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Zinc Biofortification in Groundnut

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Abstract

Mineral nutrient deficiencies are worldwide issue correlated directly with poverty and food insecurity as population is increasing day by day rapidly. Zinc is an essential component of a variety of dehydrogenases, proteinases and peptidases. In developing countries like India, where rural people generally depend on oilseed crops like groundnut, there biofortification can play a key role for their nourishment. Biofortification is the process of increasing bio available concentration of essential elements in edible portion of crop plant through agronomic or genetic or molecular approach. Developing crop cultivars with high concentration of micronutrients in edible part through genetic engineering is known as genetic biofortification which is a complex and time taking process. So, agronomic fortification with soil and foliar application of micronutrients particularly zinc not only increase the yield but also the quality of groundnut for obtaining good economic returns and nutritional security. Improvement of yield and quality of groundnut by agronomic biofortification is the most cost-effective and sustainable solution to this global health problem. Therefore, zinc biofotification in groundnut sustain agriculture-based income and food security within the context of climate change.

Keywords: Biofotification, Climate change, Foliar application.

Introduction

About half of the world's population suffers from micronutrient malnutrition including selenium, zinc, iron and iodine which is mainly associated with low dietary intake of micronutrients in diets with less diversity of food (Mayer *et al.*, 2008). Micronutrient malnutrition can lower intelligence quotient, cause stunted growth and blindness in children, lower disease resistance in both children and adults and increase risks for both mothers and infants during child birth. Zn deficiency is a well-documented

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problem in food crops, causing decreased crop yields and nutritional quality. Generally, the regions in the world with Zn deficient soils are also characterized by widespread Zn deficiency in humans. According to WHO report on the risk factors responsible for development of illnesses and diseases, Zn deficiency rank 11th among the 20 most important factors in the world and 5th among the 10 most important factors in developing countries (Anonymous, 2002). In India, zinc is now considered as the fourth most important yield-limiting nutrient after nitrogen, phosphorus and potassium respectively. Among oilseeds, groundnut in particular suffers from Zn deficiency (Singh, 2007). However, in India due to low productivity, the per capita availability of groundnut is less. High Zn density groundnuts may be a solution to ensure adequate level of Zn intake (Singh and Lal, 2007) which necessitates increasing Zn concentration of seed through fortification and selection of high Zn density genotypes. Thus, an effort was made to increase the seed Zn content in a number of groundnut cultivars through soil and foliar application of Zn.

Groundnut and Its Present Status of Production

Among the oilseed crops, Groundnut (*Arachis hypogaea* L.), is "king of oilseeds" belongs to the family leguminosae and is commonly called as poor man's almond or peanut. It is the world's fourth most important source of edible oil and third most important source of vegetable protein. It is a unique crop, combining the attributes of both oilseed and legume crop in the farming system of Indian agriculture. It contains about 50% oil, 25-30% protein, 20% carbohydrate and 5% fiber and ash which make a substantial contribution to human nutrition and also a valuable source of vitamin E, K and B. The high-energy value protein content and minerals make groundnut a rich source of nutrition at a comparatively low price. About two third of world production is crushed for oil and remaining one third is consumed as food. It is a richest plant source of thiamine and niacin, which is low in cereals. The plant, kernel, oil and cake are economically used in one or the other way.

The major groundnut producers in the world are China, India, Nigeria, USA, Indonesia and Sudan. In India groundnut is being grown over an area of 4.76 million hectares with a total production of 7.40 million tonnes with productivity of 1555 kg ha^{-1}. Andhra Pradesh is one of the leading states with 0.87 million hectares under groundnut producing 0.49 million tonnes with a productivity of 564 kg ha^{-1} (Ministry of Agriculture and Farmers Welfare, Government of India, 2014-15).

Need of Zn Biofortification in Groundnut

Zinc plays significant role in various enzymatic and physiological activities of the plant. Zinc catalyses the process of oxidation in plant cells and is vital for transformation of carbohydrates, regulates the consumption of sugar, increases source of energy for the production of chlorophyll, aids in the formation of auxins which produce more plant cells and more dry matter, that in turn will be stored in seed as a sink and promotes absorption of water. In plants, the deficiency of zinc arises mainly due to alkaline soil pH, calcareous soil, low organic matter, exposed sub soil, use of Zn free fertilizers and flooding induced electrochemical changes. The fact that at least 60% of cultivated soils have growth-limiting problems with mineral nutrient deficiencies and toxicities, and about 50% of the world population suffers from micronutrient deficiencies make plant nutrition research a major promising area in meeting the global demand for sufficient food production with enhanced nutritional value in this millennium (Cakmak, 2002). Zinc deficiency in crops is the common micronutrient problem world over; therefore, zinc malnutrition has become a major health burden among the resource poor people. There are several approaches to increase the concentration of micronutrients in foods, including food stuff nutrient fortification, supplementation programmes, conventional breeding and genetic engineering to diagnose and manage the problem of micronutrient malnutrition. However, these approaches appear to be expensive and not easily accessible by those living in developing countries. However, plant breeding, the most powerful agricultural approach, may not effectively work in regions where soils have very low plant available pools of micronutrients due to adverse soil chemical and physical conditions (Cakmak, 2008). Besides, finding sufficient and promising genotypic variation and maintaining the stability of targeted micronutrient traits across diverse types of environments may also be difficult. Under such circumstances, agronomic bio-fortification, including the use of micronutrient fertilizers, is an important complementary solution (White and Broadley, 2009). To reduce Zn deficiency along with the day by day increasing population of the developing nations, there is a need to nourish them with Zn enriched foodstuff on sustainable basis. Enrichment of plant food material with Zn is termed as 'agronomic biofortification' is compulsory (Cakmak, 2008).

Agronomic Biofortication

Biofortification is derived from greek word "bios" means "life" and latin word "fortificare" means "make strong". The process of adding vitamins or minerals to the crops in order to improve their overall nutrient content is called as biofortification. It is two types, genetic biofortification and agronomic fortification (Fig.1). Enhancing of a particular nutrient by addition of fertilizer to soil or to foliage in appropriate form, time and growth stages of the crop is known as agronomic fortification which is a simple and rapid solution to the problem. Application of fertilizers to soil and/or foliar to improving grain nutrient concentration and the potential of nutrient containing fertilizers for increasing nutrient concentration of grains.

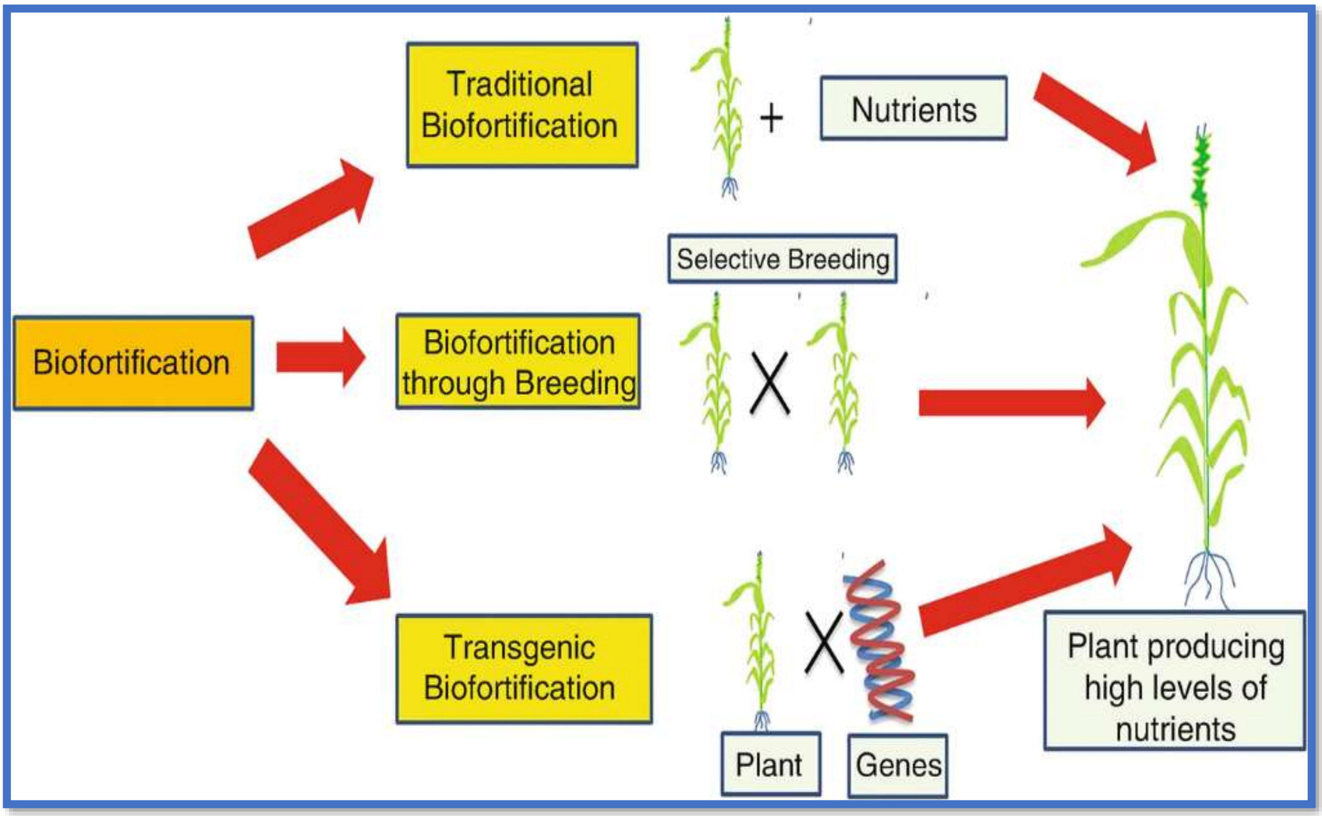

Fig. 1: Methods of Biofortification

Effect of Zn Biofortification in Groundnut

Gunri and Nath (2012) reported that the significantly highest nodule number (21.3) and nodule weight (25.9 mg) in groundnut was recorded at 45 DAS when farm yard manure was applied @10 t ha^{-1} along with recommended dose of fertilizer and it was at par with the treatment received poultry manure @ 5 t ha^{-1} along with recommended dose of fertilizer. Patro *et al*. (2014) reported that soil application of recommended dose of fertilizer with 7.5 t ha^{-1} of FYM and borax @ 10 kg ha^{-1} recorded significantly highest number of root nodules per plant at 40 DAS (15.6) and 80 DAS (18.9) as compared to other fertility levels. Irmak *et al*. (2015) reported that in the control plots Zn concentration of grain was 37.0 mg kg^{-1} and which was raised to 55.0 mg kg^{-1} with soil application of zinc @ 20 kg ha^{-1}. Similar to soil application, the foliar applied Zn enhanced grain Zn concentration of NC-7 variety which was 12.0 mg kg^{-1} at control plot and increased to 21.0 mg kg^{-1} with foliar application of zinc @ 0.5 kg ha^{-1}. Nadaf and Chidanandappa (2015) observed that N, P and K contents and their uptake in haulm and kernel significantly increased due to application of zinc sulphate at three levels 5, 10 and 20 kg ha^{-1} either alone are in combination with borax @ 5 kg ha^{-1}. Rana and Noman (2016) reported that soil application of 2.5, 5.0 and 7.5 kg Zn ha^{-1} was found to increase Zn-content in kernel, shell and haulms at harvest over no application. Thota (2017) revealed that at peg formation stage, significantly highest zinc uptake (57.03 g ha^{-1}) was recorded in the treatment T_7 and lowest zinc uptake (33.99 g ha^{-1}) was recorded in the treatment T1(RDF). At pod development stage, significantly highest zinc uptake (112.07 g ha^{-1}) was recorded in the treatment T_7 and the lowest zinc uptake (67.99 g ha^{-1}) was recorded in the treatment T_1. At harvest stage, significantly highest uptake (113.22, 6.83 and 47.62 g ha^{-1} in haulm, shell and kernel, respectively) was recorded in the treatment T_7, while the lowest zinc uptake (65.28, 5.08 and 29.19 g ha^{-1} in haulm, shell and kernel, respectively) was recorded in the treatment (Table 1).

Table 1: Effect of zinc in combination with organic manures on Zn uptake (g ha^{-1}) in different plant parts at different growth stages of groundnut (Thota, 2017)

Treatments	Peg formation	Pod development	Harvest		
			Haulm	Shell	Kernel
T_1: RDF (30 kg N-40 kg P2O5-50 kg K_2O ha^{-1})	33.99	67.99	65.28	5.08	29.19
T2 : T1 + 50 kg ZnSO4 ha^{-1} (soil application)	43.37	84.70	91.04	5.88	36.95
T3 : T1 + 0.2% ZnSO4 foliar spray at 30 and 40 days after sowing	36.39	79.34	90.15	5.99	36.06

T4 : T1 + 37.5 kg ZnSO4 ha^{-1} + Vermicompost @ 5 t ha^{-1}	49.34	92.84	97.03	6.43	39.50
T5 : T1 + 37.5 kg ZnSO4 ha^{-1} + Poultry manure @ 5 t ha^{-1}	50.43	97.86	98.33	6.68	40.65
T6 : T1 + 37.5 kg ZnSO4 ha^{-1} + Farmyard manure @ 5 t ha^{-1}	45.15	87.59	94.51	6.37	38.60
T7 : T1 + 37.5 kg ZnSO4 ha^{-1} + Press mud @ 5 t ha^{-1}	57.03	112.07	113.22	6.83	47.62
SEm±	1.99	4.58	4.66	0.32	1.84
CD (0.05)	6.14	14.14	14.37	1.01	5.67

Conclusion

As, groundnut is an important oilseed crop zinc biofortification is too much beneficial. Zinc deficiency in human beings has these days acquired international attention as it is an essential element for human being which is involved in growth as well as development. Biofortification of staple food crops with micronutrient fertilization can be potential solution to this problem. Adding zinc-enriched fertilizer to the soil results in increased uptake of zinc in groundnut crop besides increasing the bioavailable zinc concentration in the edible portion of the plant. However, Zn biofortification in groundnut requires more research leading to improvement of human health and nutrition sectors.

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