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Influence of plant growth regulators and zinc fertilization on growth & yield attribute of *Pearl millet* [*Pennisetum glaucum* L.]

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Abstract
A field experiment was conducted during the *Kharif* season in 2018 on loamy sand soil at the OPJS University, Churu (Rajasthan). To study the influence of plant growth regulators (PGRs) and zinc fertilization on the growth and yield attribute of *pearl millet* comprised of three PGRs (1000 ppm triacontanol, 50 ppm naphthalene acetic acid (NAA) including water sprayed (control) with four levels of zinc (0, 2, 4 and 6 kg ha-^{1}). The experiment was conducted in a factorial randomized block design with two factors and replicated thrice. The results revealed that foliar application of 20 and 40 DAS in *pearl millet* of PGRs and zinc significantly was recorded an increase in chlorophyll value, the total number of tillers/ plants, effective tillers/ plant, ear length, number of grains/ ears, grain weight panicle-^{1}, test weight, grain yield, stover yield, biological yield, and harvest index over water sprayed (control). Triacontanol and NAA gave significantly over control in growth and yield attributed. Significantly increased with zinc fertilization @ 4 kg Zn/ha over control, which was remained at par with 6 kg Zn/ha in growth and yield attributed.

Keywords: Chlorophyll, total tillers, PGRs, NAA, Zinc, attributes, and yield

Introduction
Pearl millet [*Pennisetum glaucum* (L.) R. Br. emend Stuntz] is the world's sixth and India's fourth most widely cereal food crop after rice, wheat, and maize. India is the largest *pearl millet* growing country contributing thirty-six percent of production in the world (FAO, 2020) [5]. *Pearl millet* is globally cultivated on about thirty-one million ha, mostly in the arid and semiarid tropics where no other cereal can be easily grown. India has been the largest area of about 7.44 million ha with a production of 10.86 million tones and productivity of 1243 kg/ha during 2020-21 (Directorate of Millets Development, 2022). It is the most widely cultivated *pearl millet* in Rajasthan. In India, *pearl millet* is pre-dominantly cultivated as a rainfed crop in diverse soils, climatic conditions, and indispensable arid zone. It is generally cultivated in areas with rainfall ranging from 150 to 600 mm. *Pearl millet* is supposed to be a traditionally arid crop because; it is tolerant to drought and efficient in utilization of solar radiation. It is not only a quick-growing short-duration crop but, also of scant and uncertain distribution of rainfalls. It is growing on a large-scale area due to its drought escaping mechanisms and lower water requirement as compared to other *Kharif* crops. The plant growth regulators (PGRs) have the potential for increasing crop productivity under environmental stress. PGRs are chemical substances, which can alter the growth and developmental processes leading to increased yield, improved grain quality, or facilitated harvesting (Bisht *et al.* 2020) [3]. Foliar application of PGRs improved the drought tolerance of plants. PGRs are known to play a positive role in enhancing qualitative and quantitative characteristics in plants. Micronutrients are found in small amounts in plants but play an important role in plant growth and development, as well as in the yield and yield attributes. In, Zinc is an essential element for crop production and optimum size of fruit, also compulsory in the carbonic enzyme, which is present in all photosynthetic tissues and is compulsory for chlorophyll biosynthesis (Mousavi *et al.* 2013) [9]. The soils of arid regions are moderately deficient in zinc and its external application is required for the optimization of productivity. Out of applied zinc fertilizer, only three to six percent is utilized by the first crop so the fertilizer added once to the soil leaves significant residual effects for the succeeding crops. The north western parts of Indian states are having predominantly saline and alkaline soils with poor fertility.

Poor availability of micronutrients mainly zincs as well as poor agronomic practices further reduce the availability of these nutrients to plants which led to reduced growth and yield. Foliar supplementation of zinc had improved the grain quality, yield and higher economic production (Rani *et al.* 2017) [11]. Therefore, the present investigation is designed on the effect of PGRs and zinc application on growth and yield attributes in *pearl millet.*

Materials and Methods

The field experiment was conducted during the *Kharif* season, in 2018 at the Agronomy farm, OPJS University, Churu (Rajasthan). It is geographically on the western side is 28.39, North latitude, 75.34 East longitude, and altitude of 233 meters above mean sea level. The area of research is according to agroecological classification lying under Agroclimatic Zone II A. Rajasthan is the transitional plain of inland draining. The twelve treatment combinations of three PGPs treatments (1000 ppm triacontanol, 50 ppm naphthalene acetic acid (NAA) including water sprayed) and four zinc treatments (Zero, 2, 4, and 6 kg /ha) were randomized in a factorial randomized block design (FRBD) with replicated three times. Two foliar sprays of Triacontanol and NAA, and fours zinc treatments (Zero, 2, 4, and 6 kg /ha) respectively were done at 20 and 40 DAS using 500 liters of water per sprayed per hectare (Gurrala *et al.* 2018) [7]. In order to evaluate the influence of different treatments on plant growth & yield attributes, necessary periodical observations were recorded. Total chlorophyll content was should be estimated by the SPAD method used (Abunyewa *et al.* 2016) [1]. The periodical chlorophyll content was recorded at 30, 60 DAS (Day After Sowing) and at harvest as influenced by PGRs and zinc fertilization. The yield attributes and yield parameters were estimated like the number of effective tillers at harvest, ear head length, grains/ ear, grain weight panicle^{-1}, test weight (gm), grain yield, stover yield, biological yield, and harvest index in percent. In this experiment is used *pearl millet* variety 'RHB-177' is suitable for well-drained soils.

Table 1: Effect of PGRs and zinc on Chlorophyll SPAD Meter Value & total tillers at harvest of *pearl millet*

Treatments	Chlorophyll SPAD Meter Value			Total tillers/plant
	30 DAS	60 DAS	At harvest	
PGRs				
NAA	49.61	55.85	35.43	4.47
Triacontanol	50.73	57.06	36.45	4.74
Water spray (control)	47.49	53.80	32.73	3.53
SE(m)	0.01	0.05	0.01	0.01
C.D	0.02	0.14	0.02	0.08
Zinc levels (kg Zn/ha)				
0	48.50	54.74	33.73	4.10
2	49.08	55.32	34.36	4.11
4	49.61	55.88	35.54	4.34
6	49.91	56.35	35.86	4.42
SE(m)	0.01	0.06	0.01	0.01
C.D.	0.02	0.16	0.02	0.01
Factor(A·B) or				
SE(m)	0.01	0.10	0.02	0.01
C.D.	0.04	NS	0.04	0.02

NS =Non Significant

Table 2: Effect of PGRs and zinc on yield attributes, grain weight panicle-1, test weight, Grain, Stover and biological yield and harvest index in *Pearl millet*

Treatments	Effective tiller/ Plant	Ear length (cm)	Number of Grains/ ear	Grain Weight panicle^{-1}	Test Weight (g)	Grain yield (Kg/ ha^{-1})	Stover yield (Kg/ ha^{-1})	Biological yield (Kg/ha^{-1})	Harvest index (%)
PGRs									
NAA	2.27	26.28	1550.92	22.81	7.11	2009.42	5024.17	7033.58	28.62
Triacontanol	2.32	28.44	1661.92	23.38	7.37	2127.25	5201.08	7328.33	28.87
Water spray (control)	2.19	22.57	1171.25	21.73	6.38	1727.67	4564.83	6292.50	27.45
SE(m)	0.01	0.12	0.64	0.01	0.03	3.34	33.23	32.89	0.12
C.D	0.01	0.35	1.90	0.01	0.10	9.87	98.10	97.08	0.37
Zinc levels (kg /ha)									
0	2.22	23.82	1299.67	21.99	6.66	1785.89	4714.22	6500.11	27.46
2	2.24	24.42	1352.00	22.44	6.81	1905.78	4847.67	6753.44	28.03
4	2.28	26.86	1568.56	22.92	7.09	2027.22	5048.78	7076.00	28.69
6	2.30	27.95	1625.22	23.21	7.26	2100.22	5109.44	7209.67	29.07
SE(m)	0.01	0.14	0.74	0.01	0.04	3.86	38.37	30.00	0.14
C.D.	0.01	0.40	2.19	0.01	0.12	11.40	113.30	112.10	0.42
Factor (A B)									
SE(m)	0.005	0.70	1.29	0.01	0.07	6.69	66.47	65.78	0.25
C.D.	0.02	0.24	3.80	0.01	N/A	19.74	NS	194.167	0.73

Results and Discussion

Chlorophyll content and the total number of tillers

PGRs: A critical examination of data in (table-1) showed that foliar application of NAA and triacontanol was found significantly improved the chlorophyll content over water sprayed (control) the extent of 6.81 and 4.45 percent at 30 DAS, 3.81 and 6.06 percent at 60 DAS and 11.38 and 8.28 percent at harvest, respectively over water sprayed (control). The maximum chlorophyll content was recorded 57.06 at the 60 DAS crop growth stage. Foliar spray of triacontanol remained at par with NAA and showed significant improvement in total tillers/plant by 34.52 and 26.66 percent over control, respectively. The high chlorophyll content noticed with the application of triacontanol and NAA was attributed to the protection of chlorophyll content from photo-oxidation and increased chlorophyll content synthesis. The improvement in growth characters with these PGRs seems to be due to their role in modifying various physiological and metabolic processes in the plant system. The foliar spray of triacontanol and NAA caused a favorable influence on the growth of crops, when summer and environment wet conditions, the temperature occurred during the growing period of *pearl millet*. Singh (2007) [13] reported that foliar application of triacontanol and NAA was proven to significantly increase chlorophyll content in leaves. Gurrala *et al.* (2018) [7] evaluated those PGRs on the growth of *pearl millet* that had a significant influence on chlorophyll content were recorded foliar application.

Zinc fertilization

A critical examination of data (table-1) revealed that successive addition in four levels of zinc from 0 to 6 kg Zn/ha was found to significantly increase the crop chlorophyll content at 30 DAS, 60 DAS, and at harvest over lower levels. The level of zinc at 4 kg Zn/ha registered chlorophyll content at 30 DAS, 60 DAS and at harvest stages, respectively and thus improved, to the extent of 1.20 and 2.29 percent at 30 DAS, 1.06 and 2.09 percent at 60 DAS and 1.89 and 5.38 percent at harvest stage over 2 kg Zn/ha and lower-level control, respectively. However, it showed statistical resemblance with 6 kg Zn/ha, wherein the maximum at 30 DAS, 60 DAS, and at harvest was recorded 49.91, 56.35, and 35.86 content. However, maximum chlorophyll content was recorded 56.35 at crop growth stage 60 DAS. Application of graded levels of Zinc upto 4 kg Zn/ha significantly increased the total number of tillers/plants over preceding levels. It attained 4.34 tillers/plant which was 0.19 and 5.80 percent more than recorded under 2 kg Zn/ha and lower-level control, respectively. Further increase in the level of zinc to 6 kg Zn/ha did bring significant variation in the total number of tillers/plants 4.42 recorded. Besides this zinc also enhances the absorption of essential elements via increasing the cation exchange capacity of roots. These results are in close conformity with those of Yadav (2018) [14] reported that showed that zinc fertilization brought considerable improvement in the growth of *pearl millet*. Results further indicated a total number of tillers/plants. Other researchers are also improving in growth parameters with Zinc fertilizer levels reported by Prasad *et al.* (2014) [10] and Arshewar (2018) [2] in *pearl millet* reported a significant improvement in growth parameters due to application.

Interaction effect

An examination of data revealed that the interaction effect of PGRs and Zinc fertilization did not have a significant effect on chlorophyll content at 60 DAS, whereas a significant effect was different show at 30 DAS and at harvest.

Yield attributes and yield

Data pertaining to yield attributes and yield *viz.*, number of effective tillers/plants, number of grains/ears, length of ear, test weight, grain yield, stover yield, biological yields, and harvest index are given in table 2.

PGRs

A perusal of data (table-2) showed that foliar application of triacontanol produced a maximum number of effective tillers/ plants, ear length, grains/ear, grain weight panicle-^{1,} test weight, grain yield, stover yield, biological yield, and harvest index in *pearl millet*, which was found at par with NAA but superior to water spray. The increase in the number of effective tillers/ plants, ear length, grains/ear, grain weight panicle-^{1,} test weight, grain yield, stover yield, biological yield, and harvest index due to triacontanol was recorded at 6.08 and 3.93, 26.02 and 16.4,1661.92 and 1550.92, 41.89 and 32.42, (23.38 gram) and 7.57, 15.48 and 11.45 (2127.25 kg ha^{-1}) and 23.13, 13.94 & 10.06, 16.46 and 10.11 & 5.18 and 4.28 percent NAA over control, respectively.

A perusal of data (table-2) showed that foliar application of triacontanol produced a maximum number of effective tillers/ plants in *pearl millet*, which was found at par with NAA but superior to over control. It might be due to the stimulating effect of NAA, which induced a large number of reproductive sinks, which led to greater activity of carboxylate enzymes resulting in a higher photosynthetic rate with greater translocation and accumulation of metabolites in the sinks and ultimately the higher seed yield. Among the different PGRs foliar spray of triacontanol and NAA remaining at par with each other were found superior in increasing the ear length, grains/ear, grain weight panicle-^{1}, stover yield, grain yield, biological yield, and harvest index in *pearl millet* to over water spray. The foliar application of PGRs brought perceptible was found improvement in grain yield per ha^{-} of *pearl millet*. These PGRs stimulated carbohydrate and nitrogen status in the leaves which might be responsive to produce more seed yield. A significant increase in stover and biological yields seems to be on account of improvement in vegetative and reproductive growth of the crop. Further, the favorable effects of PGRs on grain yield and total dry matter production might have resulted on account of greater nutrient concentration at cellular levels as well as their uptake due to greater nutrient absorption as evidenced in the present investigation. The significant improvement due to triacontanol application seems to be attributed to photosynthetic efficacy and the availability of assimilates for the partitioning of photosynthetic to reproductive structures. Singh (2007) [13] reported that foliar application of triacontanol and NAA was proven to significantly increase test weight and seed, stover, and biological yield over control. Gupta (2017) proves that the effect of foliar spray of triacontanol and NAA on the yield of *pearl millet* and show application of triacontanol was found to be the best in increasing the grain yield.

Zinc fertilization

The number of effective tillers/plants, ear length, grains/ear, grain weight panicle-^{1}, test weight, grain yield, stover yield, biological yield, and harvest index in *pearl millet* was recorded significantly influenced by different levels of Zinc fertilization (table-2). Application of Zinc at 4 kg Zn/ha attained 2.28, 26.86 cm, 1568.56 and 1625.226, 22.92 and 23.21, 2027.22 kg/ha 5048.78 kg/ha, and effective tillers/plant, ear length, grains/ear, grain weight panicle,-^{1} test weight, grain yield, stover yield, biological yield and harvest index thereby increasing them to the extent of 2.93 and 1.13, 12.75 and 2.45, 4.03 and 20.69, 2.04 and 4.20, 2.33 and 6.58, 6.71 and 13.51, and 2.10 and 7.10, 0.68 and 8.86, 2.08 and 4.48 percent over 2 kg Zn/ha and lower-level control, respectively. However, it was shown was statistical similarity with 6 kg Zn/ha, wherein the maximum number of 2.30, 27.95, (7.26 g), 2100.22 kg/ha, 7209.67, and 29.07 effective tillers, ear length, grains/ear, grain weight panicle,-^{1} test weight, grain yield, stover yield, biological yield, and harvest index were recorded. As stated, earlier zinc plays a vital role in the growth and development of plants because of its stimulatory and catalytic effects on the various physiological and metabolic processes of the plant. The role of zinc played in the synthesis of chlorophyll benefited the crop in proper growth and development owing to greater absorption of nutrients from the soil. The absorption of nutrients might have helped the plant in greater photosynthesis, nitrogen metabolism, and synthesis of carbohydrates. Thus, these beneficial effects of zinc brought a substantial was recorded improvement in yield attributes and ultimately in seed and stover yield of *pearl millet*. Singh (2007) [13] reported that Zinc in increasing levels upto 4 kg ha^{-1} was proved to significantly increase the test weight and seed yield, stover yield, and biological yield. Further, the increase might be owing to the role of zinc in biosynthesis and especially due to its role in the initiation of primordia for reproductive parts and partitioning of photosynthates towards them, which resulted in better flowering and fruiting. Yadav (2018) [14] showed that Zinc fertilization brought considerably was prove an improvement in the yield of *pearl millet* and effective tillers/ plant, ear length, number of grains/ ears, test weight, grain, stover, and biological yield, harvest index was proved significantly increased with Zinc fertilization @ 4 kg Zn /ha over control, which remained at par with 6 kg Zn /ha. These results corroborate the findings of Prasad *et al.* (2014) [10], Shekhawat and Kumawat (2017) [12], Arshewar (2018) [2], and Meena *et al.* (2018) [8] in *pearl millet* reported a significant improvement in yield and yield attributes due to the application of Zinc.

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