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Integrated Nutrient Management to Enhanced Growth and Yield of Pearl Millet

Arun, Parvinder Kumar, A. K. Dhaka, Anu, Sushil Kumar, Harsh

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ABSTRACT

An experiment was conducted at Research Farm Area, Department of Agronomy, Chaudhary Charan Singh Haryana Agricultural University, Hisar during *kharif* 2022 to study the effect of integrated nutrient management on growth and yield parameters of pearl millet. The experiment was conducted in randomized block design with three replications containing 12 treatments. The crop was sown on 12 July, 2022 using pearl millet hybrid 'HHB 67 improved'. Among the treatments, application of recommended dose of fertilizer (156.25:62.50 kg ha^{-1} N:P) + 0.5% $ZnSO_4$ + 0.5% $FeSO_4$ + BIOMIX (T_{12}) resulted in significantly higher plant height (191.67 cm), dry matter accumulation (79.53 g plant^{-1}), leaf area index (3.72), grain yield (3002 kg ha^{-1}) and biological yield (10035 kg ha^{-1}) of pearl millet closely followed by (T_{11}) RDF + 0.5% $ZnSO_4$ + 0.5% $FeSO_4$ at 25 DAS and (T_8) RDF + 25 kg ha^{-1} $ZnSO_4$ which were 11.4, 22.4, 19.1, 7.1 and 5.5% higher over RDF, respectively.

Keywords Pearl millet, Growth, Yield, Biomix and INM.

INTRODUCTION

Pearl millet (*Pennisetum glaucum* L.) is one of the most extensively cultivated cereals in the world after rice, wheat and sorghum particularly in arid and semi-arid regions. It is an important dual purpose crop grown for food and fodder. In India, it is one of the important millet crops which flourishes well even under adverse conditions of weather. It provides staple food for the poor people in a short period in the relatively dry tracts of the country. In India, it is grown over an area of 7.6 mha with total production of 10.86 m t and productivity of 1368 kg ha^{-1} (2020-21) (Anonymous 2022). In Haryana, area under this crop is 0.48 m ha with total production of 1.11 m t with productivity of 2318 kg ha^{-1} (202-22) (Anonymous 2023).

Integration of chemical fertilizers with organic manures has been found quite promising in sustaining the soil health and productivity and stabilizing the crop production in comparison to the use of each component, separately. Farm yard manure can be supplemented with NPK fertilizers. Although, it is costlier than chemical fertilizers on nutrient basis but other beneficial effects which it has on soil can

Arun[1]*, Parvinder Kumar[2], A. K. Dhaka[3], Anu[4], Sushil Kumar[5], Harsh[6]

[2,3]Assistant Professor, [4,5]PhD Research Scholar
[1,2,3,4,5,6]Department of Agronomy, College of Agriculture CCS, Haryana Agricultural University, Hisar 125004, Haryana, India

Email: arungill101@hau.ac.in
*Corresponding author

compensate for the added cost.

Micronutrients are better applied to the foliage than to the soil. Since application rates are lower than for applying nutrients to soil, it is easier to apply the same amount of nutrients, and crops respond to nutrient applications quickly. When the roots are unable to supply the required nutrients, it is highly beneficial. Also, the application of micronutrients to the soil would significantly worsen soil contamination. Foliar spraying was suggested because people are worried about the environment and nutrient absorption through plant leaves is preferable than soil application (Bozorgi *et al.* 2011). Due to soil characteristics like high pH, lime content, or thick texture, crop roots are unable to absorb some essential minerals like zinc. In these circumstances, foliar spraying could be 6 to 20 times more effective as compared to soil application. A feasible alternative to applying micronutrients directly to plants is to apply enriched manures, which react with the environment's natural micronutrient stores and make them available to plants. Also, it is well known that these materials have positive effects on soil quality, productivity, and nutrient absorption as well as on soil structure, nutrient retention capacity, and bio-regulatory roles in the soil (Patil *et al.* 2017).

Increased use of fertilizers without organic recycling has not only aggravated multi-nutrient deficiencies in soil-plant-system but also become detrimental to soil health and has created environmental pollution. Moreover, chemical fertilizers are becoming costlier in agriculture. However, with increasing awareness on soil health and to bring sustainability in agriculture, organic source of nutrition have gained importance as components of integrated plant nutrient management. Therefore, it is the right time to evaluate the feasibility and efficiency of organic sources in integration with organic sources not only for improving and building up of soil fertility but also to increase the fertilizer use efficiency. Hence present investigation was carried out to evaluate the effect of integrated nutrient management on growth and yield of pearl millet.

MATERIAL AND METHODS

A field experiment was conducted in *kharif* 2022 at Research Farm, Department of Agronomy, CCS Haryana Agricultural University, Hisar (India). Experiment was laid out in randomized Block Design with a total number of 12 treatments and replicated thrice. Details of the treatments used in experiment are given in (Table 1). Soil of the experimental field was low in organic matter (0.32 %) and available N (119.0 kg ha^{-1}) with medium P_2O_5 (15.8 kg ha^{-1}) and K_2O (232.0 kg ha^{-1}). Meteorological data during crop growing period was obtained from Department of Agricultural meteorology, CCS HAU and presented in (Fig. 1). Pearl millet variety HHB 67 (Improved) was sown on 12th July 2022 using seed rate of 5 kg ha^{-1} with spacing of 45 × 15 cm. Seed was treated with biomix (mixture of azotobacter, azospirillum and PSB) @ 250 ml ha^{-1} in respective treatments. Two manual weeding and hoeing at 22 and 35 DAS were done to control the weeds. For the maintenance of desirable plant to plant distance (15 cm) thinning and gap filling were done at 20 DAS. One irrigation was given at 55 DAS. Crop was grown in accordance with recommendations of CCS HAU, Hisar. All the procedure as mentioned in package and practices of CCS HAU, Hisar was followed except nutrient management. Different dose of FYM, vermicompost, nitrogen, phosphorus, potassium and micronutrient were applied as per the treatments. The N, P and K nutrients were applied in the form of Urea, Di-ammonium Phosphate (DAP) and Single Super Phosphate (SSP). Soil application of $ZnSO_4$ and foliar spraying of 0.5% $FeSO_4$ and $ZnSO_4$ was done at 25 DAS.

To calculate the plant population at 20 DAS and maturity, plants were counted per meter row length randomly from each plot and converted to number of plants/m^2. To measure the plant height, five plants were tagged in each plot and height was recorded at 40 DAS and at harvest. The plants were taken from

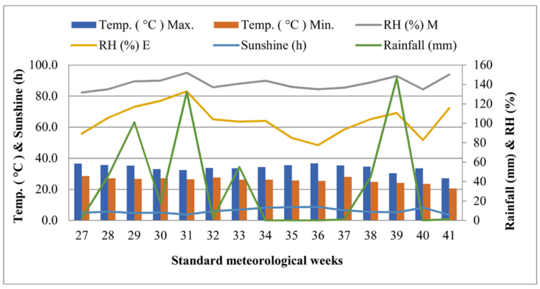

Fig. 1. Weekly meteorological data recorded during crop season.

last but one row of each side of the plot to calculate dry matter accumulation plant^{-1} at 40 DAS and at harvest. The selected and cutted plant were sun dried for three to four days after followed by drying in oven at a temperature of 60±5ºC until a constant weight was achieved and weighed on weighting balance. Leaf area index (LAI) was calculated using following formula, leaf area index is equal to leaf area (cm^2) by ground area (cm^2) at 40 DAS.

Each of the plots were harvested and threshed separately. Grain yield from each plot was recorded and this was converted to grain yield in kg ha^{-1}. The stover yield for each plot was worked out by subtracting grain weight from total produce of individual plot and it was computed in kg ha^{-1}. Total weight of these plants (stover + grain yield) from plot was recorded and computed as biological yield in kg ha^{-1}. Harvest index (HI) for each plot was computed by using following formula (Donald 1962).

$$\text{Harvest index (\%)} = \frac{\text{Economic yield (Grain)}}{\text{Biological yield (Grain + Stover)}} \times 100$$

Data was statistical analysed using OP STAT software developed by CCS HAU, Hisar

RESULTS AND DISCUSSION

Growth Parameters

Different nutrient management treatments failed to show any significant effect on plant population at 20 DAS and at harvest (Table 1). Significantly higher plant height, dry matter accumulation and leaf area index (at 40 DAS) were reported under treatment T_{12} (RDF (156.25:62.50 kg ha^{-1} N:P) + 0.5% ZnSO4 + 0.5% $FeSO_4$ + BIOMIX) followed by T_{11} (RDF + 0.5% $ZnSO_4$ + 0.5% $FeSO_4$) and T_8 (RDF + 25 kg ha^{-1} $ZnSO_4$ (soil application) at 25 DAS) at 40 and 60 DAS. Plant height, dry matter accumulation and leaf area index (at 40 DAS) was 31.8 and 9.5%, 89.9 and 22.4% and 122.5 and 19.1%, respectively higher over control and RDF at 60 DAS.

Availability of nutrients in a balanced form especially N, P and K through integrated nutrient management resulted in better nutritional environment in root zone for growth and development resulting in better interception of solar radiations, determining photosynthetic activity of plant. Since soil of the experimental field was low in N, medium in P and K, therefore adequate supply of NPK through chemical fertilization might have helped in early root ramification and establishment of the crop leading to increased growth in T_{12}, T^{11} and T_8 treatments. These results

Table 1. Plant height, dry matter accumulation and leaf area index of pearl millet as influenced by different nutrients management treatments.

Treatments	Plant Population /m^2		Plant height (cm)		Dry matter accumulation (g plant^{-1})		Leaf Area Index
	20 DAS	At harvest	40 DAS	At harvest	40 DAS	At harvest	40 DAS
T_1: Control	18.00	15.00	126.67	146.31	25.00	41.87	1.67
T_2: RDF (156.25:62.5:0) kg ha^{-1} N:P:K through inorganic source	18.14	16.23	140.00	172.00	36.67	64.94	3.12
T_3: RDF + BIOMIX	18.20	16.70	145.67	176.33	38.33	67.16	3.23
T_4: 50% RDN through inorganic source + 50% RDN through FYM + BIOMIX	18.07	15.10	130.63	151.00	28.62	47.55	1.83
T_5: 50% RDN through inorganic source + 50% RDN through Vermicompost + BIOMIX	18.10	15.13	131.07	153.17	28.90	49.57	1.93
T_6: 75% RDN inorganic source + 25% N through FYM +BIOMIX	18.10	15.33	135.90	161.33	33.25	57.05	2.83
T_7: 75% RDN inorganic source + 25% N through vermicompost + BIOMIX	18.13	15.63	137.30	163.00	34.50	60.45	2.96
T_8: RDF + 25 kg ha-1 ZnSO4 (soil application)	18.36	16.92	150.80	184.21	40.03	73.48	3.54
T_9: RDF + 0.5% ZnSO4 (foliar spray) at 25 DAS	18.29	16.82	146.67	180.00	38.93	68.36	3.32
T_{10}: RDF + 0.5% FeSO4 (foliar spray) at 25 DAS	18.32	16.79	147.94	181.73	39.96	69.32	3.39

Table 1. Continued.

Treatments	Plant Population /m^2		Plant height (cm)		Dry matter accumulation (g plant^{-1})		Leaf Area Index
	20 DAS	At harvest	40 DAS	At harvest	40 DAS	At harvest	40 DAS
T_{11}: RDF + 0.5% $ZnSO_4$ + 0.5% $FeSO_4$ at 25 DAS	18.40	17.10	150.47	186.13	42.60	76.23	3.59
T_{12}: RDF + 0.5% $ZnSO_4$ + 0.5% $FeSO_4$ + BIOMIX	18.53	17.71	155.73	191.67	44.68	79.53	3.72
SEm ±	0.58	0.85	1.88	2.67	1.59	2.05	0.09
CD 5%	NS	NS	5.57	7.90	4.75	6.10	0.27

are in line with (Yadav *et al*. 2014), (Anilkumar and Kubsad 2017), (Kadam *et al*. 2019).

Yield

Among the nutrient management treatments significantly higher grain yield (3002 kg ha^{-1}), stover yield (7033 kg ha^{-1}) and biological yield (10035 kg ha^{-1}) were recorded with treatment T_{12} (RDF (156.25:62.50 kg ha^{-1} N:P) + 0.5% $ZnSO_4$ + 0.5% $FeSO_4$ + BIOMIX) and it was statistically at par with T_{11} (RDF + 0.5% $ZnSO_4$ + 0.5% $FeSO_4$ at 25 DAS) and T_8 (RDF + 25 kg ha^{-1} $ZnSO_4$ (soil application) at 25 DAS). A trend similar to grain and stover yield was shown by biological yield as summarized in (Table 2). Biological yield of pearl millet varied from 6928 to 10035 kg ha^{-1}, the maximum value being observed in treatment T_{12} and lowest in treatment T_1 (control) respectively. The grain yield, stover yield and biological yield of pearl millet with treatment T_{12} were 47.4 and 7.1%, 43.7 and 9.4% and 44.8 and 5.5% higher over control and RDF, respectively. Harvest index ranged between 29.39 to 30.1% among different treatments, higher harvest index value was obtained in treatment T_{11} (RDF + 0.5% $ZnSO_4$ + 0.5% $FeSO_4$ at 25 DAS).

Crop production is a function of the environment and the genetic potential of the crop variety. As genetic potential of specific crop cultivar remains constant, interaction of crops and environment affects yield of various components. Grain yield of pearl millet showed a greater variance from 2036 to 3002 kg ha^{-1} among different nutrient treatments. Increase in grain, stover and biological yield in T_{12}, T_{11} and T_8 may be ascribed to better root growth and development, nutrient uptake and elevated dry matter accumulation plant^{-1} and its ensuing translocation to the developing ear head. These results were in conformity with

Table 2. Yield of pearl millet as influenced by different nutrient management treatments.

Treatment	Grain yield (kg ha^{-1})	Stover yield (kg ha^{-1})	Biological yield (kg ha^{-1})	Harvest Index (%)
T_1: Control	2036.00	4892.00	6928.00	29.39
T_2: RDF (156.25:62.5:0) kg ha^{-1} N:P:K through inorganic source	2802.67	6701.67	9504.33	29.48
T_3: RDF + BIOMIX	2817.00	6760.79	9577.79	29.42
T_4: 50% RDN through inorganic source + 50% RDN through FYM + BIOMIX	2629.00	6255.00	8884.00	29.59
T_5: 50% RDN through inorganic source + 50% RDN through Vermicompost + BIOMIX	2693.00	6321.00	9014.00	29.88
T_6: 75% RDN inorganic source + 25% N through FYM+BIOMIX	2702.67	6389.00	9091.67	29.70
T_7: 75% RDN inorganic source + 25% N through vermicompost + BIOMIX	2736.00	6430.00	9166.00	29.85
T_8: RDF + 25 kg ha^{-1} $ZnSO_4$ (soil application)	2895.00	6897.00	9721.00	29.78
T_9: RDF + 0.5% $ZnSO_4$ (foliar spray) at 25 DAS	2824.00	6805.32	9653.67	29.26
T_{10}: RDF + 0.5% $FeSO_4$ (foliar spray) at 25 DAS	2848.35	6844.01	9739.01	29.26
T_{11}: RDF + 0.5% $ZnSO_4$ + 0.5% $FeSO_4$ at 25 DAS	2991.00	6976.00	9967.00	30.01
T_{12}: RDF + 0.5% $ZnSO_4$ + 0.5% $FeSO_4$ + BIOMIX	3002.00	7033.00	10035.00	29.92
SEm ±	46.65	58.54	85.64	0.44
CD 5%	137.72	172.81	252.00	NS

(Reddy *et al.* 2016) and (Prashantha *et al.* 2019) in finger millet.

CONCLUSION

Based upon one year field research study pearl millet growers are suggested to go for integrated nutrient management using RDF (156.25:62.50 kg ha^{-1} N:P) + 0.5% $ZnSO_4$ + 0.5% $FeSO_4$ + BIOMIX to obtain significantly higher growth and yield.

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