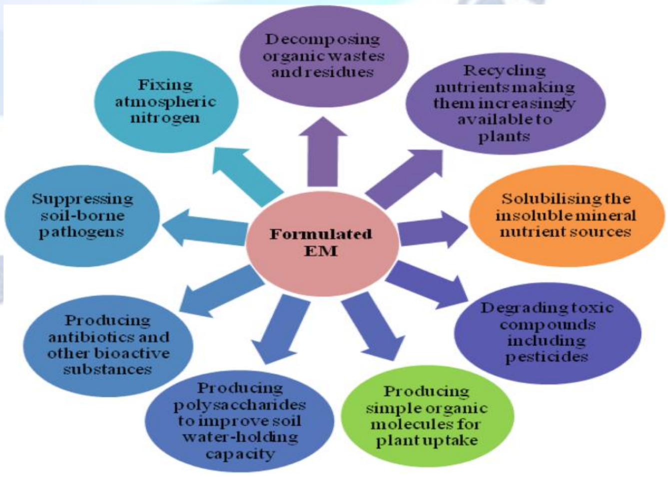
Among the various pulses, chickpea dominates, claiming a more than 40 percent share in production of all pulses grown, followed by pigeon pea (18–20 percent), green gram (11 percent), black matpe (10–12 percent), lentil (8–9 percent), and other legumes (20 percent) .The major pulses—chickpea, pigeon pea, lentil, green gram, and black matpe—account for nearly 80 percent of total pulse production in India. India's total production, in turn, accounts for 33 percent of world production by area and 22 percent of world production by volume. By area, India's production makes up 90 percent of global production of pigeon pea, 65 percent of chickpea, and 37 percent of lentil; this corresponds to 93 percent, 68 percent, and 32 percent of the global production of these pulses, respectively, by volume . Among all pulses, lentil is the most actively traded (about 25 percent of world production of lentil is internationally traded) . Lentil is an important rabi pulse crop, next only to gram, and it is distinctive in being the only pulse grown in India with a net exportable surplus (all other pulse trade has a significant net import reliance).[12]

Typical Zn deficiencies mainly occur in sandy soils, which are low in soil organic matter (SOM), and on organic soils.



Zinc solubilising and mobilizing microbes

Zinc deficiency is also noticed in the soil derived from parent material having low zinc, and clay soil with high magnesium levels. Zinc deficiencies may be observed during cold and wet spring weather and result in reduced root growth and activity. Lower microbial activity decreases zinc release from SOM. Zinc uptake by plants decreases with increase in the soil pH. High pH and low SOM reduce root absorption and cause Zn deficiency in all dry regions of the world . Uptake of zinc is also adversely affected with high levels of available P in soils. Since Zinc is not mobile in the plants, thus zinc-deficiency symptoms occur mainly in new/terminal growth. Due to poor mobility in plants, constant supply of zinc is essential for optimum growth. Besides its major role in formation of chlorophyll, it is involved in several enzyme systems, growth hormone (auxins) and the synthesis of nucleic acids and plays an important role in the intake and use of water by plants. Plants suffering with zinc deficiency exhibit delayed maturity, short internodes and a decrease in leaf size. The biochemical inhibitions as a result of its toxic concentrations include negative effects on photosynthetic electron transport, photo-phosphorylation and photosynthetic enzymes. One of the primary mechanisms of Zn toxicity may be an increased permeability of root membranes resulting in nutrients leakage from the roots .[13]



Formulated environmental microbes and crop production

CONCLUSION

Different cropping systems also show differential responses to Zn application. In the soybean-chickpea system, application of different doses of Zn/Zn+S to soybean increased seed yield of soybean from 260 – 590 kg/ha, while its residual effect on chickpea was 240-550 kg/ha.It was also reported higher system productivity and elevated soil organic carbon (SOC), available N, P and K status of the soil in INM treatments with $ZnSO_4$ in the system. Studies on the direct and residual response of application of Zn enriched FYM in various pulse based cropping systems and observed that in a soybean- chickpea system, there was a 27.3 and 30.9% increase in seed yields of soybean and chickpea, respectively due to direct and residual effect of 5 kg Zn+200kg FYM/ha respectively .[14] It is also concluded that application of recommended dose of NPK (60:40:20 kg/ha)+20 kg $ZnSO_4$/ha during kharif significantly increased grain yield of maize as well as the succeeding crops of chickpea . It has been observed that the application of either Zn alone or with S increased seed yield of both the crops in the system . There is no need to apply fertilizer in each crop.[15] They also observed that application of 5 kg Zn + 40 kg S to blackgram increased seed yield of blackgram to the tune of 530 kg/ha and due to its residual effect, the increase in the seed yield of chickpea was also observed to the extent of 530 kg/ha. Similarly, in blackgram - pea cropping system, direct effect of different doses of fertilizer was 130-530 kg/ha, while its residual effect on succeeding pea was 530-690 kg/ha. It is also reported that in a calcareous soil of Bangladesh, the optimum rate of Zn for the maize-mungbean-rice cropping system was found to be 4-0-2 kg/ha for the first year and 2-0-2 kg/ha for subsequent years particularly when mungbean residue was removed, and such rates for mungbean residue incorporation were 4-0-1 and 2-0-1 kg/ha, respectively . Further, Zn and N concentrations of grain were significantly increased following Zn application in all pulse crops in the system.[16]

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