International Journal of Chemical Studies 2019; 7(3): 3621-3624

International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
IJCS 2019; 7(3): 3621-3624

Received: 19-03-2019
Accepted: 21-04-2019

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Effect of plant growth hormones on growth and yield of ashwagandha (*Withania somnifera* L. Dunal.)

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Abstract
A field experiment was conducted during Late *Kharif* season 2017-18 at Research Farm, College of Horticulture, Mandsaur (MP) to study plant growth hormones on growth and yield of ashwagandha. The experiment was laid out ten treatments and three replications in randomized block design. The results found that spray of IBA 100 mg l^{-1} found maximum in plant height (39.17, 45.80, 46.97 and 47.27 cm $plant^{-1}$), no. of leaves (32.80, 83.00, 160.00, 182.33 and 117.80 $plant^{-1}$), no. of branches (2.67, 4.33, 4.83, 5.17 and 5.17 $plant^{-1}$), root girth (13.43 mm $plant^{-1}$), root shoot ratio by weight (125.40 g), root yield (461.33 kg ha^{-1}), root harvest index (31.00 %), fresh of weight root (19.83, 28.67, 29.90 and 33.33 g $plant^{-1}$) and dry of weight root (0.87, 6.50, 9.50, 11.83 and 13.67 g $plant^{-1}$) compared to other growth hormones *viz.* TIBA, CCC and control, while no. of berries (100.20 $plant^{-1}$), seed yield (5.50 q ha^{-1}), and seed Harvest index (38.83 %), was maximum with CCC 250 ppm mg l^{-1}, spray of 50 mg l^{-1} individually were very effective in increasing shoot girth (15.70 mm $plant^{-1}$) and spraying of TIBA suppressed the shoot girth.

Keywords: PGR, Withania, TIBA, CCC and Ashwagandha

Introduction
Ashwagandha (*Withania somnifera* L. Dunal) is an important medicinal crop belongs to family Solanceae. It is commercially cultivated in western MP especially in (Mandsaur and Neemuch) and southern Rajasthan. The plant is erect, herbaceous, evergreen shrub with ovate, hairy, thin leaves growing up to 60-75 cm height. It can be grown successfully in sandy loam or light-red soil with pH range of 7.5 to 8 and good organic matter and drainage (Kukreti *et al*., 2013) [3]. It is cultivated in 10000-15000 hectare area to produce 2500-3500 tonnes with average productivity 6-7q/ha, (Bhaure *et al*., 2014) [1]. Ashwagandha is late sown rainy season crop and is ready for harvest in 150-170 days after sowing. The root and leaves of this plant contain many alkaloids and with anolides are medicinally important which used to increase vigour; vitality and to cure many diseases (Bhaure *et al*., 2014) [1] there is a good demand of roots of ashwgandha which is also called Indian ginseng owing to its use as sex tonic leaves and seeds are also valued owing to their medicinal property. Ashwagandha roots and occasionally its leaf and seeds are used in ayurvedic and unani medicine preparations. The important alkaloid present in the roots is with a nine constituting 38 per cent of the total alkaloids. Other alkaloids recorded are somniferine, somniferinine, somnine, with anine, pseudo with anine, with a naninine and with somine (Majumdar, 1955) [6]. The total alkaloid content of the roots under Indian conditions is reported to vary between 0.13 to 0.31 percent. Apart from roots, alkaloids have also been reported in leaves and berries (Sreerekha *et al*., 2004) [16].

Materials and methods
The experiment was laid out at the "Research Field of the Department of Plantation, Spices, Medicinal and Aromatic Crops", College of Horticulture, RVSKVV, Mandsaur (M.P.) during Late *Kharif* season of 2017-18. Mandsaur is situated in Malwa Plateau in western part of Madhya Pradesh at North latitude of 23.45º to 24.13º and 74.44º to 75.18º East longitudes and an altitude of 435.02 meters above mean sea level. The soil of the experimental field was light black loamy in texture with low nitrogen (192 kg/ha), low phosphorus (7.6kg/ha), medium potassium (145.0kg/ha) soil having (pH 8.36) and EC (0.18dS/m). The field experiment comprising 10 treatments with three replication was laid out in (RBD) randomized block

design. The experiment consisted of foliar application at 30, 45 and 75 DAS (IBA, TIBA, and CCC). The crop variety RVA-100 were sown in spacing 30 x 20 cm with seed rate of 5-7 kg/ha. The observation was recorded plant height (cm plant^{-1}), no. of leaves (plant^{-1}), no. of branches (plant^{-1}), root girth (mm plant^{-1}), root shoot ratio by weight (g), root yield (kg ha^{-1}), root harvest index (%), fresh of weight root (g plant^{-1}) and dry of weight root (g plant^{-1}), while no. of berries (plant^{-1}), seed yield (q ha^{-1}), and seed Harvest index (%).

Results and discussion

Significant variations were noted with different plant growth hormones in relation to plant height at all the growth intervals except 45 days after sowing. However, the highest plant height (39.17, 45.80, 46.97 and 47.27cm plant^{-1}) was recorded in treatment T_1 (IBA 100ppm). The lowest plant height was recorded under treatment T_9 (CCC 750ppm). It was found that growth retardant CCC reducing plant height by Kar *et al.* (1989) [2]. The exogenous auxin or is combination, with IBA often giving the best results. However, Naik *et al*. (2004) [9] also reported that plant height was reduced with foliar application of 1000ppm CCC in marigold; similar results were reported by Kumar *et al.* (2012) [4] in tomato, Bhaure *et al.* (2014) [1] in ashwagandha and Shital *et al.* (2017) [13] in tomato.

The maximum number of leaves (32.80, 83.00, 160.00, 182.33 and 117.80) was found in the treatment T_1 (IBA 100 ppm), and lowest number of leaves was recorded under in treatment T_9 (CCC 750ppm). Indole-3-butyric acid is used for enhancing crop production and regulation of plant growth and development, rapid growth of shoot tissue and young leaves and also to promote lateral root development (Saktheivel *et al.*, 2015) [12]. Similar results were reported by Venkatsan and Arumugam (2008) [19] in medicinal solanum, Bhaure *et al.* (2014) [1] in ashwagandha, Pal *et al*. (2014) [10] in marigold and Shital *et al.* (2017) [13] in tomato.

Treatment T_1 (IBA 100ppm) was registered the highest number of branches (2.67, 4.33, 4.83, 5.17 and 5.17), while lowest number of branches were recorded under treatment T_9 (CCC 750ppm). The increase in number of primary branches could be due to suppression of apical dominance by the application of growth retardant, which diverts the polar transport of auxin towards the basal buds there by leads to increased branching (Patel, 2016), earlier reported by Bhaure *et al.* (2014) [1] in ashwagandha.

Maximum number of berries (100.20) were recorded in the treatment T_7 (CCC250 ppm), while lowest number of berries were recorded under treatment T_{10} control. According to Kumar *et al.* (2012) [4] found that the volume and number of fruits were significantly increased with the increase in the concentration of growth retardant cycocel in tomato. Similarly kinds of results were reported by Bhaure *et al.* (2014) [1] in ashwagandha.

Root girth was found to be significantly differed with the application of plant growth hormones and was (13.43mm) superior with T_1 (IBA100ppm), while it was inferior under T_{10} control. The results showed that the root girth reduced at lower concentration but increased at higher concentration as compared to control. Similarly results were reported by Upadhyay *et al.* (2007) [18] in ashwagandha.

Maximum shoot girth (15.70 mm) was recorded in the treatment T_4 (TIBA 40 ppm), while the lowest root girth was recorded under treatment T_{10} control. The increase in shoot girth can be attributed to decrease in plant height and increased cambium activity (Pravin and Prakash, 1999), similarly results were reported by Kancham 2013) [5].

The maximum root shoot ratio (124.40g) was recorded with the foliar application of T_1 (IBA 100 ppm) and it significantly differed among the genotypes, while the lowest ratio was recorded under treatment T_{10} control. This may be due to the stimulation of breaking up of apical dominant ices which is controlling factor of height but the lateral growth increased which ultimately resulted in higher root shoot ratio Upadhyay and Patel (2007) [18] in ashwagandha. Similar kinds of results were reported by (Meena, 2015) [8] in ashwaghandha.

Physiological, biological and morphological traits of the plant are major constituent of seed yield and it has got a higher degree of complexity. The yield of the crop in general depends upon the accumulation of the photosynthates and partitioning in different parts of the plant. Significant variations were found in seed yield with the foliar application of different plant growth hormones. The highest seed yield (5.50q/ha) was recorded with the foliar treatment T_7 (CCC 750ppm), while it was lowest under the treatment T_{10} Control. Seed yield, number of fruits per plant and number of seeds per fruit were increased by foliar application of CCC 200 ppm in okra (Ashok *et al.*, 2003). Pal *et al.* (2014) [10] reported that the cycocel increased the nutrients and carbohydrates content by greatly retarding the vegetative growth of the plants and also influenced the total flower yield in terms of weight as compared with control in marigold. Similarly results were reported by Venkatsan and Shsakila (2008) [19] in medicinal solanum and Sahitya (2013) in ashwagandha.

Root yield of ashwagandha is more important, therefore to divert the source towards root through the source manipulation like growth retardant to diversified physiological forms and functions contributing to the higher root yield (Meena, 2015) [8]. The maximum root yield (461.67kg/ha) was recorded it the treatment T_1 (IBA 100ppm), while lowest root yield was recorded under treatment T_{10} Control. These plant growth regulators modify the plant characters by influencing the physiological processes within the plant body, which ultimately affect the growth and yield of crop. Therefore, plant growth regulators are playing a very important role in boosting the growth and yield and improving the quality of crop products (Swamy, 2004) [17]. Similarly results were reported by Upadhyay and Patel (2007) [18] and Bhuare *et al*. (2014) [1] in ashwagandha.

Harvest index gives the ratio of economic yield to the biological yield. Harvest index has been recognized as favourable in terms of partitioning of photosynthates to organs having economic yield (Meena *et al.* 2013) [7]. Significant variations were noted among the treatments with the application of plant growth hormones in harvest index. The highest seed harvest index (38.83%) was recorded with T_7 (CCC 750ppm) whereas, the maximum root harvest index (31.00%) in T_1 (IBA100ppm) and they were lowest under control T_{10} Control. Singh and Singh (1991) [15] stated that the source sink relationship in okra. It is evident from the results that growth and development of different plant parts in Okra were compensatory and relationship between source and sink seems to be interdependent (Meena, 2015) [8].

The response of the ashwagandha crop to any treatment is determined by measuring economic part of the plant *i.e.* root. As far as ashwagandha root is concerned the root lengths, root diameter, root fresh weight and root dry weight are important considerations. Root fresh and dry weight of root was found to be significantly influenced and was superior with the application of T_1 (IBA 100ppm), while lowest fresh and dry weight of root were recorded under treatment T_{10} control at all the growth stages of ashwagandha. Similar results were earlier reported by several workers, Shukla and Shukla (2012) [14] in ashwagandha and Rohaniyazdi *et al.* (2014) [11] in cannabis sativa and Shital *et al.* (2017) [13].

Table 1: Effect of plant growth hormones on growth of ashwagandha

Treat.	Plant height (cm plant^{-1})					Number of leaves (plant^{-1})					Number of branches (plant^{-1})				
	45 DAS	75 DAS	105 DAS	135 DAS	At harvest	45 DAS	75 DAS	105 DAS	135 DAS	At harvest	45 DAS	75 DAS	105 DAS	135 DAS	At harvest
T_1	17.07	39.17	45.80	46.97	47.27	32.80	83.00	160.00	182.33	117.80	2.67	4.33	4.83	5.17	5.17
T_2	16.83	36.39	45.40	46.27	46.43	31.93	80.47	149.20	177.33	115.07	2.33	4.17	4.50	5.00	5.00
T_3	14.80	32.97	38.40	42.60	43.13	28.07	73.67	132.96	158.17	102.67	2.00	3.33	3.67	4.17	4.50
T_4	16.50	34.87	43.13	43.93	44.00	31.40	79.33	148.33	171.67	114.07	2.33	3.67	4.33	4.44	4.67
T_5	16.80	34.47	42.60	43.27	43.93	30.93	79.00	147.67	169.40	107.73	2.00	3.50	3.83	4.33	4.67
T_6	14.30	32.30	38.90	40.50	40.63	27.40	73.00	130.33	160.67	102.67	1.67	3.17	3.67	4.17	4.33
T_7	15.87	34.20	42.60	42.87	43.43	29.93	76.40	140.33	164.67	107.00	2.00	3.50	3.83	4.33	4.50
T_8	15.07	33.90	42.07	42.87	43.00	29.47	74.47	136.33	168.47	105.27	2.00	3.33	3.83	4.33	4.50
T_9	14.13	31.57	40.53	38.53	38.53	27.07	72.00	124.33	157.13	105.00	1.67	3.17	3.33	4.00	4.33
T_{10}	16.37	35.33	45.17	45.50	45.67	31.33	78.47	147.17	170.17	112.33	2.00	3.53	3.89	4.23	4.57
S.EM±	1.20	1.26	1.28	1.10	1.02	0.37	1.14	2.79	3.11	2.09	0.24	0.19	0.27	0.59	0.14
CD at % 5	NS	3.75	3.81	3.26	3.04	1.10	3.38	8.28	9.24	6.21	0.71	0.56	0.80	0.74	0.43

Table 2: Effect of plant growth hormones on yield of ashwagandha

Treatments	Number of berries (plant^{-1})	Root girth (mm plant^{-1})	Shoot girth (mm plant^{-1})	Root shoot ratio by weight (g)	Seed yield q/ha	Root yield kg/ha	Seed harvest index (%)	Root harvest index (%)
T_1	94.60	13.43	13.87	125.40	5.43	461.33	35.93	31.00
T_2	92.63	12.97	13.37	124.23	5.40	446.33	35.67	27.33
T_3	96.13	11.83	13.27	114.57	5.27	435.00	33.67	24.00
T_4	96.20	12.90	15.70	114.33	5.42	320.00	35.67	20.67
T_5	94.53	11.57	14.40	120.00	5.27	275.33	31.60	18.00
T_6	99.20	11.83	14.07	108.47	5.33	315.33	30.50	17.67
T_7	100.20	12.30	13.69	107.67	5.50	409.33	38.83	18.00
T_8	99.27	11.97	13.63	110.49	5.47	363.67	38.67	22.00
T_9	98.60	12.27	13.93	106.08	5.33	348.00	30.67	22.67
T_{10}	81.40	10.13	12.90	103.18	4.77	269.67	25.00	14.33
S.EM.±	2.47	0.53	0.38	2.54	0.12	30.19	1.90	1.47
CD at 5%	7.34	1.59	1.12	7.54	0.34	89.71	5.63	4.38

Table 3: Effect of plant growth hormones on yield of ashwagandha

Treat.	Fresh weight of root (g plant^{-1})					Dry weight of root (g plant^{-1})				
	45 DAS	75 DAS	105 DAS	135 DAS	At harvest	45 DAS	75 DAS	105 DAS	135 DAS	At harvest
T_1	5.33	19.83	28.67	29.90	33.33	0.87	6.50	9.50	11.83	13.67
T_2	5.17	19.50	27.83	28.33	32.67	0.83	6.33	9.27	11.83	13.33
T_3	3.57	16.00	24.83	26.07	29.17	0.57	4.67	7.67	10.50	10.67
T_4	4.50	18.83	26.83	27.33	31.00	0.83	5.83	8.83	11.70	12.33
T_5	4.17	18.67	26.67	27.17	31.00	0.78	5.67	8.17	11.53	12.00
T_6	3.50	15.17	24.67	25.50	28.33	0.58	4.50	7.50	10.33	10.00
T_7	4.17	16.67	26.50	27.33	30.83	0.72	5.00	8.00	11.17	11.67
T_8	4.07	16.17	26.00	27.00	29.33	0.63	5.50	7.83	10.67	10.67
T_9	3.17	14.83	25.17	25.43	27.67	0.49	4.50	7.17	10.00	9.17
T_{10}	3.07	14.33	21.67	21.67	25.00	0.46	4.50	6.33	8.67	9.00
S.EM±	0.50	1.26	1.06	1.04	1.32	0.13	0.40	0.39	0.41	0.92
CD at % 5	1.47	3.73	3.15	3.10	3.91	NS	1.20	1.17	1.23	2.73

Conclusion

On the basis of one year research it could be concluded that the growth and yield of ashwagandha crop can be increased by plant growth hormone (IBA @ 100ppm, CCC @ 250ppm and TIBA @ 50ppm).

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