Original Research Article

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

ABSTRACT

A field experiment was conducted during *Rabi* 2022 at Crop Research Farm, Department of Agronomy, Sam Higginbottom University of Agriculture, Technology And Sciences, Prayagraj (U.P). The soil of the experimental field was sandy loam in texture, nearly neutral in soil reaction (pH 7.8), low level of organic carbon (0.62%), available N (225 Kg/ha), P (38.2kg/ha) and K (240.7 kg/ha). To determine the "Influence of phosphorus and plant growth regulators on Growth, Yield and Economics of pearl millet **(***Pennisetum glaucum* L**.)** to study the response of phosphorous levels *viz* (30kg/ha),(40kg/ha) and (50kg/ha)with combination of 3 plant growth regulators *viz*. NAA(50ppm),Chloromequat chloride(250ppm),Triacontanol(500ppm).The experiment was laid out in RBD with 10 treatments each replicated thrice The results showed that significant and higher Plant height (178.10 cm), Plant dry weight (69.60 g) and Crop growth rate (5.53 g/m^2/day), relative growth rate (0.0058 g/g/day), higher ear head length (26.00 cm),maximum number of grains per ear head (1757.67), higher test weight (11.73 g), higher grain yield (2.69 t/ha), maximum stover yield (4.05 t/ha), higher harvest Index (39.96 %), maximum gross return (INR 109625), net return (INR 74389) and B:C ratio (2.11) were observed in treatment 7 (Phosphorous 50 kg/ha + NAA 50 ppm).

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 and survive under different Agro-climatic conditions with less inputs and more economic returns". The crop is critically important for food and nutritious security of humans and animals in arid and semiarid regions as pearl millet is early maturing, drought tolerant, tolerate high temperatures upto 42°C during reproductive stage enable the crop cultivation in hostile conditions. Pearl millet is well adapted to grow under most adverse Agro-climatic conditions considered by drought, low soil fertility & high temperatures (**Reddy *et al*., 2022)**. The nutrient content of pearl millet compares very well with other cereals and millets. It has high protein content with slightly superior amino acid profile. Pearl millet grain contains 13-14% protein, 5-6 % fat, 74 % carbohydrate and 1-2 % minerals concern regarding agriculture's capacity to meet the demands of a population that is expanding at an exponential rate have increased due to a lack of new land available for food cultivation and deteriorating soil fertility. When compared to solitary cropping, intercropping increases overall production per unit area per unit time by making efficient use of resources. Planting short-lived crops like pearl millet alongside cluster beans and green gram crops may increase economic returns per unit of land since there will be less rivalry due to their temporally varying peak resource demand **(Neha *et al*., 2017)**.

Pearl millet ranks first in area and production , it is grown in all most tropical and sub-tropical regions of different countries. Globally, Pearl millet covers an area about 9.5 million hectares with production of 11.83 million tonnes and the productivity of 1200 kg/ha **(USDA, 2023)**.In India pearl millet grown cover an area about 7.57 million hectares with production of 10.86 million tonnes and productivity of 1436 kg/ha under 2021, During 2020-21 total area coverage under pearl millet in Uttar Pradesh was cultivated in 0.91 million hectares area with production of 2.01 million tonnes and productivity of 2221 kg/ha which accounts 11.99% total cultivable area and productivity 18.54% of Pearl millet in India **(GOI, 2021)**.

One of the major problems to crop production is a phosphorus deficiency. Due to slow diffusion and strong soil fixation, P has a special property that makes it limited. After nitrogen, phosphorus is the second most important nutrient for plant growth since it is an essential component of several biochemicals, including nucleic acids, nucleotides, phospholipids, and phosphoproteins. The capacity of plants to carry out various functions, including the process of photosynthesis nitrogen fixation, flowering, seed formation, root development, and crop maturity, is improved by proper P nutrition. According to discoveries, P fertilizer decreased the amount of Na^+ in shoots, which improved rice survival, growth, and yield . Additionally, phosphorus has a major part in the molecule ATP, which gives that plant energy for actions like respiration, nutrient uptake, and nutrient translocation. In addition, phosphorus is a component of other compounds required for the transfer of DNA and RNA and for the synthesis of proteins **(Thrupthi *et al*., 2023)**.

Under environmental stress, plant growth regulators have the potential to boost crop yield. Chemicals known as "growth regulators" can change how organisms grow and develop, which might enhance output, improve grain quality, or make harvesting easier . The amount of nutrients and the use of plant growth regulators had a big impact on Pearl millet's growth metrics. the exogenous use of NAA to boost yield and growth in the face of diverse stresses as salt, drought, extremely high or low temperatures, and heavy metal toxicity. Also, they participate in very significant agronomic developmental processes such seed germination, leaf angle, blooming duration, and seed yield **(Sandeep *et al*., 2023)**.

Plant growth regulators known as bio-stimulants or bio inhibitors can modify physiological processes in plants. Plant growth regulators improve the effective partitioning and translocation of accumulates from source to sink in the field crops. Naphthalene acetic acid, being an auxin, promote vegetative growth by active cell division, cell enlargement and cell elongation and thus, help in improving growth characteristics and in stimulating reproductive growth . Growth regulator spray had a positive effect on growth and yield of pearl millet **(Rao *et al*., 2021)**. Under environmental stress, plant growth regulators have the potential to boost crop yield. Chemicals known as "growth regulators" can change how organisms grow and develop, which might enhance output, improve grain quality, or make harvesting easier . The amount of nutrients and the use of plant growth regulators had a big impact on Pearl millet's growth metrics. the exogenous use of NAA to boost yield and growth in the face of diverse stresses as salt, drought, extremely high or low temperatures, and heavy metal toxicity. Also, they participate in very significant agronomic developmental processes such seed germination, leaf angle, blooming duration, and seed yield **(Mourya and Singh, 2022)**.

Adequate phosphorus nutrition enhances many aspects of plant growth development including flowering, fruiting, root growth and yield components of different crops. P uptake in plants is often constrained by the very low solubility of P in the soil. In agricultural systems, phosphorus in the harvested crops is removed from the system, resulting in P deprived soils if no P is supplemented as fertilizer **(Singh *et al*., 2016)**. Phosphorus is a component of flowers complex nucleic acid structure that governs protein production. As a result, phosphorus is essential in the cellular department and the production of new tissue. Phosphorus is also linked to a variety of internal plant strength disparities. Phosphorus is frequently recommended as a row-carried out beginning fertilizer for early boom growth. Early increase response to phosphorus was confirmed in fewer than 40% of the test fields in university of Nebraska starter fertilizer research carried out in the 1980s . Even while phosphorus does not boost grain output, starter packets may also boom early. Manufacturers must carefully weigh the aesthetic effects of fertilizer application against increased revenue from increased production **(Ganesh *et al*., 2022)**. 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.)"**

MATERIALS AND METHODS

The experiment was conducted during *Rabi* season of 2022 at Crop Research Farm, Department of Agronomy, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj (U.P). The soil of the field constituting a part of central gangetic alluvium is neutral and deep. The soil of the experimental field was sandy loam in texture, nearly neutral in soil reaction (pH 7.8), low level of organic carbon (0.62%), available N (225 Kg/ha), P (38.2 kg/ha) and K (240.7 kg/ha). The treatment consisted of 3 levels of phosphorous *viz.* (30kg/ha), (40kg/ha) and (50kg/ha)with combination of 3 plant growth regulators *viz*. NAA(50ppm),Chloromequat chloride(250ppm),Triacontanol(500ppm).The experiment was laid out in RBD with 10 treatments each replicated thrice. The treatment combinations were as follows: Treatment 1 Phosphorous (30 kg/ha + NAA (50 ppm), Treatment 2 Phosphorous (30 kg/ha) + Chloromequat chloride (250 ppm), Treatment 3 Phosphorous (30 kg/ha)+ Triacontanol (500 ppm), Treatment 4 Phosphorous (40 kg/ha) + NAA (50 ppm), Treatment 5 Phosphorous (40 kg/ha) +Chloromequat chloride (250 ppm), Treatment 6 Phosphorous (40 kg/ha) + Triacontanol (500 ppm), Treatment 7 Phosphorous (50 kg/ha) + NAA (50 ppm), Treatment 8 Phosphorous (50 kg/ha) + Chloromequat chloride (250 ppm) T9 Phosphorous (50 kg/ha) + Triacontanol (500 ppm), Treatment 10 Control [RDF: 80:40:40] NPK Kg/ha. 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).**

RESULT AND DISSCUSSION

Growth parameters

Plant height (cm):

The data revealed that significantly higher plant height(178.10 cm) was recorded in treatment 7 [Phosphorous (50 kg/ha) + NAA (50ppm)]. However, treatment 9 [Phosphorous (50 kg/ha) + Triacontanol (500 ppm)] was found to be statistically at par with treatment 7 [Phosphorous (50 kg/ha) + NAA (50ppm)] (Table-1). Significant and higher plant height was observed with application of phosphorous (50kg/ha) might be due to effective utilization of nutrients through the extensive root system developed by crop plants under adequate phosphorus nutrient application, resulted increase in plant height. Similar results were reported by **Singh *et al*. (2017)**. Further, increase in plant height with application of NAA may be due to its regulatory function are produce the shoot apex primary in the leaf primordial and root system stimulates stem growth dramatically and also stimulates cell division, cell elongation and enzyme secretion, which eventually increased in plant height. Similar results were reported by **Mourya and Singh (2022).**

Plant dry weight (g):

Data showed that significantly higher plant dry weight (69.60 g) was recorded in treatment 7 [Phosphorous (50 kg/ha) + NAA (50 ppm)]. However, treatment 9 [Phosphorous (50 kg/ha) + Triacontanol (500 ppm)] was found to be statistically at par with treatment 7 [Phosphorous (50 kg/ha) + NAA (50 ppm)] (Table-1). Significant and higher plant dry weight(g) was observed with application of phosphorous(50kg/ha) might be due to it may have provided a favorable nutritional environment for the plants, which contributes to their essential role in several physical and chemical processes that remain critical for plant growth and development ,resulted increase in plant dry weight. Similar results were reported by **Reddy *et al.* (2022)**. Further, increase in plant dry weight with application of NAA(50ppm) may be due to it promotes cell proliferation in plant developmental stages due to their own metabolism regulation and promotes the development of cells by increasing turgor pressure and it also activates different enzymes and has a positive effect on plant growth, resulted increase in plant dry weight. Similar results were reported by **Mourya and Singh (2022).**

Crop Growth Rate (g/m^2/day):

The data recorded that significantly higher crop growth rate (5.53 g/m$^{2/}$day) was observed in treatment 7 with [Phosphorous (50 kg/ha) + NAA (50 ppm)]. However, treatment 4 [Phosphorous (40 kg/ha) + NAA (50 ppm)],treatment 6 [Phosphorous (40 kg/ha)+ Triacontanol (500 ppm)], treatment 8 [Phosphorous (50 kg/ha) + Chloromequat chloride (250 ppm)] and treatment 9 [Phosphorous (50 kg/ha) + Triacontanol (500 ppm)] was found to be statistically at par with treatment 7 [Phosphorous (50 kg/ha) + NAA (50 ppm)] (Table-

1).Significant and higher crop growth rate was observed with application of phosphorous(50kg/ha) might be due to higher accumulation of photosynthates in various sinks, which resulted in higher rate of crop growth rate. Similar results were reported by **Sowjanya *et al*.(2021).**

Relative growth rate (g/g/day) :

Data showed that Highest Relative growth rate (0.0058 g/g/day) was recorded with the treatment 7 [Phosphorous (50 kg/ha) + NAA (50 ppm)] (Table-1). However, there was no significant difference among the treatments.

Yield Attributes & Yield:

Ear head length (cm):

The data showed that significantly higher ear head length (26.00 cm) was observed in treatment 7 [Phosphorous (50 kg/ha) + NAA (50ppm)]. However, treatment 9 [Phosphorous (50 kg/ha)+ Triacontanol (500 ppm)] was found to be statistically at par with the treatment 7 [Phosphorous (50 kg/ha) + NAA (50 ppm)] (Table-2). Significant and higher ear head length was recorded with the application of phosphorous (50 kg/ha) might be due to it is recognized as an essential constituent of all living organism which plays a very important role in the conservation and transfer of energy in the metabolic reactions of living cells including biological energy transformation. resulted increase in ear head length. Similar results were reported by **Gojariya *et al.*(2020)**. Further, increase in ear head length with the application of NAA (50 ppm) might be due to rapid cell division and increased elongation of individual cell, resulted in increase in ear head length. Similar results were reported by **Suresh *et al.* (2020).**

Number of grains/ear head:

The data showed that significantly maximum number of grains/ear head (1957.67) was observed in treatment 7 [Phosphorous (50 kg/ha) + NAA (50 ppm)]. However, 8 [Phosphorous (50 kg/ha) + Chloromequat chloride (250 ppm)] and treatment 9 [Phosphorous (50 kg/ha) + Triacontanol (500 ppm)] was found to be statistically at par with the treatment 7 [Phosphorous (50 kg/ha) + NAA (50 ppm)] (Table-2). Significant and maximum number of grains /ear head was recorded with the application of phosphorus (50kg/ha) might be due to it is ascribed to an overall enhancement in plant development as reflected by increased dry weight, which resulted in increased supply of phosphorus and other nutrients to plants and nutrient availability to plants during the flower primordial initiation stage, which may have resulted in more effective tiller formation and ultimately, increased the number of grains/ear head. Similar results were reported by **Reddy *et al.* (2022).** Further, increase in number of grains/ear head with the application of NAA (50ppm) might be due to plants may have benefited from an earlier delivery of nutrients during the floral primordial initiation stage through plant growth regulators, resulting in a higher number of functional tillers and eventually more grains/ear heads. Similar results were reported by **Gurrala *et al.* (2018).**

Test weight (g):

Data showed that Highest test weight (11.73g) was recorded in Treatment 7 [Phosphorous (50 kg/ha) + NAA (50 ppm)] (Table-2). However, there was no significant difference among the treatments

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Grain Yield (t/ha):

The data revealed that significantly higher grain yield (2.69 t/ha) was recorded in treatment 7 [Phosphorous (50 kg/ha) + NAA (50 ppm)]. However, treatment 3 [Phosphorous (30 kg/ha) + Triacontanol (500 ppm)], treatment 8 [Phosphorous (50 kg/ha) + Chloromequat chloride (250 ppm)] and treatment 9 [Phosphorous (50 kg/ha) + Triacontanol (500 ppm)] was found to be statistically at par with the treatment 7 [Phosphorous (50 kg/ha) + NAA (50 ppm)] (Table-2). Significant and higher grain yield(t/ha) was recorded with application of phosphorous (50kg/ha) might be due to its optimal availability resulted in increase of nutrient use efficiency by the provision of adequate energy and an early proliferation of growth attributes which increased the grain yield potential. Similar results were reported by **Dharmendra and Umesha (2022)** in finger millet. Further, increase in grain yield (t/ha) was recorded with application of NAA(50ppm) may be due to it plays a vital role in increasing seed yield because they takes place in many physiological process of plant such as plant growth, chlorophyll formation, stomatal regulation, starch utilization and resistance to various biotic and abiotic stress which enhances seed yield. Similar results were reported by **Mourya and Singh (2022)**.

Stover yield (t/ha):

The data showed that Significantly maximum stover yield (4.05 t/ha) was recorded in treatment 7 [Phosphorous (50 kg/ha) + NAA (50 ppm)]. Treatment 4 [Phosphorous (40 kg/ha) + (NAA 50 ppm)], treatment 8 [Phosphorous (50 kg/ha) + Chloromequat chloride (250 ppm)] and treatment 9 [Phosphorous (50 kg/ha) + Triacontanol (500 ppm)] was found to be statistically at par with the treatment 7 [Phosphorous (50 kg/ha) + NAA (50 ppm)] (Table-2).

Significant and maximum stover yield (t/ha) was recorded with the application of phosphorous (50kg/ha) might be due to increased vegetative growth could be linked to phosphorus fertilization, presumably as a result of effective uptake and utilization of other nutrients received through the plant's large root system and biological yield is determined by the amount of straw produced, which might have increased straw yield. Similar results were reported by **Ganesh *et al*.(2022)**. Further, increase in stover yield (t/ha) was recorded with application of NAA (50ppm) may be due to it has unique role in delaying senescence process, hastening root and shoot growth, higher fertility rate of reproductive organ due to creation of favorable balance of hormones and setting more fruits, resulted increased in stover yield. Similar results were reported by **Suresh *et al*.(2020).**

Harvest Index (%):

Data showed Highest harvest index (39.96%) was recorded in Treatment 7 [Phosphorous (50 kg/ha) + NAA (50 ppm)]. However, there was no significant difference among the treatments.

ECONOMIC ANALYSIS

Economics:

The result showed maximum gross returns (109625INR/ha), maximum net return (74389.08INR/ha) and highest benefit cost ratio (2.11) were observed in the treatment 7[[Phosphorous (50 kg/ha) + NAA (50 ppm)] as compared to other treatments (Table 3). The maximum gross return, net return and benefit cost ratio was recorded with application of phosphorous (50kg/ha) might be due to it is an essential plant nutrient, it involves in various physiological process like seed formation, maximum number of grains/ ear head, which increases grain yield resulted with higher benefit cost ratio. Similar results were reported by **Krishna et al.(2019)** in finger millet.

CONCLUSION:

It is concluded that with the Application of phosphorous (50kg/ha) along with NAA(50ppm) (Treatment 7) was observed highest grain yield and benefit cost ratio.

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Table 1. 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 2. 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	--

Table 3. 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