International Journal of Research in Agronomy 2024; 7(6): 406-412

E-ISSN: 2618-0618
P-ISSN: 2618-060X

www.agronomyjournals.com
2024; 7(6): 406-412
Received: 06-04-2024
Accepted: 13-05-2024

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Agronomic fortification of zinc enhances the growth, yield and quality of different genotypes of Pigeon pea (*Cajanus cajan* L.) on swell-shrink soil

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DOI: https://doi.org/10.33545/2618060X.2024.v7.i6f.901

Abstract
The field experiment entitled "Agronomic fortification of zinc enhances the growth, yield and quality of different genotypes of pigeon pea (*Cajanus cajan* L.) on swell – shrink soil" was conducted during *Kharif* season 2022-23 at Pigeon pea Breeding Field, Central Research Station, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola. The experiment was laid out in Split-Plot Design and fifteen treatments combination comprised of five main-plots (pigeon pea genotypes) and three sub-plots (zinc levels). The pigeon pea genotypes were AKTE 1905(G_1), AKTE 1904(G_2), AKTE 16-12(G_3), AKTE 19-01(G_4) and AKT 8811(G_5). The zinc levels were recommended dose of fertilizer (RDF) (Z_0), RDF with soil application of Zn @ 5 kg Zn ha^{-1} at the time of sowing (Z_1) and RDF with foliar spraying of $ZnSO_4$ @ 0.5% at branching and flowering stage (Z_2). The results of the present investigation in interaction between genotypes and zinc levels revealed that significantly highest seed yield (24.73 q ha^{-1}) of AKTE 1905 and straw yield 52.83(q ha^{-1}) of AKTE 16-12 was recorded in combination with the soil application of 5 kg Zn ha^{-1} through $ZnSO_4$ at the time of sowing. The interaction between different genotypes and zinc levels on growth and quality parameters are non-significant.

Keywords: Agronomic, fortification, zinc, growth, yield, quality, pigeonpea genotypes

Introduction
Pigeonpea commonly known as red gram or tur or arhar. After gram, pigeonpea is the second most important pulse crop in the country. It belongs to family Leguminosae. It has very deep root system and consists of a central tap root with numerous laterals and secondary branches. Pigeonpea is an often cross pollinated, C_3 short day plant. Pigeonpea (*Cajanus cajan* (L.) Millsp.), a protein rich legume crop and cultivated in tropical and subtropical regions. It is a vital grain legume crop in several countries of Asia, Africa and Latin America. The largest share approximately 75% of global pigeonpea production comes from India. In India, pigeonpea is cultivated in an area of 3.96 million ha. mainly in Maharashtra, Karnataka, Gujrat, Jharkhand, Uttar Pradesh, Odisha, Andhra Pradesh, Madhya Pradesh and Telangana (Behera *et al.*, 2020) [2]. The total world acreage under pulses is about 93.18 (Mha.) with production of 89.82 (Mt.) at 964 kg ha^{-1} yields level. India, with more than 28 M ha pulses cultivation area is the largest pulse producing country in the world. It ranks first in area and production with 31% and 28% respectively. The India's total area coverage and production of pigeonpea has been about 47 lakhs ha. and 41 lakhs tonnes respectively. Karnataka ranked first (>13 lakhs ha.) and contributes 29% in area and 24% in production whereas Maharashtra has contributed 27% of area and 28% of total production. Maharashtra is having area of 12.81 lakhs ha., productivity 11.74 lakhs tonnes and yield of 916 kg ha^{-1} (Ministry of Agriculture & Farmers Welfare, GoI. 2020-21) [1].

Pigeonpea is a legume reported to have 20-22% protein, 1.2% fat, 65% carbohydrates and 3.5% minerals. It can provide high quality protein in diet especially to the vegetarian population. It is having medicinal uses. Leaves contain anti-inflammatory, anti-bacterial and abirritative properties. Leaves can be used to treat burnt infection, traumatism, cough and diarrhoea.

Genistein and apigenin is a pair of isomeric compounds found as the main constituents present in pigeonpea roots and possess a wide spectrum of pharmacological activities (Sarkar *et al.*, 2020) [10].

Biofortification of cereals and pulses through use of Zn fertilizers (e.g., agronomic fortification) is an economically feasible option which aims at: 1) Keeping sufficient amount of available Zn in soil solution 2) Maintaining adequate Zn transport to the seeds during reproductive growth stages 3) Optimizing the success of biofortification of staple food crops with Zn through use of breeding tools. Agronomic fortification is effective in improving grain Zn concentration.

Fortification works for twin objective of increasing the concentration of the micronutrients in the grains and simultaneously improving the availability of micronutrients in the grains to alleviate the micronutrient deficiency in human beings and also animals. Hence agronomic fortification of zinc can be done through soil and foliar applications. The use of micronutrient in pigeonpea is one of the ways to boost up the productivity and to improve the seed quality parameters (Sharma *et al.*, 2010) [12].

The plants exhibited lower rate of protein synthesis and protein accumulation under zinc deficiency. The mode of zinc application improves the major factor, considering the importance of zinc to pigeonpea (Yashona *et al*., 2020-b) [17].

Materials and Methods

The experiment entitled "Agronomic fortification of zinc enhances the growth, yield and quality of different genotypes of pigeon pea (*Cajanus cajan* L.) on swell – shrink soil" was carried out during *Kharif* season 2022-23 at Pigeon pea Breeding Field, Central Research Station, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola. The site is situated in the subtropical region at $22^0 42'$ North latitude and $77^0 02'$ East longitude and at an altitude of 307.42 m above mean sea level with average annual precipitation was 944.4 mm. Experimental field is situated at the latitude of 20^0 40' 35" North and longitude of 76^0 59' 10" East. The experiment was laid out in Split-Plot Design and fifteen treatments combination comprised of five main-plots (pigeon pea genotypes) and three sub-plots (zinc levels). The pigeon pea genotypes were AKTE 1905(G_1), AKTE 1904(G_2), AKTE 16-12(G_3), AKTE 19-01(G_4) and AKT 8811(G_5) and the zinc levels were RDF (Z_0), RDF with soil application of Zn @ 5 kg Zn ha^{-1} at the time of sowing(Z_1) and RDF with foliar spraying of $ZnSO_4$ @ 0.5% at branching and flowering stage(Z_2).The Recommended dose of fertilizer 25:50:30 NPK will be common to all the treatments. Nitrogen through Urea & DAP, Phosphorous through DAP, Potassium through MOP, Zinc through zinc sulphate ($ZnSO_4$) was applied as per the treatment. The experimental soil was vertisol with pH 8.32, EC 0.24 dSm^{-1}, organic carbon 4.6 g kg^{-1}, available nitrogen 168.07 kg ha^{-1}, phosphorus 12.13 kg ha^{-1}, potassium 305.50 kg ha^{-1} sulfur 10.47 mg kg^{-1}, Zn 0.52 mg kg^{-1}, Mn (4.66 mg kg^{-1}), Fe (5.23 mg kg^{-1}) and Cu (1.31 mg kg^{-1}). The experiment was laid out in Split-plot design with five main-plots and three sub-plots replicated three times. Pigeonpea genotypes was sown at spacing 60 cm X 20 cm by the dibbling method. The seed was sown at the seed rate of 12 kg ha^{-1} in the first week of July 2022. The experimental data were recorded and analyzed statistically using Panse and Sukhatme (1985) [6].

Results and Discussion

Agronomic fortification of zinc application on growth parameters of plant height, number of branches, number of nodules per plant and dry weight of nodules per plant are presented in Table 1.

Plant height (cm)

Main-plots: Genotypes

The plant height of various pigeon pea genotypes was influenced significantly. The plant height was noticed significantly highest at (G_5) AKT 8811 (165.69 cm) followed by (G_2) AKTE 1904 (164.78 cm), and lowest in (G_4) AKTE 19-01(163.44 cm).

The findings were reported by Behera *et al*. (2020) [2], who reported that the increase in growth attributes of pigeon pea due to zinc application the increase in plant height is mainly attributed due to higher shoot growth through cell elongation, cell differentiation and apical dominance promoted by zinc.

Sub-plots: Zinc levels

The significantly highest plant height (166.36 cm) was recorded with the treatment of soil application of Zn @ 5 kg ha^{-1} (Z_1) at the time of sowing which was followed by two foliar spraying of @ 0.5% $ZnSO_4$ (Z_2) at branching and flowering stage (164.27 cm) and lowest was Control (Z_0) is (162.19).

The findings were reported by Behera *et al*. (2020) [2], who reported that the increase in growth attributes of pigeon pea due to zinc application the increase in plant height is mainly attributed due to higher shoot growth through cell elongation, cell differentiation and apical dominance promoted by zinc.

Interaction

The interaction effect of genotypes and zinc levels on plant height was found non- significant.

Number of branches per plant

Main-plots: Genotypes

The number of branches per plant was noticed significantly highest at (G_1) AKTE 1905 (13.59) compared to other genotypes followed by the genotype (G_3) AKTE 16-12 (13.13) while lowest number of branches were observed in genotype (G_4) AKTE 19-01 (11.56).

Sub-plots: Zinc levels

The soil application @ 5 kg Zn ha^{-1} at the time of sowing (Z_1) recorded significantly highest number of branches (14.19) of pigeon pea genotypes which was followed by two foliar spraying of 0.5% $ZnSO_4$ (Z_2) at branching and flowering stage (12.42) and lowest was observed in Control (Z_0) is (10.87).

The findings were reported by Dube *et al.* (2001) [4] stated that there was an increase in plant height due to zinc application plant throughout the crop growth period and promoted various physiological activities indispensable for proper growth and development and formation of growth hormones and the metabolism of auxin increasing the number of branches.

Interaction

The interaction effect of pigeon pea genotypes and zinc levels on number of branches was found non- significant.

Number of root nodules per plant

Main-plots: Genotypes

The number of root nodules per plant of various pigeon pea genotypes found significant. The number of root nodules was significantly highest in (G_1) AKTE 1905 (34.22) followed by (G_3) AKTE 16-12 (33.56) and lowest was (G_4) AKTE 19-01. This could be attributed to the genetic makeup of the respective genotypes.

Sub-plots: Zinc levels

The significantly highest number of root nodules per plant (35.07) was recorded with soil application of Zn @ 5 kg ha^{-1} (Z_1) at the time of sowing and followed by the treatment of two foliar spraying of 0.5% $ZnSO_4$ at branching and flowering stage (Z_2) (32.60) and the lowest number of root nodules per plant (30.93) was observed in control (Z_0).

The findings were reported by Praveena *et al*. (2020) [7]. The increase in nodulation might be attributed to established rooting system and production of different enzymes responsible for root nodule formation with the application of zinc. Favourable response of zinc application on nodulation.

Ram and Katiyar (2013) [8] reported that application of 40 kg S ha^{-1} and 10 kg Zn ha^{-1} significantly increased the number of root nodules per plant. The findings of present investigation correspond with the results quoted by Yashona *et al*. (2020) [17].

Interaction

The interaction effect of genotypes and zinc levels on number of root nodules per plant was found non-significant.

Dry weight of root nodule (g)

Main-plots: Genotypes

The data in relation to dry weight of root nodules per plant found significant. Among all the genotypes (G_1) AKTE 1905 recorded significantly highest dry weight of root nodules per plant (0.82) which was found at par with the genotypes (G_3) AKTE 16-12 (0.80) and the lowest dry weight of root nodules per plant was observed in (G_4) AKTE 19-01 (0.76).

Sub-plots: Zinc levels

The effect of zinc levels was found significant in respect of dry weight of root nodules per plant. Significantly highest dry weight of root nodules per plant (0.83) was recorded with soil application of Zn @ 5 kg ha^{-1} (Z_1) at the time of sowing and followed by two foliar spraying of $ZnSO_4$ @ 0.5% (Z_2) at branching and flowering stage (0.79) and least in control (Z_0) (0.73).

The findings of present investigation correspond with the results quoted by Yashona *et al*. (2020) [17] increase in number and dry weight of root nodule with application of zinc might be owing to role of zinc in nodulation, which results in more numbers of nodules per plant.

Agronomic fortification of zinc application on yield attributes of number of pods per plant and number of seeds per plant are presented in Table 2

Number of pods per plant

Main-plots: Genotypes

The data in relation to the number of pods per plant found to be significant and indicated that (G_1) AKTE 1905 recorded significantly highest number of pods per plant (133.26) which was followed by (G_3) AKTE 16-12 (131.69) and lowest was (G_4) AKTE 19-01 is (127.10).

Sub-plots: Zinc levels

The number of pods per plant was significantly influenced by zinc application and soil application of Zn @ 5 kg ha^{-1} at the time of sowing (Z_1) recorded significantly highest number of pods per plant (140.48) followed by two foliar spraying of $ZnSO_4$ @ 0.5% at branching and flowering stage (Z_2) (129.55) and lowest in control (Z_0) is (118.91).

The findings of present investigation correspond with the results quoted by Umesh *et al*. (2014) [15], Pandey *et al*. (2014) [5] and Praveena *et al*. (2018) [7] the result revealed that the yield attributes *viz.*, number of pods per plant recorded significantly higher in treatment of 20 and 35 DAS (0.2% foliar spray) of boron + 5.0 kg ha^{-1} of zinc.

Interaction

The interaction effect of pigeon pea genotypes and zinc levels on number of pods per plant was found non- significant.

Number of seeds per pod

Main-plots: Genotypes

The data in relation to number of seeds per pod was found significant (G_1) AKTE 1905 recorded significantly highest number of seeds per pod (3.86) which was found at par with the genotypes (G_3) AKTE 16-12 (3.83) and the lowest number of seeds per pod was observed in (G_2) AKTE 1904 (3.74).

Sub-plots: Zinc levels

The effect of zinc levels was found significant with respect to number of seeds per pod. Significantly highest number of seeds per pod (4.09) was recorded with soil application of Zn @ 5 kg ha^{-1} at the time of sowing (Z_1) followed by two foliar spraying of $ZnSO_4$ @ 0.5% at branching and flowering stage (Z_2) (3.73) and lowest was Control (Z_0) is (3.59).

The findings were reported by Shah *et al*. (2014) [11] revealed that three levels of zinc application 0, 10 and 20 kg Zn ha^{-1} were tested and findings indicated that the Zn @ 20 kg ha^{-1} registered higher seeds per pod as compared to control.

Interaction

The interaction effect of pigeon pea genotypes and zinc levels on number of seeds per pod was found non-significant.

Agronomic fortification of zinc application on seed and straw yield are presented in Table 3.

Seed yield (q ha^{-1})

Main-plots: Genotypes

The data regarding of seed yield of various pigeonpea genotypes were found to be significant the highest seed yield at (G_1) AKTE 1905 (23.08 q ha^{-1}) which found at par with (G_3) AKT 16-12 (22.18) and lowest in (G_4) AKTE 19-01.

Singh *et al*. (2011) [14] reported that the seed yield of pigeonpea influenced with application of zinc. Zn @5 kg ha^{-1} resulted highest grain yield which was 66.98% higher than that in control.

Sub-plots: Zinc levels

The effect of zinc levels was found significant in respect of seed yield. significantly highest seed yield (22.81 q ha^{-1}) was recorded with the treatment of soil application of 5 kg Zn ha^{-1} through $ZnSO_4$ (Z_1) which was found significantly superior over two foliar sprays @ 0.5% of $ZnSO_4$ (Z_2) at branching and flowering stage (21.79 q ha^{-1}) and lowest in control (20.40 q ha^{-1}).

Interaction

Interaction effect between pigeonpea genotypes and zinc levels of seed yield is found significant and reported table 3a.

The significantly highest seed yield (24.73 q ha^{-1}) of AKTE 1905 genotype was registered in combination with the soil application of 5 kg Zn ha^{-1} (G_1Z_1) and followed by treatment combination of G_3Z_1.

Zinc is a constituent of several enzymes such as carbonic hydrogenase and also helps in the formation of growth hormones such as auxin, which promote the seed maturation. This might be the reason for increasing grain yield per ha^{-1}. The findings of present investigation correspond with the results quoted by Umesh *et al*. (2014) [15], Yadav *et al*. (2020) [16] and Behera *et al.* (2020) [2].

Straw yield (q ha^{-1})
Main-plots: Genotypes

The data regarding straw yield of various pigeonpea genotypes was found significantly highest straw yield (G_1) AKTE 1905 (50.88 q ha^{-1}) and which was found at par with (G_3) AKTE 16-12 (49.91 q ha^{-1}) and lowest in (G_4) AKTE 19-01.

Shivay *et al*. (2014) [13] stated that zinc application on yield of pigeonpea and concluded that application of Zn @ 7.5 kg Zn ha^{-1} significantly increased the grain and straw yield of pigeonpea.

Sub-plots: Zinc levels

The effect of zinc levels was found significantly highest straw yield (50.98 q ha^{-1}) was recorded with the treatment of soil application of 5 kg Zn ha^{-1} through $ZnSO_4$ (Z_1) which was significantly superior over two foliar sprays @ 0.5% of $ZnSO_4$ (Z_2) at branching and flowering stage and lowest control (Z_0) (46.75 q ha^{-1}).

The straw yield was increased might be due to the involvement of zinc in a variety of physicochemical and biochemical processes. Similar results quoted by Umesh *et al*. (2014) [15], Shivay *et al*. (2014) [13], Praveena *et al*. (2018) [7] reported that the increased straw yield over the RDF. Chalak *et al*. (2018) [3] quoted that application of Zn significantly increased straw yield.

Interaction

Interaction effect between pigeon pea genotypes and zinc levels of straw yield was found significant in Table 3b.

The significantly highest straw yield (52.83 q ha^{-1}) was recorded in combination of AKTE 16-12 with soil application of 5 kg Zn ha^{-1} (G_3Z_1) followed by G_1Z_1.

Agronomic fortification of zinc application on Quality parameters of test weight (g), Protein content (%) and protein yield (Kg ha^{-1}) are presented in Table 4

Test weight (g)
Main-plots: Genotypes

The test weight of pigeon pea seed is significantly highest in (G_1) (AKTE 1905 (9.82 g) at par is (G_5) AKT 8811(9.80) and lowest was recorded (G_4) AKTE 19-01 (9.74 g).

Sub-plots: Zinc levels

The result revealed that effect of test weight of pigeonpea seeds found to be significant the soil application of 5 kg Zn ha^{-1} at the time of sowing (Z_1) recorded highest test weight (9.87 g) which was superior over two foliar spraying of 0.5% $ZnSO_4$ at branching and flowering stage (9.78 g) (Z_2) and control (Z_0) (9.69 g).

This might be due to involvement of Zn in physiological processes such as enzymes activation involved in sucrose, membrane integrity, chlorophyll formation, stomata regulation and starch utilization. Similar results were reported by Shah *et al*. (2011) [11].

The results are in agreement with the findings reported by Pandey *et al*. (2014) [5] wherein they found that application of zinc sulphate recorded highest 100 seed weight, while Dube *et al*. (2001) [4] reported that 100 seed weight was recorded highest when zinc was applied at 10 mg kg^{-1} soil.

Interaction

Interaction effect of genotypes and zinc levels on test weight of pigeonpea seed was found non-significant.

Protein content (%)
Main-plots: Genotypes

Significantly highest protein content was recorded in (G_1) AKTE 1905 (20.57%) at par with (G_3) AKTE 16-12 (20.39 and lowest is (G_4) AKTE 19-01(20.24).

Sub-plots: Zinc levels

The soil application of 5 kg Zn ha^{-1} at the time of sowing (Z_1) recorded protein content (21.05%) at par with two foliar spraying of 0.5% $ZnSO_4$ at branching and flowering stage (Z_2) (20.38%) and lowest is control (Z_0) (19.67%).

The zinc concentration in the plant which associated with RNA and ribosome induction the result of which accelerated in protein synthesis. Similar result quoted by Shah *et al.* (2011) [11] increased conversion of N to protein compound and the build-up of free amino acids and amides in the plant with Zn application.

Shah *et al*. (2011) [11] stated that increased protein content with application of zinc. However, Zn had a significant positive effect on protein and S-containing amino acids of pigeonpea grain.

Interaction

Interaction effect of genotypes and zinc levels on protein content in pigeonpea genotypes was found non-significant.

Protein yield (Kg ha^{-1})
Main-plots: Genotypes

The protein yield is significantly highest recorded in (G_1) AKTE 1905 (474.68 kg ha^{-1}) followed by (G_3) AKTE 16-12 (452.23 kg ha^{-1}) and lowest (G_4) AKTE 19-01 (417.59 kg ha^{-1}).

Sub-plots: Zinc levels

The soil application of 5 kg Zn ha^{-1} at the time of sowing (Z_1) recorded highest protein yield (456.15 kg ha^{-1}) followed by two foliar spraying of 0.5% $ZnSO_4$ at branching and flowering stage (Z_2) (441.60 kg ha^{-1}) and lowest control (Z_0) (426.26 kg ha^{-1}).

Interaction

Interaction effect of genotypes and zinc levels on protein yield in pigeonpea genotypes was found non-significant.

Table 1: Agronomic fortification of zinc on growth parameters of pigeonpea genotypes

Treatments	No. of pods/plant	No. of seeds /pod
A) Main-plots: Genotypes		
G_1: AKTE 1905	133.26	3.86
G_2: AKTE 1904	127.83	3.74
G_3: AKTE 16-12	131.69	3.83
G_4: AKTE 19-01	127.10	3.77
G_5: AKT 8811	129.13	3.81
SE (m) ±	1.05	0.03
CD at 5%	3.44	0.10
B) Sub-plots: Zinc levels		
Z_0: control	118.91	3.59
Z_1: SA of Zn @ 5 kg ha^{-1} at the time of sowing	140.48	4.09
Z_2: Two FS of 0.5% $ZnSO_4$ at branching and flowering stage	129.55	3.73
SE (m) ±	0.52	0.04
CD at 5%	1.54	0.11
C) Interaction (a x b)		
SE (m) ±	1.17	0.08
CD at 5%	NS	NS

Table 2: Agronomic fortification of zinc on yield attributes that number of pods per plant and number of seeds per pod of pigeon pea genotypes

Treatments	Plant height (cm)	No. of branches/Plant	No. of nodules/plant	Dry weight of nodules/ plant
A) Main-plots: Genotypes				
G_1: AKTE 1905	164.54	13.59	34.22	0.82
G_2: AKTE 1904	164.78	11.71	32.28	0.77
G_3: AKTE 16-12	163.90	13.13	33.56	0.80
G_4: AKTE 19-01	163.44	11.56	31.02	0.76
G_5: AKT 8811	165.69	12.49	33.26	0.79
SE (m) ±	0.21	0.05	0.11	0.02
CD at 5%	0.67	0.16	0.37	0.07
B) Sub-plots: Zinc levels				
Z_0: Control	162.19	10.87	30.93	0.73
Z_1: SA of Zn @ 5 kg ha^{-1} at the time of sowing	166.36	14.19	35.07	0.83
Z_2: Two FS of 0.5% $ZnSO_4$ at branching and flowering stage	164.27	12.42	32.60	0.79
SE (m) ±	0.16	0.04	0.06	0.01
CD at 5%	0.48	0.12	0.16	0.04
C) Interaction (a x b)				
SE (m) ±	0.37	0.09	0.12	0.03
CD at 5%	NS	NS	NS	NS

Table 3: Agronomic fortification of zinc on seed and straw yield of pigeon pea genotypes

Treatments	Yield (q ha^{-1})	
	Seed	Straw
A) Main-plots: Genotypes		
G_1: AKTE 1905	23.08	50.88
G_2: AKTE 1904	21.51	48.19
G_3: AKTE 16-12	22.18	49.91
G_4: AKTE 19-01	20.62	47.13
G_5: AKT 8811	20.94	48.27
SE (m) ±	0.09	0.14
CD at 5%	0.31	0.47
B) Sub-plots: Zinc levels		
Z_0: Control	20.40	46.75
Z_1: SA of Zn @ 5 kg ha^{-1} at the time of sowing	22.81	50.98
Z_2: Two FS of $ZnSO_4$ @ 0.5% of $ZnSO_4$ branching & flowering stage	21.79	48.90
SE (m) ±	0.06	0.05
CD at 5%	0.19	0.14
C) Interaction (a x b)		
SE (m) ±	0.14	0.10
CD at 5%	0.42	0.31

Table 3a: Agronomic fortification of zinc on interaction between genotypes and zinc levels of seed yield of pigeon pea genotypes

Main-plots: Genotypes	**Sub-plots: Zinc levels**			
	Z_0: Control	**Z_1: SA of zinc @ 5 kg Zn ha^{-1} at the time of sowing**	**Z_2: Two FS @ 0.5% $ZnSO_4$ at branching and flowering stage**	**Mean**
G_1: AKTE 1905	21.03	24.73	23.47	23.08
G_2: AKTE 1904	20.83	22.37	21.33	21.51
G_3: AKTE 16-12	21.00	23.20	22.35	22.18
G_4: AKTE 19-01	19.45	21.77	20.63	20.62
G_5: AKT 8811	19.67	21.98	21.17	20.94
Mean	20.40	22.81	21.79	21.66
SE (m) ±	0.14			
CD at 5%	0.42			

Table 3b: Agronomic fortification of zinc on interaction between genotypes and zinc levels of straw yield of pigeon pea genotypes

Main-plots: Genotypes	**Sub-plots: Zinc levels**			
	Z_0: Control	**Z_1: SA of zinc @ 5 kg Zn ha^{-1} at the time of sowing**	**Z_2: Two FS @ 0.5% $ZnSO_4$ at branching and flowering stage**	**Mean**
G_1: AKTE 1905	48.37	52.40	51.88	50.88
G_2: AKTE 1904	47.10	49.70	47.77	48.19
G_3: AKTE 16-12	46.70	52.83	50.20	49.91
G_4: AKTE 19-01	44.80	49.80	46.80	47.13
G_5: AKT 8811	46.80	50.17	47.83	48.27
Mean	46.75	50.98	48.90	48.88
SE (m) ±	0.10			
CD at 5%	0.31			

Table 4: Agronomic fortification of zinc on quality parameters of pigeon pea genotypes

Treatments	**Quality parameters**		
	Test weight (g)	**Protein content (%)**	**Protein yield (kg ha^{-1})**
A) Main-plots: Genotypes			
G_1: AKTE 1905	9.82	20.57	474.68
G_2: AKTE 1904	9.77	20.28	436.18
G_3: AKTE 16-12	9.78	20.39	452.23
G_4: AKTE 19-01	9.74	20.24	417.59
G_5: AKT 8811	9.80	20.35	426.24
SE (m) ±	0.02	0.10	1.93
CD at 5%	0.06	0.32	5.80
B) Sub-plots: Zinc levels			
Z_0: control	9.69	19.67	426.40
Z_1: SA of Zn @ 5 kg ha^{-1} at the time of sowing	9.87	21.05	456.15
Z_2: Two FS of 0.5% $ZnSO_4$ at branching and flowering stage	9.78	20.38	441.60
SE (m) ±	0.01	0.09	2.46
CD at 5%	0.03	0.26	7.38
C) Interaction (a x b)			
SE (m) ±	0.02	0.20	5.51
CD at 5%	NS	NS	NS

Conclusion

The results of present investigation revealed that the yield (seed and straw) of pigeon pea was significantly highest in genotypes with (G_1) AKTE 1905 seed yield (23.08 q ha^{-1}) and straw yield (50.88 q ha^{-1}) and in zinc levels with soil application 5 kg Zn ha^{-1} at the time of sowing (Z_1) seed yield (22.81 q ha^{-1}) and straw yield (50.98 q ha^{-1}) and there interaction are also significantly highest seed yield (24.73 q ha^{-1}) of AKTE 1905 (G_1Z_1) and straw yield 52.83(q ha^{-1}) of AKTE 16-12(G_3Z_1).The growth parameters like plant height (G_5) AKT 8811 (165.69),number of branches (G_1) (13.59), number of nodules (G_1) (34.22) and dry weight of nodules (G_1) (0.82) are significantly highest in genotypes and in zinc levels soil application of 5 kg Zn ha^{-1} (Z_1) is significantly highest in plant height (166.36), number of branches (14.19), number of nodules (35.07) and dry weight of nodule (0.83) respectively and there interactions are non-significant. The quality parameters are significantly highest in (G_1) AKTE 1905 genotype of test weight (9.82), protein content (20.57) and protein yield (476.68) respectively and in zinc levels with soil application of 5 kg Zn ha^{-1} (Z_1) is significantly highest in test weight (9.87), protein content (21.05) and protein yield (456.15) respectively and their interactions are non- significant.

References

1. Anonymous, Ministry of Agriculture and Farmers Welfare. GOI. 2020-21.
2. Behera KS, Shukla AK, Tiwari PK, Tripathi A. Classification of Pigeonpea (*Cajanus cajan* L.) genotypes for zinc efficiency. Plants. 2020;9:952.
3. Chalak AL, Vaikar SL, Ajabe M. Effect of Potassium and zinc on nutrient uptake on pigeonpea. International Journal of Chemical Studies. 2018;6(5):1474-1477.
4. Dube BK, Sharma CP, Chatterjee C. Response of pigeonpea to applied Zinc in Ustifluvent soils of western Uttar Pradesh. J Indian Soc Soil Sci. 2001;49:471-475.
5. Pandey IB, Tiwari S, Kumar R. The effect of fertility levels

on the productivity of pigeonpea under rainfed condition. J Food Legumes. 2014;7:206-209.
6. Panse VG, Sukhantme PV. Statistical method of Agricultural. Indian council of Agricultural research, New Delhi; 1985.
7. Praveena RG, Singh V. Effect of foliar spray of boron and different zinc levels on growth and yield of kharif green gram (*Vigna radiata*). Int. J Curr Microbiol Appl. Sci. 2018;7(8):1422-1428.
8. Ram S, Katiyar TP. Effect of sulphur and zinc on the seed yield and protein content of summer mung bean under arid climate. Int J Sci Nat. 2013;4(3):563-566.
9. Sahu RK, Kauraw DL, Sawarkar SD. Effect of integrated resources of nutrients management on yield, nutrient content and quality of chickpea in Vertisol. J Soils Crop. 2010;20(2):221-225.
10. Sarkar S, Panda S, Yadav KK, Kandasamy P. Pigeonpea (*Cajanus cajan* L.) an important food legume in Indian scenario – A review. Legume Res Int J. 2020;43(5):601-610.
11. Shah KA, Gurjar R, Parmar HC, Sonani VV. Effect of sulphur and zinc fertilization on yield and quality of pigeonpea in sandy loam soil. Green Farming. 2016;7(2):495-497.
12. Sharma A, Nakul HT, Jelgeri BR, Surwenshi A. Effect of micronutrients on growth, yield and yield components in pigeonpea (*Cajanus cajan* (L.) Millsp.). Res J Agric Sci. 2010;1(2):142-144.
13. Shivay YS, Prasad R, Pal M. Genetic variability for zinc use efficiency in chickpea as influenced by zinc fertilization. Int J Bio-resour Stress Manage. 2014;5(1):31-36.
14. Singh KK, Praharaj CS, Choudhary AK, Kumar N, Venkatesh MS. Zinc Response in Pulses. Indian J Fertilizer. 2011;7(10):118-126.
15. Umesh MR, Shankar MA. Yield performance and profitability of Pigeonpea varieties under different nutrient supply levels in dryland Alfisols of Karnataka. Indian J Dry Land Agric Res. 2013;28:63-69.
16. Yadav A, Kumar N, Ahamad N, Singh H, Kumar R, Bahadur R, Yadav S, Kumar. Nutrient management in pigeonpea [*Cajanus cajan* (L.) Millisp.] Based intercropping system under rainfed condition of eastern Uttar Pradesh. Pharma Innov J. 2021;10(6):853-857.
17. Yashona DS, Mishra US, Aher SB, Sirotha P, Mishra SP. Nutrient uptake zinc use efficiency and yield of pigeonpea as by various modes of zinc application under rainfed condition. J Food Legumes. 2020;33:151-159.