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Yield and economics of pearl millet (*Pennisetum glaucum* (L.)) as influenced by moisture conservation practices and zinc fertilization under rainfed conditions

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Abstract
A field experiment was conducted at Agronomy farm, S.K.N. College of Agriculture, Jobner (Rajasthan) during *kharif*, 2017 to find out the effect of moisture conservation practices and zinc fertilization on growth, yield and quality of pearl millet. The experiment consisted of 20 treatment combinations of five moisture conservation practices i.e. control, dust mulch, pusa hydrogel, stover mulch and pusa hydrogel + stover mulch and four zinc fertilization levels i.e. control, 2 kg Zn/ha, 4 kg Zn/ha and 6 kg Zn/ha. Among moisture conservation practices stover mulch proved significantly superior to control, dust mulch, pusa hydrogel with respect to grain yield (2511), stover yield (5765) and biological yield (8276) but remained at par with pusa hydrogel + stover mulch. Significantly higher net returns (□ 41117/ha) and B: C ratio (1.80) were achieved under treatment stover mulch over rest of the treatments. Results further indicated that grain, stover and biological yield, harvest index, net returns and B: C ratio significantly increased with zinc fertilization @ 4 kg Zn/ha over control and 2 kg Zn/ha which remained at par with 6 kg Zn/h

Keywords: pearl millet, pusa hydrogel, zinc fertilizer and stover mulch

1. Introduction

Pearl millet [*Pennisetum glaucum* (L.) R. Br. emend Stuntz] is one of the important millet crop for arid and semi-arid climatic condition. It is world's hardiest warm season crop. It grows in poor sandy soil due to drought escaping character and popular crop for drought prone areas. India is the largest producer of pearl millet having 7.9 m ha area with an annual production of 9.18 m tonnes and average productivity is 1298 kg/ha (Anonymous 2014-15). It is well known fact that about 85 per cent of annual rainfall is received during south-west monsoon season. In this period knowledge of crop growth phases and moisture availability is more essential because the deficiency of rain water at any critical growth stage may affect the plant growth, nutrient availability and yield. In rain fed areas, not all the rainfall received is available for the crops, but a significant part is lost as runoff, percolation and evaporation which leads to low and unstable productivity due to moisture stress at critical stages of crop growth. Hence, concerned efforts are needed to develop soil moisture conservation practices to mitigate the water stress condition to increase production with minimum environment degradation. The risk factor can be minimized through *in-situ* moisture conservation, selection of suitable crop and its variety (Kumar *et al*., 2008). Dust mulching decrease evaporation on the assumption that dry soil acts as a blanket and also reduce the point of contact between the soil particles due to loosening attraction between them. Application of crop residue on soil surface as a mulch reduces the loss of water through evaporation and moderate the soil profile temperature (Ram *et al.*, 2012). The Pusa hydrogel, a semi-synthetic super absorbent polymer which absorbs water and expands 300 times from its original size. It sticks to the roots of the plants and when the soil moisture falls as the temperature rises, the gel shed water to nourish the crop. It increases plant yield by 10-25 per cent. Due to use of Pusa hydrogel, there is 40 to 70 percent saving of water. Hydrogel reduces the leaching of herbicide, fertilizer and requirements of irrigation for crops. It also promotes early dense flowering and tillering and delay the permanent wilting point (Mehr and Kourosh, 2008). At present, widespread and acute deficiency of zinc is another serious problem in arid and semi-arid region (Sahrawat *et al*, 2007). It is well known fact that zinc is now considered as fourth most important yield-limiting nutrient after, nitrogen, phosphorus and potassium (Maclean *et al.,* 2002). Zn deficiency is occurring in both crops and human. Zinc deficiency reduces not only the grain yield, but also the nutritional quality of grain (Cakmak, 2008) and ultimately nutritional quality of human diet. Zn is essential for both plants and animals because it is a structural constituent and regulatory co-factor in enzymes and proteins involved in many biochemical pathways (Kabata and Pendias, 2001). Zinc plays a vital role in synthesis of chlorophyll, protein and nucleic acid and helps in the utilization of nitrogen and phosphorous by plants as it acts an activator of dehydrogenase and proteinase enzymes, directly and indirectly in synthesis of carbohydrates and protein. Zinc is constituent of tryptophan which is precursor of auxin hormone. Chaube *et al.,* (2007) and Badiyala and Chopra (2011) were reported that use of Zn increase the productivity as well as improve the fertility status of soil. Thus, keeping these facts in view, a research problem was undertaken to find out the effect of zinc fertilization under different moisture conservation practices on yield and economics of pearl millet under rainfed conditions.

2. Materials and methods

The experiment was conducted at Agronomy Farm of S.K.N. College of Agriculture, Jobner (26^0 05' N latitude and 75^0 28' E longitude and at an altitude of 427 metres above mean sea level). The region falls in Agro-climatic zone III-a (Semi-Arid Eastern Plain) of Rajasthan. The climate of this region is a typically semi-arid, characterized by extremes of temperature during both summers and winters. The average annual rainfall of this tract varies from 300 mm to 400 mm and is mostly received during the month of July to September. During summer, temperature may go as high as 48^0C while in winter, it may fall as low as -1.5 ^{0}C. The relative humidity fluctuates between 43 to 87 per cent. There is hardly any rain during winter and summers. The experimental soil was loamy sand in texture with high infiltration rate (22.4 cm/hr) and saturated hydraulic conductivity 10.20 cm/h. The soil was low in organic carbon (0.24%), low available nitrogen (125.7 kg N/ha) and Zn (0.4 mg/kg of soil), medium in available phosphorus (16.12 kg P_2O_5/ha) and in available potassium (151.24 kg K_2O/ha). The soil was non saline with a pH value of 8.2. The experiment was laid out in randomized block design (RBD) comprised of five treatments of moisture conservation practices (control, dust mulch, pusa hydrogel, stover mulch and pusa hydrogel + stover mulch) and four treatments of zinc fertilization (control, 2.0kg Zn/ha and 4.0 kg Zn/ha and 6.0 kg Zn/ha) in pearl millet with three replications. The pearl millet variety 'RHB -173' was taken for experiment and planted at 45 cm x 10 cm spacing. Pusa hydrogel was applied in respective plots as band and Zinc fertilization treatments were applied as per treatment through zinc sulphate (ZnSO4.7H2O) containing 21% zinc and 10% S at the time of sowing as basal dose. The crop was grown with recommended package of practices. Need based application of pesticide was also followed to protect the crops from termites. The weight of the thoroughly sun dried harvested produce from net area of each plot was recorded separately before threshing and expressed as biological yield in kg/ha. After proper drying harvested produce were threshed separately. Grain yield from each net plot was recorded and computed as grain yield kg/ha. The stover yield for each plot was worked out by subtracting grain yield from total biomass of each net plot and stover yield was expressed in kg/ha. Economics of different treatment was worked out by taking into account the cost of inputs and income obtained from output based on the prevailing market price.

3. Results and discussion

3.1 Effect of moisture conservation practices in pearl millet

Effect on yields

Use of stover mulch in Pearl millet produced significantly higher grain (2511 kg/ha), stover (5765 kg/ha) and biological yield (8276 kg/ha) than control, dust mulch and pusa hydrogel but remained at par with pusa hydrogel + stover mulch. Harvest index was increased linearly with moisture management practices but fails to bring any significant improvement. The increase in grain yield of pearl millet with stover mulch might be due to the better availability of moisture and addition of organic matter. Rapid decomposition of organic residue helped in greater availability of nutrients, which led to increase in growth and yield attributes and finally the grain yield. Similar findings were also reported by Kumar and Gautam (2004) and Parihar *et al.,* (2012).

3.2 Effects on economics

Stover mulch remained at par to pusa hydrogel + stover mulch, fetched significantly higher profitability of ₹ 2950/ha which was higher by ₹ 12834/ha, ₹10316/ha and ₹ 8270/ha over control, dust mulch and pusa hydrogel, respectively. In terms of returns per rupee invested stover mulch application in pearl millet recorded significantly higher returns per rupee invested (1.80) over control.

3.3 Effect of zinc fertilization in pearl millet

3.3.1 Effect on yield

Yield and harvest index of pearl millet were enhanced significantly with zinc fertilization treatments. Application of 4.0 kg Zn/ha to pearl millet remained at par with 6 kg Zn/ha, produced significantly higher grain yield, stover yield, harvest index and net return as compared to control. Fertilization of pearl millet with 4.0 kg Zn/ha recorded significantly higher grain yield (2470 kg/ha), stover yield (5675 kg/ha) and biological yield (8145/ha) than lower levels of zinc, being at par with 6 kg Zn/ha. The cumulative beneficial effect of growth and yield attributing characters was finally reflected in grain yield of pearl millet. These results are in close conformity with Mehta *et al.,* (2008) and Ram Pratap *et al.,* (2008).

3.3.2 Effect on economics

Profitability of pearl millet was increased significantly with increasing levels of zinc up to 4.0 kg Zn/ha. Zinc fertilization treatment received 4.0 kg Zn/ha proved significantly profitable one with returns of ₹ 38347/ha with returns of ₹ 1.36 per rupee invested. This might be due to the cost involved under this treatment was comparatively lower than its additional income, which led to more returns under this treatment. Similar findings were also reported by Jakhar *et al.,* (2006).

Table 1: Yield performance of pearl millet as influenced by moisture conservation practices and zinc fertilization

Treatments	Grain yield (kg/ha)	Stover yield (kg/ha)	Biological yield (kg/ha)	Harvest index (%)
Moisture conservation practices				
Control	1905	4595	6500	29.28
Dust mulch	2112	4975	7087	29.77
Pusa hydrogel	2306	5385	7691	29.96
Stover mulch	2511	5765	8276	30.31
Pusa hydrogel + stover mulch	2613	5895	8506	30.67
SEM±	60	123	184	0.65
CD (P=0.05)	173	351	525	1.85
Zinc level (kg Zn/ha)				
0	1954	4694	6648	29.35
2	2246	5173	7419	30.23
4	2470	5675	8145	30.28
6	2486	5750	8236	30.14
SEM±	54	110	164	0.58
CD (P=0.05)	155	314	470	1.66

Table 2: Effect of moisture conservation practices and zinc fertilization on net returns and B: C ratio of pearl millet

Treatments	Net returns (□/ha)	B:C ratio
Moisture conservation practices		
Control	28283	1.32
Dust mulch	30801	1.30
Pusa hydrogel	32847	1.24
Stover mulch	41117	1.80
Pusa hydrogel + stover mulch	38167	1.37
SEM±	724	0.03
CD (P=0.05)	2073	0.08
Zinc level (kg Zn/ha)		
0	26978	1.14
2	33061	1.37
4	38347	1.56
6	38586	1.55
SEM±	648	0.02
CD (P=0.05)	1854	0.07

4. Conclusions

Based on the results of this experiment, it may be concluded that stover mulch was found significantly most suitable treatment for obtaining higher yield but it was at par with pusa hydrogel + stover mulch. However, these results are only indicative and require further experimentation to arrive at more consistent and final conclusion.

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