Indian J. Dryland Agric. Res. & Dev. 2014 29(1) : 97-106

Profitability and Labour Use in Cropping Systems

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ABSTRACT: The study used plot level data from 16 villages of semi-arid tropics of India for the crop year 2010 for analysis of the profitability and resource use among different cropping systems. It also examined the relationship between farm size and labour use. The study estimated production function to know the resource use efficiency across the cropping systems and locations. The study shows that input intensive cropping systems like cotton, paddy, wheat, fruits and vegetables were more profitable across many of the SAT villages than coarse cereals, pulses and oilseeds based cropping systems. The results also show that the sub-optimal use of land and labour, as indicated by higher marginal returns. Farm mechanization is higher in rice-wheat and high value crop based cropping systems, while labour use is more in cotton based cropping systems. Farm size is having positive association with the hired labour use and farm mechanisation, but had negative association with family labour. Female employment had inverted "U" shape relation with farm size. The expenditure on seed and other inputs including irrigation, pesticides, FYM was sub-optimum.

Key words: Cropping systems, semi-arid tropics, cost-benefit analysis, production function, labour use efficiency

In the last decade Indian agriculture changed rapidly, new varieties and technological innovation are available for wider adoption by farmers most noticeable among them are Bt cotton varieties, hybrid rice, pest and disease resistant and short duration varieties of pulses and oilseeds and wider farm mechanisation which changed relative profitability of cropping systems. Agriculture in semi-arid tropics (SAT) was also benefited through these technological changes in the dryland farming systems mainly through adoption of short duration varieties, pest and disease resistant varieties like Bt cotton, drought tolerant varieties. The increasing productivity of rainfed cropping systems is an urgent task to meet the food demand of an ever-increasing population, most of them are located in SAT India (Srinivasarao, *et al.,* 2013). The changing rural socio-economic conditions, shortage of labour, higher wage rates and adoption of farm machinery are also having significant influence on the choice of cropping pattern. The wider availability of subsidised inputs like free electricity for irrigation, subsidised distribution of high-yielding variety (HYVs) seeds, modern agricultural equipment, fertilizers, pesticides, etc have also influenced wider adoption of input intensive crops like paddy, wheat and cotton based cropping systems. In most of the villages, there is an increasing trend in wage rates, feminisation of agriculture due to out-migration of male workers which also have impact on choice of cropping systems in favour of less labour intensive crops like pulses and oilseeds and horticultural crops (Birthal *et al.,* 2013). However, many of the past studies have indicated that dryland crops have not benefited as much as irrigated crops due to technological advances in SAT India (Tripp and Pal, 2001). Some of the other findings also show that the technology for dryland cropping systems mostly dominated by pulse crops, oilseeds and coarse cereals are not proven to be highly profitable, although they reduced risk considerably in SAT India (Chand *et al.,* 2007; Reddy, 2009; Srinivasarao *et al.,* 2012). However, recently evidence on Bt cotton shows that it benefited many dryland farmers through increase in profitability and employment opportunities for the poor agricultural labourer (Ramasundaram *et al.,* 2011). The evidence shows that Bt cotton is scale neutral and profitable to all groups of farmers. Monocrop based studies are not able to capture the impacts of the adoption of new technology on farmers' income and employment, hence in this study, the impact of adoption of new technology and cropping systems on farm profitability and labour use was studied with the following major objectives: i) To assess the profitability among different cropping systems in the semi-arid tropics; ii) To assess the labour use pattern among different cropping systems and farm size; iii) To determine the resource use efficiency of the different cropping systems in the SAT India; and finally iv) To assess the influence of regional/ local factors on incomes of farmers in the SAT India.

Materials and Methods

The data were obtained from the project namely Village Dynamic Studies in South Asia (VDSA) in which International Crops Research Institute for Semi-Arid Tropics (ICRISAT) collected a range of data from households engaged farm activities in 16 villages in SAT India for the crop year 2010. The sixteen villages were selected from four states (Andhra Pradesh, Maharashtra, Gujarat and Karnataka), which represent the broad agro-climatic sub regions in the SAT India. The study villages are Aurepalle, Babrol, Chata, Dokur, Kappanimbargi, Kanzara, J.C. Agraharam, Pamidipadu, Markabbinhalli, Shirapur, Kinkheda, Makhiyala, Kalman, Tharati, Belladamadugu and Karamdichingariya. The total sample of farmers comprises 677 which includes 281 small (below 2 ha), 207 medium (2-4 ha) and 189 large farmers (above 4 ha). The sample contain 43 small farmers, 50 medium farmers and 61 large farmers in Andhra Pradesh; similarly 40 small, 40 medium and 40 large farmers in Gujarat; 40 small, 40 medium and 41 large farmers in Karnataka; 20 small, 20 medium and 20 large farmers in Madhya Pradesh; and, 138 small, 57 medium and 27 large farmers in Maharashtra. We have used plot level data of the sample farmers to know the profitability, labour use pattern and resource use efficiency. The data were collected by the residence field investigators located in each village by using standard questionnaire Y- cultivation schedule of Village Dynamics Studies in South Asia. The questionnaire and data collection methods and the data is available at http://VDSA/ ICRISAT website vdsa.icrisat.ac.in/VDSA-database.htm. The number of plots under different cropping systems in each village is presented in Table 1. Altogether, there are 380 plots from Andhra Pradesh, 409 from Gujarat, 279 from Karnataka and 743 from Maharashtra. The village wise distribution of plots along with the dominant cropping system is also given in the table. Altogether 1811 plots data are available for the analysis.

Table 1 : Village wise top five dominant cropping systems in the sample plots in 2010

Andhra Pradesh			
Aurepalle village (146)	J.C. Agraharam village (71)	Dokur village (78)	Pamidipadu village (85)
Paddy (65)	Sunflower (34)	Paddy (56)	Chickpea (25)
Cotton (46)	Pigeonpea (15)	Pigeonpea (11)	Sesamum (21)
Sorghum + pigeonpea (20)	Chickpea (15)	Groundnut (6)	Sorghum fodder (16)
Cotton + pigeonpea (15)	Paddy (9)	Castor (3)	Blackgram (15)
Pigeonpea (14)	Cotton (bt) (7)	Castor + pigeonpea (2)	Sorghum fodder (8)
Gujarat			
Babrol village (124)	Chatha village (110)	Karamdichingariya village (107)	Makhiyala village (68)
Maize (47)	Maize (35)	Groundnut (52)	Groundnut (36)
Paddy (31)	Paddy (29)	Wheat (28)	Wheat (9)
Maize + pigeonpea (25)	Maize + pigeonpea (26)	Pearlmillet (17)	Cotton (9)
Chickpea (21)	Blackgram (20)	Chickpea (5)	Coriander (8)
Wheat (9)	Pigeonpea (2)	Sorghum (5)	Sesamum (6)
Karnataka			
Belladamadugu village (55)	Kappanimbarg village i (87)	Markabbinhalli village (84)	Tharati village (53)
Paddy (20)	Wheat (19)	Pigeonpea (34)	Crysanthemum (21)
Finger millet (16)	Maize (18)	Chickpea (21)	Finger millet + pigeonpea (10)
Groundnut (9)	Pigeonpea (18)	Cotton (12)	Arecanut (8)
Groundnut + pigeonpea + cowpea + horsegram(6)	Sorghum (17)	Sorghum (9)	Paddy (7)
Maize fodder (4)	Cotton (15)	Wheat (8)	Finger millet (7)
Maharashtra			
Kinkheda village (93)	Kanzara village (137)	Shirapur village (297)	Kalman village (216)
Wheat (38)	Soybean + pigeonpea (56)	Sugarcane (129)	Sorghum (72)
Soybean + pigeonpea (26)	Wheat (38)	Seasonal fallow (91)	Seasonal fallow (70)
Soybean (14)	Sorghum (15)	Sorghum (37)	Pigeonpea (47)
Cotton (bt) + greengram + pigeonpea (9)	Cotton + greengram + pigeonpea (14)	Sorghum fodder (23)	Onion (16)
Cotton + pigeonpea (6)	Soybean (14)	Wheat (17)	Chickpea (11)

Source: ICRISAT, VDSA data; Figures in parentheses indicate number of plots

In Telangana villages (Dokur and Aurepalli) of Andhra Pradesh, paddy based cropping systems were dominant. Next to paddy, area under the cotton based cropping system was more in Aurepalle, while area under pigeonpea based cropping system was more in Dokur village. In coastal Andhra village, J.C. Agraharam, oilseed based cropping system (sunflower) was dominant followed by chickpea and cotton. In Pamidipadu (another coastal Andhra village), major cropping systems were largely pulse based and dominated by chickpea. The two Maharashtra villages (Kinkheda and Kanzara) were dominated by wheat, soybean and cotton based cropping systems, and in Shirapur, sugarcane based cropping system was the major one, while Kalman was dominated by sorghum and pigeonpea. It clearly shows that Maharashtra villages were much progressive in terms of cropping systems with commercial crops like sugarcane, cotton and soybean. This is mainly due to the adoption of new improved varieties like Bt cotton and promotion of sugarcane by the cooperatives. In Karnataka, Belladamadugu was dominated by paddy and finger millet based cropping systems. In Kappanimbargi village, wheat was the major crop followed by maize, pigeonpea and sorghum based cropping systems. Markabbinhalli was dominated by pigeonpea and chickpea based cropping systems. Tharati village is commanded by crysanthemum and finger millet + pigeonpea. It shows that the Karnataka villages are dominated by a mixture of traditional sorghum, millets and pulse crops like chickpea and pigeonpea and to some extent by commercial crops like chrysanthemum and other horticultural crops. In Gujarat, Babrol and Chata were dominated by maize and paddy based cropping systems. While other two villages of Gujarat (Karamdichingariya and Makhiyala), groundnut and wheat based cropping systems were the major cropping systems. Obviously, the cropping systems were diverse in SAT villages, but mostly dominated by coarse cereals and legume crops (both oilseeds and pulses) and in some progressive villages like Kanzara and Kinkheda commercial crops like cotton and sugarcane were the major cropping systems. The area under paddy and wheat based cropping systems was also higher which is mainly due to the subsidized electricity for irrigation pump sets and assured Minimum Support Price and markets.

Data was collected for all the operations and for all the inputs, outputs and prices. The costs were calculated by taking into all paid out costs and imputed family labour and rental value of land. The cost components include seed, imputed value of family child, female and male labour and wages of hired child, female and male labour, cost of herbicide, pesticide, FYM, fertilizer and irrigation cost and imputed rental value of owned land. Prices of all inputs and main and by-products were related to the year 2010. The net returns per hectare were calculated by deducting all the cost components from the value of production (including main and by-products). The data were collected for farm plot as a unit and the costs were aggregated on the plot basis and cropping system as a whole. The cropping systems were reclassified into eight major cropping systems based on the share of income from different crops for easy of analysis. There are (i) coarse cereal based cropping system (14.6% of the total plots), (ii) rice or wheat based (15.7%), (iii) cotton based (8.3%), (iv) oilseed based (19.3%), (v) pulses based (14.3%), (vi) pulses-cereal based (2.9%), (vii) high-value crops which include fruits, vegetables, plantations, flowers and other horticultural crops (25%).

Different types of production functions were fitted for the plot level data by using ordinary least square (OLS) method. The final functional form was chosen after testing for multicolliniarity and autocorrelation problems and keeping high adjusted R^2 and also theoretically right signs. The variables included in the model are given in Table 2. Production function was fitted for each cropping system separately to know the resource use efficiency in all the cropping systems and the results were presented in Table 6. In this, value of crop production per plot (₹ /plot) was used as dependent variable and area, female labour, male labour, seed, farm machinery, fertiliser, FYM, rental value of land per hectare as independent variables. The rental value of land is included to control for the quality of the soil and other local factors. Hence the marginal returns from each input were after controlling for the local factors and soil quality. While, Cobb-Douglas production function was used for state wise data, in which the coefficients directly indicate the elasticity of production (% change in dependent variable (gross returns) due to 1% change in independent variable. The marginal effects (change in dependent variable due to one unit change in independent variable) of inputs and dummy variables are estimated by using standard methods (Mundlak *et al.,* 2012). For dummy variables, if b is the estimated coefficient and V (b) is the estimated variance of b then g = 100 (exp (b-V (b)/2) - 1) gives an estimate of the percentage impact of the dummy variable on the dependent variable. The season dummies and the village dummies were introduced into the model to control for the seasonal and local factors in the model. With the introduction of these dummies, we can safely attribute the differences in the gross incomes to the changes in the cropping system after controlling for the local and seasonal factors.

The general functional form is

$$y = a \times x_1^{b_1} \times x_2^{b_2} \times \dots\dots\dots\dots x_n^{b_n}$$

On linearization, the translog modified production function model becomes

$$\begin{aligned}\log(y) &= \log(a) + b_1 log x_1 + b_2 log x_2 + b_3 log x_3 \\ &+ b_4 log x_4 + b_5 log x_5 + b_6 log x_6 + b_7 log x_7 \\ &+ b_8 x_8 + \sum_{i=1}^{n} CS_i + \sum_{j=1}^{m} S_j + \sum_{k=1}^{l} V_k \\ &+ U_l \dots\dots\dots\dots\dots\dots Eq(1)\end{aligned}$$

Table 2 : Descriptive variables used in the Cobb-Douglas production function model

Determinants	Cropping system (Dummy=0,1) (cs)	Season (Dummy=0,1) (s)	Village (Dummy=0,1) (v)
Area in ha (x_1)	Cereals (control)	*Kharif* (control)	Aurepalle (control)
Seed cost/plot in ₹ (x_2)	Cereal mixed	*Rabi*	Babrol
Fertiliser cost/plot in ₹ (x_3)	Pulses	Summer	Belladamadugu
Man day in hours/plot (x_4)	Pulses + mixed	Annual	Chatha
Bullock day in hours/plot (x_5)	Oilseeds	Perennial	Dokur
Machinery cost in ₹ (x_6)	Rice,wheat	Mixed	J.C Agraharam
Other cost/plot in ₹ (x_7)	Cotton		Kalman
Land status (Own=1, Rent=0) (x_8)	Others		Kanzara
			Kappanimbargi
			Karamdichingariy
			Kinkheda
			Makhiyala
			Markabbinhalli
			Pamidipadu
			Shirapur
			Tharati

Note: Dependent variable: log (Gross revenue/plot.)

Results and Discussion

Economics of different cropping systems

Season wise net returns of different cropping systems is given in Table 3. On an average net returns was ₹ 32427/ha for the pooled sample of all the villages. The highest returns were observed in double or triple cropping systems (₹ 174739/ha) followed by perennial crops (₹ 100210/ha), annual crops (₹ 53866/ha), *summer* (₹ 42875/ha), *rabi* (₹ 25816/ha) and the lowest was observed in *kharif* season (₹ 23008/ha). It indicates that the increase in area in *rabi and summer* seasons, wherever feasible would increase net returns to farmers with the provision of irrigation facilities. The perennial and annual cropping systems were also fetching higher returns. Creating irrigation facilities is important to increase the area under double cropping systems, perennial crops (like horticultural crops), annual and summer crops.

Table 3 : Season-wise net returns (₹/ha) in SAT villages

Name of the village	Season						
	Kharif	Rabi	Summer	Annual	Perennial	Kharif – Rabi	Total
Aurepalle	32814	22700	-	37920	44288	32431	31846
Babrol	21727	33028	-	51806	-	-	27171
Belladamadugu	5138	30078	-	-	-	53391	8769
Chatha	33092	70219	-	-	-	-	40232
Dokur	13989	32761	-	51519	-	-	22650
J.C. Agraharam	9672	25199	-	79058	-	-17948	27812
Kalman	12532	15017	96406	-	86875	76790	15728
Kanzara	33958	34217	38655	-	-	-	34158
Kappanimbargi	7803	18113	32440	-	140806	369119	53473
Karamdichingariy	34483	34471	-	-	-	39588	34499
Kinkheda	18703	17118	-9278	-	-	5624	18144
Makhiyala	39683	64529	93480	-	-	-	51655
Markabbinhalli	21227	16338	-	-	-	-	18267
Pamidipadu	24193	51545	-	51371	-	30711	45931
Shirapur	3695	7237	3481	-	98450	12896	50712
Tharati	28233	289352	-11385	-	94450	104021	65095
Total	23008	25816	42875	53866	100210	174739	32427

Net returns in different cropping systems

In Table 4, cropping system wise net returns are presented. The net returns per hectare was highest among high value crop based systems (like sugarcane, fruits and vegetables etc.,) with ₹ 60628/ha, followed by cotton based systems (₹ 40661/ha), oilseeds based cropping systems (₹ 32762/ha) and rice or wheat based systems (₹ 25870/ha). However, net returns were lowest in coarse cereal based cropping system (₹ 13429/ha). Pulse based cropping system, pulse-cereal mixed systems performed at average level. The net return from the cultivation of high-value crops like fruits and vegetables, cotton, rice or wheat are also accompanied by higher cost of cultivation. To realize higher returns from these crops, farmers have to spend more on seed, fertilizer, labour, irrigation and adopt newer technologies. For the same cropping system, the net returns vary significantly across the villages. For example in cotton based cropping system net returns ranged between ₹ 11230/ha to ₹ 79696/ha in Dokur and J.C. Agraharam respectively and paddy-wheat cropping system, it ranged between ₹ 10744/ha to ₹ 64656/ha in Kinkeda and J.C. Agraharam , respectively. In case of high value crops variation is much higher and ranged from ₹ 4704/ha to ₹ 244757/ha in J.C. Agraharam and Kappanimbargi, respectively. The variation in high value crops may be due to high market orientation, fluctuation in market prices for crops like flowers, vegetables and fruits.

Table 4 : Village-wise and croping system wise net returns (₹/ha)

Name of the village	Cropping systems								
	Coarse cereals	Cereals mixed	Pulses	Pulses + mixed	Oilseeds	Rice or wheat	Cotton	High value crops	Total
Aurepalle	11727	-	-717	-	14701	25401	43802	68360	31846
Babrol	19101	21420	28303	-	-	41470	-	5921	27171
Belladamadugu	6751	-1919	326	-	5843	30147	-	39466	8769
Chatha	33428	41604	28336	-	-	55062	-	-	40232
Dokur	6525	-	-7116	-	20616	26867	11230	-	22650
J.C Agraharam	-	-	12383	-	26703	64656	79696	-4704	27812
Kalman	14865	27249	9526	-	8267	16094	-	19469	15728
Kanzara	9422	71222	33130	28335	13662	19721	50436	81042	34158
Kappanimbargi	10095	10205	14032	-	6346	24886	31879	244757	53473
Karamdichingariy	31970	-	47336	-	38261	20806	45763	20955	34499
Kinkheda	8127	26321	23007	17453	-	10744	22047	207	18144
Makhiyala	16986	-	12803	-	57530	43390	46218	32896	51655
Markabbinhalli	10843	12467	19782	-	8810	11443	49743	15117	18267
Pamidipadu	14685	-	16968	-	55257	-	54602	86148	45931
Shirapur	8097	-	3229	-	1580	25447	-	56865	50712
Tharati	20928	20650	10814	-	12975	48817	-	146052	65095
Total	13429	24870	17504	24783	32762	25870	40661	60628	32427

Cropping system wise cost structure

Cost structure of different cropping systems was given in Table 5. The cost of cultivation per hectare is higher in high value crops (₹ 40467/ha) followed by cotton (₹ 22735/ha), rice-wheat cropping system (₹ 22664/ha), oilseed based cropping system (₹ 21595/ha), pulses-cereal based cropping system (₹ 18557/ha), pulses based cropping system (₹ 15349/ha) and the least in coarse cereal based cropping system (₹ 11812/ha). The share of seed cost is higher in oilseed based cropping system (19.8% of total cost), followed by cotton (15.4%). The high share of seed cost for oilseed-based cropping systems was mainly due to high seed rate in case of groundnut, while in case of cotton based cropping systems, the seed cost of Bt cotton is much higher. Female labour share was higher in cotton based cropping system as it requires more women labour for picking of cotton during harvest season. The share of male labour in total cost of cultivation was higher in coarse cereal based cropping systems (28.1%) followed by pulse-cereal based cropping systems (26.2%), high value crops (25.8%) and also rice-wheat cropping systems (23.9%). Overall, the share of human labor in total cost is higher in coarse cereal based cropping system (39.2%) followed by pulses-cereal based (33.8%), rice-wheat (30.9%) and cotton (30.4%). The oilseed and pulse based cropping systems require less labour. Overall, only in cotton based cropping system, women labour requirement was significantly higher. On average, bullock labour share was about 8%, however its share was much higher in coarse cereals (28.3%). Again the least bullock labour use was found in high value cropping system. The share of farm machinery use was highest in rice-wheat (25.1%), pulses (20.1%) and pulse-cereal (19.1%) based cropping system. The share of farm machinery use was lower in high value crops. Less share of female labour, bullock labour and machine labour use while larger share of other inputs use like seed, fertilizer and irrigation were found in high value crops. The share of pesticides was higher in pulses and high value crops. As expected the share of fertilizer was higher in high value crop and rice-wheat cropping systems and lower in oilseeds, pulses and coarse cereal based cropping systems. The total cost per hectare was higher in high value crops followed by cotton, oilseeds, rice-wheat, pulse-cereal based, pulse based and the least in coarse cereal based cropping systems. The benefit-cost ratio was higher in cotton (2.79), oilseed (2.52), and high value crops (2.50) and lower in coarse cereal, pulses and rice-wheat cropping systems (each 2.14). The net returns per one rupee spent on cotton, oilseed and pulse based cropping systems gave divided of ₹ 2.79, ₹ 2.52 and ₹ 2.34, respectively.

Table 5 : Share (%) of inputs in total cost of different cropping systems

Inputs/output	Rice-wheat	Cotton	Oilseed	Pulses	Pulses-cereal	High value crops	Coarse cereal	All
Seed	10.4	15.4	19.8	6.5	12.8	6.8	6.4	12.0
Female labour	7.0	14.2	6.6	6.1	7.6	6.5	11.1	7.7
Male labour	23.9	16.2	21.1	16.6	26.2	25.8	28.1	22.6
Human labour	30.9	30.4	27.7	22.7	33.8	32.3	39.2	30.3
Bulluck labour	6.9	13.0	7.0	9.0	11.9	5.9	23.3	8.5
FYM	6.3	8.0	8.5	7.6	5.2	9.3	9.9	8.0
Machinery use	25.1	10.3	15.3	20.1	19.1	6.8	11.8	14.2
Pesticide	4.9	10.6	12.2	21.8	8.2	18.2	1.8	13.3
Fertilizer	14.3	11.5	6.8	7.6	8.8	14.4	7.6	10.9
Other costs	1.4	0.8	2.7	4.7	0.2	6.2	0.0	2.8
Total cost	100	100	100	100	100	100	100	100
Total cost (₹/ha)	22664	22735	21595	15349	18557	40467	11812	23089
Net return (₹/ha)	25870	40661	32762	17504	24783	60628	13429	32427
Gross returns (₹/ha)	48534	63396	54357	32853	43340	101095	25241	55516
Net returns (₹/₹ spent on labour	3.7	5.9	5.5	5.0	4.0	4.6	2.9	4.6
Benefit-cost ratio	2.14	2.79	2.52	2.14	2.34	2.50	2.14	2.40
Average area (ha)	0.56	0.92	1.00	0.77	0.57	0.50	0.48	0.68

Results from the cropping system wise production function

The results of cropping system wise production function was given in Table 6. The inputs taken into the production function explained a significant variation in the production as indicated by high value of R^2 in all production functions for different cropping systems. Independent variable associated with area revealed that an additional one hectare increase in cropped area (all other inputs held constant) will increase gross returns by ₹ 16599 in high value crops, ₹ 115974 in cotton, ₹ 14044 in oilseeds, whereas only ₹ 4066 in rice or wheat based cropping systems. It indicates that shifting area from paddy or wheat based cropping systems to cotton will accrue higher profitability. Marginal returns to female labour was much higher, a one rupee increase in spending in female labour would increase the gross returns by ₹ 8.86 in rice-wheat, ₹ 5.36 in oilseeds, ₹ 5.21 in coarse cereal and ₹ 3.03 in cotton based cropping systems. In similar lines, a one rupee additional spending on male labour would increase gross returns by ₹ 14.58 in high value crops, ₹ 6.32 in pulses, ₹ 5.41 in cotton, ₹ 3.19 in oilseeds, ₹ 2.74 in rice-wheat cropping systems. However, male labour is excessively used in pulse-cereal based cropping system. A marginal increase of one rupee on seed would increase gross returns more than one rupee in all the cropping systems except high value crops, as the share of expenses on seed was already higher in high value crops. Again in farm machinery also there were higher gross returns for an additional one rupee spending, except high value crops. For fertilizer, marginal returns were higher in case of pulse-cereal (₹ 9.61) and coarse cereal (₹ 3.03) based cropping system. For FYM, higher marginal returns were observed in high value crops (₹ 8.73 per one rupee expenditure on FYM). Overall, there were higher marginal returns to expenditure on land and labour compared to capital based inputs like seed, farm machinery, fertilizer and FYM indicating the shortage of land and labour in the crop production.

Table 6 : Cropping system wise production function

Independent variables	Rice-wheat	Cotton	oilseed	Pulses	Pulses-cereal	High value crop	Coarse cereal
Area	4066*	15974***	14044***	6908***	4034	16599**	4131***
(ha)	(1.4)	(3.4)	(4.5)	(5.7)	(0.9)	(2.5)	(4.7)
Female labour	8.8***	3.0***	5.4***	-0.2	3.3	0.39	5.2***
(₹/plot)	(7.7)	(3.3)	(3.4)	(-0.2)	(0.8)	(0.1)	(7.6)
Male labour	2.7***	5.4***	3.2***	6.3***	-1.9	14.6***	1.5***
(₹/plot)	(3.8)	(4.9)	(4.6)	(11.9)	(-1.1)	(14.8)	(3.7)
Seed	4.7***	1.4	2.6***	4.0***	4.5***	-5.9***	0.8
(₹/plot)	(5.1)	(1.0)	(4.3)	(4.8)	(3.2)	(-2.9)	(1.3)
Farm machinery	2.2***	4.1***	2.9***	1.5***	2.5	-5.8***	2.87***
(₹/plot)	(4.2)	(3.1)	(3.3)	(6.4)	(1.6)	(-2.8)	(4.3)
Fertilizer	-0.03	1.6	1.3	1.0	9.6**	0.6	3.03***
(₹/plot)	(0.0)	(1.1)	(0.6)	(0.8)	(2.5)	(0.6)	(5.8)
FYM	0.90	1.9	-1.5	3.6	-3.1*	8.7***	1.29***
(₹/plot)	(0.7)	(1.2)	(-0.9)	(1.3)	(-1.6)	(4.2)	(4.3)
Rental value	1.4**	5.8***	1.9**	0.07	1.2	-1.2	-0.29**
(₹/ha)	(2.2)	(3.9)	(2.3)	(0.1)	(0.6)	(-0.9)	(-2.2)
Adj. R^2	0.72	0.73	0.72	0.85	0.52	0.64	0.69

Note: Dependent variable = value of crop production per plot; *** indicates significant at 1% level, ** indicates at 5% level and * indicates at 10% level; Figures in parentheses indicate t-values

Land and labour use

Given the shortage of labour and limited availability of land faced by the farmers in the recent years and higher marginal productivity of labour and land in almost all cropping systems from the above regression, the paper examined the labour and land use in detail. Table 7 depicts labour use among different cropping systems. Average plot area was higher in oilseed based cropping systems, followed by pulse based cropping systems, cotton based cropping systems, and the least plot size was observed among coarse cereal based cropping systems. Percent irrigated area was highest among paddy and wheat based cropping systems, followed by high value crops, oilseed based cropping systems and the least irrigated area was in cotton based and pulse-cereal based cropping systems. In Indian agriculture, there is increased commercialization of both inputs and outputs. It is also applicable to labour use. With the increase in market orientation of farming, there is a decline in the share of family labour and increase in the share of hired labour. Data revealed that very few farmers were using child labour in cultivation, most of the child labour was concentrated in cotton based cropping systems that too from within the family, and hired child labour is almost nonexistent. In general, among female labour hired labour is predominant, while among males, family labour is predominant. Highest hired female labour employed in cotton (71.5 days/ha) and high value crops (53.5 days/ha). Highest family female labour was engaged in rice-wheat system (35.7 days/ha) and high value cropping system (36.3 days/ha). The share of female labour in total labour is much higher in cotton (46.7%), followed by coarse cereal (28.3%), pulses (26.9%) and oilseed (23.8%) based cropping systems. The share

Table 7 : Labour use per hectare among different cropping systems

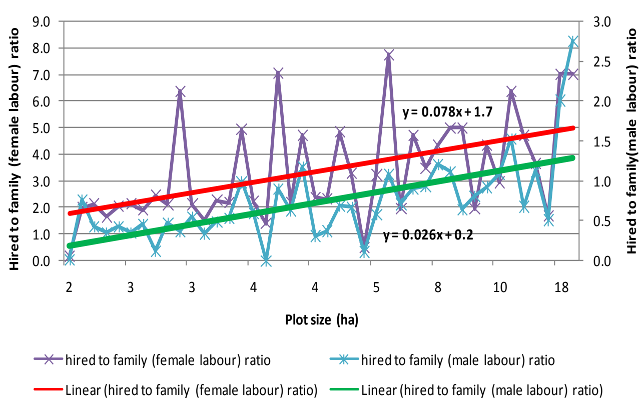
Cropping system	Plot area (ha)	% irrigated area	Days						Female labour to total labour (%)	Pair days	
			Family Child	Hired child	Family Female	Hired Female	Family male	Hired male		Own bullock	Hired bullock
Rice-wheat	0.56	85.2	0.7	0.0	14.5	38.9	35.7	7.7	22.7	6.6	1.3
Cotton	0.92	25.5	4.9	0.0	31.0	71.5	19.9	7.5	46.7	10.1	1.8
Oilseed	1.00	29.0	1.0	0.0	12.4	21.6	18.1	11.4	23.8	5.7	1.3
Pulses	0.77	11.1	1.5	0.0	8.9	14.3	10.5	4.4	26.9	4.2	1.4
Pulses-cereal	0.57	37.0	0.3	0.2	12.5	16.4	19.8	9.0	22.5	3.2	2.9
High value	0.50	61.8	2.3	0.0	23.1	53.5	36.3	27.4	20.1	5.5	2.6
Coarse cereal	0.48	24.8	0.7	0.0	13.8	9.1	18.1	4.9	28.3	6.5	3.1
Total	0.68	38.8	1.3	0.0	16.2	32.9	22.7	11.5	25.4	6.2	1.9

of female to total labour was the least in high value cropping system (20.1%). The share of own-bullock labour is higher than hired-bullock labour in all the cropping systems, indicating that the owning bullocks is one of the determinant factors in the use of bullocks in farming, farmers who don't own bullocks generally use either human labour or machine labour rather than going for hiring of bullock labour.

Farm size and labour use

Figure 1 presents the ratio between hired labour to family labour for both male and female. It increased for both male and female as plot size increases, indicating strong positive association between hired labour and plot size. The ratio of hired labour to family labour was higher among female across all the farm size categories. This indicates the consolidation of land will increase demand for hired labour particularly for women in the process of commercialization of agriculture.

Fig. 1 : Plot size and hired to family labour ratio



There were many studies which dealt with the relationship between farm size and profitability (Reddy, 2011). But very few studies were examined the relationship between farm size and labour use. Figure 2 depicts the relationship between farm size and feminization. In the paper feminization is defined as ratio of female to male labour days. The relationship is inverted "U" shape, indicating up to certain farm size, the female labour is increased, then after as farm size increases the female labour use decreased. It indicates, as the plot size increases beyond 4 hectares, the farm mechanization will increase and it displace female labour compared to male labour on the farm activities. Hence, results show that the corporate farming and contract farming, where the possibility of farm size increases beyond 4 to 5 hectare will have adverse effect on women employment in agriculture, which have important socio-economic consequences.

Fig. 2 : Female to male labour days ratio (%)

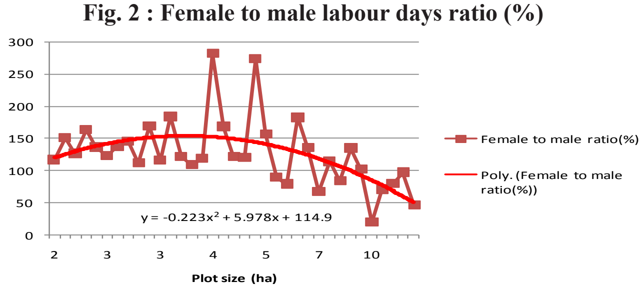
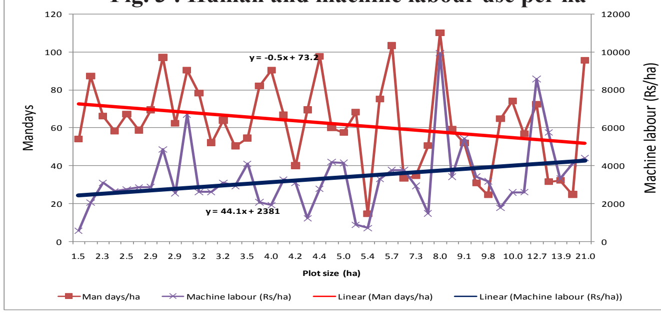


Figure 3 depicts the relationship between plot size and human and machine labour use. It indicates that the one hectare increase in plot size may lead to 0.5 mandays decrease and ₹ 44.1 increase in expenses in farm mechanization. It shows clear inverse relationship between plot size and human labour use, while there is a positive relation between plot size and machine labour use.

Fig. 3 : Human and machine labour use per ha



Results of state wise production function

In Table 8, marginal returns to one ha of land after controlling for all other inputs was higher in Gujarat (₹ 28082/ha) followed by Andhra Pradesh (₹ 11762/ha), Maharashtra (₹ 11467/ha) and Karnataka (₹ 11365/ha). Marginal returns to expenses on seeds was higher in Karnataka (₹ 3 per one additional rupee spending on seed) and Maharashtra (₹ 2). While marginal returns on fertilizers was higher in Maharashtra (₹ 3.2 per one additional rupee spent). The marginal returns to human labour hour was higher in Karnataka (₹ 96/hour) followed by Gujarat (₹ 65/hour), Andhra Pradesh (₹ 62/hour) and Maharashtra (₹ 33/hour). This indicates that there is higher shortage of labour in Karnataka villages followed by Gujarat, Andhra Pradesh and Maharashtra. Marginal returns on machine labour cost is higher in Maharashtra villages (₹ 1.9/each additional rupee spent) among all the villages. In Andhra Pradesh villages, cotton based cropping system gave 80% more gross returns, while pulses based cropping systems gave 28% less returns than the coarse cereal based cropping systems. In Karnataka villages, oilseed cropping systems and cotton based cropping systems gave 47% and 43% less returns than coarse cereal crops as there are higher prices for sorghum during the study year. It is interesting to see that in Maharashtra, the estimated gross returns on all cropping systems namely cereal mixed, pulses, pulse mixed, oilseeds, paddy, wheat, cotton and other cropping systems were significantly higher by 72%, 95%, 86%, 90%, 67%, 82% and 120% respectively compared to coarse cereal crops in the study villages. In Gujarat villages, oilseeds, cotton and other commercial cropping systems have 48% and 108% higher gross returns, but other commercial crops have 36% lower gross returns than coarse cereal cropping systems. In Karnataka state villages, plots with summer crop show 46% less returns than *kharif* season crops. In Maharashtra villages, again returns of summer crop are 42% less than *kharif* crops. On the other hand in Gujarat villages' summer and annual crops have significantly high returns to the extent of 60% and 51% respectively compared to *kharif* season coarse cereal crops. Overall, the state-wise regression results indicated that the profitability varied across the regions and villages among different cropping systems and needs location specific strategies for choosing cropping systems which maximize income and employment.

Table 8 : State-wise production function regression results

Explanatory variables	Andhra Pradesh		Karnataka		Maharashtra		Gujarat	
	B	Marginal effect	β	Marginal effect	β	Marginal effect	B	Marginal effect
Mean dependent variable (log of gross returns/plot)		(32299)		(33995)		(33401)		(35124)
Constant	2.71*		3.95*		3.61*		6.42*	
Log area (in ha)	1.3*	29405 (0.58)	1.63*	28413 (0.74)	1.63*	28668 (0.73)	3.62*	70205 (0.67)
Log seed cost (₹/plot)	-0.08	-1.4 (1877)	0.12***	3.0 (1296)	0.11*	2.0 (1735)	0.02	0.2 (2821)
Log fertiliser (₹/plot)	0.09	1.4 (2045)	-0.01	-0.2 (1730)	0.19	3.2 (1919)	-0.02	-0.8 (822)
Log man day (hours/plot)	0.93*	62 (484)	0.99*	96 (333)	0.36*	33 (355)	0.57*	65 (283)
Log bullock day (hours/plot)	0.03	37 (26)	-0.12**	-241 (16)	0.03	29 (33)	-0.13*	-98 (43)
Log machinery cost (₹/plot)	0.07	0.7 (3284)	0.04	0.7 (1950)	0.12*	1.9 (2034)	0.02	0.4 (1613)
Log other cost in (₹/plot)	0.07***	1.6 (7690)	0.01	0.1 (2619)	0.11*	3.0 (1203)	0.04	0.7 (1893)
Ownership Status (Own=1, Rent=0)	0.03	0.03	-0.01	-0.01	0.15*	0.16	-	
Cropping system dummies (Control: coarse cereal based =1, else=0)								
Pulse based	-0.33**	-0.28	-0.30	-0.26	0.67*	0.95	0.16	0.17
Pulse-cereal based	-		-		0.62*	0.86	-	
Oilseed based	0.12	0.13	-0.63*	-0.47	0.64*	0.90	0.39**	0.48
Rice, wheat based	0.07	0.07	0.03	0.03	0.51*	0.67	0.14	0.15
Cotton based	0.59*	0.80	-0.57**	-0.43	0.60*	0.82	0.73*	1.08
High value crop based	0.10	0.11	-0.29	-0.25	0.79*	1.20	-0.44*	-0.36
Adjusted R-Square	0.88		0.79		0.80		0.93	
Sample Size	246		164		375		243	

Note: *** Significant at 1% level, ** Significant at 5% level, * Significant at 10% level, figures in parentheses are means of the variables. Coefficients indicate the elasticities. Positive coefficient indicates independent variable influences the returns positively, negative coefficient indicate the independent variable influences negatively. Marginal effects indicate that the change in the gross returns due to one unit change in the independent variable. Village and seasonal dummies were included to control for local factors. Plots with some missing values were not included in analysis.

Conclusion

The paper examined the structure of cropping systems in semi-arid tropics of India in 16 villages of Andhra Pradesh, Maharashtra, Karnataka and Gujarat for the year 2010. Area under cotton based cropping systems, paddy and wheat and high value (horticultural) crop based cropping systems was higher even in dry lands. The net returns were more in cotton, paddy, wheat and high value crop based cropping systems mostly driven by technological improvements and subsidized inputs, improved seeds and stable output prices. Whereas pulses based cropping systems are benefited from higher market prices. Eventhough pulse and oilseed based cropping systems were profitable, the seed cost was much higher for some crops, hence needs to be subsidized keeping in view of the growing demand for these crops. The high value (horticultural) based cropping systems are picking up due to higher profitability. All the villages in SAT are experiencing the shortage of labour and land as indicated by higher marginal returns. The labour use per hectare decreased and farm mechanization increased with the farm size. The feminization is having inverted "U" shape relationship with farm size. This indicates that the farms with more than four to five hectares of land are detrimental to women employment as farm mechanization in large farms displaces women labour. The use of seed and other expenses (which include irrigation, pesticides, FYM, etc.,) were less than optimum levels, which needs to be rectified, given the possible higher returns to high-input-high-output cropping systems. The future policies to address incomes of the farmers require location specific strategies.

Acknowledgment

The funding support for this study from CGIAR Research Program Markets, Institutions and Policies, Activity #26 Study of spatial and temporal dynamics of labor market behavior by using household panel data of ICRISAT in South Asia.

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Received: August 2013; Accepted: February 2014