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Evaluation of Irrigated Farming Systems of Hot Arid Region of Northwestern Rajasthan

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Abstract: A study was undertaken to identify micro farming situations (MFSs) in irrigated area of district Bikaner and assess the area under different crops, livestock composition, productivity, economics and constraints associated with crops and dairy animals in these MFS's. Three micro farming situations viz. MFS-I: well irrigated, MFS-II: canal + well irrigated and MFS-III: canal irrigated were identified. Groundnut and clusterbean was major kharif crops in MFS-I and MFS-II. Cotton was the major crop of kharif season in MFS-III. Wheat was major crop of rabi season in all the MFSs. The average productivity of groundnut, clusterbean and wheat was 23.0, 8.0, 18.8 q ha^{-1} in MFS-I and 18.7, 9.6 and 23.6 q ha^{-1} in MFS-II, respectively. In MFS-III, the average productivity of American cotton, cotton, wheat and mustard were 16.3, 13.4, 27.3 and 10.3 q ha^{-1}, respectively. Groundnut was most remunerative crop in MFS-I and MFS-II, whereas in MSF-III it was wheat. Total yield gap (TYG) of crops varied from 9.0 to 26.2 q ha^{-1} and index of yield gap (IYG) varied from 39.3 to 49.5%. Shortage of canal water, shortage of electricity for irrigation, pest and disease incidences, frost, less remunerative price of produce and lack of improved seed were important constraints of crop production and their relative significance was crop and micro farming situation specific. Livestock composition varied considerably among different MFSs. Cow constituted 65.5, 67.1 and 39.2% and buffalo had 25.5, 29.6 and 55.7% share in total livestock in MFS-I, II and III, respectively. The average annual productivity of milk per standard animal unit (SAU) was highest in MFS-II (1125.9 kg) followed by MFS-III (1113.8 kg) and MFS-I (1058.2 kg). Dairy animal is the most remunerative in MFS-III, with highest annual net return per SAU followed by MFS-II and I. Scarcity of fodder, less remunerative price of milk and high cost of inputs were major constraint in milk production in MFS-I, II and III, respectively.

Key Words: Micro-farming situations, arid, irrigation, crops, dairy animals, productivity, economics, constraints, yield gap.

Several converging forces in past led to a resurgence of interest in research client linkage realizing that many innovations being proposed were not being adopted by farmers (Byerlee *et al*., 1982). The most important reason for non-adoption of the innovations that these were generally not suitable for the socio-economic circumstances of the farmers (Simmonds, 1986). Furthermore, commodity-based or discipline oriented research has limited relevance because farm household operating diversified production system are striving to meet both consumption and production goals under marginal conditions for agriculture and formulate management strategies and make decision within the context of the whole economic system exploited by the household including off-farm enterprises (Shanner *et al*., 1982). Consequently, it was realized that research should be determined by explicitly identified farmer's needs springing from an understanding of farming systems which is an essential prerequisite for formulating sensible innovations (Bunting and Padwick, 1983). This led to foundation of the farming system research/extension (FSR/E) approach to agricultural research, extension and development that is considered most opportune and perhaps the only pathway that can ensure food security (Shukla *et al*., 2002) and sustainability (Ikerd, 1990; Butler and Wand, 1990). FSR/E involves broadly three activities viz. diagnosis, planning and experimentation and assessment. The diagnosis include target grouping, selection of priority group and survey (CIMMYT, ESA, 1986). Thus, survey of existing farming system becomes the first step of FSR/E. The present study was undertaken to assess the productivity, economics and associated constraints of crop and dairy animal components of existing farming system in irrigated areas of district Bikaner as the information on these aspects are scanty and diffused.

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Materials and Methods

Three micro-farming situations (MFSs) based on source of irrigation viz. MFS-I: well irrigated,

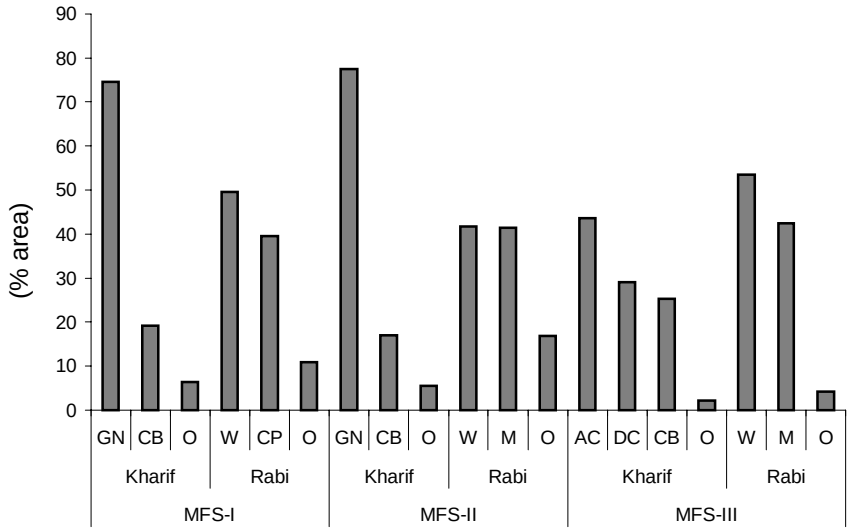

Fig. 1. Area (%) under various crops in different micro-farming situations (MFSs) where GN: Groundnut, CB: Clusterbean, O: Others, W: Wheat, CP: Chicpea, M: Mustard, AC: American cotton, DC: Desi cotton.

MFS-II: canal + well irrigated and MFS-III: canal irrigated were identified in irrigated area of district Bikaner. Two villages from each MFS, and 20 farmers having average land holding (5-10 ha) and dairy animals were selected randomly from each village. Data were collected through personnel interview method by using pre-tested schedule during year 2005. Economics of crops was computed by using cost concept. Various indices related with economics of crops were computed as follows:

Net Income (NI): Gross Income – Cost C_2

Farm Business Income (FBI): Gross Income – Cost A_2

Family Labor Income (FLI): Gross Income – Cost B_2

Return per rupee invested (RPR): Gross Income / Cost C_2

Cost of production per quintal (CPQ): (cost C_2- value of by production / qt. of main product

Economics of dairy animals was computed by using standard procedure as followed by Khatri (2000). Simple tabular and percentage analysis is employed for drawing inferences. To identify constraint associated with crop and dairy animal, a comprehensive list of constraints were given to farmers and asked to rank them according to severity by assigning value one to most limiting constraint, 2 to next important and so on, then the rank value averaged across the respondents in particular MFS and a composite rank was obtained. To estimate the yield gaps, the methodology developed by IRRI as followed by Ahuja *et al.* (2005) was used. Here, potential yield (Yp) is defined as the per hectare yield realized on the research stations, potential farm yield (Yd) is defined as per hectare yield realized on the demonstration plots and the actual yield (Ya) is defined as the per hectare yield realized by the farmers on their field. Then, the total yield gap (TYG) is computed as the difference between the Yp and Ya.

$$TYG = (Yp - Ya) \quad ...(1)$$

$$\text{Yield Gap-I (YG-I)} = (Yp - Yd) \quad ...(2)$$

$$\text{Yield Gap-II (YG-II)} = (Yd - Ya) \quad ...(3)$$

$$\text{Index of Yield Gap (IYG)} = [(Yp/Ya)/Yp] \quad ...(4)$$

$$\text{Index of realized Potential Yield (IRPY)} = (Ya/Yp) \times 100 \quad ...(5)$$

$$\text{Index of Realized Potential Farm Yield (IRPFY)} = (Ya/Yd) \times 100 \quad ...(6)$$

Potential yield (Yp) of the crops for district Bikaner was collected from discussion with scientists of Agricultural Research Station (ARS), Bikaner, and package of practices published by the Department of Agriculture, Govt. of Rajasthan for the zone. Demonstration yield (Yd) was collected from the results of demonstration conducted by the Department of Agriculture, and canal area development (CAD) office of district Bikaner.

Table 1. Productivity, economics and constraints of production of major crops of different irrigated MFSs

Micro farming situation				
MFS I	Groundnut	Clusterbean	Wheat	Chickpea
Productivity (q ha^{-1})				
Main product	23.0	8.0	18.8	8.7
By-product	29.9	13.1	27.7	10.9
Economics (Rs. ha^{-1})				
Cost C_2	23438.2	11757.6	15202.4	12278.2
Gross income	34773.2	13659.1	18656.8	13900.0
Net income	11335.0	1901.5	3454.4	1621.8
FBI[1]	18774.7	7384.8	8929.2	7011.1
FLI[2]	15383.1	3993.2	5537.5	3619.5
RPR[3]	1.49	1.16	1.24	1.14
CPQ[4] (q ha^{-1})	833.5	1248.5	598.1	1273.0
Constraints*				
I	A (1.2)	C (1.5)	A (1.4)	C (1.4)
II	B (1.8)	B (1.6)	G (2.2)	B (2.6)
III	C (3.4)	D (3.5)	D (2.4)	D (2.7)
IV	D (4.1)	A (4.2)	B (4.1)	E (3.8)
V	E (4.6)	F (4.4)	C (4.7)	F (4.6)
MFS II	Groundnut	Clusterbean	Wheat	Mustard
Productivity (q ha^{-1})				
Main product	18.7	9.6	23.6	10.1
By-product	27.2	13.9	34.1	15.6
Economics (Rs. ha^{-1})				
Cost C_2	21237.6	14307.6	17636.8	14064.9
Gross income	28750.9	17090.5	22731.4	17376.8
Net income	7513.3	2782.9	5094.5	3312.0
FBI[1]	14532.8	9484.6	10759.1	9753.9
FLI[2]	11355.0	5234.1	7584.5	5567.9
RPR[3]	1.36	1.19	1.29	1.23
CPQ[4] (q ha^{-1})	921.0	1287.6	623.6	1463.7
Constraints*				
I	J (1.3)	C (1.1)	J (1.2)	I (1.4)
II	B (2.0)	B (1.9)	D (2.1)	C (2.6)
III	D (2.8)	J (3.5)	H (2.7)	B (2.7)
IV	C (4.4)	D (3.8)	B (4.3)	J (3.8)
V	E (4.7)	F (4.8)	E (4.7)	D (4.6)
MFS III	American cotton	Desi cotton	Wheat	Mustard
Productivity (q ha^{-1})				
Main product	16.3	13.4	27.3	10.3
By-product	–	–	38.8	14.5
Economics (Rs. ha^{-1})				
Cost C_2	18794.1	18479.8	18504.9	12895.9
Gross income	25031.3	23159.4	25912.5	17619.4
Net income	6237.2	4679.6	7407.6	4723.5

Table 1 contd...

Table 1. Contd.....

Micro farming situation				
FBI[1]	13615.50	11845.40	15948.60	11165.70
FLI[2]	10186.90	8416.80	10563.00	7436.40
RPR[3]	1.34	1.26	1.39	1.36
CPQ[4] (q ha^{-1})	1270.80	1428.60	542.40	1255.10
Constraints*				
I	C (1.9)	C (1.8)	J (1.2)	C (1.5)
II	J (2.0)	J (1.9)	B (1.8)	B (1.6)
III	B (2.8)	B (3.0)	C (3.4)	D (3.5)
IV	D (3.5)	D (3.5)	D (4.1)	J (4.2)
V	F (4.9)	F (4.9)	E (4.6)	F (4.4)

where 1. FBI stands for farm business income, 2. FLI- family labor income, 3. RPR- return per rupee invested and4. CPQ cost of production per quintal of main product. *A- shortage of electricity for irrigation, B- less remunerative price of produce; C- Pest and disease incidences; D- High price of inputs; E- lack of improved seed; F- Lack of technical know-how; G- atmospheric drought; H- weed infestation; I- frost and J- shortage of canal water. Figure in parenthesis is average rank of constraint on 1 to 5 scale, lower the value more severe is the constraint.

Results and Discussion

Crops

Groundnut is major crop of kharif season in MFS-I and II and covered more than 74% of the total cropped area (Fig. 1). Cotton is major kharif season crop in MFS-III. Wheat is major crop of rabi season in all MFSs and had 49.6, 41.7 and 53.5% share of total cropped area in rabi season in MFS-I, II and III, respectively. Chickpea in MFS-I and rapeseed and mustard in MFS-II and III are second major crops with respect to coverage of total cropped area in rabi season.

In MFS-I the average productivity of groundnut, clusterbean, wheat and chickpea was 23.0, 8.0, 18.8 and 8.7 q ha^{-1}, respectively (Table 1). Cultivation of groundnut incurred maximum cost (Cost C_2 Rs. 23438.2 ha^{-1}), which was 54.2, 90.9 and 99.3% higher over cost of cultivation of wheat, chickpea and clusterbean, respectively. Maximum gross return is realized with the cultivation of groundnut followed by wheat, chickpea and clusterbean. Groundnut is most remunerative crop with highest net return, farm business income, family labor income and return per rupee invested followed by wheat, clusterbean and chickpea. Maximum cost of production of main produce

Table 2. Yield gaps of major crops under different micro-farming situations

	Ya*	Yd	Yp	YG-I	YG-II	TYG	IYG	IRPY	IRPFY
MFS-I									
Clusterbean	8.0	13.0	17.0	4.0	5.0	9.0	52.9	47.01	61.5
Wheat	18.8	31.0	45.0	14.0	12.2	26.2	58.2	41.8	60.6
Chickpea	8.7	17.0	25.0	8.0	8.3	16.3	65.2	34.8	51.2
MFS-II									
Clusterbean	9.6	13.0	17.0	4.0	3.4	7.4	43.5	56.5	73.8
Wheat	23.6	31.0	45.0	14.0	7.4	21.4	47.6	52.4	76.1
Mustard	10.1	16.0	20.0	4.0	5.9	9.9	49.5	50.5	63.1
MFS-III									
Cotton	16.3	20.2	30.0	9.8	3.9	13.7	445.7	54.3	80.9
Wheat	27.3	31.0	45.0	14.0	3.7	17.7	39.3	60.7	88.1
Mustard	10.3	16.0	20.0	4.0	5.7	9.7	48.5	51.5	64.4

*Where Ya refers to actual yield, Yd- demonstration yield, Yp- potential yield, YG-I: yield gap-I, YG-II: yield gap-II, TYG: total yield gap, IYG: index of yield gap, IRPY: Index of realized potential yield; IRPFY: Index of realized potential farmer yield.

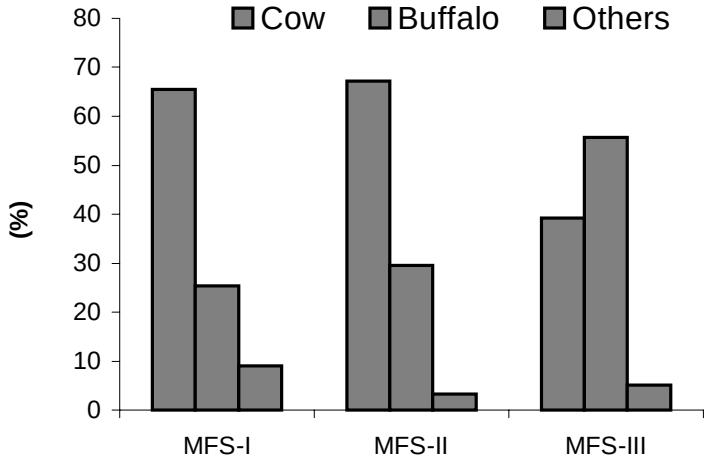

Fig. 2. Livestock composition in different MFSs.

(Rs. q^{-1}) is recorded in chickpea (Rs. 1273.0 q^{-1}) followed by clusterbean (Rs. 1248.5 q^{-1}), groundnut (Rs. 833.5 q^{-1}) and wheat (Rs. 598.1 q^{-1}). IYG is highest in chickpea (65.2%) followed by wheat (58.2%) and clusterbean (52.9%) (Table 2). Shortage of electricity for irrigation is most important constraint in production of groundnut and wheat. Pest and disease incidences and less remunerative price of produce are major constraints in production of clusterbean and chickpea.

In MFS-II the average productivity of groundnut, clusterbean, wheat and mustard is 18.7, 9.6, 23.6 and 10.1 q ha^{-1}, respectively (Table 1). Highest cost of cultivation (cost C_2 Rs. ha^{-1}) was incurred in groundnut (Rs. 21237.6 ha^{-1}) which is 20.4, 48.4 and 51.0% higher over wheat, mustard and clusterbean, respectively. Cultivation of groundnut is most remunerative with highest net return (Rs. 7513.3 ha^{-1}), which was 47.5, 126.9 and 170.0% higher over wheat, mustard and clusterbean. Groundnut recorded highest farm business income (FBI), family labor income (FLI) and return per rupee invested (RPR) followed by wheat, mustard and clusterbean. Cost incurred in production of per unit of economic produce is lowest in wheat followed by groundnut, clusterbean, and mustard. IYG is highest in rapeseed and mustard (49.5%) followed by wheat (47.6%) and clusterbean (7.4%) (Table 2). IRPY and IRPFY of clusterbean and wheat are higher in MFS-II, than MFS-I. Shortage of canal water is major constraint in production of groundnut and wheat. Pest and disease incidences and frost are most severe constraints in production of clusterbean and mustard, respectively.

In MFS-III the average productivity of American cotton, desi cotton, wheat and mustard is 16.3, 13.4, 27.3 and 10.3 q ha^{-1}, respectively (Table 1). Cultivation of American cotton incurred maximum cost (Rs. 18794.1 ha^{-1}) followed by wheat (Rs. 18504.9 ha^{-1}), desi cotton (Rs. 18479.8 ha^{-1}) and mustard (Rs. 12895.9 ha^{-1}). Cultivation of wheat is most remunerative with maximum FBI and FLI followed by American cotton, desi cotton and mustard. Cost of production is lowest in wheat (Rs. 542 q^{-1}) followed by rapeseed mustard, desi cotton and American cotton. IYG is 39.3, 44.7, and 48.5% in wheat, cotton and rapeseed and mustard, respectively (Table 2). IRPY and IRPFY are highest for wheat followed by cotton and rapeseed and mustard. Pest and disease incidences and shortage of canal water are major production constraints of desi and American cotton. Shortage of canal water and less remunerative price of produce are major constraints associated with wheat.

Dairy animals

The number of SAU per household was highest in MFS-II (13.8) followed by MFS-III (7.2) and MFS-I (4.8). Considerable variation exists with respect to composition of livestock among different MFSs. Cow had maximum share in MFS-I and II, whereas buffalo had maximum share in MFS-III (Fig. 2).

In MFS-I average productivity of milk was 1058.8 kg SAU^{-1} $year^{-1}$ (Table 3). Total cost of maintenance was Rs. 10867.4 SAU^{-1} $year^{-1}$. Net return realized with per SAU per year was Rs. 387.0. Scarcity of fodder was most important constraint in milk

Table 3. Economics and constraints of dairy animals in different micro-farming situations

	MFS-I	MFS-II	MFS-III
Productivity (kg SAU^{-1} $year^{-1}$)			
Milk	1058.8	1125.9	1113.8
Economics (Rs SAU^{-1} $year^{-1}$)			
Total variable cost	10657.7	9618.3	11230.0
Total fixed cost	209.7	346.0	579.9
Total cost	10867.4	9964.3	11809.9
Gross return	11254.4	10756.2	12721.7
Net return	387.0	791.9	911.8
Constraints			
I	A (1.3)	E (1.5)	C (1.5)
II	E (1.8)	A (1.6)	A (1.6)
III	C (3.3)	C (3.5)	E (3.5)
IV	D (4.2)	D (4.2)	D (3.8)
V	B (4.5)	B (4.4)	B (4.7)

*A- Scarcity of fodder, B- Health problem; C- High cost of inputs; D- Lack of veterinary facilities; E- Less remunerative prices. Figure in parenthesis is average rank of constraint on 1 to 5 scales; lower the value more severe is the constraint.

production followed by less remunerative price of milk, high cost of inputs, lack of veterinary facility, and health problem.

In MFS-II milk productivity was highest (1125.9 kg SAU^{-1} $year^{-1}$) and total cost of maintenance per SAU was lowest in MFS-II (Table 3). Net return realized with per SAU per year was Rs. 791.9. Important constraints of milk production in order of severity was less remunerative price milk, fodder scarcity, high cost of inputs, lack of veterinary facilities and health problems.

In MFS-III average milk productivity was 1113.8 kg SAU^{-1} $year^{-1}$; Cost of maintenance was highest in this MFS. Maximum net return per SAU per year was realized in this MFS. High cost of inputs and scarcity of fodder were major constraints in milk production.

Considerable variation exits among different MFSs with respect to area under different crops, livestock composition, productivity, economics and associated constraints of crop and dairy animals. IYG clearly indicates that there is huge gap between the yield realized by the farmers and at research stations. Therefore, fine-tuning of technologies to suit the agro-climatic and socio-economic circumstances and more effective dissemination of technology are required to bridge the gap. Shortage of canal water, shortage of electricity for irrigation, pest and disease incidences, frost, less remunerative price of produce and lack of improved seed were important constraints in crop production and their relative significance was crop and micro farming situation specific. In case milk production, scarcity of fodder, less remunerative price of milk, high cost of inputs were most important constraints. Considerable variations in different MFS's call for different strategy for improving farming system, which can cater diverse need of farmers in sustainable manner.

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