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Influence of phasing and different levels of zinc application on yield of cotton and soybean in vertisol

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Abstract

The field experiment was conducted to study effect of phasing and levels of Zinc application on yield of cotton and Soybean and soil fertility status during *kharif* season 2017-18 and 2018-19 at Research Farm, All India Co-ordinated Research Project on Micro and Secondary Nutrients and Pollutant Elements in Soils and Plants, Department of Soil Science and Agricultural Chemistry, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola. The experiment was laid in a Factorial randomized block design with two factors viz, Factor A as phasing of zinc application and factor B as levels of Zinc application. The significantly highest seed cotton yield (11.03 q ha⁻¹) and stalk yield (20.22 q ha⁻¹) were recorded with application of zinc @ 7.5 kg ha⁻¹ in alternate year while, the significantly highest seed yield (27.70q ha⁻¹) and straw yield (39.43 q ha⁻¹) were recorded with application of zinc @ 7.5 kg ha⁻¹ in alternate year. Alternate year application of zinc recorded highest grain and straw yield followed by zinc application in every year and first year.

Keywords: Zinc phasing, levels, seed yield, straw yield, vertisols, alternate year

Introduction

Cotton is one of the important cash as well as fibre crop and play vital role in the history and civilization of mankind, with enormous potential in textile industries and is a means of livelihood for millions of farmers and those concerned with its trade, processing, manufacturing and other allied industries. No agricultural commodity in the world exercised a profound influence on economy as cotton had done from the time immemorial. Therefore, it is popularly known as white gold. Cotton seed contains about 15-20 per cent oil and is used as vegetable oil and in soap industries. After extraction of oil, the left-over cake is proteinous which is used as cattle feed. It is the king among the fibre crops, taking into consideration the economic impact it generates. Besides, its enormous role in national economy, its contribution in the foreign exchange is tremendous. Nearly one third of India's export earnings are from textile sectors of which cotton alone contributes nearly 70 per cent of raw material. Cotton contributes 29.8 per cent of the Indian agricultural gross domestic product (Barwale *et al.*, 2004) [3]. Still there exists large potential for export of raw cotton and value-added products.

Soybean is one of the important oilseed as well as leguminous crop. It is the cheapest and richest source of high-quality protein (40%). It supply most of the nutritional constituents essential for human health. Soybean occupies an intermediate position between legumes and oilseed. Soybean helps to builds up the soil fertility by fixing atmospheric nitrogen through nodules. Symbiotically soybean fixes nitrogen and leaves about 25 per cent for succeeding crop. All these qualities have made it an ideal crop in rotation. In India, the area under this crop increased due to its high yielding potential and multifarious industrial uses. Soybean is called as boon of malnourished world because of its high nutritive value mainly due to its high protein (40%), oil (20%) and carbohydrate (35%). In India it is mainly grown as 'oilseed crop'. Hence, soybean is called as "Wonder bean" or "Miracle bean". Soybean occupies an intermediate position between legumes and oilseed.

The plant requires essential nutrients viz., primary, secondary and micro nutrients which have assumed a greater importance in a modern agriculture. Among the micro nutrients, zinc deserves special attention. Recently, zinc has gained key position in intensive cropping system with the use of organic manures resulting in the depletion of zinc from soils of majority of agriculturally productive areas of Maharashtra. However, soil has not received due attention because of the presumption that these soils have adequate reserves of micronutrients. Though, large group of soil contain sufficient amount of total zinc (10-300 mg kg⁻¹) but, its availability in soil is very less (Swaine, 1995) [26].

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Food and Agriculture Organization (FAO) has determined that zinc is the most commonly deficient micronutrient in agricultural soils; almost 50 per cent of agricultural soils are Zn deficient. Plants growing on potentially zinc-deficient soils have reduced productivity and contain very low concentrations of zinc in the edible parts (such as in cereal grains). Therefore, zinc deficiency represents a serious nutritional and health problem in human and cattle populations, especially in the developing world where cereal-based foods are the dominating source of diet. Therefore, the present investigation was carried out to assess the impact of phasing and different levels of Zn application on productivity of cotton and soybean in Vertisols.

Materials and Methods

Climate

Akola is situated at 307.41 meters above mean sea level at 22° 42' North latitude and 77° 02' East longitude and lies in subtropical continental climate. The climate of Akola is characterized by a hot summer and general dryness throughout the year except during South-West monsoon (June to 15th Sept.). Major rainfall (80 per cent) received in the month of June to September i.e. in monsoon season; however, 20 per cent rainfall received during post monsoon season. Akola receives an annual mean precipitation of 805.6 mm in about 46 days and grouped under assured rainfall zone. During monsoon July is the wet month with 253.1 mm average monthly rainfall. The mean maximum temperature varies from 29.0 °C to about 42.7 °C in May, whereas, the mean minimum temperature varies from 10.3 °C during winter to 27.6 °C in summer. The data collected on rainfall, number of rainy days, temperature, relative humidity, sunshine hours and evaporation at meteorological observatory, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola during the period of experimentation (2017-18 and 2018-19).

Experimental site

The experiment 'Influence of phasing and different levels of zinc application on yield of cotton and soybean in Vertisol' Conducted during 2017-18 and 2018-19 at Research Farm, All India Co-ordinate Research Project on Micro and Secondary Nutrients and Pollutant Elements in Soils and Plants, Department of Soil Science and Agricultural Chemistry, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola. This experiment was superimposed on the ongoing experiment which was started during the year 2013-14 under AICRP on Micro and Secondary nutrients. The present experiment was conducted on same site and same randomization.

Soil of experimental site

The soil of experimental site was deep black swell shrink, montmorillonitic mineralogy with clay texture and classified under Vertisols. The initial soil properties at the start of experiment (kharif, 2013-14) was slightly alkaline (8.26), non-saline (0.29 d S m⁻¹), moderately calcareous (8.13%) and medium in organic carbon (5.30 g kg⁻¹). The available nitrogen was low (216.2 kg ha⁻¹), medium in available phosphorus (14.17 kg ha⁻¹) and high in available potassium (346.2 kg ha⁻¹) while marginal in available sulphur (12.42 mg ka⁻¹). The experimental soil was deficient in DTPA-zinc (0.48 mg kg⁻¹) and sufficient in DTPA-Fe, Mn and Cu.

Experimental layout

The experiment was laid in a Factorial randomized block design with two factors viz, Factor A as phasing of zinc application and factor B as levels of Zinc application with 12 treatments (1 control) and three replications. Factor a (3 phasing of Zn) and factor b (4 levels of Zn).

Treatment details

Factor (a): Phasing of Zinc application (P)

P1 - Once in six years.

P2 - Alternate year.

P3 - Every year.

Factor (b): Levels of soil application of zinc (Zn)

Zn1 - 2.5 kg Zn ha⁻¹

Zn2 - 5 kg Zn ha⁻¹

Zn3 - 7.5 kg Zn ha⁻¹

Zn4 - 10 kg Zn ha⁻¹

Methods adopted

The seed of cotton and soybean was purchased from market and sown in kharif season by dibbling and drilling respectively at the rate 12-15 kg⁻¹ for cotton (Ajit-199 BGII) for soybean @ 75 kg ha⁻¹ (JS-335). For the first year of cotton crop the Recommended Dose Fertilizers N, P₂O₅, K₂O was applied @ 60:30:30 basal doses out of this 50% of nitrogen, phosphorus and potassium were applied through urea, di-ammonium phosphate, muriate of potash and 50% of N was applied at 30 DAS through urea. Soil application of zinc was carried as per treatments (Zn1, Zn2, Zn3, Zn4) at the time of sowing @ (2.5, 5, 7.5, 10 kg Zn ha⁻¹) through zinc sulphate (ZnSO₄·7H₂O). ZnSO₄ was mixed with FYM and applied in soil to treatment plots. During second year for soybean crop the RDF of N, P₂O₅, K₂O was 30:75:30. Soil application through urea, di-ammonium phosphate and murate of potash carried as basal dose at the time of sowing and zinc was applied as per treatments.

Seed cotton and stalk yield

After harvesting, seed cotton and stalk yield of cotton of each plot was recorded per hectare yield was calculated.

Seed and straw yield of soybean

After harvesting, soybean grain and straw yield of each plot was recorded per hectare yield was calculated.

Statistical analysis

The treatment Zn0 as the no application of zinc and P0 as no phasing was considered as control in the present investigation. The data recorded for each observation in this investigation was analysed statistically with desired statistical design i.e. Factorial Experiment with one additional treatment (or control) which was describe by P₀Zn₀ and standard error and critical difference for each observation was determined. The statistical analysis of the data was carried out by statistical methods suggested by Gomez and Gomez (1984) [8].

Result and Discussion

Effect of phasing and levels of zinc on seed cotton and stalk yield of cotton

Seed cotton and stalk yield

The data pertaining to seed cotton and stalk of cotton as influenced by various treatments are presented in Table 1 and seed cotton yield graphically depicted in Fig 1.

From the data, it is observed that seed cotton yield registered in the range of 9.89 to 10.20 q ha⁻¹ due to phasing of zinc application and found non-significant. The highest value of seed cotton yield (10.20 q ha⁻¹) in phasing was observed in alternate year of zinc application. It could be noticed that, the reduction in the seed cotton yield in the treatment every year application (P3) of zinc as compared to alternate year of zinc application (P2) by 2.25 per cent. The reduction in the seed cotton yield could be attributed to every year application of zinc to soil reduce yield as compared to alternate year application of zinc in Cotton- Soybean rotation.

From the data, it is observed that stalk cotton yield recorded in the range of 17.39 to 18.50 q ha⁻¹ due to phasing of zinc application and found significant. The highest value of stalk cotton yield (18.50 q ha⁻¹) in phasing was observed in alternate year of zinc application. It could be noticed that, the reduction in the stalk cotton yield in the treatment every year application (P3) of zinc as compared to alternate year of zinc application (P2) by 2.10 per cent. The reduction in the stalk cotton yield could be attributed to every year application of zinc to soil reduce yield as compared to alternate year application of zinc in Cotton-Soybean rotation.

Maninder Kaur *et al.*, (2007) [15] reported that the soil application of zinc sulphate with foliar application of ferrous sulphate increase the seed cotton yield per plant as compare to control and other treatments.

The finding corroborates with results reported by Polara *et al.*, (2010) [19], Jadhav *et al.*, (2009) [10] reported that zinc application increased yield over control. Similar result has

been also reported by Radhika *et al.*, (2013) [21] and Yaseen *et al.*, (2013) [31] reported that seed and stalk yield of cotton increased significantly with soil application of Zn 5.0 kg ha⁻¹ as compared to control.

In case of zinc levels (Factor B), seed cotton yield recorded in the range of 9.67 to 10.52 q ha⁻¹ and significantly highest seed cotton yield (10.52 q ha⁻¹) registered in the treatment of zinc @ 7.5 kg ha⁻¹ (Zn3) as compared to the other treatments and followed by Zn @ 10 kg ha⁻¹ (Zn4) (9.99 q ha⁻¹) and Zn @ 5 kg ha⁻¹ (9.90 q ha⁻¹). It could be noticed that soil application of Zn @ 10 kg ha⁻¹ decreased seed cotton yield to the extent of 5.04 per cent as compared to soil application of Zn @ 7.5 kg ha⁻¹. This indicated that the higher doses of Zn might lead to decrease in seed cotton yield due to antagonistic effect of higher doses on other treatments in the soil.

In case of zinc levels (Factor B), stalk cotton yield found in the range of 17.16 to 19.24 q ha⁻¹ and significantly highest stalk cotton yield (19.24 q ha⁻¹) recorded in the treatment of zinc @ 7.5 kg ha⁻¹ (Zn3) as compared to the other treatments and followed by Zn @ 10 kg ha⁻¹ (Zn4) (17.81 q ha⁻¹) and Zn @ 5 kg ha⁻¹ (17.80 q ha⁻¹). It could be noticed that soil application of Zn @ 10 kg ha⁻¹ decreased stalk cotton yield to the extent of 5.04 per cent as compared to soil application of Zn @ 7.5 kg ha⁻¹.

Similar results were registered by Radhika *et al.*, (2013) [21] and Yaseen *et al.*, (2013) [31] confirmed that seed and stalk yield of cotton increased significantly with soil application of Zn @ 5.0 kg ha⁻¹ as compared to control.

Table 1: Seed cotton and stalk yield as influenced by phasing and levels of zinc treatments

Treatments	Seed cotton yield (q ha ⁻¹)	Cotton stalk yield (q ha ⁻¹)
Factor A Phasing		
P1 - First year application only	9.89	17.39
P2 - Alternate year application	10.20	18.50
P3 - Every year application	9.97	18.11
SE (m) +	0.11	0.11
CD at 5%	-	0.34
Factor B Levels of zinc (kg ha⁻¹)		
Zn1: 2.5	9.67	17.16
Zn2: 5.0	9.90	17.80
Zn3: 7.5	10.52	19.24
Zn4: 10	9.99	17.81
SE (m) +	0.13	0.14
CD at 5%	0.37	0.40
Interaction P X Zn	Sig	Sig
CV (%)	10.86	12.31

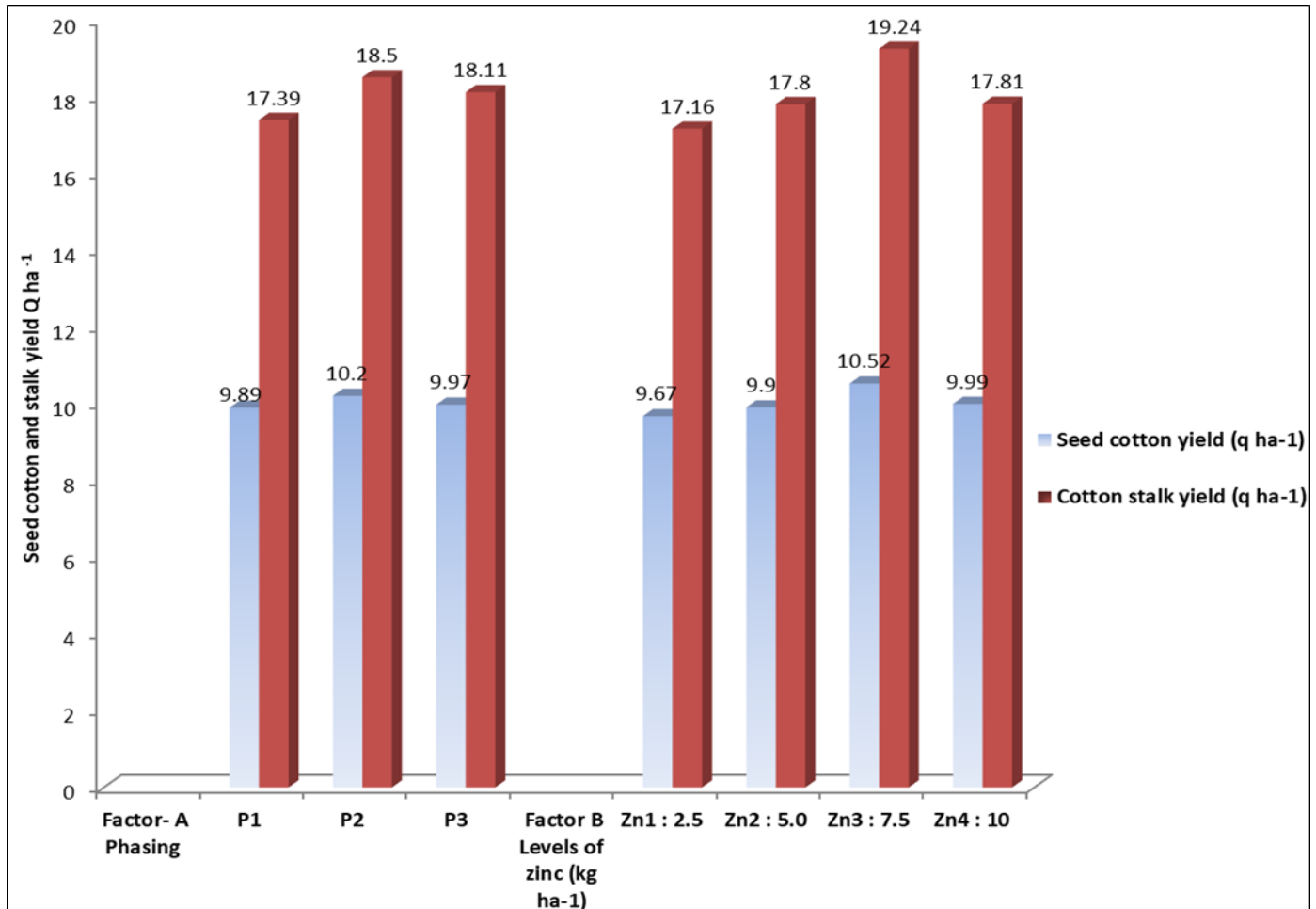


Fig 1: Seed cotton and stalk yield as influenced by phasing and levels of zinc treatments

Interaction effect of phasing and levels of zinc on seed cotton and stalk yield of cotton

Interaction effect of phasing and levels of zinc was recorded significantly in (Table 2) and treatment combination of alternate year soil application of zinc @ 7.50 kg ha⁻¹ (P₂Zn₃) recorded significantly higher seed cotton yield (11.03 q ha⁻¹) over all the treatment combinations and followed by (P₃Zn₃) and (P₂Zn₄). P₂Zn₃ combination recorded 22.69 per cent higher seed cotton as compared to control (P₀Zn₀). The close scrutiny of data also showed that, all the treatment combinations of P X Zn registered significantly higher seed cotton yield as compared to P₀Zn₀.

The results corroborate with the results reported by Ahmed *et al.*, (2014) reported that yield of cotton increased progressively with increasing zinc rates also, Maninder Kaur *et al.*, (2007) [15] reported that the soil application of zinc sulphate with foliar application of ferrous sulphate increase the seed cotton yield per plant as compare to control and other treatments.

The finding corroborates with results reported by Polara *et al.*, (2010) [19] Jadhav *et al.*, (2009) [10] reported that zinc application increased yield over control. This could be described that excess use of zinc with every year application creates imbalance of nutrient in soil which might lead to reduced availability to plant root ultimately decrease in seed cotton yield. Similar type of findings was reported by Atta Hussain *et al.*, (2017) [2].

Table 2: Interaction effect of phasing and levels of zinc on seed cotton and stalk yield of cotton

Treatment combinations (P X Zn)	Yield (q ha ⁻¹)	
	Seed cotton	Stalk
P ₁ Zn ₁	9.52	16.76
P ₁ Zn ₂	9.98	17.27
P ₁ Zn ₃	10.21	17.99
P ₁ Zn ₄	9.98	17.56
P ₂ Zn ₁	9.65	17.41
P ₂ Zn ₂	10.00	18.23
P ₂ Zn ₃	11.03	20.22
P ₂ Zn ₄	10.15	18.01
P ₃ Zn ₁	9.84	17.18
P ₃ Zn ₂	9.73	17.91
P ₃ Zn ₃	10.33	19.52
P ₃ Zn ₄	9.98	17.87
SE(m)±	0.22	0.23
CD at 5%	0.67	0.69
Control Vs other treatments		
P ₀ Zn ₀	8.99	15.44
SE (m) ±	0.23	0.24
CD at 5%	0.47	0.51

Effect of Phasing and Levels of Zinc on Soybean seed and straw yield

Seed and straw yield of soybean

The data in relation to seed yield and straw yield of soybean as influenced by various treatments are presented in Table 2 and soybean seed yield graphically represented in Fig 2.

Due to phasing of zinc application (Factor A), it was observed that seed yield of soybean recorded in the range of 23.32 to

25.31 q ha⁻¹ and found significant. It could be noticed that reduction in seed yield with treatment of every year application (P3) of zinc as compared with alternate year application of zinc (P2) by 2.76 per cent. The reduction in the seed yield could be attributed to every year application of zinc to soil reduced yield as compared to alternate year application of zinc.

Similar findings were also confirmed by Ghasemian *et al.*, (2010) [7]. Also, Kanase *et al.*, (2008) [11] reported that seed and straw yield of soybean increased significantly with 7.5 kg Zn ha⁻¹ application with RDF as compared to control and Sonkambale *et al.*, (2015) [24] reported highest seed yield of soybean with Zn application.

Table 2: Seed and straw yield of soybean as influenced by phasing and levels of zinc

Treatments	Seed yield (q ha ⁻¹)	Straw yield (q ha ⁻¹)
Factor A Phasing		
P1-First year application only	23.32	33.99
P2-Alternate year application	26.01	36.87
P3-Every year application	25.31	35.88
SE (m) +	0.28	0.26
CD at 5%	0.83	0.78
Factor B Levels of zinc (kg ha⁻¹)		
Zn1: 2.5	24.09	35.09
Zn2: 5.0	24.66	36.04
Zn3: 7.5	25.76	37.54
Zn4: 10	25.01	36.64
SE (m) +	0.32	0.31
CD at 5%	0.95	0.90
Interaction P X Zn	Sig	NS
CV (%)	11.66	-

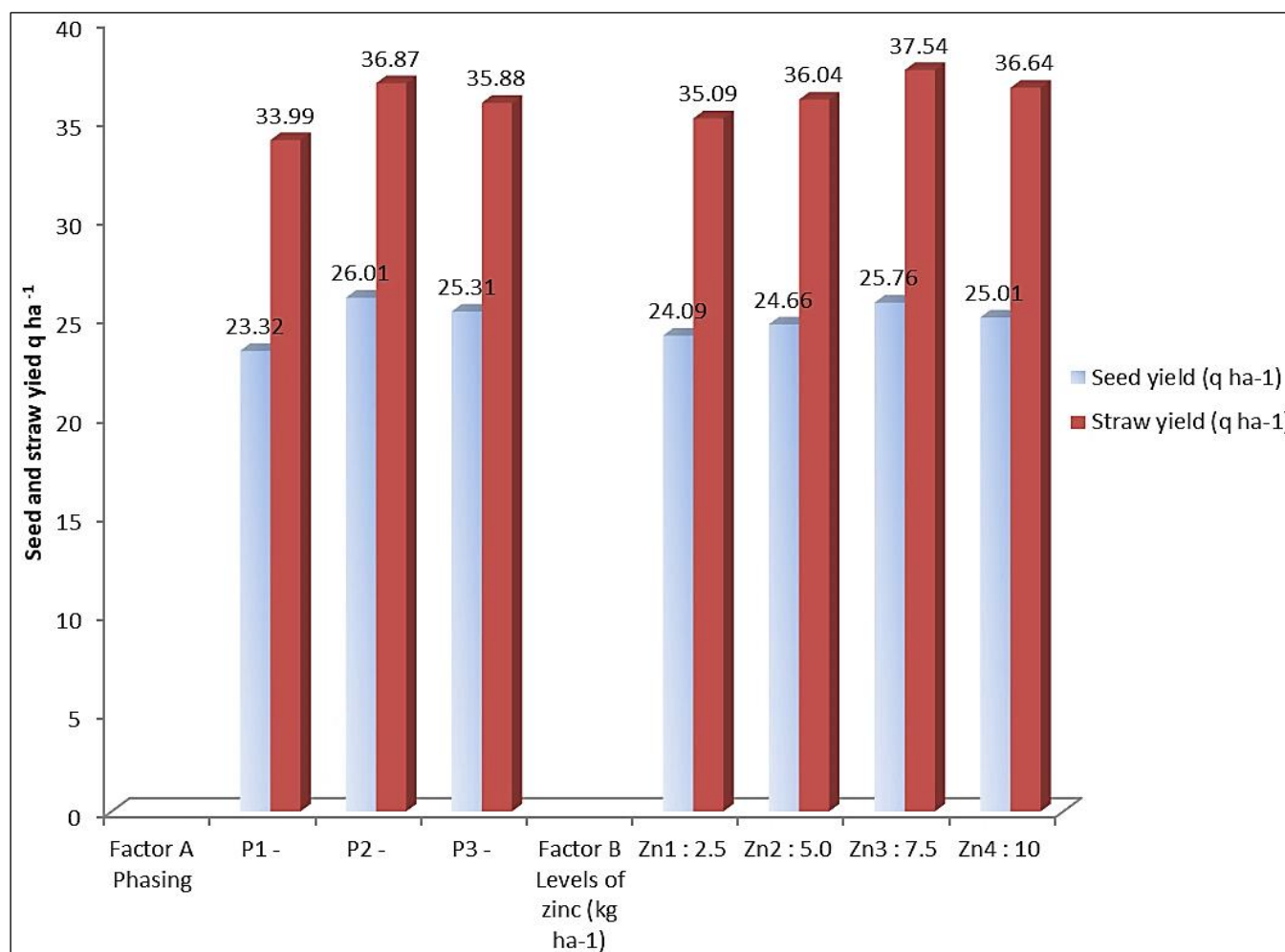


Fig 2: Seed and straw yield of Soybean as influenced by Zinc phasing and levels of Zinc application

Interaction effect of phasing and levels of zinc on soybean seed and straw yield of soybean

Interaction effect of phasing and levels of zinc application was found significant for seed yield of soybean highest seed

yield of soybean was found in treatment receiving alternate year application of zinc @ 7.5 kg ha⁻¹ (27.70 q ha⁻¹) which was followed by treatment of 10 kg Zn ha⁻¹ alternate year application (27.01 q ha⁻¹) and treatment of 5 kg Zn ha⁻¹ every

year application (26.12 q ha^{-1}), lowest value of seed yield was (21.27 q ha^{-1}) observed with treatment of P_0Zn_0 . Straw yield of soybean as influenced by phasing of zinc showed significant result, it was ranged from 33.99 to 36.87 q ha^{-1} . Highest straw yield was observed with alternate year application of zinc (P_2) 36.87 q ha^{-1} , which was followed by every year application of zinc (P_3) 35.88 q ha^{-1} . It could be noticed that, the reduction in straw yield in the treatment of every year application of zinc as compared to alternate year of zinc application by 2.68 per cent. This indicated that the higher doses of zinc might lead to decrease in straw yield due to antagonistic effect of higher doses on other nutrients in the soil.

In case of levels of zinc (Factor B) influenced straw yield significantly, it was in between 35.09 to 37.54 q ha^{-1} . Highest straw yield 37.54 q ha^{-1} was found with treatment of zinc application @ 7.5 kg ha^{-1} (Zn_3) which was followed by zinc @ 10 kg ha^{-1} (Zn_4) 36.64 q ha^{-1} , here the same trend was found that increasing the doses of zinc lead to decreased in straw yield of soybean by 2.39 per cent.

Interaction effect of phasing and levels of zinc was recorded non-significant for straw yield (Table 2a). Straw yield was registered in the range of 32.59 to 39.43 q ha^{-1} . Highest straw yield is found with treatment of P_2Zn_3 (39.43), which were

followed by treatment of P_2Zn_4 (38.52), P_3Zn_3 (38.51) and P_2Zn_2 (37.28). P_2Zn_3 combination recorded 17.34 per cent higher straw yield as compared with control (P_0Zn_0). From the data it was clearly observed that all the treatment combination of P X Zn registered significantly higher straw yield as compared to P_0Zn_0 . The result corroborates with the result reported by Kanase *et al.*, (2008) [11] they also reported that seed and straw yield of soybean increased significantly with $7.5 \text{ kg Zn ha}^{-1}$ application with RDF as compared to control and Sonkambale *et al.*, (2015) [24] reported highest seed yield of soybean with Zn application

The findings confirmed with results reported by Ghasemian *et al.*, (2010) [7]. Pable *et al.*, (2010) [17] reported that zinc application increased the seed and straw yield of soybean over control. Similar result has been also reported by Chauhan *et al.*, (2013) [4] and Nandanwar *et al.*, (2007) [16] reported that seed and straw yield of soybean increased significantly with soil application of Zn 5.0 kg ha^{-1} as compared to control.

This could be ascribed that excess use of zinc with every year application creates imbalance of nutrient in soil which might lead to reduced availability to plants root ultimately decrease in seed yield. Similar type of findings was reported by Kobraee and Keyvan (2015) [12] and Yasari and Vahedi (2012) [30].

Table 2a: Interaction effect of phasing and levels of zinc on seed and straw yield of soybean

Treatment combinations (P X Zn)	Soybean yield (q ha)	
	Seed	Straw
P_1Zn_1	23.15	33.42
P_1Zn_2	23.46	34.11
P_1Zn_3	23.95	34.70
P_1Zn_4	24.20	35.16
P_2Zn_1	25.14	36.53
P_2Zn_2	27.70	37.28
P_2Zn_3	27.01	39.43
P_2Zn_4	25.35	38.52
P_3Zn_1	25.71	35.33
P_3Zn_2	26.12	36.74
P_3Zn_3	24.09	38.51
P_3Zn_4	23.15	36.26
SE(m)±	0.57	0.54
CD at 5%	1.66	-
Control Vs other treatments		
P_0Zn_0	21.37	32.59
SE (m) ±	0.59	0.56
CD at 5%	1.22	1.15

Conclusion

From the present investigation the significantly highest seed cotton yield (11.03 q ha^{-1}) and stalk yield (20.22 q ha^{-1}) were recorded with application of zinc @ 7.5 kg ha^{-1} in alternate year it similarly, the significantly highest grain yield (27.70 q ha^{-1}) and straw yield (39.43 q ha^{-1}) were recorded with application of zinc @ 7.5 kg ha^{-1} in alternate year. Therefore, it can be concluded that soybean and cotton productivity along with soil fertility status can be improved with $7.5 \text{ kg Zn ha}^{-1}$ in alternate year.

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