

# 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 and HKI-161 seeds during *rabi* 2022-23 to evaluate the effect of liquid biofertilizers (*Azospirillum*, Phosphorus solubilizing bacteria and Potassium solubilizing bacteria) on seed quality attributes in Quality Protein Maize (QPM) genotypes. The seeds were subjected to different concentration and duration of hydropriming and biopriming (Concentration: 10,15 and 20%; Duration: 6,12,18 and 24h). The non primed seeds were used as control. HQPM-5 seeds bioprimed with combination of *Azospirillum* @ 20 % + Phosphorous solubilizing bacteria @ 20 % + Potassium solubilizing bacteria @ 20 % at 12h (T<sub>9</sub>) 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 biofertilizers, Quality Protein Maize (QPM), Biopriming, Hydropriming.

## INTRODUCTION

Maize (*Zea mays* L.) is the third most important cereal crop in the world agriculture. It has got the sobriquet “Queen of cereals” because of its highest yield potential and wider adaptability. Maize belongs to the grass family *Poaceae*. As maize is a C<sub>4</sub> plant it has a higher potential for the synthesis of carbohydrates. 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) is a family of maize varieties. QPM grain contains nearly twice as much lysine and tryptophan, amino acids that are essential for humans and monogastric animals but are limiting amino acids in grains. QPM is a product of

conventional plant breeding (i.e., it is not genetically modified) and an example of biofortification. Given the importance of the energy crisis, 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 to original moisture content prior to sowing (Lutts *et al.*, 2016). Bio-priming is an efficient inoculation method to apply beneficial bacteria prior to sowing that enhances the chances of bacterial candidates to colonize the rhizosphere and establish a liaison with the plant.

Utilising biofertilizers 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 clearly reported that inoculation of maize with *Azospirillum* increased the uptake of nutrients, plant growth and yield. (Dobbelaere *et al.*, 2001) The utilization of Phosphorous solubilizing bacteria and Potassium solubilizing bacteria as biofertilization 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)

## MATERIAL AND METHODS

A laboratory experiment on enhancement of seed quality parameters through hydropriming and biopriming in hybrid maize HQPM-5 and its parental lines i.e., HKI-163 and HKI-161 was conducted at Regional Agricultural Research Station (RARS), Nandyal 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 Table 1.

**Table 1: Details of seed priming treatments under study**

Treatment	Treatment
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No.	
T <sub>1</sub>	Untreated Seed (control)
T <sub>2</sub>	Hydropriming
T <sub>3</sub>	<i>Azospirillum</i> @ 20 %
T <sub>4</sub>	Phosphorous solubilizing bacteria @ 20 %
T <sub>5</sub>	Potassium solubilizing bacteria @ 20 %
T <sub>6</sub>	<i>Azospirillum</i> @ 20 % + Phosphorous solubilizing bacteria @ 20 %
T <sub>7</sub>	<i>Azospirillum</i> @ 20 % + Potassium solubilizing bacteria @ 20 %
T <sub>8</sub>	Phosphorous solubilizing bacteria @ 20 % + Potassium solubilizing bacteria @ 20 %
T <sub>9</sub>	<i>Azospirillum</i> @ 20 % + Phosphorous solubilizing bacteria @ 20 % + Potassium solubilizing bacteria @ 20 %

The seed and seedling quality was studied in Two Factorial Completely Randomized Design (FCRD). 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.

### Germination

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

$$G\% = \frac{\text{Number of normal seedlings}}{\text{Total number of seed sown}} \times 100$$

### 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. 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 centimetre.

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

### **Seedling fresh weight (g)**

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

### **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  $75\pm 1^\circ\text{C}$  for 48 hours until attaining constant weight of the sample. After cooling, weight of the dried shoots and roots was recorded using an electronic weighing balance and average weight was calculated and was expressed in grams per seedling.

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

### **Seed vigour index-I and II**

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

$$\text{Seed vigour index} = \text{Germination (\%)} \times (\text{Seedling length}) \text{ (cm)}$$

$$\text{Seed vigour index-II} = \text{Germination (\%)} \times \text{Seedling dry weight (g)}$$

### **Electrical conductivity of seed leachates ( $\mu\text{S cm}^{-1}$ )**

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  $\mu\text{Scm}^{-1}$ .

## **Nitrogen content**

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

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

## **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).

$$\text{Protein content (\%)} = \text{Nitrogen content (\%)} \times 6.25 \text{ (factor)}$$

## **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 15<sup>th</sup> day after sowing and the field emergence percentage was calculated as per the formula:

$$\text{Field Emergence (\%)} = \frac{\text{Number of seedlings emerged}}{\text{Total number of seed sown}} \times 100$$

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).

## **RESULTS AND DISCUSSION**

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. The interaction effects of genotypes and treatments was found significant for all the parameters studied except for germination, field emergence, shoot length, seedling fresh weight, seedling dry weight, EC of seed leachates, nitrogen and protein content of seed.

### **Germination percentage (%)**

The highest (96.67 %) germination was recorded after seed priming with T<sub>9</sub> (*Azospirillum* @ 20 % + Phosphorous solubilizing bacteria @ 20 % + Potassium solubilizing bacteria @ 20 %) in HQPM-5 and lowest (77.51 %) germination was observed in T<sub>1</sub> (control) in HKI-161 with overall mean germination of 85.85 % (Table 2). The results are in accordance with Karthika and Vanangamudi (2013) in which biopriming with *Azospirillum* @ 20 % and Phosphobacteria @ 20 % concentration for 12 h in maize hybrid COH(M) significantly improved the germination.

**Table 2. Influence of seed hydropriming and biopriming 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 <sub>1</sub>	79.81 (63.30)	77.51 (61.69)	85.12 (67.31)	<b>80.81</b> <b>(64.10)</b>	79.35 (62.97)	76.67 (61.12)	83.65 (66.15)	<b>79.89</b> <b>(63.41)</b>
T <sub>2</sub>	80.67 (63.92)	78.67 (62.49)	86.23 (68.22)	<b>81.86</b> <b>(64.88)</b>	80.19 (63.57)	76.98 (61.33)	84.29 (66.65)	<b>80.49</b> <b>(63.85)</b>
T <sub>3</sub>	82.67 (65.40)	79.06 (62.77)	88.46 (70.14)	<b>83.40</b> <b>(66.10)</b>	81.38 (64.44)	77.31 (61.55)	85.61 (67.61)	<b>81.43</b> <b>(64.57)</b>
T <sub>4</sub>	83.94 (66.37)	81.04 (64.19)	89.67 (71.26)	<b>84.49</b> <b>(67.27)</b>	83.66 (66.16)	80.05 (63.47)	86.43 (68.38)	<b>83.38</b> <b>(66.00)</b>
T <sub>5</sub>	86.67 (68.59)	81.57 (64.58)	92.07 (73.64)	<b>86.77</b> <b>(68.94)</b>	84.76 (67.02)	81.18 (64.29)	90.57 (72.12)	<b>85.50</b> <b>(67.81)</b>
T <sub>6</sub>	85.33 (67.48)	82.15 (65.01)	94.25 (76.13)	<b>87.24</b> <b>(69.58)</b>	85.12 (67.31)	80.34 (63.68)	92.31 (73.90)	<b>85.92</b> <b>(68.30)</b>
T <sub>7</sub>	86.12 (68.13)	83.33 (65.90)	93.53 (75.26)	<b>87.66</b> <b>(69.76)</b>	85.86 (67.91)	82.67 (65.40)	89.79 (71.37)	<b>86.11</b> <b>(68.23)</b>
T <sub>8</sub>	87.67 (69.44)	84.67 (66.95)	94.72 (76.72)	<b>89.02</b> <b>(71.04)</b>	86.49 (68.43)	83.88 (66.33)	93.95 (75.76)	<b>88.11</b> <b>(70.17)</b>
T <sub>9</sub>	89.33 (70.93)	86.91 (67.79)	96.67 (79.49)	<b>90.97</b> <b>(73.07)</b>	87.73 (69.50)	84.49 (66.81)	94.16 (76.02)	<b>88.79</b> <b>(70.78)</b>
Mean	<b>84.69</b> <b>(67.06)</b>	<b>81.66</b> <b>(64.71)</b>	<b>91.19</b> <b>(73.13)</b>	<b>85.85</b> <b>(68.30)</b>	<b>83.84</b> <b>(66.37)</b>	<b>80.40</b> <b>(66.37)</b>	<b>88.97</b> <b>(70.90)</b>	<b>84.40</b> <b>(67.01)</b>
	<b>G</b>	<b>T</b>	<b>G×T</b>		<b>G</b>	<b>T</b>	<b>G×T</b>	
<b>SE m±</b>	0.41	0.71	1.23		0.44	0.76	1.32	
<b>CD (5%)</b>	1.17	2.02	NS		1.25	2.16	NS	
<b>CV</b>	2.72				2.95			

\*Values in the parenthesis indicate arc-sine transformed values

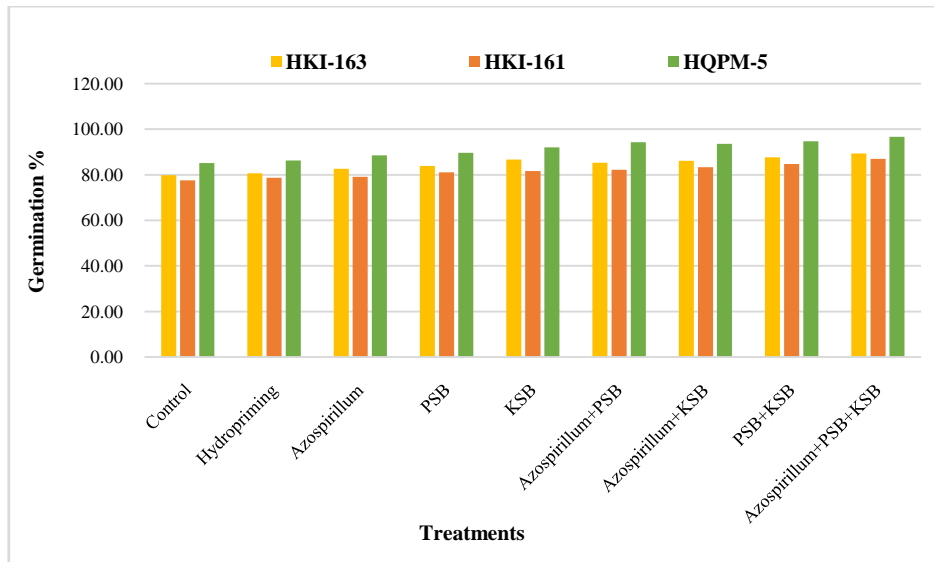


Fig.1: Influence of seed hydropriming and bioprimering on germination (%) of quality protein maize (QPM) genotypes.

### Field emergence (%)

The Highest (94.16%) and lowest (76.67%) field emergence was recorded after seed priming with a combination of *Azospirillum* @ 20 per cent + Phosphorous solubilizing bacteria @ 20 per cent + Potassium solubilizing bacteria @ 20 per cent (T<sub>9</sub>) and control (T<sub>1</sub>) seed in HQPM-5 and HKI-161 respectively. The overall mean field emergence is 84.40 per cent (Table 2). The results are in consistent with Madhukeswara and Ashok (2017) showing the significantly higher field emergence due to bio-priming treatments *Azospirillum brasilense* (20%) and *Pseudomonas striata* (20%) over the non-primed (control) in maize hybrid.

**Table 3: Influence of seed hydropriming and bioprimering 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 <sub>1</sub>	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 <sub>2</sub>	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 <sub>3</sub>	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 <sub>4</sub>	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 <sub>5</sub>	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 <sub>6</sub>	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 <sub>7</sub>	16.73	14.85	16.42	16.00	17.46	16.27	22.37	18.70	34.19	31.12	38.79	34.70

<b>T<sub>8</sub></b>	17.46	15.26	17.16	16.63	18.27	16.76	23.04	19.36	35.73	32.02	40.20	35.98
<b>T<sub>9</sub></b>	18.14	16.36	18.19	17.56	19.54	17.19	24.61	20.45	37.68	33.55	42.80	38.01
<b>Mean</b>	14.85	12.61	15.60	14.35	16.00	14.58	21.00	17.20	30.85	27.19	36.61	31.55
	<b>G</b>	<b>T</b>	<b>G×T</b>		<b>G</b>	<b>T</b>	<b>G×T</b>		<b>G</b>	<b>T</b>	<b>G×T</b>	
<b>S Em±</b>	0.067	0.115	0.200		0.083	0.144	0.250		0.111	0.193	0.334	
<b>CD (5%)</b>	0.189	0.328	0.568		0.237	0.410	NS		0.316	0.548	0.949	

### Root length (cm)

The highest (18.19 cm) and lowest (9.31 cm) root length was recorded for seed primed with T<sub>9</sub> (*Azospirillum* @ 20 % + Phosphorous solubilizing bacteria @ 20 % + Potassium solubilizing bacteria @ 20 %) in HQPM-5 and T<sub>1</sub> (Control) in HKI-161 respectively with overall mean root length of 14.35 cm. Similar results were obtained by Karnan *et al.* (2012) and reported that seeds bioprimered with a combination of *Rhizobium* and *Azospirillum* significantly enhanced the root length over control in cowpea.

### Shoot length (cm)

After seed priming with T<sub>9</sub> (*Azospirillum* @ 20 % + Phosphorous solubilizing bacteria @ 20 % + Potassium solubilizing bacteria @ 20 %) highest (24.61 cm) in HQPM-5 and lowest (11.46 cm) shoot length with T<sub>1</sub> (Control) in HKI-161 with overall mean shoot length of 17.20 cm was recorded. Similar results were observed by Shirin *et al.*, (2012) that the maize seed inoculated with nitragin (*Azospirillum* and *Pseudomonas*) bio-fertilizer showed an improvement in shoot length by 35 per cent over control.

### Seedling length (cm)

The highest (42.80 cm) and lowest (20.77 cm) seedling length was recorded after seed priming with T<sub>9</sub> (*Azospirillum* @ 20 % + Phosphorous solubilizing bacteria @ 20 % + Potassium solubilizing bacteria @ 20 %) in HQPM-5 and T<sub>1</sub> (Control) in HKI-161 respectively with overall mean seedling length of 31.55 cm (Table 3). The results are consistent with Karthika and Vanangamudi (2013) that seeds primed with *Azospirillum* solution @ 20 % for 12h expressed longer seedling length which was at par with Phosphobacteria @ 20 % concentration for 12 h.

### Root dry weight (g)

The highest (0.036 g) and lowest (0.011 g) root dry weight was recorded after seed priming with T<sub>9</sub> (*Azospirillum* @ 20 % + Phosphorous solubilizing bacteria @ 20 % + Potassium solubilizing bacteria @ 20 %) in HQPM-5 and T<sub>1</sub> (Control) seed in HKI-161 respectively with overall mean root dry weight of 0.024 g (Table 4). The results are in harmony with Parmar and Sindhu (2013) that inoculation of K-solubilizing isolate HWP47 in wheat (*Triticum aestivum* L.) var. WH711 resulted in increase in root dry weight.

**Table 4: Influence of seed hydropriming and bioprimering on root dry weight (g) and**

Treatments	Root dry weight (g)				Shoot dry weight (g)			
	HKI-163	HKI-161	HQPM-5	Mean	HKI-163	HKI-161	HQPM-5	Mean
T <sub>1</sub>	0.013	0.011	0.018	0.014	0.073	0.048	0.081	0.067
T <sub>2</sub>	0.015	0.014	0.021	0.016	0.079	0.051	0.084	0.071
T <sub>3</sub>	0.017	0.016	0.022	0.018	0.083	0.059	0.091	0.077
T <sub>4</sub>	0.023	0.021	0.025	0.023	0.084	0.064	0.097	0.081
T <sub>5</sub>	0.027	0.024	0.028	0.026	0.089	0.069	0.104	0.087
T <sub>6</sub>	0.029	0.025	0.026	0.026	0.093	0.073	0.109	0.091
T <sub>7</sub>	0.028	0.027	0.031	0.028	0.095	0.074	0.113	0.093
T <sub>8</sub>	0.031	0.029	0.033	0.031	0.098	0.076	0.116	0.096
T <sub>9</sub>	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
	<b>G</b>	<b>T</b>	<b>G×T</b>		<b>G</b>	<b>T</b>	<b>G×T</b>	
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			

**shoot dry weight (g) of quality protein maize (QPM) genotypes.**

### Shoot dry weight (g)

The highest (0.118 g) and lowest (0.048 g) shoot dry weight was recorded after seed priming with T<sub>9</sub> (*Azospirillum* @ 20 % + Phosphorous solubilizing bacteria @ 20 % + Potassium solubilizing bacteria @ 20 %) in HQPM-5 and T<sub>1</sub> (Control) 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 bioprimering with *T. asperillum* BHUT8 showed enhancement in shoot dry weight, as compared to the control in pea.

**Table 5. Influence of seed hydropriming and bioprimering 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 <sub>1</sub>	0.97	0.87	1.03	0.96	0.086	0.059	0.099	0.081
T <sub>2</sub>	1.08	0.95	1.10	1.04	0.094	0.065	0.105	0.087
T <sub>3</sub>	1.12	0.98	1.14	1.08	0.100	0.075	0.113	0.095
T <sub>4</sub>	1.13	1.02	1.15	1.10	0.107	0.085	0.122	0.104
T <sub>5</sub>	1.14	1.04	1.12	1.10	0.116	0.093	0.132	0.113
T <sub>6</sub>	1.17	1.07	1.18	1.14	0.122	0.098	0.135	0.117
T <sub>7</sub>	1.19	1.08	1.22	1.16	0.123	0.101	0.144	0.121
T <sub>8</sub>	1.20	1.14	1.24	1.19	0.129	0.105	0.149	0.127
T <sub>9</sub>	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
	<b>G</b>	<b>T</b>	<b>G×T</b>		<b>G</b>	<b>T</b>	<b>G×T</b>	
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			

### Seedling fresh weight (g)

The highest (1.27 g) and lowest (0.87 g) seedling fresh weight was recorded after seed priming with T<sub>9</sub> (*Azospirillum* @ 20 % + Phosphorous solubilizing bacteria @ 20 % + Potassium solubilizing bacteria @ 20 %) in HQPM-5 and T<sub>1</sub> (Control) in HKI-161 respectively with overall mean seedling fresh weight of 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.

### Seedling dry weight (g)

The highest (0.154 g) and lowest (0.059 g) seedling dry weight was recorded after seed priming with T<sub>9</sub> (*Azospirillum* @ 20 % + Phosphorous solubilizing bacteria @ 20 % + Potassium solubilizing bacteria @ 20 %) in HQPM-5 and T<sub>1</sub> (Control) seed in HKI-161 respectively with overall mean seedling dry weight of 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.

### Seed vigour index-I

The highest (4137.48) and lowest (1609.88) seed vigour index-I was recorded after seed priming with T<sub>9</sub> (*Azospirillum* @ 20 % + Phosphorous solubilizing bacteria @ 20 % +

Potassium solubilizing bacteria @ 20 %) in HQPM-5 and T<sub>1</sub> (Control) seed in HKI-161 respectively with overall mean seed vigour index-I of 2737.06.

### Seed vigour index-II

The highest (14.89) and lowest (4.57) seed vigour index-II was recorded after seed priming with T<sub>9</sub> (*Azospirillum* @ 20 % + Phosphorous solubilizing bacteria @ 20 % + Potassium solubilizing bacteria @ 20 %) in HQPM-5 and T<sub>1</sub> (Control) 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) that seed biopriming with *Trichoderma viridae* @ 80 % for 6 h showed more seedling vigour index when compared to control in maize.

**Table 6. Influence of seed hydropriming and biopriming 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 <sub>1</sub>	1782.16	1609.88	2541.61	<b>1977.88</b>	6.86	4.57	8.43	<b>6.55</b>
T <sub>2</sub>	2083.71	1728.38	2746.43	<b>2186.17</b>	7.58	5.11	9.05	<b>7.12</b>
T <sub>3</sub>	2262.68	1893.49	3030.64	<b>2395.60</b>	8.27	5.93	10.00	<b>7.92</b>
T <sub>4</sub>	2484.62	2085.24	3199.54	<b>2589.80</b>	8.98	6.89	10.94	<b>8.83</b>
T <sub>5</sub>	2733.57	2209.73	3517.07	<b>2820.13</b>	10.05	7.59	12.15	<b>9.81</b>
T <sub>6</sub>	2846.61	2343.74	3565.48	<b>2918.61</b>	10.41	8.05	12.72	<b>10.21</b>
T <sub>7</sub>	2944.44	2593.23	3627.88	<b>3055.18</b>	10.59	8.42	13.47	<b>10.61</b>
T <sub>8</sub>	3132.43	2711.13	3807.74	<b>3217.10</b>	11.31	8.89	14.11	<b>11.31</b>
T <sub>9</sub>	3365.95	2915.83	4137.48	<b>3473.09</b>	12.24	9.82	14.89	<b>12.19</b>
Mean	<b>2626.24</b>	<b>2232.30</b>	<b>3352.65</b>	<b>2737.06</b>	<b>9.49</b>	<b>7.19</b>	<b>11.58</b>	<b>9.36</b>
	<b>G</b>	<b>T</b>	<b>G×T</b>		<b>G</b>	<b>T</b>	<b>G×T</b>	
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			

### Electrical conductivity ( $\mu\text{S cm}^{-1}$ )

The highest ( $696.34 \mu\text{S cm}^{-1}$ ) and lowest ( $654.64 \mu\text{S cm}^{-1}$ ) electrical conductivity was recorded after seed priming with control (T<sub>1</sub>) in HKI-161 and with T<sub>9</sub> (*Azospirillum* @ 20 %

+ Phosphorous solubilizing bacteria @ 20 % + Potassium solubilizing bacteria @ 20 %) in HQPM-5 respectively with overall mean electrical conductivity of 677.97  $\mu\text{S cm}^{-1}$ . The results are in conformation with Mahmoodi *et al.* (2011) where hydro-priming in maize seed significantly reduced electrical conductivity of seed leachates, compared with unprimed seeds.

### **Nitrogen content (%)**

The highest (1.65 %) and lowest (1.24 %) nitrogen content was recorded with T<sub>9</sub> (*Azospirillum* @ 20 % + Phosphorous solubilizing bacteria @ 20 % + Potassium solubilizing bacteria @ 20 %) in HQPM-5 and seed priming with T<sub>1</sub> (Control) in HKI-161 respectively with overall mean nitrogen content of 1.40 % (Table 7 and Fig. 2). **Fig.1:**

**Influence of seed hydropriming and biopriming on germination (%) of quality protein maize (QPM) genotypes.**

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.

### **Protein content (%)**

The highest (10.30 %) and lowest (7.76 %) protein content was recorded with T<sub>9</sub> (*Azospirillum* @ 20 % + Phosphorous solubilizing bacteria @ 20 % + Potassium solubilizing bacteria @ 20 %) in HQPM-5 and seed priming with T<sub>1</sub> (Control) in HKI-161 respectively with overall mean protein content of 8.73 % (Table 7 and Fig.3). The results are in conformation with Ragab and Ibrahim (2009) where 120 kg N/fed plus [bio fertilizer notroben] resulted in a significant increase of crude protein percentage in maize.

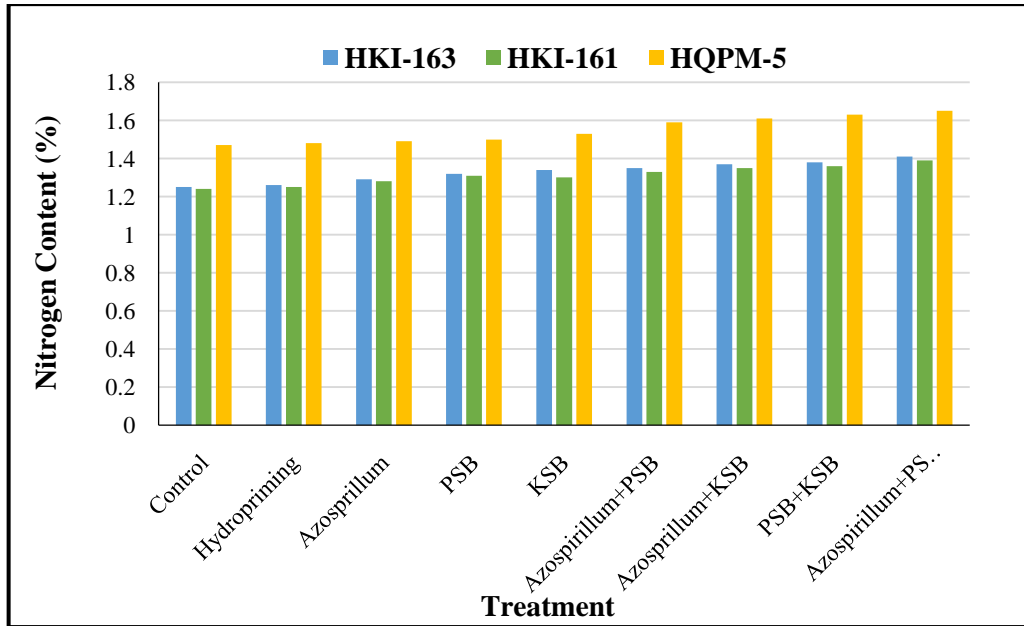


Fig.2: Influence of seed hydropriming and biopriming on nitrogen content (%) of quality protein maize (QPM) genotypes.

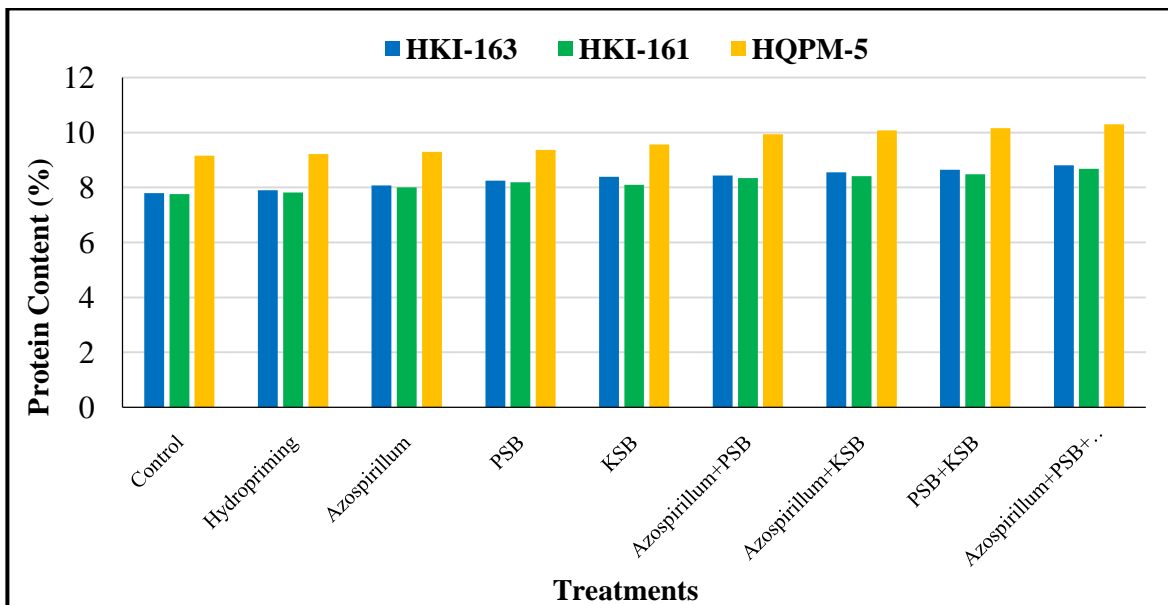


Fig.3: Influence of seed hydropriming and biopriming on protein content (%) of quality protein maize (QPM) genotypes.

**Table 7. Influence of seed hydropriming and biopriming on EC of seed leachates ( $\mu\text{s}/\text{cm}$ ) and nitrogen content (%) and protein content (%) of Quality Protein Maize (QPM) genotypes.**

Treatments	EC of seed leachates ( $\mu\text{S}/\text{cm}$ )				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 <sub>1</sub>	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 <sub>2</sub>	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 <sub>3</sub>	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 <sub>4</sub>	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 <sub>5</sub>	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 <sub>6</sub>	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 <sub>7</sub>	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 <sub>8</sub>	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 <sub>9</sub>	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.

## CONCLUSIONS

Based on the results obtained from the present study it can be concluded that among the seed biopriming treatments combination of *Azospirillum* + Phosphorous solubilizing bacteria + Potassium solubilizing bacteria each at @ 20 % and at duration of 12 h was more 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. Female parent (HKI-163) showed better performance than the Male parent (HKI-161) to the priming treatments.

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