Influence of Planting Methods, *Mycorrhiza* and Zinc Fertilization on Growth and Grain Yield of Pearl Millet (*Pennisetum glaucum* L.) in hot Arid Region

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Abstract: A field experiment entitled "Influence of planting methods, *Mycorrhiza* and zinc fertilization on growth and productivity of pearl millet (*Pennisetum glaucum* L.) in hot arid region" was conducted during *Kharif* season 2020 and 2021 at Instructional Farm, College of Agriculture, Swami Keshwanand Rajasthan Agriculture University (SKRAU), Bikaner. The experiment comprised of 24 treatments combination having three planting methods (flat bed S_1, ridge & furrow S_2, pit technique S_3) & two *Mycorrhiza* level (control M_0, 8 kg ha^{-1} *Mycorrhiza* basal) in main plot and four zinc fertilization practices (control Z_0, 0.5% $ZnSO_4$ two foliar spray Z_1, zinc sulphate @10 kg ha^{-1} basal+ 0.5% foliar spray Z_2 & zinc sulphate @ 20 kg ha^{-1} basal Z_3) in sub plots were laid out in split plot design and replicated thrice. It may be inferred that in pearl millet pit planting technique (S_3), *Mycorrhiza* (M_1) + fertilized with zinc sulphate (Z_2) practice gave significantly higher growth parameters *viz*., plant stand, plant height, dry matter accumulation, crop growth rate, relative growth rate, chlorophyll content, root dry weight and number of green leaves $plant^{-1}$ and quality parameters *viz*., protein content and protein yield in grain, ash and fibre content in stover as compared to all other treatment combinations on pooled basis.

Keywords: planting method, pit, ridge & furrow, pearl millet, *Mycorrhiza*, zinc

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1. Introduction

Pearl millet (*Pennisetum glaucum* L.) is known as *bajri* or *bajara* has unique tolerance to high temperature and moisture stress even at flowering, seed setting and grain filling stages where no other cereal crop can perform. Realizing the excellent nutritional composition of these grains, pearl millet is now called as nutri cereal. Average composition of the edible portion of grain is 12.4 per cent moisture, 11.6 per cent protein, 3-5 per cent fat, 67 per cent carbohydrates, 1.5 to 3 per cent fiber and 2.7 per cent minerals (Sharma and Burark, 2015). It provides staple food for the poor people in a short period in the relatively dry tracts of the world and cultivated by the economically poor farmers using either insufficient production technology or using it at suboptimal levels. Pearl millet is grown on 26 million ha in semi-arid tropical environments of Asia and Africa. India and Africa together account 93.2 per cent of the total pearl millet production in the world. The share of pearl millet in total food grain production is 10.7 per cent (Chaudhari *et al.,* 2018). India is the largest producer of this crop, both in terms of area (7.57 million ha) and production (10.86 million tons), with an average productivity of 1436 kg ha^{-1} (Anonymous, 2021). The major pearl millet growing states in the country are Rajasthan, Uttar Pradesh, Haryana, Gujarat, and Maharashtra. In Rajasthan, the crop is cultivated in about 4.32 million hectares area producing 4.53 million tons of grain with productivity of 1049 kg ha^{-1} (Anonymous, 2021). It is the most important crop of *kharif* season grown in the district of Jodhpur, Bikaner, Barmer, Churu, Sikar, Jhunjhunu, Jaipur, Jalore and Alwar. Optimum planting geometry leads to effective utilization of nutrients, soil moisture, sunlight etc., which ensure maximum yield per unit area. It has been observed that the major hurdle in the way of increasing yield at farmer field is conventional method of planting. Generally, pearl millet is sown by broadcasting or row method. Though these methods are easy in adoption and takes less time in planting but low germination is reported due to fast depletion of moisture from soil. Pit planting is one of the important methods which has tremendous scope of exploiting the highest biological yield potential (Maqsood *et al*., 2005). After the success of pit method of planting in sugarcane; recently pit planting technology has been developed for various crops, but it is still to be standardized in comparison to other existing methods to establish its superiority. Pit planting in pearl millet may help to increase the pearl millet productivity. Furthermore, *Mycorrhizal* fungi form symbiotic relationship with over 95% of plant species. They provide nutrients such as phosphorus and water to plants in exchange for carbohydrates, usually sugars. In fact, some plants may trade more than 50% of their carbohydrates with these fungi and other microbes. Nasim (2005) reported that a root associated with *Mycorrhizal* fungi can transport phosphorus at a rate more than four times higher than that of a root not associated with *Mycorrhiza*. Extra radical hyphae of AM fungi contribute to soil aggregation and structural stability. When the supply of Zn to the plant is inadequate not only crop yield is reduced but also the quality of crop is deteriorated. In plants, Zn 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). Zinc is essential element for crop production and growth development of plant (Ali *et al*., 2008). Spraying zinc on the leaves may improve the efficiency of zinc uptake. This is consistent with the result of Ning *et al.* (2009).

2. Material and Methods

The experiment was conducted at the Instructional Farm, Department of Agronomy, Bikaner during kharif seasons of 2020 and 2021. This location is situated on NH-15, Sriganganagar Road at 28°4‘21‖ North latitude and 73°20‘17‖ East longitude with an altitude of 235 meters above the mean sea level. According to National Planning Commission, Bikaner falls under Agro-climatic zone XIV (Western Dry Region) of India. The maximum and minimum temperature ranged between 30.4 to 41.8°C and 9.9 to 29.9°C in 2020 and 25.5 to 42.3°C and 12.8 to 30.5°C in 2021 respectively. The relative humidity of the locality fluctuated from 19.7 to 91.9 per cent during 2020 and 32.4 to 93.6 per cent during 2021. The total rainfall received during kharif seasons was 287.4 mm in 14 rainy days during 2020 and 246 mm of in 15 rainy days during 2021. The total evaporation from open pan evaporimeter Class A was 126.8 mm and 202.2 mm, during crop growing period of 2020 and 2021, respectively. Bright sunshine hour during crop growing seasons was 4.0 to 9.9 and 3.4 to 10.4 hrs, and wind velocity was 2.8 to 12.7 Km hr^{-1} and 2.8 to 17.9 Km hr^{-1} in 2020 and 2021, respectively. Potential evapotranspiration (PET) of this region ranges between 1500-2000 mm annually. Soil analysis data clearly indicate that experimental field soil was loamy sand in texture, low in organic carbon (0.12 & 0.14) and available nitrogen (87.14 & 89.15 kg ha^{-1}), medium in available phosphorus (18.8 & 20.0 kg ha^{-1}) and rich in available potassium (316.85 & 304.51 kg ha^{-1}). Also, the soil was alkaline in reaction having pH (1:2 soil water suspensions) of 8.28 and 8.14 with electrical conductivity (EC) of 0.18 and 0.20 dSm-1 during 2020 and 2021, respectively. The experiment was laid out in a Split Plot Design with 24 treatment combinations which were replicated thrice. The plot size 3.60 m x 4.50 m was used. The details of treatment was given in Table 1. The pearl millet variety MPMH-17 has been used for experimentation, which sown firstly in nursery using seed rate of 2 kg ha^{-1} and direct seed sowing in field @ 4 kg ha^{-1}. In nursery seed were sown by broadcasting method on 27th June 2020 and 29th June 2021. Sowing in flat bed treatment was done at 45 cm row interval by “pora” method (seeds are dropped in funnel which attached with hoe) on 20 July 2020 and 29 July 2021, respectively. Nearly three-week-old healthy seedlings were transplanted in experimental plots.

The biometric observation was recorded on five randomly selected plants from net plots of each treatment. Crop growth rate (CGR) was estimated using the formula reported by Brown (1984) and expressed as g m^{-2} day^{-1}. Relative growth rate (RGR) was calculated using the formula given by Radford (1967) and expressed as g $g^{-1}day^{-1}$.

$$\text{Crop Growth Rate (g m}^{-2}\text{ day}^{-1}) = \frac{W_2 - W_1}{t_2 - t_1}$$

Where,

W_1 = dry matter production per unit area at time t_1

W_2 = dry matter production per unit area at time t_2

t_1 = days to first sampling

t_2 = days to second sampling

$$\text{Relative Growth Rate (g g}^{-1}\text{ day}^{-1}) = \frac{\log_e W_2 - \log_e W_1}{t_2 - t_1}$$

Where,

$\log_e W_1$ = Initial dry weight of plant (g)
$\log_e W_2$ = Final dry weight of plant (g)
t_1 = Initial time period
t_2 = Final time period

$$\text{Leaf area} = \frac{\text{Total leaf area (cm}^2)}{\text{Total land area (cm}^2)}$$

Number of green leaves:

The number of leaf's per plant of the five plant randomly selected in each plot was counted at 60 DAS/DAT and average was worked out for further study.

Root dry weight:

Root dry weight was observed from taken 5 randomly tagged plant root dig out from each plot followed washed well in water, airdrying and then keep in oven until dry. Weight individually dry plant root recorded for further needful.

3. Result and discussion

3.1 Plant height

The result reveled that there was significant effect of planting method, Mycorrhiza and zinc fertilization on plant height during both seasons. Plant height noted at 40 DAS/T and harvest was significantly more in pit planting technique (135.42 & 171.12 cm) followed by ridge & furrow (107.37 & 161.41 cm) and flat bed sowing method (86.85 & 142.75 cm) on pooled data analysis basis. Deshmukh and patel (2013) stated that methods of planting significantly affected plant height of pearl millet crop at Navsari (Gujarat). Plant height of pearl millet recorded at 40 DAS/T and at harvest increase by *Mycorrhiza* treatment (113.86 & 162.70 cm) as compared to control during 2020 & 2021 and on pooled data basis. Similarly, Jayne and Quigley (2014) reported that the AM fungi was the most efficient for its ability to increase plant growth, histochemical and level of active arbuscular formation compared over control. Plant height of pearl millet was at harvest maximum under Z_2 treatment (161.40 cm) which was at par with Z_3 treatment and both these treatments were significantly higher over control during individual year of study and on pooled data basis.

3.2 Crop Growth Rate (CGR)

Data presented in Table 2&3 revealed that the pearl millet transplanting in pit (S_3) computed significantly higher crop growth rate values (4.77, 21.22, 27.26 & 21.70 g m^{-2} day^{-1}) recorded at 0-20, 20-40, 40-60 DAS/T and 60 DAS/T- harvest stage over ridge & furrow and flat bed sowing method, respectively on pooled mean data basis. The increased growth characters with pit techniques might have been due to better, light penetration even to lower leaves because of lower plant density per unit area and efficient utilization of soil moisture and nutrients which ultimately enhanced the plant growth and development. The finding of present study also confirmed with those reported by Fatondji (2002) who revealed that zai pit increased millet growth as compared to planting in flat bed. Significantly higher CGR values was noticed over control due to *Mycorrhiza* treatment between 0-20 and 20-40 DAS/T with mean value of 3.96 & 19.68 g m^{-2} day^{-1} on pooled data basis. However, crop growth rate at 40-60 DAS/T and 60 DAS/T to harvest registered non significant variation due to with *Mycorrhiza* and without *Mycorrhiza*. Kanta (2019) reported in pearl millet that growth parameters *viz*., dry matter accumulation, leaf area index, number of green leaves and chlorophyll content significantly increased in *Mycorrhiza* applied treatments compared to control. Further CGR at 0-20 & 20-40 DAS/T observed significantly maximum under Z_3 treatment (3.89 & 18.51 g m^2 day^{-1}) over rest of zinc application practices and control on pooled data basis. While, CGR at 40-60 DAS/T & 60 DAS/T to harvest recorded statistically maximum in Z_2 treatment (23.33 & 21.68 g m^2 day^{-1}) over Z_3 & Z_1 treatments and lowest CGR were recorded in control (20.63 & 11.69 g m^2 day^{-1}) on pooled mean data basis.

3.3 Relative Growth Rate (RGR)

Data furnished in Table 4 revealed that relative growth rate observed with pit technique had significantly higher RGR values (6.01, 6.65 and 6.56 g g^{-1} day^{-1}) as compared to ridge & furrow and flat bed sowing method on pooled data basis. Further relative growth rate of pearl millet between 20-40, 40-60 & 60 DAS/T to harvest growth stages were recorded maximum under *Mycorrhiza* treatment while minimum value under no *Mycorrhiza* control on pooled data basis. The zinc treatment Z_2 realized significantly the highest relative growth rate (6.41, 6.50, 6.45 & 6.39, 6.49, 6.44 g g^{-1} day^{-1}) at growth stages 40-60 DAS/T & 60 DAS/T to harvest, though it was found at par with Z_3 treatment during year of 2020, 2021 and on pooled data basis. Though, during early growth stages zinc treatment Z_3 proved superiority over rest zinc treatments during 2020, 2021 and on pooled data basis.

3.4 Green leaves plant^{-1}, leaf area and root dry weight

It was obvious from data (Table 5) that among planting practices pit planting was recorded significantly more number of green leaves plant^{-1}, leaf area and root dry weight during both years and on pooled data basis because in exponential growth due to solar light interception and thereby increased photosynthesis rate which ultimately increased plant height and DMA plant^{-1} at later stage. The increased growth characters with pit techniques might have been due to better, light penetration even to lower leaves because of lower plant density per unit area and efficient utilization of soil moisture and nutrients which ultimately enhanced the plant growth and development. Similarly, Maqsood *et al.* (2006) and Fatondji *et al.* (2006) opined that in pit technique, manure (FYM) and nutrients was applied in the vicinity of roots *Rhizosphere* which favours crop growth and alleviated the adverse effect of frequently occurring dry spell as well. Basal application of *Mycorrhiza* @ 8 kg ha^{-1} with FYM in pearl millet crop significantly influenced green leaves plant^{-1}, leaf area and root dry weight. *Mycorrhiza* inoculations change the growth and biochemical composition of the host plant and soil. *Mycorrhiza* root system do augment the absorbing area of roots from 10 to 100 time thereby greatly improving the ability of the plants to utilize the soil resources. Similarly, Jayne and Quigley (2014) reported that the AM fungi was the most efficient for its ability to increase plant growth, leaf area, histochemical and level of active arbuscular formation compared over control. The number of green leaves plant^{-1}, leaf area (cm^2 plant^{-1}) and root dry weight was observed significantly higher in Z_2 treatment over rest of zinc application treatments during both years and on pooled data basis. Tarafdar *et al.* (2014) studied on zinc nano particles and results indicate that significant improvement in root length (4.2 per cent), number of functional leaves plant^{-1} (12.80 %), root area (24.2 per cent), chlorophyll content (24.4 per cent) and plant dry biomass (12.5 per cent) was observed over control. Similarly, Dadhich and Gupta (2004) also reported that Zn application influenced plant morphology and growth parameters *viz.* leaves per plant, leaf area, stem grith and tillers per plant of pearl millet under semiarid eastern plain zone of Rajasthan.

3.5 Grain Yield (q ha^{-1})

A thoughtful perception of the data revealed that pit technique (S_3) recorded significantly higher grain yield (30.75 q ha^{-1}) over ridge & furrow and flat bed sowing method on pooled data basis. Data further indicated that transplanting at ridge and furrow (S_2) technique gave significantly higher grain yield (24.04 q ha^{-1}) over flat bed seed sowing (15.71 q ha^{-1}) on pooled basis. The highest grain yield of 30.75 q ha^{-1} recorded by S_3 (pit technique) was higher by 27.91 and 95.73 per cent over S_2 and S_1 respectively. Ehsanullah *et al.* (2017) also reported increased yield attributes of cotton under pit planting. Kumar *et al.* (2022) in pearl millet reported that transplanting of 4 plants pit^{-1} produced maximum grain yield (3086 kg ha^{-1} which was significantly higher over ridge & furrow and direct seeded treatment in arid region of Rajasthan. Data showed that *Mycorrhiza* had significant effect on grain yield of pearl millet. The highest grain yield was realized in the treatment M_1 (25.57 q ha^{-1}), which was statistically superior over no mycorrhiza control practice (M_0) on pooled analysis basis. Mycorrhiza application 8 kg ha^{-1} to pearl millet gave 19.31 per cent higher grain yield over control on pooled mean basis. Ajay Pal and Sonali Pandey (2017) reported that the grain yield and biomass (fresh/dry) of pearl millet were significantly influenced by AM fungi inoculation and the AM fungi treated host plants showed increased level of plant total height, chlorophyll content and per cent of *Mycorrhiza*l-root colonization over control. Data illustrated that grain yield of pearl millet significantly influenced by zinc fertilization based on pooled analysis and as well as individual years of study. The grain yield of Z_2 treatment (27.62 q ha^{-1}) was significantly higher by 4.46, 22.05 and 59.47 per cent over Z_3, Z_1 and Z_0, treatments, respectively on pooled data basis. Similarly, founding also reported by Kumar *et al.* 2016, Shekhawat and kumawat (2017) and Partap *et al.* 2008.

Table 1. Treatment detail of planting technique, Mycorrhiza and zinc fertilization under pearl millet cultivation

Treatment	**Symbol**
A. Sowing method (Main plot)	
1. Flat bed-seed sowing (45 cm ×15 cm)	S_1
2. Ridge and furrow- 2 seedling transplanting (60 cm × 22.5 cm)	S_2
3. Pit technique- 4 seedling transplanting (60 cm × 45 cm) (1 ft^3 pit)	S_3
B. *Mycorrhiza* (Main plot)	
1. Without *Mycorrhiza* (Control)	M_0
2. with *Mycorrhiza* @ 8.0 kg/ha basal application at sowing (BAS)	M_1
C. Zinc fertilization (Sub plot)	
1. Control (no zinc)	Z_0
2. Zinc sulphate 0.5% foliar spray at 35 and 45 days of sowing	Z_1
3. Zinc sulphate 10 kg/ha as BAS +0.5% foliar spray at 45 days of sowing	Z_2
4. Zinc sulphate 20 kg/ha basal application at sowing (BAS)	Z_3

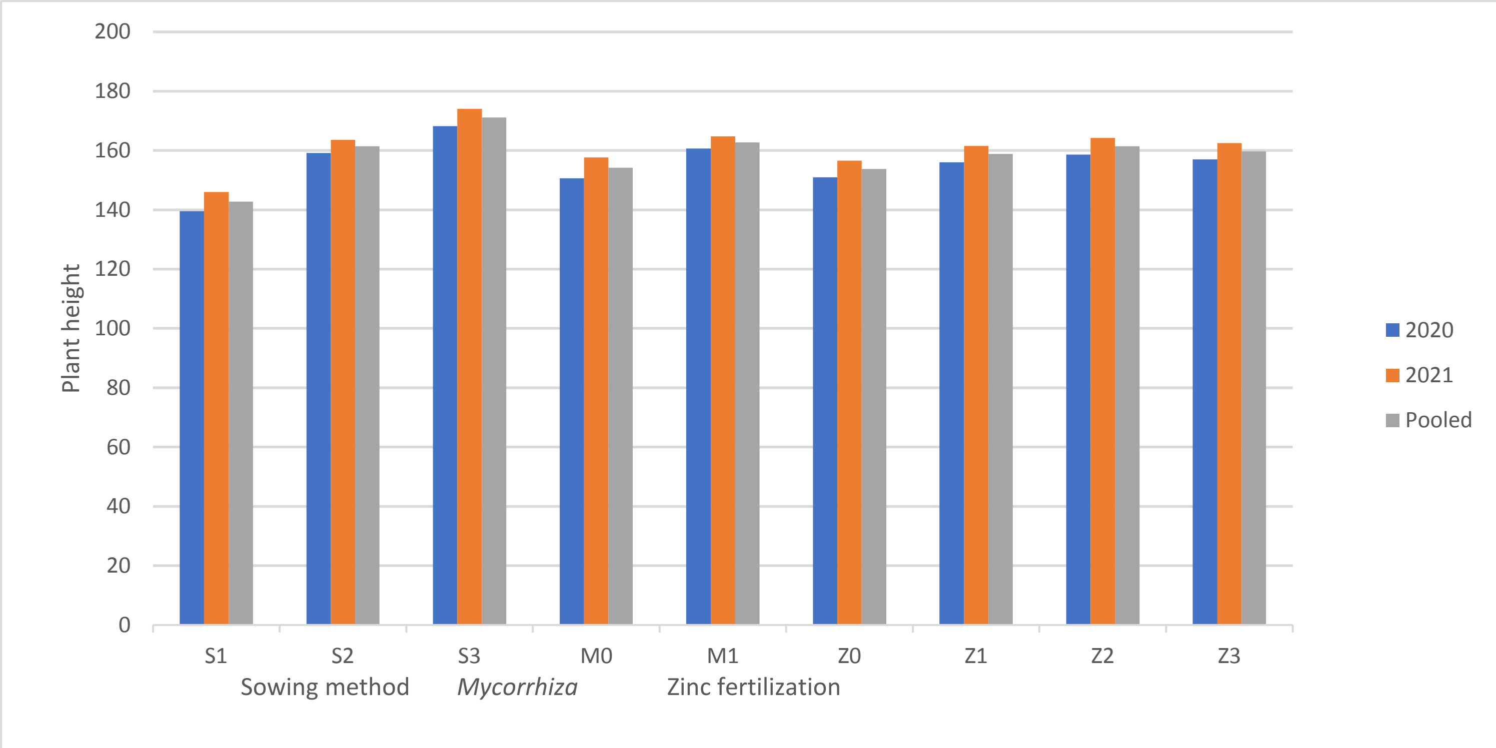

Fig.1 Effect of planting technique, *Mycorrhiza* and zinc fertilization on plant height at harvest

Table 2. Effect of planting technique, *Mycorrhiza* and zinc fertilization on crop growth rate at 0-20 and 20-40 DAS of pearl millet

Treatment	CGR at 0-20 DAS (g m^{-2} day^{-1})			CGR at 20-40 DAS (g m^{-2} day^{-1})		
	2020	**2021**	**Pooled**	**2020**	**2021**	**Pooled**
			Sowing method			
S_1	2.19	2.28	2.24	9.80	11.59	10.70
S_2	4.12	4.29	4.21	15.79	18.99	17.39
S_3	4.65	4.88	4.77	19.32	23.11	21.22
S.Em±	0.19	0.19	0.15	0.699	0.65	0.52
CD (p=0.05)	0.60	0.61	0.44	2.203	2.06	1.52
			Mycorrhiza			
M_0	3.43	3.60	3.51	11.24	15.14	13.19
M_1	3.88	4.04	3.96	18.71	20.66	19.68
S.Em±	0.15	0.16	0.12	0.57	0.53	0.42
CD (p=0.05)	NS	NS	0.35	1.80	1.68	1.25
			Zinc fertilization			
Z_0	3.54	3.70	3.62	13.31	14.80	14.05
Z_1	3.56	3.72	3.64	14.65	16.14	15.40
Z_2	3.71	3.87	3.79	15.92	19.64	17.78
Z_3	3.81	3.97	3.89	16.01	21.01	18.51
S.Em±	0.04	0.04	0.02	0.19	0.19	0.14
CD (p=0.05)	0.11	0.11	0.07	0.56	0.54	0.38

Table 3. Effect of planting technique, *Mycorrhiza* and zinc fertilization on crop growth rate at 40-60 and 60 to harvest of pearl millet

Treatment	CGR at 40-60 DAS (g m^{-2} day^{-1})			CGR at 60-harvest (g m^{-2} day^{-1})		
	2020	2021	Pooled	2020	2021	Pooled
Sowing method						
S_1	15.96	17.33	16.65	10.12	15.98	13.05
S_2	21.81	23.22	22.52	15.58	20.68	18.13
S_3	26.78	27.75	27.26	18.53	24.86	21.70
S.Em±	1.21	1.15	0.91	0.94	1.31	0.86
CD (p=0.05)	3.81	3.64	2.70	2.96	4.12	2.54
Mycorrhiza						
M_0	20.14	22.14	21.14	14.10	19.64	16.87
M_1	22.89	23.39	23.14	15.39	21.38	18.38
S.Em±	0.99	0.94	0.74	0.77	1.07	0.70
CD (p=0.05)	NS	NS	NS	NS	NS	NS
Zinc fertilization						
Z_0	20.62	20.65	20.63	8.89	14.50	11.69
Z_1	21.34	23.09	22.22	13.55	19.37	16.46
Z_2	22.63	24.03	23.33	18.77	24.59	21.68
Z_3	21.48	23.30	22.39	17.76	23.58	20.67
S.Em±	0.47	0.33	0.29	0.75	0.76	0.53
CD (p=0.05)	1.33	0.95	0.80	2.15	2.18	1.49

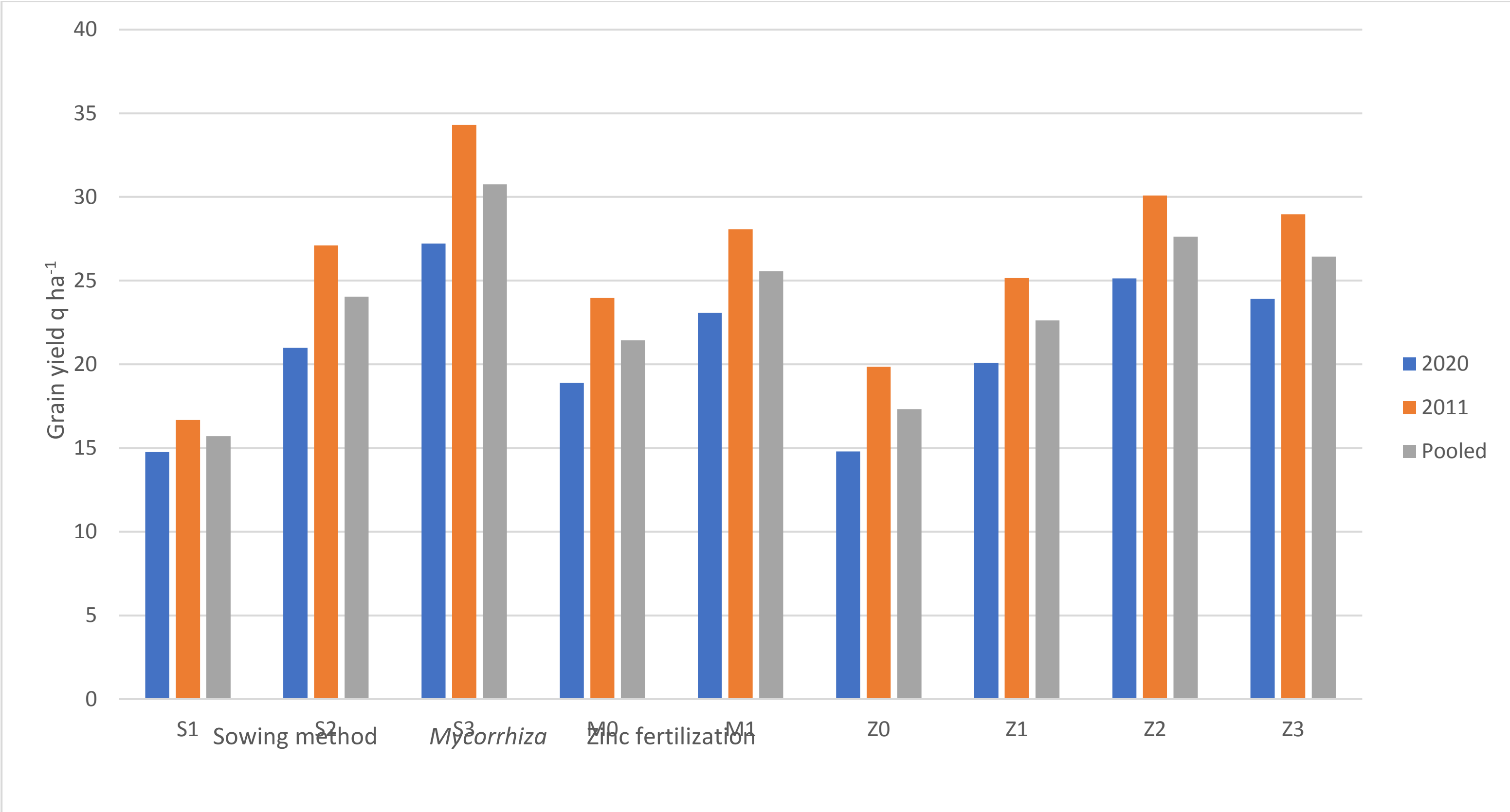

Fig.2 Effect of planting technique, *Mycorrhiza* and zinc fertilization on grain yield of pearl millet

Table 4: Effect of planting technique, *Mycorrhiza* and zinc fertilization on relative growth rate at 20-40 DAS, 40-60 DAS and at 60-harvest of pearl millet

Treatment	RGR at 20-40 DAS (g g^{-1} day^{-1})			RGR at 40-60 DAS (g g^{-1} day^{-1})			RGR at 60-harvest (g g^{-1} day^{-1})		
	2020	2021	Pooled	2020	2021	Pooled	2020	2021	Pooled
				Sowing method					
S_1	5.22	5.39	5.31	6.03	6.15	6.09	5.97	6.11	6.04
S_2	5.75	5.90	5.82	6.42	6.52	6.47	6.31	6.46	6.38
S_3	5.93	6.09	6.01	6.61	6.70	6.65	6.52	6.60	6.56
S.Em±	0.04	0.03	0.03	0.03	0.02	0.02	0.03	0.05	0.01
CD (p=0.05)	0.13	0.10	0.09	0.10	0.08	0.06	0.10	0.16	0.03
				Mycorrhiza					
M_0	5.39	5.65	5.52	6.22	6.38	6.30	6.15	6.32	6.24
M_1	5.87	5.94	5.90	6.48	6.54	6.51	6.38	6.46	6.42
S.Em±	0.03	0.03	0.02	0.03	0.02	0.02	0.02	0.04	0.01
CD (p=0.05)	0.11	0.08	0.08	0.08	0.06	0.04	0.09	0.13	0.03
				Zinc fertilization					
Z_0	5.54	5.64	5.59	6.28	6.40	6.34	6.08	6.24	6.16
Z_1	5.59	5.69	5.64	6.34	6.45	6.39	6.24	6.37	6.31
Z_2	5.69	5.89	5.79	6.41	6.50	6.45	6.39	6.49	6.44
Z_3	5.70	5.95	5.83	6.38	6.48	6.43	6.35	6.46	6.41
S.Em±	0.02	0.01	0.01	0.01	0.01	0.01	0.05	0.05	0.01
CD (p=0.05)	0.05	0.04	0.03	0.04	0.02	0.02	0.15	0.15	0.3

Table 5: Effect of planting technique, *Mycorrhiza* and zinc fertilization on green leaves, leaf area and root dry weight at 60 DAS of pearl millet

Treatment	Green leaves (Nos plant^{-1})			Leaf area (cm^2 plant^{-1})			Root dry weight (g plant^{-1})		
	2020	2021	Pooled	2020	2021	Pooled	2020	2021	Pooled
Sowing method									
S_1	7.53	9.03	8.28	1377.42	1569.42	1473.42	5.97	6.58	6.28
S_2	10.41	11.41	10.91	2135.21	2242.21	2188.71	8.21	9.31	8.76
S_3	12.87	14.87	13.87	2745.63	2825.63	2785.63	9.40	10.20	9.80
S.Em±	0.40	0.44	0.09	70.71	79.08	57.24	0.14	0.16	0.11
CD (p=0.05)	1.27	1.38	0.24	222.80	249.18	169.19	0.44	0.51	0.32
Mycorrhiza									
M_0	9.07	10.29	9.68	1849.11	1987.11	1918.11	7.51	7.73	7.62
M_1	11.47	13.26	12.36	2323.06	2437.72	2380.39	8.21	9.66	8.94
S.Em±	0.33	0.36	0.07	57.73	64.57	46.74	0.11	0.13	0.09
CD (p=0.05)	1.04	1.13	0.20	181.91	203.45	138.13	0.36	0.41	0.25
Zinc fertilization									
Z_0	9.21	10.71	9.96	1875.00	2001.33	1938.17	7.68	8.52	8.10
Z_1	10.29	11.79	11.04	2087.94	2214.28	2151.11	7.84	8.68	8.26
Z_2	11.09	12.59	11.84	2243.33	2369.67	2306.50	8.01	8.85	8.43
Z_3	10.50	12.00	11.25	2138.06	2264.39	2201.22	7.90	8.74	8.32
S.Em±	0.13	0.15	0.10	32.80	36.23	24.44	0.07	0.07	0.05
CD (p=0.05)	0.37	0.42	0.28	94.06	103.92	68.17	0.19	0.20	0.14

4. Conclusion

Based above results it can be concluded that pit technique S_3 helps to get higher plant height and maximum grain yield in arid environmental conditions. Further growth parameters v*iz*., plant height, crop growth rate, relative growth rate at different intervals and grain yield also significantly increase with fertilized *Mycorrhiza* (M_1) + zinc dose @ 10 kg ha^{-1} + 0.5 per cent foliar spray at 45 DAS/T (Z_2) compared to rest of treatments during both years and on pooled data basis.

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References

[1]. Ali, S., Riaz, K. A., Mairaj, G. M., Arif, M., Fida, S. and Bibi. 2008. Assessment of different crop nutrient management practices for yield improvement. *Australian Journal of Crop Science*. **2**(3):150-157.

[2]. Alloway, B. J., 2004. Zinc in soils and crop nutrition. International Zinc Association (IZA), 168 Avenue de Tervueren, 1150 Brussels, Belgium, 123.

[3]. Anonymous. 2021. Agriculture statistics of India.

[4]. Brown, R. H. 1984. Growth of the green plants. In M.B. Tesar (ed.), Physiological Basis of Crop Growth and development. *American Society of Agronomy*, Madispon, WI, pp, 153-174.

[5]. Chaudhari, R. P., Patel, P. M., Patel, B. M., Kumar, U., Darji, S. S. and Patel, S. J. 2018. Performance of summer pearl millet (*Pennisetum glaucum* L.) hybrids under north Gujarat conditions. *International Journal of Current Microbiology and Applied Sciences* **7**(1): 637-644.

[6]. Dadhich, L. K. and Gupta, A. K. 2004. Plant morphology, yield, nutrient content and uptake of fodder pearl millet as influenced by S, Zn supply and its inter-cropping with cowpea. *Annals of Agriculture Bio Research*. **9**: 183-186

[7]. Deshmukh, S. P. and Patel, J. G. 2013. Influence of Non-monetary and Low cost Input in Sustainable Summer Pearl millet (*Pennisetum Glaucum* L.) Production. *International Journal of Agriculture and Food Science Technology*. **4**(6): 579-588.

[8]. Ehasnullah, Shahzad, M. A., Anjum, S. A., Zohaib, A., Ishfaq, M. and Warraich, E. A. 2017. Effect of different sowing methods and planting densities on growth, yield, fiber quality and economic efficacy of cotton. *Pakistan Journal* of *Agricultural Research.* **30** (1): 67-74.

[9]. Fatondji, D. (2002). Organic amendment decomposition, nutrient release and nutrient uptake by pearl millet (*Pennisetum glaucum* L.) in a traditional land rehabilitation technique (zai) in the Sahel. Ph.D. Thesis. Ecological and development series No I. Centre for Development Research. University of Bpnn. Cuvillier Verlag, Gouingen. Germany.

[10]. Fatondji, D., Martius, C., Bielders, C. L., Vlek, P. L., Bationo, A. and Gerard B. 2006. Effect of planting technique and amendment type on pearl millet yield, nutrient uptake, and water use on degraded land in Niger. *Nutrient Cycling in Agroecosystems.* **76** (2-3): 203–217.

[11]. Jayne, B. and Quigley, M. 2014. Influence of arbuscular *Mycorrhiza* on growth and reproductive response of plants under water deficit; a meta-analysis. *Mycorrhiza* **24**: 109-119.

[12]. Kanta, 2019. Influence of Mycorrhiza and Iron Fertilization on Growth, Yield and Quality of Pearl millet (*Pennisetum glaucum*) in Arid Region. M.Sc. thesis, Department of Agronomy, Swami Keshwanand Rajasthan Agriculture university, Bikaner.

[13]. Kumar, S., Kumawat, S. M., Poonia, T., Choudhary, A., Kumawat, S. and Kumar, P. 2022. Performance of Pearl Millet (*Pennisetum glaucum* L.) as Influenced by Different Planting Techniques and Nutrient Management Practices in Arid Western Rajasthan. *International Journal of Plant & Soil Science.* **34** (4): 1-9, ISSN: 2320-7035.

[14]. Maqsood, M., Hussain, T., Tayyab, M. and Ibrahim, M. (2006). Effect of different irrigation levels on the yield and radiation use efficiency of cotton (*Gossypium hirsutum*) under two sowing method.

Pakistan Journal of Agricultural Science. **43** (1): 21-24.

[15]. Maqsood, M., Iqbal, M. and Tayyab, M. 2005. Comparative productivity performance of sugarcane (*Saccharum officinarum* L.) sown in different planting patterns at farmer's field. *Pakistan* Journal of *Agricultural Sciences.* **42** (3-4): 25-28.

[16]. Nasim, G. 2005. The role of symbiotic soil fungi in controlling roadside erosion and the establishment of plant communities. *Caderno de Pesquisa serie Biologia*, **17** (1): 119-136.

[17]. Ning, Y. W. 2009. Zinc and zinc-rich agricultural development in the soil-plant-human system. *Jiangsu Agricultural Sciences*. **3**: 1–3 (in Chinese).

[18]. Pratap, R., Sharma, O. P. and Yadav, G. L. 2008. Effect of integrated nutrient management under varying levels of zinc on pearl millet yield. *Annals of Arid zone*. **47** (2): 197- 199.

[19]. Radford, P. G. 1967. Growth analysis formulae-their use abuse. *Crop Science*, **7**: 171-175.

[20]. Sharma, H. and Burark, S. S. 2015. Bajra price forecasting in Chomu Market of Jaipur district: An application of SARIMA model. *Agricultural Situation in India.* **71**: 7-12.

[21]. Shekhawat, P. S. and Kumawat, N. 2017. Response of zinc fertilization on production and profitability of Pearl millet (*Pennisetum glaucum*) under rainfed condition of Rajasthan. *Journal of Agri Search.* **4** (4): 251-254

[22]. Tarafdar, J. C., Raliya, R., Mahawar, M. and Rathore, I. 2014. Development of Zinc Nano fertilizer to Enhance Crop Production in Pearl Millet (*Pennisetum americanum*). *Agricultural Research.* ISSN 2249-720