

Effect of Seed Priming on Growth and Yield of Hybrid Maize-Lathyrus Sequence under Rainfed Situation

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Authors' contributions

This work was carried out in collaboration among all authors. Authors SB, KJ, RM and KM designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors SB and KJ managed the analyses of the study. Authors SB and AM managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

Seed priming is a low-cost technology and effective way of improving nutrient supply to crops as well as the importance of priming to get a good crop stand of maize. Pre-sowing soaking of seeds with KH_2PO_4 , Na_2HPO_4 etc. or simple water was earlier reported to improve seed germination, seedling vigor and root growth early in the season, resulting in good establishment, better drought tolerance and more yields of crop plants. In this context a field was conducted at Central Research Farm (CRF), Gayeshpur of BCKV, Nadia Under New alluvial zone of West Bengal during *kharif* season of 2016 and 2017 and *rabi* season of 2016-17 and 2017-18. The experiment was laid out in Randomized Block Design (RBD) with nine (9) different treatments of seed priming methods. Seed priming with ZnSO_4 @ 0.5% for 12 hrs could be recommended due to higher germination percentage (93.6%), number of leaves per plant (9.6), highest plant height (258.2 cm) at 60 DAS, maximum value of crop growth rate ($26.6 \text{ g/m}^2/\text{day}$) at 46-60 DAS of hybrid maize and highest plant height (19.5 cm & 42.8 cm at 30 & 60 DAS, respectively), highest value of dry matter accumulation

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(198.4 g/m² at 60 DAS), maximum value of crop growth rate (4.87 g/m²/day) at 31-60 DAS for lathyrus. On the basis of pooled values of 2 years of experimentation, seed priming with ZnSO₄ @ 0.5% for 12 hrs could be recommended due to higher yield (7.94 t ha⁻¹ of *kharif* hybrid maize and 1682 kg ha⁻¹ of lathyrus).

Keywords: Seed priming; maize; lathyrus; growth parameters; yield.

1. INTRODUCTION

Maize (*Zea mays* L.) is one of the most versatile crops grown throughout the tropical as well as temperate regions of the world. The outstanding features of maize have been well documented all over the world. This crop is being considered as “Queen of Cereals” because of its special characteristics that include its carbon pathway (C₄), wider adaptability, higher multiplication ratio, desirable architecture, superior transpiration. It has become one of the important food, fodder and industrial crops of the world. In India, maize was grown in area of 8691.2 thousand hectare, with production of 21,806.5 thousand tones and productivity of 2505.00 kg ha⁻¹ while in West Bengal the area, production and productivity were 156 thousand hectare, 720 thousand tones and 4615 kg ha⁻¹ respectively in the year 2015-16 [1]. It has yield potential far higher than any other cereal. Since long, maize has been cultivated for grain and fodder purpose, and more recently for fuel. Maize is grown under diversified environment unmatched by any another crops as the expansion of maize to new areas and environment still continues. Though the yield potential of our present varieties is high enough, but it has not been explored fully due to some production constraints. Among the limiting factors; proper level and ratio of fertilizer, irrigation management, plant protection and also proper seedlings establishment at the time of sowing are of prime importance. Maize is a high nutrient-demanding crop, which also requires micronutrients (particularly Zn), along with major elements for proper growth and yield formation [2]. Among these, Zn (zinc), B (boron) and Mn (manganese) are of special consideration. So, there is a need to develop approaches that are pragmatic and easy to adapt for integrated nutrient management [3]. Zinc deficiency is usually widespread in the cereal crops. Regions with Zn-deficient soils are also regions where human population suffers from Zn deficiency. Zn application in cereals also increase the seed quality in terms of germination %, viability, vigour index that ultimately produced healthy seedling

and better crop yield [4]. Seed priming is a well-known dimension in crop improvement through early emergence, uniform stand establishment, better growth and improved yield. Moreover, increase in the nutrient content of grains and further using the enriched seeds can also produce yields with higher nutrient contents [5,6]. So, priming is the substitution of fertilizer application and also increase the emergence rate as well as crop yield.

The grass pea or chickling pea is also called ‘*khesari*’ and ‘*teora*’ in hindi, ‘*kasari*’ in Bengali and ‘*Kisara*’ in nepali. It is very hardy and versatile crop and thrives well under adverse climatic conditions. It is high yielding and drought tolerant winter legume crop. There is no alternative to *Lathyrus sativus* at present since it is a very hardy crop that tolerates adverse environmental conditions such as drought and excessive soil moisture. To increase the yield potential in diverse condition seed priming is the best and low-cost option. Improvement of yield and create a profit-making crop, improved and innovative seed priming are employed to reduced emergence time, accomplish uniform emergence, better allometric attributes and ultimately crop yield.

In the above premise, there is a need to understand the improvement in seedling emergence and early germination through chemical as well as micronutrient seed priming in maize and lathyrus to improve crop yield. Such information scanty in the archives. This work has tried to present effect of different type of seed priming on crop growth and yield.

2. MATERIALS AND METHODS

Field experiment was conducted at the Central Research Farm, Gayeshpur, Bidhan Chandra Krishi Viswavidyalaya, Nadia, situated at 22°05' N latitude and 88°32'E longitude with an altitude of 9.75 m above mean sea level to study the ‘Effect of seed priming on growth and grain yield of maize- lathyrus cropping sequence during *kharif* season of 2016 & 2017 and *rabi* season of 2016-17 & 2017-18. The experimental

site falls under sub-tropical sub-humid climate. The average rainfall is 1450 mm, 75% of which is received during June to September. The temperature begins to rise from end of February reaching towards April-May. The relative humidity remains high during June to October. During the crop growth period in maize average maximum temperature ranged between 30.50°C to 35.10°C and minimum temperature varied between 25.80 to 27.01°C. In case of lathyrus maximum temperature ranged between 31.50°C to 32.20°C and minimum temperature varied between 7.80 to 22.20°C. The average maximum relative humidity varied from 90 to 98.0% and minimum relative humidity varied from 44.0 to 90.0%. The texture of the experimental soil was sandy clay loam and belongs to the order inceptisol with medium fertility and almost neutral in soil reaction. The experiment was conducted on a medium land, well-drained Gangetic alluvial soil. The experiment was laid down in Randomized Block Design with three replications comprising of nine different type of chemical priming viz. T₁-seed priming with water for 6 hours, T₂- seed priming with water for 12 hours, T₃- seed priming with ZnSO₄ @ 0.5% for 6 hours, T₄- seed priming with ZnSO₄ @ 0.5% for 12 hours, T₅- seed priming with KNO₃ @ 0.5% for 6 hours, T₆- seed priming with KNO₃ @ 0.5% @ for 12 hours, T₇- seed priming with KH₂PO₄ @ 0.5% for 6 hours, T₈- seed priming with KH₂PO₄ @ 0.5% for 12 hours, T₉- control (no priming) respectively. The size of individual plot was 4 m x 3 m. The plant height was measured from the base of the plant at ground surface to the tip of the tallest leaf/panicle. Heights of five plants were taken from each replication and the mean values were computed and expressed in cm. For dry matter accumulation plants cut from middle row close to ground from each plot and then samples were oven dried at 65 ±5°C till constant weight was obtained. Also measure the root length, root weight, of maize and lathyrus. The dry weight was expressed in g m⁻². LAI of the samples were calculated through the area-weight relationships. LAI was expressed as the ratio of leaf area (one side only) to the ground area occupied by the plant. Crop growth rate was calculated by the following formula which was discovered by Watson. The formulae is

$$CGR = \frac{W_2 - W_1}{t_2 - t_1} \quad g \text{ m}^{-2} \text{ day}^{-1}$$

Where, w₂ and w₁ are the final and initial total dry weights of all plants per unit land area (m²) at the

time t₂ and t₁ respectively. Finally, at maturity plot wise crop was harvested and sun-dried for three days in the field and then after threshing and cleaning grain yield was recorded in t ha⁻¹ and reported at 15% moisture content. Statistical analysis was done for determining the standard error of mean (S. Em±) and the value of CD (Critical difference) at 5% level of significance using standard methodology.

3. RESULTS AND DISCUSSION

3.1 Effect of Seed Priming on Growth Attributes of Hybrid Maize

3.1.1 Germination percentage

The germination of crop is greatly influenced by the different seed priming practices. The germination percentage of maize grown during *kharif* season, 2017 and 2018 was recorded at 5 and 10 days after sowing (DAS). It has been revealed from experimental results presented in the (Table 1) germination percentage of hybrid maize at 5 and 10 DAS was significantly influenced by the different seed priming methods. The highest germination percentage (70.7 and 93.6% at 5 and 10 DAS, respectively) was obtained from the treatment T₄ *i.e.* Seed priming with ZnSO₄ @ 0.5% for 12 hours. It was statistically at par with the treatment T₆ *i.e.* seed priming with KNO₃ @ 0.5% for 12 hours (64.4 and 86.3% at 5 and 10 DAS, respectively) and treatment T₈ *i.e.* seed priming with KH₂PO₄ @ 0.5% for 12 hours (63.2 and 85.1% at 5 and 10 DAS respectively). The lowest germination percentage of 42.4 and 67.6% at 5 and 10 DAS respectively were obtained from the treatment T₉ *i.e.* no seed priming (Control). This might due to seed priming with inorganic salts (ZnSO₄, KNO₃, KH₂PO₄) may significantly alter the activity of enzyme in germinating seeds. Seed priming enhance the activity of dehydrogenase and α-amylase. Such increase in enzyme activity has direct or indirect effect on subsequent seed germination, growth and development. It helps in mobilisation of seed food reserves to the developing embryo during germination. Storage products such as carbohydrates amino acids, fatty acids and inorganic nutrients are mobilised in germinating seed at varying rates.

3.1.2 Number of leaves per plant

Number of leaves per plant is an important factor for accumulation of carbohydrate through

photosynthesis. The number of leaves per maize plant grown during *kharif* season, 2017 and 2018 was recorded at 30 days after sowing (DAS). It has been revealed from experimental results presented in the (Table 1). The maximum number of leaves per plant (9.6) was obtained from the treatment T₄ *i.e.* seed priming with ZnSO₄ @ 0.5% for 12 hours. It was statistically at par with the treatment T₆ *i.e.* seed priming with KNO₃ @ 0.5% for 12 hours (number of leaves per plant: 9.1 at 30 DAS) and treatment T₈ *i.e.* seed priming with KH₂PO₄ @ 0.5% for 12 hours (number of leaves per plant: 8.9 at 30 DAS). The minimum number of leaves per plant (8.4 at 30 DAS) was obtained from the treatment T₉ *i.e.* no seed priming (Control).

3.1.3 Days to 50% flowering

Seed priming practices greatly influence the flower initiation of crop plant. The results presented in (Table 1) reveal that the days to 50% flowering of hybrid maize grown during *kharif*, 2017 and 2018 are not influenced by any seed priming methods *i.e.* the days to 50% flowering was not significant in different seed priming methods.

3.1.4 Plant height

Plant height is one of the most important parameter which was greatly influenced by different crop management practices like seed priming. It has been revealed from experimental results presented in the (Table 2) that plant height of hybrid maize at 30, 60, 90 DAS and at harvest stage was significantly influenced by the different seed priming methods. In plant heights were significantly increasing in all the dates of observation till harvesting stage. The highest plant height (98.97, 258.20, 261.30 and 262.1 cm at 30, 60, 90 DAS and harvest, respectively) was obtained from the treatment T₄ *i.e.* seed priming with ZnSO₄ @ 0.5% for 12 hours. It was statistically at par with the treatment T₆ *i.e.* seed priming with KNO₃ @ 0.5% for 12 hours (96.43, 243.67, 246.6 and 246.8 cm at 30, 60, 90 DAS and at harvest, respectively) and treatment T₈ *i.e.* seed priming with KH₂PO₄ @ 0.5% for 12 hours (91.97, 243.67, 256.4 and 246.6 cm at 30, 60, 90 DAS and harvest respectively). The lowest plant height of 72.90, 211.43, 215.4 and 217.3 cm at 30, 60, 90 DAS and at harvest, respectively were obtained from the treatment T₉ *i.e.* no seed priming (control). The increase in plant height due to proper crop establishment that

accelerated nutrient uptake which encourage and improve plant growth and promote cell division. These results are in conformity with the findings of Chiu et al. [7], they reported that germination percentage increased when maize seed was primed with ZnSO₄ solution and priming can improve germination, reduce lipid peroxidation, enhance anti-oxidative activity and improve seedlings growth.

3.1.5 Leaf area index

Leaf Area Index (LAI) is a dimensionless quantity that characterizes plant canopies. It has been revealed from experimental results presented in the Table 3 the value of leaf area index of hybrid maize at 30, 45 and 60 DAS was significantly influenced by the different seed priming methods (Table 3). Leaf area index was significantly increasing in all the dates of observation at 30, 45 and 60 DAS. The highest value of Leaf Area Index (1.9, 3.38 and 5.52 at 30, 45 and 60 DAS, respectively) was recorded from the treatment T₄ *i.e.* seed priming with ZnSO₄ @ 0.5% for 12 hours. It was statistically at par with the treatment T₆ *i.e.* seed priming with KNO₃@ 0.5% for 12 hours (1.8, 3.31 and 5.42 at 30, 45 and 60 DAS, respectively) and treatment T₈ *i.e.* seed priming with KH₂PO₄ @ 0.5% for 12 hours (1.67, 3.14 and 5.22 at 30, 45 and 60 DAS, respectively). The lowest value of leaf area index of 0.6, 1.98 and 3.9 at 30, 45 and 60 DAS, respectively were obtained from the treatment T₉ *i.e.* no seed priming (Control). These results are similar with the findings of Sher Afzal et al. [8], they reported that leaf area index increased when maize was primed with 1.5% ZnSO₄, 0.5% Zn EDTA, 1.5% Zn EDTA solution and priming can improve and give higher value in physiological (LAI) parameter.

3.1.6 Dry matter accumulation

The dry matter or dry weight is a measurement of the mass of something when completely dried. Several seed priming practices influence the dry matter accumulation of crop. It has been revealed from experimental results presented in the Table 4 dry matter accumulation (g/m²) of hybrid maize at 30, 45 and 60 DAS was significantly influenced by the different seed priming methods (Table 4). In general dry matter accumulation was significantly increasing in all the dates of observation. The highest dry matter accumulation (145.5, 460.10 and 854.2 g/m² at 30, 45 and 60 DAS, respectively) was recorded from the treatment T₄ *i.e.* Seed priming with

ZnSO₄ @ 0.5% for 12 hours. It was statistically at par with the treatment T₆ i.e. seed priming with KNO₃ @ 0.5% for 12 hours (142.80, 455.90 and 840.4 g/m² at 30, 45 and 60 DAS, respectively) and treatment T₈ i.e. seed priming with KH₂PO₄ @ 0.5% for 12 hours (142.00, 453.10 and 834.8 g/m² at 30, 45 and 60 DAS, respectively). The lowest dry matter accumulation of 136.50, 430.50 and 770.3 g/m² at 30, 45 and 60 DAS, respectively were obtained from the treatment T₉ i.e. no seed priming (control). This might due to seed priming with inorganic salts (ZnSO₄, KNO₃, and KH₂PO₄) may significantly alter the activity of enzyme in germinating seeds. Zinc is a vital micronutrient, which is an integral part of various important enzymes, such as alcohol dehydrogenase, carbonic anhydrase, Cu-Zn-superoxide dismutase (SOD), alkaline phosphatase, phospholipase, carboxypeptidase, and RNA polymerase [9]. Therefore, that increase dry matter accumulation and ultimately increase the crop yield.

3.1.7 Crop growth rate

Crop growth rate is a measure of the increase in size, mass or number of crops over a period of time. It has been revealed from experimental results presented in the Table 5 crop growth rate (g/m²/day) of hybrid maize at 0-30, 31- 45 and 46-60 DAS was significantly influenced by the different seed priming methods. In general crop growth rate (g/m²/day) were significantly increasing in all the dates of observation. The highest crop growth rate (5.75, 21.37 and 26.6 g/m²/day at 0-30, 31- 45 and 46-60 DAS,

respectively was recorded from the treatment T₄ i.e. Seed priming with ZnSO₄ @ 0.5% for 12 hours. It was statistically at par with the treatment T₆ i.e. seed priming with KNO₃ @ 0.5% for 12 hours (5.23, 21.2 and 26.33 g/m²/day at 0-30, 31- 45 and 46-60 DAS, respectively) and treatment T₈ i.e. seed priming with KH₂PO₄ @ 0.5% for 12 hours (5.13, 20.76 and 25.7 g/m²/day at 0-30, 31- 45 and 46-60 DAS, respectively). The lowest crop growth rate (g/m²/day) of 4.31, 18.9 and 22.3 g/m²/day at 0-30, 31- 45 and 46-60 DAS, respectively were obtained from the treatment T₉ i.e. no seed priming (Control). These results are in conformity with the findings of Nagar et al. [10], they reported that crop growth rate increased when maize was primed with different hydro-priming solutions.

3.2 Yield

The land productivity in terms of grain yield of hybrid maize was significantly influenced by the different seed priming practices in the new alluvial soils of West Bengal (Table 7). The highest grain yield (7.94 t ha⁻¹) was obtained from the treatment T₄ i.e. seed priming with ZnSO₄ @ 0.5% for 12 hours (). It was statistically at par with the treatment T₆ i.e. seed priming with KNO₃ @ 0.5% for 12 hours for grain yield (7.68 t ha⁻¹) and treatment T₈ i.e. seed priming with KH₂PO₄ @ 0.5% for 12 hours for grain yield (7.45 t ha⁻¹). The lowest grain yield (5.85 t ha⁻¹) in the treatment T₉ i.e. no seed priming (control).

Table 1. Effect of different seed priming methods on germination percentage, number of leaves per plant and days to 50% flowering of hybrid maize grown during during kharif season (Pooled value)

Treatments	Germination % at 5 DAS	Germination % at 10 DAS	No. Of leaves per plant	Days to 50% flowering
T ₁	51.2	77.6	8.6	51.3
T ₂	57.8	79.1	8.7	51.6
T ₃	62.3	84.3	8.9	51.3
T ₄	70.7	93.6	9.6	52.6
T ₅	61.4	84.1	8.8	52.0
T ₆	64.4	86.3	9.1	52.6
T ₇	60.8	82.1	8.7	52.6
T ₈	63.2	85.1	8.9	51.6
T ₉	42.4	67.5	8.4	50.6
S.Em(±)	0.83	1.35	0.11	-
CD (0.05)	2.46	4.05	0.33	-

[T₁-seed priming with water for 6 hours, T₂- seed priming with water for 12 hours, T₃- seed priming with ZnSO₄ @ 0.5% for 6 hours, T₄- seed priming with ZnSO₄ @ 0.5% for 12 hours, T₅- seed priming with KNO₃ @ 0.5% for 6 hours, T₆- seed priming with KNO₃ @ 0.5% @ for 12 hours, T₇- seed priming with KH₂PO₄ @ 0.5% for 6 hours, T₈- seed priming with KH₂PO₄ @ 0.5% for 12 hours, T₉- control (no priming)]

Table 2. Effect of different seed priming methods on plant height (cm) of Maize and Lathyrus (Pooled Value)

Treatments	Plant Height (cm)							
	Maize				Lathyrus			
	30 DAS	60 DAS	90 DAS	Harvest	30 DAS	60 DAS	90 DAS	Harvest
T ₁	73.34	216.37	218.30	219.60	14.27	33.50	42.90	51.20
T ₂	77.70	227.23	229.50	230.10	15.10	34.20	43.70	52.80
T ₃	79.30	235.93	239.90	241.40	14.03	36.70	46.20	54.80
T ₄	98.97	258.20	261.30	262.10	19.50	42.80	51.50	62.13
T ₅	77.80	230.90	234.90	235.70	14.83	35.40	45.50	54.20
T ₆	96.43	243.67	246.60	246.80	18.87	0.87	49.53	59.73
T ₇	78.77	219.37	232.20	234.60	14.30	34.60	42.37	53.60
T ₈	91.97	243.67	246.40	246.20	18.23	39.60	47.97	59.17
T ₉	72.90	211.43	215.40	217.30	12.50	29.37	36.87	47.17
S.E(m) (±)	5.94	7.13	6.30	6.67	1.38	2.45	2.56	2.64
CD (0.05)	17.96	21.56	19.06	20.16	4.17	7.41	7.73	8.00

[T₁-seed priming with water for 6 hours, T₂- seed priming with water for 12 hours, T₃- seed priming with ZnSO₄ @ 0.5% for 6 hours, T₄- seed priming with ZnSO₄ @ 0.5% for 12 hours, T₅- seed priming with KNO₃ @ 0.5% for 6 hours, T₆- seed priming with KNO₃ @ 0.5% @ for 12 hours, T₇- seed priming with KH₂PO₄ @ 0.5% for 6 hours, T₈- seed priming with KH₂PO₄ @ 0.5% for 12 hours, T₉- control (no priming)]

Table 3. Effect of different seed priming methods on leaf area index (LAI) of Maize and Lathyrus (Pooled Value)

Treatments	Leaf Area Index							
	Maize			Lathyrus				
	30 DAS	45 DAS	60 DAS	30 DAS	60 DAS	90 DAS	At Harvest	
T ₁	0.867	2.33	4.2	0.86	1.76	1.49	1.20	
T ₂	1	2.46	4.42	0.89	1.78	1.50	1.22	
T ₃	1.5	3.05	5.11	0.92	1.91	1.63	1.34	
T ₄	1.9	3.38	5.52	0.95	2.36	2.07	1.78	
T ₅	1.4	2.86	5.05	0.91	1.84	1.60	1.32	
T ₆	1.8	3.31	5.42	0.94	2.21	1.93	1.65	
T ₇	1.2	2.74	4.93	0.90	1.82	1.53	1.27	
T ₈	1.667	3.14	5.22	0.93	2.06	1.79	1.52	
T ₉	0.6	1.98	3.9	0.81	1.71	1.43	1.07	
S.E(m) (±)	0.26	0.24	0.27	0.03	0.04	0.10	0.14	
CD (0.05)	0.79	0.75	0.81	0.08	0.12	0.31	0.41	

[T₁-seed priming with water for 6 hours, T₂- seed priming with water for 12 hours, T₃- seed priming with ZnSO₄ @ 0.5% for 6 hours, T₄- seed priming with ZnSO₄ @ 0.5% for 12 hours, T₅- seed priming with KNO₃ @ 0.5% for 6 hours, T₆- seed priming with KNO₃ @ 0.5% @ for 12 hours, T₇- seed priming with KH₂PO₄ @ 0.5% for 6 hours, T₈- seed priming with KH₂PO₄ @ 0.5% for 12 hours, T₉- control (no priming)]

Table 4. Effect of different seed priming methods on dry matter accumulation (g/m²) of Maize and Lathyrus (Pooled Value)

Treatments	Dry Matter Accumulation (g/m ²)						
	Maize			Lathyrus			
	30 DAS	45 DAS	60 DAS	30 DAS	60 DAS	90 DAS	At Harvest
T ₁	139.50	440.00	800.2	44.70	154.60	222.10	260.50
T ₂	138.50	440.50	805.5	45.60	160.90	230.60	274.70
T ₃	141.90	450.90	825.9	48.80	173.90	244.30	296.40
T ₄	145.50	460.10	854.2	57.87	198.40	252.30	315.50
T ₅	141.00	447.60	823.1	48.20	169.40	241.03	284.20
T ₆	142.80	455.90	840.4	53.87	180.20	250.20	303.10
T ₇	140.00	440.70	815.7	46.30	167.10	235.30	280.20
T ₈	142.00	453.10	834.8	51.40	175.30	247.30	300.10
T ₉	137.50	430.50	770.3	40.43	146.60	217.60	250.40
S.E(m) (±)	2.58	3.30	12.692	3.02	5.45	5.19	4.45
CD (0.05)	7.74	9.96	38.378	9.12	16.49	15.69	13.47

[T₁-seed priming with water for 6 hours, T₂- seed priming with water for 12 hours, T₃- seed priming with ZnSO₄ @ 0.5% for 6 hours, T₄- seed priming with ZnSO₄ @ 0.5% for 12 hours, T₅- seed priming with KNO₃ @ 0.5% for 6 hours, T₆- seed priming with KNO₃ @ 0.5% @ for 12 hours, T₇- seed priming with KH₂PO₄ @ 0.5% for 6 hours, T₈- seed priming with KH₂PO₄ @ 0.5% for 12 hours, T₉- control (no priming)]

Table 5. Effect of different seed priming methods on crop growth rate (g/m²/day) of Maize and Lathyrus (Pooled Value)

Treatments	Crop Growth Rate (g/m ² /day)						
	Maize			Lathyrus			
	AT 0-30 DAS	31-45 DAS	46-60 DAS	0-30 DAS	31-60 DAS	61-90 DAS	91-Harvest
T ₁	4.48	20.03	23.67	1.49	3.66	2.22	1.28
T ₂	4.57	20.06	24.37	1.52	3.84	2.32	1.47
T ₃	4.71	20.6	24.37	1.62	4.17	2.25	1.74
T ₄	5.75	21.37	26.6	1.98	4.87	2.56	2.11
T ₅	4.67	20.43	24.37	1.60	4.04	2.39	1.44
T ₆	5.23	21.2	26.33	1.67	4.33	2.33	1.77
T ₇	4.60	20.03	25	1.54	3.73	2.27	1.50
T ₈	5.13	20.76	25.7	1.64	4.20	2.27	1.76
T ₉	4.31	18.9	22.3	1.30	3.21	1.37	1.09
S.E(m) (±)	0.16	0.35	0.79	0.11	0.23	0.18	0.18
CD (0.05)	0.48	1.06	2.39	0.34	0.70	0.53	0.54

[T₁-seed priming with water for 6 hours, T₂- seed priming with water for 12 hours, T₃- seed priming with ZnSO₄ @ 0.5% for 6 hours, T₄- seed priming with ZnSO₄ @ 0.5% for 12 hours, T₅- seed priming with KNO₃ @ 0.5% for 6 hours, T₆- seed priming with KNO₃ @ 0.5% @ for 12 hours, T₇- seed priming with KH₂PO₄ @ 0.5% for 6 hours, T₈- seed priming with KH₂PO₄ @ 0.5% for 12 hours, T₉- control (no priming)]

Table 6. Effect of different seed priming methods on root length (cm) and root weight (g) of Lathyrus (Pooled Value)

Treatments	Root length (cm)				Root weight (g)			
	30 DAS	60 DAS	90 DAS	At Harvest	30 DAS	60 DAS	90 DAS	At Harvest
T ₁	6.00	10.50	11.80	14.10	0.06	0.11	0.25	0.33
T ₂	6.07	10.70	12.20	14.50	0.06	0.12	0.27	0.33
T ₃	6.50	11.50	12.80	15.50	0.07	0.13	0.33	0.37
T ₄	6.87	12.50	14.50	16.80	0.08	0.14	0.35	0.39
T ₅	6.40	11.20	12.50	15.30	0.07	0.13	0.29	0.35
T ₆	6.80	11.90	13.80	16.10	0.08	0.14	0.34	0.39
T ₇	6.30	10.80	12.40	15.10	0.06	0.13	0.29	0.35
T ₈	6.60	11.70	13.30	15.70	0.07	0.14	0.34	0.37
T ₉	5.30	9.90	11.10	13.90	0.05	0.10	0.25	0.30
S.E(m) (±)	0.20	0.36	0.30	0.39	0.01	0.02	0.02	0.01
CD (0.05)	0.59	1.09	0.91	1.17	0.03	0.06	0.07	0.03

[T₁-seed priming with water for 6 hours, T₂- seed priming with water for 12 hours, T₃- seed priming with ZnSO₄ @ 0.5% for 6 hours, T₄- seed priming with ZnSO₄ @ 0.5% for 12 hours, T₅- seed priming with KNO₃ @ 0.5% for 6 hours, T₆- seed priming with KNO₃ @ 0.5% @ for 12 hours, T₇- seed priming with KH₂PO₄ @ 0.5% for 6 hours, T₈- seed priming with KH₂PO₄ @ 0.5% for 12 hours, T₉- control (no priming)]

Table 7. Effect of different seed priming methods on yield of Maize and Lathyrus (Pooled Value)

Treatments	Maize (t ha ⁻¹)	Lathyrus (kg ha ⁻¹)
T ₁	6.03	1125
T ₂	6.67	1230
T ₃	7.01	1486
T ₄	7.94	1682
T ₅	6.73	1457
T ₆	7.68	1641
T ₇	6.47	1335
T ₈	7.45	1587
T ₉	5.85	1058
S.E(m) (±)	0.31	18
CD (0.05)	0.93	54.4

[T₁-seed priming with water for 6 hours, T₂- seed priming with water for 12 hours, T₃- seed priming with ZnSO₄ @ 0.5% for 6 hours, T₄- seed priming with ZnSO₄ @ 0.5% for 12 hours, T₅- seed priming with KNO₃ @ 0.5% for 6 hours, T₆- seed priming with KNO₃ @ 0.5% @ for 12 hours, T₇- seed priming with KH₂PO₄ @ 0.5% for 6 hours, T₈- seed priming with KH₂PO₄ @ 0.5% for 12 hours, T₉- control (no priming)]

3.3 Effect of Seed Priming on Growth Attributes of Lathyrus Grown in Sequence

3.3.1 Plant height

It has been discovered from experimental results presented in the Table 2, the plant height of lathyrus at 30, 60, 90 DAS and at harvest stage was significantly influenced by the different seed priming methods. In general plant heights were significantly increasing in all the dates of observation till harvesting stage. The highest plant height (19.50, 42.80, 51.50 and 62.13 cm at 30, 60, 90 DAS and at harvest, respectively) was obtained from the treatment T₄ i.e. Seed priming with ZnSO₄ @ 0.5% for 12 hours. It was statistically at par with the treatment T₆ i.e. seed priming with KNO₃ @ 0.5% for 12 hours (18.87, 40.87, 49.53 and 59.73 cm at 30, 60, 90 DAS and at harvest, respectively) and treatment T₈ i.e. seed priming with KH₂PO₄ @ 0.5% for 12 hours (18.23, 39.60, 47.97 and 59.17 cm at 30, 60, 90 DAS and harvest, respectively). The lowest plant height of 12.50, 29.37, 36.87 and 47.17 cm at 30, 60, 90 DAS and at harvest, respectively were obtained from the treatment T₉ i.e. no seed priming (control). These results are in conformity with the findings of Bhowmick et al. [11], they reported that plant height increased when lathyrus was primed with KH₂PO₄ solution and priming can improve germination, reduce lipid-peroxidation, enhance anti-oxidative activity and improve seedlings growth.

3.3.2 Leaf area index

It has been revealed from experimental results presented in the Table 3, leaf area index of hybrid lathyrus at 30, 60, 90 DAS and at harvest was significantly influenced by the different seed priming methods. The value of leaf area index were significantly increasing till 60 DAS and then decreasing till harvesting stage. The highest value of leaf area index (0.95, 2.36, 2.07 and 1.78 at 30, 60, 90 DAS and at harvest, respectively) was recorded from the treatment T₄ i.e. Seed priming with ZnSO₄ @ 0.5% for 12 hours. It was statistically at par with the treatment T₆ i.e. seed priming with KNO₃ @ 0.5% for 12 hours (0.94, 2.21, 1.93 and 1.65 at 30, 60, 90 DAS and at harvest, respectively) and treatment T₈ i.e. seed priming with KH₂PO₄ @ 0.5% for 12 hours (0.93, 2.06, 1.79 and 1.52 at 30, 60, 90 DAS and at harvest, respectively). The lowest value of leaf area index of 0.81, 1.71, 1.43 and 1.07 at 30, 60, 90 DAS and at harvest, respectively were obtained from the treatment T₉ i.e. no seed priming (control).

3.3.3 Dry matter accumulation

It has been discovered from experimental results presented in the Table 4, the dry matter accumulation of lathyrus at 30, 60, 90 DAS and at harvest stage was significantly influenced by the different seed priming methods. In general dry matter accumulation was significantly increasing in all the dates of observation till harvesting stage. The highest dry matter accumulation (57.87, 198.80, 252.30, and 315.50 g/m² at 30, 60, 90 DAS and at harvest, respectively) was obtained from the treatment T₄ i.e. Seed priming with ZnSO₄ @ 0.5% for 12 hours. It was statistically at par with the treatment T₆ i.e. seed priming with KNO₃ @ 0.5% for 12 hours (53.87, 180.20, 250.20 and 303.10 g/m² at 30, 60, 90 DAS and at harvest, respectively) and treatment T₈ i.e. seed priming with KH₂PO₄ @ 0.5% for 12 hours (51.40, 175.30, 247.30 and 300.10 g/m² at 30, 60, 90 DAS and harvest respectively). The lowest dry matter accumulation (g/m²) of 40.43, 146.60, 217.60 and 250.40 g/m² at 30, 60, 90 DAS and at harvest, respectively were obtained from the treatment T₉ i.e. no seed priming (control). These results are in conformity with the findings of Bhowmick et al. [12], they reported that dry matter accumulation (g/m²) increased when lentil seed was primed with different seed priming chemicals.

3.3.4 Crop growth rate

It has been discovered from experimental results presented in the Table 5, the Crop Growth Rate ($\text{g/m}^2/\text{day}$) of lathyrus at 0-30, 31-60, 61-90 DAS and at 91-110 DAS (harvest) stage was significantly influenced by the different seed priming methods. In general Crop Growth Rate ($\text{g/m}^2/\text{day}$) was significantly increasing in all the dates of observation till harvesting stage. The highest Crop Growth Rate ($\text{g/m}^2/\text{day}$) (1.98, 4.87, 2.56 and 2.11 $\text{g/m}^2/\text{day}$ at 0-30, 31-60, 61-90 DAS and at 91-harvest, respectively) was obtained from the treatment T_4 i.e. seed priming with $\text{ZnSO}_4 @ 0.5\%$ for 12 hours. It was statistically at par with the treatment T_6 i.e. seed priming with $\text{KNO}_3 @ 0.5\%$ for 12 hours (1.67, 4.33, 2.33 and 1.77 $\text{g/m}^2/\text{day}$ at 0-30, 31-60, 61-90 DAS and at 91-harvest, respectively) and treatment T_8 i.e. seed priming with $\text{KH}_2\text{PO}_4 @ 0.5\%$ for 12 hours (1.64, 4.20, 2.27 and 1.76 $\text{g/m}^2/\text{day}$ at 0-30, 31-60, 61-90 DAS and at 91-harvest, respectively). The lowest crop growth rate ($\text{g/m}^2/\text{day}$) of 1.30, 3.21, 1.37 and 1.09 $\text{g/m}^2/\text{day}$ at 0-30, 31-60, 61-90 DAS and at 91-harvest, respectively were obtained from the treatment T_9 i.e. no seed priming (control). Seed priming helps in mobilisation of seed food reserves to the developing embryo during germination.

3.3.5 Root length

It has been discovered from experimental results presented in the Table 6, the root length of Lathyrus at 30, 60, 90 DAS and at harvest stage was significantly influenced by the different seed priming methods. In general root length was significantly increasing in all the dates of observation till harvesting stage. The highest root length (6.87, 12.50, 14.50 and 16.80 cm at 30, 60, 90 DAS and at harvest, respectively) was obtained from the treatment T_4 i.e. Seed priming with $\text{ZnSO}_4 @ 0.5\%$ for 12 hours. It was statistically at par with the treatment T_6 i.e. seed priming with $\text{KNO}_3 @ 0.5\%$ for 12 hours (6.80, 11.90, 13.80 and 16.10 cm at 30, 60, 90 DAS and at harvest, respectively) and treatment T_8 i.e. seed priming with $\text{KH}_2\text{PO}_4 @ 0.5\%$ for 12 hours (6.60, 11.70, 13.30 and 15.70 cm at 30, 60, 90 DAS and harvest, respectively). The lowest root length of 5.30, 9.90, 11.10 and 13.10 cm at 30, 60, 90 DAS and at harvest, respectively were obtained from the treatment T_9 i.e. no seed priming (control).

3.3.6 Root dry weight

It has been discovered from experimental results presented in the Table 6, the root weight of lathyrus at 30, 60, 90 DAS and at harvest stage was significantly influenced by the different seed priming methods. In general root weight was significantly increasing in all the dates of observation till harvesting stage. The highest root weight (0.08, 0.14, 0.35 and 0.39 g at 30, 60, 90 DAS and at harvest, respectively) was obtained from the treatment T_4 i.e. Seed priming with $\text{ZnSO}_4 @ 0.5\%$ for 12 hours. It was statistically at par with the treatment T_6 i.e. seed priming with $\text{KNO}_3 @ 0.5\%$ for 12 hours (0.08, 0.14, 0.34 and 0.39 g at 30, 60, 90 DAS and at harvest, respectively) and treatment T_8 i.e. seed priming with $\text{KH}_2\text{PO}_4 @ 0.5\%$ for 12 hours (0.07, 0.14, 0.34 and 0.37 g at 30, 60, 90 DAS and harvest, respectively). The lowest root weight of 0.05, 0.10, 0.25 and 0.30 g at 30, 60, 90 DAS and at harvest, respectively were obtained from the treatment T_9 i.e. no seed priming (control).

3.4 Yield

Seed yield was significantly influenced by the different seed priming methods (Table 7). Yield variation due to priming varies from 1058 kg/ha to 1641 kg/ha and the yield increase was the tune of 58.97 % over control. The highest seed yield (1682 kg/ha) was observed in treatment T_4 i.e. seed priming with $\text{ZnSO}_4 @ 0.5\%$ for 12 hours and it was statistically at par with treatment T_6 (1641 kg/ha) i.e. seed priming with $\text{KNO}_3 @ 0.5\%$ for 12 hours. The lowest value of seed yield (1058 kg/ha) was obtained in treatment T_9 i.e. no seed priming (control).

4. CONCLUSION

The seed priming methods significantly influenced the germination percentage, growth parameters and yield of maize-lathyrus grown in sequence under rainfed situation. The highest germination percentage (70.7 and 93.6% at 5 and 10 DAS, respectively), dry matter accumulation (145.5, 460.10 and 854.2 g/m^2 at 30, 45 and 60 DAS respectively) of hybrid maize and highest root length (6.87, 12.50, 14.50 and 16.80 cm at 30, 60, 90 DAS and at harvest, respectively), highest root weight (0.08, 0.14, 0.35 and 0.39 g at 30, 60, 90 DAS and at harvest, respectively) were obtained from the T_4 treatment i.e. Seed priming with $\text{ZnSO}_4 @ 0.5\%$ for 12 hours. Based on the results obtained in the study, it may be concluded that seed priming with

ZnSO₄ @ 0.5% for 12 hrs could be recommended due to better growth, as well as higher yield (7.94 t/ha of *kharif* hybrid maize and 1682 kg/ha of lathyrus) for maize-lathyrus in sequence under rainfed situation. Therefore, seed priming with ZnSO₄ @ 0.5% for 12 hrs could be more effective in augmenting growth and yield of maize – lathyrus in sequence in the Gangetic plains of West Bengal.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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