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Full Length Research Paper

Impact of bamboo species on growth and yield attributes of Kharif crops under agroforestry system in wasteland condition of the Central India

Rahangdale C.P*, Pathak N.N and Koshta L.D

Department of Forestry, Jawaharlal Nehru Agriculture University, Jabalpur, Madhya Pradesh, India.

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The experiment was conducted in 3 year old plantation of bamboo species planted at a spacing of 5m x 5m during rainy season of 2007-08. The experiment consisted of two bamboo species viz., *Dandrocalamus strictus* and *Bambusa arundinacea* in main plot and four different Kharif crops viz. Moong (TM-99-37), Soybean (JS-335), Paddy (JR-201) and Til (TKG 21) in sub plot under split plot design with three replication. These Kharif crops were also sown in the open plot without bamboo species, which served as control plot. Result showed non–significant differences among the bamboo species. However, different Kharif crops showed significant differences among themselves. Magnitude of mean of all the growth and yield attributing characters of different Kharif crops was found highest in the open condition as compared to bamboo based agrisilviculture system. Among the different Kharif crops, soybean showed highest yield reduction (67.88% and 49.22%) in the magnitude for grain and straw followed by moong (61.14% and 47.25%), til (50.65% and 39.71%) and paddy (36.55% and 19.78%). The economic analysis of the system showed the economic feasibility of bamboo based agrisilviculture system (Rs 21029 ha^{-1}) as it gave higher monetary return as compared to sole crop (Rs 9801 ha^{-1}). On the basis of mean of both bamboo species, growing of moong with bamboo species gave significantly higher net monetary return (Rs 27736 ha^{-1}) but at par with til (Rs 23365 ha^{-1}) and was found significantly superior to paddy (Rs 19693 ha^{-1}) and soybean (Rs 13322 ha^{-1}) under bamboo based agrisilviculture system. Hence bamboo based agroforestry system is a viable option for raising the overall production as well as productivity of the farming systems.

Key words: Agro forestry, bamboo species, kharif crops, impact assessment, wasteland.

INTRODUCTION

Bamboo is commonly known as ‘‘**poor man timber**’’ and play a vital role in improving the socio-economic status of rural population. The most traditional uses of bamboo include housing, food and other material for handicraft. Worldwide, approximately more than 2.5 billion people trade in or use bamboo (INBAR 1999). India is one of the leading countries of the world, second to China in Bamboo production with 32.2 million tonnes per year. Bamboo species cover an area of 10.03 million hectare with 22 genera and 135 species. They contribute 12.8% of total forest cover of India (as quoted by Berry et al., 2008).

In Madhya Pradesh, bamboos cover an area 6.28 lakh hectare with the average production of 38 million culms per annum. Out of which, 33 million is obtained from forest and 5 million from farming system. Commercially *Dendrocalamus strictus* and *Bambusa arundinacea* both are of paramount importance and widely distributed in the districts of Madhya Pradesh viz., Balaghat, Seoni, Mandla, Shahdol, Panna, Hoshangabad and Betul. Bamboo resources have considerably been dwindled from the natural habitat due to overexploitation, gregarious flowering and extensive forest fire. Social and industrial demand of bamboo is increasing at faster rate than its supply. In order to achieve the targets of present and future demand, expansion of bamboo in non-forest area by adopting agro-forestry is viable approach for conservation and sustainable utilization of bamboo resources. Bamboo based agroforestry is relatively a new area.Little work has systematically been done so far on crop species compatibility (Wood, 1988) with bamboo in agroforestry. The four major kharif crops (viz. paddy, soybean, moong

*Corresponding author. E-mail: rchhatrapal87@gmail.com

and til) have been selected to study the impact of bamboo on their growth and yield attributes.

MATERIAL AND METHODS

Site Description

The field experiment was conducted at Dusty Acre Research Farm near Railway track under National Bamboo mission, Department of Forestry, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur (MP). Jabalpur lies between 22°49' to $24^0$8' North Latitude and $78^0$21' to $80^0$58' East Longitude with an average altitude of 411.78 meters above the mean sea level. Jabalpur belongs to Kymore Plateau and Satpura Hills Agro-climatic Zone as per classification of National Agricultural Research Project. Recently, this area has been classified as agro-ecological sub-region number 10.1 (Vindhyan Scarplands, Bandelkhand and Narmada Valley, hot dry sub-humid ecological sub region with medium deep black soil). Jabalpur enjoys a typical subtropical climate with hot dry summer and cool dry winter. Temperature extremes vary between minimum temperature of 2^0C in December-January months to maximum temperature of 46^0C in May–June months. Based on 20 years mean meteorological data, the average annual rainfall of the locality is 1315 mm, which mostly received between mid June to end of September with an occasional winter showers during December and January months. The soil of the experimental area was sandy loam in texture, neutral in reaction (pH 7.21) with medium organic content (46%) and having low electrical conductivity (0.26ds/m^2 at 25^0) as well as medium in available Nitrogen (207 $kgha^{-1}$), Phosphorus (16.26 $kgha^{-1}$) and low level of available Potash (172 $kgha^{-1}$) content.

Experimental Details

The experiment was conducted during rainy season of 2010-11 under 3 year old bamboo species planted at a spacing of 5m x 5m during 2007-08. The experiment consisted of two bamboo species viz., *Dandrocalamus strictus* and *Bambusa arundinacea* in main plot and four different Kharif crops viz. Moong (TM-99-37), Soybean (JS-335), Paddy (JR-201) and Til (TKG 21) in sub plot under split plot design with three replication. These kharif crops were also sown in open plot without bamboo served as control. The seed rate for Moong, Soybean, Paddy and Til was 20 $kgha^{-1}$, 100 $kgha^{-1}$, 100$kgha^{-1}$and 5$kgha^{-1}$, respectively. The crops viz. Moong, Soybean, Til were sown at 30 cm row spacing, whereas paddy was sown at 25 cm spacing in lines by opening furrow. All the crops were fertilized with recommended dose and proper method of fertilizer application.

The source of nitrogen, phosphorus and potash were Urea, Single Super Phosphate and Murate of Potash. In Moong, Soybean and Til following observations viz. plant population (m^2), plant height (cm), number of branches/plant, pod length (cm), number of grains/pod, grain yield ($Kgha^{-1}$) and stover yield ($Kgha^{-1}$) were recorded at the time of harvesting. In Paddy, plant population (m^2), plant height (cm), number of effective tillers/plant, panicle length, filled grains/panicle, grain yield ($Kgha^{-1}$), and straw yield ($Kgha^{-1}$) were recorded at the time of harvesting. All the parameters crops were analyzed statistically using analysis of variance for split plot design as suggested by (Panse and Sukhatme, 1967). The significance was tested for all the parameters at 5% level.

RESULTS AND DISCUSSION

Impact of Bamboo Species on Kharif Crops

The impact of different bamboo species on growth and yield attributing characters of different kharif crops was found non-significant. However, different Kharif crops showed significant variation which may be due to difference in crop genotype. All the Kharif crops, recorded relatively lower all the growth and yield attributing characters under agrisilviculture system in comparison to sole crop (control) which showed the negative impact of bamboo on these growth attributes under agroforestry system (Table 1, 2 and 3). Among the four different Kharif crops the highest reduction in plant population was noticed in soybean (21.81%) and the lowest in paddy (12.35%). The moong and til showed almost the similar trend of reduction (16.06% and 17.83%, respectively) under bamboo based agrisilviculture system over the control that is, sole crop (Figure 1). The reduction in plant population may be attributed to either shade or allellopathic effect of bamboo or both. Singh et al. (1992) reported in orchard grasses that under the shade of bamboo canopy optimum temperature for proper germination of seeds was not available, hence plant population was poor. Similarly, Eyini et al*.* (1989) reported in groundnut that the reduction in plant population may be due to allellopathic effect of bamboo leaf (containing some phenolic acids) under agroforestry system. In case of plant height paddy (3.90% reduction) and til (2.84% reduction) both were found relatively less sensitive to bamboo shade as compared to soybean (8.83% reduction) and moong (7.57% reduction) (Figure 2). This may be due to the fact that bamboo canopy could have even affected the proper penetration of light on the understory annual crops. Decrease in plant height of agricultural crops had also been reported in eucalyptus and mango (Dhanda, 2003) and in babul (Bargali *et al*., 2009) under agroforestry system. Among the Kharif crops highest reduction was noticed in soybean (33.66%) for number of branches per plant and the lowest was in paddy (23.75%) for number of effective tillers per plant.

Table 1. Impact of bamboo species on different growth and yield attributes of various Kharif crops under bamboo based agrisilviculture system.

Treatment	**Plant population (m^2)**				**Plant height (cm)**				**Number of effective tillers/plant in paddy & branches/ plant in soybean, moong & til**			
	***D. strictus* (B1)**	***B. arundinacea* (B2)**	**Mean of B1+B2**	**Sole crop (Control)**	***D. strictus* (B1)**	***B. arundinacea* (B2)**	**Mean of B1+B2**	**Sole crop (Control)**	***D. strictus* (B1)**	***B. arundinacea* (B2)**	**Mean of B1+B2**	**Sole crop (Control)**
Moong	59.19	57.56	58.37	69.54	50.38	48.65	49.52	53.58	2.31	2.25	2.28	3.32
Soybean	51.33	49.62	50.47	64.55	52.33	49.77	51.05	56.00	2.73	2.56	2.64	3.98
Paddy	159.89	154.07	156.98	179.11	72.32	69.52	70.92	73.80	1.92	1.74	1.83	2.40
Til	50.62	48.55	49.58	60.34	115.91	113.78	114.85	118.21	2.03	1.95	1.99	2.86
Mean	80.26	77.45	-	-	72.74	70.43	-	-	2.24	2.12	-	-
Treatments	**SEm±**	**CD (P=0.05%)**			**SEm±**	**CD (P=0.05%)**			**SEm±**	**CD (P=0.05%)**		
Bamboo (MT)	1.57	NS			0.37	NS			0.08	NS		
Kharif crops(ST)	3.14	9.74			2.04	6.29			0.13	0.40		

Table 2. Impact of bamboo species on different yield attributing characters of various Kharif crops under bamboo based agrisilviculture system.

Treatment	**Length of panicle in paddy, pod in soybean & moong & capsule in til (cm)**				**Number of grains/panicle in paddy, seeds/pod in soybean & moong & seeds/capsule in til**				**1000-seed weight of paddy & til and 100-seed weight of soybean & moong**			
	***D. strictus* (B1)**	***B. arundinacea* (B2)**	**Mean of B1+B2**	**Sole crop (Control)**	***D. strictus* (B1)**	***B. arundinacea* (B2)**	**Mean of B1+B2**	**Sole crop (Control)**	***D. strictus* (B1)**	***B. arundinacea* (B2)**	**Mean of B1+B2**	**Sole crop (Control)**
Moong	7.10	7.08	7.09	7.54	12.82	12.52	12.66	13.47	3.90	3.56	3.73	4.11
Soybean	2.55	2.49	2.52	2.68	2.53	2.31	2.41	3.00	6.50	6.23	6.36	7.02
Paddy	17.13	16.33	16.73	17.54	56.02	54.25	55.13	66.21	21.16	20.18	20.67	21.32
Til	1.96	1.93	1.94	1.98	59.97	58.87	59.41	65.42	2.82	2.77	2.79	2.86
Mean	7.18	6.95	-	-	32.83	31.98	-	-	8.59	8.18	-	-
Treatments	**SEm±**	**CD (P=0.05%)**			**SEm±**	**CD (P=0.05%)**			**SEm±**	**CD (P=0.05%)**		
Bamboo (MT)	0.04	NS			0.37	NS			0.25	NS		
Kharif crops(ST)	0.17	0.53			1.07	3.20			0.74	2.28		

Table 3. Impact of bamboo species on grain and straw yield of different Kharif crops under bamboo based agrisilviculture system.

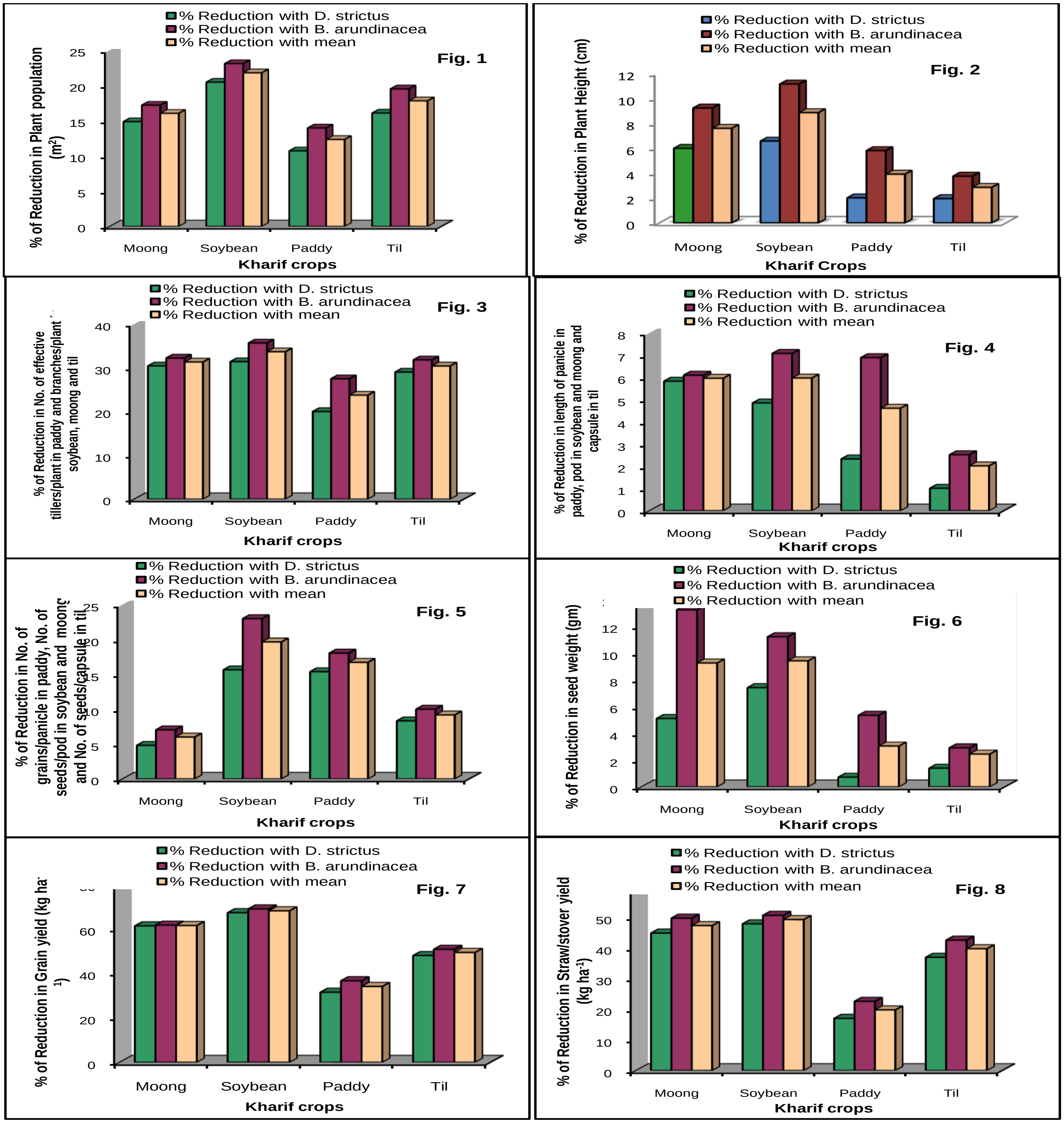
Treatment	Grain yield (kg ha^{-1})				Straw/stover yield (kg ha^{-1})			
	D. strictus **(B1)**	***B. arundinacea*** **(B2)**	**Mean of B1+B2**	**Sole crop (Control)**	***D. strictus*** **(B1)**	***B. arundinacea*** **(B2)**	**Mean of B1+B2**	**Sole crop (Control)**
Moong	211.77	210.03	210.90	545	411.07	374.88	392.97	754
Soybean	195.16	185.09	190.12	592	572.80	542.26	557.53	1098
Paddy	849.93	786.72	818.33	1240	2058.16	1920.49	1989.32	2480
Til	127.75	120.89	124.32	245	772.85	704.03	738.44	1225
Mean	346.15	325.68	-	-	944.67	894.46	-	-

Treatments	**SEm±**	**CD(P=0.05%)**	**Treatments**	**SEm±**	**CD (P=0.05%)**
Bamboo(MT)	7.56	NS	Bamboo (MT)	22.93	NS
Kharif crops (ST)	17.22	53.05	Kharif crops (ST)	35.21	108.51

Among the Kharif crops highest reduction was noticed in soybean (33.66%) for number of branches per plant and the lowest was in paddy (23.75%) for number of effective tillers per plant. The moong and til showed the almost similar trend of reduction (31.32% and 30.41%, respectively) for number of branches per plant under bamboo based agrisilviculture system over control that is, sole crop (Figure 3). Above findings are in conformity to the findings of (Mutanal, 2006; Mishra and Swamy, 2007) under teak and poplar based agroforestry system, respectively. Different Kharif crops also noticed reduction in length of pod in soybean (5.97%) and moong (5.96%), panicle in paddy (4.61%) and capsule in til (2.02%) under agrisilviculture system over control that is, sole crop (Figure 4). This reduction in length of pod/capsule/panicle may be attributed to the poor light availability, which influenced photosynthesis as well as the multiplication of cells during reproductive period under agrisilviculture system (Islam et al., 2006). Among the different Kharif crops soybean showed higher reduction in number of seeds per pod (19.66%) followed by number of grains per panicle (16.73%) in paddy whereas the lowest in number of seeds per pod (6.01%) in moong under bamboo based agrisilviculture system in comparison to sole crop that is, without bamboo (Figure 5). The reduction in seed weight of different Kharif crops viz., soybean, moong, paddy and til was 9.40%, 9.24%, 3.04% and 2.44%, respectively under bamboo shade in comparison to sole crop (Figure 6). These reductions may be due to poor light and nutrient availability beneath the canopy of bamboo. Similar findings were also reported by Dhillon et al. (2007) in *Populus deltoides* with soybean and turmeric; Dey *et al.* (2007) in *Bambusa nutans* with vegetables and Pandey *et al.,* (2010) in *Azadirachta indica* with blackgram.

All the four Kharif crops recorded lower grain yield under bamboo based agrisilviculture system in comparison to sole crop that is, without bamboo. Among the different Kharif crops, soybean (67.88%) and moong (61.30%) showed relatively higher reduction in grain yield as compared to til (49.25%) and paddy (34.00%) under three year old bamboo based agrisilviculture system over the sole crop (Figure 7). This reduction in grain yield may be due to less PAR (Photosynthesis active radiation) interception and available energy below the canopy of bamboo species in comparison to sole crop (open condition). These findings clearly showed that the soybean and moong both are highly sensitive to bamboo shade as compared to paddy and til. It has been well documented that bamboo and tree species gradually become more competitive with age and thus progressively reduce crop yield (Handa et al., 1995; Bihari, 2001; Shanmughavel and Francis 2001b; Ahlawat et al., 2008).

Like grain yields, straw yields of different Kharif crops were also reduced under bamboo shade in comparison to sole crop (without bamboo). Similarly among the Kharif crops, higher reduction in straw yield was obtained in soybean (49.22%) and the lowest was in paddy (19.78%) under three years old bamboo based agrisilviculture system over the sole crop (Figure 8). The straw yield had positive correlation with growth parameters viz., plant height, number of tillers/plant in paddy and branches/plant in moong, soybean and til. These growth parameters were markedly superior under the sole crop (without bamboo).



Impact of bamboo species on different growth and yield attributing characters of various Kharif crops under bamboo based agrisilviculture system.

Paroda and Muthana (1979) reported that in the eight year old plantation of *Holoptelea integrifolia,* minimum seed and straw yield of greengram and cluster bean both were under unlopped situation, improved under lopped tree and maximum, where tree component was absent. The straw and grain yield both were highly sensitive under bamboo shade.

These results are in close conformity with the finding of (Nandal and Singh, 2001) in case of pulses (moong and lentil).

Table 4. Net profit (Rs.ha^{-1})) of different Kharif crops grown with different bamboo species under Agrisilviculture system.

Treatments	*D. strictus*	*B. arundinacea*	Mean (*D. strictus* and *B. arundinacea*)	Sole crop (Control)
Moong	31317	24155	27736	15800
Soybean	13660	12985	13323	5624
Paddy	21646	17740	19693	8080
Til	24210	22520	23365	9700
Mean	22708	19350	21029	9801
	Treatments	**SEm±**	**CD (P=0.05%)**	
	Bamboo (MT)	1794	1612	
	Kharif crops (ST)	NS	4968	

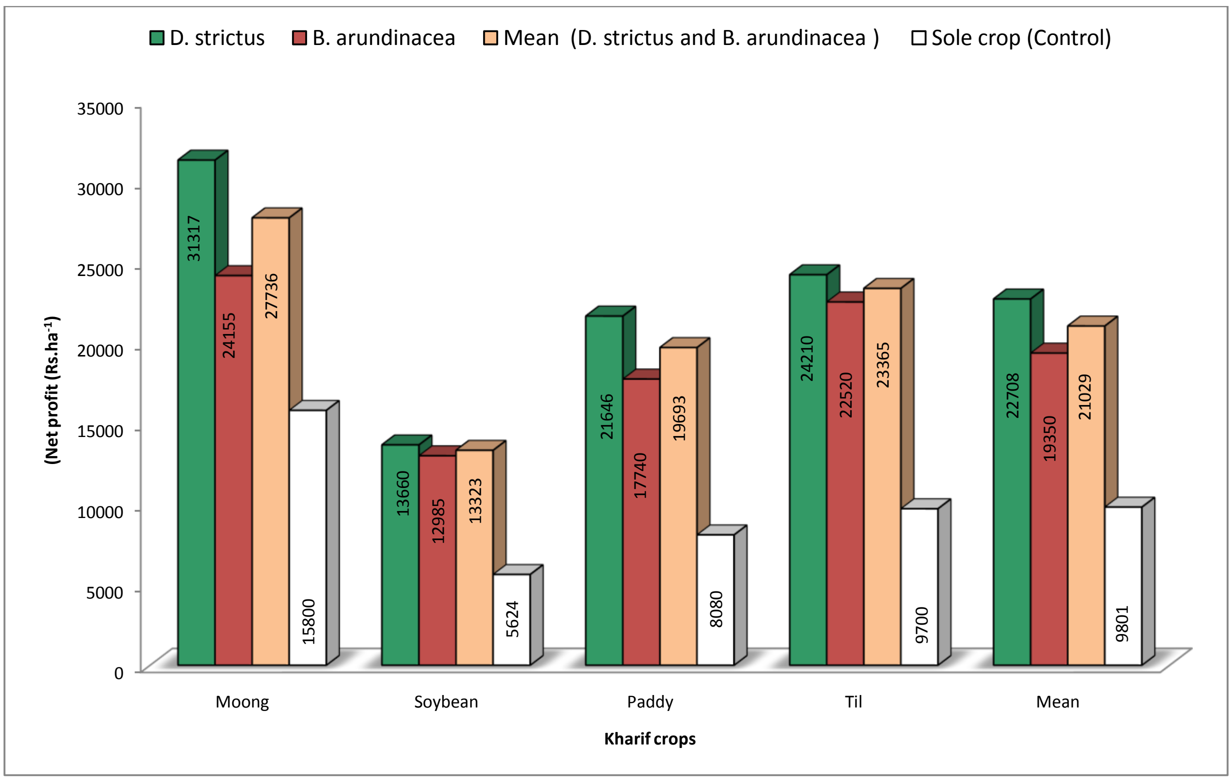


Figure 9. Net profit (Rs.ha^{-1})) of different Kharif crops grown with different bamboo species under Agrisilviculture system.

Net Monetary Return of Bamboo based Agrisilviculture System

The economic analysis of the bamboo based agroforestry system showed that, the economic feasibility of bamboo based agrisilviculture system as it gave higher net monetary return (Rs 21029 ha^{-1}) as compared to sole crops (Rs 9801 ha^{-1}).

Both the bamboo species showed non-significant differences for the net monetary (Rs.ha^{-1}). However the magnitude was high when crops were grown with *D. strictus* (Rs 22708 ha^{-1}) as compared to *B. arundinacea (*Rs 19350 ha^{-1}). On the basis of mean of both bamboo species, growing of moong with bamboo species gave significantly higher net monetary return (Rs 27736 ha^{-1}) but at par with til (Rs 23365 ha^{-1}) and was found significantly superior to paddy (Rs 19693 ha^{-1}) and soybean (Rs 13322 ha^{-1}) under bamboo based agrisilviculture system (Table 4 and Figure 9). The probable reason of lower net monetary return in soybean may be due to low yield, higher expenditure incurred in cultivation of soybean and low market price in comparison to other crops. Similar results reported by Karwar *et al.,* (2006) and Behari (2001) under agroforestry system.

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