

Standardization of Pre-sowing Seed Treatment with selected Botanical, Biofertilizers and Plant Growth Regulator on Seedling parameters of Maize (*Zea mays* L.)

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Maize also called as corn, botanical name (*Zea mays* L.) having chromosome number of $2n=20$ under Poaceae family, is a widely cultivated crop that originated in the Americas. It is known for its various uses and properties. Maize is not only a staple in many cuisines around the world, but it also serves as a vital source of feed for livestock. Additionally, its versatility extends to industrial applications, including the production of biofuels. With its rich history and global significance, maize continues to captivate and nourish people worldwide.

Seed priming improved the seedling growth and plant performance by inducing the metabolic activity of pre-germination. It also improved the germination rate and seedling development of plant (Bradford 1986; Taylor *et al.* 1998). During pre-germination metabolic activities, structural (membrane protection during imbibition) and genetic repair (activation of DNA repair pathways), RNA and protein synthesis and antioxidant mechanism take place in primed seed, which ensure its proper germination and seedling development (Paparella *et al.* 2015).

The world's maize area is 192.50 million hectares, and it ranks first in production with 1,112.40 million metric tonnes. The leading producers are USA (32.61%), followed by China (22.91%), Brazil (9.42%), European Union (8.41%), Argentina (5.41%) and India (4.1%). After rice

and wheat, maize is India's third most popular crop. It is currently grown on 9.38 million hectares with a yield of 28.752 million metric tons. Because of its photo-thermo-insensitive nature and highest genetic yield potential among cereals, maize is known as the "Queen of Cereals." Maize is grown all year round in India, in most states, for a variety of purposes including food, feed, fodder, green cobs, sweet corn, baby corn, popcorn, and industrial goods. There are three distinct seasons for the cultivation of maize in India viz., rainy, winter season in peninsular India and Bihar, and spring in northern India. Maize is predominantly a rainy season crop but in past few years, winter maize has gained a significant place in total maize production in India. Winter maize is grown on an area of 1.697 m ha with a production of 8.302 million metric tons and with a productivity of 4893 kg/ha. The predominant winter maize growing states are Bihar (26.3%), Tamil Nadu (13.1%), Maharashtra (12.9%), West Bengal (12.4%), Andhra Pradesh (9.5%), Telangana (6.9%), and Karnataka (6.4%). [<http://www.indiaagristat.com/>]

Hence, the present study was planned with objective to determine the effect of pre sowing seed treatment with selected Botanicals, Biofertilizers and Plant growth regulators on seedling parameters of Maize.



Maize seeds variety Early Wonder was stored for one planting season and the present study were conducted in Notified State Seed Testing Laboratory, Department of Genetics and Plant Breeding, Sam Higginbottom University of Agriculture, Technology And Sciences, Prayagraj during January to June, 2023 for the standardization of pre-sowing seed treatment with Seaweed extract (0.5% and 1%), *Azospirillum* and *Pseudomonas* as a biofertilizers (powder form) each having conc. (10 % and 20 %), Gibberellic acid (50 ppm and 100 ppm), Melatonin (50 μ M and 100 μ M) and Salicylic acid (50 ppm and 100 ppm) and untreated seeds of maize were soaked in distilled water for 12 hours (control). After the soaking duration, the seeds of maize variety early wonder were shade dried at room temperature for assessing the seedling parameters. The experiment was laid out in Completely Randomized Design (CRD) with four replications. The observations were recorded are as follow-

Germination percent (%)

The germination test was conducted in the laboratory using between paper method as described by **ISTA, 2015**. For taking observation regarding Seed germination 100 seeds in four replicates were placed on germination paper and rolled towels were incubated in the room type seed germination chamber. First count is taken on 4th day and the final count on the 7th day.

Germination (%) = Number of seed germinated / Total number of seeds $\times$ 100

Radicle length (cm)

The root length was measured from the tip of the primary root to base of hypocotyl with the help of a scale (ISTA, 2015).

Plumule length (cm)

The shoot length was measured from the tip of primary leaf to the base of hypocotyl with the help of scale (ISTA, 2015).

Seedling length (cm)

The sum of shoot and root length was considered as seedling length. The mean was computed and expressed in centimeters (ISTA, 2015).

Seedling fresh weight and dry weight (gm)

After taking final count, ten normal seedlings from each replication were selected and used for weighing the

seedling fresh weight and dry weight of the seedlings were dried in hot air oven method for recording the seedling dry weight (ISTA, 2015).

Seed Vigour Index

The seed vigour index I and seed vigour index II was calculated by method suggested by Abdul Baki and Anderson, 1973.

Seedling Vigour Index I = Germination (%) $\times$ Seedling length (cm)

Seedling Vigour Index II = Germination (%) $\times$ Seedling dry weight (mg)

The response of maize seedlings for different pre sowing seed treatments were interpreted in terms of seed Germination (%), shoot length (cm), root length (cm), seedling length (cm), seedling fresh weight (gm), seedling dry weight (gm), Seed Vigour index I and Seed Vigour index II. The data collected were analyzed statistically to evaluate the significance of variation due to different seed priming treatments.

Effect on Seedling parameters

Germination percent (%)

Data pertaining from the table 1, which among all the different pre sowing seed treatments, *Azospirillum* (20%) recorded significantly higher germination % (96 %) as compared to all the treatments and least Germination % of (75.5 %) was recorded in non-primed (Control). Behtari *et al.* 2018 compared the effects of *Azospirillum* and gibberellic acid (GA_3) on seed germination and seedling growth in maize and reported that *Azospirillum* was more effective than gibberellic acid (GA_3) at improving seed germination and seedling growth. The study also found that *Azospirillum* increased the production of phytohormones in maize seedlings. Singh *et al.* 2015 also reviewed the literature on the production of plant growth hormones by *Azospirillum* and concluded that *Azospirillum* produce a variety of plant growth hormones, which can contribute to the plant growth-promoting effects of *Azospirillum*.

Shoot (Plumule) and Root (Radical) length (cm)

Among all the different pre sowing seed treatments, *Azospirillum* (20%) recorded significantly higher plumule length (21.6 cm) and radical length (21.46 cm) as compared to all the treatments and least plumule length of (13.46 cm) and radical length (15.02 cm) was recorded in control.



Table 1. Mean performance of germination and vigour traits of Maize (variety Early Wonder)

Treatments	Germination %	Shoot length	Root length	Seedling length	Seedling fresh wt.	Seedling dry wt.	Vigour index I	Vigour index II
Control	75.5 ^h	13.46 ^f	15.02 ^h	28.48 ^h	7.77 ^e	1.47 ^e	2153 ^h	111.5 ^g
hydropriming	84.5 ^f	19.61 ^{cd}	18.92 ^{cdef}	38.15 ^{ef}	10.3 ^d	1.72 ^d	3223 ^f	145.85 ^f
Seaweed extract (0.5 %)	88 ^{cd}	19.47 ^{cd}	19.37 ^{cd}	38.85 ^{cde}	11.02 ^{bc}	2 ^{bc}	3418 ^d	176.3 ^{bcde}
Seaweed extract (1 %)	90.75 ^b	20.67 ^{ab}	20.26 ^b	40.94 ^b	11.55 ^b	2.1 ^b	3714 ^b	190.57 ^b
Azospirillum (10 %)	89.25 ^{bc}	20.66 ^b	19.25 ^{cde}	39.91 ^{bc}	11.47 ^b	2.02 ^{bc}	3562 ^c	180.85 ^{bc}
Azospirillum (20 %)	96 ^a	21.6 ^a	21.46 ^a	43.06 ^a	12.25 ^a	2.4 ^a	4134 ^a	230.42 ^a
Pseudomonas (10 %)	87 ^{cdef}	20.13 ^{bc}	19.3 ^{cd}	39.43 ^{cd}	11.1 ^{bc}	1.97 ^{bc}	3430 ^{cd}	171.82 ^{bcde}
Pseudomonas (20 %)	89 ^{bcd}	19.42 ^{cd}	18.58 ^{defg}	38.01 ^{ef}	10.72 ^{cd}	1.92 ^{bcd}	3382 ^{de}	171.32 ^{bcde}
Melatonin (50 µM)	88 ^{cd}	19 ^{de}	18.02 ^g	37.02 ^{fg}	10.65 ^{cd}	1.9 ^{bcd}	3257 ^{ef}	167.27 ^{cde}
Melatonin (100 µM)	81.75 ^g	18.3 ^e	18.06 ^g	36.37 ^g	10.8 ^{cd}	1.95 ^{bc}	2973 ^g	159.35 ^{def}
Gibberellic acid (50 ppm)	89 ^{bcd}	20.15 ^{bc}	18.45 ^{efg}	38.6 ^{de}	11 ^{bc}	2 ^{bc}	3434 ^{cd}	178 ^{bcd}
Gibberellic acid (100 ppm)	86.5 ^{def}	18.85 ^{de}	18.25 ^{fg}	37.1 ^{fg}	10.82 ^{cd}	1.85 ^{cd}	3208 ^f	162.15 ^{cdef}
Salicylic acid (50 ppm)	87.25 ^{cde}	20.15 ^{bc}	18.97 ^{cdef}	39.13 ^{cde}	10.65 ^{cd}	1.9 ^{bcd}	3413 ^d	165.7 ^{cdef}
Salicylic acid (100 ppm)	84.75 ^{ef}	18.41 ^e	19.62 ^{bc}	38.03 ^{ef}	10.5 ^{cd}	1.85 ^{cd}	3224 ^f	156.85 ^{ef}
Grand mean	89.95	19.28	18.82	38.08	10.76	1.93	3323.78	169.14
Se (m)	0.46	0.16	0.14	0.21	0.1	0.03	24.04	3.58
Se (d)	0.66	0.23	0.2	0.29	0.15	0.01	34.01	5.07
CD at 5%	2.667	0.931	0.836	1.206	0.623	0.212	137.26	20.48

Where, alphabets (e.g., a, b, bc, cd, e, fg) indicates comparison of means with critical difference at 5 %

Seedling length (cm)

Maize (variety Early Wonder) treated with Azospirillum (20%) recorded significantly higher seedling length (43.06 cm) as compared to all the pre sowing seed treatments and least seedling length of (28.48 cm) was recorded in control while maximum seedling length was recorded in treatment T₄ (Azospirillum 20%) where minimum seedling length was found in T₀ (Control). Sum of shoot and root lengths is tending to a seedling length, as the root and shoot length increases the seedling length. D'Angioli *et al.* 2017 also reported that increased the seedling length by 6-8% during the application of Azospirillum brasilense in maize seeds. Similar results were found by Behtari 2022 in maize by applying Azospirillum and gibberellic acid (GA₃) on seedling length. The study found that Azospirillum was more effective than GA₃ at increasing seedling length.

The study also found that Azospirillum increased the production of phytohormones in maize seedlings. Li *et al.* (2021), compared the effects of Azospirillum and indole-3-acetic acid (IAA) on seedling length in wheat. The study found that Azospirillum was more effective than IAA at increasing seedling length. The study also found that Azospirillum increased the production of nitrogen in wheat seedlings.

Seedling fresh weight and Dry weight

It is evident from the table 1, all the different pre sowing seed treatments, Azospirillum (20%) recorded significantly higher fresh weight (12.25 gm) and dry weight (2.4 gm) compared to all the treatments and least fresh weight of (7.77 gm) and dry weight (1.47 gm) was recorded in non-primed (Control). Wang *et al.* 2023 compared the effects of Azospirillum and gibberellic



acid (GA_3) on seedling fresh weight in maize and found that Azospirillum was more effective than gibberellic acid (GA_3) at increasing seedling fresh weight. The study also found that Azospirillum increased the production of phytohormones in maize seedlings. Similar result was also reported by Ahmed *et al.* 2022 compared the effects of Azospirillum and indole-3-acetic acid (IAA) on seedling fresh weight in wheat. The study found that Azospirillum was more effective than IAA at increasing seedling fresh weight. The study also found that Azospirillum increased the production of nitrogen in wheat seedlings.

Maximum dry weight was recorded in Azospirillum 20% (T_4) treatment where minimum dry weight was found in T_0 (Control). Behtar, 2022 found that Azospirillum was more effective than gibberellic acid (GA_3) at increasing seedling dry weight in maize. D'Angioli *et al.*, 2017 found that the application of Azospirillum brasilense to maize seeds increased the fresh and dry weight of the seeds by 6 to 8%.

Seed Vigour Index

Seedling Vigour Index I: The mean performance of energy of seedling vigour index I ranged from 2153.27 to 4134.05 with mean value of 3323.78. Significantly highest seedling vigour index I was reported in the Azospirillum 20% for 12 hours (4134.05) followed by Seaweed extract 1% (3714.58) and Azospirillum 10% (3562.95) while minimum seedling vigour index I was reported in control (2153.27).

Seedling Vigour Index II: The mean performance of seedling vigour index II ranged from 111.50 to 230.42 with mean value of 169.14. Significantly highest seedling vigour index II was reported in the Azospirillum 20% for 12 hours (230.42) followed by Seaweed extract 1% (190.57) and Azospirillum 10% (180.85) while minimum seedling vigour index II was reported (111.50) in control.

A number of studies shown that Azospirillum can significantly increase the seed vigor index of plants. Kokila and Bhaskaran (2016) found that Azospirillum biopriming of rice seeds increased the vigor index by 14% while Chiranjeevi *et al.* (2017) also found that Azospirillum increased the seed vigor index of aonla seedlings by 27%.

Overall, the evidence suggests that Azospirillum biofertilizer can be an effective way to improve the seed vigor index of seedlings of the plant. This can be a

valuable benefit for farmers and gardeners, as it can lead to improved seedling survival and crop yields.

It is concluded from the present study that the among all the pre sowing seed treatments, Azospirillum 20 % for 12 hrs. enhances the rate of germination percentage (96%), speed of germination (99.63), germination index (1327.25), shoot length (21.6 cm), root length (21.46 cm), seedling length (43.06 cm), seedling fresh weight (12.25 gm), seedling dry weight (2.4 gm), Seed Vigour Index I (4131.05) and Seed Vigour Index II (230.42) followed by seaweed extract 1 % and Azospirillum 10 % while lower rate of seedling parameters was observed in control.

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Authors' contribution:

This article is fully based on M.Sc. research work of the first author (S. Budhbaware) under the supervision of P.K. Rai as major advisor. P.K. Rai and S. Budhbaware conceptualized and designed the experiment. Manuscript has been drafted by S. Budhbaware and P.K. Rai. All the authors have provided critical feedback in preparation of the manuscript.

Ethical Approval

This article does not contain any studies involving human or animal participants performed by any of the authors.

Conflicts of Interest:

The authors declare no conflict of interest.

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