Original Research Article

"Influence of Phosphorus and Plant Growth Regulators on Growth, Yield and Economics of pearl millet (*Pennisetum glaucum* L.)"

A field experiment was conducted during *Rabi*season,2022 at Crop Research Farm, Departmentof Agronomy,Sam Higginbottom University of Agriculture,Technology AndSciences,Prayagraj(U.P). Thesoiloftheexperimentalfieldwassandyloamintexture, with,nearlyneutralinsoilreaction(pH7.8),containedlowleveloforganiccarbon(0.62%),N(225Kg/ha), P(38.2kg/ha) and K (240.7 kg/ha).To study the influence of phosphorous and growth regulators on the growth, yield and economics of pearl millet, phosphorous and growth regulators were applied to soil. The experiment was laid in Randomized Block Design (RBD), three levels of phosphorous, 30kg/ha, 40 kg/ha and 50kg/ha each with a combination of growth regulators, NAA (50ppm), Chloromequat chloride (250ppm) and Triacontano (500ppm) were applied to soil. Significant plant growth with maximum grain yield, gross return and high stover yield was recorded among the plants that were grown in soil supplemented with phosphorous 50kg/ha+ 50ppm NAA. We recommend the pearl millet crop with 50kg/ha of phosphorous and 50ppm NAA for a high yield of grain, stover yield and net return of pearl millet.

Keywords: Phosphorous, Plant Growth Regulators, Growth, Yield and Economics.

INTRODUCTION

Pearl millet (Pennisetum glaucum L.) is generally grown as staple food by small and marginal farmers in Asia and Africa. "Bajra is a C4 plant having high photosynthetic efficiency, more dry weight production, that survives under different Agro-climatic conditions with less inputs and more economic returns". Pearl millet is drought tolerant, can survive in low fertile soils with nutritious seeds due to which it is an important food crop in arid and semi arid regions (Reddy et al., 2022). The nutrient content of pearl millet grains is at par with that of other millets and cereals, they contain 13-14% protein, 5-6% fat, 74% carbohydrate and 1-2% minerals. Besides, it is suggested that it can be intercropped with cluster beans or green gram as their demand for soil nutrients is meagre (Neha et al., 2017).

Globally pearl millet is grown in an area of 9.5 million hectares with a production of 1200kg/ha and gross production of 11.83 million tones (USDA, 2023). In Uttar Pradesh, where the experiment is carried, during 2020-2021 it is cultivated in an area of 0.91 million hectares with production of 2221kg/ha and net yield of 2.01 million tones (GOI, 2021).

One of the major problems to crop production is a phosphorus deficiency.Phosphorous, next to nitrogen is an important nutrient for plant growth and yield. Phosphorous plays a vital role in photosynthesis, flowering, seed formation, root development and crop maturity. Besides, phosphorous is a major constituent of ATP, DNA and RNA (Thrupthi et al., 2023).Phosphorous being an important constituent of many biomolecules, its uptake by plants is limited by its low soluble form in the soil. In agricultural systems, the soil gets depleted of free phosphorous after the crop is harvested, and soil must be replenished with phosphorous fertilizer before the subsequent crop is raised (Singh et al., 2017). In the present experiment, an attempt has been made to supply the different levels of phosphorous to the soil where pearl millet crop was raised in RBD design.

Under environmental stress, plant growth regulators have the potential to boost crop yield.Growth regulator sprayed on pearl millet showed a positive effect on the growth and yield of pearl millet (Rao et al., 2021).Also, they participate in very significant agronomic developmental processes such seed germination, leaf angle, blooming duration, and seed yield **(**Mourya and Singh, 2022). Among the different growth regulators, NAA has positive effect on the growth and yield of pearl millet which were under salt, drought and temperature stress (Sandeep et al., 2023). Keeping in view the above fact, the experiment was conducted to find out the "Influence of phosphorus and plant growth regulators on growth and yield of pearl millet (*Pennisetum glaucum* L.)".

MATERIALSANDMETHODS

Theexperimentwasconductedduring*Rabi* seasonof2022atCropResearchFarm,Department of Agronomy, Sam Higginbottom University of Agriculture, Technology andSciences,Prayagraj(U.P).The experimental field represents Central Gangetic alluvium, the soil is of sandy loam texture, with neutral pH (7.8) and NPK ratio of 225: 38.2: and 240.7

Kg/ha.The experiment was laid in Randomized Block design with 9 treatments, each treatment included addition of phosphorous and a growth regulator to the soil, the combinations and the quantities are as shown in the table-1. Each treatment is replicated thrice. Growth parameters (plant height(cm), dry weight(g), crop growth rate (g/m^2/day), relative growth rate (g/g/day), yield attributes (ear head length(cm), number of grains/ear head, test weight (g), grain yield(t/ha), straw yield (t/ha), harvest index (%) were subjected to statistical analysis of variance method (Gomez and Gomez , 1976).

Table-1: The combinations of Phosphorous and growth regulators of the treatments.

Treatments	**Phosphorous Kg/Ha**	**Growth regulator /ppm**	**NPK**
Treatment-1		50 NAA	-
Treatment-2	30	250 Chloromequat chloride	-
Treatment-3		500 Triacontanol	-
Treatment-4		50 NAA	-
Treatment-5	40	250 Chloromequat chloride	-
Treatment-6		500 Triacontanol	-
Treatment-7		50 NAA	-
Treatment-8	50	250 Chloromequat chloride	-
Treatment-9		500 Triacontanol	-
Treatment-10 : Control	-	-	80:40:40

RESULTANDDISSCUSSION

Growth parameters: Plant height, growth and relative growth rate and dry weight

The treated plants are significantly taller than the control plants. Among the treated plants, those growing in soil with 50 kg/ha P are taller than the plants growing on 30 and or 40kg/ha of Phosphorous (Table-2). The increased plant height could be due to higher phosphorous content, a result consistent with that of Singh et al., (2017). Furthermore, the plants of treatment 7 are the tallest, which could be due to NAA (Table 2); as NAA stimulates cell division, cell elongation that lead to stem growth and height. Similar results are reported in pearl millet by Mourya and Singh (2022).

Like plant height, the growth rate and the relative growth rate of plants growing in soil with 50kg/h of Phosphorus with different growth regulators is the highest. Consequently, the dry weight of these plants also is high. Although the soil supplemented with 40Kg/h showed similar growth rate, significant increased growth rate is recorded among plants growing in 50Kg/h P and 50ppm NAA (Table-2). Increased phosphorous (50Kg/h) in the soil accumulates photosynthates in various sinks that could escalate plant growth rate (Sowjanya et al., 2021). Pearl millet plants grow better with increased available phosphorous content in the soil. It is reported that the seeds were treated with phosphate solubilizing bacteria and the soil was rich in microbes that escalated available phosphorous to plants (Sowjanya et al., 2021).In the present study although enhanced crop growth and relative growth rate are recorded among the plants growing in soil with P 50kg/h +50ppm NAA, it can not be concluded how there could be an increase in the free/available phosphorous in the soil.

Yield Attributes & Yield:

Ear head length:

Consistent to the plant height and growth rate, the length of the ear head is also the best among plants grown in phosphorous 50kg/h with different growth regulators (Table-3). Phosphorous is an essential nutrient and plays important role in metabolic pathways that can lead to healthy plant growth and long ear heads in pearl millet (Gojariya et al., 2020); our results are consistent with this report.

Number of grains/ear head, grain yield/ha and harvest index:

The plants of treatments 7, 8 and 9 had the highest number of grains/ear head (Table 3). It is explicated that increased supply of phosphorous in the soil encourages plant growth, more tiller formation in the flower primordial stage that yield more grains/ear head (Reddy et al., 2022). Adequate amounts of growth regulators in the soil and their availability to the plant enable it to develop many functional tillers that bear many grains/ear head (Suresh et al., 2018). Our results agree with these findings.

Consequent to higher grains/ear head, the grain yield/hectare is high in the crop that grew in soil with 50kg/ha of phosphorous with any of the growth regulator. Our results agree with those of finger millet, where phosphorous application enhanced grain yield/ha (Dharmendra and Umesha, 2022). Statistically similar grain yield/ha is observed in the treatment-4 which contained only 40kg/ha phosphorous and 50 ppm NAA in the present study (Table-3). It is well documented in literature the regulation of NAA in plant growth, chlorophyll formation, stomatal regulation, resistance to biotic and abiotic stresses that enable that plant with high yield with which our results are in accordance (Mourya and Singh, 2022).

Test Yield and Stover yield:

The test yield of the crop is the highest in treatment-7 (Table-3).The stover yield of the crop is significantly maximum in the crop that is grown in 50kg/ha phosphorous with the growth regulators (Table-3). Phosphorous is commonly used in plant fertilizers that leads to robust root system and healthy vegetative growth of the plants (Ganesh et al., 2022). Statistically similar stover yield is noticed among the plants that grew in phosphorous 40kg/ha with 50 ppm NAA. Suresh et al. (2020) reported that NAA has a unique role in delaying senescence, hastens root and shoot growth which could have led to increased stover yield.

ECONOMIC ANALYSIS

Economics:

The plants of treatment 7 showedmaximum gross returns (109625INR/ha), maximumnetreturn(74389.08INR/ha) andhighestbenefitcostratio(2.11)(Table4).Although grain yield and stover yield of the crops grown in 40kg/ha of phosphorous with 50ppm NAA is at par to that of grown in 50kg/ha +50ppm NAA, the gross and net returns of the cultivation are significantly lower, recommending 50kg/ha of phosphorous supplementation. There is evidence that phosphorous is involved in seed formation and high number seed set that increases the yield and benefits the cost ratio in finger millet (Krishna et al., 2019).

CONCLUSION:

It can be concluded that pearl millet crops can be grown in soils supplemented with 50kg/ha of phosphorous and 50ppm of NAA, to have the highest yield of grains, yield, and best benefit cost ratio.

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Table 2. Effect of Phosphorus and PGR on Growth attributes of Pearl Millet.

S No.	Treatment combinations	100 DAS		80- 100 DAS	
		Plant Height (cm)	Dry weight (g)	Crop Growth Rate ($g/m^2/day$).	Relative Growth Rate (g/g/day)
1.	Phosphorous 30 kg/ha +NAA 50 ppm	172.40	57.20	3.85	0.0049
2.	Phosphorous 30 kg/ha + Chloromequat chloride 250 ppm	170.30	54.87	3.62	0.0048
3.	Phosphorous 30 kg/ha + Triacontanol 500 ppm	171.60	56.70	3.85	0.0049
4.	Phosphorous 40 kg/ha + NAA 50 ppm	174.60	66.00	5.09	0.0056
5.	Phosphorous 40 kg/ha +Chloromequat chloride 250 ppm	172.80	57.20	3.85	0.0049
6.	Phosphorous 40 kg/ha + Triacontanol 500 ppm	173.60	64.00	4.79	0.0055
7.	Phosphorous 50 kg/ha + NAA 50 ppm	178.10	69.60	5.53	0.0058
8.	Phosphorous 50 kg/ha + Chloromequat chloride 250 ppm	176.60	66.80	5.14	0.0056
9.	Phosphorous 50 kg/ha + Triacontanol 500 ppm	177.30	67.90	5.28	0.0057
10.	Control [RDF: 80:40:40]NPK Kg/ha	169.20	53.30	3.34	0.0046
	F-test	S	S	S	NS
	Sem(±)	0.43	0.73	0.28	0.0004
	CD (p=0.05)	1.27	2.17	0.84	--

Table 3. Effect of Phosphorus and PGR on Yield and Yield attributes of Pearl Millet.

S. No.	Treatment combinations	Ear head length (cm)	Grains/ear head	Test weight (g)	Grain yield (t/ha)	Straw Yield (t/ha)	Harvest Index (%)
1.	Phosphorous 30 kg/ha +NAA 50 ppm	25.33	1721.33	10.10	2.17	3.51	38.32
2.	Phosphorous 30 kg/ha + Chloromequat chloride 250 ppm	25.20	1702.67	9.20	2.13	3.47	38.00
3.	Phosphorous 30 kg/ha + Triacontanol 500 ppm	25.27	1720.67	9.60	2.15	3.50	38.12
4.	Phosphorous 40 kg/ha + NAA 50 ppm	25.67	1734.67	10.87	2.51	3.79	39.78
5.	Phosphorous 40 kg/ha +Chloromequat chloride 250 ppm	25.47	1722.67	10.60	2.21	3.55	38.38
6.	Phosphorous 40 kg/ha + Triacontanol 500 ppm	25.66	1730.33	10.80	2.30	3.64	38.67
7.	Phosphorous 50 kg/ha + NAA 50 ppm	26.00	1757.67	11.73	2.69	4.05	39.96
8.	Phosphorous 50 kg/ha + Chloromequat chloride 250 ppm	25.73	1749.00	11.20	2.57	3.92	39.63
9.	Phosphorous 50 kg/ha + Triacontanol 500 ppm	25.90	1754.00	11.60	2.61	3.95	39.82
10.	Control [RDF: 80:40:40]NPK Kg/ha	25.07	1700.33	10.07	2.02	3.36	37.57
	F-Test	S	S	NS	S	S	NS
	SEm(±)	0.08	3.81	0.91	0.07	0.10	1.11
	CD (p=0.05)	0.23	11.31	--	0.20	0.29	--

UNDER PEER REVIEW

Table 4. Effect of Phosphorus and PGR on Economics of Pearl Millet.

S.No.	Treatment combinations	Total cost of cultivation	Gross Returns	Net Returns	B:C ratio
1.	Phosphorous 30 kg/ha +NAA 50 ppm	33986	88555	54569	1.60
2.	Phosphorous 30 kg/ha + Chloromequat chloride 250 ppm	34142	86935	52793	1.54
3.	Phosphorous 30 kg/ha + Triacontanol 500 ppm	34705	87750	53045	1.52
4.	Phosphorous 40 kg/ha + NAA 50 ppm	34611	102295	67684	1.95
5.	Phosphorous 40 kg/ha +Chloromequat chloride 250 ppm	34767	90175	55408	1.59
6.	Phosphorous 40 kg/ha + Triacontanol 500 ppm	35330	93820	58490	1.65
7.	Phosphorous 50 kg/ha + NAA 50 ppm	35236	109625	74389	2.11
8.	Phosphorous 50 kg/ha + Chloromequat chloride 250 ppm	35392	104760	69368	1.95
9.	Phosphorous 50 kg/ha + Triacontanol 500 ppm	35955	106375	70420	1.95
10.	Control [RDF: 80:40:40] NPK Kg/ha	34580	82480	47900	1.38