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Original Research Article

Effect of Nitrogen and Zinc on Growth, Yield and Economics of Pearl Millet (*Pennisetum glaucum* L.)

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Keywords

Growth, Yield, Economics, Nitrogen, Zinc, Nutrient uptake

A B S T R A C T

The field investigation was conducted at Experimental Farm, Agronomy Section, College of Agriculture, Latur to study the effect of nitrogen and zinc on growth yield and economics of Pearl Millet (*Pennisetum glaucum* L.), The experimental field was leveled and well drained. The soil was medium and black in colour with good drainage. The soil was clayey loam in nature and slightly alkaline (7.8) in reaction, low in nitrogen (118.86 kg ha^{-1}), medium in available phosphorus and rich in available potassium (485.89 kg ha^{-1}). The experiment was laid out in Factorial Randomized Block Design with two factors and replicated thrice. There were 12 treatment combinations comprising 4 levels of nitrogen *viz.* 0 (control), 45, 60 and 75 kg N ha^{-1} and 3 levels of zinc *viz.* 05, 10 and 15 kg Z ha^{-1}. The experimental site having gross and net plot size was 5.4 x 4.5 m^2 and 4.5 x 3.6 m^2 respectively. The recommended dose of fertilizer was applied at time sowing (60:30:30NPK kg ha^{-1} where N applied as per treatments). The sowing was done on 22nd June 2016 by dibbling and harvested on 1st Oct 2016. The results revealed that, application of nitrogen @ 75 kg N ha^{-1} recorded significantly higher growth (Height-179.03 cm, dry matter-52.62 g, stem girth-4.76 cm) and yield attributes (No. of ear head- 1.73, length of earhead-19.57 cm, grain weight per earhead-36.42 g), grain yield (1892.00 kg ha^{-1}), straw yield (4929.88 kgha^{-1}), biological yield (6821.80 kg ha^{-1}), gross monetary return (Rs. 42624 ha^{-1}), net monetary return (Rs 21736.09 ha^{-1}) and B: C ratio (1.04) than rest of the levels of nitrogen. The application of zinc @ 15 kg Z ha^{-1} produced significantly higher growth (Height- 164.20 cm, dry matter- 424.59 g, stem girth-4.36 cm) and yield attributes (No. of ear head-1.17, length of earhead-17.98 cm, grain weight per earhead-29.98 g), grain yield (1635.67 kg ha^{-1}), straw yield (4475.75 kg ha^{-1}), biological yield (6111.42 kg ha^{-1}), gross monetary return (Rs. 38422.92 ha^{-1}), net monetary return (Rs. 17264.22 ha^{-1}) and B: C (0.82) ratio than rest of the levels of zinc.

Introduction

Pearl millet (*Pennisetum glaucum* L) is world's sixth and India's fourth important cereal food crop after rice, wheat and maize. It is commonly known as pearl millet, cat tail, spiked or bulrush millet and locally known as Bajara. Pearl millet is not only a quick growing short duration crop, but also a high tillering, drought and heat tolerant and well adapted to different soil types. Its propensity for high dry matter production at high temperature has made a mark in tropics and subtropics. It is a drought resistant cereal having maximum potentiality of grain production in adverse conditions. The share of Pearl millet in total food grain production is to the tune of 10.7 per cent. In India, Pearl millet occupies an areas of 7.8 million hectares with production of 9.25 million tones and productivity of 1270 kg/ha (Anonymous, 2016). The major growing states in India are Rajasthan, Maharashtra, Gujarat, Punjab, Haryana and Utter Pradesh where, it is grown both in Kharif and summer season. In Maharashtra, the crop is grown in the hilly and dry areas of the central plateau on poor soils in the districts of Beed, Nasik, Dhule, Satara, Pune, Sangli, Aurangabad, Solapur, Jalgaon and Ahmadnagar. Pearl millet covers an area of 1035 thousand hectares area in Maharashtra, producing 1123 thousand tones with productivity of 1086 kg/ha (Anonymous, 2016).

The nutritive value of grains of pearl millet is fairly high and used for human consumption. Apart from grain, the forage and stover is an important secondary product for resource poor farmer that can be used as animal feed and fuel. Pearl millet a tropical cereal and most drought resistant crop is extensively grown in the arid and semi-arid regions of the world (Fageria, 1992). Amongst the major cereals, pearl millet is highly tolerant to heat and drought, to saline and acid soils and is easy to grow in arid regions where rainfall is not sufficient for maize or even sorghum (FAO, 2004). India produces more than half the world's pearl millet and contributing 42% of total world production (FAO, 2006). Pearl millet can easily provide economical grain yield (600 - 700 kg ha^{-1}) under marginal and low management conditions with the additional ability to produce a grain yield of 4-5 t ha^{-1} when hybrids of 80-85 days maturity are grown in summer season crop under irrigated and high fertility conditions. Pearl millet is nutritionally superior to maize and rice and it is known as a "high-energy" cereal with a 70% starch in the dry grain. Its protein content of 16% is higher than in maize with a good balance of amino acids. Further, it contains 5-7% fat, which is greater than the values in most maize varieties; and it is particularly high in calcium and iron. It has low contents of fiber and most vitamins, whereas it is rich in vitamin A (NRC, 1996; DeVries and Toenniessen, 2001). Mineral nutrition considered the limiting factor for plant productivity. Nitrogen is essential for plant growth and is known to be present in proteins, nucleic acids and chlorophyll. Adequate N nutrition is required for full development of tillers and leaves and also enables the plant to operate at peak photosynthetic capacity. N is the major nutrient required by pearl millet and has shown variable growth and yield response to N application. Generally, pearl millet has been known for growing under low N management (Gascho *et al.*, 1995). In plants, zinc plays a key role as a structural constituent or regulatory co-factor of a wide range of different enzymes in many important biochemical pathways. Zinc deficiency in the plant retards development and maturation of the panicles of grain crops (Alloway, 2004). As in soils and plants, Zn deficiency is also a common nutritional problem in humans, predominantly in developing countries where diets are rich in cereal-based foods and poor in animal products. Enhancing Zn in plant derived food is one of the way to improve human health in developing countries where and when the local population cannot afford food sources from which zinc can be taken up easily in large enough quantities in the human gut. Therefore, present investigation was undertaken on Effect of Nitrogen and Zinc on Growth, Yield and Economics of Pearl Millet (*Pennisetum glaucum* L.).

Materials and Methods

The field experiment was conducted during *kharif* season of 2016 at Agronomy section, College of Agriculture, Latur to assess the effect of Effect of Nitrogen and Zinc on Growth, Yield and Economics of Pearl Millet (*Pennisetum glaucum* L.). The experiment was laid out in Factorial Randomized Block Design with two factors and replicated thrice. There were 12 treatment combinations comprising 4 levels of nitrogen *viz*. 0 (control), 45, 60 and 75 kg N ha^{-1} and 3 levels of zinc *viz*. 05, 10 and 15 kg Z ha^{-1}.

The experimental site having gross and net plot size was 5.4 x 4.5 m^2 and 4.5 x 3.6 m^2 respectively. The recommended dose of fertilizer was applied at time sowing (60:30:30 NPK kg ha^{-1} where N applied as per treatments). The sowing was done on 22nd June 2016 by dibbling and harvested on 1st Oct 2016. All the cultural practices were followed by as per package of practices. Five plants were randomly selected in each net plot area for taking observations on growth and yield attributing parameters. The crop in each net plot was harvested separately as per treatment and the values were converted into hectare basis and expressed in kg.

Economics

To work out the economic information, market price of different fertilizer and labour units required for establishment of crops and harvesting was considered. Cost of labour was calculated by taking into account the prevailing labour wages at the time of investigation. Gross returns, net returns and benefit cost ratio were worked out by using the following formulae.

Gross returns = Grain yield x market price

Net returns = Gross returns – Total cost of cultivation

$$\text{Benefit: Cost ratio} = \frac{\text{Gross returns } (ha^{-1})}{\text{Total cost of cultivation } (ha^{-1})}$$

Statistical analysis and interpretation of data

Data obtained on various variables were analyzed by analysis of variance method (Panse and Sukhatme, 1967). The total variance (S2) and degree of freedom (n-1) were partitioned into different possible sources. The variance due to various treatments of mulching were compared with error of variance to find out 'F' values and ultimately for testing the significance at p = 0.05. The standard errors for the treatment based on error variance were calculated. Whenever, the results were found to be significant, critical differences were also calculated for comparison of treatment means at 5 per cent level of significance (CD at P = 0.05).

Results and Discussion

Growth attributes

Effect of nitrogen

Nitrogen is the primary nutrient and plays a vital role in growth as well development of the plant. Plant height is controlled by the genetic makeup of the species and the environment to which the plant are subjected during the growth and development. The effect of nitrogen levels on plant height was significant at all growth stage. In general plant growth increase with advancement of crop growth stages and reached to maximum at harvest. The tallest plant (158.95 cm) was recorded at harvest with N_3 level (75 kg N ha^{-1}). The results are confirmed by Dadhich and Gupta. (2003) and Prasad *et al.,* (2014). The number of tillers plant^{-1} were significantly increased with an increased in fertilizer level**.** The maximum tillers number plant^{-1} were found with N_3 level **(**75 kg Increase in nitrogen levels in general, increased the number of tillers significantly probably due to increasing the production of new meristemetic tissues. Increase in number of tillers due to application of nitrogen has also been reported by Yakardi and Reddy (2009), Mesquita and Pinto (2000) and Prasad *et al.,* (2014).

The stem girth (cm) significantly increased continuously with the advancement of the crop growth stages**.** Maximum stem girth (4.13 cm plant^{-1}) was observed by N level **(**75 kg N ha^{-1}) at harvest. It could be due to adequate supply of nutrition and favorable condition at this stage.

The crop dry matter accumulation (g plant^{-1}) significantly increased continuously with the advancement of the crop growth stages**.** The highest value was recorded with N3 level (75 kg N ha^{-1}). Dry matter accumulation of plants is the final outcome of photosynthetic activities. A significant increase in plant dry matter at different stages of growth due to increase in nitrogen levels might be attributed to the effect of nitrogen in increasing the amount and efficiency of chlorophyll which influence the photosynthetic efficiency and formation of other nitrogen compounds. Similar result also reported by Heringer and Moojen (2002) and Singh *et al.,* (2000).

Effect of zinc

The application of zinc @ 15 kg ha^{-1} recorded significantly more plant height than other treatments. However, it was at par with application of zinc @ 10 kg ha^{-1}. The maximum numbers of tillers were recorded with Z level (15 kg Zn ha^{-1}) at harvest. Zinc nutrition is known to increase tillering in pearl millet which may perhaps cause a significant increase in dry matter accumulation. Similar result was reported by Jain *et al.,* (2001) and Jakhar *et al.,* (2006), Prasad *et al.,* (2014).

Interaction effect was found to be non-significant.

Yield attributes

Effect of nitrogen

The application of nitrogen @ 75 kg ha^{-1} recorded significantly higher ear head length (19.57 cm), ear head breadth (9.68 cm), ear head weight (36.42 g), Weight grain plant^{-1} (22.03 g) and test weight (8.51g) as compare to lower levels of nitrogen. However, nitrogen level 60 kg ha^{-1} statistically at par with 75 kg ha^{-1} level.

Effect of zinc

The application of zinc @ 15 kg ha^{-1} recorded significantly higher ear head length (17.98 cm), ear head breadth (9.16 cm,) ear head weight 29.98g), Weight grain plant^{-1} (18.31 g) and test weight (8.22 g) as compare to lower levels of zinc. However application of zinc @ 10 kg ha^{-1} was found to be at par with application of Zinc @ 15 kg ha^{-1}. Interaction effect was found to be non-significant.

Grain yield, straw yield and biological yield

Effect of nitrogen

Grain yield was significantly influenced by levels of nitrogen and maximum grain yield, straw yield and biological yield was recorded with N_3 level (75 kg N ha^{-1}).

Table.1 Mean plant height, no. of tillers, stem girth and dry matter of pearl millet as influenced by various treatments at harvest

Treatments	Height (cm)	No. of tillers plant^{-1}	Stem girth plant^{-1} (cm)	Dry matter plant^{-1}
Levels of nitrogen (kg ha^{-1})				
N0 : 00	157.82	0.55	3.19	26.88
N1 : 45	169.93	1.58	4.06	43.30
N2 : 60	170.84	1.82	4.53	49.40
N3 : 75	179.03	2.00	4.76	52.62
S.Em.±	3.20	0.64	0.12	0.92
CD @5 %	9.52	0.18	0.35	3.09
Levels of zinc (kg ha^{-1})				
Z1 : 05	152.07	1.23	3.98	40.98
Z2 : 10	160.59	1.58	4.08	43.59
Z3 : 15	164.20	1.68	4.36	44.59
S.Em.±	2.81	0.05	0.10	0.91
CD @5 %	8.25	0.16	0.30	2.68
Interaction (N x Z)				
S.Em.±	5.6	0.11	0.21	1.83
CD @5 %	N.S.	N.S.	N.S.	N.S.

Table.2 Mean ear head length, ear head breadth, ear head weight, weight of grain plant^{-1} and test weight of pearl millet as influenced by various treatments at harvest

Treatments	Ear head length (cm)	Ear head breadth (cm)	Ear head weight (g)	Weight grain plant^{-1} (g)	Test weight (g)
Levels of nitrogen (kg ha^{-1})					
N0 : 00	13.16	6.90	13.96	12.21	8.54
N1 : 45	17.23	8.80	30.44	14.94	8.20
N2 : 60	18.11	9.26	33.93	20.95	8.28
N3 : 75	19.57	9.68	36.42	22.03	8.51
S.Em.±	0.49	0.24	1.08	0.45	0.13
CD @5 %	1.46	0.71	3.18	1.34	NS
Levels of zinc (kg ha^{-1})					
Z1 : 05	15.98	7.98	26.29	16.80	8.53
Z2 : 10	17.11	8.90	29.80	17.50	8.14
Z3 : 15	17.98	9.16	29.98	18.31	8.22
S.Em.±	0.43	0.21	0.94	0.39	0.11
CD @5 %	1.26	0.61	2.75	1.16	NS
Interaction (N x Z)					
S.Em.±	0.86	0.42	1.88	1.16	0.23
CD @5 %	N.S.	N.S.	N.S.	N.S.	

Table.3 Mean grain yield, straw yield and biological yield of pearl millet as influenced by various treatments at harvest

Treatments	Grain yield kg ha $^{-1}$	Straw yield kg ha $^{-1}$	Biological yield kg ha $^{-1}$
Levels of nitrogen (kg ha $^{-1}$)			
N0 : 00	1247	3719	4966
N1 : 45	1354	3989	5344
N2 : 60	1833	4882	6716
N3 : 75	1892	4929	6821
S.Em.±	31.81	85.04	85.45
CD @5 %	93.29	249.41	250.59
Levels of zinc (kg ha $^{-1}$)			
Z1 : 05	1526	4219	5746
Z2 : 10	1583	4445	6029
Z3 : 15	1635	4475	6111
S.Em.±	27.55	73.65	74.00
CD @5 %	80.79	216.00	217.00
Interaction (N x Z)			
S.Em.±	55.10	147.30	148.00
CD @5 %	N.S.	N.S.	N.S.

Table.4 Mean gross monetary returns (GMR), net monetary returns (NMR), cost of cultivation and benefit cost ratio (B: C ratio) of pearl millet as influenced by various treatments

Treatments	Gross monetary returns (GMR) Rs. ha $^{-1}$	cost of cultivation Rs. ha $^{-1}$	Net monetary returns (NMR) Rs. ha $^{-1}$	benefit cost ratio (B: C ratio)
Levels of nitrogen (kg ha $^{-1}$)				
N0 : 00	29354	18879	10475	0.55
N1 : 45	31504	19636	11868	0.60
N2 : 60	41460	20589	20870	1.01
N3 : 75	42624	2088	21736	1.04
S.Em.±	560.73	-	517	-
CD @5 %	1424.00	-	1313.00	-
Levels of zinc (kg ha $^{-1}$)				
Z1 : 05	33999	18833	15166	0.80
Z2 : 10	36285	20003	16281	0.81
Z3 : 15	38422	21158	17264	0.82
S.Em.±	484.60	-	447.83	-
CD @5 %	1424.11	-	1313.34	-
Interaction (N x Z)				
S.Em.±	971.21	-	895.67	-
CD @5 %	N.S.	N.S.	N.S.	N.S.

However, it was at par with application of 60 kg nitrogen ha^{-1}. It is well known fact that grain yield is the outcome of yield attributing characters, which also increased with increasing levels of nitrogen. Increasing in grain yield may be due to nitrogen being a major nutrient, affected all physicochemical process. The finding of present investigation corroborates with the findings of Alkaff and Saeed (2007), Ayub *et al.,* (2009) and Yakadri and Reddy (2009).

Effect of zinc

The application of zinc @ 15 kg ha^{-1} recorded significantly higher grain yield, straw yield and biological yield as compare to lower levels of zinc. However application of zinc @ 10 kg ha^{-1} was found to be at par with application of Zinc @ 15 kg ha^{-1}.

Interaction effect was found to be non-significant.

Economics

Effect of nitrogen

Application of nitrogen @ 75 kg ha^{-1} (42624 kg ha^{-1}) was found to be significantly superior over nitrogen @ 45 kg ha^{-1} (31504 kg ha^{-1}) and control (29354 kg ha^{-1}) in recording highest gross monetary returns. However, it was at par with nitrogen 60 kg ha^{-1} (41460 kg ha^{-1}). In case of net monetary returns and benefit cost ratio also application of nitrogen @ 75 kg ha^{-1} was found to be significantly superior over other levels of nitrogen.

Effect of zinc

Application of zinc @ 15 kg ha^{-1} recorded significantly higher gross monetary returns (38422 kg ha^{-1}), net monetary returns (17264 kg ha^{-1}) and benefit cost ratio (0.82) as compare to other levels of zinc,

Interaction effect was found to be non-significant.

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