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Effect of Zinc Biofortification Methods on Symbiotic and Phenological Parameters of Chickpea Varieties

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ABSTRACT

A field experiment was conducted at Instructional farm, Rajasthan College of Agriculture, MPUAT, Udaipur (Rajasthan) during the *rabi* season 2021-22 and 2022-23 to evaluate the effect of zinc biofortification methods on symbiotic and phenological parameters of chickpea varieties. The experiment consisted four chickpea varieties and six zinc biofortification methods thereby involving 24 treatment combinations which was replicated four times in split plot design. The chickpea variety GNG 2144 recorded highest mean effective root nodules plant^{-1} (39.82) and their dry weight (140.4 mg plant^{-1}) which was significantly higher over varieties GNG 1958, RVG 203 and Pratap Chana 1. The soil application of 25 kg $ZnSO_4$ ha^{-1} + foliar application of 0.5% $ZnSO_4$ recorded significantly higher mean effective root nodules plant^{-1} (37.93) and their dry weight (136.3 mg plant^{-1}) over rest of zinc biofortification methods. The chickpea variety Pratap Chana 1 took minimum days to attain 50% flowering (66.55) and maturity (134.5) as compared to rest of chickpea varieties. Among zinc biofortification methods, soil application of 25 kg $ZnSO_4$ ha^{-1} + foliar application of 0.5% $ZnSO_4$ took minimum days to attain 50% flowering (124.5) and brings early crop maturity over rest of zinc biofortification methods.

Key words: *Biofortification, Chickpea, Root nodules, Soil and foliar application and Zinc*

Introduction

In India, chickpea (*Cicer arietinum* L.) is the most important *rabi* season pulse crop and secures the first position in both area and production among the pulses. It contains 17-21% protein, 62% carbohydrates, 4% fat and minerals such as calcium, phosphorus, zinc, iron and magnesium (Diapari *et al*., 2014). During 2021-22, chickpea cultivated in the area of 10.91 m ha with production of 13.75 m t with average productivity of 1260 kg ha^{-1} (MoA & FW, 2023).

Zinc, essential for plant growth and human health, plays critical roles in various biological functions. Nearly 10% of all proteins in biological systems need zinc for their functions and structure. Plants require zinc in small but critical concentrations for several key functions, including: membrane function, photosynthesis, protein synthesis, phytohormone synthesis (e.g. auxine) and defensive mechanism against disease and abiotic stress factors (Alloway, 2008). Zinc is vital for many biological functions in the human body. Zinc is essential for the proper functioning of a large number of proteins and over 100 specific enzymes in the human body (Andreini *et al*., 2006).

Biofortification boosts certain micronutrient levels in crop plants' edible parts using agronomic methods (mineral fertilizers) and conventional breeding approaches (Majeed *et al*., 2020). Zinc fertilizers offer a sustainable solution to enhance crop yields and grain zinc concentration, addressing both agricultural and nutritional challenges. Furthermore, agronomical biofortification approaches are cost effective and delivering more micro-nutrients in the grains on long term basis. However, the response of varieties varies based on the rate, source, and methods of zinc fertilizer application (Shivay *et al*., 2015). This study aims to explore the influence of zinc biofortification methods on symbiotic and phonological parameters chickpea varieties.

Materials and Methods

The experiment was laid out at the Instructional Farm, Rajasthan College of Agriculture, MPUAT, Udaipur, Rajasthan. The experiment comprised of four chickpea variety (GNG 2144, GNG 1958, RVG 203 and Pratap Chana 1) and zinc biofortification methods (Control, Seed priming with 0.05% $ZnSO_4$, Soil application of 25 kg $ZnSO_4$ ha^{-1}, Foliar application of 0.5 % $ZnSO_4$ at flowering and pod development stage, Seed priming with 0.05% $ZnSO_4$ + Foliar application of 0.5% $ZnSO_4$ and Soil application of 25 kg $ZnSO_4$ ha^{-1} + Foliar application of 0.5% $ZnSO_4$) thereby involving 24 treatment combination which was replicated four time in split plot design. Seeds were sown in furrow opened at 30 cm apart using seed rate 80 kg ha^{-1}. Recommended dose of fertilizer was applied at 20 kg N + 40 P_2O_5 kg ha^{-1} by using urea and single super phosphate. Symbiotic studies involved uprooting five randomly selected plants from each plot at 75 days after sowing (DAS). Roots were meticulously washed to remove soil; nodules were removed, counted and expressed as the number of nodules plant^{-1}. For the dry weight of nodules, nodules were then sun-dried for 2 days, followed by oven drying until a constant weight was reached after that, the average dry weight of nodules plant^{-1} was calculated. In phenological studies, observations are recorded for the time when 50% of plants attain flowering, measured from the date of sowing. Similarly, the days to maturity are calculated from sowing to harvest, when more than 80% of plants turn yellowish and reach maturity.

Results

Symbiotic Parameters

Effective nodules and their dry weight plant^{-1} at 75 DAS

The highest numbers of effective nodules and their dry weight plant^{-1} were recorded with chickpea variety GNG 2144 which were significantly higher over rest of varieties during both years. On pooled basis, chickpea variety GNG 2144 significantly increased number of effective nodules and their dry weight plant^{-1} by10.06, 14.92, 18.24 and 9.18, 12.05, 22.09 per cent, respectively over variety GNG 1958, RVG 203 and Pratap Chana 1, respectively. Amongst zinc biofortification methods, the highest numbers of effective nodules plant^{-1} and their dry weight were recorded with the soil application of 25 kg $ZnSO_4$ + foliar application of 0.5% $ZnSO_4$ which was significantly higher by 4.32, 5.10, 8.56, 10.97, 17.21 and 4.36, 5.58, 8.17, 9.74, 15.90 per cent over soil application of 25 kg $ZnSO_4$, seed priming with 0.05% $ZnSO_4$ + foliar application of 0.5% $ZnSO_4$, seed priming with 0.05% $ZnSO_4$, foliar application of 0.5% $ZnSO_4$ and control, respectively.

Phenological Studies

Days to 50% flowering and maturity

The chickpea variety GNG 1958 took maximum days to attain 50% flowering and maturity which was significantly delayed compared to varieties GNG 2144, RVG 203 and Pratap Chana 1 during both years. Pooled results show that chickpea variety Pratap Chana 1 took 64.19 days to attain 50% flowering and 123.7 days to attain maturity which was significantly earlier by 2.49, 4.38, 8.81 and 6.20, 6.40, 10.80 days, respectively over variety RVG 203, GNG 2144 and GNG 1958. Among zinc biofortification methods, chickpea crop took maximum days to 50% flowering and maturity under control which was significantly later than zinc biofortification methods. On pooled basis, zinc biofortification through seed priming with 0.05% $ZnSO_4$ + foliar application of 0.5% $ZnSO_4$, seed priming with 0.05% $ZnSO_4$, soil application of 25 kg $ZnSO_4$ + foliar application of 0.5% $ZnSO_4$ and soil application of 25 kg $ZnSO_4$ took 67.77, 67.56, 66.55, 66.24 days to attain 50 % flowering and which was significantly earlier by 2.77, 2.98, 3.99 and 4.30 days compared to control, respectively. However, zinc biofortification through foliar application of 0.5%

Table 1. Effect of zinc biofortification methods on symbiotic and penological parameters of chickpea varieties

Treatments	Effective nodules plant^{-1}			Nodules dry weight			Days of 50 % flowering			Days to maturity		
	2021-22	2022-23	Pooled	2021-22	2022-23	Pooled	2021-22	2022-23	Pooled	2021-22	2022-23	Pooled
Varieties												
GNG 2144	37.62	42.02	39.82	137.1	143.7	140.4	66.27	70.87	68.57	126.8	133.1	129.9
GNG 1958	34.55	37.80	36.18	126.6	130.5	128.6	71.06	74.94	73.00	132.2	136.9	134.5
RVG 203	32.94	36.36	34.65	124.2	126.3	125.3	65.20	68.17	66.68	129.0	131.2	130.1
Pratap Chana 1	28.75	32.44	30.60	112.9	117.1	115.0	62.24	66.13	64.19	121.3	126.0	123.7
S.Em.±	0.74	0.78	0.54	2.8	2.7	1.9	1.23	1.28	0.89	2.3	2.2	1.6
C.D. (P=0.05)	2.38	2.48	1.60	8.9	8.6	5.7	3.92	4.11	2.64	7.4	7.1	4.8
Zinc biofortification methods												
Control	30.75	33.96	32.36	115.7	119.5	117.6	68.51	72.57	70.54	131.8	136.9	134.4
Seed priming with 0.05% $ZnSO_4$	33.07	36.80	34.94	123.5	128.6	126.0	65.86	69.26	67.56	129.3	133.9	131.6
Soil application of 25 kg $ZnSO_4$ ha^{-1}	34.52	38.21	36.36	128.3	132.9	130.6	64.35	68.12	66.24	125.1	129.8	127.5
Foliar application of 0.5 % $ZnSO_4$	32.38	35.99	34.18	122.3	126.1	124.2	67.90	72.12	70.01	128.4	133.0	130.7
Seed priming + Foliar application	34.14	38.04	36.09	126.9	131.3	129.1	65.82	69.73	67.77	126.4	131.1	128.8
Soil application + Foliar application	35.94	39.93	37.93	134.6	137.9	136.3	64.72	68.38	66.55	122.9	126.1	124.5
S.Em.±	0.43	0.46	0.32	1.6	1.6	1.1	0.91	0.96	0.66	1.6	1.7	1.2
C.D. (P=0.05)	1.22	1.31	0.88	4.6	4.6	3.2	2.58	2.73	1.86	4.5	4.8	3.3

$ZnSO_4$, seed priming with 0.05% $ZnSO_4$ + foliar application of 0.5% $ZnSO_4$, soil application of 25 kg $ZnSO_4$ and soil application of 25 kg ZnSO4 + foliar application of 0.5% $ZnSO_4$ took 130.7, 128.8, 127.5 and 124.5 days to maturity which was significantly later by 3.7, 5.6, 6.9 and 9.9 days compared to the control, respectively.

Discussion

The variation in symbiotic and phenological parameters among chickpea varieties is primarily driven by genetic differences, genotypic potential, and adaptability to varying soil and climatic conditions. Each variety possesses a distinct genetic makeup that influences its growth characteristics.

Early flowering in chickpea, induced by soil application of 25 kg $ZnSO_4$ ha^{-1} + foliar application of 0.5% $ZnSO_4$, can be attributed to the essential role of zinc in stimulating various physiological and metabolic processes crucial for plant development. Previous studies on chickpea by Khan (1998) and Parmar and Poonia (2020) collectively indicate that zinc deficiency delays both flowering and maturity, highlighting the significance of zinc supplementation. The significant increase in the number and dry weight of effective root nodules with the aforementioned zinc applications is attributed to enhanced nutrient supply and improved soil properties, promoting root growth and facilitating higher nitrogen fixation. Additionally, the rise in microbial activity in chickpea plants can be linked to increased tryptophan synthesis, promoting the formation of indole-3-acetic acid (IAA), which plays a crucial role in nutrient transformation and availability in the soil. Previous research by Pal *et al*. (2019) has also highlighted the positive impact of zinc on effective root nodulation in chickpea plants.

Conclusion

In conclusion, chickpea variety GNG 2144 exhibited superior performance in terms of effective root nodules and their dry weight per plant, indicating its potential for better nitrogen fixation and overall plant health. Among the various zinc biofortification methods tested, soil application of 25 kg $ZnSO_4$ ha^{-1} + foliar application of 0.5% $ZnSO_4$ at flowering and pod development emerged as the most effective approach, leading to increased nodulation and earlier flowering and maturity compared to other methods.

Conflict of Interest

None

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