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Research Paper

Productivity, quality and economics of *ashwagandha* (*Withania somnifera*) as influenced by planting methods, spacings and nutrient management under drip irrigation

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ABSTRACT

A field experiment was conducted during the winter *(rabi)* seasons of 2010–11 and 2011–12 at Rahuri, Maharashtra, to study the response of *ashwagandha* [*Withania somnifera* (L.) dunal] to 3 methods of planting (broad bed and furrow, ridge and furrow and flat bed), 2 levels of spacing (30 cm × 20 cm and 45 cm × 20 cm) and 4 levels of nutrient management (75, 37.5, 37.5 kg N, P_2O_5, K_2O + 5 t FYM/ha; 50, 25, 25 kg N, P_2O_5, K_2O + 5 t FYM/ha; 25, 12.5, 12.5 kg N, P_2O_5, K_2O + 5 t FYM/ha and control) under drip irrigation. Broad bed and furrow planting method recorded significantly higher values of yield attributes, viz. number of roots, root length, root diameter, dry root weight, number of berries and seed yield/plant, and consequently higher dry root (790 kg/ha) and seed yield (1.15 t/ha), nutrient uptake and total withanolide content as compared to ridge and furrow and flat bed. The closer spacing of 30 cm × 20 cm resulted in significantly maximum dry root yield (762 kg/ha), seed yield (1.13 t/ha), nutrient uptake and total withanolide content than wider spacing of 45 cm × 20 cm. At 30 cm × 20 cm spacing, the increase in dry root yield and seed yield was 19.89 and 15.20% over 45 cm × 20 cm respectively. Significant increase in dry root yield, seed yield, nutrient uptake and total withanolide content was noticed with increase in fertilizer levels from control to 75, 37.5, 37.5 kg N, P_2O_5, K_2O + 5 t FYM/ha. Application of 75, 37.5, 37.5 kg N, P_2O_5, K_2O + 5 t FYM/ha recorded significantly higher yield attributes as well as dry root yield (837 kg/ha), seed yield (1.28 t/ha), N, P and K uptake and total withanolide content than rest of the fertilizer levels. The broad bed and furrow planting registered higher gross returns (₹2,20,379/ha), net returns (₹1,60,796/ha) and benefit: cost ratio (3.67), followed by ridge and furrow and flat bed. The spacing of 30 cm × 20 cm and fertilized with 75, 37.5, 37.5 kg N, P_2O_5, K_2O + 5 t FYM/ha resulted in the maximum gross returns, net returns and benefit: cost ratio than the others.

Key words : *Ashwagandha*, Drip irrigation, Nutrient management, Nutrient uptake, Planting methods, Seed, Spacing, Roots, Withanolide, Yield

Medicinal plants have attained high significance in recent years owing to their demand for industrial use and alluring market price (Lubbe and Verpoorte, 2011). Several medicinal plants can be commercially grown in India, as its climate and soils suit their cultivation. The roots of *ashawagandha* [*Withania somnifera* (L.) dunal] are the economic part of the plants and are used in the preparation of Ayurvedic and Unani medicines (Nagella and Murthy, 2011). Occasionally, the leaves and seeds are also used for medicinal purpose. In the US market, *ashwagandha* has recently acquired considerable significance on account of its large demand due to its reported male sex stimulating properties. *Ashwagandha* has been a prized top-notch adaptogenic tonic in India since 3000 to 4000 years. The plants contain alkaloids and withanolides, which are used to treat nervous disorders, intestinal infection and leprosy (Andrade, 2009). It is native to the drier parts of India and it is cultivated over an area of 10,780 ha with a production of 8,429 tonnes in India. The present requirement of this plant root is 15 million tonnes, whereas its annual production of root in India is about 7 million tonnes (Senthil, 2010) necessitating the increase in its cultivation and higher production. In rainfed areas, the productivity of traditional crop is at stake due to vagaries of weather. The method of transplanting seedlings is considered to be one of the important factors in the raising of *ashwagandha*

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crop. Proper planting layout helps maintain optimum moisture level, resulting in better growth and yield. There is a meager scientific information available on planting techniques of *ashwagandha*. Diversified responses of *ashwagandha* to spacing and fertilizer levels were reported by different workers including Kubsad *et.al.* (2009). Drip irrigation is considered to be most efficient in improving the yield, quality and saving of water. This crop is irrigated at 70% of pan evaporation through drip at alternate day gave higher root yield than micro sprinkler and surface irrigation during *rabi* season (AICRP, 2010). Thus, the economic potential of the crop could be realized by expanding its cultivation to better agricultural lands with scientific production technologies. Considering the medicinal value of the crop, its increasing demand and meager scientific information on the cultivation of *ashwagandha* under drip, the present investigation was carried out to study the response of *ashwagandha* to planting methods, spacings and nutrient management under drip irrigation for Maharashtra region.

MATERIALS AND METHODS

The field experiment was conducted during the winter (*rabi)* season of 2010–11 and 2011–12 at the Farm of All-India Coordinated Research Project on Water Management, Mahatma Phule Krishi Vidyapeeth, Rahuri, Maharashtra without changing randomization. The soil was clayey in texture with *p*H 8.10, medium in organic carbon (0.50%), low in available N (194.4 kg/ha), medium in available P (16.6 kg/ha) and high in available K (616.0 kg/ha). The experiment was laid out in a split plot design with 3 replications. There were 24 treatment combinations. Three treatments of planting methods, viz. broad bed and furrow, ridge and furrow, flat bed along with 2 treatments of spacing, viz. 30 cm × 20 cm and 45 cm × 20 cm, were embedded in main plots. While 4 levels of nutrient management, viz. 75, 37.5, 37.5 kg N, P_2O_5, K_2O + 5 t FYM/ha; 50, 25, 25 kg N, P_2O_5, K_2O + 5 t FYM/ha; 25, 12.5, 12.5 kg N, P_2O_5, K_2O + 5 t FYM/ha and the control (no nutrient) treatments were assigned in subplots. Since it is Vertisols, the K-fixation capacity of soil is high because of which availability of K is very low and so, applications of K levels were taken. The gross plot size was 5.00 m × 3.60 m and net plot size was 4.20 m × 2.70 m. 'Nagori' variety was used. The crop was transplanted on 28 October 2010 during first year and 5 November 2011 during second year. Half N, full P_2O_5 and K_2O applied at planting and half N applied 45 days after transplanting through conventional fertilizer as per treatment. The farmyard manure (FYM) was incorporated in soil at land preparation as per treatment. First irrigation was given at planting and subsequent irrigation was applied through drip at 70% of pan evaporation at alternate day common to all treatments. Rainfall, if any in between irrigation cycles was deducted and irrigation water was applied accordingly. The total amount of rainfall received during cropping period were 103.2 mm and 7.4 mm in 6 and 2 rainy days during 2010–11 and 2011–12 respectively. The crop was sprayed with dimethoate 30% EC @ 1 ml/liter water for control of aphids and propargite 57% EC @ 1.5 ml/litre water for control of mites. The crop was harvested on 16 and 27 April during the first year and second year respectively. At harvesting, 5 plants were randomly selected in each treatment for recording growth and yield parameters. These samples were oven-dried at 70°C temperature, powdered and analyzed for N, P and K concentrations following standard procedures and the total uptake was calculated. The total withanolide content (%) in roots was estimated by modified spectrophotometer method (Mishra, 1994). The plants from each net plot were uprooted and the roots and shoots were separated and sun dried for a week. The root yield was recorded and expressed in kg/ha. Cost of laying-out of drip irrigation system and cultivation charges were worked out/ha. The life of drip system was assumed to be 10 seasons. For working out the economics, prevailed market price for *ashwagandha* seeds (₹50 and 55/kg during 2010–11 and 2011–12, respectively, dry roots (₹200 and 205/kg during 2010–11 and 2011–12 respectively), urea (₹12.15/kg N), SSP (₹50/kg P) MOP (₹28.40/kg K) and cost of labour (₹150/day) were considered. The data were statistically analyzed and the results of pooled analysis are presented.

RESULTS AND DISCUSSION

Dry root and seed yield and yield attributes

Dry root yield was significantly influenced by planting layouts, spacing and nutrient-management levels. Broad bed and furrow planting method recorded the maximum dry root yield followed by ridges furrow and flat bed, which was 10.92 and 33.09% higher than ridge and furrow and flat bed respectively. Broad bed and furrow resulted in higher number of roots, root length, root diameter and dry root weight/plant than ridges furrow and flat bed. Similarly, significantly higher seed yield obtained in broad bed and furrow followed by ridge and furrow and minimum in flat bed (0.94 t/ha) owing higher number of berries and seed yield/plant (Tables 1, 2). In broad bed and furrow planting, the maximum yield was obtained owing to physical modification of soil; these modifications might have helped physiological process of plants such as root respiration and absorption of nutrients and moisture through easy penetration of roots, better root development and root activities in properly aerated and moist soils. Pandey *et al.* (2007) reported that *safed musli* gave higher root yield

(0.49 t/ha) on raised bed planting than ridges and furrow (0.39 t/ha) and flat bed (0.33 t/ha). Similar results were also obtained by Ardeshna *et al.* (2013) in turmeric, who reported higher rhizome yield of turmeric under raised bed planting than ridge furrow and flat bed.

The dry root yield was higher at a closer spacing of 30 cm × 20 cm than 45 cm × 20 cm. The magnitude of increase in dry root yield was up to 19.89% over 45 cm × 20 cm in pooled mean. The yield increment at closer spacing is attributed to improvement in root length and higher plant population/unit area compared to wider spacing of 45 cm × 20 cm. Singh *et al.* (2003) also reported 53.8% higher root yield of *ashwagandha* at higher plant density when compared with lower plant density. The seed yield/ha of closer spacing 30 cm × 20 cm was 15.20% more than the spacing 45 cm × 20 cm (Tables 1, 2). It was mainly attributed to the higher plant population per unit area at closer spacing which cumulatively increased the growth and seed yield attributes. While the performance of number of roots, root diameter, number of berries, dry root weight and seed yield/plant was superior under wider spacing of 45 cm × 20 cm owing to better resource availability and reduced interplant competition in the community. Karad *et al.* (2009) and Shukla and Shukla (2012) also reported similar findings.

There was linear and significant increase in dry root yield with the increase in fertilizer levels from the control to 75, 37.5, 37.5 kg N, P_2O_5, K_2O with 5 t FYM/ha. Application of 75, 37.5, 37.5 kg N, P_2O_5, K_2O with 5 t FYM/ha resulted in the significantly maximum yield, being 8.89, 24.03 and 62.07% higher over than 50, 25, 25 kg N, P_2O_5, K_2O with 5 t FYM/ha; 25, 12.5, 12.5 kg N, P_2O_5, K_2O with 5 t FYM/ha and control treatment on pooled mean of 2 years respectively. The application of 75, 37.5, 37.5 kg N, P_2O_5, K_2O with 5 t FYM/ha proved its superiority by recording significantly higher seed yield than rest of the fertilizer levels. It gave 9.53, 25.99 and 66.01% higher seed yield than over 50, 25, 25 kg N, P_2O_5, K_2O with 5 t FYM/ha; 25, 12.5, 12.5 kg N, P_2O_5, K_2O with 5 t FYM/ha and the control treatment on pooled mean basis respectively. The higher dry root and seed yield was mainly owing to higher values of yield attributes like number of roots, root length, root diameter, number of berries, dry root weight and seed yield/plant than the other fertilizer levels (Tables 1, 2). This might be owing to supply of balanced nutrients in appropriate quantity which enhanced the use efficiency of added nutrients and created favourable environment for increasing microbial population which increased the nutrient availability and thereby increased the uptake of nutrients by crop. Ultimately enhanced all the growth and yield attributes of crop coupled with increase in physiological processes and efficient translocation of photosynthates towards reproductive organs which reflected in higher dry root yield and seed yield of *ashwagandha*. Pandey *et al.* (2006) recorded the highest yield attributes, viz. root length, root diameter, number of berries/plant, 1,000-seed weight and root yield with application N_{100}+ P_{50}+ K_{100}+ $Mg_{20}S_{25}B_5Zn_{20}$, whereas, the minimum growth parameters,

Table 1. Yield attributes of *ashwagandha* at harvest as influenced by various treatments (pooled data of 2 years)

Treatment	Roots/ plant	Root length (cm/plant)	Root diameter (cm/plant)	Dry root weight (g/plant)	Berries/ plant	Seed yield (g/plant)
Planting methods						
Flat bed	3.90	28.48	1.58	5.67	253.37	13.64
Ridge and furrow	4.28	30.90	1.69	6.86	289.27	16.17
Broad bed and furrow	4.64	32.21	1.76	7.55	309.72	17.44
SEm±	0.07	0.22	0.02	0.07	2.55	0.16
CD (P=0.05)	0.22	0.81	0.06	0.21	9.24	0.60
Spacings						
30 cm × 20 cm	4.04	31.39	1.63	6.40	266.61	14.56
45 cm × 20 cm	4.50	29.67	1.73	7.00	301.64	16.94
SEm±	0.06	0.18	0.02	0.06	2.08	0.13
CD (P=0.05)	0.18	0.66	0.05	0.18	7.55	0.49
Nutrient management levels						
75, 37.5, 37.5 kg NPK + 5 t FYM/ha	4.84	33.36	1.85	7.62	332.36	19.30
50, 25, 25 kg NPK + 5 t FYM/ha	4.56	31.73	1.75	7.20	308.71	17.99
25, 12.5, 12.5 kg NPK + 5 t FYM/ha	4.12	29.67	1.63	6.54	273.89	14.83
Control	3.57	27.36	1.48	5.43	221.44	10.87
SEm±	0.04	0.10	0.01	0.05	1.34	0.17
CD (P=0.05)	0.10	0.30	0.03	0.15	3.98	0.50

yield attributes and root yield was found under the control (no nutrient) treatment. These results confirm those of Karad *et al.* (2009). Seed yields were high because experiment was conducted in Vertisols where fertility status of soil is high as well as the variety 'Nagori' is a high-yielding one responsive to fertilizers which has capacity to give more production. Similarly, Kaushal *et al.* (2002) at Palampur (Himachal Pradesh) recorded the highest seed yield (1.09 t/ha) in *ashwagandha* with application of 15 kg N + 60 kg P_2O_5/ha while minimum in the control.

The interaction effect of spacing and nutrient management levels was found significant. The spacing 30 cm × 20 cm spacing and fertilized with 75, 37.5, 37.5 kg N, P_2O_5, K_2O + 5 t FYM/ha found significantly superior in respect to dry root yield over other treatment combinations (Table 3). This was mainly attributed to more plants/unit area, higher values of yield parameters and dry-matter accumulation in roots/ha at harvesting because of more availability of nutrients to the plants through fertilizers.

Quality of dry roots

Broad bed and furrow planting layout recorded the significantly higher total withanolide content in roots than flat bed (0.35%), whereas it was at par with ridge and furrow (0.39%) on pooled mean (Table 2). This might be owing to congenial rhizosphere environment in broad bed and furrow because of porosity was increased and comfortable root growth and proportion of thick and thin roots were higher than medium roots. Patel *et al.* (2003) reported that the thick and thin roots were high in total withanolide content than medium roots. The spacing of 30 cm × 20 cm recorded significantly higher total withanolide content in roots of *ashwagandha* at harvesting over 45 cm × 20 cm due to larger proportion of thin roots. In closer spacing, Kubsad *et al.* (2009) reported higher total withanolide content at closer spacing and lower withanolide content at wider spacing in roots of *ashwagandha*. A linear and significant increase was noticed in total withanolide content with increase in fertilizer levels from control to 75, 37.5, 37.5 kg N, P_2O_5, K_2O + 5 t FYM/ha. The total withanolide content was significantly maximum at 75, 37.5, 37.5 kg N, P_2O_5, K_2O + 5 t FYM/ha, which was 5.0, 13.51 and 27.26% higher than 50, 25, 25 kg N, P_2O_5, K_2O + 5 t FYM/ha, 25, 12.5, 12.5 kg N, P_2O_5, K_2O + 5 t FYM/ha and the control respectively (Table 2). The total withanolides being alkaloids are the products of nitrogen metabolism. Hence the production of total withanolides is related to nitrogen supply to the plants. Thus, application of higher N levels might have resulted in higher total withanolide content in roots of *ashwagandha*.

Nutrient uptake

Broad bed and furrow planting method registered significantly maximum uptake of N, P and K by the crop followed by ridge and furrow and minimum in flat bed (Table 4). Broad bed and furrow planting method helped in

Table 2. Dry root yield, seed yield, biological yield and harvest index and anolide content in roots of *ashwagandha* as influenced by different treatments (pooled data of 2 years)

Treatment	Dry root yield (kg/ha)	Seed yield (t/ha)	Biological yield (t/ha)	Harvest index (%)	Total anolide content in roots (%)
Planting methods					
Flat bed	594	0.94	8.05	18.86	0.35
Ridge and furrow	713	1.08	8.82	20.10	0.39
Broad bed and furrow	790	1.15	9.24	20.77	0.41
SEm±	10.5	0.01	0.02	0.13	0.01
CD (P=0.05)	37.9	0.04	0.07	0.48	0.02
Spacings					
30 cm × 20 cm	762	1.13	9.10	20.57	0.40
45 cm × 20 cm	636	0.98	8.31	19.25	0.36
SEm±	8.5	0.01	0.02	0.11	0.01
CD (P=0.05)	30.9	0.03	0.06	0.39	0.02
Nutrient management levels					
75, 37.5, 37.5 kg NPK + 5 t FYM/ha	837	1.28	9.86	21.33	0.42
50, 25, 25 kg NPK + 5 t FYM/ha	768	1.16	9.30	20.69	0.40
25, 12.5, 12.5 kg NPK + 5 t FYM/ha	674	1.01	8.58	19.59	0.37
Control	516	0.77	7.09	18.04	0.33
SEm±	5.1	0.01	0.05	0.10	0.01
CD (P=0.05)	15.2	0.02	0.15	0.29	0.02

maintaining better moisture conditions in loose and porous soil mass throughout the crop-growth period. It increased the availability of nutrients and also owing to higher total dry-matter production (straw, seed and dry root yield)/ha resulted in increase the uptake of nutrients by crop in broad bed and furrow. Similar findings were reported by Chandra *et al.* (2007) in turmeric. Maximum uptake of N, P and K by the crop was noticed at a spacing of 30 cm × 20 cm which was significantly higher than 45 cm × 20 cm spacing. The higher uptake of N, P and K can be related to higher dry root, seed yield and higher total dry matter. The uptake of N, P and K increased with application of every additional unit of fertilizer from the control to 75, 37.5, 37.5 kg N, P_2O_5, K_2O + 5 t FYM/ha. The significantly maximum total uptake of N, P and K was recorded by crop owing to fertilizer level of 75, 37.5, 37.5 kg N, P_2O_5, K_2O with 5 t FYM/ha compared with the remaining fertilizer levels. It was followed by application of 50, 25, 25 kg N, P_2O_5, K_2O with 5 t FYM/ha and significantly minimum in control treatment (Table 4). This increase in uptake of nutrients may be attributed to higher N, P, K content, higher dry-matter production and higher root and seed yield/ha which was due to continuous supply of essential plant nutrients to plants throughout crop-growth period at higher fertilizer levels. Ramesh Babu (1996) and Patel (2001) observed significantly higher uptake of N, P and K by *ashwagandha* with 90 and 75 kg N/ha, respectively, than the control treatment.

Residual soil fertility

The available N, P and K content in soil after harvest was low in all the planting methods (Table 4) compared to initial nutrient status. This was mainly attributed to uptake of the nutrients by the crop. The significantly higher N, P

Table 3. Interaction effect between spacing and nutrient management on dry root yield at harvesting

Nutrient management / Spacing	Dry root yield (kg/ha)			
	F_1, 75, 37.5, 37.5 kg NPK + 5 t FYM/ha	F_2, 50, 25, 25 kg NPK + 5 t FYM/ha	F_3, 25, 12.5, 12.5 kg NPK + 5 t FYM/ha	F_4- Control
S_1, 30 cm × 20 cm	916	841	732	560
S_2, 45 cm × 20 cm	757	695	617	473
Source			SEm±	CD (P=0.05)
Between sub plot (F) means at same level of main plot (S) means			7.2	21.5
Between main plot (S) means at same level of sub plot (F) means			11.3	32.4

Table 4. Nutrient uptake by *ashwagandha,* residual soil fertility and economics as influenced planting methods, spacing and nutrient management levels (pooled data of 2 years)

Treatment	Nutrient uptake (kg/ha)			Soil available nutrients (kg/ha)			Cost of cultivation	Gross returns
	N	P	K	N	P	K	($\times 10^3$ ₹/ha)	($\times 10^3$ ₹/ha)
Planting methods								
Flat bed	89.7	20.8	110.2	166.4	13.6	477.4	57.2	170.0
Ridge and furrow	104.5	24.2	129.2	172.5	14.4	502.3	58.9	200.9
Broad bed and furrow	113.8	26.1	139.9	177.2	15.0	511.2	59.6	220.4
SEm±	0.5	0.1	0.5	1.0	0.1	2.7	-	2.1
CD (P=0.05)	1.6	0.2	1.7	3.2	0.4	8.8	-	7.8
Spacings								
30 cm × 20 cm	106.7	24.4	129.6	176.9	14.6	506.2	61.5	213.8
45 cm × 20 cm	98.6	23.0	123.3	167.1	14.0	487.8	55.6	180.4
SEm±	0.4	0.1	0.4	0.8	0.1	2.2	-	1.8
CD (P=0.05)	1.2	0.3	1.2	2.4	0.3	6.7	-	6.3
Nutrient management levels								
75, 37.5, 37.5 kg NPK + 5 t FYM/ha	130.3	30.1	159.5	184.2	15.6	541.6	61.5	236.5
50, 25, 25 kg NPK + 5 t FYM/ha	114.6	26.6	141.3	178.2	15.1	522.4	60.3	216.9
25, 12.5, 12.5 kg NPK + 5 t FYM/ha	94.7	22.1	118.4	170.6	14.3	490.0	58.9	189.9
Control	71.2	15.9	86.6	154.9	12.3	434.0	53.6	145.1
SEm±	0.9	0.2	1.0	0.8	0.1	7.0	-	1.5
CD (P=0.05)	2.9	0.7	3.3	2.4	0.4	21.4	-	4.5

and K content in soil after harvesting of *ashwagandha* were recorded under 30 cm × 20 cm than 45 cm × 20 cm spacing. This might be due to the higher initial nutrient content in soil. The available N, P and K in soil increased with increase in fertilizer levels from 25, 12.5, 125 kg N, P_2O_5, K_2O with 5 t FYM/ha to 75, 37.5, 37.5 kg N, P_2O_5, K_2O with 5 t FYM/ha. This was due to addition of N, P and K through fertilizers. However, the availability of N, P and K in soil in all the treatments was low at harvest when compared with initial nutrient status. This was mainly attributed to uptake of the nutrients by *ashwagandha*.

Economics

An economics of the crop based on dry root yield and seed yield revealed that broad bed and furrow planting method obtained significantly higher gross returns, net returns and benefit: cost ratio on pooled mean basis (Table 4 and 5). It was followed by ridge and furrow and the lowest gross and net returns and benefit: cost ratio was obtained in flat bed. The gross returns were 13.18 and 42.63% as well as net returns 9.68 and 29.66% higher under broad bed and furrow over ridge and furrow and flat bed respectively. The closer spacing of 30 cm × 20 cm realized higher gross returns, net returns and benefit: cost ratio than 45 cm × 20 cm spacing owing to maximum dry root and seed yield. The highest nutrient management level, i.e. 75, 37.5 and 37.5 kg N, P_2O_5, K_2O + 5 t FYM/ha realized the maximum gross returns, net returns and benefit: cost ratio, which was significantly higher than other fertilizer levels. The gross returns were 9.06, 24.58 and 63.05% as well as net returns were 11.72, 33.60 and 91.27% higher at 75, 37.5 and 37.5 kg N, P_2O_5, K_2O + 5 t FYM/ha over 50, 25, 25 kg N, P_2O_5, K_2O + 5 t FYM/ha; 25, 12.5, 125 kg N, P_2O_5, K_2O + 5 t FYM/ha and the control respectively. The returns appeared very high owing to higher dry root yield and seed yield obtained in Vertisols under drip irrigation and received higher market price for dry roots and seed in comparison with those reported earlier.

Table 5. Economics based on dry root and seed yield of *ashwagandha* as influenced by planting methods, spacing and nutrient management levels (pooled data of 2 years)

Treatment	Net returns (× 10^3 ₹/ha)	Benefit: cost ratio
Planting methods		
Flat bed	112.7	2.94
Ridge and furrow	142.0	3.38
Broad bed and furrow	160.8	3.67
SEm±	2.1	0.03
CD (P=0.05)	7.7	0.10
Spacings		
30 cm × 20 cm	152.3	3.45
45 cm × 20 cm	124.7	3.21
SEm±	1.7	0.02
CD (P=0.05)	6.2	0.08
Nutrient management levels		
75, 37.5, 37.5 kg NPK + 5 t FYM/ha	175.0	3.83
50, 25, 25 kg NPK + 5 t FYM/ha	156.6	3.58
25, 12.5, 12.5 kg NPK + 5 t FYM/ha	130.9	3.21
Control	91.5	2.70
SEm±	1.5	0.02
CD (P=0.05)	4.5	0.06

Price, Dry roots, ₹202.50 kg/ha; Seed, ₹52.50 kg/ha

Thus, it could be concluded that, planting of *ashwagandha* on broad bed furrow at 30 cm × 20 cm spacing and fertilized with 75, 37.5, 37.5 kg N, P_2O_5, K_2O + 5 t FYM/ha was found beneficial for achieving maximum dry root yield, seed yield, total withanolide content and net returns under drip irrigation during winter (*rabi)* season in Vertisols of Western Maharashtra.

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