

Seed Invigoration with Antioxidants Improves Growth and Yield Attributing Characters in Soybean

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ABSTRACT: A field experiment was conducted on four soybean (*Glycine max* L.) cultivars viz., JS-335, DS-228, KDS-726 and Type-49 to study the effect of seed invigoration with varied antioxidants (Ascorbic acid, α -tocopherol and Butylated Hydroxytoluene) on growth and yield attributing characters during *kharif* 2016 and *kharif* 2017 at Post Graduate Institute Research Farm, Department of Agricultural Botany, Mahatma Phule Krishi Vidyapeeth, Rahuri. Field observations such as field emergence percentage, days to 50 % flowering, plant height, number of primary branches per plant, number of pods per plant, days to maturity, seed yield per hectare and seed index were recorded. Among the seed invigoration treatments, seed invigorated with α -tocopherol (200 ppm) exhibited higher field emergence percentage, plant height, number of pods per plant, seed yield per plant, seed yield per hectare and seed index. The seeds of variety KDS-726 invigorated with α -tocopherol (200 ppm) followed by ascorbic acid (100 ppm) were found effective in increasing seed yield due to increase in field emergence, number of pods per plant, number of primary branches, seed index and seed yield per plant and seed yield per ha than varieties viz., DS-228, JS-335 and Type-49.

Keywords: Seed invigoration, Ascorbic acid, α -tocopherol, Butylated Hydroxytoluene

Soybean (*Glycine max* L.) is the world's most important oilseed crop and is having pivotal place in world's oilseed industry, due to its high productivity, profitability and vital contribution towards maintaining soil fertility. The crop also has a prominent place as the world's most important seed legume, which contributes 25% to the global vegetable oil production, about two third of the world's protein concentrate for livestock feeding and is a valuable ingredient in formulated feeds for poultry and fish [1]. As per the 4th advance estimate, during 2018-19, production of soybean in India was 11.21 million tons wherein productivity of soybean in India was 1217 kg/hectare [2]. Seed offers to integrate production, protection and quality enhancement technologies in a single entity, in a cost-effective way. Seed can play pivotal role in achieving higher productivity, as use of quality seeds alone could increase productivity by 15-20 % which highlights the important role of seed in agriculture [3]. Seed invigoration is a technique shown to cause an increased seed vigour as well as synchronize and accelerated germination, stress resistance and enhanced plant growth and productivity [4]. Seed invigoration may initiate physiological and biochemical changes, which reflect on the plant growth and development processes and

ultimately improve the yield and quality of produce. It is proven that exogenous antioxidants that stimulate the host antioxidant enzyme response in plants may also stimulate flux through the pentose phosphate pathway (PPP), potentially leading to increased endogenous phenolic synthesis [5]. Vitamin C and Folic acid, due to their inherent antioxidant potential, appear to be suitable growth regulators for increasing seed vigour and phenolic elicitation. Both vitamins are water soluble with antioxidant potential and have the ability to donate protons to the cytosol, similar to salicylic acid [6]. Natural antioxidants such as ascorbates, tocopherols and carotenoids are well known for their role in free radical scavenging activities. Thus, it is essential to know that, which seed invigoration treatment with antioxidants will be able to enhance plant growth and productivity.

Phytohormone Jasmonic acid and antioxidant ascobin found to be effective in promoting growth, yield and metabolism of soybean. Jasmonic acid and Ascobin treatments, improved salt tolerance in soybean by enhancing the accumulation of nontoxic metabolites (sugars, free proline and proteins) as well as N, P and K as a protective adaptation[7]. Foliar application of SA

showed positive effect on seed yield, seed health, germination and seed vigour in soybean during storage. Plant height was significantly improved by the GA₃ spray in NRC-7 and JS-335 varieties of soybean. While, foliar spray of α -tocopherol resulted in higher seed yield [8]. Hence, present experiment was carried out with three different antioxidants viz., Ascorbic acid, α -tocopherol, Butylated Hydroxytoluene and their effect on plant growth and yield attributing characters was studied.

MATERIALS AND METHOD

The seed material of four soybean varieties were obtained from Agricultural Research Station, Digraj, District-Sangali, MPKV, Rahuri. For seed invigoration, soybean seeds were sand conditioned with white sand which was pre-sterilized in autoclave for 8 hours to avoid any contamination to seeds. Pre-moist sand was mixed with seeds in 3:1 ratio and kept for 12 hours at room temperature. 100 ppm and 200 ppm solution of different antioxidants viz., Ascorbic acid and Butylated Hydroxytoluene and α -tocopherol were prepared. As Butylated Hydroxytoluene and α -tocopherol were insoluble in water, firstly dissolved in 10 ml of ethanol and then aqueous solutions were prepared. Further, conditioned seeds were soaked in above antioxidant solution for 1 hour. After that, invigorated seeds were shade dried for 72 hours to bring back to original moisture content. Invigorated seeds of different varieties were sown in the field. Experiments were laid out during *kharif*, 2016 and *Kharif*, 2017 in a Factorial Randomized Block Design (FRBD) with three replications. Invigorated seeds were hand sown by dibbling at 45 × 10 cm spacing in each plot size of 2.70 m × 3.0 m. All the cultivation practices were followed as per the standard

recommendations. Crop was harvested at physiological maturity based on visual observation *i.e.*, yellowing of pods and leaves. The harvested plants from each treatment and replication were sun dried separately and threshed manually by beating with wooden stick. The seeds were cleaned and sun dried before storage.

Morphological data such as field emergence (%) at 10 days of sowing, days to 50 % flowering, plant height at maturity, number of primary branches, number of pods per plants, days to maturity were calculated on 10 random plants. Further, seed yield per hectare and seed index [9] were calculated and data obtained from all the parameters was analyzed using statistical software SAS 9.3 following Factorial Randomized Block Design (FRBD) for field and Factorial Completely Randomized Design (FCRD) in the laboratory [10].

RESULT AND DISCUSSION

Seeds invigorated with different antioxidants treatments resulted in significant interaction with respect to growth and yield attributing characters in four soybean varieties (Table 1). Field emergence percentage was significantly differed due to seed invigorated treatments on pooled basis. Regarding the effect of seed invigorated treatments on field emergence percentage, seed invigorated with α -tocopherol (200 ppm) (T₅) was found most effective in increasing the field emergence percentage over the non-treated seeds. Among the seed invigorated treatments, seed invigorated with α -tocopherol (200 ppm) recorded higher field emergence percentage by 18.44% as compared to control. Wherein, among the four varieties, KDS-726 recorded higher field emergence percentage by 2.36% than that of variety Type-49. Among the

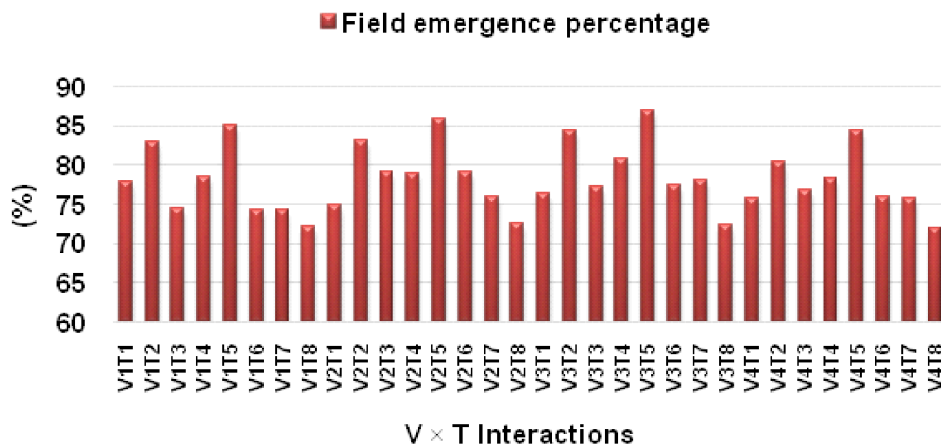


Figure 1. Effect of varieties (V), seed invigoration treatments (T) and their interactions on field emergence percentage of soybean

Table 1. Effect of seed invigoration with different antioxidants on growth and yield parameters in soybean cultivars (Pooled data of *kharif* 2016 and *kharif* 2017)

Variety	Field emergence (%)	Days to 50% flowering (No.)	Plant height (cm)	Number of primary branches	Number of pods/plants	Days to maturity (number)	Seed yield/plant (g)	Seed yield/ha (q)	Seed index (g)
JS 335	77.47 (61.78)*	40.92	36.96	4.32	93.06	90.71	25.16	20.12	12.64
DS 228	78.73 (62.66)	39.69	37.46	4.36	99.75	89.25	25.72	22.28	13.28
KDS 726	79.26 (63.06)	43.35	46.98	4.48	105.88	93.10	26.76	23.40	13.89
Type 49	77.43 (61.73)	48.94	60.28	4.26	135.21	106.75	24.40	20.01	10.58
SEm±	0.209	0.195	0.255	0.037	1.407	0.301	1.376	0.049	0.045
CD @ 5%	0.585	0.547	0.714	0.103	3.939	0.842	3.851	0.136	0.126
Treatment									
T ₁ - Hydropriming	76.26 (60.86)	44.17	42.78	4.27	104.38	96.42	23.31	20.44	12.14
T ₂ - Ascorbic Acid (100 ppm)	82.76 (65.49)	42.29	49.09	4.42	116.45	93.75	27.79	22.35	13.06
T ₃ - Ascorbic Acid (200 ppm)	76.92 (61.32)	42.79	44.87	4.31	107.66	94.83	25.77	21.73	12.72
T ₄ - α -Tocopherol (100 ppm)	79.19 (62.88)	42.67	46.96	4.35	112.22	94.29	27.14	22.01	12.82
T ₅ - α -Tocopherol (200 ppm)	85.61 (67.74)	41.63	51.05	4.71	128.57	93.42	28.59	23.23	13.40
T ₆ - Butylated Hydroxytoluene (100 ppm)	76.71 (61.20)	43.33	43.82	4.31	103.59	94.96	24.63	21.35	12.51
T ₇ - Butylated Hydroxytoluene (200 ppm)	76.04 (60.72)	42.83	44.64	4.27	103.39	94.46	24.88	20.64	12.32
T ₈ - Control	72.28 (58.24)	46.08	40.16	4.19	91.55	97.5	21.94	19.88	11.84
SEm±	0.296	0.276	0.36	0.052	1.99	0.425	1.946	0.069	0.064
CD @ 5%	0.827	0.774	1.01	0.146	5.571	1.191	5.446	0.192	0.179
Variety X Treatment Interaction									
SEm±	0.59	0.55	0.72	0.1	3.98	0.85	3.89	0.14	0.13
CD @ 5%	1.65	1.55	2.02	NS	11.14	2.38	10.89	0.38	0.36

(*figure in parenthesis arc sin values)

interactions, the interaction V₃T₅ recorded maximum field emergence percentage by (9.87%) as compared to interaction V₄T₈ (Figure 1). The improved field emergence in invigorated seeds might be due to induction of physiological processes like hydrolysis, imbibition, enzymes activation and protrusion which triggered speed of germination and percentage [11].

Soybean varieties were differed significantly in terms of days to 50% flowering, DS-228 required minimum (39.69 days) to 50% flowering whereas, the maximum days required to 50% flowering was 48.94 days, in Type-49. Seed invigoration treatments with α-tocopherol (200 ppm) resulted in reducing days to 50% flowering by 4 days as compared to control (Table 1). This might be due to the

fast emergence of the seeds and rapid growth of seedlings at the initial stages of growth. [12].

The variety, Type 49 showed higher plant height at maturity 60.28 cm followed by KDS-726, while the lower plant height was recorded in JS-335 (36.96 cm). Among the seed invigoration treatments, seed invigorated with α-tocopherol (200 ppm) recorded higher plant height by 27.11% as compared to control. The interaction (V₄T₅) recorded significantly higher plant height, which may be due to genetic constitution of variety and rapid and uniform emergence of seedling due to seed invigoration treatment. Plant height at maturity is an important morphological attribute, which may be influenced by genetic constitution, soil nutrition, seed vigor and

environmental conditions [13]. Foliar application of folic acid, ascorbic acid and cobalamin significantly increased the growth parameters as well as photosynthetic pigments compared with the control plants in flax [14].

Although Days to maturity indicated significant differences among the soybean varieties, minimum days to maturity required for variety DS-228 were recorded as 89.25 days followed by JS-335 as 90.71 days. Whereas, the maximum days to maturity of 106.75 days recorded for variety Type-49 on pooled basis. Among the varieties, DS 228 was found to be 17 days earlier than Type 49. Among the seed invigoration treatments, seed invigorated with α -tocopherol (200 ppm) were effective in reducing the days to maturity by 3 days as compared to control (T_8). Effects of varieties and seed invigoration treatments on number of primary branches per plant of soybean were non-significant at pooled basis.

Number of pods per plant was significantly differed by various antioxidant treatments. Type 49 (V_4) had significantly higher number of pods per plant (135.21) followed by variety KDS-726 as 105.88. While, less number of pods recorded in variety JS 335 (93.06) on pooled basis. Among the varieties, seed invigorated with α -tocopherol (200 ppm) (T_5) recorded significantly higher number of pods per plant (128.57) followed by ascorbic acid (100 ppm) as 116.45 and α -tocopherol (100 ppm) 112.22 respectively. Among the varied seed invigoration treatments, seed invigorated with α -tocopherol (200 ppm) recorded higher number of pods per plant by 40.43 % as compared to control. Interaction of V_4T_5 recorded significantly highest number of pods per plant as 166.05 followed by interaction V_4T_2 (144.30) on pooled basis. This might be due to tocopherols play crucial role in phloem loading and protection of photosystem II from photo inhibition under abiotic stresses [15].

The data presented in (Table 1) revealed that there was significant effect of varieties, treatments and their interaction on seed yield per plant (g). Among the varieties, KDS 726 had significantly higher seed yield per plant (26.76g). Whereas, lower seed yield per plant has observed in variety Type 49 (24.40g) on pooled basis. KDS 726 showed higher seed yield per plant by 9.68 % than that of variety Type 49. The seed invigorated with α -tocopherol (200 ppm) (T_5) recorded significantly higher seed yield per plant (28.59g) followed by ascorbic acid (100 ppm) (T_2) (27.79g) as compared to whereas, the lower seed yield per plant was recorded in non-treated seeds (T_8) (21.94g) on pooled basis, respectively. Further, interaction of V_3T_5 recorded significantly highest seed yield per plant of 29.96g followed by interaction V_2T_5 , recorded 29.09g and V_3T_2 recorded 28.95g respectively. Growth and yield in soybean were enhanced by accumulation of nontoxic metabolites (sugars, free proline and proteins) and enhancing protective adaptation [7].

In terms of seed yield per hectare (Table1), KDS-726 had significantly higher seed yield per hectare as 23.40 q followed by DS-228 (22.28 q) while the Type 49 showed lowest seed yield per hectare (20.01q) on pooled basis. The seed invigorated with α -tocopherol (200 ppm) (T_5) recorded significantly higher seed yield per hectare (23.23q) followed by ascorbic acid (100 ppm) (T_2) (22.35q) and α -tocopherol (100 ppm) (T_4) (22.01q). Among the seed invigoration treatments, seed invigorated with α -Tocopherol (200 ppm) (T_5) increased seed yield per hectare by 16.85 % over control (T_8). The highest seed yield per hectare was recorded in V_3T_5 followed by interaction V_3T_2 whereas the interaction V_4T_8 recorded lowest seed yield per hectare (Figure 2). The superiority of plants from invigorated seeds in seed yield per ha may be due to the higher seedling vigour, more leaflets and

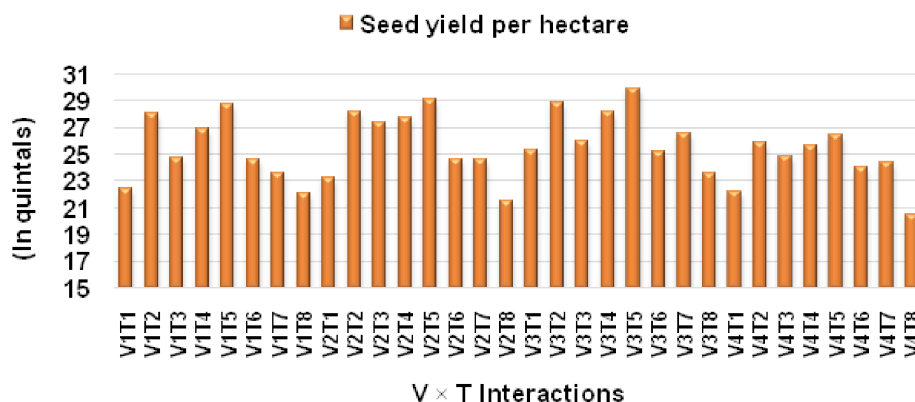


Figure 2. Effect of varieties (V), seed invigoration treatments (T) and their interactions (V x T) on seed yield per hectare of soybean

leaf area with boosting the source sink relationship and production of more seeds per plant as compared to those from un-primed seeds [16].

Seed index (100 seed weight) is varietal character and bold seeded varieties tend to have higher seed index as compared to small seeded varieties. The variety KDS-726 had significantly higher seed index (13.89 g) followed by DS-228 (13.28g) whereas, lower seed index was recorded in Type 49 (10.58g) owing to small seed size (Table1) Seeds invigorated with α -tocopherol (200 ppm) (T_5) recorded significant higher seed index (13.40g) followed by ascorbic acid (100 ppm) (T_2) (13.06g) and α - tocopherol (100 ppm) (T_4) (12.82g) on pooled basis. Interaction V_3T_5 recorded significantly higher seed index (14.91g) followed by interaction V_3T_2 recorded as 14.51g and interaction V_3T_4 as 14.35 on pooled basis.

CONCLUSION

Among the four soybean varieties, the variety KDS-726 recorded highest yield (23.40 q) followed by DS-228 (22.28 q). Seed invigorated with α - tocopherol (200 ppm) (T_5) showed better performance for field emergence percentage, plant height, number of pods per plant, seed yield per plant and seed index in all four varieties. The seeds of variety KDS-726 invigorated with α - tocopherol (200 ppm) followed by ascorbic acid (100 ppm) were found effective in increasing seed yield due to increase in field emergence, number of pods per plant, number of primary branches, seed index and seed yield per plant than other varieties viz., DS-228, JS-335 and Type-49. Seed invigoration with α - tocopherol (200 ppm) shortened life cycle (3 days) in all varieties of soybean as compared to control.

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