Journal of Spices and Aromatic Crops
Vol. 12 (2) : 101-106 (2003)

Indian Society for Spices

Potential and economics of ashwagandha (*Withania somnifera* (Linn.) Dunal) in overlapping cropping system under rainfed conditions of sub-tropical North India

Saudan Singh, S P S Khanuja, Aparbal Singh, Man Singh & U B Singh

Central Institute of Medicinal and Aromatic Plants
Lucknow-226 015, Uttar Pradesh, India

E-mail : s.singh@cimap.res.in

Received 22 January 2003; Revised 09 June 2003; Accepted 30 December 2003

Abstract

Field experiments were conducted at Central Institute of Medicinal and Aromatic Plants, Lucknow to find out production potential and economic returns of traditional monocropping systems vis-a-vis alternative cropping system. The cropping systems evaluated were: pearl millet (*Pennisetum glaucum*) - fallow, maize (*Zea mays*) - fallow and okra (*Ablmoschus esculentus*) - fallow (traditional monocropping system) and medicinal plant, ashwagandha (*Withania somnifera*), at low (100 x 10^3 plants ha^{-1}) and high (200 x 10^3 plants ha^{-1}) population densities (LPD and HPD, respectively), as mono as well as overlap crop with pearl millet, maize or okra (alternate cropping systems). All the overlapping cropping systems recorded higher productivity in terms of pearl millet grain equivalent yield (PGEY) and economic returns over traditional cropping systems. Pearl millet-ashwagandha (at HPD) overlapping cropping system, recorded 6.8 to 176.7% higher PGEY over remaining traditional as well as alternate cropping systems; the minimum being over maize-aswagandha and maximum over maize-fallow. The corresponding increase in net economic returns was 22.4-278.7%. Ashwagandha at HPD of 200 x 10^3 plant ha^{-1} under monocropping yielded 53.8% and 66.7-73.3% higher roots than it was grown at LDP under monocropping and overlapping cropping systems, respectively. Also, ashwagandha at either of the population densities under monocropping system proved more economical than traditional mono cropping systems. Better yield and economic returns make ashwagandha an ideal crop for moisture stress rainfed conditions. Overlapping cropping of ashwagandha is suggested as a way to improve the productivity and economic returns from resource constrained rainfed agriculture in sub-tropical North India.

Key words: cropping system, production economics, *Withania somnifera*

Introduction

Income enhancement in agriculture through integration of new crops and maximal land use strategy seems the necessity for the sustainability of cropping systems. In rainfed areas of subtropical North India, fast growing and early maturing and moisture stress tolerant crops such as pearl millet (*Pennisetum glaucum*), maize (*Zea mays*) or okra (*Abelmoschus esculentus*) are usually grown as monocrops. However, the success of traditional monocrops solely depends on the amount, duration and distribution of rainfall during the cropping season; the low productivity and/or total failure of the crop is not very uncommon in such a system of agriculture. Ashwagandha (*Withania somnifera* (L.) Dunal), an important medicinal plant, cultivated for the production of its dried roots, has extensive uses in traditional systems of medicine (Dey 1988; Singh *et al.* 1996), being an important constituent in more than 114 drugs in indigenous system of medicine in India (Singh & Kumar 1998). According to an estimate, India produces about 3500 tonnes of dried roots annually, as against an estimated annual demand of about 7000 tonnes. The cultivation of ashwagandha is confined to certain areas in Gujarat, Madhya Pradesh and Rajasthan states in the western parts of the country. Traditionally, the crop is cultivated as rainfed monocrop through direct seeding during the period from mid to end of rainy season (August-September) to April-May. The present study was aimed to evaluate the production potential and economics of cultivation of ashwagandha under mono as well as in overlapping cropping system under rainfed conditions of subtropical North India.

Materials and methods

A field experiment was conducted on a deep sandy loam soil during 1997-98 and 1998-99 (July - April), at the research farm of the Central Institute of Medicinal and Aromatic Plants, Lucknow (26.5°N latitute, 80.5°E longitude and 120 M altitude), India. The soil (pH 8.4 and bulk density 1.48 g cc^{-1}) of the experimental plot was low in available nitrogen (136 kg ha^{-1}) and medium in available phosphorus (12 kg ha^{-1}) and potassium (140 kg ha^{-1}). The amount and distribution of rainfall during the experimental period are given in Table 1.

The productivity and economics of monocropping of pearl millet - fallow, maize - fallow, okra - fallow (agricultural crops) and medicinal crop, ashwagandha, at low (50 cm x 20 cm spacing) and high (25 cm x 20 cm spacing) population densities, were evaluated against overlapping cropping of ashwagandha at two plant population densities (as in monocrop) with pearl millet, maize and okra. The experiment was done in randomized block design with four replications and the plot size was 4 m x 3 m. Pearl millet, maize and okra were sown in lines spaced at 50 cm apart in the second week of July in each experiment. Ten days after planting, the plants were thinned to maintain 20, 30 and 50 cm plant to plant distance within rows for pearl millet, maize and okra, respectively. For overlapping cropping, ashwagandha seeds were drilled in shallow furrows between the two lines of agricultural crops before their harvest in first week of September (Fig. 1). The dates of planting and harvesting of different crops are given in Table 2.

For low population density (LPD) of overlap crop, one row of ashwagandha was placed at the centre of two rows of agricultural crops, whereas for high population density (HPD), two rows were sown between the two rows of agricultural crops, maintaining 25 cm distance between overlap crop rows. Two weeks after planting, ashwagandha plants were thinned to

Table 1. Monthly rainfall (mm) received during the experimental period

Period	July	August	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	Total
1997-98	280.5	177.6	157.8	107.6	36.4	99.6	8.0	25.4	16.3	10.8	920.0
1998-99	395.2	307.6	168.2	19.8	6.4	-	28.8	8.4	-	-	934.4

Table 2. Planting and harvesting schedule of various crops

Crop	1997-98		1998-99	
	Date of planting	Date of harvesting	Date of planting	Date of harvesting
Pearlmillet	8 July 97	17 Sept. 97	7 July 98	17 Sept. 98
Maize	8 July 97	25 Sept. 97	7 July 98	24 Sept. 98
Okra	8 July 97	18 Sept. 97	7 July 98	16 Sept. 98
Ashwagandha	3 Sept. 97	11 April 98	4 Sept. 98	10 April 99

maintain 20 cm distance from plant to plant within the rows at both low and high population density (Fig. 1), thus, giving a plant population of 100 x 10^3 and 200 x 10^3 plants ha^{-1} for LPD and HPD, respectively. For monocrop ashwagandha the row to row and plant to plant distance were the same as for overlapping cropping. The recommended agronomic practices for growing agricultural crops were followed (Singh 1988). Pearl millet and maize were harvested in 3rd and 4th week of September, respectively, and grain and stover yields were recorded at 10% moisture content. Okra plants were uprooted in 3rd week of September when fruiting came to an end. Ashwagandha was harvested in the 2nd week of April and root yield was recorded at 10% moisture content.

Grain and stover yields of agricultural crops and root yield of ashwagandha were converted into 'Pearl millet Grain Equivalent Yield' (PGEY) as per method suggested by Lal & Ray (1976), to make valid comparison among treatments and to facilitate statistical analysis. The procedure for the calculation of PGEY is given

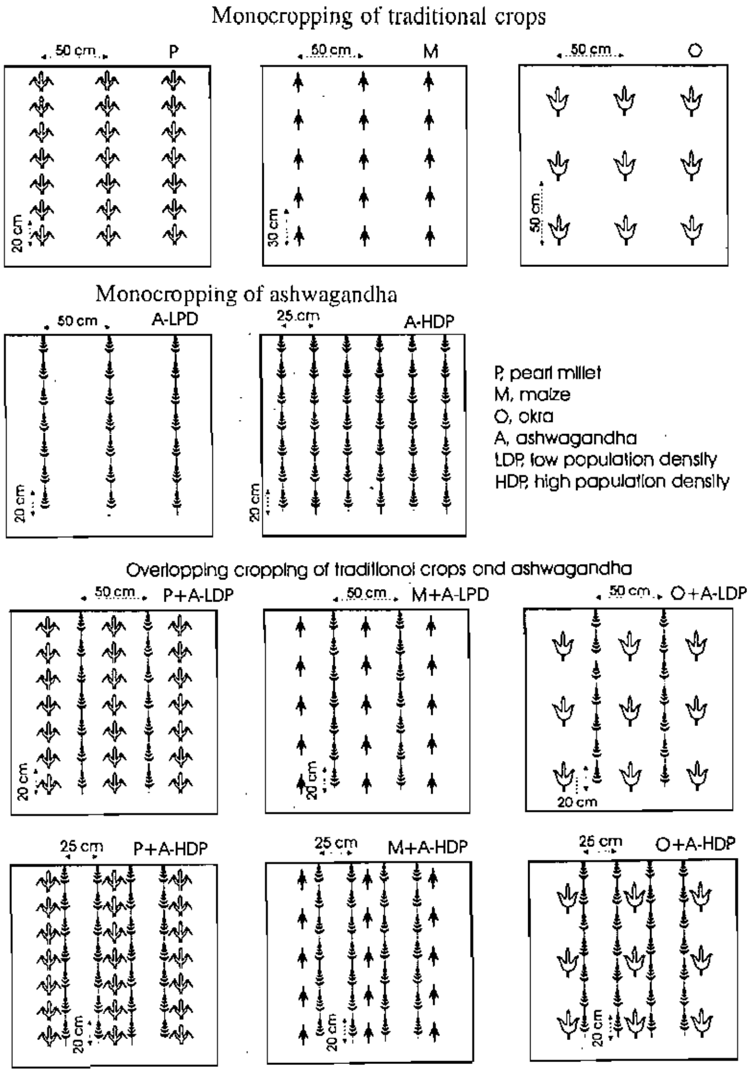

Fig. 1. Schematic diagram showing planting pattern of traditional crops and ashwagandha under mono and overlapping cropping systems

below:

$$PGEY = \sum_{i=1}^{n} (yi\ ei)$$

Where y = the economic yield of 1 to n number of crops (q ha^{-1})

e = pearlmillet grain equivalent factor which can be calculated as Pc/Pp, where Pc is the price of a unit weight of concerned crop and Pp is the price of unit of pearl millet grain and i = 1 to n number of crops.

Data on root yield of ashwagandha and PGEY were subjected to statistical analysis by ANOVA, and treatment means were separated at 5% level of probability. Economics of cropping systems were worked out taking the current costs of various inputs and produce into account.

Results and discussion

Crop yield

Yields of agricultural crop and medicinal plants ashwagandha under mono and overlapping cropping system were comparable during two years of experimentation owing to no significant variations in weather conditions, soil and crop management practices. Therefore, no year x treatment interaction could be observed. Grain and stover yields of traditional agricultural crops and root yield of ashwagandha recorded in present experiment were optimum and comparable to the level of yield achieved under rainfed conditions in subtropical plains of North India (Tewari *et al.* 1987; Ramalu *et al.* 1998). Overlapping cropping of ashwagandha did not adversely affect the production of agricultural crops but the production of ashwagandha itself was significantly reduced over its monocropping. It may be worth noting that the association of overlap crop with agricultural crops was for a short period of only about two to three weeks that too near maturity stage of agricultural crops, and ashwagandha being a slow growing plant in early stage of its growth could not have posed much competition to agricultural crops. These might have been the reasons for no effect of overlapping cropping on the yield of agricultural crops. In general, root yield of ashwagandha under overlapping cropping was 23.0 to 38.5% less at LPD and 13.3 to 33.3% at HPD as compared with the respective yield under monocropping system. The root yield with HPD over LDP was 53.8% higher under monocropping and 66.7 to 73.3% under overlapping cropping system (Table 3). Thus, ashwagandha at HPD showed superiority over LPD both under mono and overlapping cropping systems. For optimum root production of ashwagandha, maintaining a higher plant population has been suggested (Singh & Kumar 1998). Root production of ashwagandha under overlapping cropping system, both at LPD and HPD, was significantly reduced, compared to monocropping. However, the reduction was greater at LPD than HPD and the highest with okra and lowest with pearl millet, at both HPD and LPD (Fig. 2). Shading by tall growing agricultural crops, lower moisture content (data not given) and lower level of available nutrients in soil under overlapping cropping, compared to monocropping, could be the possible reasons for reduction in root yield. The lower reduction in root yield under overlapping cropping at HPD than at LPD, in comparison to yield under monocropping, may be explained in a manner that at HPD there was higher competition for various growth resources, especially

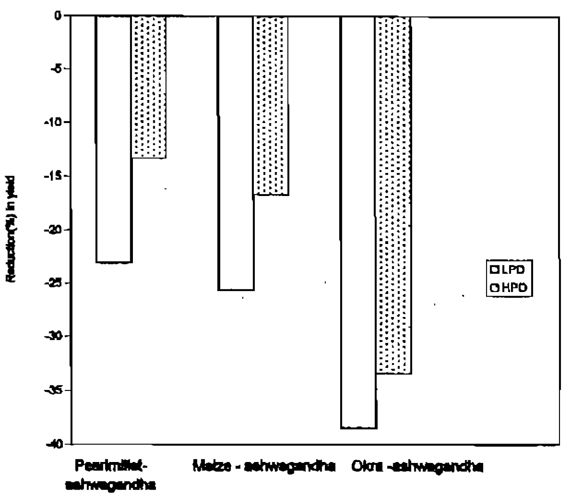

Fig. 2. *Reduction in root yield (%) of ashwagandha under overlapping cropping over monocropping at low (LPD) and high (HPD) population densities*

Table 3. Yield of different crops under monocropping and overlapping cropping systems

Cropping system	Yield (q ha^{-1})*			PEGY	Per cent increase in PEGY pearl
	Grain	Stover	Ashwagandha (dry roots)	(q ha^{-1})	millet-aswagandha (HDP) over remaining cropping systems
Pearlmillet - fallow	25.0	50.0	-	43.8	146.3
Maize – fallow	26.0	52.5	-	39.0	176.7
Okra – fallow	40.0[3]	-	-	50.0	115.8
Fallow- ashwagandha[1]	-	-	3.9	48.8	121.1
Fallow- ashwagandha[2]	-	-	6.0	75.0	43.9
Pearl millet-ashwagandha[1]	25.2	53.0	3.0	82.6	44.0
Pearl millet-ashwagandha[2]	24.8	51.0	5.2	107.9	-
Maize-ashwagandha[1]	26.0	50.5	2.9	74.9	30.6
Maize-ashwagandha[2]	25.5	52.0	5.0	101.0	6.8
Okra- ashwagandha[1]	36.5[3]	-	2.4	79.4	35.9
Okra- ashwagandha[2]	40.0[3]	-	4.0	100.0	7.9
CD at 5%	-	-	0.6	8.1	

[1]Low ashwagandha population density. [2]High ashwagandha population density. [3]Green fruit yield
*Average of two years

for soil moisture, between ashwagandha plants and because of this reason stressed plants diverted greater percentage of assimilate towards root development than the plants under LPD where the diversion of assimilate might have been comparatively higher towards shoot than root, and thus the difference. In narrow spaced soybean the diversion of assimilate towards sink (pods) was 1.8 times greater than wider spaced soybean (Shepherd *et al.* 1988).

Pearl millet grain equivalent yield (PEGY)

The PGEY, in general, of overlapping cropping system was significantly higher (P=0.05) than of monocropping system, except that of ashwagandha at HPD under monocropping which was statistically similar to maize-ashwagandha (74.9 q ha^{-1}), okra - ashwagandha (79.4q ha^{-1}) and pearlmillet – ashwagandha (82.6 q ha^{-1}) overlapping cropping at LPD of ashwagandha (Table 3). The PGEY with ashwagandha overlapping cropping at HPD was significantly (P=0.05) higher over overlap-

Table 4. Economics of monocropping and ashwagandha based overlapping cropping systems

Cropping system	Cost of cultivation ('000, Rs ha^{-1})			Gross returns ('000, Rs ha^{-1})			Net return ('000, Rs ha^{-1})		
	Rainy season crop	Ashwa-gandha	Total	Rainy season crop	Ashwa-gandha	Total	Rainy season crop	Ashwa-gandha	Total
Pearl millet-Fallow	7.7	-	7.7	17.5[3]	-	17.5	9.0	-	9.8
Maize-Fallow	8.2	-	8.2	15.7[4]	-	15.7	7.5	-	7.5
Okra-Fallow	9.7	-	9.7	20.0[5]	-	20.0	10.3	-	10.3
Fallow-ashwagandha[1]	-	8.0	8.0	-	19.5[6]	19.5	-	11.5	11.5
Fallow-ashwagandha[2]	-	9.0	9.0	-	30.0	30.0	-	21.0	21.0
Pearl millet- ashwagandha[1]	7.7	8.0	15.7	18.0	15.0	33.0	10.3	7.0	17.3
Pearl millet- ashwagandha[2]	7.7	9.0	16.7	17.6	26.0	43.6	9.9	17.0	26.9
Maize-ashwagandha[1]	8.2	8.0	16.2	15.5	14.5	30.0	7.3	6.5	13.8
Maize-ashwagandha[2]	8.2	9.0	17.2	15.4	25.0	40.4	7.2	16.0	23.2
Okra-ashwagandha[1]	9.7	8.0	17.7	18.3	12.0	30.3	8.6	4.0	12.6
Okra-ashwagandha[2]	9.7	9.0	18.7	20.0	20.0	40.0	10.3	11.0	21.3

[1]Low population density of ashwagandha. [2]High population density of ashwagandha [3]Pearmillet grain Rs 4 kg^{-1} and stover Rs. 1.50 kg^{-1} [4]Maize grain Rs. 4 kg^{-1} and stover Rs. 1 kg^{-1} [5]Okra fruits Rs 5 kg^{-1} [6]Ashwagandha roots Rs. 50 kg^{-1}
* Average of two years

ping cropping with LPD with all the agricultural crops. The maximum PGEY value (107.9 q ha^{-1}) was recorded with pearl millet - ashwagandha HPD overlapping cropping. However, it was statistically at par to maize - ashwagandha (101.0 q ha^{-1}) and okra - ashwagandha (100.0 q ha^{-1}) overlapping cropping at HPD (Table 3). The PGEY values with overlapping cropping ashwagandha at HPD were maximum and 2 to 2.5 folds higher than any of the agricultural crops under monocropping. Since the yields of agricultural crops were least affected by overlapping cropping of aswagandha, the additional yields of 4 – 6q roots ha^{-1} of aswagandha at HDP under overlapping cropping and high selling price of roots (Rs 50 kg^{-1}) could greatly influence the PGEY.

Economics

Ashwagandha at HPD under monocropping gave a net economic return of Rs. 21,000 ha^{-1} which was about 21.4 to 180% higher than the remaining cropping systems, except the overlapping cropping treatments at HPD of ashwagandha. Under the overlapping cropping system, ashwagandha with HPD recorded maximum net economic return (Rs. 26,900) as against Rs 17,300, 13,800, 23,200, 12,600 and 21,300 with pearl millet - ashwagandha (LPD), maize - ashwagandha (LPD), maize - ashwagandha (HPD), okra - ashwagandha (LPD) and okra - ashwagandha (HPD), respectively (Table 4).

The results of the studies suggest that farmers in rainfed/dryland areas in sub-tropical North India may be economically benefited by adopting overlapping cropping of ashwagandha over traditional monocropping system.

Acknowledgement

The authors are grateful to the CSIR, New Delhi for facilities and support.

References

Dey A C 1988 Indian Medicinal Plants Used in Ayurvedic Preparations. Bishan Singh, Mahendra Pal Singh, Dehradun, India.

Lal R B & Ray S 1976 Economics of crop production of different intensities. Indian J. Agric. Sci. 46 : 93-96.

Ramulu B, Gautam R C & Kaushik S K 1998 Intercropping in pearl millet (*Pennisetum glaucum* L.) with grain legumes and oilseeds crops under rainfed conditions. Indian J. Agron. 43 : 382-386.

Shepherd K D, Greygory P J, Woodhead T, Pandey R K & Magbugos E L 1988 Growth of soyabean (*Glycene max*) and mungbean (*Vigna radiata*) in post monsoon season after upland rice. Exp. Agric. 24 : 433-441.

Singh S & Kumar S 1998 *Withania somnifera*. The Indian ginseng Ashwagandha pp. 202-207. Central Institute of Medicinal and Aromatic Plants. Lucknow. India.

Singh S, Singh A & Kumar S 1996 Important medicinal plants used in health care : Propects of their large scale cultivation and production in India. 66th Annual Session of the National Academy of Sciences, India. Dr. B.R. Ambedkar Marathwada University, Aurangabad Oct. 31- Nov. 2, 1996.

Singh S S 1988 Crop Management Under Irrigated and Rainfed Conditions. Kalyani Publishers, New Delhi, India.

Tewari A N, Rathi K S, & Yadav A N 1987 Effect of intercrop and herbicides on weed control in maize. Indian J. Agron. 32 : 97-98.