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Effect of different organic sources of nutrients on growth and root yield of Ashwagandha (*Withania somnifera* (L.) Dunal

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Abstract
The present investigation entitled effect of different organic sources of nutrients on the growth and root yield Ashwagandha [*Withania somnifera* (L.) Dunal] was carried out during *Kharif* 2021-22 at College Farm, College of Horticulture, Sardarkrushinagar Dantiwada Agricultural University, Jagudan, Dist. Mehsana and Gujarat. Experiment was laid out in randomized block design with three replications and twenty treatments. The results revealed that significantly maximum plant height (35.45 and 54.83 cm) and number of branches (5.53 and 7.17) were recorded with treatment T_{16}: 80% RDN through Poultry manure + *Azotobacter* + KSM at 90 DAS and at harvest, respectively. Maximum fresh and dry weights of plant (46.08 and 16.94 g, respectively) at harvest were also noted with same treatment. The similar trends were also recorded in yield and yield contributing traits *viz.*, maximum root length (23.79 cm), root diameter (1.34 cm), fresh root weight per plant (6.35 g), fresh root weight per plot (231.44 g), fresh root weight per hectare (1285.80 kg), dry root weight per plant (2.78 g), dry root weight per plot (100.61 g) and dry root weight per hectare (558.96 kg) with treatment T_{16}.

Keywords: Organic sources, growth parameters, root yield

Introduction
Ashwagandha (*Withania somnifera* (L.) Dunal) commonly known as asgandh is one of the most important medicinal plants that belongs to family Solanaceae. It is an erect, small, annual shrub having indeterminate growth habit with 40 to 60 centimeters height. The species is under domestication for a long period in the central India. It is of interest to record that cultivated plants have sizable difference for the wild plants, not only in their morphological characters including less branching and height but also in their therapeutically action. The roots of wild plants are heavily branched and fibrous, therefore, considered as low grade quality.
The quality of the raw herbal drug or medicinal herb is the major concern regarding export in international market. One of the major factors contributing to the poor quality of the medicinal herb is represented by their residues and contaminants. These residues (pesticides and other synthetic chemicals) and contaminants (heavy metals) can accumulate during cultivation of medicinal herbs and may have adverse effects on the consumer health (Tripathy *et al*., 2015) [11]. In this context, organic cultivation technology is the only solution to produce quality medicinal herb by avoiding excessive use of synthetic fertilizers and chemicals. Introduction 3 Organic manures have several advantages like they supply plant nutrients, including micronutrients, and improve soil biological properties. Organic nutrient sources (FYM and vermicompost) can be utilized as plant growth media and soil conditioner which supply plant nutrients slowly but steadily throughout the plant growth period (Mandal *et al*., 2009 [9]; Basak *et al*., 2013) [11]. In addition to that, the bioinoculants improve plant available nutrients in the rhizosphere and also release plant growth promoting substances (Arpna and Bhagyaraj, 2007). Some promising results were observed regarding the improvement of quality in medicinal and aromatic plants through organic nutrient managements (Khan *et al*., 2015) [6].
At the same time, there is increasing demand of organically products or certified medicinal herbs which are eco-friendly and free from synthetic chemicals (Khan *et al.,* 2015) [6]. Considering the economic importance of ashwagandha in national and international markets and possible environmental benefits, organic nutrient management is the need of the hour. Therefore, present studies were aimed at promotion of high valued ashwagandha by using of organic fertilizers and bio fertilizers to obtain better growth and yield of ashwagandha for

North Gujarat. Keeping this view in consideration an experiment entitled Effect of different organic sources of nutrients on the growth and Yield Ashwagandha [*Withania somnifera* (L.) Dunal].

Materials and Methods

The present investigation on the effect of different organic sources of nutrients on the growth and yield of ashwagandha [*Withania somnifera* (L.) Dunal] was carried out at College Farm, College of Horticulture, Sardarkrushinagar Dantiwada Agricultural University, Jagudan. Dist. Mehsana, Gujarat during kharif season of the year 2021-2022. Treatments consisted different recommended dose of fertilizer (100%, 80%and 60%) with organic fertilizers such as vermicompost, neem cake, poutry manure, FYM and combination with KSB, Azotobactor and PSB. The experiment consisted of twenty treatments comprising T_1 100% RDN through FYM, T_2 100% RDN through Vermicompost, T_3 100% RDN through Neem cake, T_4 100% RDN through Poultry manure, T_5 80% RDN through FYM, T_6 80% RDN through Vermicompost, T_7 80% RDN through Neem cake, T_8 80% RDN through Poultry manure, T_9 60% RDN through FYM, T_{10} 60% RDN through Vermicompost, T_{11} 60% RDN through Neem cake, T_{12} 60% RDN through Poultry manure, T_{13} 80% RDN through FYM +Azotobacter + KSM + PSB, T_{14} 80% RDN through Vermicompost + Azotobacter + KSM + PSB, T_{15} 80% RDN through Neem cake + Azotobacter + KSM + PSB, T_{16} 80% RDN through Poultry manure + Azotobacter + KSM + PSB, T_{17} 60% RDN through FYM + Azotobacter + KSM + PSB, T_{18} 60% RDN through Vermicompost + Azotobacter + KSM + PSB, T_{19} 60% RDN through Neem cake + Azotobacter + KSM + PSB, T_{20} 60% RDN through Poultry manure + Azotobacter + KSM + PSB. The experiment was laid out in a Randomized Blocked Design (RBD). Each treatment was replicated thrice having ten plants per replication.

Application of organic manures and Biofertlizer

Organic manures *viz*., farm yard manure, vermicompost, neem cake and poultry manure were used in the present investigation alongwith bio fertilizers. Well prepared vermicompost was brought from Livestock Research Station, S. D. Agricultural University, Sardarkrushinagar. The FYM, poultry manure and neem cake were procured from the local market. Azotobacter, potassium solubilizing microorganisms (KSM) and phosphate solubilizing bacteria (PSB) each @ 2.5 litre/ha were mixed thoroughly with different organic manures as per treatments before its application.

The farm yard manure (FYM), vermicompost, neem cake and poultry manure used in present experiment were analyzed for N, P and K content (%) by using standard methods. (Jackson, 1973) before application in field which was given in Table 1.

Table 1: Application of RDN through different organic sources of nutrients was given as per treatments

Sr. No.	Organic Manure	N (%)	P_2O_5 (%)	K2O (%)
1	FYM	0.52	0.26	0.52
2	Vermicompost	1.18	0.44	0.60
3	Neem Cake	5.17	1.10	1.48
4	Poutry Manure	2.99	2.65	2.10

Observations recorded

The observations on growth and yield parameters were recorded from ten randomly selected plants which were tagged in each treatment and replication from the net plot and the average was worked out.

Growth parameters

Plant height (cm): The height of ten labeled plants was measured from ground level to growing tip with help of meter scale at 90 and 180 DAS (at harvest) separately.

Number of branches: The number of primary branches per plant from ten labeled plants were recorded at 90 and 180 DAS (at harvest) separately and the average per plant was calculated.

Fresh weight of plant (g): The fresh weight of selected plants was measured after the harvesting of whole plant on weighing balance and the average was calculated. It was expressed in grams.

Dry weight of plant (g): The plants used for fresh weight were dried under sun till a constant weight was obtained and measured on weighing balance. The average was calculated and expressed in grams.

Yield parameters

Root length (cm): The length of main root was measured in centimeters from the junction of stem and root to the tip of tap root of selected plants with the help of scale.

Root diameter (cm): The diameter of tap root of selected plants was measured at thicker portion of root with the help of Digital Vernier Caliper. The average was calculated and expressed in centimeters.

Fresh root weight per plant (g): The fresh weight of roots separated from labelled plants was weighted by using electronic balance. The mean was worked out and expressed in grams per plant.

Fresh root weight per plot (g): The roots were separated from freshly harvested plants of net plot and weighed by using the electronic balance and this was added to the weight of ten labelled plants to get yield per plot and expressed in grams.

Fresh root weight per ha (kg): The fresh weight of root per hectare were calculated by using the data of fresh root per plot and expressed in kilograms.

Dry root weight per plant (g): The roots taken for fresh weight were dried under sun till a constant weight was obtained. Subsequently, roots were weighed by electronic balance. The average was calculated and expressed in grams.

Dry root weight per plot (g): The root of harvested plants from net plot were cleaned and separated. Afterward, these were dry under sun till a constant weight was obtained and expressed in grams.

Dry root weight per ha (kg): The dry weight of root per hectare were calculated by using the data of dry roots per plot and expressed in kilograms.

Root volume (cm^3): The roots of selected plants were taken

for measuring their volume in cubic centimeter by water displacement method and displaced water was measured using measuring cylinder and the average was worked out.

Results and Discussion

Effect of different organic sources of nutrients on growth different growth parameters

Effect of different organic sources of nutrients on growth different growth parameters *viz*., plant height (cm) and numbers of primary branches (cm) at 90 DAS and at harvest, fresh and dry weight of plant (g) at the stage of harvest were recorded and analyzed to evaluate the treatments. The data on plant height (cm) measured at 90 DAS and at harvest as influenced by various organic sources of nutrients are presented in Table 2. Plant height (cm) at 90 DAS Significantly maximum plant height (35.45 cm) was observed with treatment T_{16} (80% RDN through Poultry manure + Azotobacter + KSM + PSB) at 90 DAS which was at par with T_{14}, T_{15}, T_7 and T_{20} treatments. Whereas, minimum plant height (25.46 cm) was recorded with treatment T_9 (60% RDN through FYM) at 90 DAS. Significantly maximum plant height (54.83 cm) was found with treatment T_{16} (80% RDN through Poultry manure + Azotobacter + KSM + PSB) at harvest. Whereas, minimum plant height (42.93 cm) was recorded with treatment T_9 (60% RDN through FYM) at harvest. The data with respect to numbers of branches per plant at 90 DAS and at harvest as influenced by different organic sources of nutrients are presented in Table 2. Significantly maximum numbers of branches per plant (5.53) was recorded with treatment T_{16} (80% RDN through Poultry manure +Azotobacter + KSM + PSB) at 90 DAS which was at par with T_7, T_{20}, T_{14}, T_4, T_{11} and T_{18} treatments. Whereas, minimum numbers of branches (3.37) was recorded with treatment T_9 (60% RDN through FYM) at 90 DAS. Significantly maximum numbers of branches (7.17) was found with treatment T_{16} (80% RDN through Poultry manure + Azotobacter + KSM + PSB) at harvest which was at par with T_{11}, T_7, T_{20}, T_{14}, T_{18} and T_4 treatments. Whereas, minimum numbers of branches (5.00) was recorded with treatment T9 (60% RDN through FYM) at harvest. Maximum plant height and numbers of branches per plant might be due to increased soil organic matter, cation exchange capacity, water holding capacity and availability of mineral nutrients as a result of improved soil properties facilitated by application of poultry manure along with bio fertilizers (Wafaa and Abd El-Aleem, 2017) [13]. Similar result was obtained by Kumar *et al*. (2017) [7] in ashwagandha. It is explicit from the data presented in Table 2 that different organic sources of nutrients have significant difference with respect to fresh weight of plant (g). Maximum fresh plant weight (46.08 g) was observed with treatment T_{16} (80% RDN through Poultry manure + Azotobacter + KSM + PSB) at harvest which was at par with T_{14}, T_{15}, T_{20}, T_{18} and T_6 treatments. Whereas, minimum fresh weight of plant (30.19 g) at harvest was recorded with treatment T_9 (60% RDN through FYM) at harvest. The data regarding the effect of organic sources of nutrients on fresh weight of plant (g) are presented in Table 2. Significantly maximum dry weight of plant (16.94 g) was observed with treatment T_{16} (80% RDN through Poultry manure + Azotobacter + KSM + PSB) at harvest which was at par with T_{14}, T_{18}, T_{15}, T_{20} and T_6 treatments. Whereas, minimum dry weight of plant (11.74 g) was recorded with treatment T9 (60% RDN through FYM) at harvest. Poultry manure contain high amount of N, P and K. Application of bio fertilizers with poultry manure could have made easily availability of nutrients particularly nitrogen which increased number of nodes as well as internodes length and consequently plant height, leading to the increase fresh and dry weight of ashwagandha (Deryqe *et al*., 2016) [3].

Effect of different organic sources of nutrients on yield and yield attributing parameters

The observation on the different yield parameters *viz*., root length (cm), root diameter (cm), fresh and dry weight (g and kg) of root (per plant, per plot and per ha) at the stage of harvest were recorded and analyzed to evaluate the treatments. Results and discussion of each character as influenced by various treatments are presented as under Table 3. The mean data on root length (cm) as influenced by different organic sources of nutrients are presented in Table 3. Significantly maximum root length (23.79 cm) was observed with treatment T_{16} (80% RDN through Poultry manure + Azotobacter + KSM + PSB) which was at par with T_{14} and T_{20} treatments. While, minimum root length (15.30 cm) was recorded with treatment T_9 (60% RDN through FYM). Data with respect to root diameter (cm) as influenced by different organic sources of nutrients are presented in Table 3. Significantly maximum root diameter (1.34 cm) was observed with treatment T_{16} (80% RDN through Poultry manure + Azotobacter + KSM + PSB) which was at par with T_{20}, T_{14} and T_{12} treatments. Whereas, minimum root diameter (0.92 cm) was recorded with treatment T_9 (60% RDN through FYM).

Application of poultry manure along with bio fertilizers might have improved physical, chemical and biological condition of the soil which resulted in facilitating better growth and development of the roots. Similar results were obtained by Kumar *et al*. (2017) [7], Praveen *et al*. (2019) [10] and Uddain *et al.* (2010) [12] in ashwagandha. Combined application of Results and discussion 28 poultry manure with bio fertilizers might have increased higher phosphorus availability which largely influences the root growth by helping in cell division, photosynthesis, carbohydrate metabolism, enzyme activation and nutrient translocation (Gyewali *et al*., 2020) [4].

The data pertaining to fresh root weight per plant (g) as influenced by different treatments are presented in Table 3. Significantly maximum fresh root weight per plant (6.35 g) was observed with treatment T_{16} (80% RDN through Poultry manure + Azotobacter + KSM + PSB) which was at par with T_{14}, T_{15}, T_{20}, T_7 and T_{10} treatments. While, minimum fresh root weight per plant (3.92 g) was recorded with treatment T_9 (60% RDN through FYM).The data recorded on fresh root weight per plot (g) as influenced by the different organic sources of nutrients are presented in Table 3. Significantly maximum fresh root weight per plot (231.44 g) was observed with treatment T_{16} (80% RDN through Poultry manure + Azotobacter + KSM + PSB) which was at par with T_{14}, T_{15}, T_{20}, T_7, T_{10}, T_{19} and T_{18} treatments. Whereas, minimum fresh root weight per plot (135.12 g) was recorded with treatment T_9 (60% RDN through FYM). The data pertaining to fresh root weight per hectare (kg) as influenced by different treatments are presented in Table 2. Significantly maximum fresh root weight per hectare (1285.80 kg) was observed with treatment T_{16} (80% RDN through Poultry manure + Azotobacter + KSM + PSB) which was at par with T_{14}, T_{15}, T_{20}, T_7, T_{10}, T_{19} and T_{18} treatments. Whereas, minimum fresh

root weight per hectare (750.65 kg) was recorded with treatment T_9 (60% RDN through FYM). The data pertaining to dry root weight per plant (g) as influenced by the different organic sources of nutrients are presented in Table 3. Significantly maximum dry root weight per plant (2.78 g) was observed with treatment T_{16} (80% RDN through Poultry manure + Azotobacter + KSM + PSB) which was at par with T_{14}, T_{20}, T_{18}, T_{15} and T_7 treatments. Whereas, minimum dry root weight per plant (1.83 g) was recorded with treatment T_9 (60% RDN through FYM). The data pertaining to dry root weight per plot (g) as influenced by different treatments are presented in Table 3. Significantly maximum dry root weight per plot (100.61 g) was observed with treatment T_{16} (80% RDN through Poultry manure + Azotobacter + KSM + PSB) which was at par with T_{14}, T_{20}, T_{15}, T_{18} and T_7 treatments. Whereas, minimum dry root weight per plot (62.41 g) was recorded with T_9 (60% RDN through FYM). The data on fresh root weight per hectare (kg) as influenced by varying treatments are presented in Table 3. Significantly maximum dry root weight per hectare (558.96 kg) was observed with treatment T_{16} (80% RDN through Poultry manure + Azotobacter + KSM + PSB) which was at par with T_{14}, T_{20}, T_{15}, T_{18} and T_7 treatments. While, minimum dry root weight per hectare (346.70 kg) was recorded with T_9 (60% RDN through FYM).

Increased yield of root might be due to increased length and diameter of roots. The increase in fresh and dry root yield may be attributed to availability of more nutrients over long period which were continuously supplied through poultry manure inoculated with bio fertilizers thus favoring the growth and development of better root system resulting in better uptake of nutrients. Similar results were reported by Chezhiyan *et al.* (2003) in Bhumyamalaki and Praveen *et al.* (2019) [10] in ashwagandha.

It is explicit from the data presented in Table 3 that the application of different organic sources of nutrients did not have any significant effect on root volume (cm^3). Numerically maximum root volume (40.10 cm^3) was recorded with treatment T_{16} (80% RDN through Poultry manure + Azotobacter + KSM + PSB).

Table 2: Effect of different organic sources of nutrients on growth different growth parameters

Tr. No.	Treatments details	Plant height		Numbers of branches per plant		Fresh weight of plant (g)	Dry weight of plant (g)
		90 DAS	At Harvest	90 DAS	At Harvest		
T_1	100% RDN through FYM	28.23	45.27	3.70	5.13	33.64	12.69
T_2	100% RDN through Vermicompost	29.13	45.37	4.00	5.60	33.45	12.64
T_3	100% RDN through Neem cake	27.93	45.20	3.97	5.57	31.10	11.97
T_4	100%d RDN through Poultry manure	28.10	45.83	4.67	6.17	31.79	12.14
T_5	80% RDN through FYM	27.37	44.67	3.57	5.03	31.06	11.94
T_6	80% RDN through Vermicompost	26.47	44.00	4.20	5.63	38.50	14.17
T_7	80% RDN through Neem cake	32.50	47.50	4.90	6.30	31.47	12.20
T_8	80% RDN through Poultry manure	29.57	46.47	4.10	5.63	35.38	13.50
T_9	60% RDN through FYM	25.47	42.93	3.37	5.00	30.19	11.47
T_{10}	60% RDN through Vermicompost	26.07	43.70	3.73	5.37	35.28	13.46
T_{11}	60% RDN through Neem cake	30.43	47.83	4.67	6.47	30.52	11.92
T_{12}	60% RDN through Poultry manure	30.20	46.73	4.37	6.13	35.46	13.23
T_{13}	80% RDN through FYM + *Azotobacter* + KSM + PSB	30.70	46.23	4.40	5.93	32.44	12.36
T_{14}	80% RDN through Vermicompost + *Azotobacter* + KSM + PSB	33.08	48.50	4.70	6.27	43.04	15.69
T_{15}	80% RDN through Neem cake + *Azotobacter* + KSM + PSB	32.90	46.23	3.60	5.27	41.60	15.45
T_{16}	80% RDN through Poultry manure + *Azotobacter* + KSM + PSB	35.45	54.83	5.53	7.17	46.08	16.94
T_{17}	60% RDN through FYM + *Azotobacter* + KSM + PSB	28.43	44.23	4.27	5.70	35.16	13.68
T_{18}	60% RDN through Vermicompost + *Azotobacter* + KSM + PSB	29.40	47.43	4.67	6.20	39.52	15.65
T_{19}	60% RDN through Neem cake + *Azotobacter* + KSM + PSB	29.37	45.70	4.27	5.97	36.53	13.58
T_{20}	60% RDN through Poultry manure + *Azotobacter* + KSM + PSB	31.97	46.33	4.80	6.30	41.02	14.61
CD at 5%		4.08	5.19	1.12	1.02	8.55	2.84

Table 3: Effect of different organic sources of nutrients on yield and yield attributing parameters

Tr. No.	Treatments details	Root Length (cm)	Root Diameter (cm)	Fresh root weight Fresh weight of plant (g)			Dry root weight			Root Volume (cm3)
				Per plant (g)	Per plot (g)	per ha (kg)	Per plant (g)	Per plot (g)	Per Ha (kg)	
T_1	100% RDN through FYM	28.23	45.27	3.70	71.13	33.64	12.69	71.13	395.17	34.06
T_2	100% RDN through Vermicompost	29.13	45.37	4.00	5.60	33.45	12.64	74.29	412.74	36.00
T_3	100% RDN through Neem cake	27.93	45.20	3.97	5.57	31.10	11.97	69.33	385.15	35.39
T_4	100% RDN through Poultry manure	28.10	45.83	4.67	6.17	31.79	12.14	69.59	386.61	39.17
T_5	80% RDN through FYM	27.37	44.67	3.57	5.03	31.06	11.94	70.38	391.02	36.66
T_6	80% RDN through Vermicompost	26.47	44.00	4.20	5.63	38.50	14.17	74.66	414.79	35.90
T_7	80% RDN through Neem cake	32.50	47.50	4.90	6.30	31.47	12.20	83.60	464.45	38.28
T_8	80% RDN through Poultry manure	29.57	46.47	4.10	5.63	35.38	13.50	66.66	370.31	37.77
T_9	60% RDN through FYM	25.47	42.93	3.37	5.00	30.19	11.47	62.41	346.70	33.72
T_{10}	60% RDN through Vermicompost	26.07	43.70	3.73	5.37	35.28	13.46	79.42	441.22	37.58

T_{11}	60% RDN through Neem cake	30.43	47.83	4.67	6.47	30.52	11.92	66.58	369.87	36.20
T_{12}	60% RDN through Poultry manure	30.20	46.73	4.37	6.13	35.46	13.23	77.48	430.46	38.25
T_{13}	80% RDN through FYM + *Azotobacter* + KSM + PSB	30.70	46.23	4.40	5.93	32.44	12.36	68.08	378.24	36.67
T_{14}	80% RDN through Vermicompost + *Azotobacter* + KSM + PSB	33.08	48.50	4.70	6.27	43.04	15.69	98.43	546.85	39.82
T_{15}	80% RDN through Neem cake + *Azotobacter* + KSM + PSB	32.90	46.23	3.60	5.27	41.60	15.45	85.03	472.41	36.16
T_{16}	80% RDN through Poultry manure + *Azotobacter* + KSM + PSB	35.45	54.83	5.53	7.17	46.08	16.94	100.61	558.96	40.10
T_{17}	60% RDN through FYM + *Azotobacter* + KSM + PSB	28.43	44.23	4.27	5.70	35.16	13.68	69.03	383.52	36.81
T_{18}	60% RDN through Vermicompost + *Azotobacter* + KSM + PSB	29.40	47.43	4.67	6.20	39.52	15.65	84.60	470.00	37.48
T_{19}	60% RDN through Neem cake + *Azotobacter* + KSM + PSB	29.37	45.70	4.27	5.97	36.53	13.58	78.76	437.54	36.56
T_{20}	60% RDN through Poultry manure + *Azotobacter* + KSM + PSB	31.97	46.33	4.80	6.30	41.02	14.61	93.46	519.22	39.11
CD at 5%		4.08	5.19	1.12	1.02	8.55	2.84	20.58	114.34	

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