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Laxmi Bhimappa Kotambari
Department of Plant Physiology, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur, Madhya Pradesh, India

AS Gontia
Department of Plant Physiology, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur, Madhya Pradesh India

Anubha Upadhyaya
Department of Plant Physiology, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur Madhya Pradesh, India

Amit Jha
Department of Agronomy, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur, Madhya Pradesh, India

Ompal Singh
Department of Plant Physiology, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur, Madhya Pradesh, India

Correspondence
Laxmi Bhimappa Kotambari
Department of Plant Physiology, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur, Madhya Pradesh, India

Influence of seed priming on morpho-physiological traits, growth, drought indices and productivity of maize

Laxmi Bhimappa Kotambari, AS Gontia, Anubha Upadhyaya, Amit Jha and Ompal Singh

Abstract
Objective of this investigation is to study the influence of seed priming treatments on phenophases, growth. morphophysiological and biophysical traits in maize (*Zea mays* L.). The experiment was carried out during kharif 2016-17 at research farm JNKVV, Jabalpur (MP) which was laid out in a randomized block design replicated thrice. The treatments comprised of nine seed priming treatments in maize cv, African tall viz., water, $ZnSO_4$ @ 0.5%, KNO_3 @ 0.5% & KH_2PO_4 @ 0.5% for 6 and 12 hrs and control which were assessed for growth and biophysical traits. The seed priming treatments showed variable response for most of the traits. Water primed treatments indicated the highest values for phenophases, morphophysiological and biophysical traits ie., V_8 (52 days), V_9 (57.7 days), R_5 (100.7 days), R_6 (114 days), dry matter accumulation (0.92g at 20 DAS and 154.62g at 114 DAS), leaf area index(1.451), ^{leaf} area duration (34816 cm^2.days), CGR (9.18g cm^{-2} day^{-1}), RGR (0.052 g g^{-1} day^{-1},cholorophyll index (17.20),carboxylation efficiency (0.112 µmol $m^{-2}s^{-1}$($\mu molm^{-1}$)$^{-1}$), net photosynthesis (23.91 µmol $m^{-2}s^{-1}$) and quantum efficiency (0.0193). $ZnSO_4$ primed for 12 hrs had highest stomatal conductance (0.038) and transpiration rate (2.127). KH_2PO_4 primed for 12 hrs - mesophyll efficiency (4914.4).

Keywords: Maize, LAI, LAD, CGR, RGR, photosynthesis, seed priming

Introduction
Maize (*Zea may*s L.) is one of the most important cereal crops in the world and is third important position in India after rice and wheat with enormous role in food and nutritional security. Maize is having special significance because in addition to staple food for human being and quality feed for animal. It serves as a basic raw material as an ingredient to thousands of industrial products that include starch, oil, protein, alcoholic beverages, food sweetners, pharmaceutical, cosmetic, film, textile, gum, package and paper industries etc.
Seed priming, a pre-sowing partial hydration of seeds, is often used to improve crop performance (Ashraf and Foolad, 2005) [2]. Seed priming resulted in earlier emergence of seedlings by 1-3 days and significantly increased plant stand and initial growth vigour (Singh *et al*., 2015) [5]. Increase in LAI stay-green and maintain photosynthesis of green leaves during R_1 stage (Tollenaar *et al*., 2004) [7]. Though a few physiological investigations have been carried out to evaluate the performance of maize under various seed priming methods, detailed investigations are needed to identify phenophases, morphophysical and biophysical traits influencing productivity along with the constraints of productivity under drought conditions.

Material and methods
The present investigation was carried out during the Kharif 2016. The experiment was carried out at Research Farm, AICRP on FORAGE CROPS, Department of Agronomy, JNKVV, Jabalpur (M.P.). The experiment conducted in randomized block design with three replications having 9 treatments. The observations were recorded on five randomly selected plants from each plot and from each replication for the desired characters.

Results and Discussions
It has been observed (Table 1) that treatment water primed for 12 hours had reached V_E (4.67), V_2 (11.0), V_6 (30.33) and V_8 (50.67) early but to attain V_1 (8.33), V_3 (13.0) stages KH_2PO_4 primed for 12 hours acquired minimum time. Seed priming resulted in earlier emergence of

seedlings by 1-3 days and significantly increased plant stand and initial growth vigour (Singh *et al*., 2015) [5]. It has been recorded (Table 2) that seed priming with water primed for 12 hours and KH_2PO_4 for 12 hours reached early tassel initiation (73.7 days) and maturity (100.7 days) whereas control delayed to reach this stage. Hydroprimed seeds required shorter time to complete different phenological stages such as days to tasseling, days to silking and days to maturity than nonprimed seeds at every level of soil moisture under the study (Ahammad *et al*., 2014) [1]. Water primed for 12 hours (154.6 g) had significantly maximum dry weight (Table 3). The increase in plant dry weight due to priming treatments indicated that the photosynthetic activity and efficiency of the leaves have been increased which contributed to dry matter production (Kalpana *et al*., 2013) [4]. The senescence of leaves at maturity reduced the CGR, LAI and LAD and consequently the rate of dry matter accumulation (Singh and Agarwal, 2001) [6]. Water primed for 12 hours higher average LAI (1.451, Table 4),average LAD (34816, cm^2.days Table 5), CGR (9.18g cm^{-2} day^{-1}, Table 6) and RGR (0.052 g g^{-1} day^{-1}, Table 7).

Water primed for 12 hours recorded significantly (table 8) higher chlorophyll content index (17.20), carboxylation efficiency (0.112 µmol m $^{-2}s^{-1}(\mu molm^{-1})^{-1}$), quantum efficiency (0.0193) and net photosynthesis (23.91µmol m $^{-2}s^{-1}$). The faster early growth of seedlings in MB-water can probably be explained by a boost in their photosynthesis ability caused by an increase in the chlorophyll content of their cotyledons. (Ikeura *et al*., 2014) [3]. $ZnSO_4$ primed for 12 hrs had highest stomatal conductance (0.038) and transpiration rate (2.127). KH_2PO_4 primed for 12 hrs - mesophyll efficiency (4914.4). The reduction in transpiration rate and stomatal conductance and concomitant increase in intercellular CO_2 concentration suggests that both stomatal and non stomatal factors were involved in the reduction of photosynthesis (Zhao *et al*., 2007) [8].

Table 1: Various vegetative phenophases (days) of maize under various seed priming treatments during crop growth period

T No	Seed Priming Treatments	Emergence stage	First leaf stage	Second leaf stage	Third leaf stage	Fourth leaf stage	Fifth leaf stage	Sixth leaf stage	Seventh leaf stage	Eighth leaf stage	Ninth leaf stage	Tenth leaf stage
		days	days	days	days	days	days	days	days	days	days	days
T_1	H_20 for 6 hrs	5.33	8.67	11.33	13.00	17.00	25.67	30.33	43.67	52.00	57.67	67.33
T_2	H_20 for 12 hrs	4.67	8.33	11.00	13.33	17.33	26.00	30.33	47.67	50.67	58.33	67.33
T_3	$ZnSO_4$ @ 0.5% for 6 hrs	7.33	9.67	13.33	14.67	17.67	25.00	31.00	47.67	53.00	61.33	67.00
T_4	$ZNSO_4$ @ 0.5% for 12 hrs	7.67	9.67	13.67	15.33	17.33	26.00	31.00	46.67	55.67	62.33	68.00
T_5	KNO_3 @ 0.5% for 6 hrs	7.33	9.67	13.33	15.00	17.33	26.00	30.67	45.33	55.67	62.67	67.33
T_6	KNO_3 @ 0.5% for 12 hrs	8.00	9.33	12.67	15.33	18.33	26.33	31.00	47.33	53.67	63.00	66.33
T_7	KH_2PO_4 @ 0.5% for 6 hrs	6.67	8.67	11.67	13.67	17.33	25.67	31.00	47.67	53.00	63.67	67.33
T_8	KH_2PO_4 @ 0.5% for 12 hrs	6.33	8.33	11.33	13.00	17.67	25.00	31.00	47.67	52.33	62.33	67.00
T_9	CONTROL	8.00	9.33	13.67	16.00	17.67	26.33	31.33	48.00	58.00	64.33	68.67
SEm ±		0.31	0.34	0.39	0.26	0.32	0.46	0.57	1.70	0.56	0.42	0.49
CD 5%		0.93	1.03	1.17	0.78	0.95	1.37	1.71	5.09	1.68	1.25	1.47

Table 2: Various reproductive phenophases (days) of maize under various seed priming treatments during crop growth period

T No	Seed Priming Treatments	Days to tassel initiation	Days to cob emerg-ence	Days to silking	Days to grain form-ation	Days to physiol-ogical maturity	Days to field maturity
		days	days	days	days	days	days
T_1	H_20 for 6 hrs	74.3	80.33	85.00	92.67	101.0	114.7
T_2	H_20 for 12 hrs	73.7	80.00	84.00	91.67	100.7	114.0
T_3	$ZnSO_4$ @0.5% for 6 hrs	75.0	80.00	85.00	92.33	101.0	115.0
T_4	$ZNSO_4$ @0.5% for 12 hrs	74.7	80.33	84.67	93.00	101.3	113.7
T_5	KNO_3 @0.5% for 6 hrs	74.0	80.00	84.67	93.33	101.0	115.0
T_6	KNO_3 @0.5% for 12 hrs	74.3	80.33	85.00	93.00	101.3	115.0
T_7	KH_2PO_4 @0.5% for 6 hrs	74.7	80.33	84.67	92.33	101.3	115.7
T_8	KH_2PO_4 @0.5% for 12 hrs	73.7	80.00	84.00	92.00	101.0	114.0

T_9	CONTROL	76.0	80.67	85.67	93.67	102.0	115.7
SEm ±		0.65	0.29	0.48	0.55	0.34	0.26
CD 5%		1.96	0.86	1.45	0.64	1.03	0.79

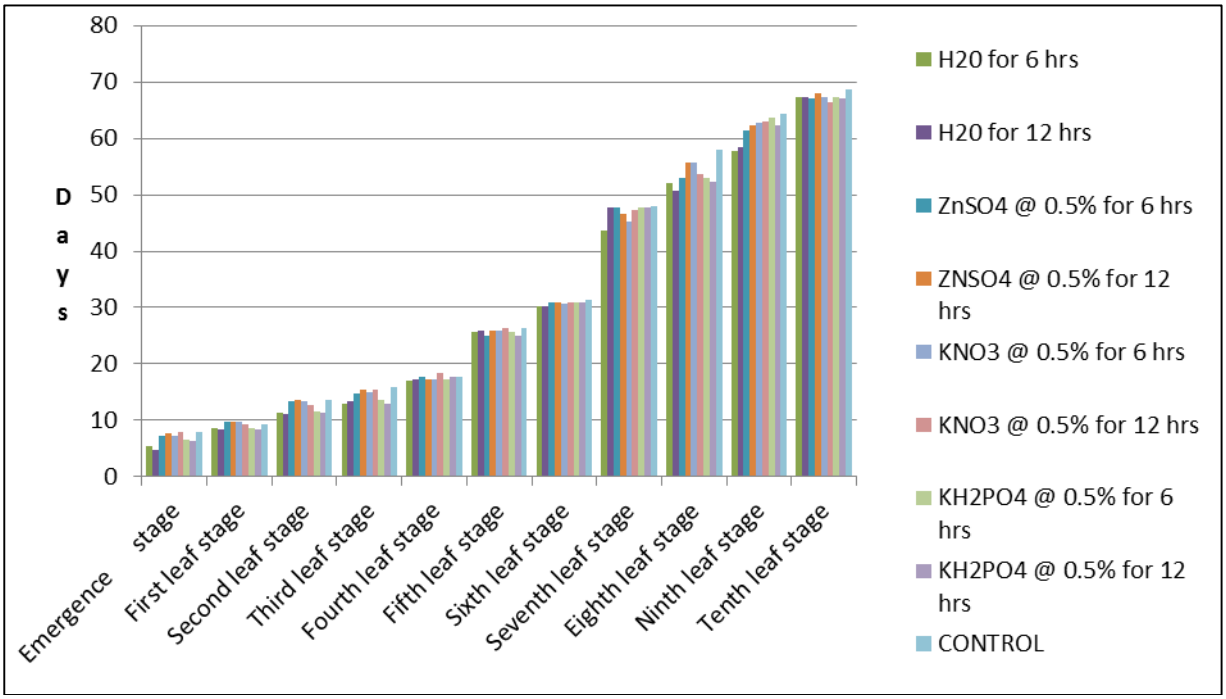

Fig 1: Various vegetative phenophases of maize under various seed priming treatments

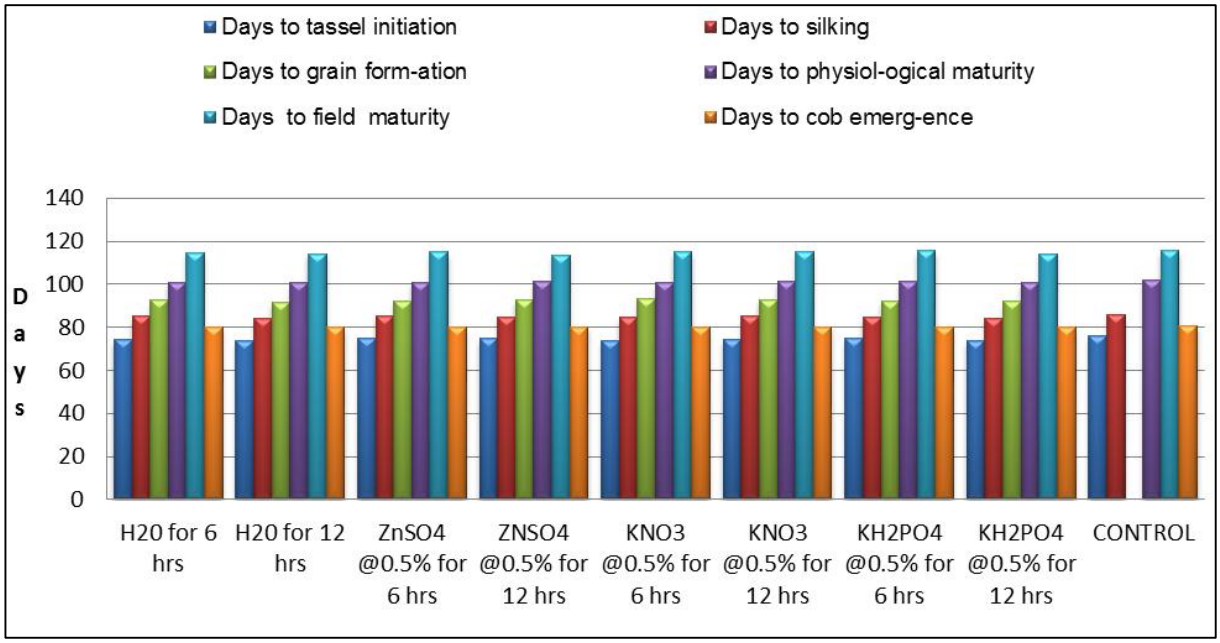

Fig 2: Various reproductive phenophases of seed priming treatments during crop growth period

Table 3: Dry matter production and partitioning (g plant^{-1}) in maize as influenced by various seed priming treatments at 114 DAS

T No.	Seed priming	Leaves	Stem	Tassel	Flag leaf	Cob	TDM
T_1	H_2O for 6 hrs	10.08	26.04	0.89	0.33	112.3	149.69
T_2	H_2O for 12 hrs	11.21	25.12	0.9	0.35	117	154.62
T_3	$ZnSO_4$ @ 0.5 % for 6 hrs	9.26	23.14	0.74	0.2	103.1	136.46
T_4	$ZnSO_4$ @ 0.5 % for 12 hrs	8.63	21.90	0.82	0.26	106.3	137.96
T_5	KNO_3 @ 0.5 % for 6 hrs	6.23	23.56	0.76	0.17	102.4	133.14
T_6	KNO_3 @ 0.5 % for 12 hrs	9.21	24.87	0.73	0.23	94.63	129.67
T_7	KH_2PO_4 @ 0.5 % for 6 hrs	7.84	23.96	0.86	0.29	98.47	131.42
T_8	KH_2PO_4 @ 0.5 % for 12hrs	7.93	21.76	0.67	0.16	102	132.5
T_9	CONTROL	5.94	21.21	0.63	0.11	92.46	120.35
SEm ±		0.01	0.001	0.01	0.09	0.001	0.001
CD 5%		0.03	0.01	0.03	0.27	0.01	0.01

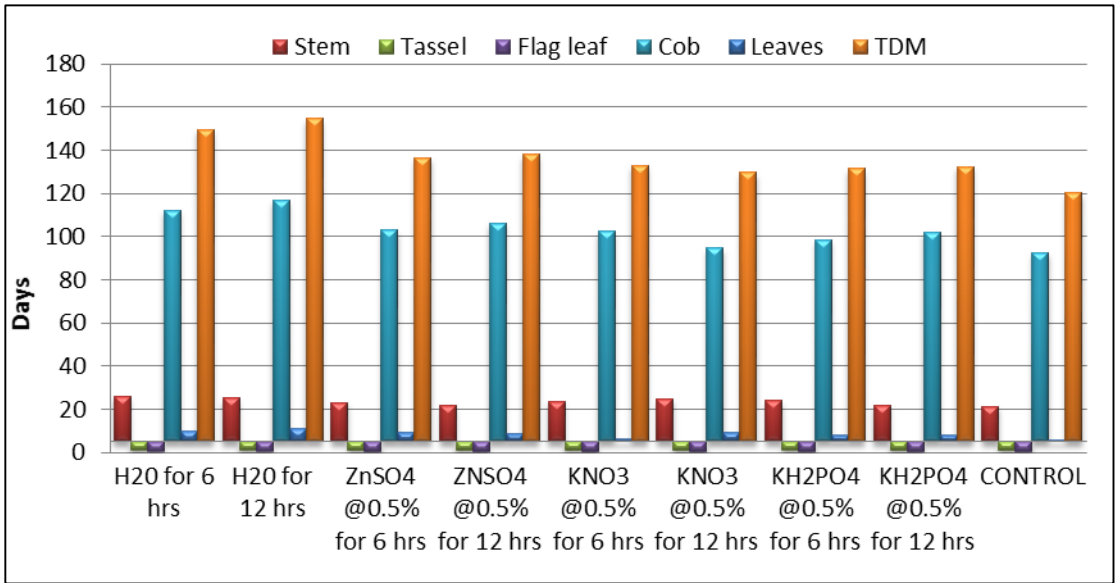

Fig 3: DM production (g plant^{-1}) in seed priming treatments in maize at 114 DAS

Table 4: Leaf Area Index (LAI) in maize under various seed priming treatments during successive growth intervals

T No.	Seed priming treatments	LAI 50 DAS	LAI 70 DAS	LAI 90 DAS	LAI 110 DAS	MEAN
T_1	H_2O for 6 hrs	0.529	1.174	1.754	1.747	1.301
T_2	H_2O for 12 hrs	0.558	1.274	1.994	1.976	1.451
T_3	$ZnSO_4$ @ 0.5 % for 6 hrs	0.51	0.989	1.326	1.274	1.025
T_4	$ZnSO_4$ @ 0.5 % for 12 hrs	0.536	1.076	1.654	1.618	1.221
T_5	KNO_3 @ 0.5 % for 6 hrs	0.51	1.056	1.579	1.57	1.179
T_6	KNO_3 @ 0.5 % for 12 hrs	0.517	1.133	1.782	1.671	1.276
T_7	KH_2PO_4 @ 0.5 % for 6 hrs	0.537	1.204	1.909	1.769	1.355
T_8	KH_2PO_4 @ 0.5 % for 12 hrs	0.542	1.234	1.996	1.842	1.403
T_9	CONTROL	0.46	0.926	1.329	1.324	1.01
SEm ±		0.02	0.04	0.07	0.04	0.04
CD 5%		0.05	0.13	0.21	0.13	0.13

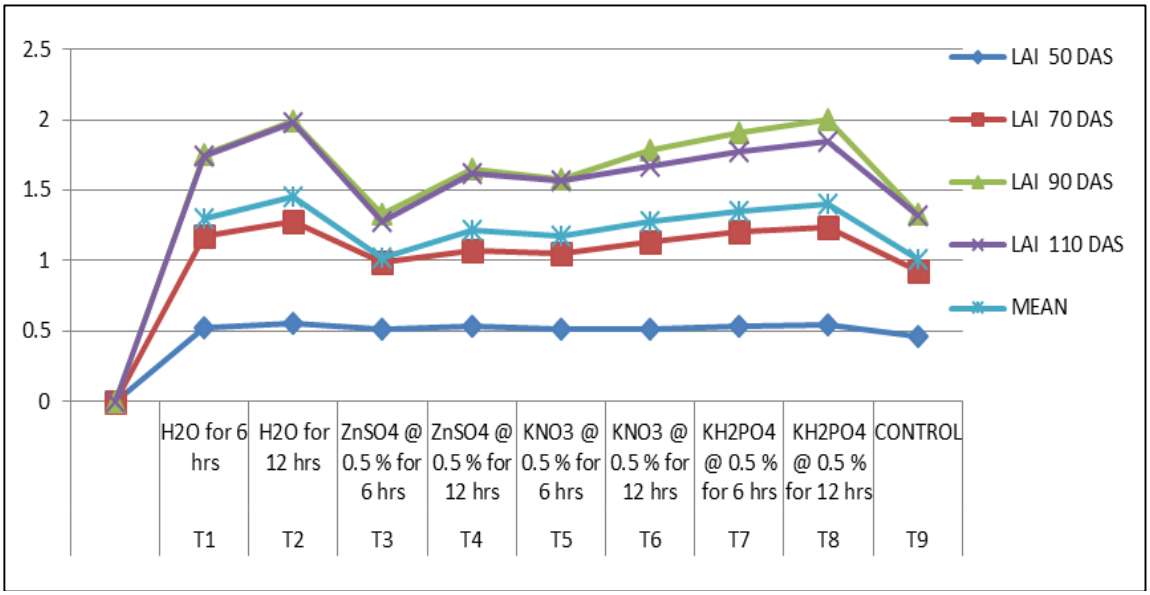

Fig 4: LAI of seed priming treatments during successive growth intervals in maize

Table 5: Leaf Area Duration (LAD) cm^2.days under various seed treatments in maize during successive growth intervals

T No.	Seed priming treatments	LAD 50 DAS	LAD 70 DAS	LAD 90 DAS	LAD 110 DAS	MEAN
T_1	H_2O for 6 hrs	12704	28188	42098	41935	31231
T_2	H_2O for 12 hrs	13400	30576	47866	47422	34816
T_3	$ZnSO_4$ @ 0.5 % for 6 hrs	12250	23729	31818	30575	24593

T_4	$ZnSO_4$ @ 0.5 % for 12 hrs	12865	25826	39689	38827	29302
T_5	KNO_3 @ 0.5 % for 6 hrs	12250	25334	37886	37670	28285
T_6	KNO_3 @ 0.5 % for 12 hrs	12398	27195	42760	40100	30613
T_7	KH_2PO_4 @ 0.5 % for 6 hrs	12879	28888	45825	42450	32510
T_8	KH_2PO_4 @ 0.5 % for 12 hrs	13006	29622	47892	44212	33683
T_9	CONTROL	11035	22231	31899	31781	24236
SEm ±		426.26	1042.7	1650.2	1015	1033
CD 5%		1271.9	3125.9	4947.2	3042	3097

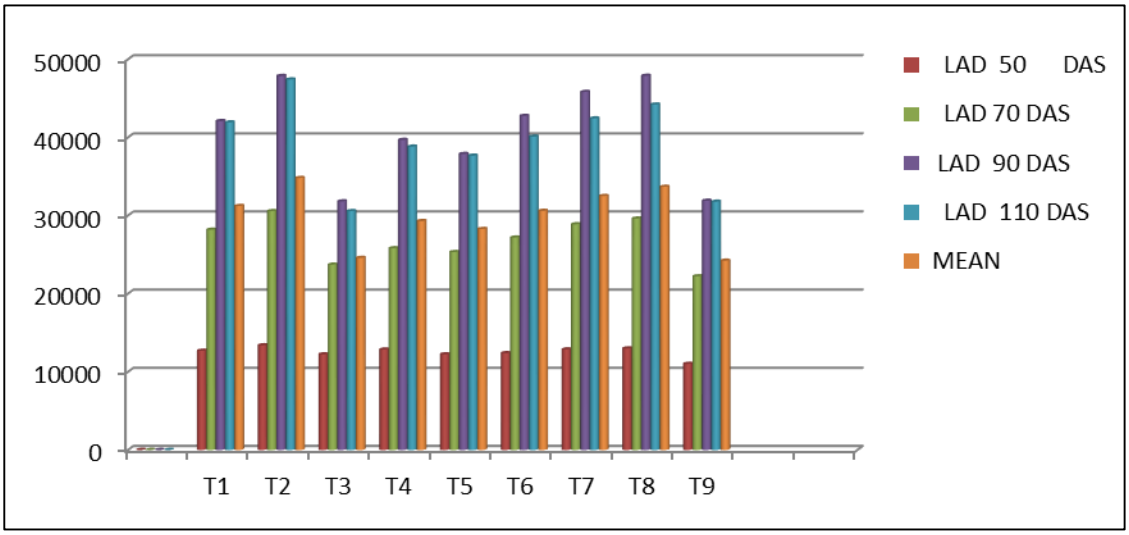

Fig 5: LAD of seed priming treatments during successive growth intervals in maize

Table 6: Crop Growth Rate (g cm^{-2} day^{-1}) in maize under various seed priming treatments

T No.	Treatments	CGR
T_1	H_2O for 6 hrs	9.08
T_2	H_2O for 12 hrs	9.18
T_3	$ZnSO_4$ @ 0.5 % for 6 hrs	8.56
T_4	$ZnSO_4$ @ 0.5 % for 12 hrs	8.46
T_5	KNO_3 @ 0.5 % for 6 hrs	8.29
T_6	KNO_3 @ 0.5 % for 12 hrs	8.80
T_7	KH_2PO_4 @ 0.5 % for 6 hrs	8.58
T_8	KH_2PO_4 @ 0.5 % for 12 hrs	8.21
T_9	CONTROL	7.93
SEm ±		0.001
CD AT 5%		0.01

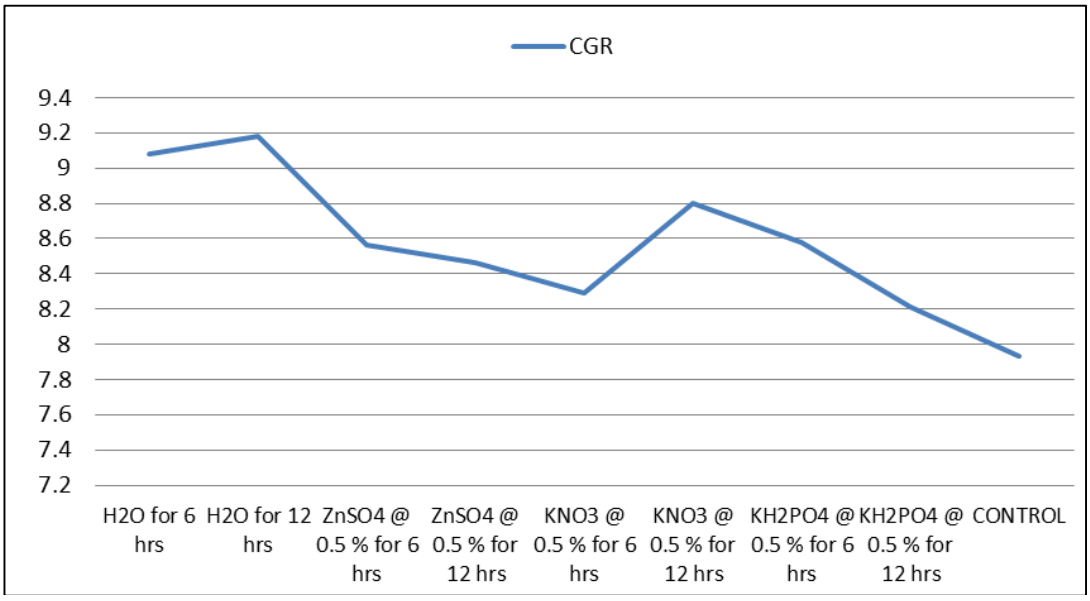

Fig 6: Crop Growth Rate (g cm^{-2} day^{-1}) in maize under various seed priming treatments

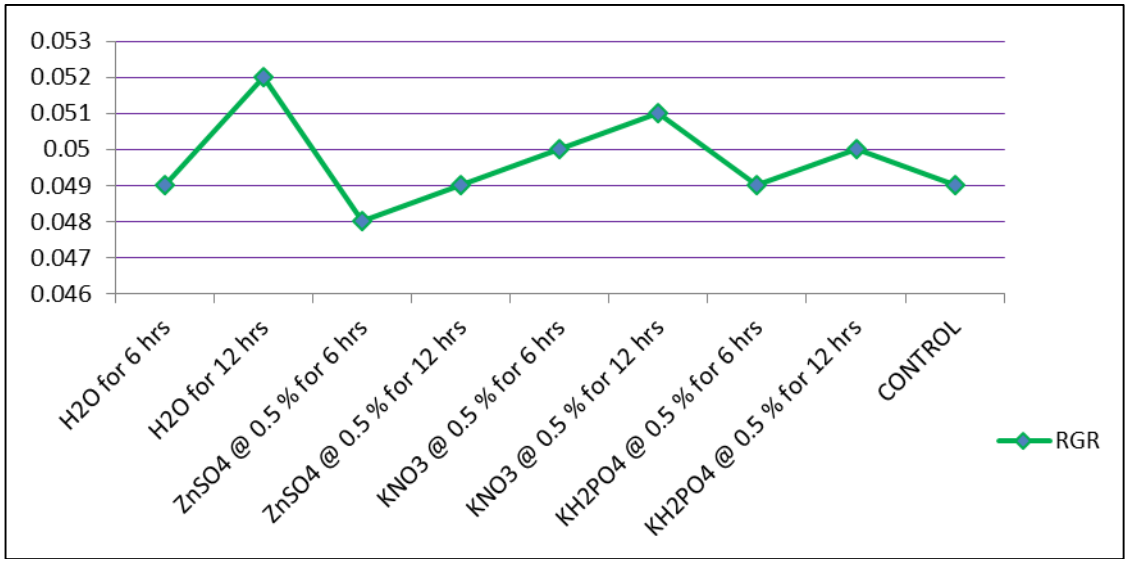

Fig 7: Relative Growth Rate (g g^{-1} day^{-1}) in maize under various seed priming treatments

Table 7: Relative Growth Rate (g g^{-1} day^{-1}) in maize under various seed priming treatments

T No.	Treatments	RGR
T_1	H_2O for 6 hrs	0.049
T_2	H_2O for 12 hrs	0.052
T_3	$ZnSO_4$ @ 0.5 % for 6 hrs	0.048
T_4	$ZnSO_4$ @ 0.5 % for 12 hrs	0.049
T_5	KNO_3 @ 0.5 % for 6 hrs	0.050
T_6	KNO_3 @ 0.5 % for 12 hrs	0.051
T_7	KH_2PO_4 @ 0.5 % for 6 hrs	0.049
T_8	KH_2PO_4 @ 0.5 % for 12 hrs	0.050
T_9	CONTROL	0.049
SEm ±		0.001
CD 5%		0.01

Table 8: Quantification of biophysical traits in maize under various seed priming treatments

T No.	Seed priming treatments	Chlorophyll content index	Carboxylation efficiency µmol m^{-2} s^{-1}(µmol m^{-1}) $^{-1}$	Mesophyll efficiency µmol mol^{1} (mol m^{-1})$^{-1}$	Quantum efficiency	Canopy temperature (°c)	Net photosynthesis (µmolm^{-2} s^{-1})	Stomatal conductance (mol $m^{-2}s^{-1}$)	Transpiration rate (mmol $m^{-2}s^{-1}$)
T_1	H_2O for 6 hours	12.73	0.093	4734.1	0.0157	32.73	15.98	0.029	1.717
T_2	H_2O for 12 hours	17.20	0.112	3972.1	0.0193	31.24	23.91	0.026	1.437
T_3	$ZnSO_4$ @ 0.5 % for 6 hours	14.26	0.096	3465.6	0.0158	29.3	15.13	0.032	1.460
T_4	$ZnSO_4$ @ 0.5 % for 12 hours	14.55	0.089	4345.3	0.0130	31.15	15.23	0.038	2.127
T_5	KNO_3 @ 0.5 % for 6 hours	15.43	0.090	3322.5	0.0118	33.33	14.82	0.031	1.547
T_6	KNO_3 @ 0.5 % for 12 hours	12.91	0.091	4149.4	0.0139	34.59	17.89	0.033	1.740
T_7	KH_2PO_4 @ 0.5 % for 6 hours	15.04	0.097	3819.2	0.0128	33.73	16.27	0.030	2.047
T_8	KH_2PO_4 @ 0.5 % for 12 hours	12.85	0.088	4931.4	0.0117	34.58	14.40	0.029	1.820
T_9	CONTROL	9.17	0.079	3059.9	0.0110	35.08	12.84	0.023	1.427
SEm ±		0.56	0.01	409.12	0.0010	1.39	0.92	0.001	0.160
CD 5%		1.69	0.020	1226.5	0.0001	4.17	2.76	0.010	0.490

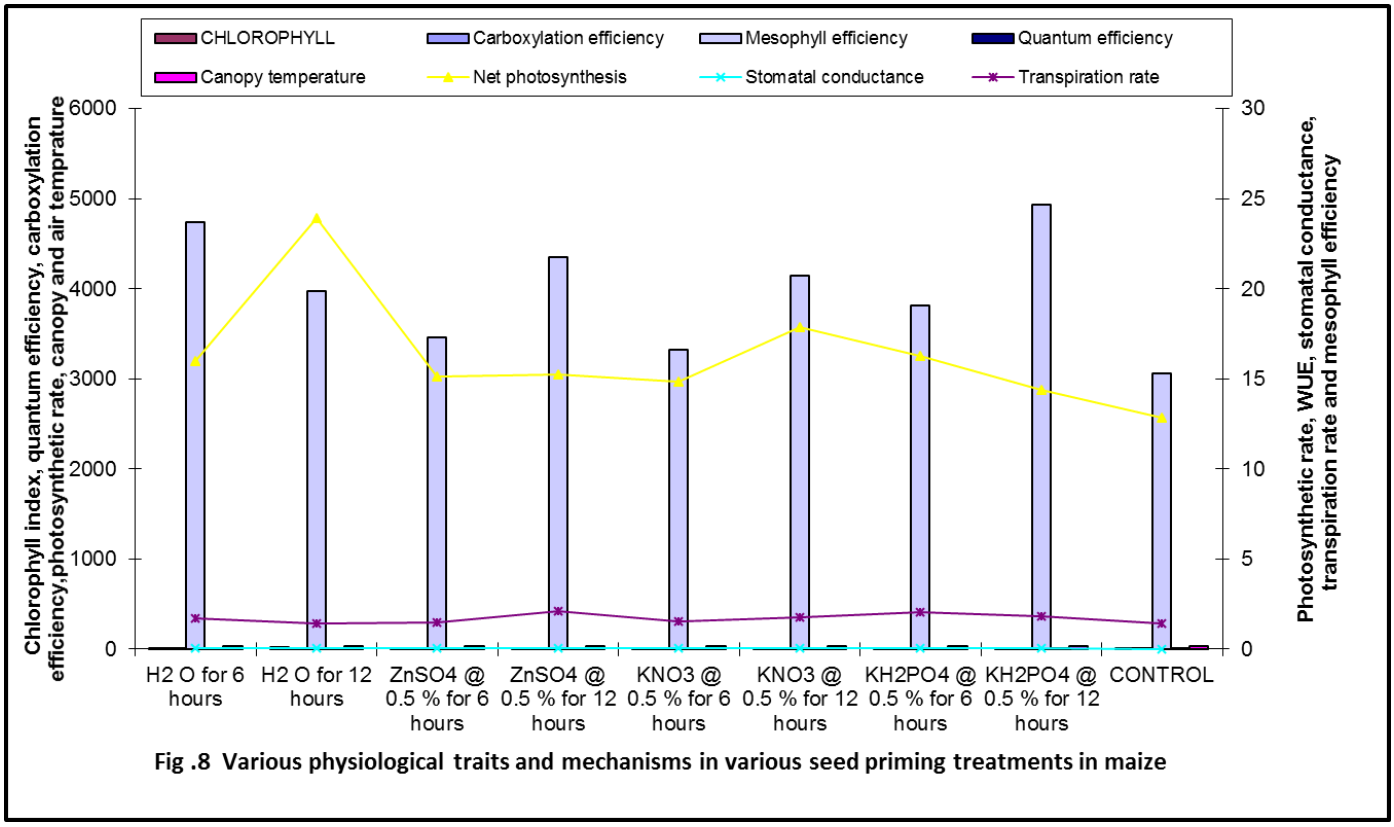

Fig 8: Various physiological traits and mechanisms in various seed priming treatments in maize

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