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Effect of method of irrigation and fertility levels on performance of rice-*Ashwagandha* sequence cropping system

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ABSTRACT

A field experiment was conducted at Directorate of Water Management, Bhubaneswar during 2006-07 and 2007-08 dry seasons to study the effect of drip irrigation regimes and fertility levels on economics of Ashwagandha [(Withania somnifera (L.), Dunal)] in rice based cropping system. The treatments consisted of three irrigation regimes (drip irrigation at 100% pan evaporation (PE), at 80% PE and at 60% PE) with three fertility levels (100%, 75% and 50% recommended dose of nitrogen, phosphorous and potassium) with control having surface irrigation and soil application of fertilizer. Application of irrigation at 80% PE through drip with recommended dose of fertilizer (RD) through fertigation to Ashwagandha produced the highest yield (862 Kg of dry roots and 82 Kg of seed ha^{-1}). Rice equivalent yield of Ashwagandha was 9,152 Kg ha^{-1}. Drip irrigation gave more gross return, net return and benefit-cost ratio than surface irrigation and soil application of fertilizer. Application of irrigation at 80% PE and fertigation of 100% RD to Ashwagandha gave maximum net return of ₹ 54,000 ha^{-1}.

Key words: *Ashwagandha, drip fertigation, economics, rice equivalent yield*

Rice-rice system is adopted after commissioning of any irrigation project in Eastern part of the country. Sustainability and economic efficiency are the most important indices for evaluation of any cropping system. Rice-based cropping system has considerable significance for Eastern India. The farmers are interested in substituting the traditional crops such as pulses and oilseeds grown after rice with remunerative crops for better return. There is good possibility of raising medicinal crops in rice fallows to increase the income. Medicinal plants have attained high significance in recent years due to its demand for industrial use and alluring market price (Lubbe and Verpoorte, 2011). Several medicinal plants like Ashwagandha can be commercially grown in India as its climate and soil suit their cultivation (Chandraprakash, 2005).

Ashwagandha, also known as Indian ginseng, is an important medicinal plant. The roots of this plant are used in Indian traditional systems of medicine, Ayurveda and Unani. It is native to the drier parts of India and cultivated in more than 4000 ha. It is a perennial herb, grows up to 180 cm and propagated by division, cuttings or seed. The estimated production of Ashwagandha roots in India is more than 1500 tonnes as against the annual requirement of 7000 tonnes. Diversification of existing rice based cropping system through introduction of medicinal crops may give good economic return to the farmers of the Eastern India.

Drip fertigation is considered to be one of the most efficient resource conservation technology in improving the yield, quality and water use efficiency and saving of water and nutrients (Behera *et al.,* 2012). Considering the medicinal value of the Ashwagandha, its increasing demand and meager scientific information on its cultivation, the present investigation was undertaken to study the production potential and to optimize the irrigation and fertilizer levels in rice

based cropping system for the eastern part of the country.

MATERIALS AND METHODS

The present experiment was conducted at Experimental Farm of the Directorate of Water Management, Bhubaneswar during dry seasons of 2006-07 and 2007-08 to study the effect of drip irrigation regimes and fertigation levels on *Withania somnifera* (L.), Dunal (Ashwagandha) grown in the rice fallow. Rice variety Surendra was transplanted at a spacing of 20 cm x 10 cm with a fertiliser dose of 60-30-30 Kg N-P_2O_5-K_2O ha^{-1} during the rainy season. The medicinal plant was grown after harvest of rice and subjected to various treatments. The experiment was laid out in factorial randomized block design with three replications. There were three irrigation regimes drip irrigation at 100% pan evaporation (PE), at 80% PE and at 60% PE, and three fertility levels 100%, 75% and 50% recommended dose of NPK) with control having surface irrigation and soil application of fertilizer. The soil was sandy loam in texture with pH 5.7, low in organic carbon (0.46%) and low in available nitrogen (159 Kg ha^{-1}); medium in both available phosphorus (21 Kg ha^{-1}) and potassium (183 Kg ha^{-1}).

Forty day's old seedlings of Ashwagandha variety Jawahar were transplanted at a spacing of 30 cm x 10 cm on 27th October during both the years and a recommended fertilizer dose (RD) of 30-30-20 Kg N-P_2O_5-K_2O ha^{-1} was applied as per the treatment. It was thinned out at 30 days after planting (DAP) to retain one seedling $hill^{-1}$. After planting, a light irrigation was provided to ensure good sprouting. The fertilizers used for supplying NPK were urea (46% N), single super phosphate (16% P_2O_5) and muriate of potash (60% K_2O), respectively. Fertigation was given in equal splits at fortnightly interval starting from 15 days after planting up to 30 days before harvest. Full dose of phosphorus was applied basally to all the treatments. Required amount of urea and potash was dissolved in water and fed to the drip using ventury system. Fertigation was made by regulating the taps of the laterals allowing the solution to the specified plots as per the treatments. Ashwagandha was harvested during last week of March. Two seedlings of rice were transplanted $hill^{-1}$. The rice seedlings were transplanted on 29th June 2007 and 1st July 2008, respectively. The rice crop was harvested on 12th and 15th October of 2007 and 2008, respectively.

Different irrigation levels were imposed on the basis of pan evaporation through meteorological approach (Jenson *et al*., 1961). The depth of water during each irrigation was maintained at 6 cm in case of surface irrigation. First irrigation was given one day prior to planting. Subsequent irrigations were given at two days interval in drip irrigation and at 60 mm cumulative pan evaporation (CPE) value in surface irrigation method. If rainfall occurred between irrigation cycles, then the rainfall amount was deducted and irrigation water was applied accordingly. Cost of laying-out of drip irrigation system and cultivation charges were worked out per hectare. The life of drip system was assumed to be ten seasons. For working out the economics, prevailed market prices for Ashwagandha seeds (₹ 60 Kg^{-1}), urea (₹ 10.90 Kg^{-1} N), SSP (₹ 21.90 Kg^{-1} P), MOP (₹ 7.70 Kg^{-1}) and cost of labour (₹ 63 day^{-1}) were taken into consideration. The price of paddy was ₹ 7 Kg^{-1}. Rice-equivalent yield was calculated as per market price.

RESULTS AND DISCUSSION

The grain yield of rice was not influenced by the residual effect of the treatments during 2007 (Table 1). Root and seed yield of Ashwagandha increased by 9% due to drip irrigation and fertigation compared to surface irrigation and soil application of fertilizers. Selvaraj *et al.,* (1997), Tiwari *et al.,* (2003), Aujla *et al.,* (2005) and Behera *et al.* (2012) have reported increase in yield due to drip irrigated as compared to surface flow irrigation.

Both irrigation and fertility levels significantly influenced the yield of Ashwagandha. Application of irrigation at 80% PE produced the highest root (0.79 t ha^{-1}) and seed yield (0.07 t ha^{-1}) of Ashwagandha. Similarly, the crop receiving 100% RD produced the maximum root (0.74 t ha^{-1}) and seed yield (0.07 t ha^{-1}) as compared to lower levels of fertilizers. The interaction effect of irrigation and fertility levels was found significant. It was observed that application of irrigation at 80% PE with 100% RD produced the maximum root yield (0.86 t ha^{-1}) and seed yield (0.082 t ha^{-1}) in Ashwagandha (Table 2). It was due to optimum level of moisture and nutrient availability. Excess moisture at 100% PE was proved to be harmful,

Table 1. Effect of fertigation on yield (t ha^{-1}) of different crops

Treatment	Rice			Ashwagandha						Rice equivalent yield		
	Grain yield (t ha^{-1})			Root yield (t ha^{-1})			Seed yield (t ha^{-1})			(t ha^{-1})		
	2006-07	2007-08	Mean	2006-07	2007-08	Mean	2006-07	2007-08	Mean	2006-07	2007-08	mean
Method of irrigation												
Control	4.13	4.17	4.15	0.70	0.59	0.64	0.06	0.06	0.06	8.05	6.75	7.40
DF	4.14	4.20	4.17	0.73	0.67	0.70	0.07	0.07	0.07	8.39	7.71	8.05
CD (P<0.05)	NS	NS	NS	0.006	0.01	0.009	0.006	0.001	0.0007	0.07	0.21	0.11
Irrigation (I)												
100% PE	4.12	4.17	4.15	0.73	0.71	0.72	0.07	0.07	0.07	8.44	8.15	8.30
80% PE	4.14	4.19	4.16	0.83	0.75	0.79	0.07	0.08	0.07	9.56	8.60	9.08
60% PE	4.17	4.23	4.20	0.62	0.55	0.59	0.06	0.06	0.06	7.18	6.37	6.77
CD (P<0.05)	NS	NS	NS	0.01	0.03	0.01	0.001	0.002	0.001	0.12	0.37	0.20
Fertility (F)												
100% RD	4.17	4.22	4.20	0.77	0.71	0.74	0.07	0.08	0.07	8.63	8.21	8.50
75% RD	4.13	4.19	4.16	0.75	0.66	0.71	0.07	0.07	0.07	7.75	7.58	8.10
50% RD	4.13	4.17	4.15	0.67	0.64	0.66	0.06	0.06	0.06	8.80	7.33	7.54
CD (P<0.05)	NS	NS	NS	0.01	0.03	0.01	0.001	0.002	0.001	0.12	0.37	0.20

PE - pan evaporation, RD - recommended dose, NS= Not Significant

whereas shortage of moisture at 60% PE reduced the yield of Ashwagandha. Preferential partitioning of biomass in roots leads to higher root yield in moderate stress conditions (Patra *et al*., 2004).

Rice equivalent yield was significantly influenced by irrigation method, level of irrigation and fertility (Table 1). Drip irrigation recorded maximum yield (8.054 t ha^{-1}), which was 9% more than that of surface irrigation method (7.40 t ha^{-1}). Irrigation at 80% PE proved the best with rice equivalent yield (REY) of 9.08 t ha^{-1} and recorded 9.4 and 34 % higher REY than irrigation at 100% PE and 60 % PE, respectively due to higher root yield.

Table 2. Interactive effect of irrigation and fertilizer levels on mean root and seed yield, yield (t ha^{-1}) of Ashwagandha

Irrigation schedules	Fertility levels		
	100% RDNPK	75% RDNPK	50% RDNPK
Mean root yield (t ha^{-1})			
Drip irrigation at 100% PE	0.75	0.71	0.70
Drip irrigation at 80% PE	0.86	0.80	0.71
Drip irrigation at 60% PE	0.65	0.56	0.54
CD (P<0.05)		0.029	
Mean seed yield (t ha^{-1})			
Drip irrigation at 100% PE	0.078	0.076	0.071
Drip irrigation at 80% PE	0.082	0.079	0.075
Drip irrigation at 60% PE	0.064	0.068	0.060
CD (P<0.05)		0.002	
Mean rice equivalent yield (t ha^{-1})			
Drip irrigation at 100% PE	8.34	8.30	8.25
Drip irrigation at 80% PE	9.15	9.06	9.03
Drip irrigation at 60% PE	8.03	6.95	5.34
CD (P<0.05)		0.35	

PE - pan evaporation, RDNPK- recommended dose of NPK

Application of full dose of fertilizer (100% RD) produced maximum equivalent yield (8.50 t ha^{-1}). The REY decreased by 5% and 11% by decreasing RD by 25% and 50%, respectively (Table 1). The maximum yield increased due to precise application of fertilizer in right quantity at right time to match the crop need to enhance the growth and yield resulting in high economic return. These results are in conformity with the findings of Panchbhai *et al*. (2006) and Kubsad *et al*., (2009).

Drip irrigation increased the gross return by 6% and net return by 28% as compared to surface irrigation with high benefit:cost ratio of 1.03 (Table 3). Application of irrigation at 80% PE gave maximum gross return of ₹ 97,471 and net return of ₹ 53,733 with B: C ratio of 1.22. The crop receiving 100% RD also recorded the highest gross, net return and B: C ratio. Application of irrigation at 80% PE with 100% RD gave highest net return of ₹ 54,000 and B:C ratio of 1.26.

Table 3. Effect of fertigation on economics of rice- Ashwagandha cropping system

Treatment	Gross return (₹ ha^{-1})			Net return (₹ ha^{-1})			Benefit-cost ratio		
	2006-07	2007-08	Mean	2006-07	2007-08	Mean	2006-07	2007-08	Mean
Method of Irrigation									
Control	89325	80526	84926	37289	34282	35786	0.71	0.74	0.72
Drip fertigation	92344	87638	89991	47991	43426	45709	1.08	0.98	1.03
CD (P<0.05)	379	1082	628	434	861	124	0.011	0.009	0.016
Irrigation (I)									
100% PE	92866	90626	91750	47080	45102	46095	1.02	0.99	1.00
80% PE	100823	94119	97471	56850	50615	53733	1.29	1.16	1.22
60% PE	83336	78170	80753	40032	34562	37297	0.92	0.79	0.85
CD (P<0.05)	751	1874	1088	753	493	215	0.019	0.016	0.028
Fertility (F)									
100% RD	95646	91368	93510	52554	46608	49585	1.21	1.04	1.12
75% RD	93941	86772	90360	47757	42756	45260	1.03	0.97	1.00
50% RD	87440	84768	86104	43655	40907	42281	0.99	0.93	0.96
CD (P<0.05)	751	1874	1088	753	493	215	0.019	0.016	0.028

PE - pan evaporation, RD - recommended dose

It can be concluded that Ashwagandha produced highest dry root yield of 862 Kg and seed yield of 82 Kg ha^{-1} when drip fertigated at 80% PE with 100% recommended dose of fertilizer. Application of irrigation at 80% PE to Ashwagandha with recommended dose of fertilizer produced the maximum rice-equivalent yield, gross and net return and B:C ratio. Application of irrigation at 80% PE and fertigation of 100% RD to rice-Ashwagandha cropping system gave maximum net return of ₹ 54,000 ha^{-1} with B:C ratio of 1.26.

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