Profitability of Agroforestry System: The Case of Udham Singh Nagar District of Uttarakhand State, India

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Authors' contributions

This work was carried out in collaboration between both authors. Author AK designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Author SKS managed the analyses of the study and the literature searches. Both authors read and approved the final manuscript.

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ABSTRACT

The paper has examined the profitability of the prevailing agroforestry system in Udham Singh Nagar district of Uttarakhand state. Two blocks of Udham Singh Nagar district was selected for study purpose. In which it was found that two spacing of agroforestry was followed by sample farmers i.e. 7m x 3m and 5m x 4m. Study was conducted by taking in to account of sole cropping system and Agroforestry system for comparing the profit realised by both the systems. CACP (Commission for agricultural cost and prices) concept was used to determine the cost and return from both the spacing and with sole crop too. The result indicated that Agroforestry with spacing 7m x 3m is profitable in comparison to spacing 5m x 4m but with comparison to sole crop both spacing of Agroforestry system was found to be beneficial. The study has suggested that policy support in terms promotion of agroforestry system is MSP (Minimum Support Price) should be there for wood produce too as in case of crop produce so that more farmers will be encouraged towards practicing Agroforestry system.

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1. INTRODUCTION

Agroforestry is a practice of agriculture and forestry in the same piece of land simultaneously [1]. It is a dynamic, and natural resource management system that, through integration of woody perennials on farms and in the agricultural landscape, diversifies and sustains production and builds social institutions [2]. They buffer against weather related production losses, enhancing resilience against climate impacts survival [3].

The inter-cropping with trees found to be beneficial as trees has the capacity to retain with all sort of problem i.e. drought, insects, pests, flood and it is economically viable too [4]. Trees add more income to the farmer. Trees under agroforestry, improve soil productivity through addition of organic matter in the soil [5]. Trees also provide food, industrial raw materials, fuel wood, timber, fodder etc. [6]. Broadly the plains and hills present different scenarios for agriculture in Uttarakhand. But in hills agroforestry is not practiced on commercial basis as in the plains [7]. In view of shrinkage of agricultural land and operational holdings due to expansion of urbanization, change in food habit of people, increasing population, farmers were adopting the practices of including trees in their cropping system [8].

2. DEMOGRAPHY AND LAND USE PATTERN

In Uttarakhand, Only Udham Singh Nagar district occupies highest area (29.12 lakh ha) under cultivation followed by Haridwar district (23.60 lakh ha) respectively [9]. In the demography and land use pattern shown that the area under forest was (2.42%), Net Sown was (18.22%) and agroforestry area was found to be (61.6%) [10].

2.1 Land Holding Pattern in Uttarakhand

The land holding pattern of the state is presented in the Table 1 for the year 2001 and 2016. The Table depicts that more than 74 per cent of the farmers belongs to marginal farm size group and about 17 per cent belongs to small farm size group [11]. Thus about 74 per cent of the land holding is less than 1 hectare in size and covers only about 36 per cent of the total land holdings, while about 28 per cent of land holdings is between 1 to 2 hectare and 33 per cent of land holding is between 2 to 10 hectare in size covering about more than 50 per cent of the total cultivated land [12].

2.2 Land Utilization Pattern in Uttarakhand

Like other hill state, the people of Uttarakhand practice integrated systems of farming including forestry, horticulture, livestock and off-farm activities. Most of the area of state is under forests and wastelands thus leaving only a small amount of land for cultivation. Table 2 presents the land use pattern in 2000-01 and in 2015-16. From the Table 2 it is clear that a mild change has been recorded in case of total reported area. Forest area increased only by 0.57 per cent. Total cultivable waste land declined by 19.17 per cent, while fallow land increased by 96.34 per cent. Land under non-agricultural uses and land under miscellaneous, tree crop and groves not included in net area sown increased by 43.21 and 52.84 per cent, respectively. Net sown area showed a decline of 7.24 per cent during the period from 2000-01 to 2015-16.

3. DATA AND METHODOLOGY

Out of total 7 blocks in the Udham Singh Nagar district, Rudrapur and Gadarpur blocks were selected randomly to represent the district. From the list of the villages in the selected blocks, one village was selected randomly then three adjoined villages were selected to form a cluster from each block. Secondly a list of all the farmers practicing agroforestry was prepared. It was found that farmers are planting both poplar and eucalyptus in blocks as well as on boundary. The number and percentage of farmers practicing these plantations in agroforestry is given in Table 3 Majority (67.39 per cent) of farmers found planting poplar based agroforestry, therefore, poplar based agroforestry was selected for the study purpose. Among block and boundary plantations with poplar it was observed that majority of farmers (52.53 per cent) are practicing block plantation.

Therefore, only block plantation of poplar based agroforestry has been considered for this study. In poplar block plantation it was found that two types of spacing viz., 7m x 3m and 5m x 4m are being followed in general in the selected villages. On the basis of these spacing farmers were divided into different strata (year wise). In the

preliminary enquiry about the expenditure incurred in different years of poplar plantation it was found that none of the sample farmers recalled the years back expenditure incurred in the agroforestry plantation. Even most of them were unable to tell the selling prices of their produce from the agroforestry system.

Table 1. Land holding pattern in Uttarakhand

S.No.	Farm size class	Number ('000)		Per cent change	Area ('000 ha)		Per cent change	Average holding size (ha)	
		2001	**2016**		**2001**	**2016**		**2001**	**2014**
1	Marginal	628 (71)	672 (74)	7.01	243 (29)	296 (36)	21.8	0.39	0.44
2	Small	158 (18)	157 (17)	-0.63	221 (26)	225 (28)	1.8	1.40	1.43
3	Semi Medium and Medium	102 (11)	82 (8.9)	-19.60	344 (41)	270 (33)	-21.51	4.11	2.64
4	Large	1 (0.1)	1 (0.1)	0.00	36 (4)	25 (3)	-30.56	36.00	25
	Total	889	912	2.59	844	816	-3.32	0.95	0.89

Note: Marginal=below 1 ha; Small=1 to less than 2 ha; Semi-medium and Medium = 2 to less than 10 ha; Large =10 ha and above
Note: Figures in parentheses indicate percentage to total farmers.
Source: Uttarakhand at a glance (2014), Directorate of Economics and Statistics, Dehradun

Table 2. Land utilization pattern in Uttarakhand

Sl. No.	Land use	Area(ha)		Percentage change in 2015-16 over 2000-01
		(2000-01)	**(2015-16)**	
1	Total reported area	5671698	5672636	0.01
2	Forest area	3465057	3484803	0.57
3	Culturable waste land	384928	311124	-19.17
4	Fallow land	68965	135412	96.34
5	Barren and unculturable land	310244	224851	-27.52
6	Land under non-agricultural uses	152247	218034	43.21
7	Permanent pasture & other grazing land	229481	198524	-13.50
8	Land under miscellaneous, tree crop and groves not included in net area sown	252351	385699	52.84
9	Net Area Sown	769944	714189	-7.24

Source: Uttarakhand at a glance (2013-14), Directorate of Economics and Statistics, Dehradun

Table 3. Major Agro- forestry systems in U. S. Nagar district

Major tree species	Agroforestry Systems	No. of farmers
Poplar	Bund/Boundary plantation	41 (14.85%)
	Agrisilviculture (Crop + Poplar Trees within the same field)	145 (52.53%)
Total number of farmers in poplar system		**186{67.39}**
Eucalyptus	Bund/Boundary plantation	55 (19.92%)
	Agrisilviculture (Crop + Eucalyptus Trees within the same field)	35 (12.68%)
Total number of farmers in eucalyptus system		**90{32.60}**
Overall number of farmer in Agroforestry system		**276 {100}**

Three farmers were selected from each of plantation year of agro forestry for complete rotation of each of the spacing. Hence, 21 farmers following spacing 7m x 3m and 21 farmers for spacing 5m x 4m were selected randomly from Rudrapur as well as from Gadarpurblocks making sample size from each block of 42 farmers.

3.1 Analysis of Cost of and Returns from Agro Forestry System

To estimate the cost of and returns from the agroforestry system cost concepts given by the Commission for Agricultural Costs & Prices (CACP), ministry of agriculture and farmers welfare, GOI have been used. The various cost concepts are summarized as follows:

Cost A_1: It is calculated by summing the following costs, as observed in the study area;

a) Value of hired human labor (casual labor)
b) Value of hired and owned machine labor
c) Value of manures (owned and purchased Value of fertilizers)
d) Value of seed (farm produced and purchased)
e) Value of plant protection chemicals
f) Irrigation charge
g) Interest on working capital
h) Depreciation on farm implements
i) Land revenue
j) Miscellaneous expenses

Cost A_2 = Cost A_1 + rent paid for leased-in land
Cost B_1 = Cost A_1 + Imputed interest on value of owned capital assets (excluding land)
Cost B_2 = Cost B_1 + Imputed rental value of owned land (net of land revenue) + Rent paid for Leased-in land
Cost C_1 = Cost B_1 + Imputed value of family labor
Cost C_2 = Cost B_2 + Imputed value of family labor.
Cost C_2* = Cost C_2 has been estimated by taking into account Statutory Minimum wage rate or actual wage rate, whichever was higher
Cost D = Cost C_2 * + 10% of Cost C_2* on account of managerial functions performed by the selected farmers.

Gross returns were calculated at the price to which the main and by products sold by the producers. Net returns were calculated by subtracting Costs A_1, A_2, B_1, B_2, C_1, C_2, C_2* and D from gross returns. To arrive at annual average cost and returns figures the total figure of entire poplar tree plantation period has been divided by 7.325. As the poplar trees have been found harvested on an average after 7.325 years of plantation.

4. RESULTS AND DISCUSSION

The results of the study are presented under different sections such as major tree species and clones, the economics of different plantation system of poplar.

4.1 Major Tree Species and Clones

In the Table 4 given below it is shown that the major tree species that was taken by number of farmers in different agroforestry system. The table given below is the major species and clones adopting by the farmers in study area.

4.2 Cost of and Returns from the Agroforestry System of Spacing 7 m x 3 m

4.2.1 Operational costs

It is evident from Table 5 that in overall the operational cost was found to be Rs. 45423 per ha annually. The Operational cost consists of human labour, bullock labour and machine labour. Human labour includes family labour and hired. The human labor plays an important role, since most of the operations were done manually. In the study area it was found that no one used the bullock labour. Whereas machine labor consists of transportation charges and other machinery charges for different operations i.e. charges of ploughing, sowing, digging etc.

4.2.2 Material costs

It is further evident from the Table 5 that purchased input like fertilizers, manures, plant protection chemicals and plant growth protection chemical plays very important role in agroforestry cultivation. Seed material/sapling was an important item for agroforestry cultivation. The annual average of material cost was found to be Rs. 28584 per ha.

4.2.3 Other costs

Other cost constitutes the rental value of owned land, depreciation and interest on value of owned

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capital assets. A perusal of the Table 5 indicates that the rental value of land was important item of fixed costs item. The Other cost for spacing 7m x 3m was found to be Rs. 50047 per ha annually.

4.3 Cost of Agroforestry System of Spacing 7m x3m

From the Table 5 it is evident that total cost at cost A1 was found to be Rs. 73170 per hectare annually, Cost A2 was found to be same as in study area it was found that no one give their land on lease. Cost B1 included Imputed interest on value of owned capital assets (excluding land) was found to be Rs. 74538, Cost B2 include Imputed rental value of owned land (net of land revenue) plus Rent paid for Leased-in land found to be Rs. 119705. Cost C1 includes imputed value of family labor and it was Rs. 78720 per hectare annually. In Cost C_2^* cost c2 has been estimated by taking into account Statutory Minimum wage rate or actual wage rate, whichever was higher. In study area actual wage rate found to be higher hence cost C2 * was obtained Rs. 123887, Cost D has been estimated on Cost C_2 * plus 10% of Cost C_2* on account of managerial functions performed by the selected farmers. And it was found to be Rs. 136276.

4.4 Return from Agroforestry System of Spacing 7m x3m

It is also evident from the Table 6 that average yield of agroforestry cultivation in the study area was 376 qt per ha (including average yields of tree log and crops) and average price received by the farmers was Rs. 1276/qt. It is also evident from the Table 6 that average yield of agroforestry cultivation in the study area was 376 qt per ha (including average yields of tree log and crops) and average price received by the farmers was Rs. 1276/qt.

Further, per year the gross return received from the agroforestry system in the study area was Rs. 239092 per ha. The yield from by product which includes per hectare production of tree branches and roots and by products of crops was

139 qt /ha. Whereas, the net returns over cost C2* and D were Rs. 115205 and Rs. 102816, respectively.

And on spending 1 rupee, farmer got Rs. 0.75 net profit this indicates extent of profitability of agroforestry system in the study area.

4.5 Cost of and Returns from the Agroforestry System of Spacing 5m x 4m

4.5.1 Operational costs

In the cultivation of agroforestry with spacing 5m x 4m the operational cost was found to be Rs. 40927 it is shown in Table 7. The Operational cost consists of human labour, bullock labour and machine labour. Human labour includes family labour and hired. The human labor plays an important role, since most of the operations were done manually. In the study area it was found that no one used the bullock labour. Whereas machine labor consists of transportation charges and other machinery charges for different operations i.e. charges of ploughing, sowing, digging etc.

4.5.2 Material costs

It is further shown that from Table 5 that annual average of material cost was found to be Rs. 64458 per ha annually. It includes purchased inputs like fertilizers, manures, plant protection chemicals and plant growth protection chemical plays very important role in agroforestry cultivation. Seed material/sapling was an basically an important item for agroforestry cultivation.

4.5.3 Other costs

The most important cost includes the Other cost that constitutes the rental value of owned land, depreciation and interest on value of owned capital assets. A perusal of the Table 5 indicates that the rental value of land was important item of fixed costs item. The Other cost for spacing 5m x 4m was found to be Rs. 49813 per ha annually.

Table 4. Major tree species and clones

Species	Plantations	Species/Clones
Poplar	Block & Boundary	*Populus deltoides* Clones- G48, UDAI, W 3 ,WSL 22, WSL 32, WSL 39, S7C15, S7C8, ST 12, Pant Poplar 5

Table 5. Cost of production incurred in agroforestry system with spacing 7m x 3m (Rs./ha)

Cost items	I year		II year		III year		IV year		V year		VI year	VII year*	Annual average
	Sugarcane Planted	Tree	Sugarcane Ratoon	Tree	Wheat	Tree	Turmeric (Dry)	Tree	Ginger	Tree	Tree	Tree	
Operational cost	46557	12526	39875	6945	18801	5451	59122	7330	58822	9810	12890	54590	45423
Material cost	37133	22703	12288	7546	18029	0	49336	0	62347	0	0	0	28584
Other cost	6016	49402	4636	48524	3804	48635	5346	48097	5593	48130	48497	49917	50047
Total cost at													
Cost A1	84898	35499	53260	14341	35245	4127	107074	6762	119187	8961	11827	54787	73170
Cost A2	84898	35499	53260	14341	35245	4127	107074	6762	119187	8961	11827	54787	73170
Cost B1	86633	35890	54854	14606	37099	4397	108554	6981	120590	9202	12054	55130	74538
Cost B2	86633	82915	54854	61855	37099	52137	108554	54113	120590	56335	59467	102288	119705
Cost C1	89706	37431	56799	15591	40634	6171	113804	8119	126762	10632	13799	57174	78720
Cost C2	89706	84456	56799	62840	40634	53911	113804	55251	126762	57765	61212	104332	123887
Cost C2*	89706	84456	56799	62840	40634	53911	113804	55251	126762	57765	61212	104332	123887
Cost D	98676	92902	62478	69124	44697	59302	125185	60777	139439	63541	67334	114766	136276
Unit cost of main product at cost D (Rs/Q)	156	0	108	0	1233	0	2504	0	762	0	0	81	727

Note: Figure has been rounded off to the nearest rupee, *VII year plus 0.325 of VIII year i.e. till harvest of poplar tree, Rs. = Indian rupees, 1 US Dollar = 64.60 Indian Rupee

Table 6. Returns from agroforestry system with spacing 7m x 3m

Returns items	I year	II year	III year		IV year		V year		VI year	VII year*	Annual
	Sugarcane Planted	Sugarcane Ratoon	Wheat	Tree	Turmeric (dry)	Tree	Ginger	Tree	Tree	Tree	average
Yield of MP (Q/ha)	591	542	28	0	50	0	183	0	0	1288	376
Yield of BP (Q/ha)	118	108	24	13	0	16	0	22	33	682	139
Selling price of MP (Rs./Q)	280	280	1585	0	3723	0	3045	0	0	430	1276
Selling price of BP (Rs./Q)	96	97	545	52	0	52	0	55	53	78	140
Gross returns	176808	162236	57460	676	186150	832	557235	1166	1749	607036	239092
Net returns over											
Cost A1	91910	108976	22215	-3451	79076	-5930	438048	-7795	-10078	552249	165922
Cost A2	91910	108976	22215	-3451	79076	-5930	438048	-7795	-10078	552249	165922
Cost B1	90175	107382	20361	-3721	77596	-6149	436645	-8036	-10305	551906	164554
Cost B2	90175	107382	20361	-51461	77596	-53282	436645	-55169	-57718	504748	119387
Cost C1	87102	105437	16826	-5495	72346	-7287	430473	-9466	-12050	549862	160372
Cost C2	87102	105437	16826	-53235	72346	-54420	430473	-56599	-59463	502704	115205
Cost C2*	87102	105437	16826	-53235	72346	-54420	430473	-56599	-59463	502704	115205
Cost D	78132	99758	12763	-58626	60965	-59945	417797	-62375	-65585	492270	102816
Net Return per rupee invested at Cost D	0.79	1.60	0.29	-0.99	0.49	-0.99	3.00	-0.98	-0.97	4.29	0.75

Note: Figure has been rounded off to the nearest rupee, MP=Main product, BP=By Product
*VII year plus 0.325 of VIII year i.e. till harvest of poplar tree, Rs. = Indian rupees , 1 US Dollar = 64.60 Indian Rupee

4.6 Cost of Agroforestry System of Spacing 5 m x 4 m

From the Table 7 it is evident that total cost at cost A1 was found to be Rs. 67760 per hectare annually, Cost A2 was found to be same as in study area it was found that no one give their land on lease. Cost B1 included Imputed interest on value of owned capital assets (excluding land) was found to be Rs. 68874, Cost B2 include Imputed rental value of owned land (net of land revenue) plus Rent paid for Leased-in land found to be Rs. 114105. Cost C1 includes imputed value of family labor and it was Rs. 72583. In Cost C_2^* cost c2 has been estimated by taking into account Statutory Minimum wage rate or actual wage rate, whichever was higher. In study area actual wage rate found to be higher hence cost C2 * was obtained Rs. 117814, Cost D has been estimated on Cost C_2 * plus 10% of Cost C_2* on account of managerial functions performed by the selected farmers. And it was found to be Rs. 129595.

4.7 Return from Agroforestry System of Spacing 5m x 4m

It is also evident from the Table 8 above that average yield of agroforestry cultivation (5m x 4m spacing) in the study area was 239 qt per ha and average price received by the farmers was Rs1612/qt. Further, the gross return received in the cultivation of agroforestry in the study area was Rs. 220186 per ha.The yield from by product was 128 qt /ha. Whereas, the net returns over cost C2* and D have been found Rs. 102372 and Rs. 90590 per hectare respectively. On spending 1 rupee, farmer got Rs.0.70 net profit. Though this spacing under agroforestry has also been found profitable the extent of profitability has been found little less than that under the spacing 5m x 4m.

4.8 Cost of and Returns from Sugarcane Cultivation as a Sole Crop

The costs and returns from sugarcane planted and sugarcane ratoon cultivation have been computed considering the inputs used and output realized by the farmers for the Sugarcane planted and sugarcane ratoon to compare with the return from the agroforestry system. The total costs and returns from sugarcane planted and sugarcane ratoon cultivation include three components i.e. operational cost, material cost and other costs. The profitability of sugarcane planted and sugarcane ratoon cultivation was worked on the basis CACP cost concepts and

have been presented in the figure 2, 3, 4, 5, 6 and 7 respectively.

4.9 Component Wise Costs Incurred in Cultivation of Sugarcane Planted and Sugarcane Ratoon Crops

4.9.1 Operational costs

The Figure reveals that the operational cost contributes a major share in cultivation of Sugarcane planted and sugarcane ratoon cultivation. The use of fertilizers and plant protection chemicals were used in optimum quantity in study area.

It is evident from Fig. 1 that in overall the operational cost was found to be Rs. 42416 per ha annually. The Operational cost consists of human labour, bullock labour and machine labour. Human labour includes family labour and hired. The human labor plays an important role, since most of the operations were done manually. In the study area it was found that no one used the bullock labour. Whereas machine labor consists of transportation charges and other machinery charges for different operations i.e. charges of ploughing, sowing, digging etc.

4.9.2 Material cost

It is further evident from the Fig. 2 that purchased input like fertilizers, manures, plant protection chemicals and plant growth protection chemical plays very important role in agroforestry cultivation. Seed material/sapling was an important item for agroforestry cultivation. The annual average of material cost was found to be Rs. 24512 per ha.

4.9.3 Other costs

Other cost constitutes the rental value of owned land, depreciation and interest on value of owned capital assets. A perusal of the Figure 2 indicates that the rental value of land was important item of fixed costs item. The Other cost for sugarcane was found to be Rs. 24512 per ha annually.

4.10 Return from Sugarcane Planted and Sugarcane Ratoon

It is also evident from the Fig. 3 that average yield of sugarcane cultivation in the study area was 604 qt per ha and average price received by the farmers was Rs. 280/qt. Further, in Fig. 4 it has been showed that the gross returns received in the cultivation of sugarcane in the study area was Rs. 180784 per ha.

Table 7. Cost of production incurred in agroforestry system with spacing 5m x 4m (Rs./ha)

Cost items	I year		II year		III year		IV year		V year		VI year	VII year*	Annual average
	Wheat	Tree	Wheat	Tree	Wheat	Tree	Turmeric (Dry)	Tree	Ginger	Tree	Tree	Tree	
Operational cost	18182	15090	18569	14160	19470	7630	69581	7659	39973	12070	15458	61950	40927
Material cost	18368	24030	18622	9948	18063	0	49753	0	60751	0	0	0	64458
Other cost	3441	49689	3721	48706	3036	48133	6403	48035	5937	48423	48545	50815	49813
Total cost at													
Cost A1	35402	39228	36683	23725	36744	6425	119731	7182	101729	11312	15222	62961	67760
Cost A2	35402	39228	36683	23725	36744	6425	119731	7182	101729	11312	15222	62961	67760
Cost B1	36914	39508	38453	24021	37834	6612	120844	7295	103023	11427	15400	63166	68874
Cost B2	36914	86897	38453	71184	37834	53816	120844	54474	103023	58843	62693	110842	114105
Cost C1	39991	41246	40912	25476	40569	8385	125737	8340	106661	12902	16535	64914	72583
Cost C2	39991	88635	40912	72639	40569	55589	125737	55519	106661	60318	63828	112590	117814
Cost C2*	39991	88635	40912	72639	40569	55589	125737	55519	106661	60318	63828	112590	117814
Cost D	43990	97498	45003	79903	44626	61148	138311	61071	117327	66350	70211	123849	129595
Unit cost of main product at Cost D (Rs/Q)	941	0	1033	0	1124	0	4838	0	265	0	0	79	949

*Note: Figure has been rounded off to the nearest rupee, * VII year plus 0.325 of VIII year i.e. till harvest of poplar tree, Rs. = Indian rupees, 1 US Dollar = 64.60 Indian Rupee*

Table 8. Returns from agroforestry system with spacing 5m x 4m (Rs. /ha)

Return items	I year	II year	III year		IV year		V year		VI year	VII year*	Annual
	Wheat	Wheat	Wheat	Tree	Turmeric (Dry)	Tree	Ginger	Tree	Tree	Tree	average
Yield of MP (Q/ha)	32	30	27	0	44		175	0	0	1441	239
Yield of BP (Q/ha)	30	28	26	16	0	20	0	28	40	747	128
Selling price of MP (Rs/Q)	1520	1534	1527	0	3725		3047	0	0	453	1612
Selling price of BP (Rs/Q)	746	743	745	54	0	52	0	53	53	79	345
Gross returns	71020	66824	60599	864	163900	1040	533225	1484	2120	711786	220186
Net returns over											
Cost A1	35618	30141	23855	-5561	44169	-6142	431496	-9828	-13102	648825	152426
Cost A2	35618	30141	23855	-5561	44169	-6142	431496	-9828	-13102	648825	152426
Cost B1	34106	28371	22765	-5748	43056	-6255	430202	-9943	-13280	648620	151312
Cost B2	34106	28371	22765	-52952	43056	-53434	430202	-57359	-60573	600944	106081
Cost C1	31029	25912	20030	-7521	38163	-7300	426564	-11418	-14415	646872	147603
Cost C2	31029	25912	20030	-54725	38163	-54479	426564	-58834	-61708	599196	102372
Cost C2*	31029	25912	20030	-54725	38163	-54479	426564	-58834	-61708	599196	102372
Cost D	27030	21821	15973	-60284	25589	-60031	415898	-64866	-68091	587937	90590
Net Return per rupee invested at Cost D	0.61	0.48	0.36	-0.99	0.19	-0.98	3.54	-0.98	-0.97	4.75	0.70

Note: Figure has been rounded off to the nearest number.
MP=Main product, BP=By product
1 US Dollar = 64.60   Indian Rupee, Rs. = Indian rupees
*VII year and 0.325 of VIII year i.e. till harvest of poplar tree.

4.11 Costs of and Returns from Paddy and Wheat Cultivation

Paddy and wheat rotation is found a common crop rotation followed in the study area. The costs and returns from paddy and wheat cultivation have been computed considering the inputs used and output realized by the farmers for the paddy and wheat cultivation as a one year crop rotation. The total costs and returns from paddy and wheat cultivation is also disused under three components i.e. operational cost, material cost and other costs. The profitability of paddy and wheat cultivation was worked out based on CACP cost concepts. The results of same have been presented in the Fig. 4. The purpose was to compare with the paddy - wheat crop rotation vis –a vis agroforestry system.

4.12 Component Wise Estimation of Costs

4.12.1 Operational costs

It is evident from Fig. 4 that in overall the operational cost was found to be Rs. 40038 per ha annually. The Operational cost consists of human labour, bullock labour and machine labour. Human labour includes family labour and hired. The human labor plays an important role, since most of the operations were done manually. In the study area it was found that no one used the bullock labour. Whereas machine labor consists of transportation charges and other machinery charges for different operations i.e. charges of ploughing, sowing, digging etc.

4.12.2 Material costs

It is further evident from the Fig. 5 that purchased input like fertilizers, manures, plant protection chemicals and plant growth protection chemical plays very important role in agroforestry cultivation. Seed material/sapling was an important item for agroforestry cultivation. The annual average of material cost was found to be Rs. 22838 per ha.

4.12.3 Other costs

Other cost constitutes the rental value of owned land, depreciation and interest on value of owned capital assets. A perusal of the Fig. 5 indicates that the rental value of land was important item of fixed costs item. The Other cost for paddy-wheat rotation was found to be Rs. 42827 per ha annually.
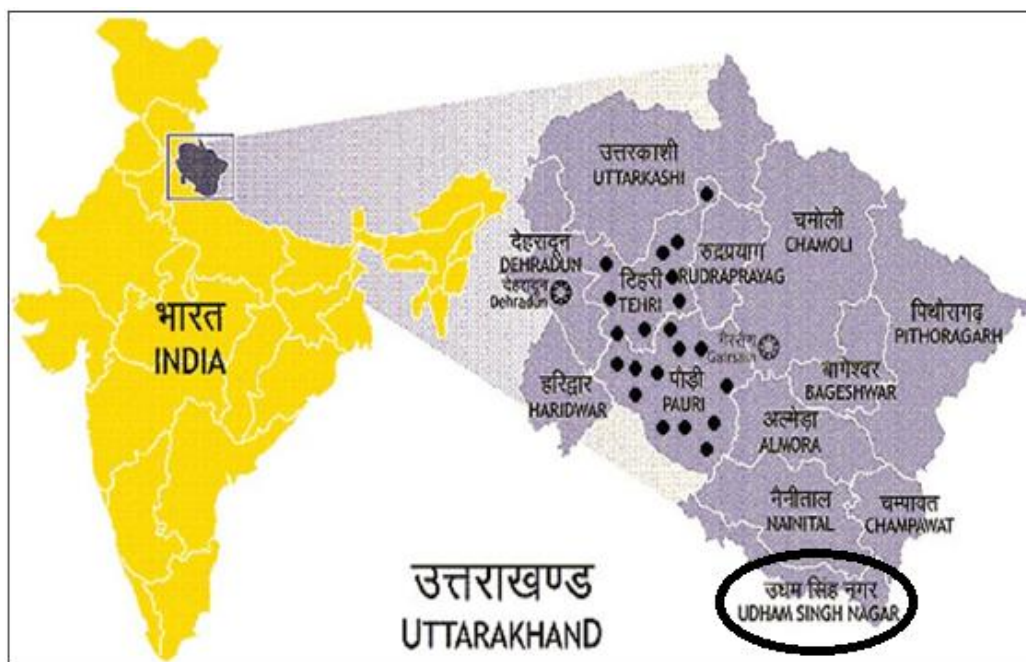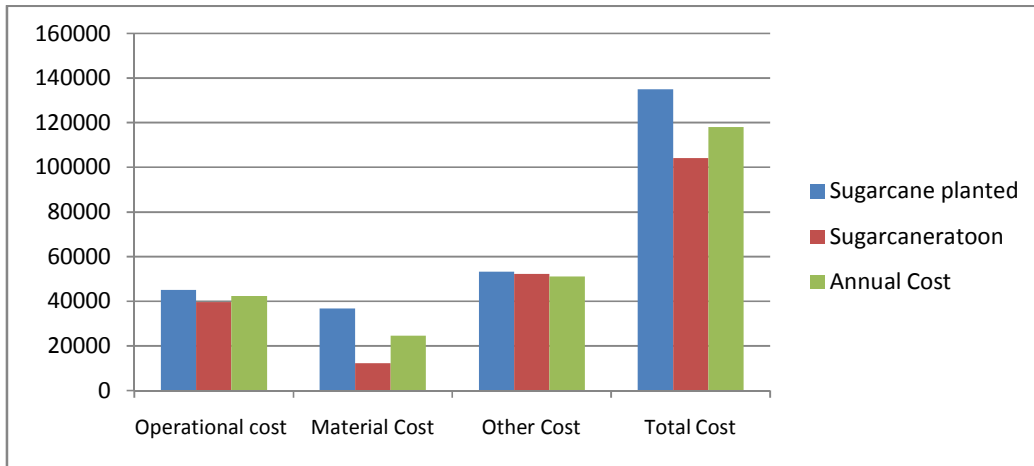

Fig. 1. Map of study area

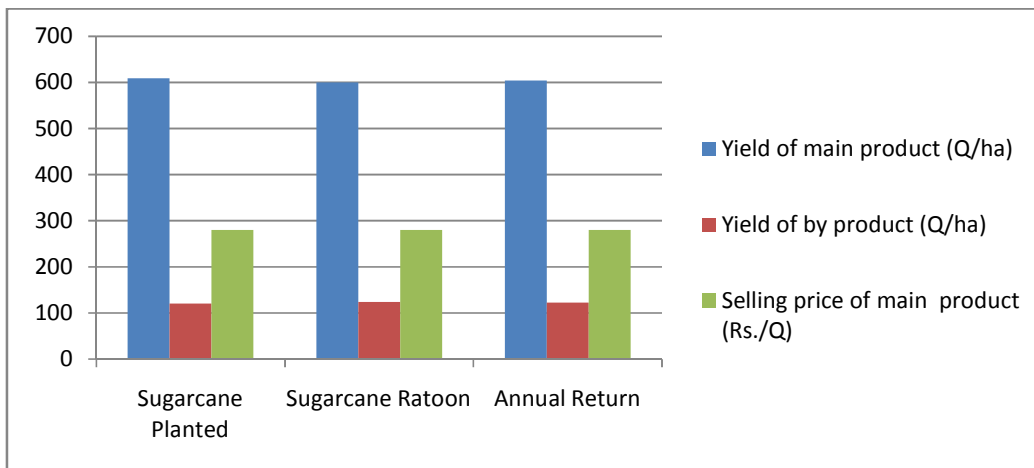**Fig. 2. Cost of sugarcane cultivation as a sole crop (Rs/ha)**

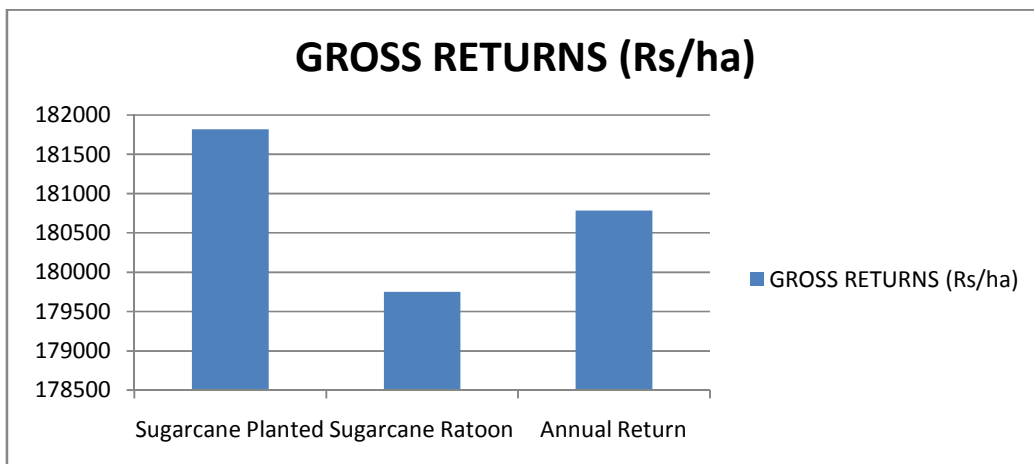**Fig. 3. Yield and return from sugarcane Main product and by product**

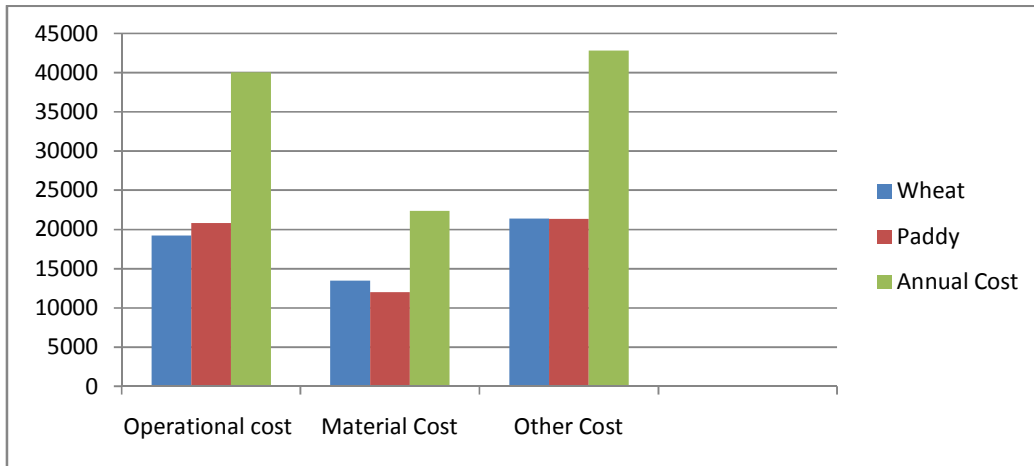**Fig. 4. Gross return from sugarcane planted and sugarcane ratoon**

Fig. 5. Cost of paddy-wheat cultivation as a sole crop (Rs./ha)
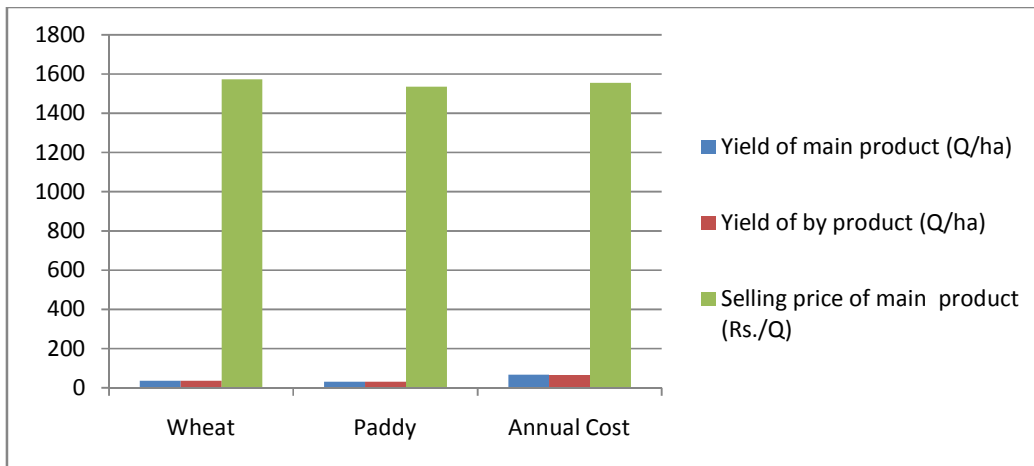

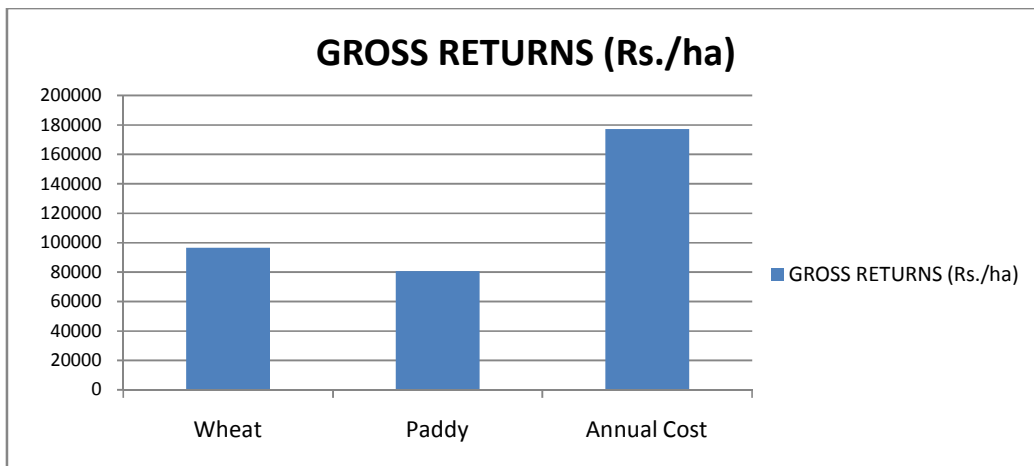**Fig. 6. Yield and return from paddy-wheat Main product and by product**

Fig. 7. Gross return from paddy-wheat rotation

4.13 Return from Paddy-Wheat Rotation

It is also evident from the Fig. 6 that average yield of paddy-wheat cultivation in the study area was 67 qt per ha per year and average price received by the farmers was Rs. 1555/qt. Further, in Fig. 7 it has been showed that the gross return received in the cultivation of paddy-wheat rotation in the study area was Rs. 177333 per ha per year.

5. CONCLUSION

Poplar based Agroforestry systems are comparatively profitable due to their fast growth and short rotation cycle. The trees component in the farming systems certainly add to the diversity dimension to the farm households besides providing increased and stable income. Agroforestry has specific role to play in the livelihoods and industrial development which have to be carefully nurtured for their sustainability.

From the above analysis it has been found that farmers obtained gross return of Rs. 239092 and Rs. 220186 per hectare per year from spacing's 7m x 3m and 5m x 4m of agroforestry system. Net return obtained over cost D from spacing 7m x 3m and 5m x 4m was Rs. 102816 and 90590 annually from agroforestry system. Net return per rupee invested at cost D was Rs. 0.75 and Rs. 0.70 for 7m x 3m and 5m x 4m spacing of agroforestry system. It means that on spending one rupee farmer got Rs. 0.75 and Rs. 0.70 of spacing 7m x 3m and 5m x 4m of agroforestry, respectively. On the basis of above analysis it can be said that spacing 7m x 3m of agroforestry is profitable than spacing 5m x 4m. For comparing the differences between the agroforestry and sole crops the annual costs and returns for sugarcane cultivation and paddy-wheat cultivation, it can be deduced from the table that in sugarcane and paddy-wheat cultivation farmer obtained gross return of Rs. 180784 and Rs. 177333, respectively and net returns obtained over cost D as Rs. 49397 and Rs. 47699. Hence, it can be concluded that agroforestry is much profitable in comparison to sole crops. From the results of this section it can be observed that the net returns over cost D in sugarcane cultivation per year is found slightly higher than that under paddy-wheat cultivation as one year crop rotation and were profitable. But the net profit per year over cost D from agroforestry system is found to be almost doubles than that of sole crop or crop rotation, besides other advantages.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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