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Effect of Integrated Nutrient Management on Growth, Yield and Quality of Ashwagandha (*Withania somnifera* (L.) Dunal.)

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Abstract A field experiment was conducted during the *kharif* season of 2015 to study the effect of different integrated nutrient management practices on growth, yield and quality of Ashwagandha (*Withania somnifera* (L.) Dunal.). The eight treatment combinations of different fertilizers doses, vermicompost and biofertilizers were tested in randomized block design with three replications. Integrated nutrient management practices significantly influenced different growth,yield and quality parameters of Ashwagandha. Significantly higher values of fresh root yield, dry root yield, root length root diameter, seed yield, total alkaloids content in leaf, stem and root and total withanolides content in leaf, stem and root were observed with treatment 75% NPK of recommended dose + 5 t/ha Vermicompost + PSB and Azotobacter @ 3 kg/ha each. While, maximum gtrss return, net profit, and benefit : Cost ratio was obtained under the treatment (75% NPK + 2.5 t/ha Vermicompost + PSB and Azotobacter @ 3 kg/ha each).

Keywords Ashwagandha, INM, Vermicompost, Biofertilizer and Residual nutrient status.

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Introduction

Ashwagandha (*Withania somnifera* (L.) Dunal), is one of the most valuable plants of the traditional Indian system of medicines, it is used in more than 100 formulation of Ayurveda, Unani and Sidha and is therapeutically equivalent to ginseng [1]. Phytochemically, the plant is unique in possessing the largest and structurally most diversified set of withanolides. Increase in the demand of *Withania somnifera* has lead to an increase in area under its cultivation. *Withania somnifera* is cultivated in over 4000 ha in the drier parts especially in Manasa, Neemuch and Jawad tehsils of Mandsaur District of Madhya Pradesh [2]. Among the several constraints, improper nutrient management is one of the factors responsible for the low productivity. Chemical fertilizers play an important role to meet nutrient requirement of the crop but their continuous indescrimate and improper use on soil have deleterious effects on physical, chemical and biological properties of soil, which in turn reflects on yield. Therefore, there is an urgent need to formulate integrated nutrient management practices for increasing the productivity and quality of *W.*

Table 1. Effect of different treatments on growth parameters.

Treatments	Plant height (cm)				Number of branches/plant				Number of leaves/plant			
	30 DAS	60 DAS	90 DAS	At harvest	30 DAS	60 DAS	90 DAS	At harvest	30 DAS	60 DAS	90 DAS	At harvest
100% RDF	9.00	26.27	44.47	48.00	0.00	3.80	7.20	8.10	7.30	26.17	61.67	30.10
100% RDF+2.5t/ha VC+BF	9.27	26.47	45.63	49.83	0.00	4.20	7.33	8.47	7.73	26.80	62.67	31.33
100% RDF+5t/ha VC+BF	9.43	27.07	46.53	50.27	0.00	4.50	8.73	9.17	8.13	27.83	63.50	31.80
75% RDF+2.5t/ha VC+BF	8.16	22.80	41.10	43.00	0.00	3.40	7.00	7.33	6.67	23.40	51.87	26.80
75% RDF+5t/ha VC + BF	8.30	23.80	42.50	44.20	0.00	3.53	7.10	7.77	6.83	24.20	53.07	27.87
50% RDF+2.5t/ha VC+BF	7.43	22.17	38.40	38.33	0.00	3.23	4.80	5.67	6.10	21.27	43.00	24.37
50% RDF+5t/ha VC+BF	7.53	23.57	40.47	39.47	0.00	3.27	4.93	6.47	6.37	21.47	50.67	22.60
5t/ha VC + BF	7.20	21.57	36.73	35.93	0.00	3.20	4.53	4.93	5.33	19.30	42.13	21.33
SEm ±	0.144	1.046	0.809	0.815	0.00	0.145	0.180	0.633	0.335	0.963	1.454	1.052
CD at 5%	0.438	3.175	2.454	2.474	0.00	0.441	0.548	1.920	1.016	2.923	4.412	3.191

somnifera. Keeping in view, present investigation was undertaken to study the effect of integrated nutrient management practices on growth, yield, and quality of Ashwagandha.

Materials and Methods

The field experiment was conducted during *kharif* season of 2015-16 at the research farm, RVSKVV, College of Horticulture, Mandsaur (Madhya Pradesh). The experimental soil is medium black clay loamy soil having pH 7.8, EC 0.65 ds/m, available nitrogen 290 kg ha^{-1}, available phosphorus 19.2 kg ha^{-1} and available potassium 455 kg ha^{-1}. The experiment was conducted in randomized block design with three replications. There were 8 treatments in the experiment viz., T_1-100% NPK recommended dose (50:30:30 kg/ha), T_2-100% NPK + 2.5t/ha Vermicompost + PSB and Azotobacter 3 kg/ha each, T_3-100% NPK + 5t/ha Vermicompost + PSB and Azotobacter 3 kg/ha each, T_4-75% NPK + 2.5t/ha Vermicompost + PSB and Azotobacter 3 kg/ha each, T_5-75% NPK + 5 t/ha Vermicompost + PSB and Azotobacter 3 kg/ha each, T_6-50% NPK + 2.5t/ha Vermicompost + PSB and Azotobacter 3 kg/ha each, T_7-50% NPK + 5t/ha Vermicompost + PSB and Azotobacter 3 kg/ha each, T_8-5t/ha Vermicompost + PSB and Azotobacter 3 kg/ha each. The Ashwagandha cv Jawahar Ashwagandha -134 was taken for the experiment. Soil samples (0-15 cm) were collected and analyzed. Standard methods as described by Jackson [3] were used for soil analysis.

Results and Discussion

Growth parameters

The data revealed that integrated nutrient management significantly affected different growth parameters of Ashwagandha viz. plant height (cm), number of branches per plant, number of leaves per plant during all stages of growth viz.,. 30, 60, 90 DAS and at harvest (Table 1). The maximum plant height, number of branches per plant, number of leaves per plant were recorded with treatment T_3 (100% NPK + 5 t/ha Vermicompost + PSB and Azotobacter 3 kg/ha each). However, it was at par with treatment T_2 and T_1. The lowest plant heights were recorded under treatment T_8. This is per hypothesis, increased nutrients through fertilizers : vermicompost and N mineralization with P solubilization must have made the nutrients available in larger quantity than the rest of the corresponding treatments. The higher available nutrient content under T_3 may be due to application of optimum quantity of enriched synthetic fertilizers with vermicompost and biofertilizers which supply ad-

Table 2. Effect of different treatments on yield , yield attributing and quality characters.

Treatments	Root length (cm)	Root diameter (cm)	Fresh root weight (q/ha)	Dry root weight (q/ha)	Seed yield (q/ha)	Alkaloids content (%)			Withanolides content (%)		
						Leaf	Stem	Root	Leaf	Stem	Root
100% RDF	18.45	10.18	13.53	3.50	6.12	0.13	0.12	0.30	0.41	0.11	0.52
100% RDF + 2.5t/ha VC + BF	18.74	10.34	15.07	5.10	6.47	0.20	0.15	0.42	0.49	0.15	0.61
100% RDF + 5t/ha VC + BF	19.41	10.54	15.50	5.40	7.87	0.23	0.16	0.43	0.50	0.16	0.64
75% RDF + 2.5t/ha VC + BF	19.95	10.75	16.37	6.30	8.17	0.25	0.17	0.44	0.53	0.18	0.66
75% RDF + 5t/ha VC + BF	20.20	11.17	17.50	8.60	4.31	0.27	0.19	0.45	0.55	0.19	0.68
50% RDF + 2.5t/ha VC + BF	18.07	9.89	14.47	4.40	4.12	0.17	0.15	0.36	0.45	0.14	0.58
50% RDF + 5t/ha VC + BF	15.84	9.75	14.77	4.80	4.25	0.16	0.14	0.34	0.44	0.13	0.56
5t/ha VC + BF	15.23	9.62	14.10	4.10	2.08	0.15	0.13	0.31	0.43	0.12	0.54
SEm ±	1.006	0.305	0.499	0.325	0.612	0.007	0.005	0.020	0.013	0.008	0.012
CD at 5%	3.051	0.926	1.515	0.985	1.857	0.022	0.015	0.061	0.039	0.026	0.038

equate amount of readily available nutrients to the soil. Though treatment T_1 (100% RDF) received the same quantity of nutrients from fertilizers as in T_3 but comparatively lower values of growth parameters were observed. This may be lack of addition of organic matter and there by depletion of native pool of available nutrients by plants which was mineralized by build up of micro-flora and fauna. Beneficial effect of fertilizer levels on Ashwagandha growth is well decumented by Patil et al. [4] in Ashwagandha is in the line of present research work and provides a scientific support.

Yield and yield attributes

Yield attributes were significantly affected by integrated nutrient management (Table 2). The maximum fresh root yield, dry root yield, root length, root diameter and seed yield were observed with treatment T_5 (75% NPK + 5t/ha Vermicompost + PSB and Azotobacter 3 kg/ha each). This may be due to major nutrients actively involved in vital processes and the availability of these nutrients was enhanced by organic manures and biofertilizers inoculations resulted in higher yield attributes. The higher yield attributes under this treatments could also be attributed to better growth and development of foliage of Ashwagandha which intercepted and efficiently utilized the incident in higher meristematic activities, thus enhancing the growth and finally attained the higher seed yield on account of better and balanced partitioning of photosynthates to the sink (roots and seeds) from source (foliage). These findings are in closely conformity with the results of Raja and Veerakumari [5]. However, reverse was true in case of other treatments, therefore, they could not registered the higher values of yield attributes on account of restricted supply of photosynthates towards the seeds. These results confirm the findings of Panchabhai et al. [6].

Quality parameters

Total alkaloids and withanolides content (%) of leaf, stem and root was significantly influenced by integrated nutrient management. T_5 (75% NPK + 5 t/ha Vermicompost + PSB 3 kg/ha + Azotobacter 3 kg/ha) showed the maximum alkaloids and withanolides content in leaf, stem and root. However, treatment T_5 was at par with treatment T_4, T_3 and T_2. The lowest values of alkaloids content in leaf, stem and root were recorded under treatment T_1.This could be associated to greater biological effects such as increase in the beneficial enzymatic activities, increased populations

Table 3. Effect of integrated nutrient management on residual soil nutrient status.

Treatments	OC (%)	EC (ds/m)	pH	N kg/ha	P kg/ha	K kg/ha
100% RDF	0.47	0.66	7.80	250	16.00	405
100% RDF + 2.5t/ha VC + BF	0.50	0.68	7.80	280	16.20	410
100% RDF + 5t/ha VC + BF	0.68	0.69	7.80	288	16.50	415
75% RDF + 2.5t/ha VC + BF	0.56	0.70	7.80	235	14.00	380
75% RDF + 5t/ha VC + BF	0.67	0.70	7.90	243	15.00	390
50% RDF + 2.5t/ha VC + BF	0.52	0.69	7.90	200	11.80	365
50% RDF + 5t/ha VC + BF	0.65	0.76	7.90	210	12.50	370
5t/ha VC + BF	0.60	0.77	7.80	180	11.00	360
SEm ±	0.019	NS	NS	13.061	1.161	10.910
CD at 5%	0.060	NS	NS	39.618	3.524	33.094

of beneficial microorganisms, on the presence of biologically active plant growth–influencing substances such as plant growth regulators or plant hormones. These findings are in closely conformity with the results of Raja and Veerakumari [7].

Residual soil nutrient status

It is evident from the data that the pH and electrical conductivity were not altered significantly by various treatments (Table 3). This could be due to high buffering capacity of the black soil, as reported earlier [8]. Significant higher organic carbon content was noted in treatment T_3 (100% NPK + 5 t/ha Vermicompost + PSB 3 kg/ha + Azotobacter 3 kg/ha) closely followed by treatment T_5 (75% NPK + 5t/ha Vermicompost + PSB 3 kg/ha + Azotobacter 3 kg/ha) and lowest values regarding soil organic carbon was under treatment T_1 (1005 NPK only). This appeared feasible due to the direct and abundant addition of organic matter through organic sources. Kulmi and Tiwari [9] reported similar increase in organic carbon content of soil due to continuous addition of organic manures.

The available nitrogen, phosphorus and potassium contents also revealed significant differences. The content of these major nutrients were maximum in treatment T_3 (100% NPK + 5 t/ha Vermicompost + PSB 3 kg/ha + Azotobacter 3 kg/ha) closely followed by treatment T_2 (100% NPK + 2.5 t/ha Vermicompost + PSB 3 kg/ha + Azotobacter 3 kg/ha) and T_1 (100% NPK only). The significantly lowest values regarding available nitrogen, phosphorus and potassium contents were registered under treatment T_8 (5 t/ha Vermicompost + PSB 3 kg/ha + Azotobacter 3 kg/ha). This is as per hypothesis, increased nutrients through fertilizers; vermicompost and N mineralization with P solubilization must have made the nutrients available in larger quantity than the rest of the corresponding treatments. The higher available nutrient content under T_3 may be due to application of optimum quantity of enriched synthetic fertilizers with vermicompost and biofertilizers which supply adequate amount of

Table 4. Effect of different treatments on economics.

Treatments	Cost of cultivation (Rs/ha)	Dry root yield (q/ha)	Gross return (Rs/ha)	Net profit (Rs/ha)	B : C ratio
100% RDF	15000	3.50	42000.00	27000.00	2.80
100% RDF + 2.5t/ha VC + BF	22200	5.10	61200.00	39000.00	2.75
100% RDF + 5t/ha VC + BF	29200	5.40	64800.00	35600.00	2.21
75% RDF + 2.5t/ha VC + BF	21450	6.30	75600.00	54150.00	3.52
75% RDF + 5t/ha VC + BF	28450	8.60	103200.00	74750.00	3.63
50% RDF + 2.5t/ha VC + BF	20700	4.40	52800.00	32100.00	2.55
50% RDF + 5t/ha VC + BF	27700	4.80	57600.00	29900.00	2.07
5t/ha VC + BF	26200	4.10	49200.00	23000.00	1.81

readily available nutrients to the soil. Though treatment T_1 (100% RDF) received the same quantity of nutrients from fertilizers as in T_3 but comparatively lower residual nutrient status values were observed. This may be lack of addition of organic matter and there by depletion of native pool of available nutrients by plants which was mineralized by biild up of micro-flora and fauna. Similar kind of findings was observed by Singh et al. [10].

Economics

The data reveals that the maximum gross return, net profit and benefit : cost ratio was obtained under the treatment T_5 (75% NPK + 2.5 t/ha Vermicompost + PSB and Azotobacter 3 kg/ha each) which was superior to other treatments whereas minimum gross return, net profit and benefit : cost ratio were recorded with T_8 (5 t/ha Vermicompost + PSB and Azotobacter 3 kg/ha each). The higher B : C ratio with T_5 could be attributed to higher yield and reduction in cost of cultivation (Table 4). These results are in the line with the findings of Patil et al. [11] in Ashwagandha.

Thus, it can be concluded that Ashwagandha supplied with 75% NPK + 2.5 t/ha Vermicompost + PSB and Azotobacter 3 kg/ha each has recorded maximum growth, root yield and net returns under rainfed condition of Malwa plateau of Madhya Pradesh.

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