

Influence of seed priming on seed yield attributes in quality protein maize (QPM) and its parental lines (*Zea mays* L.)

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Abstract The present study was conducted to assess the effect of seed priming with different bacterial suspensions viz. *Azospirillum*, Phosphorus solubilizing bacteria and Potassium solubilizing bacteria in quality protein maize, HQPM-5 and its parental lines, HKI-163 and HKI-161 on performance of seed yield attributes such as plant height, days to 50% silking and tasseling, days to maturity, number of cobs/plant, cob length, number of kernels/cob, shelling percentage, kernel yield/plot, test weight and harvest index. The bio priming treatments results revealed that HQPM-5 seeds bioprimered with combination of *Azospirillum* @ 20% + Phosphorous solubilizing bacteria @ 20% + Potassium solubilizing bacteria @ 20% at 12h recorded higher performance than other priming treatments.

Keywords: Bacterial suspensions · Kernel yield · Quality Protein Maize (QPM) · Seed priming

Introduction

The third-most significant cereal crop in world agriculture is maize (*Zea mays* L.). Its highest yield potential and widest adaptability have earned it the title of “Queen of Cereals.” The Poaceae family of grass includes maize. As a C₄ plant, maize has a larger capacity for carbohydrate synthesis. It is predominantly a cross-pollinated species

with chromosome number of $2n=2\times=20$, a feature that has contributed to its morphological variability. Maize ranks as the third most important crop in India among cereals. India ranks fourth in area and seventh in production, representing around 4% of the world maize area and 2% of the total production (<http://www.fao.org>).

Quality Protein Maize (QPM) grain contains nearly twice as much lysine and tryptophan amino acids that are essential for humans and other monogastric animals but are limiting amino acids in grains. QPM, which is not genetically engineered, is a by product of conventional plant breeding and an illustration of biofortification. The goal of QPM breeding is to produce high-quality protein maize, high-yield, taking into account the significance of the energy crisis, the need for more food and feed, and other crucial agronomical attributes (Micic-Ignjatovic *et al.*, 2008). Hydrating and drying seeds is a physiological approach known as priming and it helps to improve germination, seedling development and yield under both normal and stressful conditions. Seeds are hydro primed or soaked in water and then dried again to their initial moisture content, before being sown (Lutts *et al.*, 2016). By applying bacteria prior to seeding, an efficient inoculation method called “bio-priming” raises the possibility that bacteria will colonise the rhizosphere and establish a bond with the plant.

In addition to the soil, air and water, it is hoped that using biofertilizers instead of chemicals will improve health of soil and intern human. They are not only very nutrient-dense but also provide the soil with advantageous bacteria. Inoculating maize with *Azospirillum* improved nutrient uptake, plant development and yield (Dobbelaere *et al.*, 2001). In order to increase plant growth, nutrition, root growth, competitiveness and reactions to external stress factors, biofertilization with phosphorous and potassium-

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solubilizing bacteria and potassium-solubilizing bacteria is a sustainable approach (Meena *et al.*, 2015, Raghvendra *et al.*, 2016, Kumar *et al.*, 2016).

Materials and methods

A field experiment on enhancement of seed yield attributes through hydropriming and biopriming in hybrid maize HQPM-5 and its parental lines *i.e.*, HKI-163 and HKI-161 was conducted at the Regional Agricultural Research Station, Nandyal, Andhra Pradesh during *rabi* 2022-23. A preliminary experiment was carried out to standardize the optimum concentration of liquid biofertilizers and the duration of priming. The best concentration and duration of seed priming of each of the liquid biofertilizers identified in the preliminary experiment were used in the subsequent experiments. The details of priming agents, their concentrations and duration of priming are given in 1. The field trial was conducted following Factorial Randomized Block Design (FRBD) with nine treatments and three replications. The seeds of maize hybrid HQPM-5, were subjected to hydropriming and biopriming treatments using different biofertilizers either individually or in combination for 12 h and shade dried to 12% moisture content. Unprimed seed along with the primed seed were evaluated for the seed quality attributes. Five randomly selected plants per genotype were selected randomly for recording observations on different characters viz., plant height (cm), number of cobs per plant, cob length, number of kernels per cob, while

observations on days to 50% tasselling and silking, days to maturity, stover yield (kg/ha) and kernel yield per plot (kg/ha) were recorded on plot basis. For 100-kernel weight, a sample of 100 kernels were counted randomly from the threshed seed and the weight was recorded in grams. For shelling percentage, the grains were shelled from five randomly selected cobs at harvest for every plot by following formula kernel weight/cob weight*100. Harvest index was calculated by using the formula given by Donald and Hamblin (1976). Statistical analysis was performed on mean of five plants. The analysis of variance (ANOVA) method was used, as described by Panse and Sukhatme (1985).

Results and discussion

Analysis of variance of data in Table 2 revealed that the highly significant differences among genotypes and treatments for plant height, days to 50 per cent tasselling, days to 50 per cent silking, days to maturity, number of cobs/plant, shelling (%), kernel yield (kg/ha), test weight (g) and harvest index. Cob length was significant whereas number of kernels per cob was found non-significant among the treatments and both were highly influenced by genotypes. The interaction effects between genotypes and treatments were found non-significant for most of the parameters except highly significant for days to 50 per cent silking and found significant in days to 50 per cent tasselling. The highest (221.24 cm) and lowest (153.18 cm) plant height was recorded after seed priming with of T₉ in HQPM-5 and T₁ in HKI-163 respectively with overall mean plant height of 190.70 cm. The results are in accordance with Mutetwa *et al.*, (2019) where bio priming of maize seeds with *Trichoderma* and *Bacillus* had a significant influence on plant height which significantly increased the N and P uptake by the maize as a result of incorporating the bio fertilizers. The highest (1.40) number of cobs/plant was recorded after seed priming with T₉ in HQPM-5 while HKI-161 recorded no significant treatment effect, HKI-163 showed no significant effect by T₂ and with T₃ compared with T₁ and HQPM-5 showed no significant effect by T₂ compared with the T₁. Nawaz *et al.* (2020) reported that seed biopriming considerably ameliorated the drought induced deterioration in agronomic characters such as cobs per plant, as well as physiological parameters of maize plants.

Table 1. Details of seed priming treatments under study

Treatment No.	Treatment
T ₁	Untreated Seed (control)
T ₂	Hydro-priming
T ₃	<i>Azospirillum</i> @ 20%
T ₄	Phosphorous solubilizing bacteria (PSB) @ 20%
T ₅	Potassium solubilizing bacteria (KSB or PtSB) @ 20%
T ₆	<i>Azospirillum</i> @ 20% + Phosphorous solubilizing bacteria @ 20%
T ₇	<i>Azospirillum</i> @ 20% + Potassium solubilizing bacteria @ 20%
T ₈	Phosphorous solubilizing bacteria @ 20% + Potassium solubilizing bacteria @ 20%
T ₉	<i>Azospirillum</i> @ 20% + Phosphorous solubilizing bacteria @ 20% + Potassium solubilizing bacteria @ 20%

Table 2. Influence of seed hydro-priming and bio-priming on yield attributing traits of Quality Protein Maize (QPM)

Treat- ments	Plant height (cm)			No. of cobs/plant			Days to 50% tasseling			Days to 50% silking			Days to maturity			Cob length			No. of kernels/cob		
	HKI- 163	HQ 116	Mean PM-5	HKI- 163	HQ 116	Mean PM-5	HKI- 163	HQ 116	Mean PM-5	HKI- 163	HQ 116	Mean PM-5	HKI- 163	HQ 116	Mean PM-5	HKI- 163	HQ 116	Mean PM-5	HKI- 163	HQ 116	Mean PM-5
	163	116	PM-5	163	116	PM-5	163	116	PM-5	163	116	PM-5	163	116	PM-5	163	116	PM-5	163	116	PM-5
T ₁	153.2	189.2	192	1	1	1	69	71	58	66	71	73	60	68	112	113	102	109	15.36	14.06	15.18
T ₂	154.1	194	196	1	1	1	68	70	57	65	70	71	60	67	109	113	102	108	15.91	14.64	15.76
T ₃	158.5	201.5	204.1	1	1	1.07	68	68	56	64	69	70	59	66	108	111	99	106	16.21	15.23	16.16
T ₄	157.4	203.1	205.7	1.2	1	1.07	66	67	56	63	67	70	58	65	107	112	99	106	16.42	15.02	16.18
T ₅	161.4	204.3	208	1.2	1	1.13	64	65	54	61	68	70	57	65	108	110	97	105	16.35	15.42	16.35
T ₆	167.6	206.4	210.6	1.13	1	1.2	65	67	54	62	68	69	58	65	107	109	99	105	16.76	15.56	16.63
T ₇	165.5	207.8	216.1	1.2	1	1.2	66	67	56	63	69	70	59	66	105	110	97	104	16.78	15.67	16.64
T ₈	166.2	208.1	218.8	1.13	1	1.33	66	67	53	62	67	72	56	65	102	111	96	103	16.98	16.01	16.89
T ₉	168.1	209.8	221.2	1.33	1	1.4	63	65	52	60	64	67	55	62	99	109	92	100	17.43	16.23	17.31
Mean	161.3	202.7	208.1	1.14	1	1.16	66	67	55	63	68	70	58	65	106	110	98	105	16.47	15.32	16.34
SEm±	2.479	4.294	7.437	0.027	0.047	0.081	0.326	0.564	0.977	0.324	0.561	0.972	0.542	0.939	1.627	0.223	0.387	0.67	4.523	7.834	13.569
CD(5%)	7.048	12.21	NS	0.077	0.133	NS	0.927	1.606	2.781	0.922	1.597	2.767	1.543	2.673	NS	0.635	1.1	NS	12.87	NS	NS
CV (%)	6.85			12.75			2.7			2.58			2.68			7.1			6.11		

Table 2 contd.....

Treat- ments	Cob weight (g)			Kernel weight (g)			Shelling percentage %			Kernel yield (kg/ha)			Test weight (g)			Stover yield (kg ha ⁻¹)			Harvest Index (%)		
	HKI- 163	HQ 116	Mean PM-5	HKI- 163	HQ 116	Mean PM-5	HKI- 163	HQ 116	Mean PM-5	HKI- 163	HQ 116	Mean PM-5	HKI- 163	HQ 116	Mean PM-5	HKI- 163	HQ 116	Mean PM-5	HKI- 163	HQ 116	Mean PM-5
	163	116	PM-5	163	116	PM-5	163	116	PM-5	163	116	PM-5	163	116	PM-5	163	116	PM-5	163	116	PM-5
T ₁	138.1	126.1	178.2	147.5	87.19	73.26	63.15	58.09	69.33	64.64	3303	3089	5150	3847	26.89	26.44	28.61	27.31	5730	5384	7079
T ₂	138.5	127.2	182	149.2	88.95	79.43	64.24	62.43	73.74	67.58	3483	3270	5359	4038	27.53	27.13	29.07	27.91	5846	5415	7253
T ₃	139.3	128.5	189.7	152.5	89.62	82.14	64.35	63.91	74.85	68.58	3765	3434	5519	4240	28.97	28.47	30.19	29.21	5836	5582	7436
T ₄	141.8	129.6	191.2	154.2	93.55	83.42	65.98	64.35	77.89	70.44	3878	3593	4905	4125	29.36	29.12	30.43	29.64	5848	5552	7529
T ₅	140.6	128.5	185.7	151.6	94.91	83.63	67.52	65.11	76.06	70.32	3916	3840	5991	4582	29.86	29.54	30.81	30.07	5920	5694	7368
T ₆	142.8	130.2	194	155.7	95.63	84.07	66.98	64.55	75.91	70.01	4509	3885	6127	4840	30.11	30.08	31.23	30.47	5865	5552	7338
T ₇	141.3	131.3	196	156.2	96.35	86.81	68.21	66.14	78.53	71.94	4408	3985	6206	4866	30.56	30.34	32.84	31.25	5920	5627	7323
T ₈	143.3	132.9	197	157.7	99.91	87.22	69.74	65.63	79.67	72.72	4649	4167	6542	5119	31.11	30.76	33.75	31.87	5929	5673	7373
T ₉	147.5	133	202.5	161	105.6	89.37	71.56	67.18	83.16	75.21	5030	4569	7126	5575	31.48	31.04	34.55	32.36	6237	5705	7501
Mean	141.4	129.7	190.7	154	94.57	83.21	66.86	64.15	76.7	70.14	4105	3759	5881	4581	29.54	29.21	31.28	30.01	5903	5576	7356
SEm±	0.686	1.187	2.057	0.624	1.081	1.873	0.373	0.646	1.118	47.53	82.32	142.586	0.57	0.987	1.709	24.17	41.86	72.496	0.173	0.3	0.52
CD(5%)	1.951	3.379	5.835	1.777	3.077	5.33	1.061	1.837	NS	135.3	234.3	NS	1.621	2.808	NS	68.77	119.1	NS	0.493	0.854	NS
CV (%)	7.93			9.27			9.51			5.35			9.3			5.21			6.67		

Seed priming caused a significant reduction in the mean duration of 50 per cent tasseling and silking. The mean days to 50 per cent tasseling was recorded lowest (60 days) with T_0 and the highest (66 days) in T_1 . Similarly, mean days of 50% silking was the lowest (62 days) with T_0 and recorded highest in (68) in T_1 . The results are in confirmation with Madhukeswara and Ashok (2017) where a reduction in days to 50 per cent tasseling and silking in maize hybrid after seed treatment was observed with *pseudomonas* @ 20 per cent as well as *Azospirillum* @ 20 per cent. The days to maturity was recorded lowest (92 days) in T_0 and recorded highest in (113) in T_1 . The overall mean days to maturity was recorded as 105 days. Similar results were obtained by Harris *et al.* (1999) in which seed priming resulted in quicker growth and development with earlier flowering followed by maturity and increased yields in maize. Cob length was recorded highest (18.26 cm) and lowest (14.06 cm) with T_0 in HQPM-5 and with T_1 in HKI-161, respectively with overall mean of 16.34 cm. Obid *et al.* (2016) reported that application of liquid biofertilizers significantly increased the cob length in maize. The highest (431.74) number of kernels/cob was recorded after seed priming with T_0 in HQPM-5 and the lowest (356.72) with T_1 in HKI-161 with overall mean number of kernels/cob of 384.54. The results are in accordance with Yazdani *et al.* (2009) by use of phosphorous solubilizing microorganisms and PGPR in addition to conventional fertilizer applications (NPK) could improve row number, grain number per row and ultimately increased grain yield in maize. Highest cob weight was recorded highest (202.53g) in HQPM-5 with T_0 and recorded lowest (126.12g) in HKI-161 in T_1 with overall mean of 153.96 g. The results are in confirmation with Yazdani *et al.*, (2009) that by using phosphorous solubilizing microorganisms and PGPR in addition to conventional fertilizer applications (NPK) improved ear weight resulting in increased grain yield. The kernel weight was highest (168.42 g) in HQPM-5 with treatment combination of T_0 and recorded lowest in (73.726 g) in HKI-161 in T_1 with overall mean of 107.99 g. The highest (83.16%) and lowest (58.09%) shelling percent was recorded after seed priming with T_0 in HQPM-5 and T_1 in HKI-161 respectively with overall mean shelling percent of 70.14. The results are in confirmation with Ragab and Ibrahim (2009) where 120 kg N/fed plus [bio fertilizer nitrogen] resulted in a significant effect on shelling percentage in

maize [single cross 10]. The kernel yield/plot was highest (2.57 kg) in HQPM-5 with T_0 and lowest in (1.11 kg) in HKI-161 in T_1 with overall mean of 1.65 kg. The kernel yield was highest (7125.97 kg ha⁻¹) in HQPM-5 with T_0 and recorded lowest in (3088.72 kg ha⁻¹) in HKI-161 in T_1 with overall mean of 4581.43 kg ha⁻¹. The results are in accordance with Sahar *et al.*, (2012) that using bio-fertilizers like *Azospirillum* and *Azotobacter* as a source of natural growth regulators led to increased yield in corn as one of the ways of reducing chemical fertilization rate and cost with increased growth benefits. The highest (34.55 g) test weight was recorded in seed treatment with T_0 in HQPM-5 and lowest (26.44 g) was recorded with T_1 in HKI-161. Beigzade *et al.* (2013) reported that in their study on seed inoculation with *Azospirillum* + *Pseudomonas* bacteria increased thousand seed weight compared to control in *Zea mays*. The stover yield was highest (7500.87 kg ha⁻¹) in HQPM-5 with T_0 and recorded lowest (5384.47 kg ha⁻¹) in HKI-161 in T_1 with overall mean of 6278.37 kg ha⁻¹. The highest (48.71) harvest index was recorded after seed priming with T_0 in HQPM-5 and lowest (36.45) with T_1 in HKI-161. The findings are in accordance with Ragab and Ibrahim (2009) that 120 kg N/fed plus 9bio fertilizer notroben) resulted in a significant effect on straw yield /fed in ton and seed index in maize.

Conclusion

In conclusion, the seed biopriming treatments combination of *Azospirillum* + Phosphorous solubilizing bacteria + Potassium solubilizing bacteria each for 12 h was most effective than other priming treatments. HQPM-5 maize hybrid responded better to the priming treatments than its parental lines *i.e.*, HKI-161 and HKI-163.

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