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Seed invigoration- a technique for improving vigour and productivity of sesame (*Sesamum indicum* L.) variety Thilak

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Abstract

Experiments were conducted in the Department of Plant Physiology, College of Horticulture, Vellanikkara to study the effect of seed priming on seedling vigour, growth and productivity of *Sesame indicum* L. var. Thilak. Seed priming treatments used were, water, Gibberellic acid (100ppmGA), Borax (0.1 %), Manganese sulphate (0.3 % $MnSO_4$), and tank mixture of $MnSO_4$ (0.3 %), Borax (0.1 %) and 100 ppm GA (TM). Seedling characters were evaluated in the laboratory, and thereafter sown in field along with unprimed seeds for comparison. The biochemical parameters, growth attributes and yield components were studied. All the priming treatments improved the seedling vigour and speed of germination in laboratory studies. GA recorded 12.68 per cent improvement in germination followed by Borax and $MnSO_4$ over unprimed seeds. Field evaluation revealed that seed priming influenced the biochemical parameters *viz*., total chlorophyll content, total soluble protein content and nitrate reductase enzyme with maximum improvement in $MnSO_4$ primed seeds. The per plant seed yield also increased from 2.53 g to 3.80 g in this treatment which contributed to 50 per cent improvement in yield per hectare over conventional unprimed seeds. TM, Borax and water priming recorded 45 %, 36 % and 33 % higher per hectare yield respectively.

Key words: GA, $MnSO_4$, Priming, Thilak, Vigour index.

Introduction

Sesame is one of the oldest oil seed crops cultivated in India. Globally, India is the largest producer, consumer and exporter of sesame. Sesame has high oil content (46-64 %) and dietary energy of 6355 Kcal kg^{-1}. Seeds serve as rich source of protein (20-28 %), sugars (14-16 %) and minerals (5-7 %). The crop is heat tolerant but sensitive to water logging. In Kerala, sesame is usually grown in summer rice fallows due to its short duration and low water requirement. Lack of optimum plant population resulting from poor germination and seedling vigour is a problem affecting the productivity of the crop (Mura et al., 2015).

Seed priming is a pre-sowing strategy for improving seedling establishment by modulating pre-germination metabolic activity prior to emergence of radicle. This technique generally enhances germination rate and plant performance (Bradford, 1986). Rapid germination and emergence are essential for successful crop establishment, for which seed priming could play an important role. While information on the effect of priming treatments on seedling performance is available, the carry over effect of priming on crop performance and productivity is meagre. In this context the present study was undertaken to understand the effect of seed priming on seedling vigour, growth rate, biochemical parameters and yield potential of *Sesamum indicum* L. var. Thilak.

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Materials and Methods

Genetically pure seeds of sesame (*Sesamum indium* L.) var. 'Thilak' obtained from Onattukara Regional Agricultural Research Station (ORARS), Kayamkulam formed the base material for the study. The seed priming treatments included water, GA (100 ppm), Borax (0.1 %), manganese sulphate (0.3 %), and Tank mix (TM) of $MnSO_4$ (0.3 %), Borax (0.1 %) and GA (100 ppm). Seeds were soaked in respective concentration of each of the priming solutions for 8h and were dried back to 8 per cent moisture content. The primed seeds were sown on germination paper for a test period of 7 days and the following observations were taken.

Germination per cent: This was estimated as per the procedure outlined in ISTA rules (1999). Four replications of one hundred seeds were sown in germination paper. After seven days the seedlings were counted and the mean values were expressed in per cent.

Shoot and Root length: Length between collar and the tip of the primary shoot was measured as shoot length and the length between the collar and the tip of the primary root was measured as root length. The mean length was expressed in centimetres.

Vigour index-1 values were computed according to the procedure of Abdul-Baki and Anderson (1973).

Vigour index-I = Germination (%) × Total seedling length (cm) (1)

Speed of germination: Seeds with radicle protrusion were counted every day from the day of sowing up to 7 days. Four replicates of hundred seeds were used. Speed of germination was calculated using the following formula given by Maguire (1962) and results were expressed in number.

Speed of germination = $X_1/Y_1 + (X_2-X_1)/Y_2 + \ldots + (Xn - Xn_{-1})/Yn$ (2)

X_1- Number of seeds germinated at first count

X_2- Number of seeds germinated at second count

Xn- Number of seeds germinated at n^{th} day

Y_1- Number of days from sowing to first count

Y_2- Number of days from sowing to second count

Yn- Number of days from sowing to nth count

Field experiment was laid out at ORARS, Kayamkulam with 3 replications to compare the effect of priming treatments on the growth and yield of the crop. The crop period was from February 2017 to April 2017. Experimental area was ploughed twice to a fine tilth, and plots of size $2m^2$ (2m×1m) were prepared with a spacing of 60 cm between plots. Fertilizers were applied as per the package of practices recommendations of the Kerala Agricultural University. N: P: K @ 30:15:30 kg ha^{-1} was applied as basal dose at the time of sowing. Seeds were then dibbled at a spacing of 15 cm ×20 cm. Priming treatments were given one day before sowing. 250 g seeds were soaked for 8 hours and after shade drying, the seeds were sown in the field. Thinning was done 15 days after sowing. Two per cent foliar spray of urea was given after thinning. Observations like plant height, leaf area index (LAI), CGR (Crop growth rate), RGR (Relative Growth Rate) and NAR (Net Assimilation Rate) were computed. Biochemical observations such as total chlorophyll content, soluble protein content and nitrate reductase enzyme activity were recorded at vegetative and reproductive stages. Total chlorophyll and total soluble protein contents in the leaf were estimated by the method suggested by Hiscox and Israelstam (1979) and Lowry et al. (1951) respectively. To estimate nitrate reductase enzyme activity in the leaf, the method suggested by Hageman and Flesher (1960) was followed. Yield attributes such as number of branches per plant, number of capsules per plant, number of seeds per capsule and yield (per plant and per hectare) were recorded.

Values obtained were analyzed in CRD (completely randomized design) for laboratory study and RBD (randomized block design) for field study using OPSTAT developed by CCS HAU, Hisar.

Results and Discussion

Laboratory evaluation

Data on effect of seed priming treatments on seedling characters of sesame var. Thilak are given in Table 1. Among the treatments, highest improvement of 12.68 per cent in germination was observed with GA priming (96.85 %) followed by borax (93.75 %) and $MnSO_4$ (93.50 %) over unprimed seeds (84.17 %). GA, being a native plant growth hormone, improved germination by activating the production of hydrolytic enzymes mainly α amylase required for solubilization of endosperm reserves (Taiz and Zeiger, 2010). GA primed seedlings showed the highest shoot length of 7.25 cm whereas the unprimed seeds (control) recorded 5.55 cm length. GA increased the cell wall extensibility by removal of Ca^{2+} ions bound to cell walls, thereby increasing plant height. Improvement in root length was observed in priming with $MnSO_4$ (T_5) (11.70 cm) whereas all other treatments recorded statistically similar root length. The oxidation product of indole acetic acid (IAA) has been reported to enhance root and shoot length (Loo and Tang, 1945), and manganese, to oxidize IAA (Bhatt et al., 1976).

Highest vigour index was recorded with GA (1724) and $MnSO_4$ (1701) priming followed by TM (1586), borax (1558) and water (1555). The high germination and improvement in total seedling length in these treatments contributed to higher vigour index. Significant improvement in germination per cent and vigour index with GA priming was also reported by Mura et al. (2015) when sesame seeds were soaked in 200 ppm GA. Munawar et al. (2013) reported that soaking of carrot seeds in water (1006) and 1.5 per cent $MnSO_4$ (1448) improved the vigour index as compared to unprimed seeds (730).

Speed of germination of the variety was accelerated by all the priming treatments over unprimed seeds, which were statistically similar. Similar results were reported in sesame (Shabbir et al., 2014) and sorghum (Azadi et al., 2013) with water and GA priming respectively.

Field evaluation

Effect of seed priming on biochemical parameters

The primed seeds were grown in the field and biochemical parameters such as chlorophyll content, total soluble protein content and nitrate reductase enzyme activity were estimated at vegetative and reproductive stages (Table 2). All these biochemical parameters showed maximum increase with $MnSO_4$ priming. At vegetative stage highest total chlorophyll content was recorded in $MnSO_4$ (3.03mg g^{-1}) priming, and lowest in control (1.75 mg g^{-1}) and GA (1.82 mg g^{-1}) which were statistically similar. At reproductive stage, $MnSO_4$ (3.15 mg g^{-1}), borax (2.91 mg g^{-1}), and GA (2.80 mg g^{-1}) priming showed the highest values whereas control (2.04 mg g^{-1}) and water priming (2.27 mg

Table 1. Effect of seed priming treatments on germination per cent, shoot length, root length, vigour index and speed of germination of sesame var. Thilak

Treatments	Germination per cent (%)	Shoot length (cm)	Root length(cm)	Vigour index	Speed of germination
T_1-Control (unprimed)	84.17^c	5.55^d	9.98^b	1308^c	58.94^b
T_2-Water	92.50^b	6.27^c	10.52^b	1555^b	89.50^a
T_3-GA (100ppm)	96.85^a	7.25^a	10.57^b	1724^a	90.00^a
T_4-Borax (0.1%)	93.75^{ab}	6.25^c	10.38^b	1558^b	89.50^a
T_5-$MnSO_4$(0.3%)	93.50^{ab}	6.50^{bc}	11.70^a	1701^a	93.75^a
T_6-Tankmix (T_3+T_4+T_5)	92.90^b	6.67^b	10.40^b	1586^b	90.00^a
SEm(±)	1.25	0.08	0.30	3.28	1.23
CD (0.05)	3.73	0.26	0.89	107.80	3.66

Means with the same superscript do not differ significantly at 5% level of probability using Duncan's Multiple Range Test (DMRT)

Table 2. Effect of seed priming treatments on total chlorophyll content, total soluble protein and nitrate reductase enzyme activity of sesame var. Thilak

Treatments	Total chlorophyll content (mg g^{-1})		Total soluble protein (mg g^{-1})		Nitrate reductase enzymeactivity (µ moles of NO_2^- formed g^{-1} h^{-1})	
	Vegetative stage	Reproductive stage	Vegetative stage	Reproductive stage	Vegetative stage	Reproductive stage
T_1-Control (unprimed)	1.75^{e}	2.04^{d}	6.00^{e}	10.66^{e}	611.66^{d}	465.00^{f}
T_2-Water	2.14^{c}	2.27^{cd}	6.08^{e}	10.83^{e}	656.66 ^{c}	488.33^{e}
T_3-GA (100ppm)	1.82^{de}	2.80^{ab}	10.33H”	12.00H”	796.66^{b}	816.66^{d}
T_4-Borax (0.1%)	2.78^{b}	2.91^{a}	11.66G”	14.40œ”	673.33 ^{c}	1528.33^{b}
T_5-$MnSO_4$ (0.3%)	3.03^{a}	3.15^{a}	15.50C”	17.66C”	1568.33^{a}	1790.00^{a}
T_6-Tankmix (T_3+T_4+T_5)	1.89^{d}	2.48^{bc}	11.00œ”	15.50G”	823.33^{b}	883.33^{c}
SEm(±)	0.03	0.07	0.20	0.24	10.75	6.00
CD (0.05)	0.09	0.36	0.64	0.76	34.31	19.16

Means with the same superscript do not differ significantly ατ 5% λεϖελ οφ προβαβιλιτψ υσινγ Δυνχαν σ Μυλτιπλε Ρανγε Τεστ (ΔΜΡΤ)

g^{-1}) recorded the lowest. Role of manganese in maintaining the structural integrity of thylakoid membrane (Simpson and Robinson, 1984) and activation of specific enzymes for chlorophyll synthesis (Millaleo et al., 2010) have been reported. At both vegetative and reproductive stages highest total soluble protein content was observed with $MnSO_4$ (6.00 mg g^{-1} and 10.66 mg g^{-1}) followed by TM and borax treatments (Table 2). In plants, 30 to 50 per cent of soluble protein in leaves was contributed by the enzyme Rubisco (Spreitzer and Salvucci, 2002). Under manganese deficiency it has been reported that gene expression and activation of Rubisco is destroyed (Gong et al., 2011). Moreover, it is an essential element in protein synthesis.

Nitrate reductase enzyme plays a major role in nitrogen metabolism of plants and manganese acts as a co-factor of the enzyme nitrite reductase (Harper and Paulsen, 1969). Similar to total chlorophyll content and soluble protein content, highest nitrate reductase enzyme activity was recorded in $MnSO_4$ priming at both vegetative and reproductive stages (1568.33 µ moles of NO_2^- formed g^{-1} h^{-1} and 1790.00 µ moles of NO_2^- formed g^{-1} h^{-1}). Lowest nitrate reductase enzyme activity was observed in unprimed plants (611.66 µ moles of NO_2^- formed g^{-1} hr^{-1} and 465.00 µ moles of NO_2^- formed g^{-1} h^{-1}). It could be clearly understand from Table 2 that all treatments except control and water priming maintained higher nitrate reductase enzyme activity even during the reproductive phase of the crop.

Effect of seed priming on growth attributes

Plant height in different treatments were recorded at the time of harvest (Table 3). Priming with $MnSO_4$ (104.83 cm), TM (104.50 cm), borax (103.16 cm) and water (102.66 cm) showed statistically higher plant height than unprimed seeds (96.83 cm). The improvement in height recorded with GA priming under laboratory condition (Table 1) was not evident in the field (Table 3).

LAI is an important structural component that influences radiation uptake, energy exchange, evapotranspiration and gross photosynthesis. LAI was recorded at 20 DAS, 40 DAS and 60 DAS (Table 3). The plants showed high LAI at 60 DAS. Among the treatments, $MnSO_4$, TM, borax and water maintained higher LAI at all crop growth stages whereas the lowest LAI was recorded in control. GA priming did not influence LAI at any of the growth stages.

CGR and RGR were computed at two intervals *viz.*, 20-40 DAS and 40-60 DAS (Table 3). CGR indicates the change in dry weight over a period of time. The study revealed that priming treatments *viz.*, $MnSO_4$ and TM contributed to highest improvement in CGR at both stages (Table 3).

Table 3. Effect of seed priming on growth attributes of sesame var. Thilak

Treatments	Plant height (cm)	LAI			CGR ($g\ m^{-2}d^{-1}$)		RGR ($g\ g^{-1}d^{-1}$)	
	(At harvest)	20DAS	40DAS	60DAS	20-40 DAS	40-60DAS	20-40DAS	40-60DAS
T_1-Control (unprimed)	96.830^{c}	0.110^{c}	0.842^{c}	2.133^{b}	7.240^{d}	16.930^{c}	0.031^{c}	0.020^{b}
T_2-Water	102.660^{ab}	0.130^{ab}	0.916^{b}	2.320^{a}	7.973^{bc}	17.500^{bc}	0.039^{ab}	0.024^{a}
T_3-GA (100ppm)	98.500^{bc}	0.120^{bc}	0.867^{c}	2.160^{b}	7.741^{cd}	17.100^{c}	0.034^{bc}	0.022^{b}
T_4-Borax (0.1%)	103.160^{ab}	0.137^{a}	0.944^{ab}	2.333^{a}	8.535^{ab}	18.130^{b}	0.040^{ab}	0.024^{a}
T_5-$MnSO_4$ (0.3%)	104.830^{a}	0.143^{a}	0.973^{a}	2.403^{a}	9.032^{a}	19.230^{a}	0.041^{a}	0.025^{a}
T_6-Tankmix (T_3+T_4+T_5)	104.500^{a}	0.137^{a}	0.968^{a}	2.320^{a}	8.911^{a}	19.160^{a}	0.041^{a}	0.025^{a}
SEm(±)	1.506	0.004	0.012	0.031	0.230	0.282	0.002	0.001
CD (0.05)	4.747	0.014	0.036	0.105	0.726	0.889	0.007	0.002

Means with the same superscript do not differ significantly at 5% level of probability using Duncan's Multiple Range Test (DMRT); LAI-Leaf area index; CGR-Crop growth rate; RGR-Relative growth rate

Control and GA priming recorded lowest CGR at both stages. RGR measures the increase in dry matter with a given amount of assimilatory material at a given point of time. It is used as a measure to quantify the speed of plant growth. Plants subjected to priming treatments except for GA grew faster than unprimed plants (Table 3).

Effect of seed priming on yield attributes and yield

Yield attributes such as number of branches per plant and number of capsules per plant were recorded at the time of harvest (Table 4). $MnSO_4$ primed plants recorded highest number of branches per plant (6.00), followed by TM (5.33), water (5.33) and borax (5.00). Highest number of capsules per plant (42.83) was observed in $MnSO_4$ priming (T_5). Sulphur content in $MnSO_4$ (T_5) contributed to higher number of capsules, as it is reported to play a role in promoting floral primordial initiation (Mathew et al., 2013). GA priming did not influence the yield attributes.

Per plant and per hectare yield also recorded a similar trend with greatest improvement seen in $MnSO_4$ priming, which resulted from more number of branches and capsules (Table 4). Improved yield with 0.2 per cent $MnSO_4$ priming in wheat has been reported by Khalid and Malik (1982). Improved translocation efficiency contributed by boron priming (Herrera-Rodriguez et al., 2010) resulted in high yield in T_4. As per reports of Saric and Saciragic (1969), grain yield increased by borax priming in oats. The high yield from TM (3.67 g) was due to the synergistic effect of manganese, sulphur and boron in favourably influencing the growth and yield attributes of sesame. The improved seedling vigour along with increased number of branches and capsules resulted in enhanced yield in water primed seeds (3.33 g) over control (2.53 g).

$MnSO_4$ priming contributed to 50 per cent improvement in yield per hectare over conventional

Table 4. Effect of seed priming treatments on yield attributes and yield of sesame var. Thilak

Treatments	Number of branches per plant	Number of capsules per plant	Yield per plant (g)	Yield per ha ($t\ ha^{-1}$)
T_1-Control (unprimed)	4.00^{c}	33.33^{c}	2.53^{c}	0.84^{c}
T_2-Water	5.33^{b}	40.83^{ab}	3.33^{b}	1.12^{b}
T_3-GA(100ppm)	4.00^{c}	37.16^{bc}	2.87^{c}	0.95^{c}
T_4-Borax (0.1%)	5.00^{b}	41.00^{ab}	3.43^{ab}	1.15^{ab}
T_5-$MnSO_4$ (0.3%)	6.00^{a}	42.83^{a}	3.80^{a}	1.27^{a}
T_6-Tankmix (T_3+T_4+T_5)	5.33^{b}	40.50^{ab}	3.67^{ab}	1.22^{ab}
SEm(±)	0.17	2.10	0.13	0.04
CD (0.05)	0.55	4.59	0.41	0.14

Means with the same superscript do not differ significantly at 5% level of probability using Duncan's Multiple Range Test (DMRT) unprimed seeds. TM, borax and water recorded 45 %, 36 % and 33 % higher per hectare yield respectively (Table 4).

Priming treatments improved the seedling vigour and speed of germination of sesame var. Thilak. This was mainly due to improvement in the physiological efficiency of the crop. However, the improvement observed in the laboratory was not carried over to the field in the case of GA. All other treatments contributed to a 33 to 50 % improvement in yield. Priming hydro can be recommended as a cost effective method for improving sesame seed yield.

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