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Effect of foliar application of antioxidant on growth and yield of soybean

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Abstract

The present study was carried out under the field conditions at Post Graduate Institute Research Farm, Department of Agricultural Botany, Mahatma Phule Krishi Vidyapeeth, Rahuri, Dist Ahmednagar (M.S.) during *kharif* season 2017 and 2018. Two varieties of soybean *viz.,* V1 - KDS-726, and V2 - KDS-344 were foliar spray with antioxidants *viz.,* T0- Control, T1- Ascorbic acid (100 ppm), T2- Salicylic acid (100 ppm), T3- Humic acid (2000 ppm), T4- Perrydoxin (100 ppm), T5- Salicylic acid (100 ppm) + Ascorbic acid (100 ppm). The field experiment was conducted in Split Factorial Design with three replications. In the field experiment, growth and yield observations such as plant height, number of primary branches per plant, leaf area, seed yield per plot (kg) and seed yield per ha. (QT). Among the foliar application of antioxidants treatments, application of (T1) ascorbic acid (100 ppm) exhibited higher plant height, number of primary branches per plant, leaf area, seed yield per plot (kg) and seed yield per ha. (QT). The interaction of variety KDS-344 (V2) and foliar application with (T1) ascorbic acid (100 ppm) (V2T1) resulted in significant increase in plant height, number of primary branches per plant, leaf area, seed yield per plot (kg) and seed yield per ha. (QT). From present study, it is concluded that the soybean variety KDS-726 (V1) and KDS-344 (V2) with foliar application of ascorbic acid (100 ppm) exhibited improved growth and yield of soybean.

Keywords: *Glycine max*, antioxidant synthesis, foliar application of ascorbic acid, geographically

Introduction

Soybean (*Glycine max* (L) Merr.) belongs to leguminous family ranked as a top oilseed crop, which provides approximately 50% edible oil of the world (Akparobi, 2009) [1]. It has been recognized as an ancient crop plant since the origin of agriculture (Jandong *et al.*, 2011) [7]. Due to the large amount of macro and micro nutrients, it has been considered as a nutritious food for human needs, livestock, industrial and medicinal purposes (Akparobi, 2009) [1]. Soybean seed consists of 18 to 25% oil and 30 to 50% protein. Protein of soybean seed contains amino acids required for human nutrition and livestock (Raei *et al.*, 2008) [11]. Salwa *et al.*, (2011) [14] stated that soybean is a crop that compensates shortage of oil and protein of other crops. Ascorbic acid is a natural product of plants functions play a key role as an antioxidant and an enzyme and apparently plays a role in ameliorating cofactor. Salicylic acid (SA) is classified as a phenolic compound, a group of substances that can regulate plant growth. SA application influences a wide variety of plant processes, including stomatal closure, plant growth, yield and induction of antioxidant synthesis.

Material and methods

The present investigation, was carried out at Post Graduate Institute Farm, Department of Agricultural Botany, Mahatma Phule Krishi Vidyapeeth Rahuri, Dist. Ahmednagar (MS) India during the year 2017 and 2018.

Climatic condition: Agro-climatically, the central campus of MPKV, Rahuri falls in “Scarcity zone” of Maharashtra state, comes under semi-arid region and geographically located at 190 47’ North latitude, 740 32’ to 740 19’ longitudes and at an altitude of 657 m above mean sea level. The annual rainfall ranges between 307 to 619 mm, the average being 520 mm. The rainfall is unevenly distributed in 15 to 45 rainy days in year and out of the total annual rainfall about 80 per cent is received from South-West monsoon during June to September, while the rest is received from North-East monsoon during October.

Experiments details

a) Variety : V1: Phule Sangam (KDS-726)
: V2: Phule Agrani (KDS-344)
b) Treatments: 1. (T_0) Control
2. (T_1) Ascorbic acid (100 ppm)
3. (T_2) Salicylic acid (100 ppm)
4. (T_3) Humic acid (2000 ppm)
5. (T_4) Perrydoxin (100 ppm)
6. (T_5) Salicylic acid (100 ppm) + Ascorbic acid (100 ppm)
c) Design : Field: Split Factorial,
d) Replication : 3
e) Season : *Kharif* - 2017 and *Kharif* – 2018
f) Spacing : 30 x 10 cm
g) Plot size : Gross: 3.50 x 1.80 m^2
Net: 3.30 x 1.50 m^2

Seed: For the present study, seeds of soybean varieties V1-KDS-726 and V2-KDS-344 were used. The seeds of two varieties were collected from Agricultural Research Station, Digraj, Dist. Sangali, MPKV, Rahuri.

Foliar application: Application of foliar spray of antioxidants was given at flower initiation stage and 2nd spray at 10 days after 1st spray.

Growth parameters

1. **Plant height (cm):** The height of five randomly selected plants was measured from the ground level to the growing tip of plant at the time of harvesting. The average height of the plant in centimeter was worked out.
2. **Number of primary branches per plant:** The total number of primary branches present on main stem of five randomly selected plants was counted at physiological maturity. The average number of branches of five plants was worked out.
3. **Leaf area (dSm-1):** The leaf area of five randomly selected plants were measured by INDUS software at 50% flowering.
4. **Seed yield per plot (kg):** The seed obtained from each net plot was weighed and recorded in kilograms.
5. **Seed yield/ha (QT):** Seed yield per hectare was calculated by multiplying the seed yield per plot by hectare factor.

Results and Discussion

The experiment was under taken in *kharif* season 2017 and 2018 at Post Graduate Research Farm, Department of Agriculture Botany, Mahatma Phule Krishi Vidyapeeth, Rahuri. The observations of growth parameters, were recorded and the results are presented.

1. Plant height (cm)

Effect of varieties: From the data, it was found that plant height indicated significant differences due to the soybean varieties KDS-726 (V1) and KDS-344 (V2) during both years and on pooled basis (Table 1). The variety KDS-344 (V2) had significantly higher plant height (cm) as 69.25, 68.99 and 69.12 (cm) than that of KDS-726 (V1) 64.23, 63.95 and 64.09 (cm), during the year 2017, 2018 and on pooled basis, respectively, irrespective of foliar spray treatments.

Effect of foliar spray treatments: From the data, it was observed that the foliar spray with ascorbic acid (100 ppm) (T1) recorded maximum 72.60, 72.36 and 72.48 (cm) plant height followed by perrydoxin (100 ppm) (T4) 70.96, 70.75 and 70.86 (cm) plant height during the year 2017, 2018 and on pooled basis, respectively. While minimum plant height was recorded in control 58.25, 57.70 and 57.97 (cm) during the year 2017, 2018 and on pooled basis, irrespective of varieties.

Interaction effect of varieties and foliar spray treatments: In the interaction effect of varieties and foliar spray treatments maximum plant height was recorded in interaction of V2T1 as 73.72,73.45 and 73.59 (cm) followed by interaction V2T4 as 71.98, 71.77 and 71.88 (cm) during the year 2017, 2018 and on pooled basis, respectively. The minimum plant height was recorded in interaction V1T0 as 54.24, 53.59 and 53.92 during the year 2017, 2018 and on pooled basis, respectively. Foliar spray of ascorbic acid in most cases resulted in a significant increase in soybean plant growth parameters i.e. plant height, number of branches, number of leaves and leaf area per plant under normal or stressed conditions. These results are similar to those reported by Ghoname *et al.*, (2010) [6] for sweet pepper and Azooz and Alfredan for *Vicia faba* plants. Due to stimulating effect of ascorbic acid on plant growth may be attributed to an increase in the availability and uptake of water and essential nutrients through adjusting cell osmotic pressure and reducing the accumulation of harmful free radicals (ROS) by increasing antioxidants and enzyme activities (Farouk *et al.*, 2011) [5] in radish (*Raphanus sativus* L. var. sativus).

Table 1: Effect of varieties (V), foliar spray treatments (T) and their interactions (V x T) on plant height

	Plant height (cm)		
Varieties(V)	**2017**	**2018**	**Pooled**
V1-KDS-726 (Phule Sangam)	64.23	63.95	64.09
V2-KDS-344 (Phule Agrani)	69.25	68.99	69.12
SE (m) ±	0.480	0.312	0.495
CD at 5%	1.354	0.881	1.386
Treatments (T)			
T0-Control	58.25	57.70	57.97
T1-Ascorbic acid (100 ppm)	72.60	72.36	72.48
T2-Salicylic acid (100 ppm)	62.95	62.74	62.84
T3-Humic acid (2000 ppm)	67.03	66.82	66.92
T4-Perrydoxin (100 ppm)	70.96	70.75	70.86
T5-Salicylic acid (100 ppm) + Ascorbic acid (100 ppm)	68.67	68.46	68.56
SE (m) ±	0.831	0.540	0.858
CD at 5%	2.345	1.526	2.401
Variety × Treatment interaction (V×T)			
V1T0	54.24	53.59	53.92
V1T1	71.47	71.26	71.37
V1T2	59.14	58.92	59.03
V1T3	64.22	64.01	64.11
V1T4	69.94	69.73	69.84
V1T5	66.39	66.18	66.28
V2T0	62.25	61.80	62.03
V2T1	73.72	73.45	73.59
V2T2	66.76	66.55	66.66
V2T3	69.84	69.63	69.73
V2T4	71.98	71.77	71.88
V2T5	70.95	70.74	70.84
SE (m) ±	1.175	0.764	1.214
CD at 5%	3.317	2.158	3.395

2. Number of primary branches per plant

Effect of varieties: From the data, it was found that number of primary branches per plant indicated significant differences due to the soybean varieties KDS-726 (V_1) and KDS-344 (V_2)

during both years and on pooled basis (Table 2). The variety KDS-344 (V_2) had significantly higher number of primary branches per plant as 5.77, 5.35 and 5.56 than that of KDS-726 (V_1) 5.48, 5.05 and 5.26 during the year 2017, 2018 and on pooled basis, respectively, irrespective of foliar spray treatments.

Effect of foliar spray treatments: From the data, it was observed that the foliar spray with ascorbic acid (100 ppm) (T_1) recorded 6.73, 6.48 and 6.60 number of primary branches per plant followed perrydoxin (100 ppm) (T_4) 6.07, 5.73 and 5.90 number of primary branches per plant during the year 2017, 2018 and on pooled basis, respectively. While minimum number of primary branches per plant was recorded in control 4.18, 3.62 and 3.90 during the year 2017, 2018 and on pooled basis, respectively, irrespective of varieties.

Interaction effect of varieties and foliar spray treatments: In the interaction effect of varieties and foliar spray treatments, maximum number of primary branches per plant was recorded in interaction of V_2T_1 as 6.93, 6.68 and 6.80 followed by interaction V_1T_1 as 6.53, 6.27 and 6.40 during the year 2017, 2018 and on pooled basis, respectively. The minimum number of primary branches per plant was recorded in interaction V_1T_0 as 4.15, 3.58 and 3.87 during the year 2017, 2018 and on pooled basis, respectively. This might be due to the positive effect of ascorbic acid on plant growth parameters (plant height, number of branches, number of leaves and leaf area per plant). Also may be due to its effect on increasing nutrient uptake and increase elements content such as nitrogen, phosphorous, and potassium are essential nutrients playing an important role in the biosynthesis and translocation of carbohydrates and necessary for stimulating cell division, cell turger and forming DNA and RNA (Saeidi-Sar *et al.*, 2013) [13] in common bean (*Phaseolus vulgaris* L.). These results are in agreement with those obtained by others (Azooz, 2009) [3] in *Vicia Faba*, (Ekmekci and Karaman, 2012) [4] in *Silybum marianum* (L.). They indicated that, vitamins (such as ascorbic acid) could accelerate cell division and cell enlargement and induce improvement of membrane integrity, which may have contributed in reducing ion leakage, and consequently improving growth.

Table 2: Effect of varieties (V), foliar spray treatments (T) and their interactions (V x T) on plant height (cm) and number of primary branches

	Number of primary branches		
Varieties(V)	**2017**	**2018**	**Pooled**
V1-KDS-726 (Phule Sangam)	5.48	5.05	5.26
V2-KDS-344 (Phule Agrani)	5.77	5.35	5.56
SE (m) ±	0.016	0.023	0.024
CD at 5%	0.044	0.064	0.067
Treatments (T)			
T0-Control	4.18	3.62	3.90
T1-Ascorbic acid (100 ppm)	6.73	6.48	6.60
T2-Salicylic acid (100 ppm)	5.21	4.73	4.97
T3-Humic acid (2000 ppm)	5.67	5.19	5.43
T4-Perrydoxin (100 ppm)	6.07	5.73	5.90
T5-Salicylic acid (100 ppm) + Ascorbic acid (100 ppm)	5.87	5.46	5.67
SE (m) ±	0.027	0.040	0.041
CD at 5%	0.076	0.112	0.116
Variety × Treatment interaction (V×T)			
V1T0	4.15	3.58	3.87
V1T1	6.53	6.27	6.40
V1T2	5.03	4.54	4.78
V1T3	5.51	5.00	5.25
V1T4	5.95	5.61	5.78
V1T5	5.71	5.29	5.50
V2T0	4.21	3.65	3.93
V2T1	6.93	6.68	6.80
V2T2	5.40	4.91	5.16
V2T3	5.84	5.38	5.61
V2T4	6.19	5.85	6.02
V2T5	6.04	5.63	5.83
SE (m) ±	0.038	0.056	0.059
CD at 5%	0.108	0.158	0.164

3. Leaf area (dSm^{-1}) at 50% flowering

Effect of varieties: From the data, it was found that leaf area indicated significant differences due to the soybean varieties KDS-726 (V_1) and KDS-344 (V_2) during both years and on pooled basis (Table 3). The variety KDS-344 (V_2) had significantly higher leaf area (dsm^{-1}) as 25.77, 25.35 and 25.56 (dSm^{-1}) than that of KDS-726 (V_1) 25.48, 25.05 and 25.26 (dSm^{-1}) during the year 2017, 2018 and on pooled basis, respectively, irrespective of foliar spray treatments.

Effect of foliar spray treatments: From the data, it was observed that the foliar spray with ascorbic acid (100 ppm) (T_1) recorded 26.73, 26.48 and 26.60 (dSm^{-1}) maximum leaf area followed perrydoxin (100 ppm) (T_4) 26.07, 25.73 and 25.90 (dSm^{-1}) during the year 2017, 2018 and on pooled basis, respectively. While minimum leaf area was recorded in control 24.18, 23.62 and 23.90 (dSm^{-1}) during the year 2017, 2018 and on pooled basis, respectively, irrespective of varieties.

Interaction effect of varieties and foliar spray treatments: In the interaction of varieties and foliar spray treatments maximum leaf area was recorded by interaction of V_2T_1 as 26.93, 26.68 and 26.81 (dSm^{-1}) followed by interaction V_1T_1

26.53, 26.27 and 26.40 (dSm^{-1}) during the year 2017, 2018 and on pooled basis, respectively. The minimum leaf area was recorded in interaction V_1T_0 as 24.15, 23.59 and 23.87(dSm^{-1}) during the year 2017, 2018 and on pooled basis, respectively. This might be due to increase in leaf water potential. (Amira and Abdul 2014) [2] reported in soybean increasing relative water content (RWC) of leaves and reduction in transpiration rate indicated that these vitamins probably reflect the efficiency of water uptake and utilization or reduction of water loss, which consequently causes increase in leaf water potential. Hence, it could be concluded that the beneficial effect of ascorbic acid on growth parameters of soybean plants has been related to the efficiency of their water uptake and utilization. Many studies have reported that vitamins, when used with optimal concentration, exhibited beneficial effect on growth and yield of some crop plants grown under saline conditions (Khan *et al.,* 2011) [8], (Ekmekci and Karaman, 2012) [4] in *Silybum marianum* (L.).

Table 3: Effect varieties (V), foliar spray treatments (T) and their interactions (V x T) on leaf area (dSm^{-1})

	Leaf area (dSm^{-1}) at 50% flowering		
Varieties(V)	**2017**	**2018**	**Pooled**
V1-KDS-726 (Phule Sangam)	25.48	25.05	25.26
V2-KDS-344 (Phule Agrani)	25.77	25.35	25.56
SE (m) ±	0.016	0.023	0.024
CD at 5%	0.046	0.064	0.068
Treatments (T)			
T0-Control	24.18	23.62	23.90
T1-Ascorbic acid (100 ppm)	26.73	26.48	26.60
T2-Salicylic acid (100 ppm)	25.22	24.73	24.98
T3-Humic acid (2000 ppm)	25.67	25.19	25.43
T4-Perrydoxin (100 ppm)	26.07	25.73	25.90
T5-Salicylic acid (100 ppm) + Ascorbic acid (100 ppm)	25.87	25.46	25.67
SE (m) ±	0.028	0.039	0.042
CD at 5%	0.080	0.111	0.118
Variety × Treatment interaction (V×T)			
V1T0	24.15	23.59	23.87
V1T1	26.53	26.27	26.40
V1T2	25.02	24.54	24.78
V1T3	25.51	25.00	25.25
V1T4	25.95	25.61	25.78
V1T5	25.71	25.29	25.50
V2T0	24.21	23.65	23.93
V2T1	26.93	26.68	26.81
V2T2	25.42	24.91	25.17
V2T3	25.84	25.37	25.61
V2T4	26.19	25.85	26.02
V2T5	26.04	25.63	25.83
SE (m) ±	0.040	0.056	0.059
CD at 5%	0.114	0.157	0.166

4. Seed yield per plot (kg)

The data of seed yield per plot (kg) as influenced by harvesting stages, varieties, foliar spray treatments and their interactions are presented in Table 4.

Effect of harvesting stages

From the Table 4, it was seen that the seed yield per plot (kg) showed significant variation due to harvesting stages. The higher seed yield per plot (kg) 1.201, 1.119 and 1.160 (kg) was recorded at physiological maturity (H_1) while the lower seed yield per plot (kg) 0.946, 0.866 and 0.906 (kg) was recorded at 10 days after physiological maturity (H_3) during the year 2017, 2018 and on pooled basis, respectively, irrespective of varieties and foliar spray treatments.

Effect of varieties

From the data, it was found that seed yield per plot (kg) indicated significant differences due to the soybean varieties KDS-726 (V_1) and KDS-344 (V_2) during both years and on pooled basis (Table 4).

The variety KDS-344 (V_2) had significantly higher seed yield per plot (kg) as 1.090, 1.019 and 1.054 (kg) than that of KDS-726 (V_1) 1.007, 0.916 and 0.961 (kg) during the year 2017, 2018 and on pooled basis, respectively, irrespective of harvesting stages and foliar spray treatments.

Effect of foliar spray treatments

The data regarding seed yield per plot (kg) showed significant differences due to foliar spray treatment during both years and on pooled basis irrespective of harvesting stages and varieties. From the data, it was observed that the foliar spray with ascorbic acid (100 ppm) (T_1) recorded 1.073, 0.992 and 1.033 (kg) seed yield per plot (kg) followed by perrydoxin (100 ppm) (T_4) 1.064, 0.983 and 1.024 (kg) seed yield per plot (kg) during the year 2017, 2018 and on pooled basis, respectively. While minimum seed yield per plot (kg) was recorded in control 1.021, 0.939 and 0.979 (kg) during the year 2017, 2018 and on pooled basis, respectively, irrespective of harvesting stages and varieties.

Effect of interactions

Effect of two factor interaction

Interaction effect of varieties and foliar spray treatments

From the data, it was observed that the interaction effects of varieties and foliar spray treatments on seed yield per plot (kg) of soybean was significant during both years and on pooled basis are presented in Table 4.5.

In the interactions of varieties and foliar spray treatments maximum seed yield per plot (gm.) was recorded in interaction of V_2T_1 as 1.113, 1.043 and 1.078 (kg) followed by interaction V_2T_4 as 1.106, 1.036 and 1.071 (kg) during the year 2017, 2018 and on pooled basis, respectively. Whereas minimum seed yield per plot (kg) was recorded in interaction V_1T_0 as 0.980, 0.888 and 0.934 (kg) during the year 2017, 2018 and on pooled basis, respectively.

5 Seed yield per ha. (QT)

The data of seed yield per ha as influenced by harvesting stages, varieties, foliar spray treatments and their interactions are presented in Table 4.

Effect of harvesting stages

From the Table 4.5, it was seen that the seed yield per ha showed significant difference due to harvesting stages. The higher seed yield per ha. 24.25, 22.60 and 23.42 (qt) was recorded at physiological maturity (H_1) and the lower seed yield per ha. 19.11, 17.49 and 18.30 (qt) was recorded at 10 days after physiological maturity (H_3) during the year 2017, 2018 and on pooled basis, respectively, irrespective of varieties and foliar spray treatments.

Effect of varieties

From the data, it was found that seed yield per hac (qt) indicated significant differences due to the soybean varieties KDS-726 (V_1) and KDS-344 (V_2) during both years and on pooled basis (Table 4).

The variety KDS-344 (V_2) had significantly higher seed yield per hac. (qt) as 22.02, 20.59 and 21.31(qt) than that of KDS-726 (V_1) 20.34, 18.49 and 19.42 (qt) during the year 2017, 2018 and on pooled basis, respectively, irrespective of harvesting stages and foliar spray treatments.

Effect of foliar spray treatments

The data regarding seed yield per hac. (qt) showed significant differences due to foliar spray treatment during both years and on pooled basis irrespective of harvesting stages and varieties. From the data, it was observed that the foliar spray with ascorbic acid (100 ppm) (T_1) recorded 21.68, 20.04 and 20.86 (qt) seed yield per ha. (qt) followed by perrydoxin (100 ppm) (T_4) 21.50, 19.86 and 20.68 (qt) seed yield per hac. (qt) during the year 2017, 2018 and on pooled basis, respectively. While minimum seed yield per hac. (qt) was recorded in control 20.61, 18.97 and 19.79 (qt) during the year 2017, 2018 and on pooled basis, respectively, irrespective of harvesting stages and varieties.

4.1.8.4 Effect of interactions

Effect of two factor interaction

Interaction effect of varieties and foliar spray treatments

From the data, it was resulted that the interaction effects of varieties and foliar spray treatments on seed yield per ha. of soybean was significant during both years and on pooled basis are presented in Table 4.

In the interaction effect of varieties and foliar spray treatments maximum seed yield per ha. (qt) was recorded in interaction of V_2T_1 as 22.48, 21.06 and 21.77 (qt) followed by interaction V_2T_4 as 22.35, 20.91 and 21.63 (kg) during the year 2017, 2018 and on pooled basis, respectively. While minimum seed yield per ha. was recorded in interaction V_1T_0 as 19.79, 17.93 and 18.86 (kg) during the year 2017, 2018 and on pooled basis, respectively.This might be due to that ascorbic acid caused a stimulate influencing on many physiological processes, such as stimulate respiration activities, cell division and many enzymes activities, as reported by Zewail (2007) [15] in wheat and its important role of regulation of photosynthetic carbon reduction (Helsper *et al.*, 1982) [17] in *Ochromonas danica*. Moreover, Srivastava (1995) stated that foliar application increased photosynthetic rate, nutrient uptake from the soil to leaves and translocation of these nutrients from the leaves to seeds, thereby enhancing seed yield. Same result found by Osman *et al.*, (2014) [18] in sunflower, Gul *et al.*, (2015) [19] in Guar, El-Bassiouny (2017) [20] in sunflower and Ahmed *et al.*, (2016) [21] in chickpea.

Table 4: Effect of harvesting stages (H), varieties (V), foliar spray treatments (T) and their interactions on seed yield per plot (kg) and seed yield per ha (qt)

	Seed yield per plot (kg)			Seed yield per ha. (qt)		
Harvesting stages (H)	**2017**	**2018**	**Pooled**	**2017**	**2018**	**Pooled**
H1-At physiological maturity	1.201	1.119	1.160	24.25	22.60	23.42
H2- 5 days after physiological maturity	1.000	0.918	0.959	20.19	18.54	19.36
H3- 10 days after physiological maturity	0.946	0.866	0.906	19.11	17.49	18.30
SE (m) ±	0.030	0.030	0.037	0.61	0.62	0.75
CD at 5%	0.119	0.120	0.121	2.41	2.42	2.45
Varieties(V)						
V1-KDS-726 (Phule Sangam)	1.007	0.916	0.961	20.34	18.49	19.42
V2-KDS-344 (Phule Agrani)	1.090	1.020	1.055	22.02	20.59	21.31
SE (m) ±	0.0003	0.0003	0.0004	0.006	0.007	0.008
CD at 5%	0.0008	0.0009	0.0010	0.016	0.018	0.021
Treatments (T)						
T0-Control	1.021	0.939	0.980	20.61	18.97	19.79
T1-Ascorbic acid (100 ppm)	1.073	0.992	1.033	21.68	20.04	20.86
T2-Salicylic acid (100 ppm)	1.038	0.957	0.997	20.96	19.32	20.14
T3-Humic acid (2000 ppm)	1.044	0.963	1.004	21.09	19.45	20.27
T4-Perrydoxin (100 ppm)	1.064	0.983	1.024	21.50	19.86	20.68
T5-Salicylic acid (100 ppm) + Ascorbic acid (100 ppm)	1.053	0.972	1.012	21.26	19.62	20.44
SE (m) ±	0.0005	0.0006	0.0006	0.010	0.011	0.013
CD at 5%	0.0014	0.0016	0.0018	0.028	0.032	0.037
Harvesting stages × Variety interaction (H×V)						
H1V1	1.158	1.066	1.112	23.38	21.53	22.46
H1V2	1.243	1.172	1.208	25.11	23.67	24.39
H2V1	0.961	0.869	0.915	19.40	17.55	18.47
H2V2	1.039	0.967	1.003	20.98	19.54	20.26
H3V1	0.904	0.812	0.858	18.25	16.40	17.32
H3V2	0.989	0.919	0.954	19.98	18.57	19.27
SE (m) ±	0.000	0.001	0.001	0.010	0.011	0.013
CD at 5%	0.001	0.002	0.002	0.028	0.032	0.037
Variety × Treatment interaction (V×T)						
V1T0	0.980	0.888	0.934	19.79	17.93	18.86
V1T1	1.034	0.942	0.988	20.88	19.02	19.95
V1T2	0.995	0.903	0.949	20.09	18.24	19.16
V1T3	1.002	0.910	0.956	20.24	18.39	19.31
V1T4	1.023	0.931	0.977	20.65	18.80	19.73
V1T5	1.011	0.920	0.966	20.42	18.58	19.50
V2T0	1.061	0.991	1.026	21.43	20.00	20.72
V2T1	1.113	1.043	1.078	22.48	21.06	21.77
V2T2	1.081	1.010	1.046	21.83	20.40	21.12

V2T3	1.086	1.016	1.051	21.93	20.51	21.22
V2T4	1.106	1.036	1.071	22.35	20.91	21.63
V2T5	1.094	1.024	1.059	22.09	20.67	21.38
SE (m) ±	0.001	0.001	0.001	0.014	0.016	0.018
CD at 5%	0.002	0.002	0.003	0.040	0.045	0.052

Conclusion

The variety KDS-344 with foliar spray of ascorbic acid (100 ppm) followed by perrydoxin (100 ppm) was found superior for enhancement of plant height, number of primary branches and leaf area, than variety KDS-726. Foliar spray with ascorbic acid (100) ppm followed by perrydoxin (100 ppm) was found better for enhancing the plant height, number of primary branches, leaf area seed yield per plot (kg) and seed yield per ha. (qt).

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