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RESPONSE OF PEARL MILLET TO RHIZOSPHERE BIOFERTILIZERS AND FOLIAR APPLICATION OF *AZOTOBACTER* ISOLATE UNDER RAINFED SITUATION

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SUMMARY

The field experiment entitled *"Response of pearl millet to Rhizosphere bioferilizers and foliar application of isolate under rainfed conditions*" was conducted during the *Kharif* season of 2016 at the Research Farm of Genetics and Plant Breeding of Chaudhary Charan Singh Haryana Agricultural University, Hisar with the objective to study the effect of different bio-inoculants (Biomix and *Azotobacter*) as seed treatment or foliar application along with and without recommended inorganic fertilizers on growth, yield, quality, microbial counts and economics of pearl millet. Twelve different nutrient management combinations *i.e.* T_1 (Control), T_2 (Seed treatment with Biomix), T_3 (Foliar spray of *Azotobacter)* isolate *JFS5* @ 10^8cfu/ml at 15 DAS , T_4 (Foliar spray of *Azotobacter* isolate *JFS5* @ 10^8 cfu/ml at 30 DAS) , T_5 (RDF (40 kg N + 20 kg P_2O_5/ha) , T_6 (75 % RDF (30 kg N + 15 kg P_2O_5/ha) , T_7 (T_5 + seed treatment with Biomix), T_8 (T_5 + foliar spray of *Azotobacter* isolate *JFS5* @ 10^8 cfu/ml at 15 DAS), T_9 (T_5 + foliar spray of *Azotobacter* isolate *JFS5* @ 10^8 cfu/ml at 30 DAS) , T_{10} (T_6 + seed treatment with Biomix), T_{11} (T_6 + foliar spray of *Azotobacter* isolate *JFS5* @ 10^8cfu/ml at 15 DAS) and T_{12} (T_6 + foliar spray of *Azotobacter* isolate *JFS5* @ 10^8 cfu/ml at 30 DAS) was laid out in randomized block design along with three replications. The combined application of Biomix bio-inoculants along with RDF (T_7) significantly delayed various phenological events; wherein 50 percent flowering and physiological maturity was delayed by 4.0 and 3.7 days, respectively by this treatment compared to control. The yield attributing parameters [number of ear heads/plant, ear head length (cm), ear head girth (mm), test weight (g)] were also recorded significantly highest under this treatment T_7. The pearl millet grain and dry fodder yield were increased by 44.2% (33.40 q/ha) and 42.4% (81.50 q/ha), respectively under T_7 treatment over the control (18.64 q/ha grain; 46.95 q/ha dry fodder yield).

Key words : Pearl millet, biomix, *Azotobacter, Azospirillum, Phosphate solubilizing bacteria*, phyllosphere, phenology, yield attributes, grain & stover yield

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 was grown on 7.50 million ha area with production of 9.73 million tonnes with average productivity of 1305 kg/ha during 2018-19 (Directorate of Millet Development, 2019). 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, respectively during 2017 season (Anonymous, 2018). Introduction of hybrids have played an important role in increasing productivity of the crop. 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 50.0 q/ha) 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 better agronomic practices in the high yielding hybrids/ varieties. After green revolution in 1965-66, the continuous utilizations of chemical fertilizers increased the productivity but, had adverse effect on soil health and environment. Chemical fertilizers alone are costly and also do not support optimal microbial activities. The microbes play a significant role in the life cycle of plants through number of processes such as decomposition, solubilisation, fixation and supply of plant nutrients. The bio-fertilizers may play an important role in minimizing our dependence on inorganic fertilizers. The occurrence of nitrogen fixing and phosphorus solubilising bacteria within the rhizosphere of plants of economic importance is being recently harnessed in Indian agriculture. Inoculation of these bacteria has synergic and additive effects on

plant growth besides reducing the cost of cultivation.

The studies on seed inoculation with bio-fertilizers in the rhizosphere have been carried out at large scale levels but only very few experiments on the foliar application of bio-inoculants in pearl millet crop are being conducted. The phyllosphere refers to leaf surfaces, or total above ground surfaces of plants as a habitat for microorganisms. The inhabitants of the phyllosphere are termed epiphytes. 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 (Vorholt, 2012). Microorganisms in the phyllosphere can promote plant growth through the production of hormones (Auxins, Gibberlins, Ethylene etc.). They can also be involved in plant protection, which is due to direct interactions of microorganisms through the production of antibiotic compounds and competition for resources (Berg, 2009). Therefore, the present investigation was conducted to supplement the suboptimal use of RDF by use of bio-fertilizers as seed treatment and application of *Azotobacter* isolates as foliar sprays in pearl millet with the objectives to study the impact of rhizosphere bio-fertilizers and foliar application of *Azotobacter* isolate on phenology, yield attributes and yield of pearl millet.

MATERIALS AND METHODS

The present experiment entitled *Response of pearl millet to Rhizosphere biofertilizers and foliar application of Azotobacter isolate under rain fed conditions* was conducted at Research Area of the Department of Genetics and Plant Breeding, CCS Haryana Agricultural University, Hisar during *Kharif* season of 2016. Hisar is situated at latitude of 29° 10°N, longitude of 75°46′E and at a height of 112 meters above mean sea level with semi-arid and subtropical climate, hot and dry summer and severe cold in winter. 1. The experiment was laid out in Randomized block design with three replications and twelve treatments i.e. T_1: Control ,T_2 : Seed treatment with Biomix (*Azotobacter* + *Azospirillum* + Phosphorus Solublizing Bacteria), T_3 : Foliar spray of *Azotobacter* isolate *JFS5* @ 10^8cfu/ml at 15 DAS, T_4: Foliar spray of *Azotobacter* isolate *JFS5* @ 10^8 cfu/ml at 30 DAS, T_5: RDF (40 kg N + 20 kg P_2O_5/ha), T_6 : 75 % RDF (30 kg N + 15 kg P_2O_5/ha) , T_7 : T_5 + Seed treatment with Biomix, T_8 : T_5 + Foliar spray of *Azotobacter* isolate *JFS5* @ 10^8cfu/ml at 15 DAS, T_9 : T_5 + Foliar spray of *Azotobacter* isolate *JFS5* @ 10^8 cfu/ml at 30 DAS, T_{10} : T_6 +Seed treatment with Biomix, T_{11} : T_6 + Foliar spray of *Azotobacter* isolate *JFS5* @ 10^8cfu/ml at 15 DAS , T_{12} : T_6 + Foliar spray of *Azotobacter* isolate *JFS5* @ 10^8 cfu/ml at 30 DAS. The soil of the experimental site was sandy loam in texture, low in organic carbon, slightly alkaline in reaction, non saline, low in available nitrogen, medium in available phosphorus and high in available K. The mean maximum temperature during crop season varied from 32.7 to 36.1°C and mean minimum temperature ranged from19.4 to 26.9°C. The amount of total rainfall received during the crop period was 365.4 mm. Certified seed of hybrid HHB 197 was sown at about 2.0 cm depth by drilling in rows using 5 kg seed/ha. Seed treatment with biomix was also done as per the treatments. Full dose of phosphorus (20 kg P_2O_5/ha) and half dose of nitrogen were applied as per the treatments at the time of sowing and rest of the nitrogen was top dressed after thinning and gap filling. Urea (46% N), Diammonium Phosphate (18% N, 46% P_2O_5) and bio-fertilizers were used as the sources of N and P, respectively. Five representative plants from each plot were selected randomly and tagged for observing the effect of different treatments on plant characters. All biometric observations except dry matter and leaf area were recorded periodically on these randomly selected and tagged plants.

RESULTS AND DISCUSSION

A. Phenological development of pearl millet

In the present study, there was no significant difference in the seed germination of pearl millet hybrid HHB197 due to different nutrients management treatments than the control. Neelam (2009) also observed that bio-fertilizers (Biomix or *Azotobacter* seed treatment) along with RDF under rain fed conditions had no significant effect on germination of pearl millet crop. The 50% flowering in treatment T_7- 40 kg N + 20 kg P_2O_5/ha + seed treatment with Biomix took 4.1 more number of days than control. Similarly, other phenological events, *i.e.*, five leaf stage, panicle initiation, flag leaf, boot stage, milk stage, dough stage and physiological maturity, took more number of days, which might be due to better root development or more prominent growth of the plant. The present study also indicated that 50% flowering and days to physiological maturity under control and seed treatment with Biomix or *Azotobacter* isolate JFS5 induced early flowering and early maturity as compared to higher fertility treatments (T_7, T_9, T_{10} and T_{11}), which on the other hand prolonged the growth, flowering and maturity duration. Similar results have also been reported by Bhagchand and Gautam (2000) who reported that

TABLE 1
Effect of different treatments on phenological events (days) in pearl millet

Treatment	Emergence	Stages						Physiological maturity
		Five leaf	Panicle initiation	Flag leaf	50% flowering	Milk	Dough	
T_1	2.7	14.1	23.3	34.5	42.6	55.1	62.0	68.9
T_2	2.6	14.4	25.4	36.4	44.5	56.3	64.5	71.5
T_3	2.7	14.3	23.9	35.6	43.7	55.4	63.8	71.2
T_4	2.7	14.2	23.5	35.3	43.5	55.3	63.6	71.3
T_5	2.6	14.8	25.8	37.0	45.6	56.8	65.6	72.3
T_6	2.6	14.7	25.6	36.6	45.0	56.5	65.2	72.1
T_7	2.5	15.3	26.7	38.5	46.7	57.4	66.5	72.6
T_8	2.6	15.1	26.1	37.6	46.2	57.0	66.1	72.4
T_9	2.6	14.9	25.9	37.3	45.7	56.8	65.8	72.1
T_{10}	2.5	15.2	26.3	37.9	46.1	57.2	66.2	72.3
T_{11}	2.6	15.0	26.1	37.0	45.5	56.9	65.6	72.0
T_{12}	2.6	14.7	26.0	36.8	45.2	56.7	65.4	71.8
S. Em±	0.12	0.10	0.09	0.10	0.1	0.1	0.1	0.2
C. D. (P=0.05)	NS	0.3	0.3	0.3	0.3	0.3	0.4	0.7

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

combined application of rhizospheric bio-fertilizers along with inorganic fertilizers delayed flowering and maturity in pearl millet.

B. Yield and Yield attributes

In the present study, the combined application of inorganic fertilizers along with bio-fertilizers improved the yield attributing characters *viz.*, number of ear heads/plant, ear head length, ear head girth, test weight (g), grain, stover and biological yield (q/ha) (Table 2 and 3). Grain yield was found significantly highest in the treatment T_7- 40 kg N + 20 kg P_2O_5/ha + seed treatment with Biomix. The combined application of Biomix along with RDF (T_7) increased the grain yield by 44.2% (33.40 q/ha) over the control (18.64 q ha).

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 Lakum *et al*. (2011). The increase in yield of pearl millet might also be due to the fact that phytohormones produced by the bio-fertilizers stimulated root growth and induced changes in root morphology, which in turn affected the assimilation of the nutrients. 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. As nitrogen is a constituent of protein and chlorophyll, it plays vital role in the photosynthesis. These finding support those of Singh *et al*. (2013).

Seed treatment with Biomix or *Azotobacter* isolate JFS5 significantly increased the stover yield (q/ha) was found highest in treatment T_7- 40 kg N + 20 kg P_2O_5/ha + seed treatment with Biomix but, it was statistically at par with T_8- T_5 + foliar spray of *Azotobacter* isolate *JFS5* @ 10^8 cfu/ml at 15 DAS (76.28 q/ha). The stover yield increased by 42.4% (81.50 q/ha) in T_7 treatment over the T_1- control (46.95 q/ha).This increase in Stover yield might be attributed to increased height, leaf area and dry matter production. In the inorganic + bio-fertilizer 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 Neelam (2009).

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TABLE 2
Effect of different nutrient management on yield attributes of pearl millet

Treatment	No. of effective tillers/plant	Ear head length (cm)	Ear head girth (cm)	Test weight
T_1 : Control	1.45	22.5	2.68	8.3
T_2 : Seed treatment with Biomix*	1.97	24.8	2.74	8.7
T_3 : Foliar spray of *Azotobacter* isolate *JFS5* @ 108 cfu/ml at 15 DAS	1.82	24.4	2.72	8.5
T_4 : Foliar spray of *Azotobacter* isolate *JFS5* @ 108 cfu/ml at 30 DAS	1.74	23.6	2.71	8.3
T_5 : RDF (40 kg N + 20 kg P_2O_5 /ha)	2.14	25.3	2.80	9.0
T_6 : 75% RDF (30 kg N+15 kg P_2O_5 /ha)	2.06	24.8	2.78	8.8
T_7 : T_5+seed treatment with Biomix	2.58	27.4	2.82	9.5
T_8 : T_5+foliar spray of *Azotobacter* isolate *JFS5* @ 108 cfu/ml at 15 DAS	2.42	26.8	2.81	9.3
T_9 : T_5+foliar spray of *Azotobacter* isolate *JFS5* @ 108 cfu/ ml at 30 DAS	2.23	26.3	2.80	9.1
T_{10} : T_6+seed treatment with Biomix	2.49	26.6	2.81	9.3
T_{11} : T_6+foliar spray of *Azotobacter* isolate *JFS5* @ 108 cfu/ ml at 15 DAS	2.31	25.1	2.79	9.0
T_{12} : T_6+foliar spray of *Azotobacter* isolate *JFS5* @ 108 cfu/ ml at 30 DAS	2.17	25.4	2.78	8.8
S. Em±	0.01	0.75	0.01	0.08
C. D. at 5% level of significance	0.04	2.2	0.03	0.24

**Biomix = Azotobacter+Azospirillum+Phosphate Solubilising bacteria.*

TABLE 3
Effect of different nutrient management treatments on yield, harvest index and grain: chaff of pearl millet

Treatment	Yield (q/ha)			Harvest index (%)	Grain : Chaff
	Grain	Stover	Biological		
T_1: Control	18.64	46.95	65.59	28.51	1.12
T_2: Seed treatment with Biomix*	22.43	57.69	80.13	27.98	2.17
T_3: Foliar spray of *Azotobacter* isolate *JFS5* @ 108 cfu/ml at 15 DAS	21.39	56.09	77.49	27.59	1.81
T_4: Foliar spray of *Azotobacter* isolate *JFS5* @ 108 cfu/ml at 30 DAS	21.80	54.50	76.30	28.64	1.75
T_5: RDF (40 kg N+20 kg P_2O_5/ha)	29.93	72.65	102.59	29.20	2.70
T_6: 75% RDF (30 kg N+15 kg P_2O_5/ha)	25.36	63.42	88.78	28.26	2.50
T_7: T_5+seed treatment with Biomix	33.40	81.50	114.90	29.06	4.07
T_8: T_5+foliar spray of *Azotobacter* isolate *JFS5* @ 108 cfu/ml at 15 DAS	31.14	76.28	107.42	28.99	3.31
T_9 : T_5+foliar spray of *Azotobacter* isolate *JFS5* @ 108 cfu/ml at 30 DAS	30.70	74.25	104.95	29.26	2.80
T_{10}: T_6+seed treatment with Biomix	28.75	73.55	102.30	28.37	3.47
T_{11}: T_6+foliar spray of *Azotobacter* isolate *JFS5* @ 108 cfu/ml at 15 DAS	27.04	70.83	97.87	28.22	2.90
T_{12}: T_6+foliar spray of *Azotobacter* isolate *JFS5* @ 108 cfu/ml at 30 DAS	27.13	68.62	95.75	28.30	2.66
S. Em±	1.13	2.06	2.77	0.9	0.04
C. D. (P=0.05)	3.35	6.09	8.19	NS	0.14

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