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Effect of bio-organics and seed priming on crop productivity, post-harvest soil fertility profile, biological counts and economics of pearl millet under rain-fed condition of Rajasthan

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Abstract
A field experiment was conducted during *kharif* seasons of 2022 and 2023 at the research farm of Rajasthan Agricultural Research Institute, Durgapura, Jaipur to study Effect of bio-organics and seed priming on crop productivity, post-harvest soil fertility profile biological counts and economics of pearl millet under rain-fed condition of Rajasthan". Experiment was conducted in split plot design and replicated thrice. Bio-organics factor comprised of 4 treatments, *viz*. Control, FYM + bio-mix, vermicompost + bio-mix and poultry manure + bio-mix and seed priming factor comprised of 4 treatments, *viz*. control, potassium nitrate @0.5%, salicylic acid @200 ppm and abscisic acid @150 ppm. Significantly higher grain, stover and biological yield of pearl millet were recorded with poultry manure+ bio-mix but these parameters were at par with vermicompost + bio-mix. Soil parameters *viz*. Ec, pH, available K, Fe and Zn numerical increase with poultry manure+ bio-mix. But available N, P and actinomycetes were obtained maximum under poultry manure+ bio-mix, bacteria and fungi were recorded higher with vermicompost+ bio-mix and FYM+ bio-mix, respectively. In seed priming treatments significantly higher grain, stover and biological yield of pearl millet were recorded under abscisic acid @150 ppm over control but these were recorded at par with salicylic acid @200 ppm. Soil nutrient and biological counts was not significantly influenced by seed priming. However, Gross returns was recorded significantly higher with abscisic acid @150 ppm but being at par with salicylic acid @200 ppm. Hence, poultry manure + bio-mix along with seed priming through salicylic acid @200 ppm may be recommended for enhancing crop productivity, quality and economics in pearl millet.

Keywords: Bio-organics, pearl millet, nutrient, seed priming, yield

Introduction
Among various millets, pearl millet is the most important staple food crop of arid and semi-arid regions of the country. Pearl millet is the most important cereal crops and widely grown in India because of its tolerance to drought, high temperatures and low soil fertility. Pearl millet stover is a useful livestock feed, whereas pearl millet grain is utilized as animal feed in poultry and cattle farms due to its high nutritional content. A 100 grams of Bajra contains- energy (360 calories), moisture (12 g), protein (12.1 g), fat (5 g), mineral (2 g), fibre (1g), carbohydrate (69.4 g), 2.4% sugar, calcium (42mg), phosphorus (242 mg) iron (8 mg) and high amount vitamins A and B (Anonymous 2014) [2]. During 2023, the overall acreage of our country was 7.55 million hectares with an overall production of 9.22 million tonnes. (Anonymous 2022-23a) [3]. The goal of organic farming is to maximize the use of organic resources. Some of the better options we have on the farm are plant-based nutrients, mineralization of nutrients, nutrient transformations, animal dung and urine, composts, vermicompost, poultry manure, green manures, legume crop rotations with BNF, and crop residues. These bio-organics have the capacity to fullfill nutrient demand of crops adequately and promote the activity of beneficial macro and micro flora in the soil. Preserving fertility and nutrition management (nitrogen self-sufficiency) are the two most important aspects of organic farming.

During the biological decomposition process, FYM, vermicompost, and poultry manure encourage the activity of microorganisms that help plants absorb macro- and micronutrients. Continous application of FYM on long-term basis can lead to increase the content of N, P, K, Ca, Mg and other soluble ions in soil (watts *et al*., 2010) [19] (Maman and Mason, 2013) [12]. *Azospirillum and Azotobacter* are benefit to plants by mechanisms related to enhancement of plant growth, increases the mineral uptake, increases the dry matter, improve the water absorption and improve the yield. The crop's growth parameters may have been enhanced by the roots' absorption of the nitrogen fixed by the azotobacter in the rhizosphere, the soil near the root zone. (Kumar *et al*., 2012) [10]. The conventional attitude to as a phenomenon usually drought occurring in arid and semi-arid areas because of failure and uncertainty of rainfall from south-west monsoon. Seed priming is a pre-sowing treatment which leads to a physiological state that enables seed to germinate more efficiency under drought stress. Seed priming ensures enhanced and uniform germination by reducing the imbibition time, increasing the pre-germination enzyme activation, improving metabolite production, repairing the damaged DNA, and regulating osmosis. (Balaji *et al.*, 2019) [4]

Materials & Methods

A field experiment was conducted during rainy (*kharif)* seasons of 2022 and 2023 at Agronomy Research Farm, Rajasthan Agricultural Research Institute, Durgapura, Jaipur, Rajasthan to study the "Effect of bio-organics and seed priming on crop productivity, post-harvest soil fertility profile, biological counts and economics of pearl millet under rain-fed condition of Rajasthan". The experimental site was located at 26°512 N latitude and 75°472E longitude and at an altitude of 390 m above mean sea level. The mean maximum temperature was 34.9 °C, 34.7 °C and minimum temperature was 21.6 °C, 18.7 °C and total rainfall was 725.2 mm and 604.7 mm during the crop period in the year 2022 and 2023, respectively. Well-drained loamy sand and coarse in texture soil was found at the experimental site. It was low in organic carbon (0.323%) and available nitrogen (140.0 kg/ha), medium in available phosphorus (29.7 kg/ha) and available potash (267.0 kg/ha) with pH 8.05 and EC 0.09 dS m^{-1}. DTPA extractable Zn and Fe was 0.54 and 2.98 ppm. The experiment was laid out in split plot design with 3 replications and 16 treatment combinations. First factor, 4 treatments of bio-organics, *viz*. F0: Control, F1: FYM + bio-mix, F_2: vermicompost + bio-mix and F3: poultry manure + bio-mix and second factor, 4 treatments of seed priming, *viz*. P0: control (water), P1: potassium nitrate @ 0.5%, P2: salicylic acis @ 200 ppm and P_3: abscisic acid 150 ppm. Bio-mix are microbial bio-fertilizer consortia (consisting of *Azotobactor*, *Azospirillium* and phosphate solubilizing bacteria) commercially branded as Bio-mix, convert nutrients present in the soil and in the manure to a form which can easily be absorbed by plants.The experiment was taken on the fixed site continuously for the two years. Certified seeds of pearl millet variety RHB - 234 were used for sowing. The seeds were sown manually 2-3 cm deep after seed priming in previously opened furrows as per the treatments with a recommended seed rate of 4.0 kg /ha. In organic plots whole RDF was applied through FYM, Vermicompost and poultry manure after calculating the concentration of nutrients present in them. For applying 100% RDN per hectare through FYM, 12.5 tons of well decomposed FYM., having 0.48, 0.23, 0.49% NPK was applied in the plots before sowing and mixed well, 3 tons of vermicompost having 2.0, 1.4, 0.90% NPK was applied for 100%, in the plots Likewise, 2 tons of poultry manure having 3.0, 2.60, 1.4% NPK was applied for 100%, in the plots before sowing. In both the year crop was sown in second week of July and harvested in first week of October. Harvesting was done from the net plot area (3 × 2.7 m^2marked by leaving border rows), harvested samples were sun-dried for three days and weighed for total biological yield. Thereafter the samples were threshed, cleaned and dried to obtain 14% content to measure grain yield and then expressed in kilogram/ hectare (kg/ha). Ec, pH, OC, available nitrogen phosphorus, potassium Zinc and Iron and biological counts were estimated from the freshly collected rhizospheric soil samples by walkley and black rapid titration method (Jackson 1973) [8], Alkaline permanganant method (Subbiah and Asija, 1956) [17], olsen's method (1954), Flame photometer method (Jackson, 1973) [8], Lindsay and Norvell (1978) and Allen, Martin, Allen (1959) [1] respectively. Minimum support price of pearl millet for the respective year was used to calculate net returns. Experimental data was statistically analyzed by the standard technique of analysis of variance (ANOVA) and significance was tested by F-test at 5% level of significance.

Results and discussion

Crop productivity: Yield *viz*. grain yield, stover yield, and biological yield were significantly influenced by both bio-organics and seed priming (Fig 1). Grain, stover and biological yield were reported significantly higher under poultry manure + bio-mix over control but was being equivalent with vermicompost + bio-mix. Poultry manure+ bio-mix recorded 1096, 2352 and 3448 kg/ha higher grain, stover and biological yield over control and 631, 1298 and 1930 kg/ha higher grain, stover and biological yield over FYM + bio-mix during pooled basis, respectively. However, the grain, stover and biological yield with vermicompost + bio-mix was similar from the yield under poultry manure + bio-mix. The reason for increase in 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 earhead. The results are in conformity with those of Kumar *et al.* (2022) [11] and Nazeema and Mehera (2022) [14]. Yield *viz*. grain, stover and biological yield were significantly higher (897, 1933, 2829 kg/ha) under abscisic acid @ 150 ppm over control, respectively, but were at par with salicylic acid @ 200 ppm. (Kanwar *et al.*, 2017) [9] and Balaji *et al.* (2019) [4] also reported similar results.

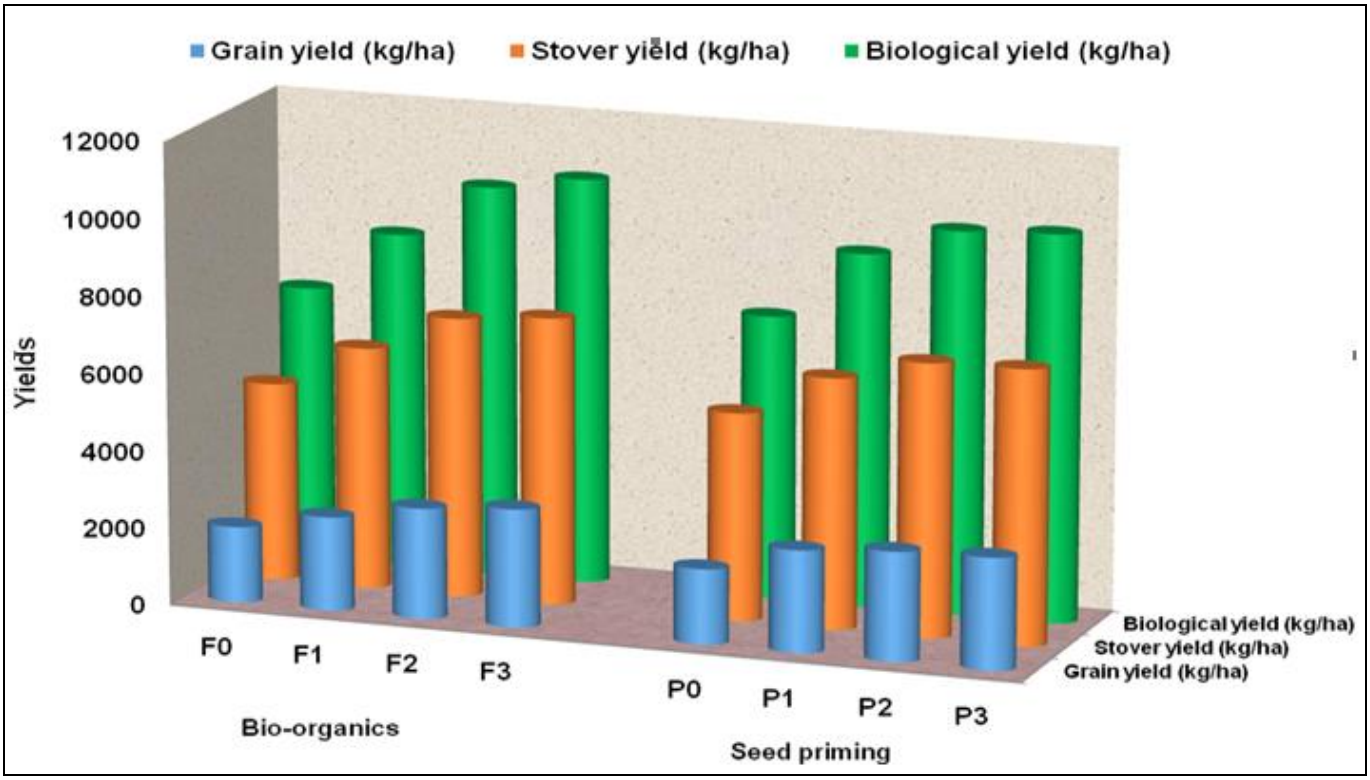

Fig 1: Effect of bio- organics and seed priming on grain, stover and biological yield of pearl millet

Nutrient content in soil

Nutrient content *viz.* available N, P, and biological count (bacteria, fungi and actinomycetes)) were influenced significantly by the bio-organics only but, Ec, pH, OC available K, Fe and Zn were non- significantly affected by bio-organics and Ec, pH, OC available N, P, K, Fe and Zn and biological counts such as bacteria, fungi and actinomycetes were not significantly influenced by seed priming treatments during both the years (Table1 and Table 2). Poultry manure + bio-mix recorded higher available nitrogen (173 and 181 kg/ha), phosphorus uptake (47.04 and 52.65 kg/ha) and actinomycetes (4.93 and 4.67 x 10^6cfu/g soil) in comparison to control during both the years, respectively and however these parameters were also similar with vermicompost + bio-mix. But in the case of available N and actinomycetes population in soil after crop harvest FYM + bio-mix was found similar with poultry manure + bio-mix and vermicompost during both the years. Vermicompost + bio-mix recorded higher bacteria population (7.83 in 2022 and 7.37 x 10^9cfuin 2023) over to control, but was being equivalent with vermicompost + bio-mix during individual's years of experimental. FYM + bio-mix was obtained maximum colony of fungi (5.30 and 5.14 x 105 cfu/g soil) in comparison to control, while being at par with vermicompost + bio-mix and FYM + bio-mix during both years. Addition of bio-mix *i.e.* live population of nutrient cycling microbes might have acted on the existing organic matter to get food substrate, favorable habitat and soil environment and thus proliferated heavily resulting in microbial biomass enhancement and improve nutrient content in soil under the treatment. The results are in conformity with those of Bharti *et al.* (2022) and Hegad *et al*. (2023). In case of seed priming was not significantly affected on Ec, pH, OC, available N, P, K, Fe and Zn and biological counts in soil after crop harvest. The results are in line with findings of Patil *et al*. (2018) [16].

Economics

Gross returns were recorded significantly higher with poultry manure + bio-mix during both the years of experimentation. Among seed priming significantly higher gross returns were recorded with abscisic acid @ 150 ppm which were at par with salicylic acid @ 200 ppm.

It may be concluded that poultry manure + bio-mix recorded higher yield and soil fertility and microbial population but results were at par with vermicompost + bio-mix. In case of seed priming, abscisic acid @ 150 ppm recorded higher yield and after salicylic acid @ 200 ppm and were economically feasible too but soil fertility was not significantly influenced by seed priming. Thus, poultry manure + bio-mix along with seed priming through salicylic acid @ 200 ppm or abscisic acid @ 150 ppm can be recommended for enhancing growth, productivity, profitability and quality of pearl millet.

Table 1: Effect of bio-organics and seed primingon zinc and iron content and biological counts of soil after harvest

Treatments	Fe (ppm)		Zn (ppm)		Bacteria (x10^9 cfu/g soil)		Fungi (x10^{5}cfu/g soil)		Actinomycetes (x 10^{6}cfu/ g soil)	
	2022	2023	2022	2023	2022	2023	2022	2023	2022	2023
Bio-organics										
F_0: Control	0.080	0.079	8.05	7.95	5.55	4.95	4.55	4.35	3.75	3.95
F_1: FYM + Bio-mix	0.078	0.078	7.49	7.48	7.58	7.12	5.30	5.14	4.88	4.46
F_2: Vermi-compost + Bio-mix	0.077	0.077	7.51	7.56	7.83	7.37	5.15	5.07	4.83	4.65
F_3: Poultry manure + Bio-mix	0.076	0.076	7.64	7.62	7.35	6.85	5.25	5.10	4.93	4.67
SEm±	0.001	0.001	0.26	0.24	0.13	0.13	0.13	0.13	0.12	0.12
CD (P=0.05)	NS	NS	NS	NS	0.44	0.45	0.44	0.45	0.42	0.42
Seed priming										
P_0: Control (water)	0.079	0.079	8.03	7.99	6.86	6.42	5.00	4.83	4.45	4.33
P_1: Potassium nitrate (0.5%)	0.078	0.078	7.50	7.48	7.03	6.55	5.06	4.88	4.59	4.40
P_2: Salicylic acid (200ppm)	0.077	0.077	7.52	7.50	7.23	6.71	5.10	4.90	4.64	4.48
P_3: Abscisic acid (150ppm)	0.076	0.077	7.63	7.65	7.18	6.61	5.08	5.05	4.71	4.52
SEm±	0.001	0.001	0.22	0.21	0.11	0.09	0.10	0.09	0.10	0.09
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

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