Int.J.Curr.Microbiol.App.Sci (2019) *8*(7): 2065-2074

International Journal of Current Microbiology and Applied Sciences
ISSN: 2319-7706 **Volume 8 Number 07 (2019)**
Journal homepage: http://www.ijcmas.com

Original Research Article https://doi.org/10.20546/ijcmas.2019.807.248

Response of Different Levels of Plant Spacing on Vegetative Growth and Yield Attributes of Ashwagandha (*Withania somnifera*) var. Poshita and Sarpagandha (*Rauvolfia serpentina.* Benth) var. Sheel under Open Environment and Orchard Conditions

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Keywords

Ashwagandha, Sarpagandha, Plant Spacing, Environment, Shade conditions, Growth and Yield

Article Info

Accepted:
15 June 2019
Available Online:
10 July 2019

A B S T R A C T

A field experiment was conducted during the two years research study. The experiment shows the effect of different planting distance under open based and Anola shade condition revealed that maximum vegetative growth *viz.*, plant height (104.84cm), Number of leaves per plant (215.36), Number of branches per plant (44.78), Root length (51.05 cm), Shoot length (45.82 cm), Root fresh weight (30.19 g), Root dry weight (7.59 g) and Total dry matter production (g) per plant (25.14 g) is associated with treatment T_6-S_6 Ashwagndha (M_2 S_2) 70 x 70cm (under Aonla shade condition), T_8-S_8 Sarpagandha (M_2 S_4) 50 x 50cm (under Aonla shade condition) along with T_5-S_5Ashwagndha (M_2S_1) 60 x 60cm (under Aonla shade condition). Whereas the highest yield and yield attributes parameters *viz.*, Root yield (g) per plant (38.21g), Root yield (kg) per plot (2.53kg) and Root yield tones per ha. (1.69t/ha^{-1}) was observed maximum in treatment T_8-S_8 Sarpagandha (M_2 S_4) 50 x 50cm (under Aonla shade condition). While the maximum economics and Benefit: Cost ratio i.e. (1:4.76) was also found to be the highest with treatments T_8-S_8 Sarpagandha (M_2 S_4) 50x50cm (under Aonla shade condition).

Introduction

Medicinal plants can be cultivated as pure crop, intercrop and border crop in plantation crops, perennial fruit orchards and agro-forestry plantation system. Since the cultivable land is limited, efforts are needed to push these crops along with priority crops like Aonla and Guava orchards. Introduction of highly profitable medicinal crops into the existing cropping system without completely replacing the traditional crops is a strategy that is acquiring acceptance in India. According to one estimate of botanical survey of India, about 7,500 plants are used for medicinal purposes out of 15,000 plants of our country. There is a growing demand for medicines of Ayurveda, Siddha, Unani and Homeopathy both for domestic consumption and export purposes. Out of 80,000 tonnes of

medicinal plants imported by Western countries, India tops the list of exporters to USA and Europe with a share of over 10,000 tonnes Kumar *et al.,* (2007).

The values of trade in medicinal plants are about Rs. 5,000 crores, while the world trade is about US $ 62 billion. India exports herbal products and medicines to the tune of Rs. 550 crores annually Reddy (2004). A survey indicated that the use of herbal medicines will reach to the tune of US $ 5 trillion during 2050 Kumar and Singh (2003). Currently, the Ayurvedic and herbal products turnover is estimated to be Rs. 25,000 crores.

Ashwagandha *(Withania somnifera)*, a member of family Solanaceae, in an important medicinal plant used for drugs mentioned in ancient ayurvedic literature. The plant is erect, herbaceous, evergreen to –mentose and branched under – shrub reaching upto15-170cm of height. India officially recognized over 3000 plants for their medicinal values. India being one of the 12th mega-diversity centers in the world, with this bio-resource wealth, it ranks 10th in the world and 4th in Asia having 15 to 20 thousand plants species with medicinal value of which 30 per cent are considered as endemic to India. Currently, there are about 880 species of medicinal plants in all India trade Kumar *et al.,* (2007). Among the various medicinal plants, *Withania somnifera* is also known as 'Winter cherry' in English and 'Asgandh' in Hindi. *Withania* is an important medicinal plant and it is used in Ayurvedic and Unani systems of medicine extends back over 3000 to 4000 years. The crop is grown on marginal land and is also suitable for dry land farming (Hudge *et al.,* 2002). The yield and quality in cultivated plants depend on several factors including environmental adaptability of particular cultivar or variety 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 behavior, development and bio-synthesis of secondary metabolites in medicinal and aromatic plants (Audus, 1959; Steward and Kriikorian, 1971).

Rauvolfia roots or Serpentine roots are one of the important crude drugs used in modern medicine. The global market for medicinal plants has been growing and capitalizing on the growing awareness of herbal and aromatic plants worldwide. *Rauvolfia serpentina* (L.) *Benth* belongs to the family Apocyanaceae. There are approximately 85 species in the genus *Rauvolfia* found in tropical regions. Its leaves are simple, 7.5 -10 cm long and 3.5 -5 cm broad. Root is prominent, tuberous, usually branched, 0.5 to 2.6 cm diameter, goes 40 to 60 cm deep into soil. The root bark, which constitutes 40-60% of the whole root, rich in 90% alkaloids. The fresh root emits a characteristic acrid aroma and is very bitter in taste. The plant grows generally in the region in the annual rainfall of 200-250 cm and upto an altitude of 1000 m and favors deep fertile soil with rich organic matter De and Dey, (2010). About 80 alkaloids are isolated from *Rauvolfia species*. The most important among these are reserpine, serpentine, rauvolfinine, ajmalicine, indobinine, reserpiline, serpagine, serpentinine, rescinamine, doserpidine, ajmaline, ajmalinine, sandwicolidine, ajmlicidine, yohimbine etc. (Deshmukh *et al.,* 2012). The total alkaloid content varies from 1.7-3% of the dried roots depending upon varieties and cultivation practices. *Rouvolfia* has been categorized as an endangered species based on the IUCN Red Data Book and critically endangered in CAMP 2001 report Bhattarai *et al.,* (2002) (Table 1).

Rauvolfia is used in Ayurveda, Siddha and Yunani sciences of medicines for the treatment of high blood pressure, insomnia, cardiac diseases and a number of mental

problems such as psychic disorders, mental retardation, epilepsy, agitation and neurotic disorders. The powder of Sarpagandha roots is also used for the treatment of snakebites or snake poisoning. Root decoction and leaves are given to cure snakebite in Satar tribe of Morang and Jhapa districts Siwakoti and Siwakoti (2000). Extracts of the roots are valued for intestinal troubles; aqueous decoction of root is given to cattle in diarrhoea Dey (1998). Since the information on these aspects of Ashwagandha and sarpagandha is meager and have a standardization of agro-techniques for its cultivation and shall leads a long way to research works and practice of commercial cultivation among the growers. The present investigation on Ashwagandha and Sarpagandha was conducted to evaluate the Response of different levels of plant spacing on vegetative growth and yield performance of Ashwagandha *(Withania Somnifera)* var. Poshita and Sarpagandha (*Rauvolfia serpentina.* Benth) var. Sheel under open environment and orchard shade conditions.

Materials and Methods

A field experiment on research entitled "Response of different levels of plant spacing on vegetative growth and yield attributes of Ashwagandha (*Withania Somnifera*) var. Poshita and Sarpagandha (*Rauvolfia serpentina.* Benth) var. Sheel under open environment and orchard conditions" was conducted at Central Orchard, Horticulture Research Farm, Department of Horticulture, Naini Agricultural Institute (NAI), Sam Higginbottom University of Agriculture, Technology and Sciences, (SHUATS) Prayagraj (Allahabad) along with the support of financial assistance through U.P. Council of Agricultural Research (UPCAR) Lucknow, U.P. India. The area is situated on the south of Prayagraj (Allahabad) on the right bank of the river Yamuna at Rewa Road at a distance of about 6 Km from Prayagraj city. It is positioned at 25.41^0N latitude and 81.84^0E longitude and about 98 m from above mean sea level. Prayagraj has sub-tropical climate, which prevails in the South-East part of Uttar Pradesh, with the both extremes of temperature i.e. the winters and the summers. In fairly cold winters (during Oct-Feb), the temperature falls to nearly $2\text{-}5^0$C, sometimes below as 1^0C. During summer (March-June), the temperature raises upto 46^0C, sometimes peak $48\text{-}49^0$C with low relative humidity (20%) and dust laden winds. During monsoon (June-Sept) it reaches 85% with average rainfall of 1100 mm. The soil of experimental plot was well drained, fairly level land rich in sandy loam texture along with uniform fertility with optimum level of soil microbes' availability status along with low clay and higher percentage of sand particles. The experiment was design with 8 treatments and laid out in Randomized Block Design (RBD) with 3 replications on well prepared and pulverized piece of land. The allocation of these 8 treatment combination was done randomly. All the cultural practices related to Ashwagandha and Sarpagandha was conducted as per recommended requirement. Under this research work a nursery block was established to fulfill the availability and requirement of planting material throughout the research programme. Seedlings of Ashwagandha and Sarpagandha was raised through bed system technique (raised bed method) followed by establishment of 2000 plants each for Ashwagandha and Sarpagandha through cup system. The planting materials which was evolved is used for cultural operations like re-planting, gap-filling and transplanting under open condition and orchard based shade condition. The treatment combinations were formulated from two different spacings of Ashwagandha and Sarpagandha under open based enviornment and Aonla shade condition *viz.*, T_1-S_1Ashwagndha (M_1 S_1) 60 x 60cm (under

open condition), T_2-S_2Ashwagndha (M_1 S_2) 70 x 70cm (under open condition), T_3-S_3Sarpagandha (M_1 S_3) 40 x 50cm (under open condition), T_4-S_4 Sarpagandha (M_1 S_4) 50 x 50cm (under open condition), T_5-S_5Ashwagndha (M_2 S_1) 60 x 60cm (under Aonla shade condition), T_6-S_6 Ashwagndha (M_2 S_2) 70 x 70cm (under Aonla shade condition), T_7-S_7 Sarpagandha (M_2 S_3) 40 x 50cm (under Aonla shade condition), T_8-S_8Sarpagandha (M_2 S_4) 50 x 50cm (under Aonla shade condition). The data were recorded on vegetative growth and yield attributes. The mean data of each character was subjected to statistical analysis of variance and test the significance of each character as per the procedure of Panse and Sukhatme (1967).

Results and Discussion

The Analysis of variance revealed significant differences among different treatment combination. A wide range of variations among the different combination of shade condition and different spacing of Ashwagandha and Sarpagandha in respect of Plant height (cm), Number of leaves per plant, Number of branches per plant, Root length (cm), Shoot length (cm), Root fresh weight (g), Root dry weight (g) per plant, Total dry matter production (g) per plant, Root yield (g) per plant, Root yield (kg) per plot and Root yield (t ha^{-1}) were recorded.

The maximum plant height (104.84cm) was recorded in treatment T_6-S_6Ashwagndha (M_2 S_2) 70 x 70cm (under Aonla shade condition) and the minimum plant height (59.14cm) was found in treatment T_3-S_3Sarpagandha (M_1 S_3) 40 x 50cm (under open condition). Similar findings were also reported by Manish *et al.*, (2003), Pakkiyanathan *et al.*, (2004), Kahar *et al.*, (1991) and Mohd. Abbas *et al.*, (1994).

The maximum Number of leaves per plant (215.36) was recorded with T_8-S_8 Sarpagandha (M_2 S_4) 50 x 50 cm (under Aonla shade condition) and the minimum Number of leaves per plant (193.62) was found in treatment T_1-S_1 Ashwagndha (M_1 S_1) 60 x 60cm (under open condition). The maximum Number of branches per plant (44.78) was recorded in T_5-S_5 Ashwagndha (M_2 S_1) 60 x 60cm (under Aonla shade condition) and the minimum Number of branches per plant (22.65) was found in treatment T_7-S_7Sarpagandha (M_2 S_3) 40 x 50cm (under Aonla shade condition) were due to availability of more space, soil moisture and nutrients to individual plants. Similar findings were reported by Agarwal *et al.*, (2003), Desai *et al.*, (2017), Kahar *et al.*, (1991) and Mohd. Abbas *et al.*, (1994). The maximum Root length (51.05cm) was concealed with in T_8-S_8 Sarpagandha (M_2 S_4) 50 x 50cm (under Aonla shade condition) and the minimum Root length (30.51cm) was found in treatment T_1-S_1Ashwagndha (M_1 S_1) 60 x 60cm (under open condition). The maximum Shoot length (45.82cm) was observed with T_6-S_6Ashwagndha (M_2 S_2) 70 x 70cm (under Aonla shade condition) and the minimum Shoot length (39.07cm) was found in treatment T_1-S_1Ashwagndha (M_1 S_1) 60 x 60cm (under open condition). The maximum Root fresh weight (30.19g) was pertain with T_6-S_6Ashwagndha (M_2 S_2) 70 x70cm (under Aonla shade condition) and the minimum Root fresh weight (g) (17.51g) was found in treatment T_4-S_4Sarpagandha (M_1 S_4) 50 x 50cm (under open condition).

These results were in conformity with the findings of Patel *et al.*, (2004) and Desai *et al.*, (2017), Kahar *et al.*, (1991) and Mohd. Abbas *et al.*, (1994). in Ashwagandha. The maximum Root dry weight (g) (7.59g) was recorded in T_8-S_8Sarpagandha (M_2 S_4) 50 x 50cm (under Aonla shade condition) and the minimum Root dry weight (5.66g) was found in treatment T_1-S_1Ashwagndha (M_1 S_1) 60 x 60cm (under open condition) (Fig. 1 and 2).

Table.1 Impact of different levels of plant spacing on growth and yield attributes of Ashwagandha *(Withania Somnifera)* var. Poshita and Sarpagandha (*Rauvolfia serpentina.* Benth) var. Sheel under different open environment and shade condition

Treatments	Plant height (cm)	No. of leaves per plant	No. of branches per plant	Root length (cm)	Shoot length (cm)	Root fresh weight (g)	Root dry wt. (g) per plant	Total dry matter production (g) per plant	Root yield (g) per plant	Root yield (kg) per plot	Root yield (t ha^{-1})
T_1-S_1Ashwagndha (M_1S_1) 60x60cm (under open condition)	104.29	193.62	42.40	30.51	39.07	28.34	5.66	24.34	9.17	0.43	0.27
T_2-S_2Ashwagndha (M_1S_2) 70x70cm (under open condition)	101.18	195.62	43.10	32.30	42.11	27.52	6.10	25.02	8.89	0.35	0.20
T_3-S_3Sarpagandha (M_1S_3) 40x50cm (under open condition)	59.14	207.85	23.08	46.11	0.00	19.50	7.06	0.00	13.04	1.49	1.33
T_4-S_4Sarpagandha (M_1S_4) 50x50cm (under open condition)	61.11	212.74	23.29	47.09	0.00	17.51	7.44	0.00	34.16	2.20	1.41
T_5-S_5Ashwagndha (M_2S_1) 60x60cm (under Aonla shade)	104.05	198.93	44.78	33.48	43.21	29.25	6.33	25.14	9.51	0.50	0.32
T_6-S_6Ashwagndha (M_2S_2) 70x70cm (under Aonla shade)	104.84	202.58	43.63	36.47	45.82	30.19	6.80	24.80	10.17	0.69	0.22
T_7-S_7Sarpagandha (M_2S_3) 40x50cm (under Aonla shade)	61.20	211.49	22.65	50.63	0.00	18.50	7.52	0.00	32.31	1.85	1.50
T_8-S_8Sarpagandha (M_2S_4) 50x50cm (under Aonla shade)	62.32	215.36	23.49	51.05	0.00	19.75	7.59	0.00	38.21	2.53	1.69
F-test	S	S	S	S	S	S	S	S	S	S	S
C.D. at 05	0.031	0.051	0.049	0.111	0.051	0.048	0.394	0.394	10.729	0.041	9.657
Sed.	0.014	0.024	0.023	0.052	0.024	0.022	0.183	0.183	5.003	0.019	4.502

Table.2 Economics with Benefit: Cost ratio of Ashwagandha and Sarpagandha as a (intercrops) under different treatments.

Tr. Symbol	Treatment Combinations	Cost of cultivation (Rs. ha^{-1})	Root Yield (t/ ha^{-1})	Root Selling (Rate/kg)	Gross Return (Rs. Qt / ha^{-1})	Net return (Rs. Qt / ha^{-1})	B:C Ratio
T_1	T_1-S_1Ashwagndha (M_1 S_1) 60x60cm (under open condition)	33, 834	0.27	175	47250	13416	1: 1.40
T_2	T_2-S_2Ashwagndha (M_1 S_2) 70x70cm (under open condition)	33, 834	0.20	175	35000	1166	1: 1.03
T_3	T_3-S_3Sarpagandha (M_1 S_3) 40x50cm (under open condition)	88, 700	1.33	250	332500	243800	1: 3.75
T_4	T_4-S_4Sarpagandha (M_1 S_4) 50x50cm (under open condition)	88, 700	1.41	250	352500	263800	1: 3.97
T_5	T_5-S_5Ashwagndha (M_2 S_1) 60x60cm (under Aonla shade condition)	33, 834	0.32	175	56000	22166	1: 1.66
T_6	T_6-S_6Ashwagndha (M_2 S_2) 70x70cm (under Aonla shade condition)	33, 834	0.22	175	38500	4666	1: 1.14
T_7	T_7-S_7Sarpagandha (M_2 S_3) 40x50cm (under Aonla shade condition)	88, 700	1.50	250	375000	286300	1: 4.23
T_8	T_8-S_8Sarpagandha (M_2 S_4) 50x50cm (under Aonla shade condition)	88, 700	1.69	250	422500	333800	1: 4.76

Fig.1 Influence of different levels of plant spacing on vegetative growth parameters of Ashwagandha *(Withania Somnifera)* var. Poshita and Sarpagandha (*Rauvolfia serpentina.* Benth) var. Sheel under different environmental condition

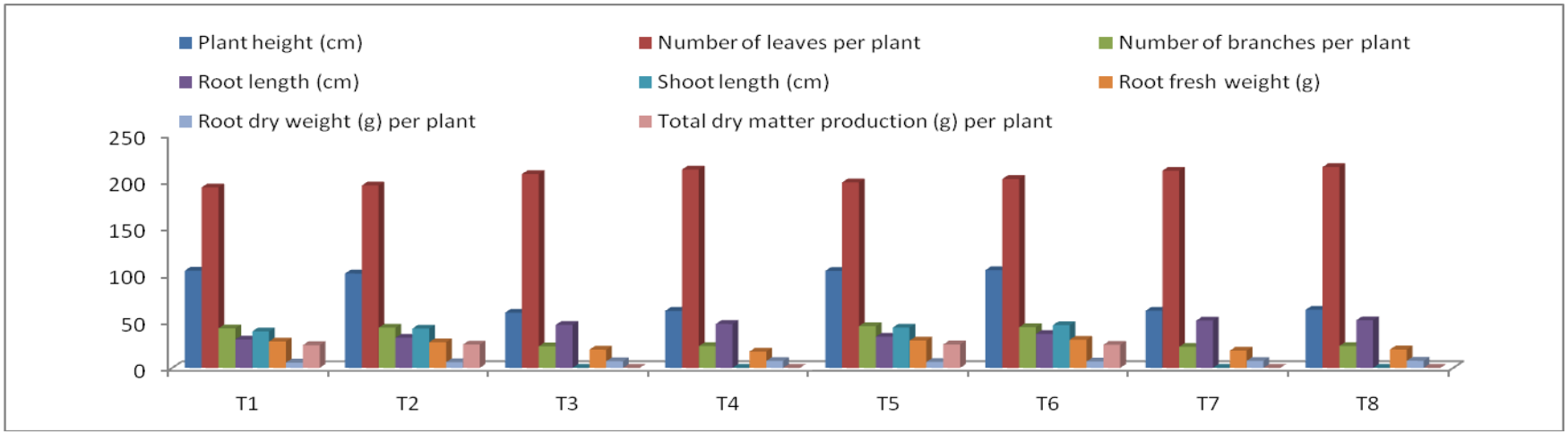
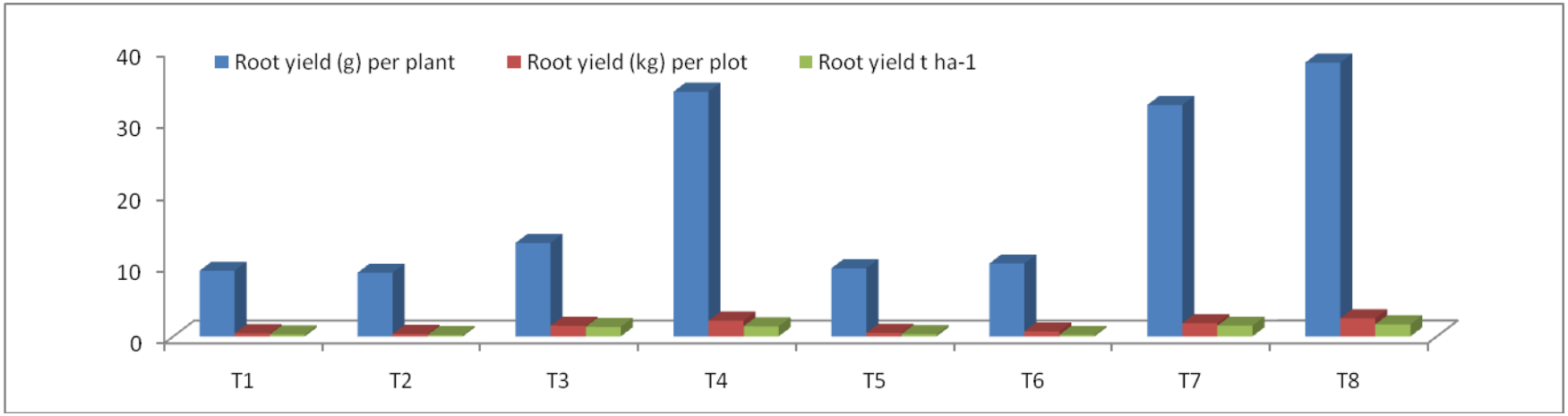


Fig.2 Effect of different levels of plant spacing on yield performance of Ashwagandha *(Withania Somnifera)* var. Poshita and Sarpagandha (*Rauvolfia serpentina.* Benth) var. Sheel under open environment and shade condition



The maximum Total dry matter production per plant (25.14g) was recorded with T_5-S_5Ashwagndha (M_2 S_1) 60 x 60cm (under Aonla shade condition) and the minimum Total dry matter production per plant (24.34g) was found in treatment T_1-S_1Ashwagndha (M_1 S_1) 60 x 60cm (under open condition). These results are in accordance with Kubsad *et al.,* (2008), Kahar *et al.,* (1991), Mohd. Abbas *et al.,* (1994), Desai *et al.,* (2017). The maximum Root yield per plant (38.21g) was recorded in T_8-S_8Sarpagandha (M_2 S_4) 50 x 50cm (under Aonla shade condition) and the minimum Root yield per plant (9.17g) was concealed with treatment T_1-S_1Ashwagndha (M_1 S_1) 60 x 60cm (under open condition). The maximum Root yield per plot (2.53kg) was recorded with T_8-S_8Sarpagandha (M_2 S_4) 50 x 50cm (under Aonla shade condition) and the minimum Root yield per plot (0.35kg) was pertain with treatment T_2-S_2Ashwagndha (M_1 S_2) 70 x 70cm (under open condition). The maximum Root yield (1.69 t/ha^{-1}) with the application T_8-S_8Sarpagandha (M_2 S_4) 50 x 50cm (under Aonla shade condition) and the minimum Root yield (0.20 t/ha^{-1}) were found in treatment T_2-S_2Ashwagndha (M_1 S_2) 70 x 70cm (under open condition). Similar results were also observed by Maheshwari *et al.,* (2000) and Desai *et al.,* (2017). The above results are in close conformity with those of Kahar *et al.,* (1991) and Mohd. Abbas *et al.,* (1994).

The data presented in Table 2 indicated that the response of different plant spacing under different environmental condition (Open and Aonla shade). The maximum Gross return (422500), Net return (333800) and Benefit: cost ratio (1:4.76) was observed highest with treatment T_8-S_8Sarpagandha (M_2 S_4) 50 x 50cm (under Aonla shade condition) along with highest Gross return (56000), Net return (22166) and Benefit: cost ratio (1:1.66) was found best in treatment T_5 S_5Ashwagndha (M_2 S_1) 60 x 60cm (under Aonla shade condition) respectively. Based on the above findings and economic returns, it is concluded that the potential production of Ashwagandha and Sarpagandha can be secured by raising the crop with a different plant spacing under suitable environmental condition of Prayagraj (Allahabad) agro-climatic region. The above results are in close conformity with those Kapur *et al.,* (2010), Srinivasappa *et al.,* (1999) and Chandrashekhar *et al.,* 2007).

In conclusion, the demand, acceptability and market value of Sarpgandha and Ashwagandha is increasing rapidly for medicinal utility around the globe. The modern scientific agro-cultivation approaches of Ashwagandha and Sarpagandha practiced as an intercrop with different plant spacing under different environmental conditions (Open & shade) has a great impact on successive vegetative growth, yield potential and market profitability in India. Replacing traditional practices, systematic agricultural activities can play a significant role in maintaining the status of environment.

Hence the above experimental findings concluded that Ashwagandha and Sarpagandha when accommodate with different planting distance i.e. T_8-S_8Sarpagandha (M_2 S_4) 50 x 50cm (under Aonla shade condition), T_5-S_5Ashwagndha (M_2 S_1) 60 x 60cm (under Aonla shade condition) and T_6-S_6Ashwagndha (M_2 S_2) 70 x 70cm (under Aonla shade condition) was recorded the best treatment combination in-terms of maximum vegetative growth and Root yield. While the highest economics and B:C ratio (1:4.76) was obtained with treatments T_8-S_8Sarpagandha (M_2 S_4) 50 x 50cm (under Aonla shade condition). Therefore investigation of this research project reveals that Ashwagandha & Sarpagandha are grown as an intercrops which shows high economic returns, more foreign exchange, high benefit: cost ratio.

Whereas these crops are also very much found to be viable, adaptable, tolerant against water stress, heat stress, resistant against several insect-pest & diseases and also they were recommended for its commercial cultivation under existing perennial Aonla orchard.

Acknowledgment

The authors are very much delighted, grateful and thankful to the U.P. Council of Agricultural Research (UPCAR), Lucknow, and Department of Horticulture, Sam Higginbottom University of Agriculture, Technology and Sciences, (SHUATS), Prayagraj (Allahabad), Uttar Pradesh-211007, India for providing all necessary helps, facilities and financial assistance during the course of whole research investigation.

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How to cite this article:

Saravanan, S.S., Deepak Lall, Vijay Bahadur and Sanjeev Kumar. 2019. Response of Different Levels of Plant Spacing on Vegetative Growth and Yield Attributes of Ashwagandha (*Withania somnifera*) var. Poshita and Sarpagandha (*Rauvolfia serpentina.* Benth) var. Sheel under Open Environment and Orchard Conditions. *Int.J.Curr.Microbiol.App.Sci.* 8(07): 2065-2074.
doi: https://doi.org/10.20546/ijcmas.2019.807.248