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Impact Assessment of Manure and Nitrogen Level on Phenology, Yield Attributes, Yield and Energy Use Efficiency in Pearlmillet

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Authors' contributions

This work was carried out in collaboration between all authors. Authors Manjeet and PK designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Author AK managed the analyses of the study. Author Harender managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

A field experiment was conducted at Agronomy Research Area, Chaudhary Charan Singh Haryana Agricultural University, Hisar during *Kharif* season 2016 to assess the impact of manure and nitrogen on phenology, yield and energy use efficiency of pearl millet hybrid (HHB-223). The treatment consisted of manurial treatment *viz.* control, biomix, and vermicompost at the rate of 2.5 t ha^{-1} and vermicompost at the rate of 2.5 t ha^{-1} + biomix and nitrogen levels *viz.* 70, 80, 90 and 100 percent recommended dose of nitrogen (RDN). Different nutrient management practices did not differ significantly in respect of various phenological events *viz*. emergence, five leaf stage and initiation of the milking while boot stage, 50 percent flowering and physiological maturity were affected significantly. Yield attributing characters *viz*. effective tiller per plant, earhead length, earhead girth, test weight and grain, stover yield affected significantly by the application of manure and nitrogen levels. Among manurial and nitrogen level treatment these character were higher with biomix + vermicompost at the rate of 2.5t ha^{-1} and 100 percent recommended

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dose of nitrogen (RDN). The radiation used efficiency among different treatment there was not found the significant variation in the incepted photosynthetic radiation use efficiency and lowest radiation use efficiency (RUE) was in grain yield and highest in biological yield of respective treatments.

Keywords: Manure; nitrogen; phenology; yield and energy use efficiency.

1. INTRODUCTION

Pearl millet [*Pennisetum glaucum* (L.) R. Br. Emend. Stuntz] commonly known as *Bajra* is a dual purpose crop that ensures both food and fodder security in the arid and semi-arid regions of the country [1]. It is impossible to beat the pearl millet grown as rainfed crop on marginal lands under low input management conditions in the world's hardest agricultural production environment due to its tolerance to drought, high temperature, low soil fertility, rapid growth rate when conditions are favourable and ability to extract mineral nutrition and water even from the poorest soil. Hence, it is getting more attention due to increasing evidence of less seasonal rainfall, terminal heat, frequent occurrence of extreme weather events coupled with scanty water resources [2]. In India, it is the fifth most important cereal grain crop next to rice, wheat, maize and sorghum. India is the largest producer of pearl millet in the world occupying about 7.1 million hectare area with annual production of 9.1 million tones and with average productivity of 1272 kg ha^{-1}.In Haryana, area under this crop was 0.38 million hectare with total production of 0.67 million tones and productivity of 1749 kg ha^{-1} [3]. Increasing use of the high analysis chemical fertilizers in association with the high yielding varieties has no doubt increased the food grain production many a fold but these intensive agricultural practices has led to a decline in the soil physical, chemical and biological properties and also the major cause for contamination of the ground water. Simultaneously, the chemical fertilizers are quite expensive and the small and marginal farmers are unable to use these fertilizers in required quantity. Current trends in agriculture are focused on reduction in the use of inorganic fertilizers compelling the search for alternatives that enhance both yield and environment quality. To meet the ever growing food demand with limited resources, we need to increase the productivity by adopting better efficient fertilization. Fertilizer deficiency affects crop growth by reducing the pearl millet leaf area and intercepted photosynthetically active radiation (IPAR) and found the exponential positive relationship between PAR interception and dry matter production in pearl millet by Sharma. [4]; Rathore [5]. Hence, the present study was, therefore, designed to assess the impact of manure and nitrogen level on phenology, yield attributes, yield and energy use efficiency in pearlmillet.

2. MATERIALS AND METHODS

2.1 Experimental Site

A field experiment was conducted at Agronomy Research Area, Chaudhary Charan Singh Haryana Agricultural University, Hisar during *Kharif* season 2016 to assess the impact of vermicompost, biofertilizers and nitrogen level on phenology, yield and energy use efficiency of pearl millet hybrid (HHB-223). The treatment consisted of manurial treatment *viz.* control, biomix, and vermicompost at the rate of 2.5 t ha^{-1} and vermicompost at the rate of 2.5 t ha^{-1} + biomix and nitrogen levels *viz.* 70, 80, 90 and 100 percent RDN so there were a total 16 treatment combination.The soil was sandy loam in texture, pH (1:2) 7.9, electrical conductivity (1:2) 0.17 dS/m. The soil was low in organic carbon (0.43%), available nitrogen (133 kg ha^{-1}) medium in available P_2O_5 (18.3 kg ha^{-1}) and medium in available K (263 kg ha^{-1}). Total rain fall during crop growing period was 340 mm receivedduring the crop season bifurcated as 244.8, 80.4 and 2.8 mm during July, August and September month, respectively.

2.2 Statistical Analysis

The data presented in this thesis are the mean values of different measurements. The statistical method described by Panse and Sukhatme [6] was followed for statistical analysis and interpretation of the experimental results. In order to evaluate the comparative performance of the various treatments, the data were analysed by the technique of analysis of variance described by Fisher [7]. All the tests of significance were made at 5% level of significance. To judge the significance of difference between two

treatments, critical difference (CD) was worked out by the following formula:

$$CD = \sqrt{\frac{2 \times \text{Error vari ance}}{n}} \times t \text{ value at error of d.f.}$$

Where,

n = number of observation averaged
t = Value from Fisher's and Yates's table (1950) for error degree of freedom at 5 % level of significance
CD = Critical difference

2.3 Experimental Design

The experiment was conducted in split plot design with three replication.The treatment consisted of manurial treatment *viz.* control, biomix, and vermicompost at the rate of 2.5 t ha^{-1} and vermicompost at the rate of 2.5 t ha^{-1} + biomix in the main plot and nitrogen levels *viz.* 70, 80, 90 and 100 percent RDN in the sub plot, so there were a total 16 treatment combination as given in Table 1.

2.4 Prevailing Weather Conditions

The relation of incoming solar radiation and intercepted photosynthetic active radiation is use full to estimating the dry matter of manure and nitrogen level on phenology, yield attributes, yield and energy use efficiency in Pearlmillet. The concept of use radiation used efficiency has great potential for the prediction crop productivity. The life cycle of crop the prevailing weather condition was normal. The total amount of rainfall 231.7 mm was received with 13 rainy days. The cumulative pan evaporation pan evaporation 347.8 mm. An average sunshine hour was varied from the 0.0 to 10.5 hrs with the average value 6.8 hrs. The maximum mean temperature 34.67℃ and 25.6℃ minimum temperature. The computation of intercepted photosynthetic active radiation (IPAR) use the numerical equation for the computation with using the cloud percentage daily basis and it considered as intercepted photosynthetic radiation over the Pearlmillet. The total IPAR during the crop cycle i.e. from date of sowing to harvesting of pear millets was 316.20 $MJm^{-2.}$

2.5 Cultural Operations

The details of cultural operations in the experimental field were as under (Table 2).

2.6 Observations and Methods of Analysis

The observations on phenology, yield attributes, yield and energy use efficiency were recorded. Phenological development of the pearl millet crop was observed in terms of number of days taken by the crop to reach a particular phenological event [8]. Determination of phenological stage(s) was done on the basis of visual observations except certain stages except milk stage, physiological maturity. In case of milk stage, it was observed by pressing the grain between thumb and index finger some milky fluid comes out. Physiological maturity is marked by the formation of small black layer in the hilar region

Table 1. Various treatment combination of nitrogen levels and manures used

Treatments	70 percent RDN	80 percent RDN	90 percent RDN	100 percent RDN
Control (C)	C+70 percent RDN	C+80 percent RDN	C+90 percent RDN	C+100 percent RDN
Biomix (B)	B+70 percent RDN	B+80 percent RDN	B+90 percent RDN	B+100 percent RDN
Vermicompost (V)	V+70 percent RDN	V+80 percent RDN	V+90 percent RDN	V+100 percent RDN
Biomix+ Vemicompost (B+V)	B+V+70 percent RDN	B+V+80 percent RDN	B+V+90 percent RDN	B+V+100 percent RDN

of the seed. Three randomly selected plants were used for recording yield attributes *viz*. effective tiller per plant, earhead length, ear head girth and test weight. The dried earhead of pearl millet from each plot were threshed to record grain yield per plot, which was converted to grain yield inMgha^{-1}. The statistical method described by Panse and Sukhatme [6] was followed for statistical analysis and interpretation of the experimental results. In order to evaluate the comparative performance of the various treatments, the data were analysed by the technique of analysis of variance described by Fisher [7]. The computed the Radiation use efficiency. RUE=Bio/Eco yield /Accumulated IPAR (MJ/m2). The PAR was computed data was collected of the season from Department of Agricultural Meteorology, CCS HAU of Agromet observatory, Hisar Station (situated at 290 10' N Latitude, 750 46' E Longitude and Altitude 215.2 m).

3. RESULTS AND DISCUSSION

3.1 Effect on Days Taken to Different Phenophases

Effect of different manurial and nitrogen treatments on days taken to emergence, five leaf and milk stage of the crop was found to be non significant, however boot, 50 percent flowering and physiological stages were influenced significantly. Increasing each level of nitrogen, increased the number of days taken to boot, 50 percent flowering and physiological maturity stages over its preceding RDN level. These stages were delayed with application of biomix + vermicompost at the rate of 2.5 t ha^{-1} (Table 3). Because, application of vermicompost supply macronutrients and micronutrients in optimum amount along with increasing moisture holding capacity and better physical properties of soil which might extended crop vegetative phase. Similarly, more number of days were taken in the higher doses of nitrogen application because of better root development or more prominent growth of plant in vegetative phase due to more nitrogen supply which play a dominant role in plant vegetative growth. Similar results of delay in days to flowering and maturity due to higher doses of nitrogen application have also been reported by Bhagchand and Gautam, [9].

3.2 Effect on Yield Attributes and Yield

Increasing levels of fertility either under manures or nitrogen doses improved most of the yield attributing characters *viz*. number of effective tillers plant^{-1}, earhead length, earhead girth, test weight, grain, stover and biological yield In the manurial treatment, grain yield was found maximum with the treatment biomix + vermicompost at the rate of 2.5 t ha^{-1} followed by vermicompost at the rate of 2.5 t ha^{-1} and differ significantly. Also, with the increase in the nitrogen level grain yield was maximum with 100 percent RDN but did not differ significantly with 90 percent RDN. This increase in grain yield may be ascribed to better root growth and development, resulting in more nutrient uptake and higher dry matter accumulation per plant and its subsequent translocation to the developing panicle. Thus, balanced nutrition due to combined use of biomix, vermicompost and chemical fertilizers throughout the crop period probably resulted in better growth, enhanced yield attributes and finally yield. Similar results have also been reported by Rathore [10]. Under the manurial treatment highest stover yield was recorded with biomix + vermicompost at the rate of 2.5 t ha^{-1} and lowest in control whereas under different nitrogen levels it was maximum with 100 percent RDN and lowest with 70 percent RDN (Table 4). This increase in the stover yield may be attributed to the increased plant height, leaf area and dry matter production. The remarkable improvement in yield attributes owing to different combinations of vermicompost, nitrogen and biofertilizers has resulted in increased grain yield, stover yield over the control. These findings corroborate the results of Thavaprakaash and Velayudham [11], Khambalkar [12].

3.3 Radiation Use Efficiency (RUE) Impact

The RUE were computed to grain, stover and biological yield of pear millet with different treatment used to get the efficient utilization to produced the unit mill gram of biological produces([13]. The different treatments were influence the efficient use of energy, the over all in biological yield were got the higher RUE and compared to Stover and grain yield. The result of RUE was revealed that the in control found the lower RUE but other treatment at par with range 0.008 to 0.009 mgha^{-1}MJ^{-2} which detailed depicted in the Table 4. The RUE among different treatment there was not found the significant variation in the incepted PAR use efficiency. The lowest RUE was found in grain yield and highest in biological yield of respective treatment depicted in the Table 4.

Table 2. Details of cultural operations in the experimental field

Nature of operation	Details
Seed bed preparation	Pre-sowing irrigation was applied to the ploughed field to facilitate preparatory tillage and good seed germination. Seed bed was prepared by two harrowing and one cultivator followed by planking to attain good soil tilth
Fertilizer application	Full dose of phosphorus and half nitrogen, as per treatments, were applied at the time of sowing and remaining half of the nitrogen was top dressed in two splits, one after thinning and gap filling, and another at the time of ear head formation stage. Vermicompost was applied 15 days prior to sowing as per treated.
Thinning and gap filling	Thinning and gap filling was done 21 days after sowing to maintain the proper plantto plant spacing (10 cm) within the row
Irrigation management	Post sown irrigation could not be applied because of sufficient and intermittent rains during the crop season
Inter-cultural	Two hand hoeing were done to control the weed at 20 and 40 days after sowing.

Table 3. Effect of vermicompost, biofertilizers and nitrogen levels on different phenological stages in pearl millet

Treatment	Phenological events (DAS)					
	Emergence	Five leaf stage	Boot stage	50 percent flowering	Milk stage	Physiological maturity
Manure						
Control	3.3	14.6	40.2	47.0	54.3	68.2
Biomix	3.2	14.5	40.5	47.5	54.6	68.5
Vermicompost @ 2.5 t ha^{-1}	3.3	14.3	40.9	47.7	54.7	69.3
Biomix + vermicompost @ 2.5 t ha^{-1}	3.3	14.1	41.3	48.5	54.9	70.3
CD at 5%	NS	NS	0.8	0.5	NS	0.5
Nitrogen level						
70 % RDN	3.3	14.6	40.3	47.1	54.4	68.3
80 % RDN	3.3	14.4	40.5	47.4	54.6	68.8
90 % RDN	3.2	14.3	40.8	47.8	54.8	69.4
100 % RDN	3.2	14.2	41.2	48.3	54.9	69.9
CD at 5%	NS	NS	0.6	0.5	NS	0.4

Table 4. Effect of vermicompost, biofertilizers and nitrogen levels on yield attributes,yields and energy use efficiency of pearl millet

Treatment	Effective tillers plant^{-1}	Ear head length (cm)	Ear head girth (cm)	Test weight (g)	Grain yield (Mg ha^{-1})	energy use efficiency	Stover Yield (Mg ha^{-1})	energy use efficiency	Biological yield (Mg ha^{-1})	energy use efficiency
Manure										
Control	2.6	23.6	8.8	9.0	2.3	0.007	5.6	0.018	7.9	0.025
Biomix	3.0	24.1	8.9	9.1	2.6	0.008	6.3	0.020	8.9	0.028
Vermicompost @ 2.5 t ha^{-1}	3.0	24.0	9.1	9.5	2.7	0.009	6.7	0.021	9.4	0.030
Biomix + vermicompost @ 2.5 t ha^{-1}	3.2	25.4	9.4	9.8	3.0	0.009	7.1	0.022	10.1	0.032
CD at 5%	0.3	NS	0.2	0.3	0.1	-	0.4	-	0.5	-
Nitrogen level										
70% RDN	2.5	23.0	8.6	8.9	2.4	0.008	5.9	0.019	8.3	0.026
80% RDN	2.9	24.1	8.7	9.3	2.6	0.008	6.5	0.021	9.1	0.029
90% RDN	3.1	24.9	9.2	9.6	2.8	0.009	6.8	0.022	9.6	0.030
100% RDN	3.3	25.1	9.4	9.6	2.9	0.009	6.9	0.022	9.8	0.031
CD at 5%	0.2	1.1	0.1	0.2	0.1	-	0.2	-	0.3	-

4. CONCLUSION

Based on the study it may be concluded that different nutrient management practices did not differ significantly in respect of various phenological events with respect to emergence and five leaf stage while other were affected significantly. The radiation use efficiency was found higher with the biological yield. But significant enhancement in yield and yield attributing characters were found so pearl millet seed should be treated with biomix and fertilized with 90% RDN along with vermicompost application at the rate of 2.5 t ha^{-1}.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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