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Effect of Zinc and Boron on Physiological and Yield Attributing Traits and the Trait Contribution to Grain Yield in Popular Finger Millet (*Eleusine coracana* (L.) Gaertn.) cv GPU-28

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ABSTRACT

The finger millet variety GPU-28, released in 1998, is a popular variety with blast resistance, and is cultivated in more than 60% of the area under finger millet cultivation in India. The varieties released after 1998 showed a declining trend in yield increase. Earlier reports have shown an increase in grain yield by the external application of zinc and boron over the recommended organic manure and major nutrients (FYM+NPK). The zinc and boron concentration in the soil are low, the additional application of zinc and boron was expected to increase yield-attributing traits. Furthermore, assessing the trait contribution to yield would help to improve the grain yield of finger millet, and in particular the cv. GPU-28. The experiment was conducted in a Randomized Complete Block Design (RCBD) with eight treatments in three replications. The treatments involved the application of zinc and boron individually and in combination. Seeds treated with zinc were another treatment. All treatments were imposed in addition to the recommended FYM + NPK treatment. The effect of treatments was analyzed in RCBD using OPSTAT software. The traits contributing to grain yield were identified using backward multiple linear regression (MLR) analysis. The contribution of each trait to the grain yield was computed using the derived MLR. The results revealed that the application of zinc and boron markedly improved physiological and yield parameters. Seed treatment was useful for increasing physiological traits, leaf area index (LAI), dry matter at flowering, and the soil application for yield-attributing traits. The grain yield was positively and significantly correlated with LAI, dry matter at flowering, straw weight at harvest, productive tillers per plant, and total biomass at harvest. Productive tillers per plant (0.685), dry matter at harvest (0.531) and threshing percentage (0.348) showed a high positive direct effect on grain yield. From the multiple linear regression analyses, it is predicted that, an increase in LAI from the existing 1.84 to 4.0 increases the grain yield from 275.1 g^{-2} to 487.6 g^{-2}. Among the yield-attributing traits, increasing the productive tillers from the existing 1.96 to 3.00 per plant can predict an increase in grain yield from 275.1 g^{-2} to 424.9 g^{-2} (54.5%), mean ear weight from the existing 5.95 g to 8.0 g can increase the grain yield

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to 356.3 g^{-2} (29.5%), and threshing percentage from 79.8% to 85.0% can increase the yield by only 5.9%.

Keywords Finger millet, LAI, Zinc, Productive tillers, Mean ear weight.

INTRODUCTION

Finger millet is cultivated in more than 25 countries in Africa and Asia, including India (Vetriventhan *et al*. 2016), China, Nepal, Kenya, Uganda, Sudan, Rwanda, and Zimbabwe (Dwivedi *et al*. 2012). Finger millet is gaining importance because of its superior nutritional quality and climate resilience. The grains have higher protein, phosphorus, vitamins, fiber, calcium, and iron contents than rice (Devi *et al*. 2014, Chandra *et al*. 2016, Hiremath *et al*. 2018, Nakarani *et al*. 2020, Hassan *et al*. 2021). Food products of finger millet provide better health by regulating cholesterol, blood pressure, cancer, and cardiovascular disease (Ekesa 2017). The carbohydrate of finger millet grain has the unique property of slow digestibility with higher fiber content and thus suitable for the diabetic population (Hadimani and Malleshi 1993). It is being a C_4 species (Ueno *et al*. 2006), better adapted to arid and semi-arid regions (Goron and Raizada 2015), where other cereals, such as rice and wheat, fail to yield substantially (Adekunle *et al*. 2012). Therefore, there is a demand for finger millet production to supply in public distribution systems (Lakshmikumari and Sumathi 2002), which could be one of the most appropriate crops in the coming years.

The productivity of finger millet has increased over the years but has stagnated in recent years (Adugna *et al*. 2011, Swetha 2011, Megha 2022). However, among the management practices, the addition of micronutrients, especially zinc and boron, in addition to the recommended FYM+NPK, found to enhance grain yield, and grain zinc content (Pradhan *et al*. 2016, Prashantha *et al*. 2019, Dholariya *et al*. 2020). Zinc is an essential micronutrient that plays a vital role in the activation of several enzymes, particularly carbonic anhydrase, which is involved in photosynthesis. In most crops, the typical leaf zinc concentration required for adequate growth is 15-20 ppm (Marschner 1995). Zinc improves crop yields, especially in zinc-deficient soils, by increasing auxin biosynthesis (Broadley *et al*. 2007, Alloway 2008). Boron is an essential element that plays a role in fertilization and seed-filling, and boron application has been found to enhance grain yield in finger millet, especially in boron-deficient soils (Shankar *et al*. 2017, Prashantha *et al*. 2019).

Identifying the traits through which these micronutrients increase yield could be helpful in breeding for such traits in the background of GPU-28. Hence, it is important to identify the traits and their extent of contribution to grain yield. Therefore, an experiment was conducted to study the effect of zinc and boron on physiological and yield-attributing traits, and to identify the extent of contribution of traits to grain yield in the popular cv GPU-28.

MATERIALS AND METHODS

The experimental site was the Project Coordinating Unit (Small Millets), University of Agricultural Sciences, GKVK, Bangalore, India. The experiment was conducted during *kharif* season, in a Randomized Complete Block Design with eight treatments in three replications. The plot size was 3.3 m width x 3.6 m length (11 rows of 3.6 m long). The spacing was 30 cm between rows and 10 cm between plants. The net plot area leaving the border plants was 2.7 m width and 3.1m long. Fifteen days prior to sowing, the organic manure (FYM) was incorporated into the soil @ 7.5 t/ha, and mixed thoroughly. The fertilizer NPK was applied @ 50:40:25kg/ha respectively, as per the package of practices for finger millet. Seeds were sown on 17-08-2007. Single plant per hill was maintained within 20 days after sowing (DAS) by thinning the plants. Hand weeding was followed as and when required. The crop was raised as a rainfed system, and irrigation was provided when there was no rainfall for 15 days. At the time of flowering, physiological parameters were measured from 0.5 m row length (5 plants continuously) in one of the rows. Yield attributes were measured at physiological maturity.

At the time of seed sowing, zinc sulphate (@12.5 kg/ha) and borax (@10 kg/ha) were applied individually or in combination to the furrows in the respective treatments (described in Table 1). The seed treatment

Table 1. Effect of external application of zinc and boron on physiological parameters at flowering stage of finger millet (cv GPU-28).

Parameter	LA (cm^2 /plant)	LAI	Leaf wt. (g/pl)	St wt (g/pl)	Ratio St / LW	SLW (mg/ cm^{-2})	TDMF (g/ plant)	DM/LA (mg/ cm^{-2})
Absolute control	276.0	0.92	2.13	3.93	1.85	7.74	6.07	21.6
FYM	445.9	1.49	3.47	7.21	2.07	7.77	10.68	22.8
NPK	497.2	1.66	3.93	8.60	2.18	7.91	12.53	24.1
FYM + NPK	657.0	2.19	5.20	10.83	2.08	7.88	16.04	25.1
FYM + NPK + $ZnSO_4$	611.7	2.04	4.82	10.73	2.26	7.88	15.56	25.3
FYM + NPK + $ZnSO_4$ (Seed)	673.2	2.24	5.30	15.50	2.91	7.89	20.80	30.1
FYM + NPK + Borax	561.0	1.87	4.90	10.92	2.28	8.10	15.82	26.8
FYM + NPK + $ZnSO_4$ + Borax	701.2	2.34	5.79	12.25	2.16	7.66	18.04	24.3
Mean	**552.9**	**1.84**	**4.44**	**10.00**	**2.22**	**7.85**	**14.44**	**25.0**
SEm +	32.9	0.11	0.35	0.65	0.12	0.16	0.89	2.2
CD @ 5%	100.8	0.34	1.06	2.00	0.38	NS	2.72	NS
CV (%)	10.3	10.31	13.46	11.31	9.66	3.58	10.65	15.3

LA: Leaf area (cm^2 per plant), LAI: Leaf area index, Leaf wt.: Leaf weight (g/pl), St wt: Stem weight (g/plant), SLW: Specific leaf weight (mg/ cm^{-2}), TDMF: Total dry matter at flowering, DM/LA: Ratio of dry matter at ear emergence to leaf area, $ZnSO_4$ @ 12.5kg/ha and Borax @ 10.0 kg/ha were applied to soil, seed treatment with $ZnSO_4$ @ 12.5 g/2.5 kg seed.

was made with 12.5 g $ZnSO_4$ for 2.5 kg seed in water for 9 h. These treatments were in addition to the recommended FYM+NPK.

Physiological parameters such as leaf area, leaf area index (LAI), specific leaf weight (SLW), dry matter accumulation/unit leaf area (DM/LA), and total dry matter were monitored with destructive sampling in 0.5m continuous row length consisting of five plants. The leaf area of randomly selected 20 leaves was measured as leaf length × leaf width x 0.75 (leaf shape factor, Rajappa *et al*. 1972). After measuring the leaf area, the leaves were dried to a constant weight in a hot-air oven at 70°C. SLW was calculated as leaf dry weight (mg)/ leaf area (cm^2). Following this, the total leaf dry weight per plant was multiplied by 1/SLW to arrive at the leaf area per plant. LAI was computed by dividing the leaf area by spacing. The DM/LA ratio at flowering was computed by dividing the dry matter at flowering with the leaf area at flowering.

At the time of harvest, from the net plot area, the parameters viz., productive tillers, number of ears, total ear weight were monitored. The total ear weight was divided by the total number of ears to arrive at the mean ear weight. The total ear weight was threshed to obtain grain weight. The grain weight was divided by the total ear weight to obtain the threshing ratio. The straw weight (stem + leaf) was added to the total ear weight to calculate the total dry matter at harvest. All parameters were converted to one square meter area and presented. Statistical analysis was performed using OPSTAT software (Sheoran *et al*. 1998). Furthermore, using Microsoft Excel Toolpak, stepwise multiple linear regression (MLR) (stepwise backward regression) the traits contributing to grain yield significantly were identified. Using the derived MLR equation, the contribution of each trait to grain yield was computed.

RESULTS AND DISCUSSION

Leaf area, leaf area index (LAI), leaf dry weight, stem dry weight, and total biomass at flowering (TDMF) differed significantly with the zinc and boron application treatments (Table 1). Previous studies have shown that leaf area increases with the external application of zinc (Qureshi *et al*. 2021). But, compared to the recommended NPK+FYM, the application of zinc and boron to soil did not significantly increase the leaf area or other parameters in the present study (Table 1). However, seed treatment with zinc significantly increased the stem weight, ratio of stem weight to leaf weight, and total biomass at flowering (Table 1), which could be due to enhanced early seedling vigor and increased photosynthetic rate. The ratio of dry matter produced to the leaf area per plant at flowering (DM/LA; nothing but net assimilation rate or indirect measure of photosynthetic rate) did not differ significantly between the treatments, however, seed treatment with zinc resulted in markedly higher NAR (30.1 mg cm^{-2}) as compared to recommended package of practice (25.1 mg cm^{-2}). The expected increase in DM/LA could be due to enhanced carboxylation in C_4 plants through higher carbonic anhydrase activity (Alloway 2008), and enhanced stomatal opening through potassium regulation (Sharma *et al*. 1995). From these results, it is evident that zinc plays an important role in increasing the leaf area, photosynthesis, and dry matter production, thus increases the grain yield of finger millet.

Diets with poor micronutrients such as iron and zinc cause malnutrition, especially in children (Krishnaswamy 2009). Therefore, to reduce malnutrition, an economically viable approach could be the exploitation of genetic variability rich in micronutrients, and introducing such varieties for cultivation and meal preparations (Upadhyaya *et al*. 2010), or by external application of zinc to increase the grain zinc content in addition to grain yield. In the present study, $ZnSO_4$ (@12.5 kg/ha) did not significantly increase the yield-contributing traits over the recommended package of NPK+FYM treatment. However, incorporation of $ZnSO_4$ (@12.5 kg/ha) increased the grain yield by 3.3% (104 kg/ha) due to increased straw weight, and total biomass at harvest (Table 2). Similarly, an increase in grain yield from 195 gm^{-2} to 241 gm^{-2} by application of zinc 2.0 kg/ha in the form of $ZnSO_4$ (Pradhan *et al*. 2016) and from 2313 kg/ha to 2692 kg/ha by application of zinc sulphate at 12.5 kg/ha has been reported (Dholaria *et al*. 2020). An increase in yield was reported even at native zinc concentration of 1.95 mg/kg soil, with additional application of 1.0 mg/kg soil (Patil *et al*. 2014). The application of borax (@ 10 kg/ha) had no advantage over the recommended NPK+FYM treatment or in combination with zinc (Table 2, Chowdary and Patra 2019). Although the application of zinc influences grain yield to a lesser extent compared to other reported studies, it increases grain zinc content (Pradhan *et al*. 2016, Dholaria *et al*. 2020), which is essential for cellular processes in plants as well as in the human body. Therefore, incorporation of $ZnSO_4$ (@ 12.5 kg/ha) into soil is indeed advantageous. In other words, zinc @ 2.5 kg/ha (11–12 kg/ha $ZnSO_4$), or foliar spray of 0.5% $ZnSO_4$ is recommended for finger millet (Alloway 2008).

The correlations showed that grain yield was positively and significantly correlated with LAI (r=0.830**), dry matter at flowering (r= 0.762**), straw weight at harvest (r= 0.860**), productive

Table 2. Effect of external application of zinc and boron on yield attributing traits in finger millet (cv GPU-28).

Parameter	Str wt (g/m^{-2})	EHW (g/m^{-2})	TDM (g/m^{-2})	GY (g/m^{-2})	HI	Th%	ENo (m^{-2})	MEW (g)	PT/ Plant
Absolute control	116.3	213.0	329.3	171.2	0.52	81.3	35.2	6.08	1.17
FYM	194.9	277.5	472.4	221.8	0.47	80.5	51.9	5.41	1.73
NPK	262.5	339.2	601.6	273.7	0.45	80.8	52.7	6.48	1.76
FYM + NPK	322.3	394.5	716.8	316.4	0.44	80.3	70.3	5.62	2.34
FYM + NPK + $ZnSO_4$	330.2	419.6	749.8	326.8	0.44	78.2	68.7	6.19	2.29
FYM + NPK + $ZnSO_4$ (Seed)	339.8	386.9	726.8	308.9	0.43	79.8	64.7	5.98	2.16
FYM + NPK + Borax	276.3	357.3	633.6	284.9	0.45	79.8	61.2	6.02	2.04
FYM + NPK + $ZnSO_4$ + Borax	294.5	382.3	676.9	297.5	0.44	78.0	66.1	5.82	2.20
Mean	**267.1**	**346.3**	**613.4**	**275.2**	**0.46**	**79.8**	**58.9**	**5.95**	**1.96**
SE(m)	16.1	17.5	21.3	16.1	0.02	5.6	3.4	0.32	0.11
CD	49.3	53.5	65.1	49.4	NS	NS	10.5	NS	0.35
CV	10.4	8.7	6.0	10.2	7.60	12.1	10.1	9.20	10.04

Str wt: Straw weight, EHW: Ear head weight, TDMH: Total dry matter at harvest, GY: Grain yield, HI: Harvest index, Th%: Threshing percentage, ENo: Ear number (No.m^{-2}), MEW: Mean ear weight (g/ear), PT/Plant: Productive tiller number per plant.

Table 3. Correlation matrix for physiological traits and yield attributes in finger millet (cv GPU-28).

Parameter	LAI	DM/LA	SLW	St/LW	TDMF	Str Wt	PT/Plant	MEW	Th%	TDMH	HI	GY
LAI	1.000											
DM/LA	-0.119	1.000										
SLW	0.080	0.009	1.000									
St/LW	0.365	0.454	0.206	1.000								
TDMF	0.943	0.001	0.222	0.590	1.000							
Str wt	0.817	0.289	0.226	0.579	0.806	1.000						
PT/Plant	0.850	-0.047	0.035	0.194	0.754	0.761	1.000					
MEW	-0.192	0.339	0.156	0.202	-0.100	0.013	-0.430	1.000				
Th%	0.006	-0.226	0.086	-0.095	-0.019	0.052	0.101	-0.598	1.000			
TDMH	0.855	0.234	0.186	0.489	0.825	0.966	0.842	0.043	-0.087	1.000		
HI	-0.367	-0.475	-0.132	-0.535	-0.414	-0.529	-0.169	-0.556	0.730	-0.541	1.000	
GY	0.830	0.013	0.140	0.283	0.762	0.860	0.921	-0.259	0.272	0.897	-0.124	1.000

LAI: Leaf area index, DM/LA: Ratio of dry matter at ear emergence to leaf area, SLW: Specific leaf weight, St/LW: Ratio of stem weight to leaf weight at ear emergence, DMF: Dry matter at ear emergence, Str wt: Straw weight, PT/Plant: Productive tiller number per plant, MEW: Mean ear weight, Th%: Threshing percentage, TDMH: Total dry matter at harvest, HI: Harvest index, GY: Grain yield, r= >0.404* and 0.515** are significant at 5% and 1% proportion respectively.

tillers per plant (r= 0.921**), and total biomass at harvest (r= 0.897**, Table 3). Similar correlations have been reported earlier (Pallavi *et al*. 2016; Nanja Reddy *et al*. 2019, Mujahid *et al*. 2020, Nanja Reddy and Krishne Gowda 2020, Ramya and Reddy 2022). These correlations suggest that physiological traits, LAI, and dry matter at flowering are important for grain yield in finger millet. In this study among the yield-attributing traits, productive tillers showed a highly positive relationship with grain yield, because GPU-28 is a shy-tillering type, and the threshing percentage has a moderate positive relationship because the threshing percentage in variety GPU-28 is fairly high (78-80%), and further increase leads to shattering (Nanja Reddy *et al*. 2021). The negative relationship between ear-head size and grain yield could be due to the lack of differences in the mean ear-head weight between the treatments.

Path analysis provides the direct and indirect effects of an independent trait on grain yield by partitioning the correlation values. Lenka and Mishra (1973) classified the path coefficients with values 0.00 to 0.09 as negligible, 0.10 to 0.19 low, 0.20 to 0.29 moderate, 0.30 to 0.99 high and more than 1.00 as very high. Accordingly, source size (LAI), total

Table 4. Direct and indirect effects of physiological and yield attributes on grain yield in finger millet (cv GPU-28).

Parameter	LAI	DM/LA	SLW	St/LW	TDMF	Str Wt	PT/Plant	MEW	Th%	TDMH	HI	'r' for GY
LAI	**-0.066**	0.003	-0.002	-0.001	0.040	-0.092	**0.582**	-0.054	0.002	**0.454**	-0.036	0.830
DM/LA	0.008	**-0.021**	0.000	-0.002	0.000	-0.032	-0.032	0.095	-0.079	0.124	-0.048	0.013
SLW	-0.005	0.000	**-0.024**	-0.001	0.009	-0.025	0.024	0.044	0.030	0.099	-0.011	0.140
St/LW	-0.024	-0.010	-0.005	**-0.003**	0.025	-0.065	0.135	0.058	-0.033	0.261	-0.053	0.284
TDMF	-0.062	0.000	-0.005	-0.002	**0.043**	-0.090	**0.517**	-0.028	-0.007	**0.438**	-0.041	0.762
Str wt	-0.054	-0.006	-0.005	-0.002	0.034	**-0.112**	**0.522**	0.004	0.018	**0.513**	-0.052	0.860
PT/Plant	-0.056	0.001	-0.001	-0.001	0.032	-0.086	**0.685**	-0.121	0.035	**0.448**	-0.016	0.921
MEW	0.013	-0.007	-0.004	-0.001	-0.004	-0.002	-0.293	**0.282**	-0.208	0.024	-0.058	-0.258
Th%	0.000	0.005	-0.002	0.000	-0.001	-0.006	0.070	-0.169	**0.348**	-0.046	0.075	0.273
TDMH	-0.056	-0.005	-0.004	-0.002	0.035	-0.108	**0.577**	0.013	-0.030	**0.531**	-0.053	0.897
HI	0.024	0.010	0.003	0.002	-0.017	0.058	-0.107	-0.161	0.257	-0.279	**0.101**	-0.109

Residual: 0.005
LAI: Leaf area index, DM/LA: Ratio of dry matter at ear emergence to leaf area, SLW: Specific leaf weight, St/LW: Ratio of stem weight to leaf weight at ear emergence, DMF: Dry matter at ear emergence, Str wt: Straw weight, PT/Plant: Productive tiller number per plant, MEW: Mean ear weight, Th%: Threshing percentage, TDMH: Total dry matter at harvest, HI: Harvest index, GY: Grain yield.

Table 5. Predicted contribution of leaf area index on grain yield in finger millet (cv GPU-28).

Parameter	Observed mean LAI	Higher trait (LAI) value in MLR (x_1)	Mean DM/LA (x_2) (mg/cm^{-2} leaf area)	MLR equation	Ob GY (g^{-2})	Est GY (g^{-2})	% inc in GY using MLR
LAI	1.84		25.0	$Y= 62.7 + 98.6\ x_1 + 1.22\ x_2$ (x_1= 1.84, x_2= 25.0)	275.1	274.6	0.20
LAI		3.0	25.0	$Y= 62.7 + 98.6\ x_1 + 1.22\ x_2$ (x_1= 3.0, x_2= 25.0)	275.1	389.0	41.4
LAI		4.0	25.0	$Y= 62.7 + 98.6\ x_1 + 1.22\ x_2$ (x_1= 4.0, x_2= 25.0)	275.1	487.6	77.2

$Y= 62.7 + 98.6\ x_1 + 1.22\ x_2$; where, Y= Estimated (predicted) grain yield, MLR: Multiple linear regression (MLR), 62.7 is intercept in the MLR, x_1: LAI, x_2 DM/LA, LAI: Leaf area index, DM/LA: Dry matter per plant at flowering /Leaf area per plant at flowering, GY: Grain yield (g^{-2}), Ob: Observed, Est: Estimated, %Inc: Percent increase.

dry matter at flowering, and straw weight at harvest showed an indirect high positive effect on grain yield through tiller number and total dry matter at harvest. Among the yield-contributing traits, a high positive direct effect on grain yield was observed for productive tillers per plant (0.685), followed by dry matter at harvest (0.531) and threshing percentage (0.348). A moderate effect was observed for mean ear weight (0.282), with a low direct effect of harvest index (0.101) on grain yield (Table 4, Ramya and Nanja Reddy 2022). Therefore, there is potential for increasing the LAI and biomass at harvest in the variety GPU-28, for improving the grain yield

Biomass production and yield-attributing traits depend on source size and photosynthetic rate (Nanja Reddy *et al*. 2019). It has been well demonstrated that the photosynthetic rate in finger millet is already high compared to other crops (Uma 1987), as finger millet is a C_4 species (Ueno *et al*. 2006). In the present study, DM/LA (an indirect measure of the net assimilation or photosynthetic rate) did not differ significantly be-

Table 6. Predicted contribution of yield attributing traits on grain yield in finger millet (cv GPU-28).

Parameter	Observed value of given parameter	Higher given parameter value for MLR	MLR equation	Ob GY (g^{-2})	Est GY (g^{-2})	% inc in GY using MLR
Observed			$Y= -495.3 + 144.2x_1 + 39.7x_2 + 3.15x_3$ (X_1=1.96, x_2=5.95, x_3= 79.8)	275.1	274.9	-
PT / Plant (x_1)	1.96	3.0	$Y= -495.3 + 144.2x_1 + 39.7x_2 + 3.15x_3$ (X_1=3.0, x_2=5.95, x_3= 79.8)	275.1	424.9	54.5
MEW (g/ear) (x_2)	5.95	8.0	$Y= -495.3 + 144.2x_1 + 39.7x_2 + 3.15x_3$ (X_1=1.96, x_2=8.0, x_3= 79.8)	275.1	356.3	29.5
Th % (x_3)	79.8	85.0	$Y= -495.3 + 144.2x_1 + 39.7x_2 + 3.15x_3$ (X_1=1.96, x_2=5.95, x_3= 85.0)	275.1	291.3	5.9

$Y= -495.3 + 144.2x_1 + 39.7x_2 + 3.15x_3$

Where, Y= Estimated (predicted) grain yield (gm^{-2}), MLR: Multiple linear regression (MLR), -495.3 is intercept in the MLR, x_1: Productive tillers/ plant, x_2 is mean ear weight (g/ear), x_3 is threshing percentage, PT: Productive tillers per plant, MEW: Mean ear weight, Th%: Threshing percentage, GY: Grain yield, Ob: Observed, Est: Estimated, %Inc: Percent increase.

tween the treatments (Table 1). In contrast, LAI had a positive effect on grain yield, and the LAI was low in cv GPU-28 (1.84). Hence, multiple linear regression (MLR) was performed using the LAI and DM/LA, the increase in LAI from the existing 1.84 to 4.0 is predicted to increase the grain yield from 275.1 gm^{-2} to 487.6 gm^{-2} (Table 5). Therefore, the grain yield of GPU-28 can be increased by increasing LAI.

Among the yield-attributing traits, by backward multiple linear regression equation, the productive tillers per plant, mean ear weight, and threshing percentage were identified as significant contributing factors to grain yield (Table 6). Increase in productive tillers from existing 1.96 to 3.0 per plant can increase the grain yield from 275.1 gm^{-2} to 424.9gm^{-2} (54.5%), because, GPU-28 is a shy tillering type. Improving the mean ear weight from the existing 5.95 g to 8.0 g can increase the grain yield to 356.3gm^{-2} (29.5%), suggests that GPU-28 has fairly a high mean ear weight. Furthermore, an increase in the threshing percentage from 79.8% to 85.0% increased the yield by only 5.9%, which also suggests that cv GPU-28 has a high threshing percentage. Beyond 85.0%, the ear-head leads to a naked-type and catchy-to-bird menace (Nanja Reddy *et al*. 2021). Hence, increasing the productive tillers per plant could be a better strategy to improve the grain yield of GPU-28.

CONCLUSION

The popular variety of finger millet, GPU-28 has blast resistance, but is a shy tillering type, that has a limitation on productivity. It has only 2 tillers/ plant in addition to low leaf area. From the present study, it is concluded that increase in tiller number to three has possibility to increase the yield potential by 50 %. The ear-head size and threshing percentage are not the constraints for production of cv GPU-28. To enhance the tiller production, the source size is important and low (LAI 1.84), an increase the LAI to 4.0 predicts to double the grain yield, which is possible through management practices. The application of $ZnSO_4$ although increases the grain yield marginally, it has a significant role in increasing the grain zinc content, which is highly essential for nutritional security of population. Therefore, application of $ZnSO_4$ @ 12.5 kg/ha to the soil is highly apt, and boron may not be that required.

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