Microbes for mitigating drought and temperature stress and enhancing yield in rapeseed mustard

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- Introduction : With the erratic changes in global climate incidences of drought and heat stresses will limit rapeseed-mustard productivity worldwide. Role of microbes in improving nutrient availability particularly in legumes, soil health and biodiversity is well known. Microbial inoculants offers an ecofriendly and cost effective approach for improving productivity by counteracting negative effects of stresses on metabolic processes

- Objectives : There was need to test the efficacy of microbial inoculants in non-leguminous crop/rapeseed mustard under two environments, water stress and irrigated modules for stress mitigation and enhancing productivity.

Two independent field experiments were conducted to evaluate the impact of microbes for 3 years (2020-21 to 2022-23)

- Experiment 1 : Mitigation of drought stress
- Variety PBR357
- Main plots : 6 microbial seed inoculation

1. Biophos & Biophos $^{+}$
2. CRIDA MI-I
3. CRIDA MI –II
4. MRD 17
5. MKS 6 and
6. Without inoculation

- Subplots : 3 irrigation modules:

❑ No irrigation : Moisture stress

❑ 50% deficit (35 DAS) : Restricted moisture

❑Normal irrigations (35 & 65 DAS):Normal moisture

- Experiment 2: Mitigation of temperature stress

- Main plots :3 varieties
  (PBR 357, RH 725 and Giriraj)
  Two sowing dates optimum time(NS) and late sowing (LS) by one month

- Sub plots : Seed dressing with

❑Microbial formulation as bio stimulant (MFs)

❑Stress adaptive consortium (Pusa Sanjeevani)

Observations recorded

➢ **Physiological traits (70DAS)**

- Relative water content (Weatherly *et al* (1950)
- Leaf water retention (Sangakkara *et al* 1996)
- Photosynthetic pigments (Hiscox and Israelstam 1979)
- Carotenoids content (Kirk and Allen 1965)
- Canopy temperature (Reynolds *et al* (1997)
- Membrane Stability (Premchandra *et al* (1990).

➢ **Osmoprotectants (Drought)**

❑Proline (Bates *et al* 1973)

❑Total sugars (Yeme and Willis (1954)

➢ **Antioxidant enzymes**

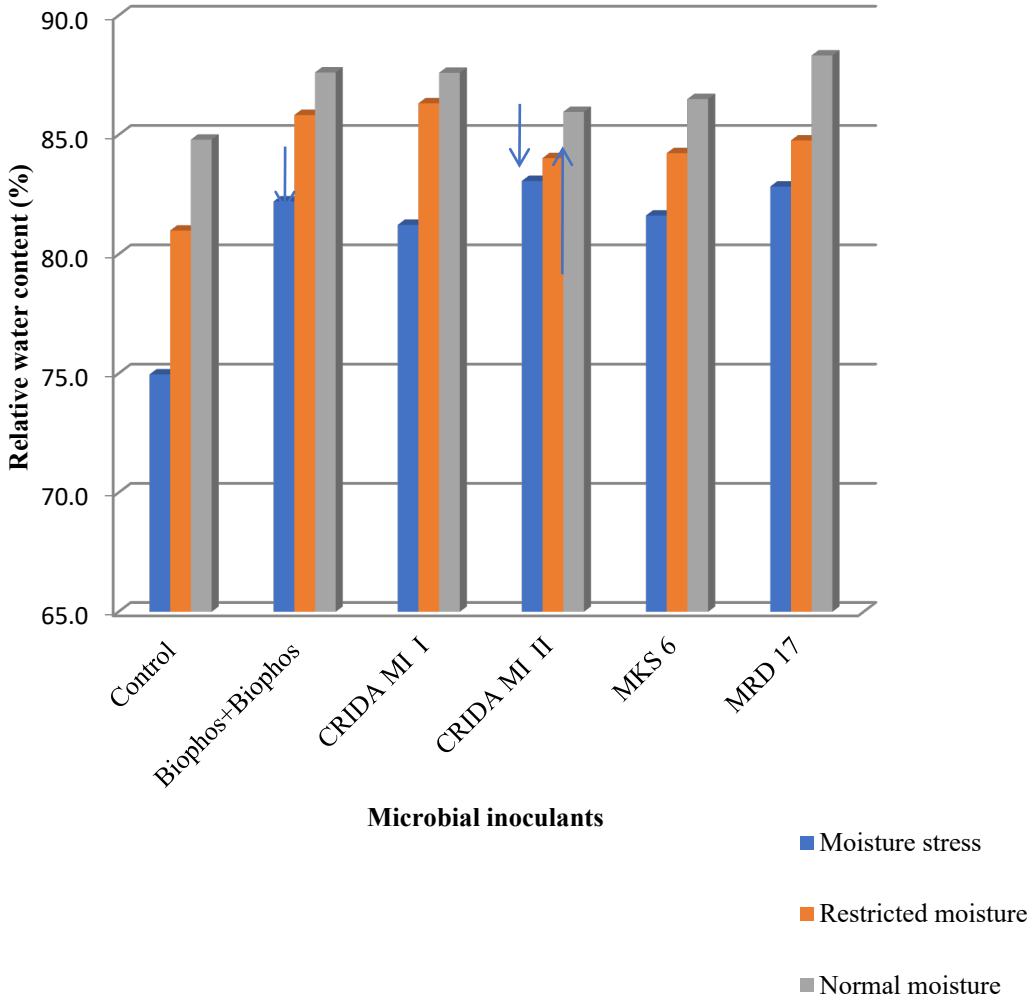
- Catalase (Chance and Maehley 1955)
- Peroxidase (Shannon *et al* 1966)
- Superoxide dismutase (SOD) (Marklund and Maeklund 1974)

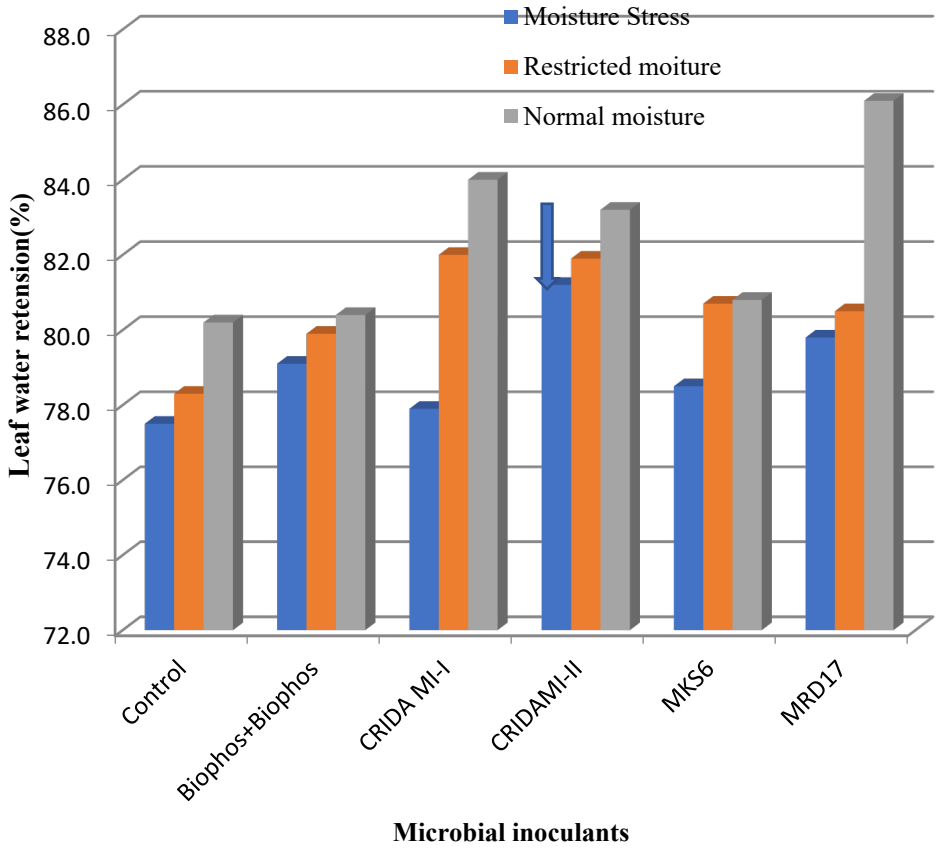
❖Seed yield and yield components at maturity

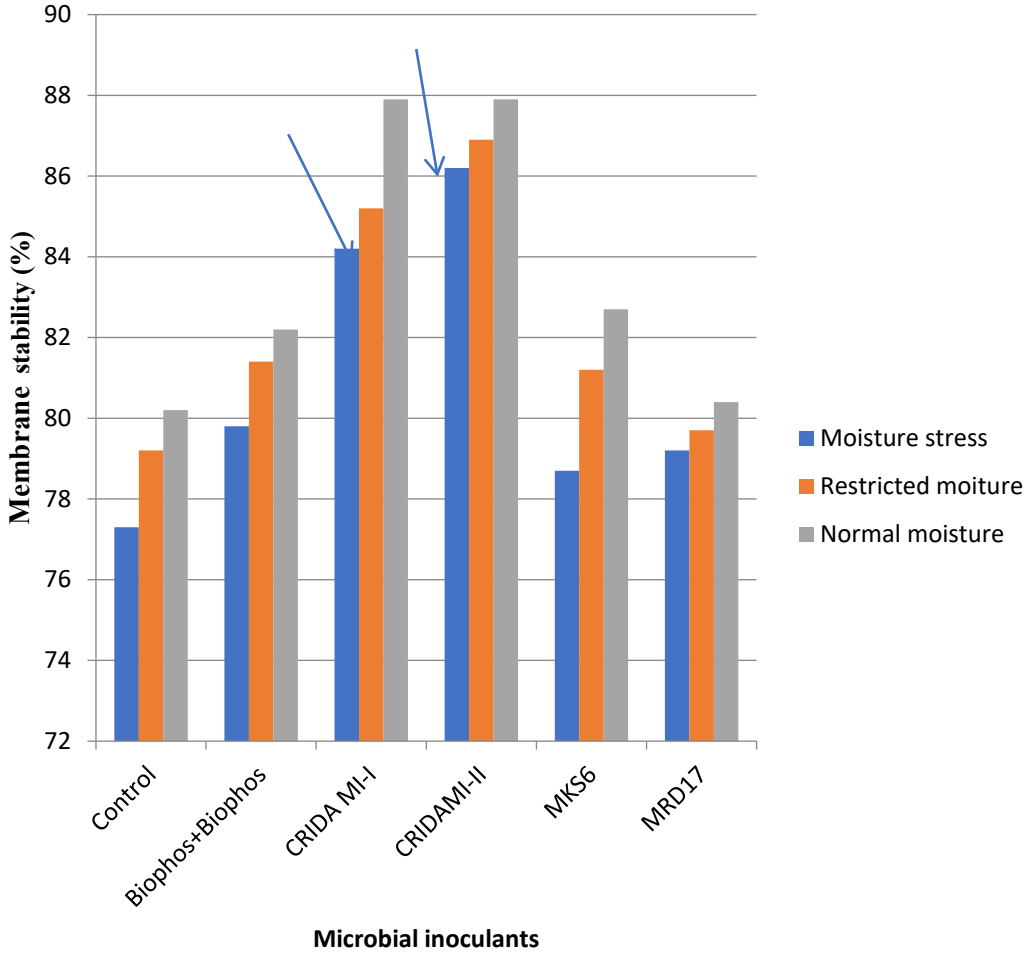
Effect of microbial inoculants on photosynthetic pigments under moisture stress

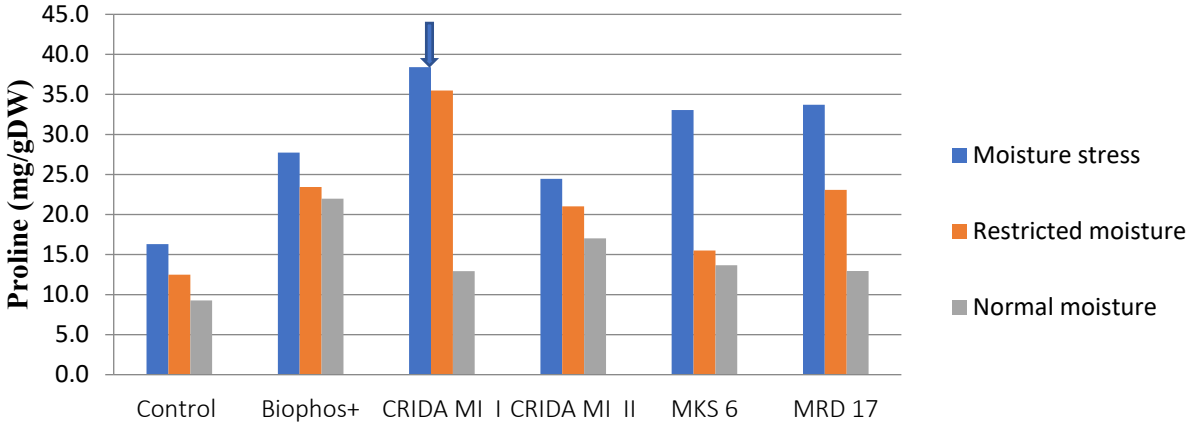
Pigments irrigation modules	Total chlorophyll (mg/g FW)						Carotenoids (mg/g FW)					
Microbial inoculants	Moisture Stress		Restricted moisture		Normal irrigation		Moisture Stress		Restricted moisture		Normal irrigation	
	Ranges	Mean	Ranges	Mean	Ranges	Mean	Ranges	Mean	Ranges	Mean	Ranges	Mean
Control	1.28-1.89	1.55	1.66-2.11	1.71	1.56-2.48	1.92	0.330-401	0.368	0.366-0.442	0.409	0.397-0.507	0.460
Biophos +Biophos	1.52-2.09	1.76	1.65-2.67	2.01	1.85-2.77	2.17	0.363 0.411	0.428	0.397-0.515	0.456	0.459-0.537	0.510
CRIDA MI-I	1.55-2.18	1.76	1.68-2.52	2.01	1.74-2.72	2.13	0.367-0.451	0.404	0.401-0.543	0.480	0.411-0.575	0.514
CRIDA MI-II	1.40-2.59	1.84	1.69-2.67	1.96	1.75-2.80	2.13	0.343-0.445	0.395	0.374-0.536	0.469	0.440-0.567	0.511
MKS6	1.46-2.09	1.75	1.67-2.31	1.98	1.69-2.64	2.06	0.350-0.424	0.391	0.405-0.509	0.467	0.410-0.607	0.517
MRD17	1.52-2.22	1.80	1.64-2.31	1.90	1.71-2.63	2.07	0.364-0.458	0.431	0.387-0.521	0.470	0.407-0.580	0.503

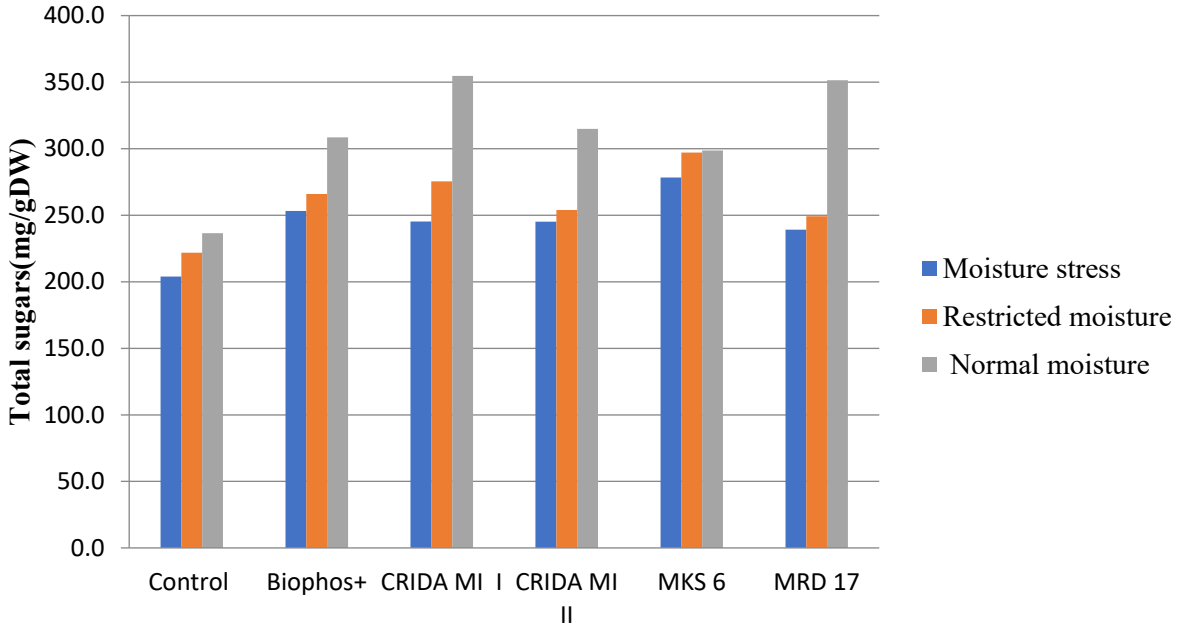
Variations in leaf water content at flowering stage







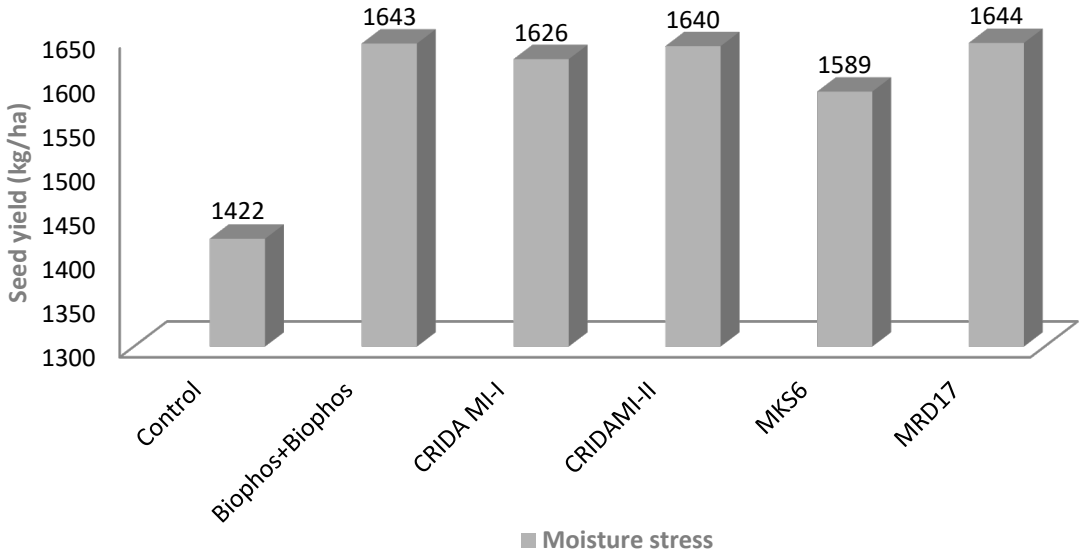


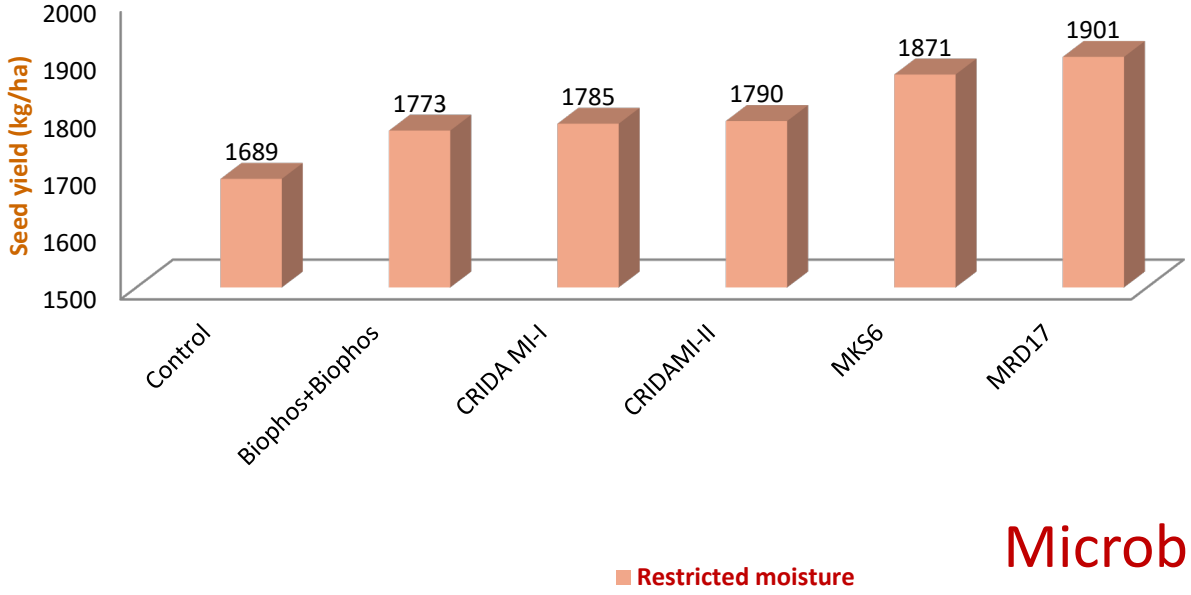


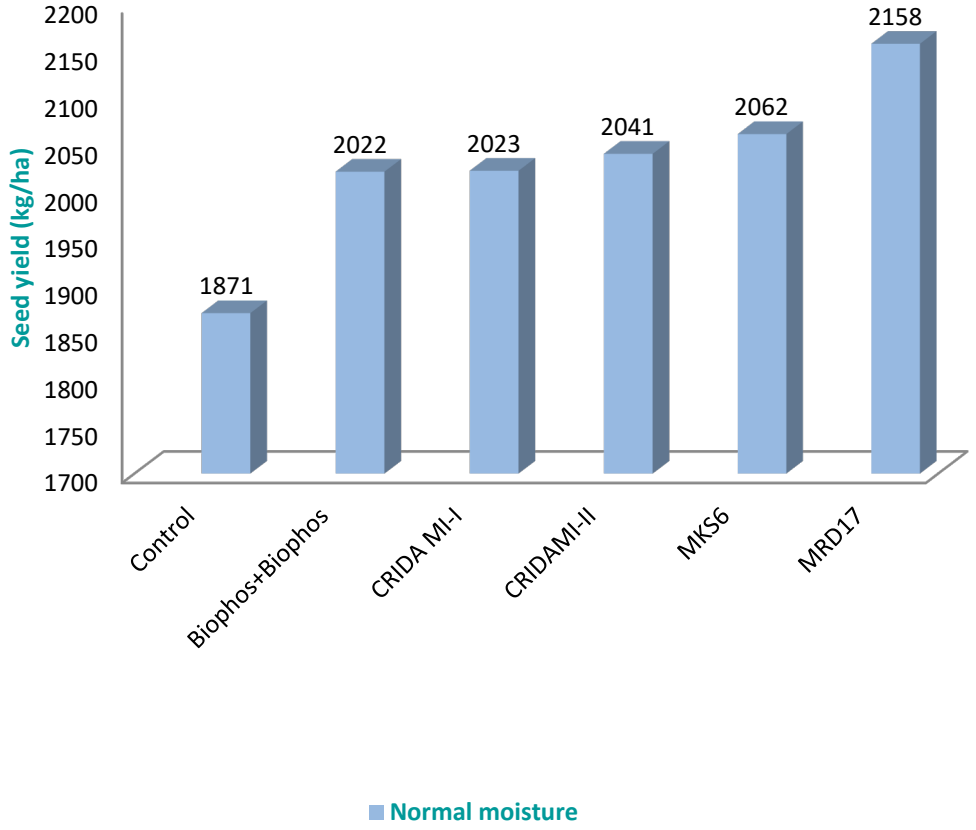
Membrane stability and osmoprotectants as influenced by microbes

Up regulation of antioxidative enzymes

Microbial treatments	Peroxidase (mmol min^{-1} g^{-1} FW)					
	Moisture stress		Restricted moisture		Normal moisture	
	Ranges	Mean	Ranges	Mean	Ranges	Mean
Control	0.548 - 1.144	**0.846**	0.483 - 0.893	**0.688**	0.504 - 0.814	**0.659**
Biophos+Biohos	0.642 - 1.498	**1.070**	0.494 - 1.130	**0.812**	0.583 - 1.086	**0.834**
CRIDA I	1.105 - 1.433	**1.269**	0.886 - 1.718	**1.302**	0.783 - 1.166	**0.974**
CRIDA II	0.818 - 1.479	**1.149**	0.782 - 1.331	**1.056**	1.076 - 1.391	**1.233**
MKS 6	0.962 - 1.567	**1.264**	0.750 - 1.138	**0.944**	0.631 - 1.585	**1.108**
MRD 17	0.782 - 1.606	**1.194**	0.741 - 1.462	**1.102**	0.592 - 1.196	**0.894**
Catalase (mmol min^{-1} g^{-1} FW)						
Control	78.5 - 92.3	**85.4**	66.4 - 81.4	**73.9**	67.3 - 77.3	**72.3**
Biophos+Biophos	87.1 - 112.5	**99.8**	75.4 - 82.5	**79.0**	76.2 - 81.4	**78.8**
CRIDA I	118.3 - 121.5	**119.9**	76.9 - 120.0	**98.5**	89.2 - 113.1	**101.1**
CRIDA II	112.0 - 118.9	**115.4**	84.5 - 114.0	**99.3**	77.9 - 86.0	**81.9**
MKS 6	91.7 - 117.7	**104.7**	84.8 - 99.6	**92.2**	70.4 - 89.5	**79.9**
MRD 17	100.4 - 104.4	**102.4**	91.8 - 95.8	**93.8**	88.7 - 107.3	**98.0**
	Superoxide dismutase (EA min^{-1} g-^{1} FW)					
Control	134.1 - 136.9	**135.5**	95.7 - 96.0	**95.8**	76.8 - 76.9	**76.8**
Biophos+Biophos	148.9 - 150.6	**149.7**	101.4 - 120.8	**111.1**	91.0 - 94.7	**92.8**
CRIDA I	162.0 - 171.9	**166.9**	118.4 - 128.4	**123.4**	96.4 - 101.5	**98.9**
CRIDA II	165.3 - 181.3	**173.3**	116.5 - 122.7	**119.6**	88.6 - 93.7	**91.1**
MKS 6	147.9 - 154.3	**151.1**	106.9 - 118.9	**112.9**	84.0 - 95.1	**89.5**
MRD 17	143.4 - 154.3	**148.9**	99.8 - 102.2	**101.0**	85.6 - 92.7	**89.1**

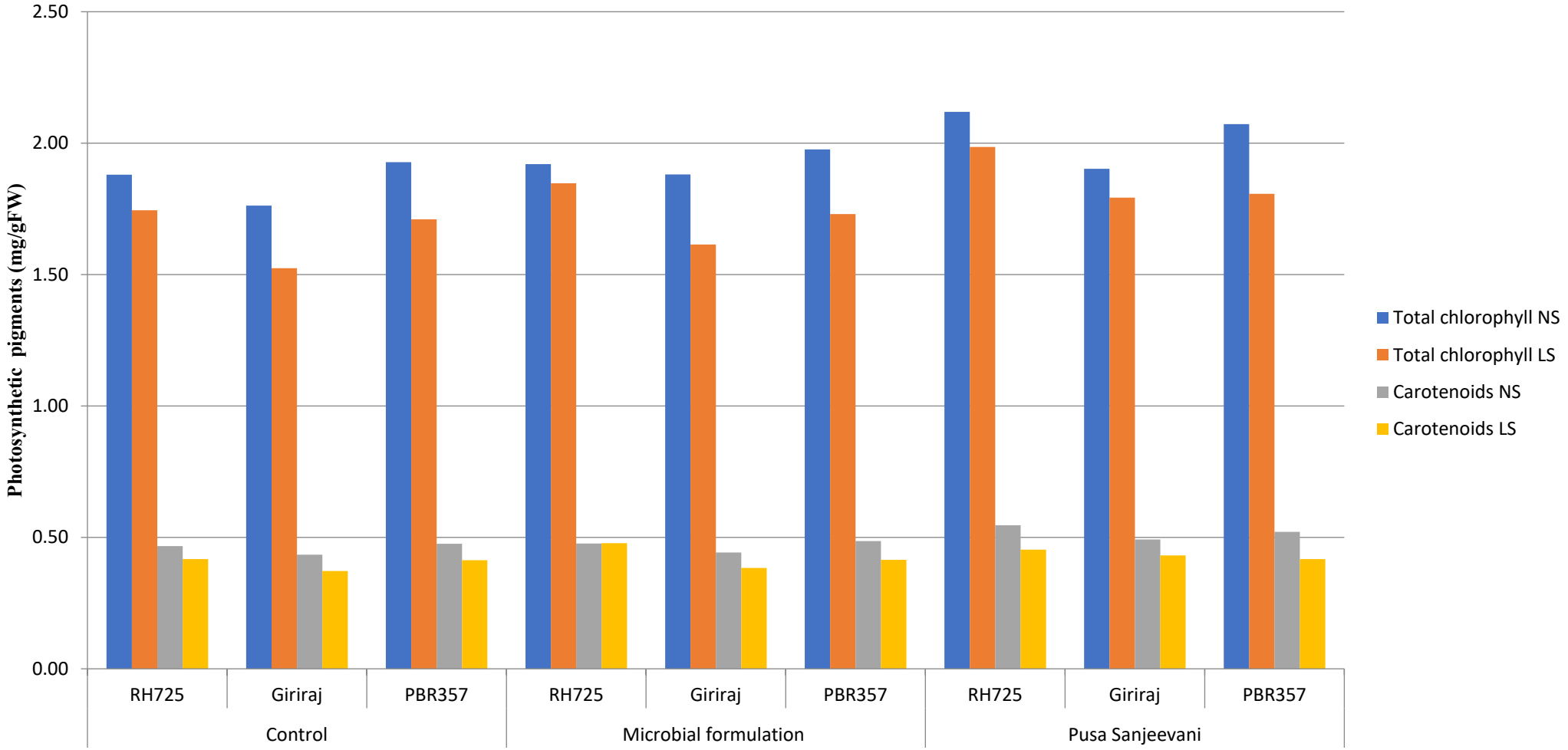


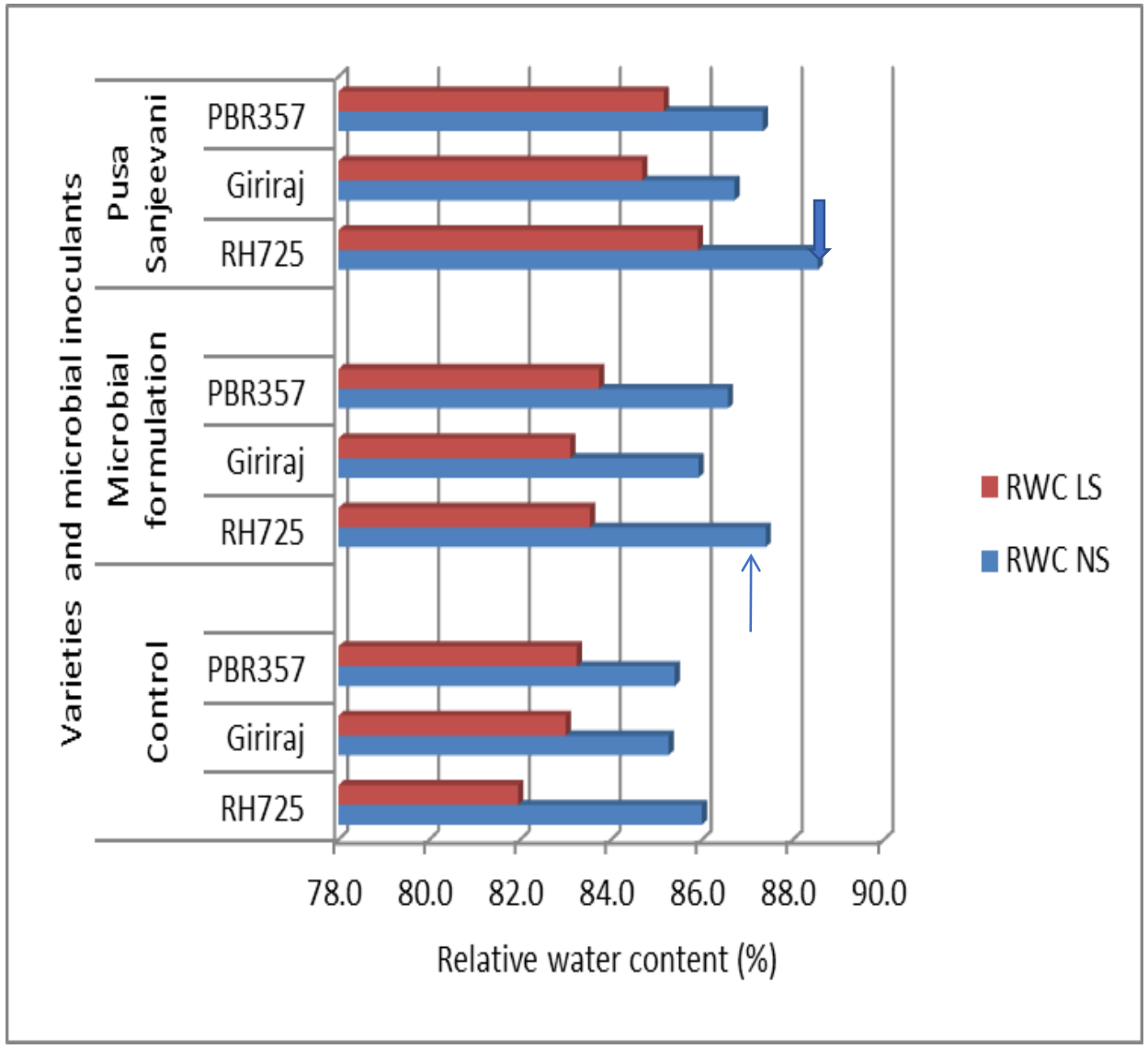


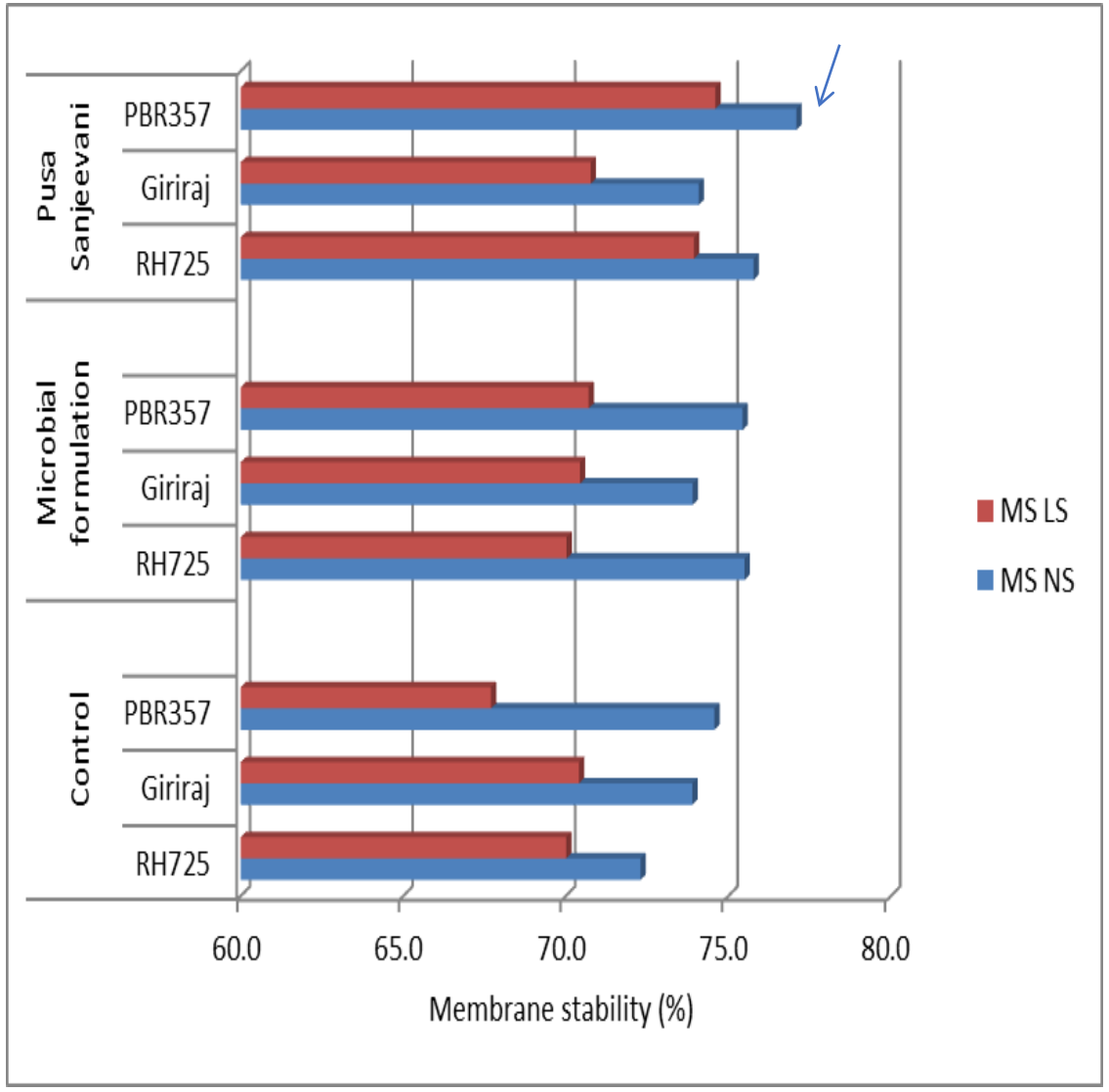


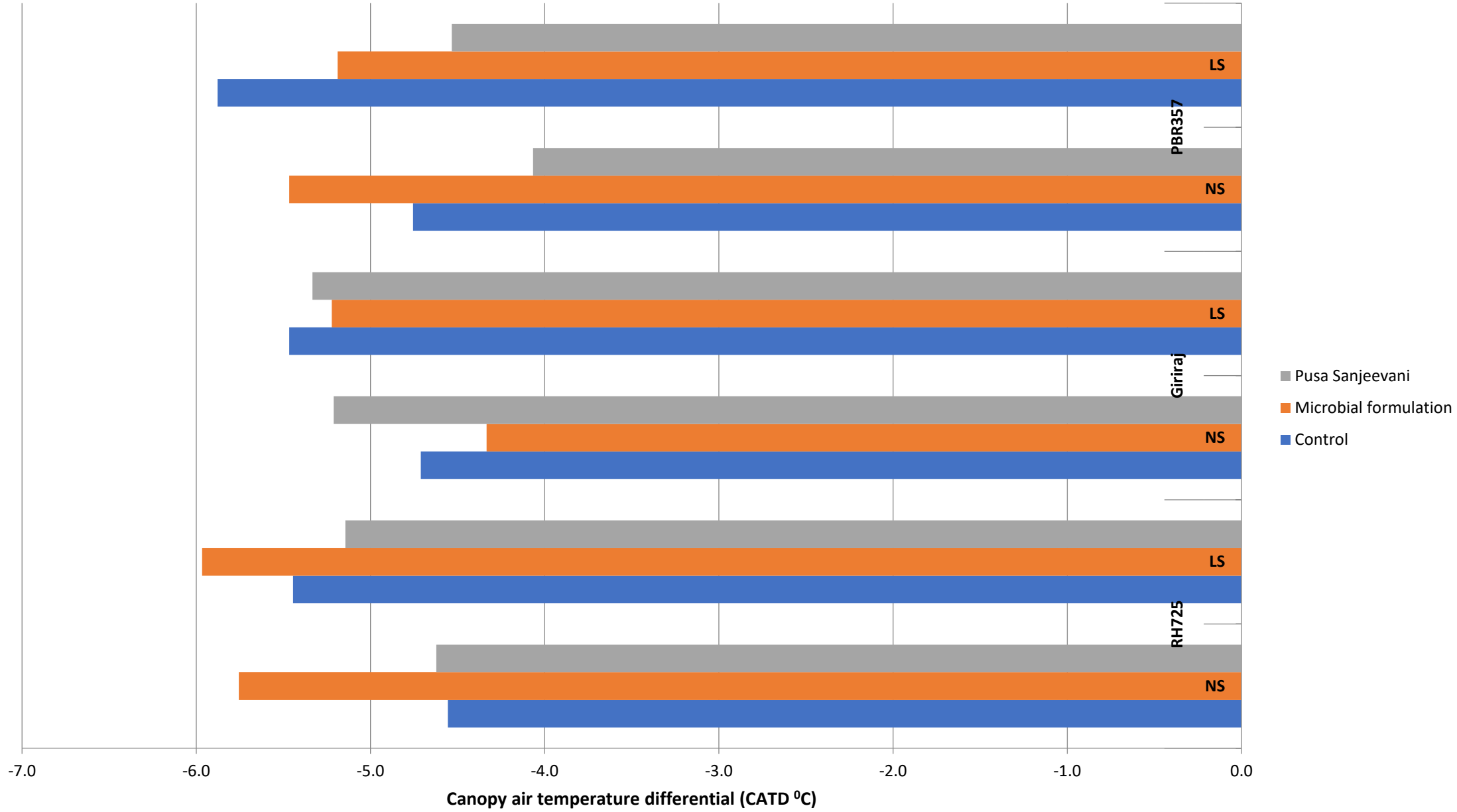
Microbes and seed yield under irrigation modules

Microbes to mitigate temperature stress



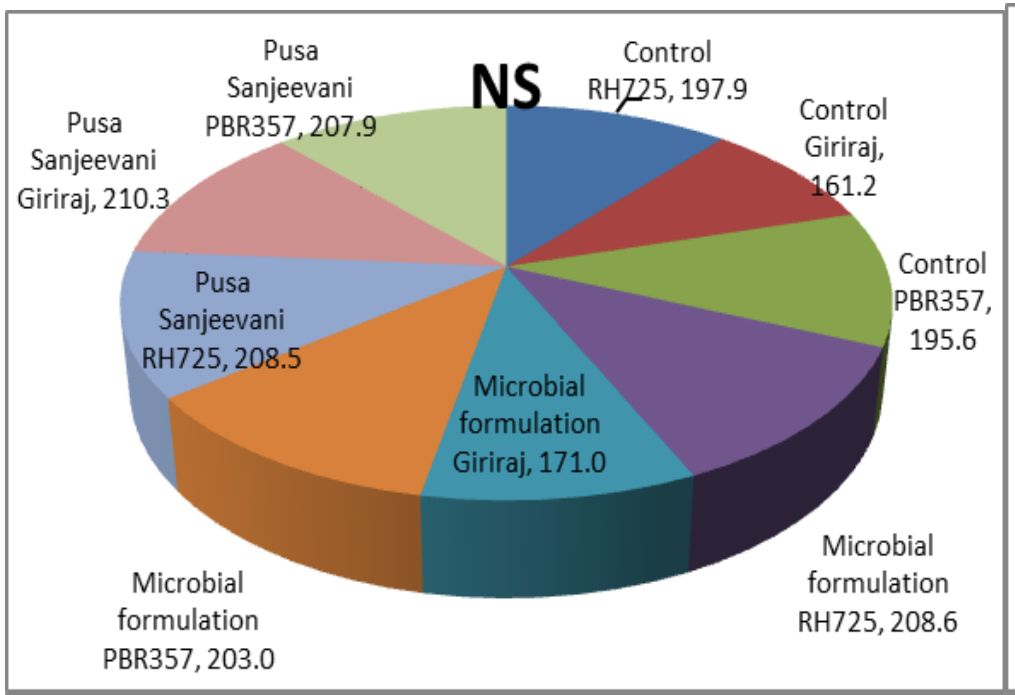

Varieties and microbial inoculants
Pusa Sanjeevani
PBR357
Giriraj
RH725
Microbial formulation
PBR357
Giriraj
RH725
Control
PBR357
Giriraj
RH725
78.0
80.0
82.0
84.0
86.0
88.0
90.0
Relative water content (%)
RWC LS
RWC NS

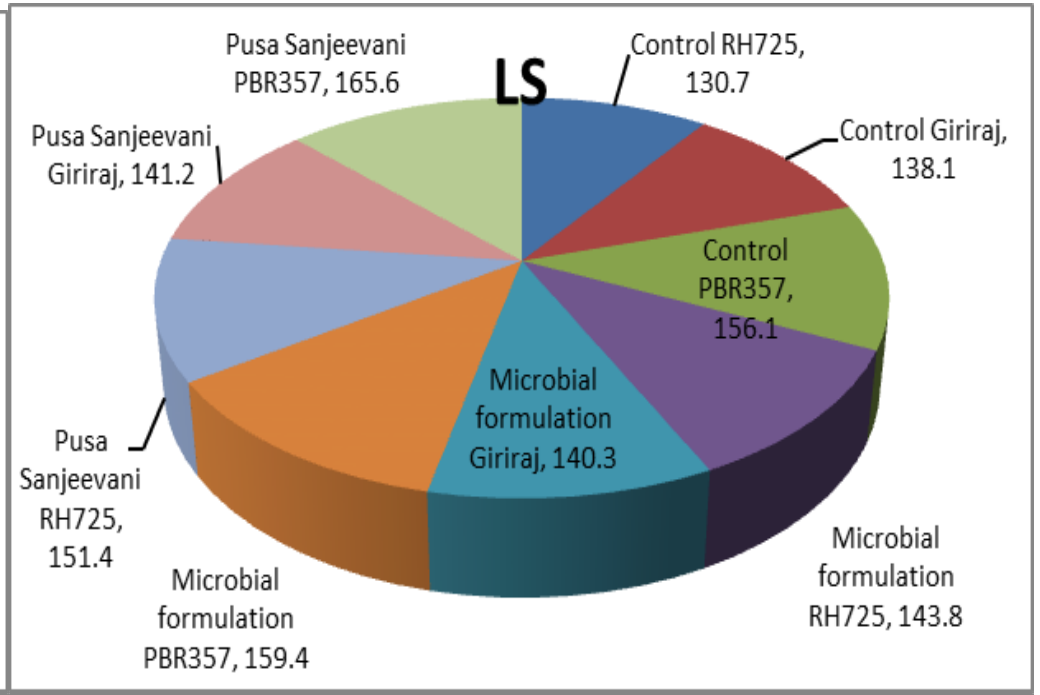

Pusa Sanjeevani
PBR357
Giriraj
RH725
Microbial formulation
PBR357
Giriraj
RH725
Control
PBR357
Giriraj
RH725
60.0
65.0
70.0
75.0
80.0
Membrane stability (%)
MS LS
MS NS


LS
NS
PBR357
LS
NS
Giriraj
LS
NS
RH725
Pusa Sanjeevani
Microbial formulation
Control
-7.0
-6.0
-5.0
-4.0
-3.0
-2.0
-1.0
0.0
Canopy air temperature differential (CATD ^{0}C)

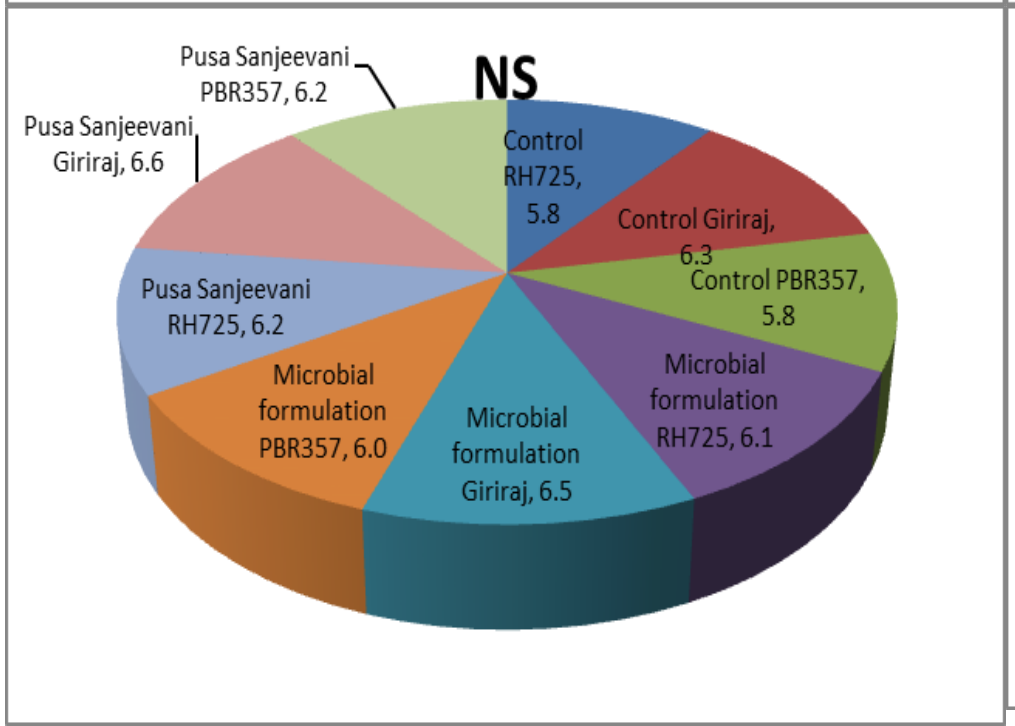
Variations in antioxidative enzymes under normal and late sowings

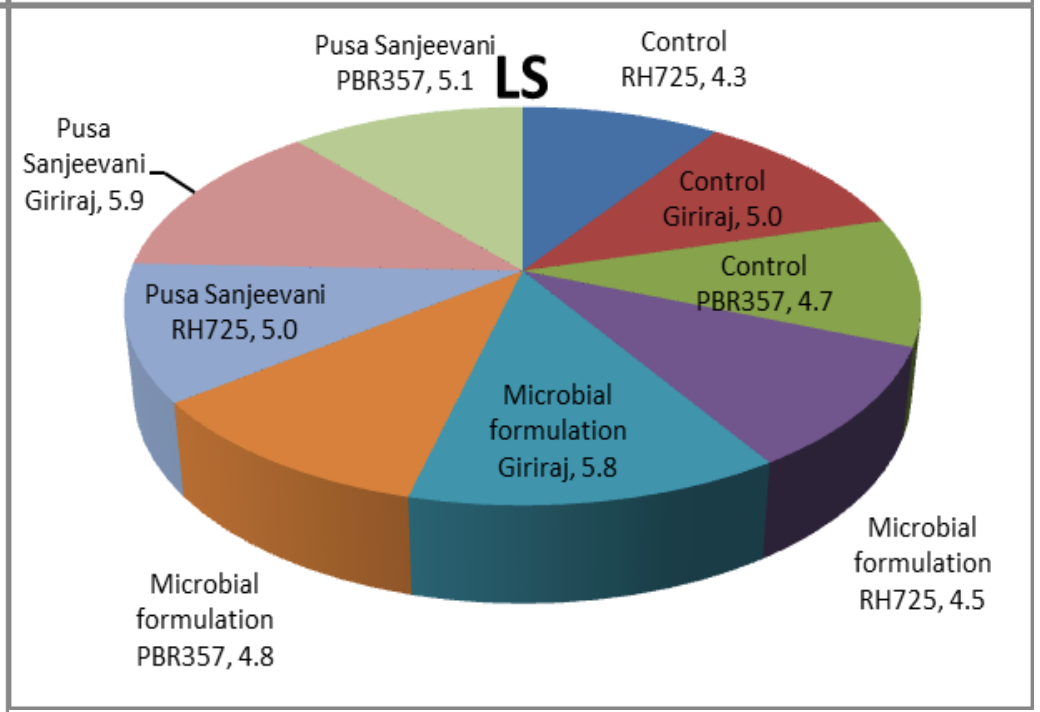
Culture	Variety	Peroxidase (mmol min^{-1} g^{-1} FW)				Catalase (mmol min^{-1} g^{-1} FW)				Superoxide dismutase (EA min^{-1} g^{-1} FW)			
		NS		LS		NS		LS		NS		LS	
		Ranges	Mean	Ranges	Mean	Ranges	Mean	Ranges	Mean	Ranges	Mean	Ranges	Mean
No culture	RH 725	0.492 - 0.682	0.587	1.122 - 1.126	1.124	53.1 - 67.8	60.5	170.8 - 198.8	184.8	76.2 - 77.9	77.1	135.8 - 143.8	139.8
	Giriraj	0.532 - 0.592	0.562	0.827 - 1.127	0.977	49.5 - 57.3	53.4	153.3 - 180.7	167.0	66.7 - 81.4	74.0	134.8 - 145.4	140.1
	PBR 357	0.383 - 0.670	0.527	1.050 - 1.110	1.080	59.9 - 64.0	61.9	159.5 - 174.4	166.9	70.6 - 76.3	73.5	127.5 - 137.0	132.2
Microbial formulation	RH 725	0.533 - 0.700	0.616	1.152 - 1.251	1.201	69.4 - 71.3	70.3	209.9 - 212.6	211.2	85.1 - 96.0	90.5	149.5 - 163.4	156.5
	Giriraj	0.591 - 0.747	0.669	1.139 - 1.265	1.202	66.9 - 68.9	67.9	189.6 - 207.1	198.3	78.2 - 88.5	83.3	142.9 - 155.0	149.0
	PBR 357	0.556 - 0.697	0.626	1.168 - 1.254	1.211	67.3 - 71.7	69.5	166.9 - 178.2	172.6	90.8 - 98.4	94.6	153.6 - 174.4	164.0
Pusa Sanjeevani	RH 725	0.535 - 0.691	0.613	1.203 - 1.271	1.237	68.5 - 78.9	73.7	191.4 - 201.9	196.6	82.6 - 97.4	90.0	173.1 - 201.9	187.5
	Giriraj	0.649 - 0.826	0.737	0.946 - 1.250	1.098	57.7 - 75.5	66.6	173.1 - 184.8	179.0	98.0 - 101.3	99.7	166.3 - 180.2	173.5
	PBR 357	0.483 - 0.742	0.612	1.133 - 1.241	1.187	61.4 - 67.0	64.2	169.0 - 185.2	177.1	87.9 - 103.8	95.8	154.0 - 178.2	166.1



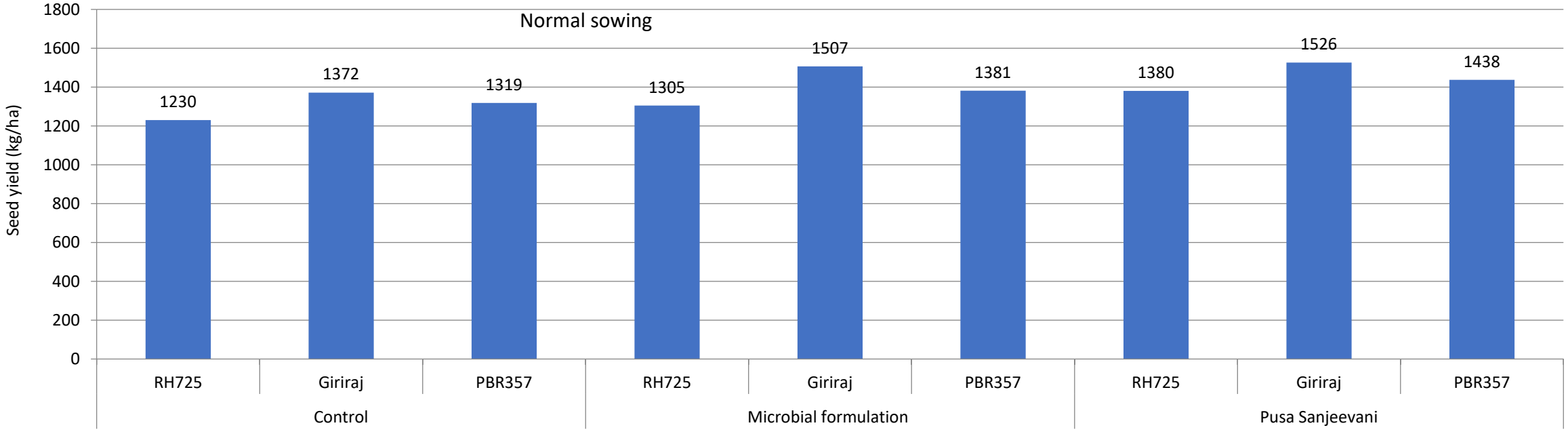


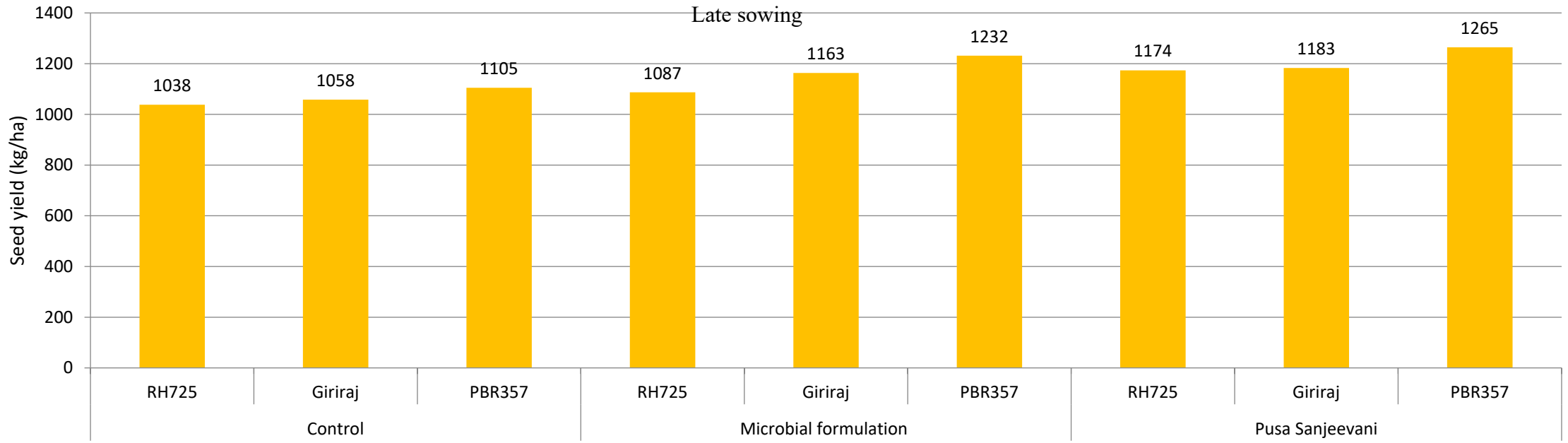
Total siliquae /plant





Seed weight (g)


Normal sowing
Seed yield (kg/ha)
1800
1600
1400
1200
1000
800
600
400
200
0
1230
1372
1319
1305
1507
1381
1380
1526
1438
RH725
Giriraj
PBR357
RH725
Giriraj
PBR357
RH725
Giriraj
PBR357
Control
Microbial formulation
Pusa Sanjeevani


Late sowing
Seed yield (kg/ha)
1400
1200
1000
800
600
400
200
0
1038
1058
1105
1087
1163
1232
1174
1183
1265
RH725
Giriraj
PBR357
RH725
Giriraj
PBR357
RH725
Giriraj
PBR357
Control
Microbial formulation
Pusa Sanjeevani

Conclusions

- Physiological traits, osmoprotectants and yield improved with the microbial treatments under moisture and temperature stress.

- Microbes were also beneficial in improving yield under restricted and normal moisture

- Variations existed in *B. juncea* varieties for the physiological and yield traits with microbial formulation and stress adaptive consortium under normal and late sown conditions. Both the microbial inoculations were effective in improving yield under late sown condition.