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Productivity and Economics of Ashwagandh [*Withania somnifers* (L.)] under Different Intercropping with Pulses and Oilseeds

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ABSTRACT

The field experiment was conducted during kharif 2009 and 2011 at Research farm, College of Agriculture, Jawaharlal Nehru Krishi Vishwa Vidhyalaya, Jabalpur (MP). The experimental soil was sandy loam with 7.5 p^H, having 0.48 % low in organic carbon, available N (230 kg/ha), available P (13.80 kg/ha) and high in available K (371.70 kg/ha). The experiment field received 1471 and 1712 mm rainfall during two respective years. The experiment comprises 05 intercropping system (Ashwagandha + red gram, Ashwagandha + green gram, Ashwagandha + soybean, Ashwagandha + sesame and Ashwagandha + niger) with 02 row ratio (3:1 and 4:1) along with 01 sole ashwagandha and, all 11 treatments were tested in randomized block design with 04 replications. The sole cropping of Ashwagandha produced significantly higher root yield (518 kg/ha), seed yield (86 kg/ha) and herbage yield (495 kg/ha) over intercropping system. Among the intercropping systems, Ashwagandha grown with the sesame gave the highest root yield (430 kg/ha), grain yield (69 kg/ha) and herbage yield (406 kg/ha) in Ashwagandha with sesame (4:1). The yield of associate crops was highest seed yield (988 kg/ha) and straw yield (918 kg/ha) in Ashwagandha + red gram (3:1). Ashwagandha equivalent yield was noted significantly maximum under ashwagandha + red gram (627 kg/ha) in 3:1 and 625 kg/ha in 4:1 row proportion. The higher cultivation costs (Rs 28110/ha) and gross monetary returns (Rs 156750/ha) was obtained in ashwagandha sole, but net monetary returns and benefit cost ratio were recorded in Ashwagandha + pigeon pea with 3:1 row ratio (Rs 129760/ha, 5.81) and Ashwagandha + pigeon pea with 4:1 row ratio (Rs 129037/ha, 5.74) and sole ashwagandha, (Rs 124140/ha, 5.42).

Key word: *Ashwagandha, red gram, green gram, soybean, sesame, niger, intercropping system*

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INTRODUCTION

Ashwagandha (*Withania somnifera* L.) is known as Indian ginseng, is an important ancient plant belongs to Solanaceae family, the roots of which have been employed in Indian traditional systems of medicine *Ayurveda* and *Unani*, it is an erect branching under shrub reaching about 0.5- 1.0 m in height. Intercropping is the agricultural practice to produce a greater yield on a given piece of land by material use of resource efficiency. Delicate or light sensitive plants may be given shade or protection or otherwise wasted space can be utilized initial growth of ashwagandha and supported to warm air, protected to natural enemies with increased nutrients and water use efficiency. Better soil use of nutrients can be possible due to difference in rooting pattern which may also occur due to mutual avoidance of different rooting system[17]. The success of any intercropping system depends mainly on selection of component crops. The component crops should invariably have different growth rhythms and rooting patterns.

The demand of pulses and oilseeds is increasing due to increased human population. It is therefore essential to increase their production under different cropping systems. The information on productivity and economical gain from Ashwagandha intercropped with pulses (red gram and green gram) and oilseeds (soybean, sesame and niger) was lacking for Kymore Plateau of Madhya Pradesh hence, the present research was taken up.

MATERIALS AND METHODS

The field experiment was conducted at research farm of Jawaharlal Nehru Krishi Vishwa Vidhyalaya, Jabalpur (M.P.) India during *kharif* of 2009 and 2011. The soil was clay-loam with 7.5 p^H low in organic carbon (0.48 %), and available nitrogen (230.2 kg/ha), medium in available phosphorus (13.80 kg/ha) and high in available potassium (371.70 kg/ha). The rainfall received 1471 and 1712 mm, in 43 and 59 rainy days, the mean maximum and minimum temperature were 31^0C and 30 ^{0}C and 19 ^{0}C and 18 ^{0}C, the relative humidity ranged from 52 to 87 % and 55 to 61 % during two respective experimental periods. The treatment comprised 05 intercropping system (Ashwagandha + red gram, Ashwagandha +green gram, Ashwagandha + soybean, Ashwagandha + sesame and Ashwagandha + niger) with 02 row ratio each (3:1 and 4:1) along with one sole Ashwagandha. In all 11 treatments with 04 replications were tested in randomized block design.

The seed rate and variety of Ashwagandha, red gram, green gram, soybean, sesame and niger were JA- 134, 05 kg/ ha; ICPH 2671, 10 kg/ha; K 851, 25 kg/ha; JS 97-52, 50 kg/ha; JTS 8, 02 kg/ha and JNC 1, 02, kg/ha, respectively. The crops sown on 26 June, 2009 and 30 June, 2011 with two intercropping system I_1- 3:1 (3 row Ashwagandha followed by 1 row intercrops) and I_2 - 4:1 (4 row Ashwagandha followed by 1 row intercrops) with spacing between sole and intercrops 30 x 15 cm. The recommended dose of fertilizers was 40 kg N + 20 kg P_2O_5 + 20 kg K_2O /ha for the Ashwagandha, sesame, and niger, while it was as 20 kg N + 60 Kg P_2O_5 + 20 kg K_2O/ha for red gram, green gram and soybean. Total two irrigations were applied in Ashwagandha and red gram in month of October during the both years. The crops were harvested in different date as per maturity those are ashwagandha, red gram, green gram, soybean, sesame and niger on 27th December, 27th November, 29th August, 15th October, 25th December, 20th October in 2009 and 28th December, 29th November, 30th August, 17th October, 27th December, 22th October in 2011, respectively. All the standard package of package of practices was following for production of ashwagandha and intercrops.

RESULTS AND DISCUSSION

Productivity of Ashwagandha

Root yields

Ashwagandha is mainly grown for its root yields. The root yields of Ashwagandha significantly varied between different treatments in both years of investigation as well as for mean yields of two years. The trend

of root yield was most similar in both the year under different treatment. Based on 2 years mean data, sole crop of Ashwagandha significantly produced higher root yields (518 kg/ha.) over all other intercropped stands producing root yields between 392 to 430 kg/ha. The root yields of Ashwagandha ranged between 420 to 430 kg/ha in 4:1 row proportions, while it ranged from 392 to 403 kg/ha in 3:1 row proportions. The root (tuber) yield, grain yield and herbage yield kg/ha were found to be significantly higher under sole cropping of ashwagandha. This may be due to complete occupation of land (per unit area) by Ashwagandha grown alone. Whereas under intercropping systems, 20 and 25 % land was occupied by associated intercrops according to the row ratio maintained. The field of ashwagandha from other intercropping treatments were found equally lower that is why under the intercropping treatments, all these productivity parameters of ashwagandha were decreased up to significant extent due to lack of occupation of lesser area of land compared to its sole stand. The productivity parameters of Ashwagandha *viz.* root yield, seed yield, herbage yield were significantly higher under sole stand compared to its different intercropping treatments because of the lesser land occupied by it. All productivity parameters of Ashwagandha had numerically greater values when it was intercropped with 4:1 row proportion than that of those obtained with 3:1 row proportion mainly due to more area of land occupied by Ashwagandha crop. Though the all phonological, physiological and growth parameters of Ashwagandha were almost alike between its sole and intercropped stands mainly due to lesser crop stands. These findings are closed conformity with those of Lingaraju *et al*[4].

Seed yields

On the basis of 2-year mean data, the sole Ashwagandha led to record significantly maximum seed yields (86 kg/ha.) over other intercropped stands. The seed yields varied from 61 to 69 kg/ha among all intercropped stands, but variations in seed yields among them were not significant. Ashwagandha + sesame/green gram 4:1 row ratio followed by Ashwagandha + soybean with 4:1 row ratio gave the significantly higher seed yield of ashwagandha.

Herbage yields

Sole Ashwagandha had produced significantly maximum herbage yields (495 kg/ha) among all treatments. It means herbage yields were significantly lesser in all intercropped stands over its sole stand. The herbage yields varied from 366 to 406 kg/ha among all ten intercropped stands, which were at par with each other. It was because of 80 and 75 % plant population of ashwagandha under 4:1 and 3:1 row ratio of intercrop maintained that of sole ashwagandha.

Productivity of Associated Crops

These all intercrops are genetically differing with each other. Among them, red gram and green gram are mostly grown for seed yield to be used as pulses, while soybean, sesame and niger are grown for their seed yield to be used as oilseeds. The all crops are quietly different with each other in their morphological features. Therefore, data on seed yield and straw yield of these crops are not directly comparable with each other (Table 1). The producer of all the associated crops have their own economic importance, hence their Ashwagandha equivalent yields (AEYs) were worked out treatment wise and then added with the Ashwagandha yields (tubes + seeds+ herbage) of respected treatment. It is clear from the data that both seed and straw yield of all associated crop were numerically higher in intercropped with Ashwagandha under 3:1 row proportion than those of obtained with 4:1 row proportion.

Ashwagandha equivalent yields

The AEY significantly varied between different intercropping treatments during both years of investigation as well as mean of the 2-year data. Based on mean data of both years, Ashwagandha + red gram intercropping system led to record AEY of 627 and 625 kg/ha in 3:1 and 4:1 row proportions, respectively which were numerically higher than sole Ashwagandha stand (609 kg/ha). Remaining intercropping system produced

significantly lesser AEYs (493 to 537 kg/ha) than sole Ashwagandha and Ashwagandha+ red gram intercropping systems. This may be due to complete occupation of land (per unit area) by Ashwagandha grown alone. Whereas under intercropping systems, some portion of the land was occupied by associated intercrops according to the row ratio maintained. The field of ashwagandha from other intercropping treatments were found equally lower that is why under the intercropping treatments all these productivity parameters of ashwagandha were decreased up to significant extent due to lack of occupation of lesser area of land compared to its sole stand. The productivity parameters of Ashwagandha *viz.* root yield, seed yield herbage yield were significantly higher under sole stand compared to its different intercropping treatments because of the lesser land occupied by it. All productivity parameters of Ashwagandha had numerically greater values when it was intercropped with 4:1 row proportion then that of those obtained with 3:1 row proportion mainly due to more area of land occupied by Ashwagandha crop. Though the all phonological, physiological and growth parameters of Ashwagandha were almost alike between its sole and intercropped stands mainly due to lesser crop stands. These findings are closed conformity with those of Yilmax *et al*[19]., and Lingaraju *et al*[4]. The advantages seed yields of red gram replacing one row of ashwagandha either of 3:1 and 4:1 row proved to better than sole cropping of ashwagandha as well as its intercropping with pulse (green gram) and oilseed (soybean, sesame and niger) crops. The descending order of different intercropping systems with regard to AEYs was Ashwagandha + redgram > Ashwagandha alone > Ashwagandha + sesame > Ashwagandha + soybean > Ashwagandha + green gram > Ashwagandha + niger. Thus, it could be said that all Ashwagandha based intercropping systems were less advantageous than sole cropping of ashwagandha except ashwagandha + red gram intercropping in both 3:1 and 4:1 row proportions. The mutual co-operation of ashwagandha and red gram for their co-existence and higher market value of red gram in the market appears to be possible reason for it. The results also corroborated the findings of several other research workers, Patra *et al*[8]., Sarkar and Shit *et al*[13]., Rout *et al*[12]., Andrade *et al*[1]., Sunil Kumar *et al*[16]., and Verma *et al*[18].

Table 1: Productivity of different crops under different intercropping systems (Pooled data of 2 years)

S. No.	Treatments	Ashwagandha			Intercrops		AEY (kg/hq)
		Root yield (k/ha)	Seed yield (kg/ha)	Herbage yield (kg/ha)	Seed yield (kg/ha)	Straw yield (kg/ha)	
1	Ashwagandha (A) sole	518	86	495	-	-	609
2	A + Red gram 3:1 rows	400	61	366	988	918	627
3	A+ Green gram 3:1 rows	397	62	369	311	335	508
4	A+ Soybean 3:1 rows	397	61	375	376	442	513
5	A + Sesame 3:1 rows	403	66	373	129	113	513
6	A + Niger 3:1 rows	392	63	372	127	119	493
7	A + Red gram 4:1 rows	423	66	395	803	855	625
8	A+ Green gram 4:1 rows	423	69	403	247	313	533
9	A+ Soybean 4:1 rows	420	68	399	314	424	536
10	A+ Sesame 4:1 rows	430	69	406	111	103	537
11	A + Niger 4:1 rows	425	67	404	114	113	527
SEm ±		**4**	**45**	**3**	**NA**	**NA**	**29**
CD 5%		**11**	**130**	**7**	**-**	**-**	**83**

ECONOMIC ANALYSIS

Cost of cultivation

The cost of cultivation was maximum (Rs 28118/ha) under Ashwagandha sole cultivation. Among all intercropping system closely followed by Ashwagandha + soybean 4:1 and 3:1 row intercropping system was Rs 27873 and Rs 27815/ha, which comparatively decreased (Rs 27213/ha) under Ashwagandha + red gram 4:1 row intercropping system. The cost of cultivation under Ashwagandha + niger 3:1 row proportion was lesser (Rs 24918) which slightly increased as Rs 25556/ha due to its 4:1 rows intercropping system. Ashwagandha + sesame is intercropping system nominally higher investment over Ashwagandha + niger intercropping system under both 3:1 as well as 4:1 row arrangement. The Ashwagandha+ green gram intercropping system needed nearly Rs1000/ha lesser investment under both spatial arrangements.

Table 2: Economics of Ashwagandha under different intercropping systems (Pooled data of 2 years)

S. No	Treatments	Cost of Cultivation (Rs/ha)	Gross Monetary Returns (Rs./ha)	Net Monetary Returns (Rs./ha)	B:C ratio
1	Ashwagandha (A) sole	28110	152250	124140	5.42
2	A + Red gram 3:1 rows	26990	156750	129760	5.81
3	A+ Green gram 3:1 rows	26040	127000	100960	4.88
4	A+ Soybean 3:1 rows	27815	128250	100435	4.61
5	A + Sesame 3:1 rows	25118	128250	103132	5.11
6	A + Niger 3:1 rows	24918	123250	98332	4.95
7	A + Red gram 4:1 rows	27213	156250	129037	5.74
8	A+ Green gram 4:1 rows	26453	133250	106797	5.04
9	A+ Soybean 4:1 rows	27873	134000	106127	4.81
10	A+ Sesame 4:1 rows	25716	134250	108534	5.22
11	A + Niger 4:1 rows	25556	131750	106194	5.16
	SEm±	-	**1545.57**	**1121.93**	**0.05**
	CD at 5%	-	**4463.94**	**3240.38**	**0.16**

Gross monetary returns

It is evident from the data that the GMRs were higher as Rs 156750/ha and Rs 156250/ha with Ashwagandha + red gram intercropping system in 3:1 and 4:1 row proportions, respectively over sole Ashwagandha cropping (Rs 152250/ha). Ashwagandha+ sesame 4:1 row intercropping led to register next best GMR (Rs 134250/ha) closely followed by Ashwagandha + soybean 4:1 rows (Rs 134000/ha), Ashwagandha+ green gram 4:1 rows (Rs 133250/ha) and Ashwagandha + niger 4:1 rows (Rs. 131750/ha) intercropping system, remaining intercropping system fetched quite lesser GMRs (Rs 123250 to Rs 128250/ha) than the above mentioned intercropping systems.

Net monetary returns

The NMR is actual monetary profit under a particular treatment, which could be fetched by the growers after deducting the cost of investment from the total marketable value of the produce on per hectare basis. The NMR was maximum (Rs 129760/ha) from the Ashwagandha + red gram with 3:1 rows which almost comparable to those obtained under Ashwagandha + red gram intercropping systems in 4:1 row (Rs 129037/ha) spatial arrangements. Other in intercropping systems led to record the quite lesser NMR values ranging from Rs 98332/ha to Rs 100435/ha. It is also obvious from the said data that the NMR values were about Rs 5000 To 7000/ha greater under 4:1 rows proportion than those of obtained with 3:1 rows proportions. Among the intercrops, red gram, sesame, green gram, niger and soybean positioned them self in descending order The similar results trends have been reported by Lingaraju *et al*[4]. The data in Table1 indicate that the AEY under Ashwagandha with red gram was found maximum (625 to 627 kg/ha) were in case of

intercropping treatments. The lowest total AEY (4.93 q/ha) was recorded from Ashwagandha+ niger intercropping. The drastic variation in AEY under sole as well as intercropping systems have also been reported by Reddy *et al*[10]., Baghel *et al*[2]., Rajput *et al*[9]., Reddy and Raddy[11]. The ultimate aim of any crops grower is to square maximum income/ha out of the applied production technology. It is general understanding that intercropping system having pulses and oilseeds not only provide the extra income to the farmers but also make available all the resources per unit area apart from covering the risk of crop failure under adverse conditions. Amongst the intercropping systems of Ashwagandha with red gram gave the maximum net income up to Rs. 129760/ha with B:C ratio 5.81 and Rs 129037 with 5.74 either 3:1 and 4:1 row ratio. This was followed by sole Ashwagandha Rs 124140/ha with 5.42 B:C ratio. The increased net income from Ashwagandha grown alone was due to maximum yield obtained/ha and increased cost of leaves and roots of this medicinal crop. The net income was decrease when pulses are oilseeds were intercropped with ashwagandha. The variation in the income from Ashwagandha grown with intercrops was due to variation in the competition and compatibility of intercrops with the main crop ashwagandha. The similar results trends have been reported by Lingaraju *et al*[4]., Shrivastava *et al*[14]., and Lingegouda *et al*[5].

Benefit-Cost ratio

Data related to B-C ratio of different intercropping system are given in Table 2. It is evident from the said data that like NMR, Ashwagandha + red gram intercropping system led to register the higher profitability (5.81) as compared to Ashwagandha grown sole crop with 5.42 B:C ratio. Ashwagandha + sesame intercropping system with 4:1 row proportion (5.22). Ashwagandha + niger 4:1 and Ashwagandha + sesame intercropping system 3:1 also stood very close to in this regard with B:C ratio of 5.16 and 5.10, respectively, followed by Ashwagandha+ green gram B:C ratio was found 5.04 and 4.88 under 4:1 and 3:1 consequently. Ashwagandha+ soybean intercropping system gained the lowest B:C ratio of in 3:1 row proportions, respectively among all the treatments, remaining intercropping systems led to record. The B:C ratio ranging from 4.61 to 5.81, on looking the overall picture of this parameter, all intercropping system with 4:1 row proportion led to register higher values than 3:1 row proportion under each respective companion crop. These findings are closed conformity with those of Andrade *et al*[1]., Maurya, and Rathi[7] Srinivasan and Ahlawat[15] Mahapatra *et al*[6]., Hiremath *et al*[3].

CONCLUSION

The present results on the productivity of ashwagandha intercropped with pulse and oilseeds under 3:1 and 4:1 row ratio can be concluded that the Ashwagandha + red gram was found most productive system in terms of Ashwagandha equivalent yield (AEYs) under 3:1 (627 kg/ha) and 4:1 (625 kg/ha) row proportion which were significantly superior than sole Ashwagandha stand (609 kg/ha). Inter cropping Ashwagandha + red gram with 3:1 (Rs 129760/ha, 5.81 B: C ratio) was found followed by 4:1 row ratio (Rs 129037/ha, 5.74 B: C ratio) most profitable system in terms of net monetary returns and benefit ratio.

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