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Economics of Yield and Production of Alkaloid of *Withania somnifera* (L.) Dunal

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ABSTRACT

The yield parameters and cost economics of *Withania somnifera* were studied using Integrated Nutrient Management (INM) treatments. *Withania somnifera* is cultivated in around 10,780 ha with a production of 8429 tones in India. The annual demand of this herb increased from 7028 tones (2001-2002) to 9127 tones (2004-2005). The field experiment was conducted at the research farm of Department of Plant Physiology, College of Agriculture, Jabalpur during *Kharif* season of 2008-2009 (1st year) and 2009-2010 (2nd year), whereas the laboratory work was carried out in Quality Laboratory, College of Agriculture, Jabalpur. The soil of experimental field was sandy loam in texture with pH 7.5, EC 0.18 dsm^{-1} having good drainage. Soil analysis revealed that available nitrogen was low (202.0 $kg \cdot ha^{-1}$) whereas available phosphorus (16.25 $kg \cdot ha^{-1}$) and potassium (236.0 $kg \cdot ha^{-1}$) were in the medium range. The present paper shows how to determine the economics of varying INM treatments. Cultivation of *W. somnifera* in India is gaining popularity among farmers; however, due to poor soil fertility, and costly chemical fertilizers and pesticides its production is not economical or profitable.

Keywords: *Withania somnifera*; INM; Yield; Alkaloid; Economics

1. Introduction

Withania somnifera (L.) Dunal commonly known as Ashwagandha is one of the important medicinal crops in Ayurvedic and an indigenous medicine for over 3000 years in India [1]. The twenty three known *Withania* species are widely distributed in the drier parts of tropical and sub-tropical zones [2-5]. The root of *W. somnifera* is a constituent of over 200 formulations in Ayruveda, Siddha and Unani medicines for the treatment of various physiological disorders [6]. Among them, only two species: *Withania somnifera* and *Withania coagulans* are of economical and medicinal importance as they are used and cultivated in several regions [7-9]. *Withania somnifera* is native of Mediterranean region in North Africa and is widely distributed in Pakistan, India, Sri Lanka, South Africa, Iraq, Iran, Syria and Turkey [10,11]. It is found naturally in forests, particularly in drier regions of India which includes Foot hills of Punjab and Himachal Pradesh and North western regions of Madhya Pradesh [1]. In India, *Withania somnifera* is cultivated in around 10,780 ha with a production of 8429 tones. The annual demand of this herb increased from 7028 tones (2001-2002) to 9127 tones (2004-2005). This 29.8% increase in the demand of *Withania somnifera* has led to an increase in area under its cultivation for higher production with good quality [12]. In Madhya Pradesh, *Withania somnifera* is cultivated in over 4000 ha in the drier parts especially in Manasa, Neemuch and Jawad tehsils of Mandsaur District [8].

Cultivated *Withania somnifera* yielded better quality roots reported by Pandey and Patra [13]. Among the several constraints, improper nutrient management is one of the factors responsible for the low productivity. Chemical fertilizers though played an important role to meet the nutritional demand of the crop, the continuous use of chemical fertilizers is reported to have deleterious effects on soil heath due to their ill effects on physical, chemical and biological properties of soil [14]. However, the use of organic manures along with inorganic fertilizers not only improves physico-chemical and biological prop-

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erties of soil but also provides all the nutrients in available form to crop plants, which in turn enhances better growth and finally the yield and quality parameters of *W. somnifera*. Thus, there is an urgent need to formulate integrated nutrient management for increasing the productivity and production of *W. somnifera*. In the absence of sufficient and reliable scientific information of integrated use of organic and chemical fertilizers on cultivation of *W. somnifera*, farmers are forced to use chemical fertilizers. The Present paper shows how to determine the economics of varying integrated nutrient management treatments. In India, cultivation of *W. somnifera* is gaining popularity among farmers; however, due to poor soil fertility, and costly chemical fertilizers and pesticides its production is not economical or profitable.

2. Material and Methods

2.1. Study Area

The study was performed during 2008-2010 in the Research Farm, Jawaharlal Nehru Krishi Vishwavidyalaya (JNKVV), Jabalpur, M.P. lies between 22˚49' to 24˚80' north latitude and 78˚21' to 80˚58' east longitude with an average altitude of 411.78 m asl. Jabalpur has a typical sub tropical climate with hot dry summers and cool dry winters. Temperature extremes vary from minimum temperatures of 2˚C in December-January months to maximum temperature of 46˚C in May-June months. Based on 30 years mean meteorological data, the average annual rainfall of the locality is 1315 mm, which mostly receives between mid June to end of September with an occasional winter showers during December and January months. The details of the material used and the methods adopted during the course of experiment are presented below.

2.2. Weather Conditions

The different weather parameters viz., temperature, rainfall, relative humidity, sun-shine and rainy days etc. of Jabalpur during two consecutive years (2008-2009 and 2009-2010) were recorded from the Meteorological Observatory, Agricultural Engineering College, JNKVV, Jabalpur (M.P.). Jabalpur received annual rainfall of 59.7 mm and 923.0 mm from the month of August to September during 2008-2009 and 2009-2010 respectively, besides, occasional showers (ranging from 35 - 160 mm) during winter months. The mean monthly maximum and minimum temperature ranged between 32.2˚C to 32.7˚C and 32.2˚C to 32.3˚C in September and October and 8.3˚C to 10.7˚C and 9.7˚C to 7.0˚C in December and January during 2008-2009 and 2009-2010, respectively as well as the mean relative humidity ranged from 85 to 93 percent during 2008-2009 and 2009-2010, respectively.

2.3. Experimental Site

The field experiment was conducted at the Research Farm in the Dusty acres, Department of Plant Physiology, College of Agriculture, JNKVV, Jabalpur during *Kharif* season of 2008-2009 (1^{st} year) and 2009-2010 (2^{nd} year), whereas the laboratory work were carried out in the Quality Laboratory, College of Agriculture, Jabalpur. The soil of experimental field was sandy loam in texture with pH 7.5, EC 0.18 dsm^{-1} and having good drainage. Soil analysis revealed that available nitrogen was low (202.0 $kg \cdot ha^{-1}$) whereas available phosphorus (16.25 $kg \cdot ha^{-1}$) and potassium (236.0 $kg \cdot ha^{-1}$) were in the medium range. The organic carbon in the soil was 0.30 per cent and Zn was 0.52 $mg \cdot kg^{-1}$ soil. The details of the present experimentation are given below.

Design: Randomized Block Design, Replications: 3, Total experimental area: 41.0 m × 31.2 m, Gross plot size: 5.0 m × 4.2 m, Net plot size: 4.0 m × 3.6 m, Total number of plots: 42, Distance between replications: 1.5 m, Distance between plots: 1.0 m, Planting geometry: 30 cm × 10 cm, Variety: JA-134, Seed rate:10 $kg \cdot ha^{-1}$, Sowing date: 16^{th} August during 2008 and 2009, & Harvesting date: 2^{nd} March during 2009 and 2010.

Nutrient management treatments (14)

T_1-100% NPK* (40:20:20)-Control, T_2-50% NPK (20:10:10), T_3-100% NPK + 5.0 ton/ha FYM**, T_4-50% NPK + 5.0 $ton \cdot ha^{-1}$ FYM, T_5-100% NPK + 0.5 $ton \cdot ha^{-1}$ NOC***, T_6-50% NPK + 0.5 $ton \cdot ha^{-1}$ NOC, T_7-100% NPK + 2.5 $ton \cdot ha^{-1}$ vermi-compost, T_8-50% NPK + 2.5 $ton \cdot ha^{-1}$ vermi-compost, T_9-100% NPK + 5.0 $ton \cdot ha^{-1}$ FYM + 20 kg $ZnSO_4$, T_{10}-100% NPK + 2.5 $ton \cdot ha^{-1}$ vermi-compost + 20 kg $ZnSO_4$, T_{11}-100% NPK + 5.0 $ton \cdot ha^{-1}$ FYM + 2.5 $ton \cdot ha^{-1}$ vermi-compost + 20 kg $ZnSO_4$, T_{12}-50% NPK + 5.0 $ton \cdot ha^{-1}$ FYM + 20 kg $ZnSO_4$, T_{13}-50% NPK + 2.5 $ton \cdot ha^{-1}$ vermi-compost + 20 kg $ZnSO_4$, T_{14}-50% NPK + 5.0 $ton \cdot ha^{-1}$ FYM + 2.5 ton ha^{-1} vermi-compost + 20 kg $ZnSO_4$.

Plant sampling: Five plants were randomly of selected from each plots. Sampling was done at a fixed interval of 30 days for bio-metrical and bio-chemical observations. The sampling was done at 30, 60, 90, 120 DAS and at the maturity stage of the crop.

2.4. Benefit—Cost Ratio

The benefit-cost ratio gives an indication of the monetary gain over one rupee invested under a particular treatment. This study is helpful to decide feasibility of the treatment for different economic groups of farmer.

$$\text{Benefit-cost ratio} = \frac{\text{Gross monetary returns } \left(\text{Rs} \cdot \text{ha}^{-1}\right)}{\text{Cost of cultivation } \left(\text{Rs} \cdot \text{ha}^{-1}\right)}$$

The net monetary returns per hectare of the treatment and benefit cost ratio of the treatment were worked out on the basis of two years pooled data.

2.5. Varietal Characteristics of Jawahar *Ashwagandha*-134

Jawahar Ashwagandha-134 has been released variety from the College of Horticulture, Mandsaur, JNKVV, Jabalpur, Madhya Pradesh, during the year 1998. This variety has been developed by pedigree selection method. It is selection from JA-20 and wild types of Ashwagandha. JA-134 is erect, tall and leaf is chordates, dark green colour, surface is hairy, berries are yellow or yellowish brown. It takes about 150 - 175 days for maturity and average dry root yield is about 4 to 6 $q \cdot ha^{-1}$.

2.6. Chemical Fertilizers

Urea, Single Super Phosphate, Muriate of Potash and Zinc Sulphate were used in the experiment for supplying nitrogen, phosphorus, potassium and zinc nutrient to the crop plants. The recommended dose of fertilizers (40 kg N + 20 kg P_2O_5 + 20 kg K_2O ha^{-1}) or 100 per cent NPK was applied by 87 kg Urea, 80 kg Single Super Phosphate and 33 kg Muriate of Potash ha^{-1}, respectively.

2.7. Organics

The organics consisted of FYM, vermi-compost and NOC. Vermi-compost was obtained from the Research Farm while FYM from the Cattle production unit of JNKVV, Jabalpur. The NOC was purchased from the open market. All the organics, zinc sulphate, phosphorus, potassium and half of nitrogen were applied at the time of sowing as basal dressing as per treatments. The remaining amount of nitrogen was applied at 40 days after sowing (DAS) during both the years.

2.8. Field Preparations

In order to obtain the optimum tilts the field was prepared by a deep summer ploughing followed by harrowing with tyne-harrow and leveled with the help of tractor driven leveler during both the years (2008 and 2009). The experiment plot was prepared as per approved layout plan. JA-134 was sown at a planting geometry of 30 cm × 10 cm using a seed rate of 10 $kg \cdot ha^{-1}$ by hand dibbling at depth of 5 cm after opening furrows in each plot on 16th August' during both the years (2009 and 2010).

2.9. Intercultural Operations

Thinning is the process of removal of excess seedlings to maintain the uniform and desired plant population and the same was carried at 50 DAS during both the years. Weeding is the process of removal of unwanted plant species from the field plots and the same which was done manually at 25 and 50 DAS.

2.10. Harvesting

The crop was harvested on 2nd March 2009 and 2010 after attaining the full maturity of Ashwagandha crop. One row from either side of each plot and 50 cm from both ends were harvested separately to remove the border effect and then net plot was harvested manually. The produce was tied into bundles, duly labeled was kept in respective plots for sun drying and bundle weight was recorded in kg plot wise.

3. Result

All the results of regarding economic yield and production of alkaloids are shows in **Tables 1-4**.

3.1. Cultivation Cost

The cost of cultivation which included operational cost and input cost, varied from treatment to treatment depending upon nutrient applied under different plots **Table 1**. The mean cost of cultivation of *W. somnifera* varied from Rs. 12,990 to 23,010 ha^{-1} under different nutrient management. The cost of cultivation was the highest (Rs. 23,010 ha^{-1}) under T_{11} treatment (100% NPK, 2.5 $t \cdot ha^{-1}$ vermi-compost, 5 $t \cdot ha^{-1}$ FYM and 20 $kg \cdot ha^{-1}$ $ZnSO_4$) followed by (Rs. 22,540 ha^{-1}) T_{14} *i.e.* 50% NPK, 2.5 $t \cdot ha^{-1}$ vermi-compost, 5 $t \cdot ha^{-1}$ FYM and 20 $kg \cdot ha^{-1}$ $ZnSO_4$), being the lowest (Rs. 12,990 ha^{-1}) under T_2 treatment (50% recommended dose of $NPK \cdot ha^{-1}$).

Table1. Mean economics of *Withania somnifera* under different treatments (2009-2010).

Treatments	Mean economics			
	Cost of cultivation ($Rs \cdot ha^{-1}$)	Gross income ($Rs \cdot ha^{-1}$)	Net income ($Rs \cdot ha^{-1}$)	Benefit cost ratio
T_1	13,460	30,980	17,520	2.30
T_2	12,990	28,230	15,240	2.17
T_3	14,910	33,280	18,370	2.23
T_4	14,440	32,020	17,580	2.21
T_5	17,660	42,210	24,550	2.39
T_6	17,190	40,020	22,830	2.32
T_7	21,160	44,890	23,730	2.12
T_8	20,690	42,940	22,250	2.07
T_9	15,310	34,980	19,670	2.28
T_{10}	21,560	51,340	29,780	2.38
T_{11}	23,010	61,280	38,270	2.66
T_{12}	14,840	34,160	19,320	2.30
T_{13}	21,090	48,730	27,640	2.31
T_{14}	22,540	55,580	33,040	2.46

3.2. Gross Monetary Returns

The mean gross monetary returns (GMR) of *W. somnifera* varied from Rs. 28,230 to 61,280 ha^{-1} under different nutrient management shows in **Table 1**. The mean gross monetary returns was maximum (Rs. 61,280 ha^{-1}) under T_{11} (100% NPK, 2.5 $t \cdot ha^{-1}$ vermi-compost, 5 $t \cdot ha^{-1}$ FYM and 20 $kg \cdot ha^{-1}$ $ZnSO_4$) followed by T_{14} (50% NPK, 2.5 $t \cdot ha^{-1}$ vermi-compost, 5 t/ha FYM and 20 $kg \cdot ha^{-1}$ $ZnSO_4$), being the lowest (Rs. 28,230 ha^{-1}) GMR was under T_2 (50% recommended dose of NPK ha^{-1}).

3.3. Net Monetary Returns

The mean net monetary returns (NMR) of *W. somnifera* under different treatments ranged from Rs. 15,240 to 38,270 ha^{-1} under different treatments (**Table 1)**. The mean NMR was the highest (Rs. 38,270 ha^{-1}) under T_{11} (100% NPK and 2.5 $t \cdot ha^{-1}$ vermi-compost along with 5 $t \cdot ha^{-1}$ FYM as well as 20 $kg \cdot ha^{-1}$ $ZnSO_4$) followed by T_{14} (Rs. 33,040 ha^{-1}) *i.e.* 50% NPK and 2.5 $t \cdot ha^{-1}$ vermi-compost along with 5 $t \cdot ha^{-1}$ FYM as well as 20 $kg \cdot ha^{-1}$ $ZnSO_4$ and T_{10} (Rs. 29,780 ha^{-1}) *i.e.* 100% NPK and 2.5 $t \cdot ha^{-1}$ vermi-compost along with 20 $kg \cdot ha^{-1}$ $ZnSO_4$. The lowest (Rs. 15,240 ha^{-1}) NMR of *W. somnifera* was recorded under T_2 (50% NPK fertilizers alone), followed by T_1 (100% NPK fertilizers alone).

3.4. Benefit Cost Ratio

The mean benefit-cost ratio of *W. somnifera* under different treatments was ranged between 2.07 to 2.66. The mean benefit-cost ratio was maximum (2.66) under T_{11} (100% NPK and 2.5 $t \cdot ha^{-1}$ vermi-compost along with 5t ha^{-1} FYM as well as 20 $kg \cdot ha^{-1}$ $ZnSO_4$) followed by T_{14} (2.46) *i.e.* 50% NPK and 2.5 $t \cdot ha^{-1}$ vermi-compost along with 5 t/ha FYM as well as 20 $kg \cdot ha^{-1}$ $ZnSO_4$ and T_{10} (2.38) *i.e.* 100% NPK and 2.5 $t \cdot ha^{-1}$ vermi-compost along with 20 $kg \cdot ha^{-1}$ $ZnSO_4$. The minimum benefit-cost ratio (2.07 and 2.12) was obtained under T_7 and T_8 respectively (**Table 1**) and dispersed pattern of benefit of cost representing **Figure 1**. Market value of dry root of *W. somnifera* was Rs. 100/kg during the year 2008-2009 and 2009-2010.

4. Discussion

4.1. Effect of INM

In a field study at Dharwar, the highest yield (18.66 $t \cdot ha^{-1}$) and net income (Rs. 28,970 ha^{-1}) were recorded from tomato due to the combined application of 100% NPK (100:75:100 $kg \cdot ha^{-1}$) with vermi-compost 2 $ton \cdot ha^{-1}$ [15]. However, vermi-compost 4 $ton \cdot ha^{-1}$ with 50% NPK gave 18.10 $ton \cdot ha^{-1}$ fruit yield and net income of Rs. 27,490 ha^{-1}. It is evident from the studies conducted under

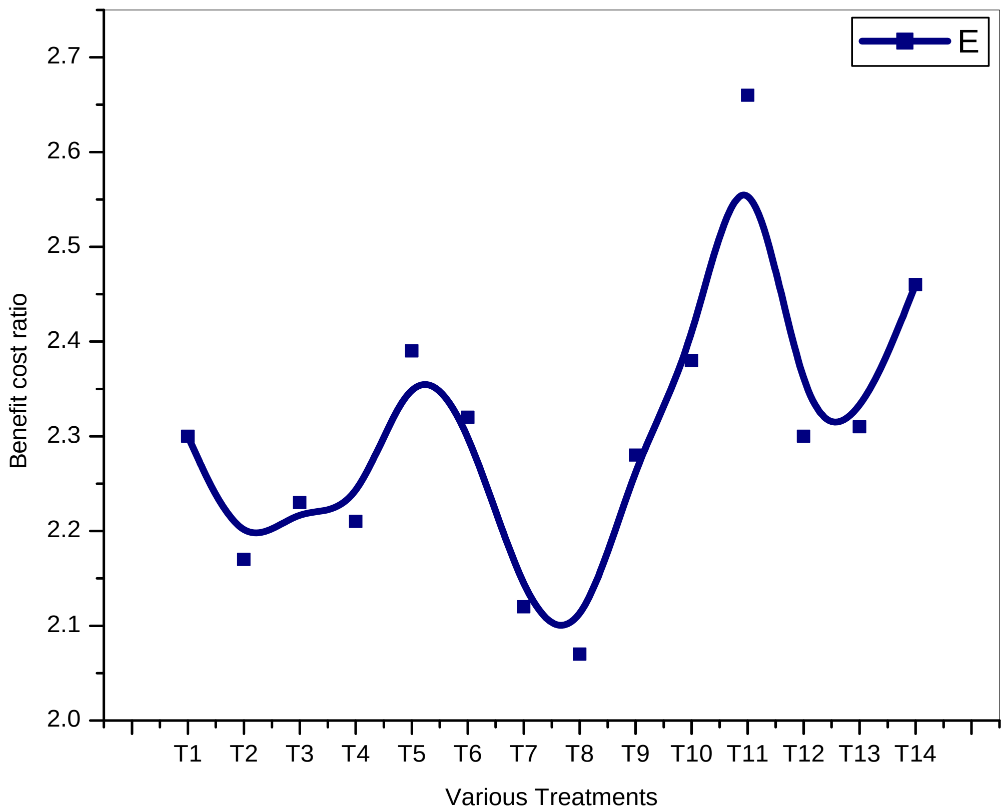

Figure 1. Showing the treatments pattern of Benefit cost ratio of *Withania somnifera*.

Table 2. Common cost in cultivation of *Ashwagandha*.

S. No.	Particulars	Numbers/ quantity ha^{-1}	Unit price ($Rs \cdot ha^{-1}$)	Cost ($Rs \cdot ha^{-1}$)
1.	**Land Preparation**			
	a. Ploughing with tractor	One pass	Rs. 750 $pass^{-1}$	750
	b. Disc harrowing	Two pass	Rs. 750 $pass^{-1}$	1500
	c. Leveling	One pass	Rs. 150 pass	150
	d. Preparation of raised beds	10 labours	Rs. 100 $labour^{-1}$	1000
2.	**Sowing management**			
	a. Cost of seed	10 kg	Rs. 100 kg^{-1}	1000
	b. Sowing charges	-	Rs. 750 ha^{-1}	750
3.	**Water management**			
	a. Irrigation	2	Rs.150 $labour^{-1}$	350
	b. Application charges	2 labours	Rs. 100 $labour^{-1}$	200
4.	**Weed management**			
	One hand weeding	25 labours	Rs. 100 $labour^{-1}$	2500
5.	Harvesting and Threshing	30 labours	Rs. 100 $labour^{-1}$	3000
6.	Interest on capital and land rent	-	10% of the total expenditure	1120
			Total cost	12,320

Table 3. Cost of nutrients and its application.

S. No.	Particulars	Quantity ha^{-1}	Unit price ($Rs \cdot kg^{-1}$)	Cost ($Rs \cdot ha^{-1}$)
1.	Fertilizers (100% NPK)	40 kg N	Rs. 10	400
		20 kg P_2O_5	Rs. 20	400
		20 kg K_2O	Rs. 7	140
	Application charges	2 labourers	Rs. 100 $labour^{-1}$	200
			Total	1140
2.	Fertilizers (50% NPK)	20 kg N	Rs. 10	200
		10 kg P_2O_5	Rs. 20	200
		10 kg K_2O	Rs. 7	70
	Application charges	2 labourers	Rs. 100 $labour^{-1}$	200
			Total	670
3.	Cost of vermi-compost	2.5 ton	Rs. 3	7500
	Application charges	2 labourers	Rs. 100 $labour^{-1}$	200
			Total	7700
4.	Cost of FYM	5 ton	Rs. 0.25	1250
	Application charges	2 labourers	Rs. 100 $labour^{-1}$	200
			Total	1450
5.	Cost of neem oil cake	500 kg	Rs. 8	4000
	Application charges	2 labourers	Rs. 100 $labour^{-1}$	200
			Total	4200
6.	Cost of zinc sulphate	20 kg	Rs. 20	400
			Total	400

Jawaharlal Nehru Krishi Vishwavidyalaya, Jabalpur that higher dry root yield (673 $kg \cdot ha^{-1}$), net return (Rs 21,070 ha^{-1}) and benefit-cost ratio (3.6) were recorded with the application of 2.5 ton of FYM + 12.5 kg N + 25 kg P_2O_5 ha^{-1} to *Ashwagandha* under rainfed condition [16]. Barik *et al.* [17] recorded the highest gross returns in rice cv. IR-36 with the application of 50% RDF in combination with 10 $ton \cdot ha^{-1}$ vermi-compost. However, the net returns and benefit-cost ratio were at par with the application of 50% RDF + 10 $t \cdot ha^{-1}$ vermi-compost and 75% RDF + 10 $ton \cdot ha^{-1}$ FYM. Singh and Rai [18] found that the application of 50% NPK through fertilizers + vermi-compost at the rate of 2.5 $ton \cdot ha^{-1}$ or FYM at the rate of 5 $ton \cdot ha^{-1}$, produced significantly higher rice equivalent yield and gross income over 100% NPK through fertilizer alone and 50% NPK + neem cake 1.5 $ton \cdot ha^{-1}$.

Table 4. Cost of cultivation under different treatments.

Treatments		Common expenditure ($Rs \cdot ha^{-1}$)	Variable expenditure ($Rs \cdot ha^{-1}$)					Total cost of treatment ($Rs \cdot ha^{-1}$)
			Fertilizers	Vermi-compost	FYM	NOC	$ZnSO_4$	
T_1	100% RDF NPK	12,320	1140	-	-	-	-	13,460
T_2	50% RDF NPK	12,320	670	-	-	-	-	12,990
T_3	100% RDF NPK + 5 $t \cdot ha^{-1}$ FYM	12,320	1140	-	1450	-	-	14,910
T_4	50% RDF NPK + 5 $t \cdot ha^{-1}$ FYM	12,320	670	-	1450	-	-	14,440
T_5	100% RDF NPK + 0.5 $t \cdot ha^{-1}$ NOC	12,320	1140	-	-	4200	-	17,660
T_6	50% RDF NPK + 0.5 $t \cdot ha^{-1}$ NOC	12,320	670	-	-	4200	-	17,190
T_7	100% RDF NPK + 2.5 $t \cdot ha^{-1}$ Vermicompost	12,320	1140	7700	-	-	-	21,160
T_8	50% RDF NPK + 2.5 $t \cdot ha^{-1}$ Vermicompost	12,320	670	7700	-	-	-	20,690
T_9	100% RDF NPK + 5 $t \cdot ha^{-1}$ FYM + 20 $kg \cdot ha^{-1}$ $ZnSO_4$	12,320	1140	-	1450	-	400	15,310
T_{10}	100% RDF NPK + 2.5 $t \cdot ha^{-1}$ Vermicompost + 20 kg/ha $ZnSO_4$	12,320	1140	7700	-	-	400	21,560
T_{11}	100% RDF NPK + 2.5$t \cdot ha^{-1}$ vermicompost + 5 ha^{-1} FYM + 20 kg/ha $ZnSO_4$	12,320	1140	7700	1450	-	400	23,010
T_{12}	50% RDF NPK + 5 $t \cdot ha^{-1}$ FYM + 20 $kg \cdot ha^{-1}$ $ZnSO_4$	12,320	670	-	1450	-	400	14,840
T_{13}	50% RDF NPK + 2.5 $t \cdot ha^{-1}$ vermicompost + 20 $kg \cdot ha^{-1}$ $ZnSO_4$	12,320	670	7700	-	-	400	21,090
T_{14}	50% RDF NPK + 2.5 $t \cdot ha^{-1}$ vermicompost + 5 ha^{-1} FYM + 20 $kg \cdot ha^{-1}$ $ZnSO_4$	12,320	670	7700	1450	-	400	22,540

*100% NPK (RDF)—40:20:20 $kg \cdot ha^{-1}$, **FYM—Farm Yard Manure, ***NOC—Neem Oil Cake, RDF—Recommended Dose of Fertilizer.

4.2. Economic of Cultivation Cost

The cost of cultivation under each treatment was determined by considering the total cost of both common and variable inputs on per hectare area basis. The detailed procedure for determining the cost of cultivation of each treatment is given in Appendix-I, II and III. The cost of cultivation is not only useful to work out the net monetary return for the farmers, but it is also useful to assess the suitability of particular treatments for the farmers. The cost of cultivation was minimum (Rs. 12,990 ha^{-1}) under the application of 50% recommended dose of chemical fertilizers but it increased marginally to Rs 13,460/ha under the application of 100% recommended dose of inorganic fertilizers. The cost of cultivation increased apparently very high (Rs. 23,010 ha^{-1}) when 100% recommended dose of NPK was applied along with 2.5 $t \cdot ha^{-1}$ vermi-compost and 5.0 $t \cdot ha^{-1}$ FYM as well as 20 $kg \cdot ha^{-1}$ $ZnSO_4$. The FYM and vermi-compost involve more expenditure on transport in addition to their cost of production through off farm sources. Hence, the cultivation cost in the case of T_{11}, T_{14}, T_{10} and other treatments is different than that under the application of nutrients solely.

4.3. Gross Monetary Returns

It is the gross return out of total produce of one hectare area under a particular treatment on the basis of existing market rate in the locality. It directly relates to quantity and price of product in the market. The increased production under a particular treatment reflects the increased gross monetary returns of the treatments. In *ashwagandha* crop not only root yield had good market value but also it produced marginal seed yield, with the market of seeds as an additional source of income. The 50% recommended dose of NPK fertilizers having the minimum root yield, fetched the lowest gross monetary return (Rs. 28,230 ha^{-1}) on the basis of two years data. The gross monetary returns increased appreciably when plant nutrients were supplied to the crop through different sources. The integrated use of FYM, vermi-compost, chemical fertilizers and micronutrient in the case of T_{11} (100% recommended dose of NPK fertilizers + 2.5 $ton \cdot ha^{-1}$ vermi-compost + 5.0 $ton \cdot ha^{-1}$ FYM + 20 $kg \cdot ha^{-1}$ $ZnSO_4$) and T_{14} (50% recommended dose of NPK fertilizers + 2.5 $ton \cdot ha^{-1}$ vermi-compost + 5.0 $ton \cdot ha^{-1}$ FYM + 20 $kg \cdot ha^{-1}$ $ZnSO_4$) fetched gross monetary returns Rs. of

61,280 ha^{-1} and 55,580 ha^{-1} respectively on account of higher dry root yield and seeds yield under aforesaid treatments with other treatments being lower under T_2 and T_1 treatments (Rs. 28,230 ha^{-1} and 31,010 ha^{-1}) respectively because of poor dry root and seed yield for *ashwagandha* crop. These findings are in close conformity with the results of Singh and Rai [18].

4.4. Net Monetary Returns

It is the actual profit gained under a particular treatment because NMR was determined by subtracting the cost of cultivation from gross monetary returns of the same treatment. The NMR was minimum (Rs. 15,240 ha^{-1}) under T_2 where 50% recommended dose of chemical fertilizers was given to *ashwagandha* which increased appreciably with the application of nutrient at different rates through various sources like organic manures, inorganic fertilizers along with micronutrient. Application of 100% recommended dose of NPK fertilizers + 2.5 $ton \cdot ha^{-1}$ vermi-compost + 5.0 $ton \cdot ha^{-1}$ FYM + 20 $kg \cdot ha^{-1}$ $ZnSO_4$ under T_{11} treatment obtained the maximum net monetary returns (Rs. 38,270 ha^{-1}) followed by T_{14} treatment receiving 50% recommended dose of NPK fertilizers + 2.5 $ton \cdot ha^{-1}$ vermi-compost + 5.0 $ton \cdot ha^{-1}$ FYM + 20 $kg \cdot ha^{-1}$ $ZnSO_4$ (Rs. 33,040 ha^{-1}) as compared to other treatments perhaps due to proportionate increase in yield parameters, root and seed yield. These findings are in conformation with the results of [15,19]. Maheshwari *et al*. [20] reported that the application of FYM 2.5 t/ha along with 12.5 kg N + 25 kg P/ha, recorded the highest dry root yield, net return and benefit-cost ratio of *Ashwagandha* (JA-134) under rainfed condition.

4.5. Profitability

Profitability is represented by benefit-cost ratio of a particular treatment. It refers to monetary gain over each rupee of investment under a particular treatment. The profitability was the highest (2.66) under T_{11} treatment receiving 100% recommended dose of NPK fertilizers + 2.5 $ton \cdot ha^{-1}$ vermi-compost + 5.0 $ton \cdot ha^{-1}$ FYM + 20 kg/ha $ZnSO_4$ followed by T_{14} treatment receiving 50% recommended dose of NPK fertilizers + 2.5 t/ha vermi-compost + 5.0 t/ha FYM + 20 kg/ha $ZnSO_4$ due to more returns per rupee of investment. However, the reverse was true in case of other treatments. These findings are in the confirmation with the results of [16,17].

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REFERENCES

[1] Annual Report, "Cultivation of Some Commercially Important Medicinal Plants. National Medicinal Plant Board, Ministry of Health and Family Welfare," Government of India, New Delhi, 2003.

[2] E. Schonbeck-Temesy, "Flora Iranica," In K. H. Rechinger, Ed., *Akademische Druck-u.Verlagsanstalt*, Graz, Austria, 1972, pp. 29-26.

[3] F. N. Hepper, "In Solanaceae III: Taxonomy, Chemistry, Evolution," In: J. G. Hawkes, R. N. Lester, M. Nee and E. Estrada, Eds., *Royal Botanic Gardens*, Kew, 1991, pp. 211-227.

[4] P. K. Warrier, V. P. K. Nambiar and C. Ramankutty, "Indian Medicinal Plants: A Compendium of 500 Species," Orient Longman, Hyderabad, 5, 1996, p. 409.

[5] A. T. Hunziker, "Genera Solanacearum: The Genera of the Solanaceae Illustrated, Arranged According to a New System," Gantner Verlag, Ruggell, Liechtenstein, 2001.

[6] R. Asthana and M. K. Raina, "Pharmacology of *Withania somnifera* (L.) Dunal—A Review," *Indian Drugs*, Vol. 26, No. 5, 1989, pp. 199-205.

[7] K. Javanshir, "Vegetation of Bashagerd," University of Tehran Publication, Tehran, 2000, pp. 156-162.

[8] R. Sharma, "Agro-Techniques of Medicinal Plants," Daya Publishing House, New Delhi, pp. 31-33.

[9] J. Panwar and J. C. Tarafdar, "Distribution of Three Endangered Medicinal Plant Species and Their Colonization with Arbuscular Mycorrhizal Fungi," *Journal of Arid Environments*, Vol. 65, No. 3, 2006, pp. 337-335. http://dx.doi.org/10.1016/j.jaridenv.2005.07.008

[10] P. Nasir, G. Gonzalez and M. Diaz, "Freshwater Larval Trematodes. XXX. Life Cycle of Petasiger novemdecim Lutz, 1928," *Proceedings of the Helminthological Society of Washington*, Vol. 39, 1972, pp. 162-168.

[11] S. M. H. Jafri, "The Flora of Karachi," The Book Corporation, Pakistan, 1966.

[12] A. K. Tripathi, Y. N. Shukla and S. Kumar, "Ashwagandha (*Withania somnifera*): A Status Report," *Journal of Medicinal and Aromatic Plant Science*, Vol. 18, No. 4, 1996, pp. 46-52.

[13] A. K. Pandey and A. K. Patra, "Influence of Propagation Method on Root Quality and Productivity of Ashwagandha (W. somnifera Dunal)," *Proceedings of National Research Seminar on Herbal Conservation, Cultivation, Marketing and Utilisation with Special Emphasis on Chhattisgarh*, The Herbal State, Raipur, Chhattisgarh, 2001, p. 57.

[14] R. K. Sarkar, S. Karmakar and A. Chakraborty, "Response of Summer Green Gram (*Phaseolus radiatus*) to Nitrogen, Phosphorus Application and Bacterial Inoculation," *Indian Journal of Agronomy*, Vol. 38, No. 4, 1997, pp. 578-581.

[15] M. P. Patil, N. C. Hulmani, S. T. Athani and M. G. Patil,

"Response of New Tomato Genotype Megha to Integrated Nutrient Management," *Advanced Agricultural Research of India*, Vol. 9, 1998, pp. 39-42.

[16] Annual Report, "Twenty Five Years of Research Medicinal and Aromatic Plants 1975-2000 AICRP on Medicinal and Aromatic Plants JNKVV," College of Agriculture, Indore (M.P.), 2000, pp. 19-20.

[17] A. K. Barik, A. Das, A. K. Giri and G. N. Chottopadhyay, "Effect of Integrated Plant Nutrient Management on Growth, Yield and Production of Wet Season Rice," *Indian Journal Agricultural Sciences*, Vol. 76, No. 11, 2006, pp. 657-660.

[18] R. R. Singh and B. Rai, "Effect of Chemical Fertilizers, Organic Manures and Soil Amendments on Production and Economics of Rice-Wheat Cropping System," *Research on Crops*, Vol. 8, No. 3, 2007, pp. 530-532.

[19] K. Barik, A. Raj and R. K. Saha, "Yield Performance, Economics and Soil Fertility through Organic Sources (Vermi-Compost) of Nitrogen as Substitute to Chemical Fertilizers in Wet Season Rice," *Crop Research*, Vol. 36, No. 1-3, 2008, pp. 4-7.

[20] S. K. Maheshwari, R. K. Sharma and S. K. Gandrade, "Response of Ashwagandha (*W. somnifera* (L.) Dunal) to Organic Manure and Fertilizer in a Shallow Black Soil under Rain Fed Condition," *Indian Journal of Agronomy*, Vol. 45, No. 1, 2000, pp. 70-72.

Abbreviation: INM—Integrated Nutrient Management; DAS—Days after Sowing; NPK—Nitrogen, Phosphorus, Potassium; *100% NPK (RDF)—40:20:20 kg/ha; **FYM—Farm Yard Manure; ***NOC—Neem Oil Cake; RDF—Recommended Dose of Fertilizer; m-Meter, asl-above sea level, T_1-T_{14}-Treatments.

