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Research Article

EFFECT OF BIOFERTILIZERS ON QUALITY AND YIELD OF PEARL MILLET UNDER RAINFED CONDITION

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Abstract: The field experiment was conducted at Research Farm Area, Department of Genetics and Plant Breeding, CCS Haryana Agricultural University, Hisar during *Kharif* 2016 to study the effect of biofertilizers on quality and yield of pearl millet under rainfed condition. The soil of the experimental site was low in organic carbon, slightly alkaline in reaction, non-saline, low in available N, medium in available P and high in available K. Twelve treatments *i.e.* T1(Control), T2 (Seed treatment with Biomix), T3(Foliar spray of *Azotobacter* isolate JFS5 @ 108cfu ml^{-1} at 15 DAS), T4(Foliar spray of *Azotobacter* isolate JFS5 @ 108cfu ml^{-1} at 30 DAS), T5[RDF (40 kg N + 20 kg P_2O_5 ha^{-1})], T6[75 % RDF (30 kg N + 15 kg P_2O_5 ha^{-1}], T7(T5 + seed treatment with Biomix), T8(T5 + foliar spray of *Azotobacter* isolate JFS5 @ 108cfu ml^{-1} at 15 DAS), T9(T5 + foliar spray of *Azotobacter* isolate JFS5 @ 108cfu ml^{-1} at 30 DAS), T10(T6 + seed treatment with Biomix), T11(T6 + foliar spray of *Azotobacter* isolate JFS5 @ 108cfu ml^{-1} at 15 DAS), T12(T6 + foliar spray of *Azotobacter* isolate JFS5 @ 108cfu ml^{-1} at 30 DAS) were laid out in RBD in three replicates. The combined application of biomix along with RDF (recommended dose of fertilizer) increased the protein content in grain over the control up to the extent of 16 percent. N content, Nand P uptake in grain was significantly increased in treatment T7[T5 + seed treatment with Biomix] then T1- control. The N and P uptake ranged from 28.41-59.01 and 4.30-9.70 kg/ha among different treatments with the maximum with T7. The highest protein yield recorded with the combined application of biomix along with RDF (T7) was 107.8 and 17.3 percent higher over control (T1) and RDF (T5), respectively.

Keywords: *Pearl Millet, Biomix, Azotobacter, Azospirillum, PSB, N content, P content, Protein content*

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Introduction

Pearl millet [*Pennisetum glaucum* (L) R.Br.] is the staple food of majority of the poor and small land holders, as well as feed and fodder for livestock in the rainfed regions of the country. It is usually grown under adverse agro-climatic conditions where other crops like sorghum and maize fail. Pearl millet is well adapted to drought prone areas, low soil fertility and high temperature conditions. It is a nutritious cereal, good source of protein (11.6%), fat (5%), carbohydrate (67%) and minerals particularly iron (2.8%). It is generally grown in arid and semi-arid areas where soils are sandy loam with low fertility, poor microbial activity, low organic content, less water holding capacity and low annual rainfall (150-400 mm). In India, pearl millet is the third most widely cultivated food crop after rice and wheat. It was grown on 7.50 million ha area with production of 9.73 million tonnes and productivity of1305 kg ha^{-1} during 2018-19. In Haryana, the area under this crop is 4.50 lakh ha with production and productivity of 7.21 lakh tons and 1602 kg ha^{-1}, respectively during2017 season [1]. Cultivation of hybrids has played an important role in increasing productivity of pearl millet. The average yield of pearl millet in the country as well as in the state is quite low as compared to its potential yield (up to 50 q ha^{-1}) because it is grown in the marginal areas with poor management practices. So, there is considerable scope for increasing the productivity of pearl millet by adopting location specific agronomic practices for suitable hybrids/varieties. The micro-organisms play a crucial role in the life cycle of plants through number of processes such as decomposition, solubilisation, fixation and supply of plant nutrients. Being a low-cost input, biofertilizers play an important role in minimizing our dependence on synthetic fertilizers. Mixed biofertilizers are nitrogen fixing, plant growth promoting and PSB.

Biofertilizers enhances carbon and nitrogen mineralization by narrowing down C: N ratio and promoting soil microbial activities besides decline in bulk density and increasing water holding capacity [2]. Use of biofertilizer (*Azospirillum*+ Vesicular-arbuscular mycorrhiza) led to higher availability of nitrogen and phosphorus that promoted growth and development, and ultimately resulted in higher yield [3]. Application of recommended dose of fertilizer (NPK 100: 50: 50 kg ha^{-1}) + FYM + microbial consortium (*Azospirillum* + phosphate solubilizing bacteria) with soil application of bio-digester at 30, 60 and 90 days after sowing (DAS) in rice recorded significantly higher protein (8.75%) and starch (22.70%) as compared to the treatment FYM (⅓) + vermicompost (⅓) + green leaf manure (⅓) equivalent to RDN (protein content 5.83% and starch content 20.2%) [4]. The microbial communities of leaves are diverse and include many genera of bacteria, filamentous fungi, yeasts and algae which are important for plant health and growth [5, 6]. Microorganisms in the phyllosphere can promote plant growth through the production of hormones (Auxins, Gibberlins, and Ethylene *etc.*). Indole acetic acid (IAA) is one of the most physiologically active (Auxins). Microorganisms may protect plants, against the pathogens by inducing systemic resistance [7].

Material and Methods

The field experiment was conducted at Research Farm Area, Department of Genetics and Plant Breeding, CCS Haryana Agricultural University, Hisar during *Kharif* 2016 to study the effect of biofertilizers on quality and yield of pearl millet under rainfed condition.

Hisar is situated at latitude of 29°10´N, longitude of 75°46´E and at a height of 112 m above mean sea level with semi-arid and subtropical climate, hot and dry summer and severe cold in winter. The rainfall is highly erratic with 20-30 percent annual and 30-50 percent seasonal variations. Mean relative humidity remains nearly constant at about 80-90% from July to end of March and decreases to about 40-50% by the end of April. The mean maximum temperature during crop season varied from 32.7 to 36.1°C and mean minimum temperature ranged from 19.4 to 26.9°C. The amount of total rainfall received during the crop period was 365.4 mm. Weekly weather data during the crop season is given in [Fig-1]. The field experiment was laid out in randomized block design in three replicates. Twelve treatments were -T1 (Control), T2 (Seed treatment with Biomix), T3 (Foliar spray of *Azotobacter* isolate JFS5 @ 108cfu ml^{-1} at 15 DAS), T4(Foliar spray of *Azotobacter* isolate JFS5 @ 108cfu ml-1 at 30 DAS), T5 [RDF (40 kg N+20 kg P_2O_5 ha^{-1})], T6 [75 % RDF (30 kg N+15 kg P_2O_5 ha^{-1}], T7 (T5+seed treatment with Biomix), T8 (T5+foliar spray of *Azotobacter* isolate JFS5 @ 108cfu ml^{-1} at 15 DAS), T9 (T5+foliar spray of *Azotobacter* isolate JFS5 @ 108cfu ml^{-1} at 30 DAS), T10 (T6+seed treatment with Biomix), T11 (T6+foliar spray of *Azotobacter* isolate JFS5 @ 108cfu ml^{-1} at 15 DAS), T12 (T6+foliar spray of *Azotobacter* isolate JFS5 @ 108cfu ml^{-1} at 30 DAS). The soil of the experimental site was sandy loam in texture, low in organic carbon (0.30%), slightly alkaline in reaction (pH 8.0), non-saline (EC 0.13 dS/m), low in available nitrogen (133 kg/ha), medium in available phosphorus (13 kg/ha) and high in available potassium (305 kg/ha). The hybrid HHB 197 was used in the experiment. Full dose of P and half dose of N were applied as basal dose. And remaining N was top-dressed after thinning and gap filling at 22 DAS.N content in digested grain samples were determined by Nessler's Reagent Method [8] and P content was determined by Vanadomolybdo phosphoric acid yellow colour method [9]. Protein content of grain was worked out by multiplying percent nitrogen in grain with a conversion factor of 6.25.

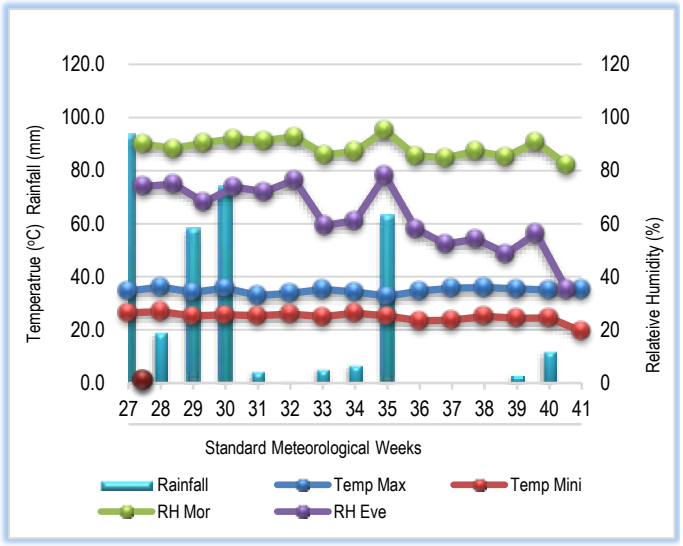

Fig-1 Weekly weather data during the crop season (*Kharif* 2016)

Results and Discussion

Quality and nutrient uptake in pearl millet

N content and uptake

The data presented in [Table-1] reveal that the estimated nitrogen content (%) in grain among the treatments varied from 1.52 to 1.77%. The treatment T7- [40 kg N + 20 kg P_2O_5 ha^{-1} + seed treatment with Biomix] had significantly higher N content in grain as compared to rest of the treatments but it was found statistically at par with T8- [T5 + foliar spray of *Azotobacter* isolate JFS5 @ 108cfu ml^{-1} at 15 DAS] and T10- [T6 + seed treatment with Biomix]. The maximum nitrogen content (1.77%) estimated with T7 was 16.4 and 5.4 percent higher over control and RDF, respectively. The increase in nitrogen content in grain under Biomix inoculation treatment might be due to more availability of nitrogen under inoculation treatment [10]. The range of nitrogen uptake in grain ranged from 28.4 to 59.0 kg ha^{-1} among the treatments, and the treatment T7 [40 kg N + 20 kg P_2O_5 ha^{-1} + seed treatment with Biomix] had significantly more uptake of nitrogen than all other treatments. The seed treatment with Biomix alone and application of inorganic fertilizers along with Biomix or foliar application of *Azotobacter* isolates caused significant increase in N uptake by grain than the T1(control). The increased uptake of nitrogen (kg ha^{-1}) under inoculation treatment could be attributed to the increased content of nitrogen and higher grain yield of pearl millet [11].

Phosphorus content and uptake

Perusal of the data from [Table-1] reveal that the phosphorus content also followed the same trend as was noticed in case of N content in grain. Highest phosphorus content (0.29 %) was estimated in treatment T7 [40 kg N + 20 kg P_2O_5 ha^{-1} + seed treatment with Biomix]. P content ranged from 0.23 to 0.29 percent among different treatments. The maximum phosphorus content (0.29%) was estimated with combined application of RDF+Seed treatment with biomix (T7) was 26.1 and 7.4 percent higher over control (T1) and RDF (T5), respectively. The biofertilizers inoculation might have increased the availability of nutrients to the plants by improving root rhizosphere, which ultimately increased the phosphorus content in grain [12, 2]. Maximum P uptake in grain was also in treatment T7[40 kg N + 20 kg P_2O_5 ha^{-1} + seed treatment with Biomix], which was statistically atpar with the treatment T5[RDF (40 kg N + 20 kg P_2O_5 ha^{-1})], T8- [T5 + foliar spray of *Azotobacter* isolate JFS5 @ 108 cfu/ml at 15 DAS] and T9[T5 + foliar spray of *Azotobacter* isolate JFS5 @ 108cfu ml^{-1}] at 30 DAS and uptake was 5.4 kg ha^{-1} more than the control (T1). The increased uptake of phosphorous under inoculation treatment could be attributed to the increased phosphorous content and higher stover yield because of the fact that mixed biofertilizers might have enhanced the availability of phosphorous to plants and increased root growth and ability of plant roots to absorb more phosphorous [13].

Protein content and its yield

The data presented in [Table-2] reveal that all the treatments receiving N, P and Biomix (T7 to T12) showed their statistical superiority in the protein content over the control, however, the highest protein content (11.04%) in grain was estimated in treatment T7 [40 kg N + 20 kg P_2O_5 ha^{-1} + seed treatment with Biomix], which was statistically at par with T8 [T5 + foliar spray of *Azotobacter* isolate JFS5 @ 108 cfu/ml at 15 DAS] (10.96%) and T9 [T5 + foliar spray of *Azotobacter* isolate JFS5 @ 108cfu ml^{-1} at 30 DAS] (10.86%) treatment. The maximum protein content (11.04%) estimated with combined application of RDF+Seed treatment with biomix (T7) was 16.0, 7.9 and 5.1 percent higher over control (T1), 75% RDF (T6) and RDF (T5), respectively. The increase in protein content in grain under Biomix inoculation treatment might be due to more availability of nitrogen and solubilization of fixed phosphorous under inoculation treatment [10]. The highest protein yield in grain was also recorded in the treatment T7 [40 kg N + 20 kg P_2O_5 ha^{-1} + seed treatment with Biomix] (368.8 kg ha^{-1}), which was significantly superior to all the treatments. Protein yield in treatment T7 [T5 + seed treatment with Biomix], T8 [T5 + foliar spray of *Azotobacter* isolate JFS5@ 108cfu ml^{-1} at 15 DAS, T9 [T5 + foliar spray of *Azotobacter* isolate JFS5 @ 108 cfu ml^{-1} at 30 DAS]and T10 [T6 + seed treatment with Biomix] was 191.3, 163.7, 151.9 and 134.6 kg ha^{-1} higher over the control, respectively. The maximum protein protein yield (368.8 kg ha^{-1}) recorded with combined application of RDF+Seed treatment with Biomix (T7) was 107.8, 42.1 and 17.3 percent higher over control (T1), 75% RDF (T6) and RDF (T5), respectively.

Effect of biofertilizer on pearl millet yield

Data given in [Table-3] shows that the pearl millet grain yield was significantly highest (33.40 q ha^{-1}) in the treatment T7 [40 kg N+20 kg P_2O_5 ha^{-1}+ seed treatment with Biomix] except T8 and T9. The combined application of Biomix along with RDF increased the grain yield by 44.2% over the control. This might be due to better root growth and development, resulting in more nutrients uptake and higher dry matter accumulation plant and its subsequent translocation to the developing panicle. Similar results have also been reported by Piccinin *et al.* (2011) and Patil *et al.* (2018) [14 &15]. Singh *et al.* (2018) [16] also reported that due to use of biofertilizer combinations grain and stover yield was increased by 79 percent 23 percent respectively over the control in pearl millet.

Table-1 *Effect of different nutrient management practices on N and P contents (%) and their uptake (kg ha^{-1}) in pearl millet*

Treatment	N content (%)	N uptake (kg ha^{-1})	P content (%)	P uptake (kg ha^{-1})
T_1: Control	1.52	28.41	0.23	4.3
T_2: Seed treatment with Biomix*	1.55	34.77	0.25	5.7
T_3: Foliar spray of*Azotobacter*isolate JFS5 @ 10^8cfu ml^{-1} at 15 DAS	1.54	32.95	0.21	4.47
T_4: Foliar spray JFS5 @ 10^8cfu ml^{-1} at 30 DAS	1.53	33.35	0.23	5
T_5: RDF (40 kg N + 20 kg P_2O_5 ha^{-1})	1.68	50.29	0.27	8.2
T_6: 75% RDF (30 kg N + 15 kg P_2O_5 ha^{-1})	1.64	41.52	0.26	6.57
T_7: T_5 + seed treatment with Biomix	1.77	59.01	0.29	9.7
T_8: T_5 + foliar spray of *Azotobacter* isolate JFS5 @ 10^8 cfu ml^{-1} at 15 DAS	1.75	54.6	0.28	8.6
T_9 :T_5 + foliar spray of *Azotobacter* isolate JFS5 @ 10^8 cfu ml^{-1} at 30 DAS	1.72	52.7	0.27	8.3
T_{10}: T_6 + seed treatment with Biomix	1.74	49.93	0.28	7.97
T_{11}: T_6 + foliar spray of *Azotobacter* isolate JFS5 @ 10^8 cfu ml^{-1} at 15 DAS	1.69	45.7	0.27	7.33
T_{12}: T_6 + foliar spray of *Azotobacter* isolate JFS5 @ 10^8 cfu ml^{-1} at 30 DAS	1.67	45.31	0.26	7.17
SE m±	0.01	0.3	0.01	0.22
CD at 5%	0.03	0.93	0.023	0.64

*Biomix = *Azotobacter* + *Azospirillum* + Phosphate solubilising bacteria

Table-2 *Effect of different nutrient management treatments on protein content and protein yield of pearl millet*

Treatment	Protein content (%)	Protein yield (kg ha^{-1})
T_1: Control	9.52	177.5
T_2: Seed treatment with Biomix*	9.69	217.3
T_3: Foliar spray of *Azotobacter* isolate JFS5 @ 10^8cfu ml^{-1} at 15 DAS	9.63	206
T_4: Foliar spray JFS5 @ 10^8cfu ml^{-1} at 30 DAS	9.56	208.5
T_5: RDF (40 kg N + 20 kg P_2O_5 ha^{-1})	10.5	314.4
T_6: 75% RDF (30 kg N + 15 kg P_2O_5 ha^{-1})	10.23	259.5
T_7: T_5 + seed treatment with Biomix	11.04	368.8
T_8: T_5 + foliar spray of *Azotobacter* isolate JFS5 @ 10^8cfu ml^{-1} at 15 DAS	10.96	341.2
T_9 :T_5 + foliar spray of *Azotobacter* isolate JFS5 @ 10^8cfu ml^{-1} at 30 DAS	10.73	329.4
T_{10}: T_6 + seed treatment with Biomix	10.86	312.1
T_{11}: T_6 + foliar spray of *Azotobacter* isolate JFS5 @ 10^8cfu ml^{-1} at 15 DAS	10.56	285.6
T_{12}: T_6 + foliar spray of *Azotobacter* isolate JFS5 @ 10^8cfu ml^{-1} at 30 DAS	10.44	283.2
SE m±	0.07	2
CD at 5%	0.21	5.8

*Biomix = *Azotobacter* + *Azospirillum* + Phosphate solubilising bacteria

Table-3 *Effect of different nutrient management treatments on yield of pearl millet*

Treatment	Yield (q ha^{-1})		
	Grain	Stover	Biological
T_1: Control	18.64	46.95	65.59
T_2: Seed treatment with Biomix*	22.43	57.69	80.13
T_3: Foliar spray of *Azotobacter* isolate JFS5 @ 10^8cfu ml^{-1} at 15 DAS	21.39	56.09	77.49
T_4: Foliar spray JFS5 @ 108cfu ml^{-1} at 30 DAS	21.8	54.5	76.3
T_5: RDF (40 kg N + 20 kg P_2O_5 ha^{-1})	29.93	72.65	102.59
T_6: 75% RDF (30 kg N + 15 kg P_2O_5 ha^{-1})	25.36	63.42	88.78
T_7: T_5 + seed treatment with Biomix	33.4	81.5	114.9
T_8: T_5 + foliar spray of *Azotobacter* isolate JFS5 @ 10^8 cfu ml^{-1} at 15 DAS	31.14	76.28	107.42
T_9 :T_5 + foliar spray of *Azotobacter* isolate JFS5 @ 10^8 cfu ml^{-1} at 30 DAS	30.7	74.25	104.95
T_{10}: T_6 + seed treatment with Biomix	28.75	73.55	102.3
T_{11}: T_6 + foliar spray of *Azotobacter* isolate JFS5 @ 10^8 cfu ml^{-1} at 15 DAS	27.04	70.83	97.87
T_{12}: T_6 + foliar spray of *Azotobacter* isolate JFS5 @ 10^8 cfu ml^{-1} at 30 DAS	27.13	68.62	95.75
SE m±	1.13	2.06	2.77
CD at 5%	3.35	6.09	8.19

**Biomix = Azotobacter + Azospirillum + Phosphate solubilising bacteria*

The increased production of pearl millet could be ascribed to bio-fertilizers *viz*., *Azospirillum* and *Azotobacter*, which fixed atmosphere nitrogen into the soil and made it available to the plants[17].The stover yield was also found significantly maximum in treatment T7 but it was statistically at par with T8[T5 + foliar spray of *Azotobacter* isolate JFS5 @ 108cfu ml^{-1}at 15 DAS]. The stover yield of T7 was 42.4% higher than control (T1). Seed treatment with Biomix or *Azotobacter* isolate JFS5 significantly increased the Stover yield in treatment T7. This increase in Stover yield might be attributed to increased height, leaf area and dry matter production. In the inorganic + biofertlizer treatments, the positive benefits of seed bacterization could be attributed mainly to nitrogen fixation and other factors like release of hormones, increase of plant growth promoting substances (PGPS) and nutrients uptake. The results of almost similar nature were also reported by Guggari and Kalaghatagi (2003) and Neelam *et al*. (2009) [18,19].

Conclusion

The highest pearl millet grain yield recorded with the application of Biomix bio-inoculants along with RDF (T7: 40 kg N + 20 kg P_2O_5 ha^{-1}+ seed treatment with Biomix) was 79.2 and 60.6 and percent higher over the control(T1) and RDF (T5), respectively. The highest protein yield recorded with the combined application of biomix along with RDF was also 107.8 and 17.3 percent higher over control and RDF, respectively. The N, P content and their uptake as well as protein content in grain were also recorded higher in T7. The treatments involving biofertilizers along with inorganic fertilizer improved the microbial population (*Azotobacter* + *Azospirillum* + PSB) as compared to inorganic fertilizers alone.

Application of research: The Use of biofertilizers along with inorganic fertilizer improved the microbial population which has positive influence on growth, development and yield of pearl millet.

Research Category: Agronomy

Abbreviations: RDF: Recommended Dose of Fertilizer

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Study area / Sample Collection: Research Farm Area, Hisar

Cultivar / Variety / Breed name: HHB 197

Conflict of Interest: None declared

Ethical approval: This article does not contain any studies with human participants or animals performed by any of the authors.
Ethical Committee Approval Number: Nil

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