



# Effect of Different Seed Treatment and Media on Shoot Growth of Ashwagandha, *Withania somnifera* (L.) Dunal

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## Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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## ABSTRACT

Indian Ginseng or Ashwagandha, is one of the most important Under the present study the seeds were soaked with treatment (S<sub>1</sub>) GA<sub>3</sub> (250 ppm - 24 h.) recorded maximum germination percentage (66.11 %) and maximum plant height at 15 (3.00), 30 (8.38), 45 (15.98), 60 (25.20), 75 (34.05), 90 (42.98), 105 (52.07) and 120 (59.02) days, respectively. Maximum no. of branches/plant at 15

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(0.0), 30 (0.22), 45 (0.71), 60 (1.73), 75 (1.76), 90 (2.80), 105 (3.0) and 120 (3.84) and no. of leaves/plant were also recorded higher in S<sub>1</sub> at 15 (3.42), 30 (7.67), 45 (20.42), 60 (33.11), 75 (41.62), 90 (55.98), 105 (67.24) and 120 (75.87) DAS respectively. In the Similar treatment, no. of leaves were also found superior over other treatments with maximum total leaf area (33.57 cm<sup>2</sup>), shoot fresh weight (55.06 g), shoot dry biomass (38.34 g), plant fresh weight (60.10 g) and plant dry weight (18.77 g) as compared to other treatments applied.

The treatment (M<sub>3</sub>) media combination of Red soil + Vermicompost + FYM (1:1:1) gave significantly highest results in context to seed germination percentage (71.94 %), total leaf area (32.08 cm<sup>2</sup>), shoot fresh weight (58.70 g), shoot dry biomass (40.91 g), plant fresh weight (64.05 g) and plant dry weight (19.82 g), respectively. In same treatment, highest plant height at 15 (3.29), 30 (9.78), 45 (18.14), 60 (26.85), 75 (35.54), 90 (44.13), 105 (55.03) and 120 (60.17), no. of branches/plant at 15 (0.0), 30 (0.27), 45 (0.68), 60 (1.89), 75 (1.97), 90 (2.87), 105 (2.90), 120 (3.83) and no. of leaves/plant at 15 (3.72), 30 (8.46), 45 (22.46), 60 (35.23), 75 (43.91), 90 (55.87), 105 (67.47) and 120 (75.92) respectively were recorded.

Interaction effect between pre-sowing treatment and different media was observed significant in seed germination percentage and maximum (80 %) in the treatment S<sub>1</sub>M<sub>3</sub>.

**Keywords:** Seed treatment; media; ashwagandha and GA<sub>3</sub>.

## 1. INTRODUCTION

Ashwagandha, *Withania somnifera* (L.) Dunal also known as Indian ginseng or prince of herb have chromosome complementation 2n=48. It is one of the most important herbal plant of medicinal importance and widely grown in various parts of the world and used in Ayurvedic system of medicine. Ayurvedic physicians and traditional healers have used it extremely in wide range of therapeutic indications. It derives its name "Ashwagandha" because its fresh root smells like horse urine and it vitalizes body to provide strength just like horse. The plant was first mentioned in English language text by Van Rheede in 1868 [1]. The use of Ashwagandha in ayurvedic medicines extends back over 3000 to 4000 years to the teaching of an esteemed Rishi (sage) Punarvasu Atriya. It has been described in the sacred texts of Ayurveda, including the charaka and Sushruta Samhitas where it is widely extolled as a tonic, especially for emaciation in people of all ages including babies, enhancing the reproductive function of both men and women [2].

## 2. MATERIALS AND METHODS

The experiment was laid out at Model Nursery on Medicinal and Aromatic Plants, NAU, Navsari. In the present experiment pre-sowing treatments viz., GA<sub>3</sub>, Kinetin, NaHClO<sub>3</sub> and KNO<sub>3</sub> along with control were applied in different concentrations to study their effects on growth of *W. somnifera*. Seeds of Ashwagandha plants were treated with GA<sub>3</sub> @ 250 ppm for 24 h, Kinetin (0.2%) for 24 h, KNO<sub>3</sub> (250 ppm) for 1 min., NaHClO<sub>3</sub> 4% for 5

min and 10 min. respectively before sowing.. Good fertile red earth was used for grow the plants and it was filled in to 7' x 9' (15 x 20 cms) sized perforated polythene bags. Polythene bags were kept under shade in a greenhouse for 4 months and irrigated by water-cane daily. Observations were taken for days required for germination percentage (10 DAS), plant height (cm) (at 15, 30, 45, 60, 75, 90, 105 and 120 DAP), branches /plant (at 15, 30, 45, 60, 75, 90, 105 and 120 DAP), leaves / branch (at 15, 30, 45, 60, 75, 90, 105 and 120 DAP), shoot fresh weight, shoot dry biomass, fresh weight of plant (g), dry weight of plant (g), leaf area (cm<sup>2</sup>) was estimated by Image J software (Abramoff et al., 2004).

## 3. RESULTS AND DISCUSSION

### 3.1 Shoot Characters

#### 3.1.1 Germination percentage (%)

The data presented in Table 1 showed that maximum germination percentage (66.11 %) were observed in the pre sowing seed treatment of (S<sub>1</sub>) [GA<sub>3</sub>- (250 ppm) - 24 hrs] followed by 64.44 per cent in (S<sub>5</sub>) [KNO<sub>3</sub>- (250 ppm)- 1 min.] and both were remained at par to each other. This result was similar with the findings of Niyaz and Siddiqui [3] and Krishna [4] in *W. somnifera*, KNO<sub>3</sub> who reported that gave good germination percentage after GA<sub>3</sub>.

The germination percentage (Table 1) was also influenced considerably by the application of different media. The highest germination

percentage (71.94 %) was observed in treatment (M<sub>3</sub>) [Red soil + Vermicompost + FYM- 1:1:1]. The present findings corroborate with the earlier findings of Manohar et al. [5] in *Withania somnifera* and Vishnoi et al. (2011) in *Terminalia arjuna*.

**Table 1. Effect of different seed treatments and media on germination % and plant height (cm) in ashwagandha (*Withania somnifera*)**

| Treatment  | Germination % | 15 DAS | 30 DAS | 45 DAS | 60 DAS | 75 DAS | 90 DAS | 105 DAS | 120 DAS |
|--|---------------|--------|--------|--------|--------|--------|--------|---------|---------|
| <b>Seed Treatment (S)</b>                              |               |        |        |        |        |        |        |         |         |
| S <sub>1</sub> : GA <sub>3</sub> (250 ppm - 24 h.)     | 66.11         | 3.00   | 8.38   | 15.98  | 25.20  | 34.05  | 42.98  | 52.07   | 59.02   |
| S <sub>2</sub> : Kinetin (0.2% - 24 h.)                | 62.22         | 2.68   | 7.55   | 13.93  | 23.40  | 31.96  | 41.39  | 50.03   | 56.80   |
| S <sub>3</sub> : NaHClO <sub>3</sub> (4% - 5 min.)     | 59.44         | 2.30   | 6.69   | 13.79  | 23.33  | 31.77  | 39.44  | 47.87   | 54.82   |
| S <sub>4</sub> : NaHClO <sub>3</sub> (4% - 10 min.)    | 60.56         | 2.55   | 6.97   | 13.82  | 23.50  | 31.56  | 40.67  | 48.87   | 55.71   |
| S <sub>5</sub> : KNO <sub>3</sub> (250 ppm- 1 min.)    | 64.44         | 2.82   | 8.19   | 15.80  | 24.89  | 33.51  | 42.24  | 51.22   | 58.06   |
| S <sub>6</sub> : Control                               | 61.11         | 2.62   | 7.34   | 14.81  | 24.01  | 33.11  | 41.09  | 49.96   | 56.76   |
| S. Em. ±   | 1.57          | 0.14   | 0.26   | 0.33   | 0.35   | 0.63   | 0.78   | 0.85    | 0.86    |
| C.D. at 5 %  | 3.19          | 0.29   | 0.52   | 0.66   | 0.71   | 1.27   | 1.57   | 1.73    | 1.75    |
| <b>MEDIA (M)</b>                                       |               |        |        |        |        |        |        |         |         |
| M <sub>1</sub> : Red Soil                              | 51.94         | 1.93   | 5.86   | 11.64  | 21.12  | 29.66  | 38.50  | 46.93   | 53.55   |
| M <sub>2</sub> : Red Soil + Vermicompost (1:1)         | 63.06         | 2.76   | 6.92   | 14.29  | 24.19  | 32.94  | 41.27  | 50.03   | 56.87   |
| M <sub>3</sub> : Red Soil + Vermicompost + FYM (1:1:1) | 71.94         | 3.29   | 9.78   | 18.14  | 26.85  | 35.54  | 44.13  | 53.05   | 60.17   |
| S. Em. ±   | 1.11          | 0.10   | 0.18   | 0.23   | 0.25   | 0.44   | 0.55   | 0.60    | 0.61    |
| C.D. at 5 %  | 3.19          | 0.29   | 0.52   | 0.66   | 0.71   | 1.27   | 1.57   | 1.73    | 1.75    |
| <b>Mean of S x M</b>                                   |               |        |        |        |        |        |        |         |         |
| S <sub>1</sub> M <sub>1</sub>                          | 51.67         | -      | -      | -      | -      | -      | -      | -       | -       |
| S <sub>1</sub> M <sub>2</sub>                          | 66.67         | -      | -      | -      | -      | -      | -      | -       | -       |
| S <sub>1</sub> M <sub>3</sub>                          | 80.00         | -      | -      | -      | -      | -      | -      | -       | -       |
| S <sub>2</sub> M <sub>1</sub>                          | 56.67         | -      | -      | -      | -      | -      | -      | -       | -       |
| S <sub>2</sub> M <sub>2</sub>                          | 63.33         | -      | -      | -      | -      | -      | -      | -       | -       |
| S <sub>2</sub> M <sub>3</sub>                          | 70.00         | -      | -      | -      | -      | -      | -      | -       | -       |
| S <sub>3</sub> M <sub>1</sub>                          | 46.67         | -      | -      | -      | -      | -      | -      | -       | -       |
| S <sub>3</sub> M <sub>2</sub>                          | 55.00         | -      | -      | -      | -      | -      | -      | -       | -       |
| S <sub>3</sub> M <sub>3</sub>                          | 65.00         | -      | -      | -      | -      | -      | -      | -       | -       |
| S <sub>4</sub> M <sub>1</sub>                          | 50.00         | -      | -      | -      | -      | -      | -      | -       | -       |
| S <sub>4</sub> M <sub>2</sub>                          | 58.33         | -      | -      | -      | -      | -      | -      | -       | -       |
| S <sub>4</sub> M <sub>3</sub>                          | 68.33         | -      | -      | -      | -      | -      | -      | -       | -       |
| S <sub>5</sub> M <sub>1</sub>                          | 53.33         | -      | -      | -      | -      | -      | -      | -       | -       |
| S <sub>5</sub> M <sub>2</sub>                          | 66.67         | -      | -      | -      | -      | -      | -      | -       | -       |
| S <sub>5</sub> M <sub>3</sub>                          | 75.00         | -      | -      | -      | -      | -      | -      | -       | -       |
| S <sub>6</sub> M <sub>1</sub>                          | 55.00         | -      | -      | -      | -      | -      | -      | -       | -       |
| S <sub>6</sub> M <sub>2</sub>                          | 61.67         | -      | -      | -      | -      | -      | -      | -       | -       |
| S <sub>6</sub> M <sub>3</sub>                          | 65.00         | -      | -      | -      | -      | -      | -      | -       | -       |
| S.Em. ± (D x N)  | 2.72          | 0.24   | 0.44   | 0.56   | 0.60   | 1.08   | 1.34   | 1.47    | 1.49    |
| C.D. at 5 % (D x N)                                    | 7.81          | NS     | NS     | NS     | NS     | NS     | NS     | NS      | NS      |
| C.V. %   | 7.56          | 15.89  | 10.22  | 6.66   | 4.35   | 5.74   | 5.64   | 5.10    | 4.54    |

The interaction effect of pre-sowing treatments and different media was significant on germination percentage. Higher germination percentage (80 %) was recorded (Table 1) in the treatment S<sub>1</sub>M<sub>3</sub> which was seed treated with GA<sub>3</sub> (250 ppm - 24 h.) sowed in red soil + vermicompost + FYM (1:1:1) and at par with treatment combination of S<sub>5</sub>M<sub>3</sub> (75 %).

### 3.1.2 Plant height (cm) at 15, 30, 45, 60, 75, 90 105 and 120 DAP

The effect of different pre-sowing treatments on plant height (Table 1) were recorded at 15 days interval. The maximum plant height was recorded in treatment (S<sub>1</sub>) [GA<sub>3</sub>- (250 ppm)- 24 hrs] at 15 (3.00), 30 (8.38), 45 (15.98), 60 (25.20), 75 (34.05), 90 (42.98), 105 (52.07) and 120 (59.02) DAS, it was at par with treatment (S<sub>5</sub>) [KNO<sub>3</sub>- (250 ppm)- 1 min.]. These observations are similar with the findings of Tzortzakis [6] in *Cichorium endivia* and *Cichorium intybus* L., Shukla and Shukla [7] in *Withania somnifera* L.

The effect of different media on plant height was also found significant as compared to control (Table 1). The highest plant height was recorded in treatment (M<sub>3</sub>) [Red soil + Vermicompost + FYM- 1:1:1] at 15 (3.29), 30 (9.78), 45 (18.14), 60 (26.85), 75 (35.54), 90 (44.13), 105 (55.03) and 120 (60.17) DAS respectively. Similar findings as reported by Manohar et al. [5] in

*Withania somnifera* and Vishnoi et al. (2011) in *Terminalia arjuna* [8-11].

### 3.1.3 No. of Branches/plant at 15, 30, 45, 60, 75, 90 105 and 120 DAP

The data pertaining to the number of branches per plant as affected by different pre-sowing treatments are shown in Table 2. The maximum no. of branches per plant was recorded in the treatment (S<sub>1</sub>) [GA<sub>3</sub>- (250 ppm)- 24 hrs] at 15 (0.0), 30 (0.22), 45 (0.71), 60 (1.73), 75 (1.76), 90 (2.80), 105 (3.0) and 120 (3.84) DAS respectively. The obtained data might be ascribed to GA<sub>3</sub> have important physiological property to regulate shoot apical dominance in plants and it stimulates the lateral buds so ultimately it increases the number of branches per plant. These results are in harmony with Tzortzakis [6] in *Cichorium endivia* and *Cichorium intybus* L., Also Shukla and Shukla [7] in *Withania somnifera* L [12-14].

The effect on production of lateral shoots plant was also modified by different media. The highest no. of branches per plant was recorded in treatment (M<sub>3</sub>) [Red soil + Vermicompost + FYM- 1:1:1] at 15 (0.0), 30 (0.27), 45 (0.68), 60 (1.89), 75 (1.97), 90 (2.87), 105 (2.90) and 120 (3.83) DAS, respectively. Similar results were also obtained by Manohar et al. [5] in *Withania somnifera* and Vishnoi et al. (2011) in *Terminalia arjuna* [15-17].

**Table 2. Effect of different seed treatments and media on no. of branches in ashwagandha (*Withania somnifera*)**

| Treatment  | 15 DAS | 30 DAS | 45 DAS | 60 DAS | 75 DAS | 90 DAS | 105 DAS | 120 DAS |
|--|--------|--------|--------|--------|--------|--------|---------|---------|
| <b>SEED TREATMENT (S)</b>                              |        |        |        |        |        |        |         |         |
| S <sub>1</sub> : GA <sub>3</sub> (250 ppm - 24 h.)     | 0      | 0.22   | 0.71   | 1.73   | 1.76   | 2.80   | 3.0     | 3.84    |
| S <sub>2</sub> : Kinetin (0.2% - 24 h.)                | 0      | 0.11   | 0.33   | 1.16   | 1.22   | 2.09   | 2.18    | 3.51    |
| S <sub>3</sub> : NaHClO <sub>3</sub> (4% - 5 min.)     | 0      | 0.07   | 0.33   | 1.11   | 1.20   | 2.16   | 2.16    | 3.02    |
| S <sub>4</sub> : NaHClO <sub>3</sub> (4% - 10 min.)    | 0      | 0.07   | 0.42   | 1.27   | 1.38   | 2.38   | 2.40    | 3.49    |
| S <sub>5</sub> : KNO <sub>3</sub> (250 ppm- 1 min.)    | 0      | 0.16   | 0.51   | 1.64   | 1.71   | 2.51   | 2.56    | 3.56    |
| S <sub>6</sub> : Control                               | 0      | 0.09   | 0.40   | 1.40   | 1.56   | 2.40   | 2.47    | 3.24    |
| S. Em. ±   | 0      | 0.04   | 0.07   | 0.10   | 0.08   | 0.09   | 0.09    | 0.12    |
| C.D. at 5 %  | 0      | 0.08   | 0.14   | 0.20   | 0.17   | 0.19   | 0.18    | 0.24    |
| <b>MEDIA (M)</b>                                       |        |        |        |        |        |        |         |         |
| M <sub>1</sub> : Red Soil                              | 0      | 0.03   | 0.32   | 0.97   | 1.11   | 2.08   | 2.10    | 3.11    |
| M <sub>2</sub> : Red Soil + Vermicompost (1:1)         | 0      | 0.06   | 0.36   | 1.30   | 1.33   | 2.21   | 2.27    | 3.39    |
| M <sub>3</sub> : Red Soil + Vermicompost + FYM (1:1:1) | 0      | 0.27   | 0.68   | 1.89   | 1.97   | 2.87   | 2.90    | 3.83    |
| S. Em. ±   | 0      | 0.03   | 0.05   | 0.07   | 0.06   | 0.07   | 0.06    | 0.08    |
| C.D. at 5 %  | 0      | 0.08   | 0.14   | 0.20   | 0.17   | 0.19   | 0.18    | 0.24    |

### 3.1.4 No. of Leaves/plant at 15, 30, 45, 60, 75, 90 105 and 120 DAP

The maximum no. of leaves per plant was significantly recorded (Table 3) higher in treatment (S<sub>1</sub>) [GA<sub>3</sub>- (250 ppm)- 24 hrs] at 15 (3.42), 30 (7.67), 45 (20.42), 60 (33.11), 75 (41.62), 90 (55.98), 105 (67.24) and 120 (75.87) DAS, respectively. This might be due to GA<sub>3</sub> have important physiological property to regulate shoot apical dominance in plants and it stimulates the lateral buds so ultimately it increases the no. of leaves per plant. Similar findings also reported by Tzortzakis [6] in *Cichorium endivia* and *Cichorium intybus* L., Shukla and Shukla [7] in *Withania somnifera* L. [18-21].

The seed sown in treatment (M<sub>3</sub>) [Red soil + Vermicompost + FYM- 1:1:1] recorded (Table 3) significantly highest no. of leaves at 15 (3.72), 30 (8.46), 45 (22.46), 60 (35.23), 75 (43.91), 90 (55.87), 105 (67.47) and 120 (75.92) DAS, respectively. These results are in harmony with the observations of Manohar et al. [5] in *Withania somnifera* and Vishnoi et al. (2011) in *Terminalia arjuna* [22,23].

### 3.1.5 Total leaf area (cm<sup>2</sup>)

The total leaf area affected by various pre-sowing treatments of ashwagandha seeds applied are presented in Table 4. The data shows that total leaf area significantly highest (33.57 cm<sup>2</sup>) in treatment (S<sub>1</sub>) [GA<sub>3</sub>- (250 ppm)- 24 hrs). These observations are also in accordance with the results obtained by Tzortzakis [6] in *Cichorium endivia* and *Cichorium intybus* L., Shukla and Shukla [7] in *Withania somnifera* L.

Maximum total leaf area (32.08 cm<sup>2</sup>) was recorded (Table 4) in the treatment of (M<sub>3</sub>) [Red soil + Vermicompost + FYM- 1:1:1] [24-26].

### 3.1.6 Shoot fresh weight (At final stage)

The highest fresh weight of shoot (55.06 g) was recorded (Table 4) significantly higher in treatment (S<sub>1</sub>) [GA<sub>3</sub> (250 ppm)- 24 hrs] which was statistically at par with treatment (S<sub>5</sub>) [KNO<sub>3</sub> (250 ppm)- 1 min.] and (S<sub>2</sub>) [Kinetin (0.2 %)- 24 hrs] with the values of 53.88 g and 53.31 g. Similar results were found by Tzortzakis [6] in *Cichorium endivia* and *Cichorium intybus* L., Shukla and Shukla [7] in *Withania somnifera* L.

The highest shoot fresh weight (58.70 g) was registered (Table 4) in treatment (M<sub>3</sub>) which was Red soil + Vermicompost + FYM- (1:1:1). These results are in harmony with Manohar et al. [5] in *Withania somnifera* and Vishnoi et al. (2011) in *Terminalia arjuna* [27-29].

### 3.1.7 Shoot dry biomass (At final stage)

The maximum shoot dry biomass (38.34 g) was reported (Table 4) in the treatment (S<sub>1</sub>) [GA<sub>3</sub> (250 ppm)- 24 hrs), which was at par with the treatment (S<sub>5</sub>) [KNO<sub>3</sub> (250 ppm)- 1 min.] with a value of 38 g. Similar findings are also reported by Tzortzakis [6] in *Cichorium endivia* and *Cichorium intybus* L., Shukla and Shukla [7] in *Withania somnifera* L.

Shoot dry biomass (Table 4) was highest (40.91 g) in treatment (M<sub>3</sub>) [Red soil + Vermicompost + FYM- 1:1:1]. Similar result was found by Manohar et al. (2012) in *Withania somnifera* and Vishnoi et al. (2011) in *Terminalia arjuna*.

### 3.1.8 Fresh weight of plant (At final stage)

The plant fresh weight recorded (Table 4) was higher (60.10 g) in treatment (S<sub>1</sub>) [GA<sub>3</sub> (250 ppm)- 24 hrs) which was at par with treatment (S<sub>5</sub>) [KNO<sub>3</sub> (250 ppm)- 1 min.] with the values of 58.91 g. It might be due to GA<sub>3</sub> have important physiological property to regulate shoot apical dominance in plants and it stimulates the lateral buds so ultimately it increases the plant fresh weight. Similar finding reported by Tzortzakis [6] in *Cichorium endivia* and *Cichorium intybus* L., Shukla and Shukla [7] in *Withania somnifera* L.

It is also further seen from Table 4 that the various media also have significant effect on the plant fresh weight. The highest plant fresh weight (64.05 g) was registered in treatment (M<sub>3</sub>) [Red soil + Vermicompost + FYM- 1:1:1].

### 3.1.9 Dry weight of plant (g)

The present data (Table 4) on plant dry weight reveals that the higher (18.77 g) plant dry weight was recorded in treatment (S<sub>1</sub>) [GA<sub>3</sub> (250 ppm)- 24 hrs), which was at par with the treatment (S<sub>5</sub>) [KNO<sub>3</sub> (250 ppm)- 1 min.] and (S<sub>2</sub>) [Kinetin (0.2 %)- 24 hrs] with the values of 18.72 g and 18.14 g, respectively [30,31].

It is also observed from Table 4 that the various media also have significant effect on the plant dry weight. The highest plant dry weight (19.82 g) was registered in treatment (M<sub>3</sub>) [Red soil + Vermicompost + FYM- 1:1:1].

**Table 3. Effect of different seed treatments and media on no. of leaves/plant in ashwagandha (*Withania somnifera*)**

| Treatment  | 15 DAS | 30 DAS | 45 DAS | 60 DAS | 75 DAS | 90 DAS | 105 DAS | 120 DAS |
|--|--------|--------|--------|--------|--------|--------|---------|---------|
| <b>SEED TREATMENT (S)</b>                              |        |        |        |        |        |        |         |         |
| S <sub>1</sub> : GA <sub>3</sub> (250 ppm - 24 h.)     | 3.42   | 7.67   | 20.42  | 33.11  | 41.62  | 55.98  | 67.24   | 75.87   |
| S <sub>2</sub> : Kinetin (0.2% - 24 h.)                | 2.76   | 6.49   | 17.13  | 30.24  | 39.58  | 51.04  | 60.73   | 73.53   |
| S <sub>3</sub> : NaHClO <sub>3</sub> (4% - 5 min.)     | 2.43   | 6.20   | 16.60  | 29.20  | 39.13  | 50.36  | 61.16   | 70.56   |
| S <sub>4</sub> : NaHClO <sub>3</sub> (4% - 10 min.)    | 2.64   | 6.38   | 17.24  | 30.07  | 39.80  | 52.11  | 62.76   | 71.89   |
| S <sub>5</sub> : KNO <sub>3</sub> (250 ppm- 1 min.)    | 3.11   | 7.36   | 19.62  | 33.22  | 42.71  | 55.27  | 64.62   | 73.64   |
| S <sub>6</sub> : Control                               | 2.84   | 6.64   | 18.50  | 31.63  | 41.07  | 52.67  | 64.20   | 71.00   |
| S. Em. ±   | 0.14   | 0.20   | 0.40   | 0.54   | 0.73   | 0.90   | 1.10    | 1.24    |
| C.D. at 5 %  | 0.28   | 0.40   | 0.81   | 1.09   | 1.48   | 1.84   | 2.22    | 2.51    |
| <b>MEDIA (M)</b>                                       |        |        |        |        |        |        |         |         |
| M <sub>1</sub> : Red Soil                              | 2.16   | 5.51   | 13.57  | 26.60  | 37.38  | 49.57  | 60.64   | 70.08   |
| M <sub>2</sub> : Red Soil + Vermicompost (1:1)         | 2.73   | 6.40   | 18.73  | 31.91  | 40.67  | 53.12  | 62.24   | 72.24   |
| M <sub>3</sub> : Red Soil + Vermicompost + FYM (1:1:1) | 3.72   | 8.46   | 22.46  | 35.23  | 43.91  | 55.87  | 67.47   | 75.92   |
| S. Em. ±   | 0.10   | 0.14   | 0.28   | 0.38   | 0.51   | 0.67   | 0.77    | 0.87    |
| C.D. at 5 %  | 0.28   | 0.40   | 0.81   | 1.09   | 1.48   | 1.91   | 2.22    | 2.51    |

**Table 4. Effect of different seed treatments and media on ashwagandha (*Withania somnifera*)**

| Treatment  | Total leaf area (cm <sup>2</sup> ) | Shoot fresh weight (g) | Shoot dry biomass | Fresh weight of plant | Dry weight of plant (g) |
|--|------------------------------------|------------------------|-------------------|-----------------------|-------------------------|
| <b>SEED TREATMENT (S)</b>                              |                                    |                        |                   |                       |                         |
| S <sub>1</sub> : GA <sub>3</sub> (250 ppm - 24 h.)     | 33.57                              | 55.06                  | 38.34             | 60.10                 | 18.77                   |
| S <sub>2</sub> : Kinetin (0.2% - 24 h.)                | 30.27                              | 53.31                  | 36.53             | 57.93                 | 18.14                   |
| S <sub>3</sub> : NaHClO <sub>3</sub> (4% - 5 min.)     | 27.95                              | 50.91                  | 35.46             | 55.22                 | 16.77                   |
| S <sub>4</sub> : NaHClO <sub>3</sub> (4% - 10 min.)    | 29.82                              | 51.71                  | 35.68             | 55.84                 | 17.47                   |
| S <sub>5</sub> : KNO <sub>3</sub> (250 ppm- 1 min.)    | 31.22                              | 53.88                  | 38.00             | 58.91                 | 18.72                   |
| S <sub>6</sub> : Control                               | 30.23                              | 52.35                  | 36.11             | 56.97                 | 17.18                   |
| S. Em. ±   | 0.58                               | 0.89                   | 0.76              | 0.97                  | 0.48                    |
| C.D. at 5 %  | 1.17                               | 1.80                   | 1.55              | 1.96                  | 0.98                    |
| <b>MEDIA (M)</b>                                       |                                    |                        |                   |                       |                         |
| M <sub>1</sub> : Red Soil                              | 28.45                              | 45.99                  | 31.33             | 50.0                  | 16.25                   |
| M <sub>2</sub> : Red Soil + Vermicompost (1:1)         | 30.99                              | 53.92                  | 37.82             | 58.44                 | 17.87                   |
| M <sub>3</sub> : Red Soil + Vermicompost + FYM (1:1:1) | 32.08                              | 58.70                  | 40.91             | 64.05                 | 19.82                   |
| S. Em. ±   | 0.41                               | 0.63                   | 0.54              | 0.68                  | 0.34                    |
| C.D. at 5 %  | 1.17                               | 1.80                   | 1.55              | 1.96                  | 0.98                    |

#### 4. CONCLUSION

Based on the investigative findings, it can be inferred that treatment S<sub>1</sub>, involving the application of GA<sub>3</sub> at a concentration of 250 ppm for a 24-hour duration, as well as treatment M<sub>3</sub> (consisting of a mixture of Red Soil, Vermicompost, and FYM in a 1:1:1 ratio), exhibited superior performance across various parameters including germination percentage,

plant height, number of branches per plant, number of leaves per plant, total leaf area, fresh weight of shoots, and both fresh and dry weights of the plant, outperforming the other applied treatments.

#### COMPETING INTERESTS

Authors have declared that no competing interests exist.

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