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Effect of stand geometry and plant growth regulators on root – shoot ratio in Ashwagandha (*Withania somnifera* Dunal.)

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Article History

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Key words

Ashwagandha
Dry root yield
Plant growth regulators
Root - shoot ratio
Stand geometry

ABSTRACT

An experiment was carried out in the Department of Horticulture, Janta College, Bakewar, Etawah (UP) during two crop seasons in split plot design, using the commercial cultivars of W. somnifera viz., cv. Poshita and cv. JA - 20 as main plot. Two planting distance 30 x 30 cm^2 and 30 x 20 cm^2 were used as sub plot. The plants were raised in nursery bed and transplanted after 30 days of sowing. After 30, 60 and 90 days of transplanting the plants were sprayed with IAA 100 ppm, IAA 200 ppm, GA 50 ppm, GA 100 ppm, CCC 2000 ppm and CCC 3000 ppm solutions, whereas in control they were sprayed with distilled water (sub sub-plot). Results abstracted that cv Poshita produced higher root – shoot ratio as compare to cv JA – Planting distance 20. 30 x 20 cm^2 gave maximum root yield per hectare however stand geometry had not any significant effect on root yield per plant. Both the concentration of CCC (2000 and 3000 ppm) provided maximum root – shoot ratio with highest root yield per plant and per hectare.

INTRODUCTION

Ashwagandha (*Withania somnifera* Dunal.), a member of family Solanaceae, is an important drug mentioned in ancient ayurvedic literature. The plant is erect, herbaceous, evergreen, tomentose and branched under – shrub reaching upto 13-150 cm. in height with ovate, hairy, thin leaves. The commercial drug consists of the dried root, which occur in small pieces 10.0 to 17.5 cm. long and 6-12 mm. in diameter. The pieces are dark-brown with a creamy interior. Ashwagandha is commonly known as winter cherry in English. In India it is known as Punir or Asgandh in Hindi; Askandhatilli in Marathi; Ghodakun, Ghoda, Asoda or Asan in Gujarati; Pulivendram, Panneru-gadda or Panneru in Telgu; Amukhura, Amkulang, Amukkuram-kilangu or Amulang-valung or Aswagandhi in Tamil; Viremaddlinagadde, Pannaeru, Aswagandhi or Kiremallinagida in Kannad and Ashwagandha or Turangi-gandha in Sanskrit. The species is native of India, Pakistan and Sri Lanka. It is strength and vigour promotion drug. The leaf and root extract of the plant contains withanolides, which exhibit marked activity against various diseases especially bacterial infections. Among the several alkaloids present in ashwagandha, withanine and somniferine are considered to be important and are used in the treatment of carbuncles, ulcer and painful swellings.

The crop is grown on marginal land and also suitable for dry land farming [5]. The yield and quality in cultivated plants depend on several factors

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including environmental adaptability of particular cultivar in specific area. Optimum plant density is important for best utilization of solar radiation and soil nutrients. Plant growth regulators (PGRs) are known to alter the growth behaviour, development and biosynthesis of secondary metabolites in medicinal and aromatic plants [1].

Looking at the view of high demand and sustainable use of natural wealth, this crop has much scope for wide cultivation. Since the information on these aspects in ashwagandha in meagre and standardization of agro–techniques of ashwagandha cultivation shall lead a long way to research workers and the producers as well. Therefore, present investigation on ashwagandha was undertaken to evaluate the effect of different plant growth regulators and planting distances.

MATERIALS AND METHODS

The present investigation was carried out in the horticulture garden of Janta College (P.G.), Bakewar, Etawah (U.P.), India during seasons 2005-2006 and 2006-2007. Geographically, the district ETAWAH falls between the parallels of 26.21^0 and 27.1^0 North latitude and 78.45^0 and 79.45^0 East longitude. It is situated 150.06 meters above mean sea level. The average rainfall of the Etawah district is about 805 mm per annum and more than 80 per cent rainfall is received in July and September. During winters the days are bright and sunny while nights are cool, with occasional frost. The soil of experimental plot was well–drained sandy loam with medium fertility. The experiment was laid out in split plot design, using cultivars viz., cv. Poshita and cv. JA - 20 as main plot. Two planting distance 30 x 30 cm^2 and 30 x 20 cm^2 were used as sub plot. These plants were raised in nursery bed and transplanted after 30 days of sowing. After 30, 60 and 90 days of transplanting the plants were sprayed with IAA 100 ppm, IAA 200 ppm, GA 50 ppm, GA 100 ppm, CCC 2000 ppm and CCC 3000 ppm solutions, where as in control they were sprayed with distilled water (sub sub-plot). The size of each plot was 180 x 120 sq.cm. At the time of harvesting the foliage and roots of lifted plants was separated above the crown and root and shoot weights were taken. The fresh root and shoot obtained from selected plants were cut into small pieces and these were kept for drying in semi-shady place for 15 days after which weight of dry roots and shoots were taken and root – shoot ratio was calculated with the help of following formulas:

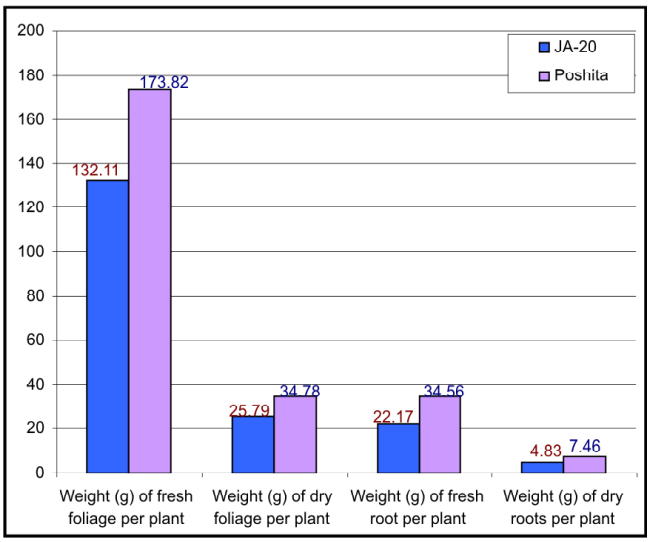

Fig 1: Root-shoot development patterns in the two cultivars of the Ashwagandha used in the present study

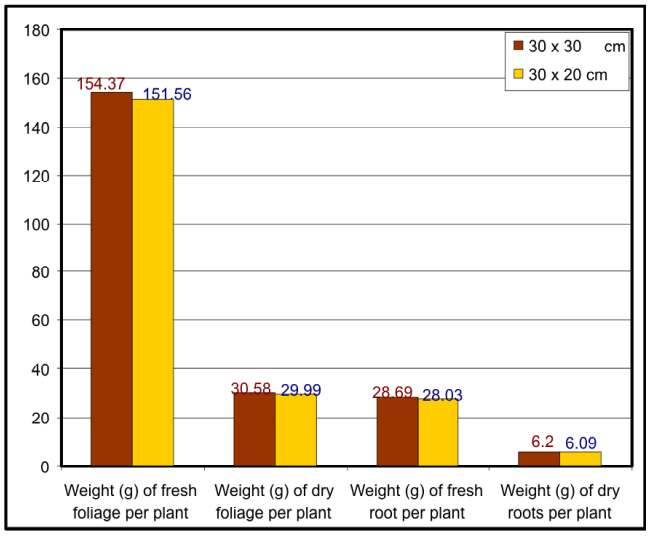

Fig 2: Effect of stand geometry on shoot and root development in Ashwagandha

$$\text{Root-shoot ratio on fresh weight basis} = \frac{\text{Average fresh root yield per plant (g)}}{\text{Average fresh herbage yield per plant (g)}}$$

Table 1: Effect of cultivar, stand geometry and plant growth regulators on root and shoot weight of Ashwagandha

Treatments	Weight (g) of fresh foliage per plant			Weight (g).of dry foliage per plant			Weight (g) of fresh root per plant			Weight (g).of dry roots per plant		
Season	**2005-06**	**2006-07**	**Pooled**	**2005-06**	**2006-07**	**Pooled**	**2005-06**	**2006-07**	**Pooled**	**2005-06**	**2006-07**	**Pooled**
JA-20	132.35	131.86	132.11	26.18	25.41	25.79	22.57	21.77	22.17	4.85	4.8	4.83
Poshita	173.59	174.05	173.82	34.67	34.89	34.78	34.55	34.56	34.56	7.39	7.52	7.46
CD at 5 %	**7.82**	**5.13**	**3.02**	**1.11**	**1.4**	**0.57**	**1.12**	**1.13**	**0.51**	**0.25**	**0.28**	**0.12**
30 x 30 cm	154.36	154.38	154.37	30.71	30.46	30.58	28.88	28.5	28.69	6.17	6.22	6.2
30 x 20 cm	151.58	151.53	151.56	30.15	29.84	29.99	28.24	27.83	28.03	6.07	6.11	6.09
CD at 5 %	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
IAA 100 ppm	149.86	149.77	149.81	30.14	29.83	29.98	28.61	28.21	28.41	6.1	6.15	6.13
IAA 200 ppm	150.63	150.56	150.59	30.35	30.06	30.21	29.23	28.88	29.05	6.29	6.35	6.32
GA 50 ppm	162.28	162.48	162.38	32.77	32.77	32.77	27.5	27.03	27.27	5.88	5.91	5.89
GA 100 ppm	164.55	164.8	164.67	33.02	33.04	33.03	26.7	26.18	26.44	5.71	5.73	5.72
CCC 2000 ppm	146.86	146.71	146.79	28.31	27.79	28.05	29.67	29.34	29.5	6.37	6.43	6.4
CCC 3000 ppm	147.77	147.64	147.71	28.38	27.87	28.12	29.98	29.68	29.83	6.44	6.5	6.47
Control	148.83	148.73	148.78	30.02	29.69	29.85	28.24	27.82	28.03	6.04	6.07	6.05
CD at 5 %	**7.79**	**8.03**	**5.51**	**1.55**	**2.07**	**1.27**	**1.71**	**1.75**	**1.21**	**0.41**	**0.42**	**0.29**

RESULTS AND DISCUSSION

The data given in Table 1 and Figs. 1-4 clearly indicate the weight of fresh foliage per plant, dry foliage per plant, fresh roots per plant and dry roots per plant were significantly affected by cultivars. The higher weight of fresh foliage per plant (173.82 g), dry foliage per plant (34.78 g), fresh roots per plant (34.56 g) and dry roots per plant (7.46 g) were recorded from plants of cv. Poshita as compared to cv. JA – 20 (132.11 g, 25.79 g, 22.17 g and 4.83 g respectively). It may be due to different genetic makeup of the cultivars.

The data further suggest that weight of fresh foliage per plant, dry foliage per plant, fresh roots per plant and dry roots per plant were not significantly affected by stand geometry. From the finding it may be concluded that the plants of ashwagandha is more efficient to use of solar radiation and soil nutrients and it can be planted at much closer spacing. However Pakkiyanathan *et al.,* [5] reported significant effect of spacing on weight of dry foliage per plant and fresh roots weight per plant in ashwagandha in Hyderabad conditions and non-significant effect of spacing on weight of fresh foliage per plant and dry root weight per plant.

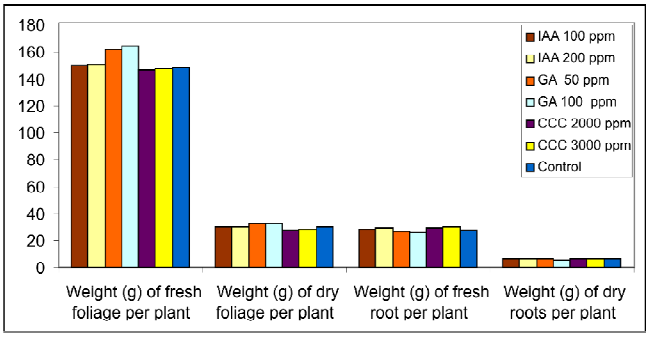

Fig 3: Effect of plant growth regulators on shoot and root development of Ashwagandha

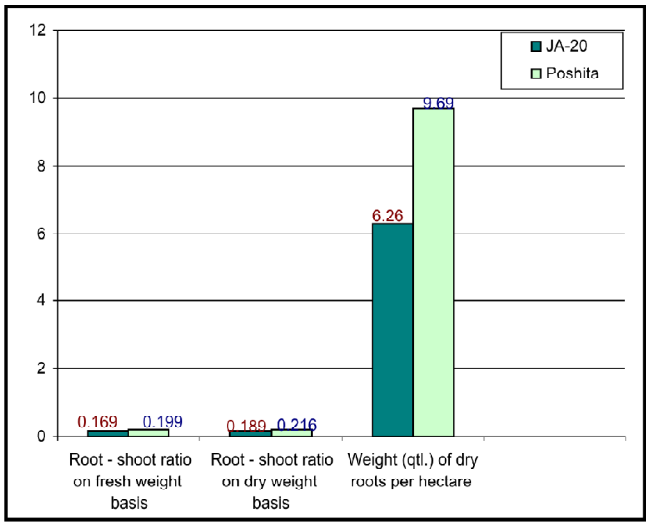

Fig 4: Effect of cultivar on root - shoot ratio and root yield of Ashwagandha

Data presented in Table 1 and Figs. 5 & 6 also reveal that the minimum average weight of fresh and dry foliage per plant was found in CCC 2000 ppm treated plants (146.79 g and 28.05 g respectively) followed by CCC 3000 ppm (147.71 g and 28.12 g respectively) yet they did not differ statistically with control. The findings are in agreement with Mansy *et al.,* [9] who also reported

Table 2: Effect of cultivar, stand geometry and plant growth regulators on root-shoot ratio and root yield of Ashwagandha

Treatments	Root - shoot ratio on fresh weight basis			Root - shoot ratio on dry weight basis			Weight (qtl.) of dry roots per hectare		
Season	**2005-06**	**2006-07**	**Pooled**	**2005-06**	**2006-07**	**Pooled**	**2005-06**	**2006-07**	**Pooled**
JA-20	0.172	0.166	0.169	0.186	0.191	0.189	6.31	6.21	6.26
Poshita	0.2	0.199	0.199	0.214	0.217	0.216	9.68	9.7	9.69
CD at 5 %	**0.01**	**0.011**	**0.005**	**0.007**	**0.012**	**0.004**	**0.32**	**0.36**	**0.16**
30 x 30 cm	0.186	0.183	0.185	0.2	0.205	0.202	6.6	6.53	6.56
30 x 20 cm	0.185	0.182	0.184	0.2	0.204	0.202	9.39	9.38	9.39
CD at 5 %	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**0.29**	**0.3**	**0.17**
IAA 100 ppm	0.189	0.186	0.188	0.2	0.204	0.202	8.03	7.99	8.01
IAA 200 ppm	0.192	0.19	0.191	0.206	0.213	0.209	8.22	8.19	8.2
GA 50 ppm	0.167	0.164	0.166	0.178	0.178	0.178	7.7	7.65	7.67
GA 100 ppm	0.16	0.157	0.158	0.171	0.172	0.171	7.44	7.38	7.41
CCC 2000 ppm	0.201	0.198	0.2	0.223	0.229	0.226	8.29	8.26	8.27
CCC 3000 ppm	0.201	0.2	0.201	0.225	0.232	0.228	8.39	8.36	8.37
Control	0.188	0.185	0.187	0.199	0.203	0.201	7.91	7.86	7.89
CD at 5 %	**0.013**	**0.018**	**0.011**	**0.011**	**0.007**	**0.007**	**0.45**	**0.45**	**0.31**

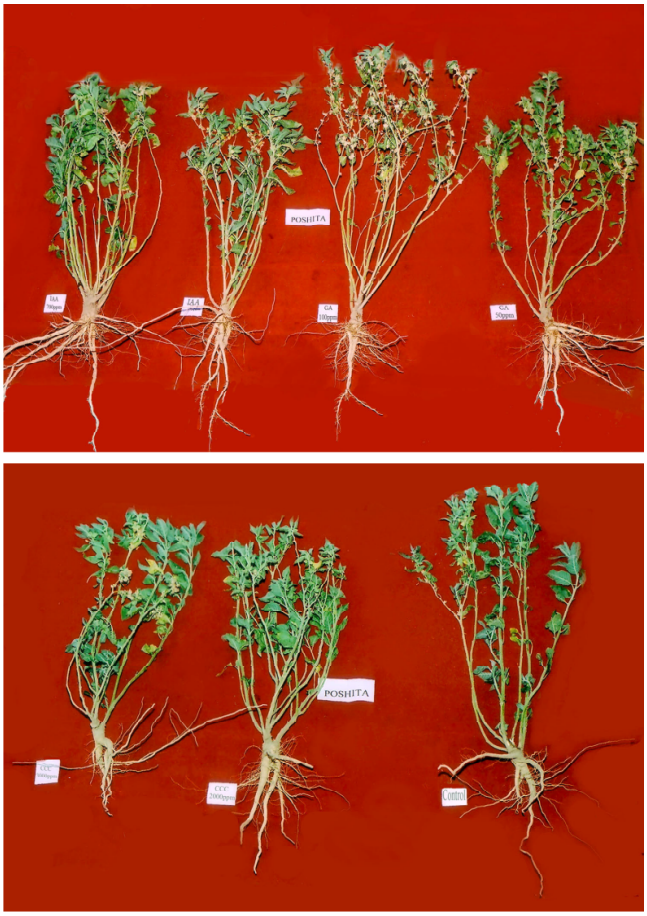

Fig. 5: Depicting performance of plant growth regulators on root and shoot growth of ashwagandha cv Poshita

decrease in leaf dry weight in carrot with CCC. Even though the maximum weight of fresh and dry roots per plant were recorded in CCC 3000 ppm treated plants (29.83 g and 6.47 g, respectively) followed by CCC 2000 ppm (29.50 g and 6.40 g, respectively). The results are in agreement with Barathkumar *et al.* [2] who recorded increased root yield in *Withania somnifera* by using combination of phosphobacteria along with CCC at the rate of 2000 ppm.

IAA 100 and 200 ppm apparently produced higher average weight of fresh (149.81 g and 150.59 g, respectively) and dry (29.98 g and 30.21 g, respectively) foliage per plant yet they were statistically at par with control. Similar trend in increase of fresh herb weight was also reported in *Vinca* and *Artimisia annua* [6, 12, 19]. Both concentrations of IAA (100 and 200 ppm) also showed higher weight of fresh (28.41 g and 29.05 g, respectively) and dry roots per plant (6.13 g and 6.32 g, respectively).

GA 100 and 50 ppm gave significantly higher average weight of fresh (164.67 g and 162.38 g, respectively) and dry (33.03 g and 32.77 g, respectively) foliage per plant as compared to all other treatments. Similar observations have also

Fig. 6: Depicting performance of plant growth regulators on root and shoot growth of ashwagandha cv JA -20 or WS - 20

been made [10], where it is reported significant increase in stem dry weight with the application of 100 mg GA_3 in Periwinkle. However, GA 100 ppm gave significantly lower weight of fresh (26.44 g) and dry roots (5.72 g) per plant as compared to control (28.03 g and 6.05 g respectively). GA 50 ppm gave statistically at par results with control. Various workers [3, 16, 18] also reported that GA inhibited root growth in various plant species. Contrary to it Joshi and Singh [7] studied the effect of GA at 10, 20 and 30 ppm on chilli and recorded at par results with control in respect of root dry weight.

Data presented in Table 2 depicts that root – shoot ratio on fresh and dry weight basis and dry root weight per hectare were significantly affected by cultivar. The higher root – shoot ratio on fresh and dry weight basis and dry root weight per hectare were recorded in plants of cv. Poshita (0.199, 0.216 and 9.69 q. respectively) as compared to cv. JA – 20 (0.169, 0.189 and 6.26 q. respectively). Contrary to these findings much higher average root yield of 14 q/ha was reported in cv. Poshita [11]. In present trial the average root yield of 6.26 q/ha of cv JA – 20 was close to yield (6.39 q/ha) [13].

Data further suggest that the root – shoot ratio on fresh and dry weight basis was not affected by stand geometry (Fig. 7). However this finding is contrary to the earlier reports [15] who recorded maximum ratio from closer spacing in ashwagandha. On the other hand stand geometry significantly affected weight of dry roots per hectare. Planting distance at 30x20 cm^2 produced higher weight of dry roots per hectare (9.39 q) as compared to 30x30 cm^2 plant spacing (6.56 q). Higher yield in closely spaced crop was due to increased number of plants per unit area. Similar findings were also reported by [8, 14, 15].

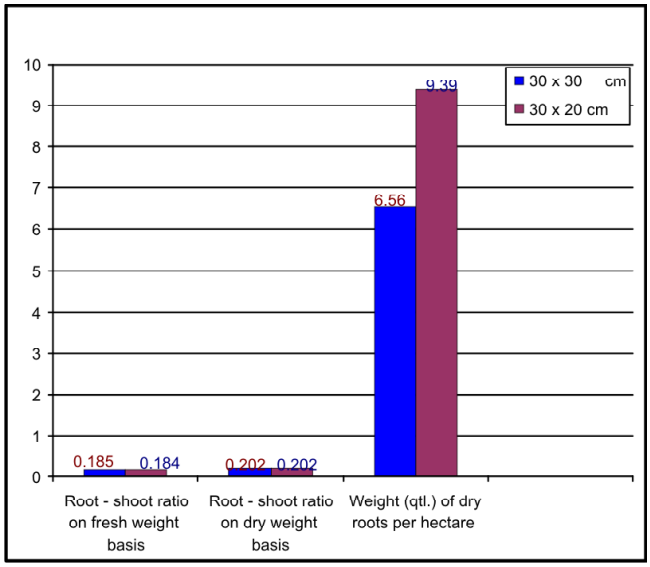

Fig 7: Effect of stand geometry on root - shoot ratio and root yield of Ashwagandha

Table 2 further indicates that the maximum root – shoot ratio on fresh (0.201) and dry (0.228) weight basis were recorded in CCC 3000 ppm treated plants followed by CCC 2000 ppm (0.200 and 0.226, respectively). The maximum weight of dry roots per hectare was recorded in CCC 3000 ppm treated plants (8.37 q) followed by CCC 2000 ppm (8.27 q). Barathkumar *et al.* [2] also reported that in *Withania somnifera* the combination of phosphobacteria along with CCC at the rate of 2000 ppm increased the root growth measured as root

yield. It may be due to dwarfing effect of CCC on plant which resulted in saving of metabolites, which were stored in roots.

Table 2 and Fig. 8 further indicates that the maximum root – shoot ratio on fresh (0.201) and dry (0.228) weight basis were recorded in CCC 3000 ppm treated plants followed by CCC 2000 ppm (0.200 and 0.226, respectively). The maximum weight of dry roots per hectare was recorded in CCC 3000 ppm treated plants (8.37 q) followed by CCC 2000 ppm (8.27 q). Barathkumar *et al.* [2] also reported that in *Withania somnifera* the combination of phosphobacteria along with CCC at the rate of 2000 ppm increased the root growth measured as root yield. It may be due to dwarfing effect of CCC on plant which resulted in saving of metabolites, which were stored in roots.

IAA 100 and 200 ppm apparently produced higher root – shoot ratio on fresh (0.188 and 0.191, respectively) and dry (0.202 and 0.209, respectively) weight basis but statistically they were at par with control. The dry root weight per hectare was also statistically at par with control.

GA 100 ppm gave significantly lower root – shoot ratio on fresh (0.158) and dry (0.171) weight basis as compared to control. The findings corroborate with findings of Currah and Thomas [4] also observed that in carrot GA increased shoot: root ratio on fresh weight basis. Plants treated with GA 100 ppm produced lower dry root weight per hectare (7.41q) as compared to control (7.89q). It may be due to the fact that GA accelerated aerial vegetative growth thus plants consumed more metabolites for this growth with consequent reduction in root growth. Joshi and Singh [7] studied the effect of GA at 10, 20 and 30 ppm on chilli and recorded at par results with control in respect of root dry weight.

CONCLUSION

It may accomplished from the findings that ashwagandha cultivar Poshita is vigorous as compare to cv JA – 20. The results also depicted that the plants of ashwagandha are more efficient to use of solar radiation and soil nutrients and it can be planted at much closer spacing. CCC at the rate of 2000 and 3000 ppm may increase the root growth and development with suppression of foliar growth of ashwagandha.

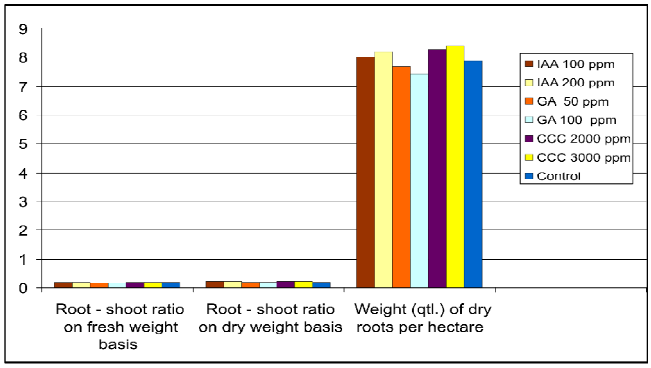

Fig 8: Effect of plant growth regulators on root-shoot ratio and root yield of Ashwagandha

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