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Effect of organic manures and bio-inoculants on dry root yield, quality and economics of Ashwagandha (*Withania somnifera* L. Dunal.)

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Abstract
An investigation was carried out to study the effect of organic manures and bio-inoculants (Azatobacter, Azospirillum, PSB and VAM) on yield, quality and economics of ashwagandha by comparing with RDF at K.R.C.C.H. College of Arabhavi. The results showed that yield parameters viz number of berries per plant (219.33), seed yield (3.15 q/ha), fresh root (19.58 q/ha) and dry root yield (5.88 q/ha) recorded maximum with the application of RDF + VAM, Quality parameter like root length and root diameter recorded maximum (27.07 cm, 1.88 cm, respectively) in T_3-RDF (N:P:K-40:50:40 kg/ha) + FYM (5 t/ha) + VAM (25 kg/ha), which was on par results of T_1, T_7 and T_5. Maximum total alkaloid content (0.31%) recorded in T_7-FYM (5 t/ha) + Azotobacter (625 g/ha) + Azospirillum (625 g/ha) + PSB (625 g/ha) + VAM (25 kg/ha) + (Panchagavya-3% + Amruthapani-3% at 15 days interval up to harvest of crop), however treatments T_3, T_1 and T_5 have shown on par results and gross return (Rs.119700/ha), net return (Rs.1,02,066/ha) and B:C ratio (6.78), however the organic treatment T_7 have shown on par results in growth, yield parameters and economics.

Keywords: Ashwagandha, Vesicular arbuscular mycorrhiza, bio-inoculants, RDF, Organic treatments

Introduction
Ashwagandha or Asgandh (*Withania somnifera* L. Dunal.*)* popularly known as 'Indian Ginseng' belongs to the family Solanaceae. It is found in wild state in the Mediterranean region of North Africa. In India it is mainly cultivated in Mandsaur district of Madhya Pradesh, adjoining villages of Kota district of Rajasthan, Punjab and Karnataka. Ashwagandha roots and occasionally its leaf and seeds are used in ayurvedic and unani medicines preparations. (Majumdar, 1955) [4]. The total alkaloid content of the Indian ashwagandha roots 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) [17]. The roots are prescribed in medicines for hiccup, several female disorders, bronchitis, rheumatism, dropsy and stomach, lung inflammation and skin diseases. They are mostly used for curing general and sexual disabilities. Roots are having anti aging property (Savitha *et al.,* 2009) [14]. The leaves are used to cure eye boils, and swellings of hands and feet, in treatment of syphilis, to kill the lice infecting the body. The leaf decoction is used for treatment of haemorrhoids and arthritis.

Materials and Methods
The field experiment was carried out in the division of plantation, Spices, Medicinal and Aromatic Crops, college of horticulture, Arabhavi during 2016-2017.The experiment was laid out in randomized block design with 7 treatments *viz.*,T_1 -Recommended dose of fertilizers (N: P: K- 40:50:40 kg/ha) + FYM (5 t/ha), T_2- FYM (5 t/ha) + Vermicompost-1.33 t/ha (N equivalent weight), T_3-T_1 + VAM (25 kg/ha), T_4- FYM (5 t/ha) + VAM (25 kg/ha), T_5- FYM (5 t/ha) + VAM (25 kg/ha) + (Panchagavya-3% + Amruthapani-3% at 15 days' interval up to harvest crop), T_6 -FYM (5 t/ha) + Azotobacter (625 g/ha) + Azospirillum (625 g/ha) + PSB (625 g/ha) + VAM (25 kg/ha) and T_7- T_6 + (Panchagavya-3% + Amruthapani-3% at 15 days' interval up to harvest of crop) and 3 replications. The spacing followed was 30 x 20 cm.
The benefit cost ratio was worked out by using the following formula.

$$\text{Benefit: cost ratio (B: C ratio)} = \frac{\text{Gross income (Rs/ha)}}{\text{Cost of cultivation (Rs/ha)}}$$

The effect of organic manures and bio-inoculants on yield, quality and economics of ashwagandha are summarized in the Table 1, 2&3.

Results and Discussion

Number of berries per node and seed yield were significantly influenced by application of organic manures and bio-inoculants (Table 1). At harvest, maximum number of berries per plant (219.33) was recorded in T_3-Recommended dose of fertilizers (N:P:K-40:50:40 kg/ha) + FYM (5 t/ha) + VAM (25 kg/ha), it was on par with T_1 (213.33/plant), T_7 (211.67/plant) and T_5 (210.13/plant).There was appreciable increase in the number of berries per plant due to excellent growth and development of root and shoot particularly more assimilatory area on account of balanced and timely supply of all the essential nutrients which in turn led to better partitioning of photosynthates from source to the sink (seeds). Similar results has been reported by Shrivatsav and Sahu (2013) [15] in ashwagandha.

Seed yield was influenced with application of organic manures and bio-inoculants (Table 1). At harvest maximum seed yield (3.15 q/ha) was obtained in T_3-Recommended dose of fertilizers (N:P:K- 40:50:40 kg/ha) + FYM (5 t/ha) + VAM (25 kg/ha), it was on par with T_1 (3.09 q/ha) and T_7 (3.0 q/ha).The enhanced seed yield in particular treatment might be due to availability of nutrients in the soil throughout the growing phase and also due to enhanced carbohydrates synthesis and effective translocation of the photosynthates to the sink and the results are in line with the findings of with Pakkiyanthan *et al.* (2004) [5], Panchabhai *et al.* (2005) [6] in ashwagandha. Immediate supply of plant nutrients by inorganic sources has enhanced seed yield were realized.

Fresh and dry root yield was significantly influenced by the application of organic manures and bio-inoculants in ashwagandha.

At harvest fresh and dry root yield were significantly influenced by treatments. The highest fresh root yield (19.58 q/ha) was recorded in T_3-Recommended dose of fertilizers (N:P:K- 40:50:40 kg/ha) + FYM (5 t/ha) + VAM (25 kg/ha), it was on par with T_1 (19.50 q/ha), T_7 (19.49 q/ha), T_5 (19.12 q/ha) and T_6 (18.61 q/ha) recorded. Highest dry root yield (5.88 q/ha) recorded in T_3-Recommended dose of fertilizers (N:P:K- 40:50:40 kg/ha) + FYM (5 t/ha) + VAM (25 kg/ha) it was on par with T_1 (5.27 q/ha) and T_7 (5.00 q/ha).

The combined application of inorganic fertilizer and organic manures (FYM) might have supplied adequate amount of nutrients, favoured metabolic rate, auxin activities in the plant, resulting in better yield attributes and higher root yield. These results are in agreement with Maheshwari *et al.* (2000) [3], Ajay *et al.* (2005) [1] in ashwagandha and Somanath *et al.* (2005) [16] in coleus.

The VAM fungus and bio-formulations, increased root geometry, nutrient access and supply resulting in the development of sound and healthy rhizosphere with increased extramycelial hyphae might had further contributed to improved growth resulting in increased nutrient uptake, photosynthesis and excellent biochemical activities. Similar results were also reported Sakhubai *et al.* (2014) [13] in buckwheat and Ravikumar *et al.* (2010) [10] in coleus, Vajantha *et al.* (2014) [18] in ashwagandha.

Significant difference was observed in root length and root diameter due to application of organic manures and bio-inoculants. At harvest, maximum root length (27.07 cm) and root diameter (1.88 cm) were recorded in T_3-Recommended dose of fertilizers (N:P:K- 40:50:40 kg/ha) + FYM (5 t/ha) + VAM (25 kg/ha). It was on par with T_1 (26.47 cm, 1.84 cm of root length and root diameter, respectively), T_7 (26.13 cm, 1.83 cm of root length and root diameter, respectively) and T_5 (24.27 cm, 1.81 cm of root length and root diameter, respectively).This might be due to the favourable soil condition by the incorporation of organic manures and further, the inorganic fertilizers would have created congenial condition for better uptake of nutrients and better development of root length and root diameter. These results are in conformity with Rashmi (2013) [9] in ashwagandha, Somnath *et al.* (2005) [16] and Ravikumar *et al.* (2012) [11] in coleus and Sandhya *et al.* (2013) [12] in *Marsdenia volubilis*.

Alkaloid content differed significantly due to application of organic manures bio-inoculants (Table 2). Maximum alkaloid content (0.31%) was recorded with application of T_7 -FYM (5 t/ha) + Azotobacter (625 g/ha) + Azospirillum (625 g/ha) + PSB (625 g/ha) + VAM (25 kg/ha) + (Panchagavya-3% + Amruthapani-3% at 15 days interval), it was on par with T_3 (0.29%), T_1 (0.27%) and T_5 (0.26%). Favourable soil condition due to the incorporation of organic and a bio-inoculants nutrient source were congenial for better development of root. This might have resulted in higher alkaloid accumulation. The results obtained in the present investigation are in agreement with earlier findings of Rajamani *et al.* (2007) [7] in turmeric, Das *et al.* (2008) [2] in stevia, Ravikumar *et al.* (2012) [11] in coleus and Sandhya *et al.* (2013) [12] in *Marsdenia volubilis*, Rajasekar and Elango (2011) [8] in ashwagandha.

Highest gross return (Rs.1,19,700/ha), net return (Rs.1,02,066/ha) and B:C ratio (6.78) was observed in T_3-RDF (N:P:K-40:50:40 kg/ha) + FYM (5 t/ha) + VAM (25 kg/ha), it was followed by T_1 (Rs.1,09,950/ha, Rs.93,316/ha and 6.6, respectively) followed by T_7 (Rs.1,03,800 /ha, Rs.83,888/ha and 5.21, respectively). Similar results were reported by Sakhubai *et al.* (2014) [13] in buckwheat and Ravikumar *et al.* (2012) [11] in coleus

Table 1: yield of ashwagandha at after harvest

Treatments	Number of berries/ plant	Seed yield (q/ha)	Fresh root yield (q/ha)	Dry root yield (q/ha)
T_1-Recommended dose of fertilizers (control) N:P:K- 40:50:40 kg per ha + FYM-5 t/ha	213.33	3.09	19.50	5.27
T_2- FYM (5 t/ha) +Vermicompost-1.33 t/ha (N equivalent weight)	183.87	2.25	15.87	4.21
T_3- T_1 +VAM (25 kg/ha)	219.33	3.15	19.58	5.88
T_4-FYM (5 t/ha) + VAM (25 kg/ha)	192.33	2.38	17.03	4.41
T_5- FYM (5 t/ha) +VAM (25 kg/ha) + (Panchagavya -3% + Amruthapani -3% at 15 days interval)	210.13	2.71	19.12	4.72
T_6- FYM (5 t/ha) + Azotobacter (625 g/ha) + Azospirillum (625 g/ha) + PSB (625 g/ha) + VAM (25 kg/ha)	208.67	2.45	18.61	4.58
T_7-T_6+ (Panchagavya -3% + Amruthapani -3% at 15 daysinterval)	211.67	3.03	19.49	5.00
Mean	205.62	2.72	18.46	4.85

SEm ±	3.49	0.13	0.71	0.32
CD at 5%	10.74	0.40	2.18	0.97

Table 3: Economics of ashwagandha (*Withania somnifera* L. Dunal.) influenced by organic manures and bio-inoculants.

Treatment	Total cost of cultivation (Rs ha^{-1})	Gross returns (Rs ha^{-1})	Net returns (Rs ha^{-1})	Benefit : Cost ratio
T_1-Recommended dose of fertilizers (control) N:P:K-40:50:40 kg per ha + FYM-5 t/ha	16634	109950	93316	6.6
T_2- FYM (5 t/ha) +Vermicompost-1.33t/ha (Nequivalent weight)	22200	85650	63450	3.85
T_3- T_1 +VAM (25 kg/ha)	17634	119700	102066	6.78
T_4-FYM (5 t/ha) + VAM (25 kg/ha)	16550	89950	73400	5.43
T_5- FYM (5 t/ha) +VAM (25 kg/ha) + (Panchagavya -3% + Amruthapani -3% at 15 days interval)	19799	97900	78101	4.94
T_6- FYM (5 t/ha) + Azotobacter (625g/ha) + Azospirillum (625g/ha) + PSB (625g/ha) + VAM (25 kg/ha)	16663	93200	79537	5.59
T_7-T_6+ (Panchagavya -3% + Amruthapani -3% at 15 days interval)	19912	103800	83888	5.21

Table 2: Root length (cm), root diameter (cm) and total alkaloid content as influenced by different nutrient sources and their combination with bio-inoculants in ashwagandha

Treatments	Root length (cm)	Root diameter (cm)	Total alkaloid content (%)
T_1-Recommended dose of fertilizers (control) N:P:K-40:50:40 kg per ha + FYM-5 t/ha	26.47	1.84	0.27
T_2- FYM (5 t/ha) +Vermicompost-1.33t/ha (Nequivalent weight)	21.03	1.60	0.20
T_3- T_1 +VAM (25 kg/ha)	27.07	1.88	0.29
T_4-FYM (5 t/ha) + VAM (25 kg/ha)	22.73	1.70	0.22
T_5- FYM (5 t/ha) +VAM (25 kg/ha) + (Panchagavya – 3% + Amruthapani -3% at 15 days interval)	24.27	1.81	0.26
T_6- FYM (5 t/ha) + Azotobacter (625 g/ha) + Azospirillum (625 g/ha) + PSB (625 g/ha) + VAM (25 kg/ha)	23.17	1.79	0.24
T_7-T_6+ (Panchagavya -3% + Amruthapani -3% at 15 days interval)	26.13	1.83	0.31
Mean	24.41	1.78	0.26
SEm ±	1.02	0.06	0.02
CD at 5%	3.13	0.18	0.06

*VAM: Vesicular Arbuscular Mycorrhiza, FYM: Farm Yard Manure, RDF: Recommended Dose of Fertilizers,
DAS - Days After Sowing, PSB: Phosphate Solubilising Bacteria,

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