Original Research Article

SEED PRIMING FOR ENHANCEMENT OF SEED QUALITY IN QUALITY PROTEIN MAIZE (QPM) (*Zea mays* L.,)

Abstract

An investigation was carried out with (HQPM-5)maize hybrid and its parental lines (HKI-163 &HKI-161)seeds during *rabi*of 2022 to evaluate the effect of liquid bio-fertilizers (*Azospirillum*, Phosphorus solubilizing bacteria and Potassium solubilizing bacteria) on seed quality attributes in Quality Protein Maize (QPM) genotypes. The seeds were subjectedfor standardization, to optimize the concentration and duration of hydro-priming and bio-priming (Concentration: 10, 15 and 20%; Duration: 6, 12, 18 and 24h). The non primed seeds formed the control. The results revealed that HQPM-5 seeds bio-primed with combination of *Azospirillum* @ 20 %+ Phosphorous solubilizing bacteria @ 20 %+ Potassium solubilizing bacteria @ 20 % at 12h (T_9) recorded higher seed quality i.e., germination, field emergence, root length, shoot length, seedling length, seedling fresh weight, root dry weight, shoot dry weight, seedling dry weight, seed vigour index I & II, nitrogen and protein content and lower EC of seed leachates than the parental lines, HKI-163 and HKI-161. The overall performance of female parent was found to be better compared to the male parent.

Key words: Liquid Bio-fertilizers, Quality Protein Maize,Bio-priming, Hydro-priming.

1. Introduction

Maize (*Zea mays L.*) isthe third most important cereal crop in the world agriculture (Majamanda *et al*., 2022a). It has got the sobriquet "Queen of cereals" because of its highest yield potential and wider adaptability( ). Maize belongs to the grass family *Poaceae*. Being a C_4 plant, maize has a higher potential for the synthesis of carbohydrates( ). It is predominantly a cross-pollinated species with chromosome number of 2n=2×=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) is a family of maize varietieswhich contains nearly twice as much lysine and tryptophan.These amino acids are essential for humans and monogastric animals but are limiting amino acids in grains ( ). QPM is a product of

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conventional plant breeding (i.e., it is not genetically modified) and an example of bio-fortification( ). Considering the energy crisis that has hit the globe, the need for more food and feed, and other essential agronomical qualities, the breeding of QPM is set up as a challenge to create high quality protein maize with high yield(Micic-Ignjatovic *et al.*, 2008).

The critical phases in the development of crops include uniform seed germination, early seedling growth, and uniform plant stand. A physiological strategy called priming involves hydrating and drying seeds to speed up the pre-germinative metabolic process for increased germination, seedling growth and eventual yield under both normal and stressful conditions. Hydro-priming involves soaking seeds in water before sowing and re-drying tooriginal moisture content prior to sowing (Lutts*et al.*, 2016). Bio-priming is an efficient inoculation method to apply bacteria prior to sowing that enhances the chances of bacterial candidates to colonize the rhizosphere and establish a liaison with the plant.

Utilising bio-fertilizers instead of chemicals is anticipated to have a positive influence on human health in addition to the soil, air, and water( ). In addition to being highly nutritious, they also give the soil beneficial microbes( ). Several studies have clearly reported that inoculation of maize with *Azospirillum* increasesthe uptake of nutrients, plant growth and yield(Dobbelaere *et al.*, 2001). The utilization of Phosphorous solubilizing bacteriaandPotassium solubilizing bacteria as bio-fertilizers is a sustainable solution to improve plant growth, nutrition, root growth, plant competitiveness and responses to external stress factors (Meena *et al*., 2015a, Meena *et al.*, 2015b, Raghvendra *et al.*, 2016,Kumar *et al.*, 2016).

2. Materials and Methods

A laboratory experiment on enhancement of seed quality parameters through hydro-priming and bio-priming in hybrid maize (HQPM-5)and its parental lines (HKI-163 and HKI-161) was conducted at Regional Agricultural Research Station (RARS), Nandyal during *rabi*of 2022. A preliminary experiment was carried out to standardize the optimum concentration of liquid bio-fertilizers and the duration of priming. The best concentration and duration of seed priming of each of the liquid bio-fertilizers 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 Table1.

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Table 1: Details of seed priming treatments under study

Treatment No.	Treatment
T_1	Untreated Seed (control)
T_2	Hydro-priming
T_3	*Azospirillum* @ 20 %
T_4	Phosphorous solubilizing bacteria @ 20 %
T_5	Potassium solubilizing bacteria@ 20 %
T_6	*Azospirillum* @ 20 %+ Phosphorous solubilizing bacteria @ 20 %
T_7	*Azospirillum* @ 20 %+ Potassium solubilizing bacteria @ 20 %
T_8	Phosphorous solubilizing bacteria @ 20 %+ Potassium solubilizing bacteria @ 20%
T_9	*Azospirillum* @ 20 %+ Phosphorous solubilizing bacteria @ 20 %+ Potassium solubilizing bacteria @ 20 %

The seedling quality was studied in Two Factorial Completely Randomized Design (FCRD).The seeds of maize hybrid (HQPM-5)were subjected to hydro-priming and bio-priming treatments using different bio-fertilizers 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.

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2.1 Germination

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The germination test was conducted bythe procedure outlined by ISTA (1999) using paper (between papers) medium. Four replicates of 100 seeds each were germinated in a germination room maintained at 25 ± 2°C temperatures and 95 ± 5% relative humidity (RH). At the end of seventh day after sowing, germination was calculated and expressed in percentage.

$$G\% = \frac{\text{Number of normal seedlings}}{\text{Total number of seed sown}} x100$$

2.2 Seedling length (cm)

At the time of germination count, 10 normal seedlings were selected at random from each replication and used for measuring the root length and shoot length of seedlings. Root length was measured from the point of attachment of seed to the tip of primary root. The shoot length was measured from the point of attachment of seed to the tip of the leaf and the mean values were expressed in centimetres.

The sum of root and shoot length of ten seedlings was calculated and their mean was expressed as seedling length in centimetres.

2.3 Seedling fresh weight (g)

Ten representative seedlings used for seedling length measurement were taken and fresh weight of these seedlings was weighed by using an electronic weighing balance. Average weight was calculated and was expressed in grams per seedling.

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2.4 Seedling dry weight (g)

Ten representative seedlings used for fresh weight measurement were taken, roots and shoots of these seedlings were separated and placed in paper cover and kept in an oven maintained at 75±1°C for 48 hours until attaining constant weight of the sample. After cooling, weight of the dried shoots and roots was weighedusing an electronic weighing balance and average weight was calculated and was expressed in grams per seedling.

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The sum of root and shoot dry weight of ten seedlings was calculated and their mean was expressed in grams per seedling.

2.5 Seed vigour index-I& II

Seed vigour index I & II was computed by adopting the following formula as suggested by Abdul-Baki and Anderson (1973) and was expressed as whole number.

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Seed vigor index = Germination (%) x (Seedling length) (cm)

Seed vigour index-II = Germination (%) x Seedling dry weight (g)

2.6 Electrical Conductivity (EC) of seed leachates (µS cm^{-1})

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Fifty randomly selected seeds from each treatment were soaked in 75 ml of deionized water for 24 h at room temperature. The seed steep water was decanted and referred to as seed leachate. The electrical conductivity of the seed leachate was measured with a digital conductivity meter (Model: Conductivity TDS meter-307) with a cell constant of one and expressed as μScm^{-1}.

2.6 Nitrogen content

Nitrogen content in maize seeds was analyzed by Micro-Kjeldahl method.

$$\text{Nitrogen (\%)} = \frac{\text{Titre value x 0.00007 x 100 x 100}}{\text{0.5 x 5}} \text{x100}$$

2.7 Protein content

Nitrogen content was multiplied with the factor 6.25 to obtain the crude protein content in the given sample as given by Doubetz and Wells (1968).

Protein content (%) = Nitrogen content (%) x 6.25 (factor)

2.8 Field emergence (%)

One hundred seeds from each treatment were counted and sown in well prepared soil at 3 cm depth. The field emergence was recorded on the 15th day after sowing and the field emergence percentage was calculated as per the formula:

$$\text{Field Emergence (\%)} = \frac{\text{Number of seedlings emerged}}{\text{Total number of seed sown}} \text{x100}$$

Analysis of variance for Factorial Completely Randomized Design (FCRD) was calculated and the percent values were transformed to angular (arcsine) values before analysis (Panse and Sukhatme, 1985).

3. Results and discussion

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The experiment revealed highly significant differences among genotypes and treatments for germination, field emergence, root length, shoot length, seedling length, root dry weight, shoot dry weight,seedling fresh weight seedling dry weight, seed vigour index I & II, nitrogen and protein content. EC of seed leachates was found significant among the treatments and it was highly influenced by genotypes( ). Maize genotype and environment influences some chemical aspects such as carotenoids, phenolics and mineral composition of maize (Majamanda *et al.*, 2022a, Majamanda *et al.*, 2022b).The interaction effects of genotypes and treatments was found significant except for germination, field emergence, shoot length, seedling fresh weight, seedling dry weight, EC of seedleachates, nitrogen and protein content of seed.The highest (96.67 %) germination was recorded after seed priming with T_9 in HQPM-5 and lowest(77.51 %)germination wasobserved in T_1seed in HKI-161 with overall mean germination of 85.85 % (Table 2 and Fig.1). The results are in accordance with Karthika and Vanangamudi (2013) in whichbio-priming with *Azospirillum* @ 20 % and Phosphobacteria @ 20 % concentration for 12 h in maize hybrid COH(M) significantly improved the germination.

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Table 2. Influence of seed hydro-priming and bio-priming on germination (%) and field emergence (%) of Quality Protein Maize (QPM) genotypes.

Treatments	Germination (%)				Field emergence (%)			
	HKI-163	**HKI-161**	**HQPM-5**	**Mean**	**HKI-163**	**HKI-161**	**HQPM-5**	**Mean**
T_1	79.81 (63.30)	77.51 (61.69)	85.12 (67.31)	**80.81 (64.10)**	79.35 (62.97)	76.67 (61.12)	83.65 (66.15)	**79.89 (63.41)**
T_2	80.67 (63.92)	78.67 (62.49)	86.23 (68.22)	**81.86 (64.88)**	80.19 (63.57)	76.98 (61.33)	84.29 (66.65)	**80.49 (63.85)**
T_3	82.67 (65.40)	79.06 (62.77)	88.46 (70.14)	**83.40 (66.10)**	81.38 (64.44)	77.31 (61.55)	85.61 (67.61)	**81.43 (64.57)**
T_4	83.94 (66.37)	81.04 (64.19)	89.67 (71.26)	**84.49 (67.27)**	83.66 (66.16)	80.05 (63.47)	86.43 (68.38)	**83.38 (66.00)**
T_5	86.67 (68.59)	81.57 (64.58)	92.07 (73.64)	**86.77 (68.94)**	84.76 (67.02)	81.18 (64.29)	90.57 (72.12)	**85.50 (67.81)**
T_6	85.33 (67.48)	82.15 (65.01)	94.25 (76.13)	**87.24 (69.58)**	85.12 (67.31)	80.34 (63.68)	92.31 (73.90)	**85.92 (68.30)**
T_7	86.12 (68.13)	83.33 (65.90)	93.53 (75.26)	**87.66 (69.76)**	85.86 (67.91)	82.67 (65.40)	89.79 (71.37)	**86.11 (68.23)**
T_8	87.67 (69.44)	84.67 (66.95)	94.72 (76.72)	**89.02 (71.04)**	86.49 (68.43)	83.88 (66.33)	93.95 (75.76)	**88.11 (70.17)**
T_9	89.33 (70.93)	86.91 (67.79)	96.67 (79.49)	**90.97 (73.07)**	87.73 (69.50)	84.49 (66.81)	94.16 (76.02)	**88.79 (70.78)**
Mean	**84.69 (67.06)**	**81.66 (64.71)**	**91.19 (73.13)**	**85.85 (68.30)**	**83.84 (66.37)**	**80.40 (66.37)**	**88.97 (70.90)**	**84.40 (67.01)**
	G	**T**	**G×T**		**G**	**T**	**G×T**	
S E m±	0.412	0.714	1.236		0.440	0.762	1.320	
CD (5%)	1.172	2.029	NS		1.251	2.167	NS	
CV	2.72				2.95			

*Values in the parenthesis indicate arc-sine transformed values

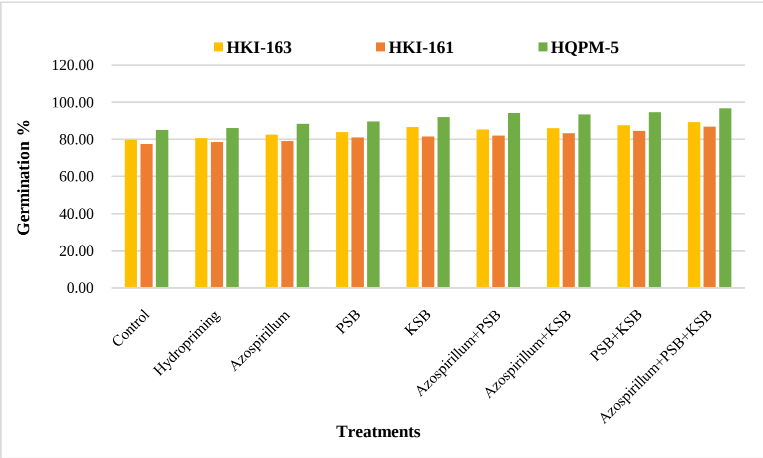

Fig.1:Influence of seed hydro-priming and bio-priming on germination (%) of quality protein maize (QPM) genotypes.

Table 3: Influence of seed hydro-priming and bio-priming on root length(cm),shoot length(cm) and seedling length (cm) of Quality Protein Maize (QPM) genotypes.

T	Root length (cm)				Shoot length (cm)				Seedling length (cm)			
	HKI-163	HKI-161	HQPM-5	Mean	HKI-163	HKI-161	HQPM-5	Mean	HKI-163	HKI-161	HQPM-5	Mean
T_1	10.26	9.31	12.41	10.66	12.07	11.46	17.45	13.66	22.33	20.77	29.86	24.32
T_2	12.67	9.82	13.53	12.01	13.16	12.15	18.32	14.54	25.83	21.97	31.85	26.55
T_3	13.09	10.53	14.64	12.75	14.28	13.42	19.62	15.77	27.37	23.95	34.26	28.53
T_4	13.87	11.84	15.34	13.68	15.73	13.89	20.34	16.65	29.60	25.73	35.68	30.34
T_5	15.23	12.36	16.86	14.82	16.31	14.73	21.34	17.46	31.54	27.09	38.20	32.28
T_6	16.17	13.17	15.89	15.08	17.19	15.36	21.94	18.16	33.36	28.53	37.83	33.24
T_7	16.73	14.85	16.42	16.00	17.46	16.27	22.37	18.70	34.19	31.12	38.79	34.70
T_8	17.46	15.26	17.16	16.63	18.27	16.76	23.04	19.36	35.73	32.02	40.20	35.98
T_9	18.14	16.36	18.19	17.56	19.54	17.19	24.61	20.45	37.68	33.55	42.80	38.01
Mean	14.85	12.61	15.60	14.35	16.00	14.58	21.00	17.20	30.85	27.19	36.61	31.55
	G	**T**	**G×T**		**G**	**T**	**G×T**		**G**	**T**	**G×T**	
S Em±	0.067	0.115	0.200		0.083	0.144	0.250		0.111	0.193	0.334	
CD (5%)	0.189	0.328	0.568		0.237	0.410	NS		0.316	0.548	0.949	

The highest (18.19 cm) and lowest (9.31 cm) root length was recorded after seed priming with T_9 in HQPM-5 and T_1 seed in HKI-161 respectively with overall mean root length of 14.35 cm.After seed priming with T_9 highest (24.61 cm) in HQPM-5 and lowest (11.46 cm) shoot length with control T_1 in HKI-161 with overall mean shoot length of 17.20 cm was recorded.The highest (42.80 cm) and lowest (20.77 cm) seedling length was recorded after seed priming with T_9 in HQPM-5 and T_1 in HKI-161 respectively with overall mean seedling length of 31.55 cm (Table 3 and Fig.2).The results are consistent with Karthika and

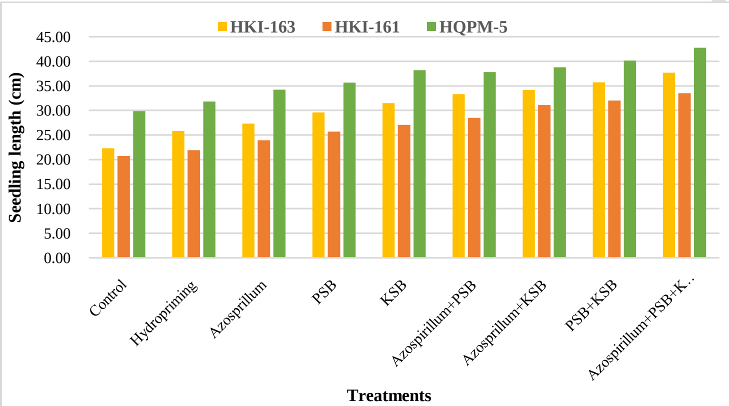

Fig. 2: Influence of hydro-priming and bio-priming on seedling length (cm) of quality protein maize genotypes.

Vanangamudi (2013),thatseeds primed with liquid Azospirillum @ 20 % concentration for 12h expressed high values for seedling length which was on par with Phosphobacteria @ 20 % concentration for 12 h.The highest (0.036 g) and lowest (0.011 g) root dry weight was recorded after seed priming with T_9 in HQPM-5 andT_1 seed in HKI-161 respectively with overall mean root dry weight of 0.024 g (Table 4).The results are in harmony with Parmar (2013),who reported that inoculation of K-solubilizing isolate HWP47 in wheat (*Triticum aestivum* L.) var. WH711 resulted in increase in root dry weight.

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Treatments	Root dry weight (g)				Shoot dry weight (g)			
	HKI-163	HKI-161	HQPM-5	Mean	HKI-163	HKI-161	HQPM-5	Mean
T_1	0.013	0.011	0.018	0.014	0.073	0.048	0.081	0.067
T_2	0.015	0.014	0.021	0.016	0.079	0.051	0.084	0.071
T_3	0.017	0.016	0.022	0.018	0.083	0.059	0.091	0.077

T_4	0.023	0.021	0.025	0.023	0.084	0.064	0.097	0.081
T_5	0.027	0.024	0.028	0.026	0.089	0.069	0.104	0.087
T_6	0.029	0.025	0.026	0.026	0.093	0.073	0.109	0.091
T_7	0.028	0.027	0.031	0.028	0.095	0.074	0.113	0.093
T_8	0.031	0.029	0.033	0.031	0.098	0.076	0.116	0.096
T_9	0.033	0.031	0.036	0.033	0.104	0.082	0.118	0.101
Mean	0.024	0.022	0.026	0.024	0.088	0.066	0.101	0.085
	G	**T**	**G×T**		**G**	**T**	**G×T**	
S Em±	0.001	0.001	0.002		0.001	0.001	0.002	
CD (5%)	0.001	0.003	0.004		0.002	0.003	0.006	
CV (%)	3.14				3.17			

Table 4: Influence of seed hydro-priming and bio-priming on root dry weight (g) and shoot dry weight (g) of quality protein maize (QPM) genotypes.

The highest (0.118 g) and lowest (0.048 g) shoot dry weight was recorded after seed priming with T_9 in HQPM-5 and T_1 in HKI-161 respectively with overall mean shoot dry weight of 0.085 g (Table 4).The results are in agreement with Singh *et al*. (2016) that bio-priming with *T. asperellum* BHUT8 showed enhancement in shoot dry weight, as compared to the control in pea.

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Table 5. Influence of seed hydro-priming and bio-priming on seedling fresh weight (g) and seedling dry weight (g) of quality protein maize (QPM) genotypes.

Treatments	**Seedling fresh weight (g)**				**Seedling dry weight (g)**			
	HKI-163	**HKI-161**	**HQPM-5**	**Mean**	**HKI-163**	**HKI-161**	**HQPM-5**	**Mean**
T_1	0.97	0.87	1.03	0.96	0.086	0.059	0.099	0.081
T_2	1.08	0.95	1.10	1.04	0.094	0.065	0.105	0.087
T_3	1.12	0.98	1.14	1.08	0.100	0.075	0.113	0.095
T_4	1.13	1.02	1.15	1.10	0.107	0.085	0.122	0.104
T_5	1.14	1.04	1.12	1.10	0.116	0.093	0.132	0.113
T_6	1.17	1.07	1.18	1.14	0.122	0.098	0.135	0.117
T_7	1.19	1.08	1.22	1.16	0.123	0.101	0.144	0.121
T_8	1.20	1.14	1.24	1.19	0.129	0.105	0.149	0.127
T_9	1.22	1.16	1.27	1.22	0.137	0.113	0.154	0.134

Mean	1.14	1.03	1.16	1.11	0.112	0.088	0.127	0.109
	G	**T**	**G×T**		**G**	**T**	**G×T**	
S Em±	0.006	0.010	0.018		0.001	0.002	0.003	
CD (5%)	0.017	0.029	NS		0.003	0.004	NS	
CV (%)	3.02				2.97			

The highest (1.27 g) and lowest (0.87 g) seedling fresh weight was recorded after seed priming with T_9 in HQPM-5 and T_1 in HKI-161 respectively with overall mean seedling fresh weightof 1.11 g (Table 5).The results are in agreement with Pathak and Chakraborti (2014), in which seed treatment with *Azospirillum* significantly increased the fresh weight of root and shoot in maize.The highest (0.154 g) and lowest (0.059 g) seedling dry weight was recorded after seed priming with T_9 in HQPM-5 and T_1seed in HKI-161 respectively with overall mean seedling dry weightof 0.109 g (Table 5).Similar results were obtained by Moeinzadeh *et al.* (2010), in which seed bio-priming with *Pseudomonas fluorescens* in sunflower significantly enhanced seedling dry weight (8.9g) compared to the control due to increased solubilization and uptake of nutrients and production of plant growth regulators.The highest (4137.48) and lowest (1609.88) seed vigour index-I was recorded after seed priming with T_9 in HQPM-5 and T_1 seed in HKI-161 respectively with overall mean seed vigour index-I of 2737.06.The highest (14.89) and lowest (4.57) seed vigour index-II was recorded after seed priming with T_9 in HQPM-5 and T_1 seed in HKI-161 respectively with overall mean seed vigour index-II of 9.36 (Table 6 and Fig.3).The results are in accordance with Revathi and Vanangamudi (2014), who reported that seed bio-priming with *Tricoderma viridae* @ 80 % for 6 h showed more seedling vigour index when compared to control in maize.

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Table 6. Influence of seed hydro-priming and bio-priming on seed vigour index I and seed vigour index II of Quality Protein Maize (QPM) genotypes.

Treatments	**Seed Vigour Index I**				**Seed Vigour Index II**			
	HKI-163	**HKI-161**	**HQPM-5**	**Mean**	**HKI-163**	**HKI-161**	**HQPM-5**	**Mean**
T_1	1782.16	1609.88	2541.61	**1977.88**	6.86	4.57	8.43	**6.55**
T_2	2083.71	1728.38	2746.43	**2186.17**	7.58	5.11	9.05	**7.12**
T_3	2262.68	1893.49	3030.64	**2395.60**	8.27	5.93	10.00	**7.92**
T_4	2484.62	2085.24	3199.54	**2589.80**	8.98	6.89	10.94	**8.83**
T_5	2733.57	2209.73	3517.07	**2820.13**	10.05	7.59	12.15	**9.81**

T_6	2846.61	2343.74	3565.48	**2918.61**	10.41	8.05	12.72	**10.21**
T_7	2944.44	2593.23	3627.88	**3055.18**	10.59	8.42	13.47	**10.61**
T_8	3132.43	2711.13	3807.74	**3217.10**	11.31	8.89	14.11	**11.31**
T_9	3365.95	2915.83	4137.48	**3473.09**	12.24	9.82	14.89	**12.19**
Mean	**2626.24**	**2232.30**	**3352.65**	**2737.06**	**9.49**	**7.19**	**11.58**	**9.36**
	G	**T**	**G×T**		**G**	**T**	**G×T**	
S Em±	11.828	20.486	35.483		0.046	0.079	0.137	
CD (5%)	33.628	58.246	100.885		0.130	0.225	0.390	
CV (%)	2.44				2.71			

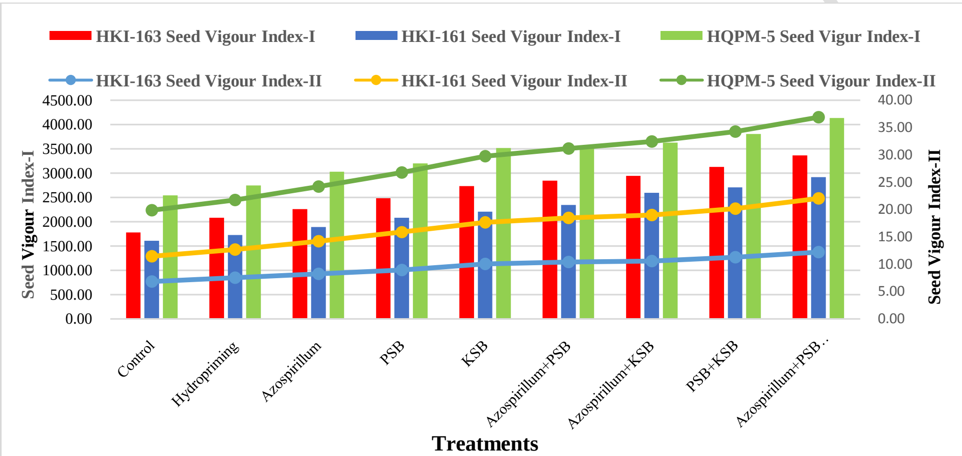

Fig.3. Influence of seed hydro-priming and bio-priming on seed vigour index I&II of quality protein maize (QPM) genotypes.

The highest (696.34 µS cm^{-1}) and lowest (654.64 µS cm^{-1})electrical conductivitywas recorded after seed priming with control (T_1) in HKI-161 and with T_9 in HQPM-5 respectively with overall mean electrical conductivity of 677.97 µS cm^{-1}.The highest (1.65 %) and lowest (1.24 %)nitrogen contentwas recorded with T_9 in HQPM-5 and seed priming with T_1 in HKI-161 respectively with overall mean nitrogen content of 1.40 %.The highest (10.30 %) and lowest (7.76 %)protein contentwas recorded with T_9 in HQPM-5 and seed priming with T_1 in HKI-161 respectively with overall mean protein content of 8.73 % (Table 7).

Table 7. Influence of seed hydro-priming and bio-priming on EC of seed leachates (μs/cm) and nitrogen content (%) and protein content (%) of Quality Protein Maize (QPM) genotypes.

Treatments	EC of seed leachates (μS/cm)				Nitrogen content (%)				Protein content (%)			
	HKI-163	HKI-161	HQPM-5	Mean	HKI-163	HKI-161	HQPM-5	Mean	HKI-163	HKI-161	HQPM-5	Mean
T_1	692.16	696.34	681.71	690.07	1.25	1.24	1.47	1.32	7.80	7.76	9.16	8.24
T_2	690.27	693.22	676.33	686.61	1.26	1.25	1.48	1.33	7.90	7.82	9.22	8.31
T_3	687.35	689.23	674.61	683.73	1.29	1.28	1.49	1.35	8.07	8.00	9.30	8.46
T_4	684.14	691.08	672.26	682.49	1.32	1.31	1.50	1.38	8.25	8.19	9.37	8.60
T_5	681.17	685.26	667.41	677.95	1.34	1.30	1.53	1.39	8.39	8.10	9.56	8.68
T_6	679.94	682.45	664.15	675.51	1.35	1.33	1.59	1.42	8.44	8.34	9.94	8.91
T_7	675.43	677.52	661.73	671.56	1.37	1.35	1.61	1.44	8.55	8.41	10.08	9.01
T_8	672.14	675.46	657.84	668.48	1.38	1.36	1.63	1.46	8.64	8.48	10.16	9.09
T_9	670.24	671.24	654.64	665.37	1.41	1.39	1.65	1.48	8.81	8.68	10.30	9.26
Mean	681.43	684.64	667.85	677.97	1.33	1.31	1.55	1.40	8.32	8.20	9.68	8.73
	G	T	G×T		G	T	G×T		G	T	G×T	
S Em±	3.253	5.634	9.758		0.007	0.012	0.021		0.044	0.076	0.132	
CD (5%)	9.248	16.018	NS		0.020	0.034	NS		0.125	0.216	NS	
CV (%)	2.71				2.85				2.85			

The results were in accordance with Kumawat *et al.* (2009), where inoculation of seeds with PSB gave the maximum nitrogen concentration in seed and their total uptake in mung bean, Navsare *et al*. (2018), reported that maximum protein content was observed in the seed which was inoculated with RDF + Rhizobium + PSB + KSB + ZSB over the control in mungbean.

4. Conclusions

Comment [U40]: edited

Based on the results obtained from the present study, the following conclusions can be drawn: Among the seed bio-priming treatments combination of *Azospirillum* + Phosphorous solubilizing bacteria+ Potassium solubilizing bacteria each at @ 20 % and at duration of 12 h soaking was found to be more effective than other priming treatments. HQPM-5 maize hybrid responded better to the priming treatments than its parental lines (HKI-161 and HKI-163). Female parent (HKI-163) showed better performance than the Male parent (HKI-161) to the priming treatments.

Comment [U41]: edited

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Comment [U42]: edited

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