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Economic Feasibility of Proposed Cropping Patterns under Different Soil Moisture Regimes of Pothwar Plateau

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ABSTRACT

Ten cropping patterns were evaluated for their economic efficiency under rainfed conditions for three years (2003-06) at three locations in Pothwar plateau representing high, medium and low rainfall conditions. The legume based cropping patterns, compared to others, conserved relatively a higher percentage of soil moisture (9.06-13.41%) at all locations. A highest benefit cost ratio in high rainfall zone was recorded in fallow-wheat (2.90) and sunflower + mungbean intercropping based cropping patterns (2.79). Under medium and low rainfall regimes, fallow-wheat and groundnut based cropping patterns proved most efficient and remunerative. The economic analysis of the data revealed the highest gross and net benefits for sunflower + mungbean based cropping pattern in high rainfall zone (Rs. 54077.00 & 34738.00 ha^{-1}, respectively). However, these benefits were highest in groundnut based cropping patterns in medium and low rainfall zones. The marginal rates of returns were substantially higher for canola based cropping patterns at all the locations (220.91-341.60%). However, fallow-wheat cropping pattern showed promising marginal rate of returns under both high and low rainfall conditions. The performance was well evident from groundnut and canola based cropping patterns at all locations in terms of soil moisture, benefit cost ratio, net returns and marginal rates of returns.

Key Words: Economics; Soil moisture; Cropping patterns; Rainfall zones; Pothwar

INTRODUCTION

The Pothwar plateau mainly comprises Attock, Rawalpindi, Chakwal, Islamabad and Jehlum districts covering an area of more than one million hectares. This rainfed tract contributes significantly to agricultural and livestock production (Supple *et al.,* 1988). The soils of this tract are low in natural fertility, deficient in nitrogen and phosphorous, however, potassium level is adequate. Similarly, the soils are also low in organic matter and having pH of 7.5 to 8.5 (Ahmad *et al.,* 1990).

Rainfall is erratic and varies greatly from 1000 mm in the north-east to 250 mm in south-west part of the region. More than 70% of annual precipitation falls in the summer months. Rainfall, being a major source of moisture for crops, is the primary yield-limiting factor in the area, although other factors such as water and soil water conservation practices, low soil fertility, excessive tillage operations and lack of appropriate practices are also important in Pothwar plateau. The rainfed environment for agriculture is extremely fragile and has limitations for soils, water and crop management. Despite this, the tract has enormous potential to share considerable magnitude of crop production to address the food security issue of the country.

A number of soil moisture management techniques are being practiced in the area. Summer fallowing is a common and traditional practice in fertile lands and about 80% of the rainfed areas are practicing fallow-wheat cropping (Razzaq *et al.,* 1990; Khan & Rizwan, 2000). Through fallow management, farmers conserve monsoon water for the forthcoming winter crops. The net farm returns and cropping intensity are low with this system. The existing cropping patterns i.e., wheat-fallow–wheat, wheat-pulses-fallow and wheat-millet-fallow are the weak cropping patterns in terms of sustainable crop productivity. The cropping intensity and yield in barani areas vary from year to year depending upon rainfall and available soil moisture (Sheikh *et al.,* 1988).

Rotations of high value crops especially legumes (mungbean & mashbean) are very popular among the farmers of Pothwar (Sharar *et al.,* 2000). The benefits of legumes to soil nitrogen fertility and cereals have been reported for various cropping patterns (Ahmad *et al.,* 2001). Legumes grown in less fertile soil could improve the soil health by fixing atmospheric N and may partially supplement the use of inorganic fertilizers (Safdar *et al.,* 2005). Legume crops also support the growth of cereal crops by improving organic matter and physical characteristics of soil (Aslam & Mehmood, 2003). Forages and legumes have great potential to improve the present farming system. At present, leguminous crops in rainfed cropping patterns are minimal but their potential is very

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high (Khan & Qayyum, 1986; Safdar *et al.,* 2002; Manaf & Fayyaz, 2006). Thus, it is important to include suitable legume crops in the existing cropping systems for better crop production in rainfed area.

The productivity of rainfed area could be increased by improving the yield potential of a crop as well as by growing of more crops per unit land instead of leaving it fallow (Aslam &Mehmood, 2003). Rainfall and available soil moisture are critical factors in determining the suitable cropping patterns and choice of crop. The prevalent cropping patterns do not make an efficient use of rainfall. The soil moisture conserved through the year-long fallow is sparingly enough for sowing of rabi crops. If winter rainfalls fail, which often do, it may lead to limit the expected crop yield. It is therefore, necessary to bring the cropping patterns in harmony with the rainfall patterns by shifting emphasis from winter to summer crops in rainfed areas. The improved cropping patterns on long term basis at field level may provide effective means for soil water conservation and its utilization to get sustainable yields of crops.

In the past, little attention has been given on selecting suitable cropping patterns for Pothwar region of Pakistan. This study investigated cropping patterns for efficient utilization of soil moisture and the economic feasibility under rainfed conditions.

MATERIALS AND METHODS

The present study was carried out to on agro-economic efficiency of 10 cropping patterns under rainfed conditions for three years (2003-06) at the three locations i.e., Pir Mehr Ali Shah Arid Agriculture University, Rawalpindi (AAUR), Barani Agricultural Research Institute, Chakwal (BARI) and Groundnut Research Station, Attock (GRS) representing high, medium and low rainfall zones, respectively. The detail of the cropping patterns is given in Table I. All the cropping patterns were arranged in a randomized complete block design with three replications. The experiment at each location comprised 30 plots. The size of plot was 10× 6 m at AAUR and GRS and 15× 10 m at BARI, depending upon the availability of land at each location.

The soil moisture was determined at fortnight intervals to 0-30 cm soil depth with the help of soil augar from kharif 2003 to Rabi 2005-06 in each cropping pattern. Then mean values were calculated for each replication at all locations. The pooled experimental data were analyzed by using methodology described by CIMMYT (1988). The partial budgets were constructed for different cropping patterns. The gross benefits and net benefits for each cropping pattern were calculated as follows:

Gross benefit =Field price × yield.

Net benefits = Gross field benefits –total cost that varied.

Marginal rate of return (MRR) for each non-dominated cropping pattern was calculated by using the formula as described by CIMMYT (1988).

$$MRR = \frac{MNB}{MC} \times 100$$

Where MRR = Marginal Rate of Return in percentage, MNB = Marginal Net Benefits and MC = Marginal Cost.

The 10 treatment cropping patterns were studied for their economic efficiency under different agro-ecological conditions of Pothwar plateau. The first four treatments were existing cropping patterns and remaining six were the proposed ones (Table I). CP-1 was fallow-wheat based, CP-2 was maize (grain) based, CP-3, CP-7 and CP-9 were groundnut based, CP-4 was canola based, CP-5 wasoats fodder based. CP-6 and CP-8 were sunflower +mungbean (intercropped) based and CP-10 was maize fodder based treatments.

The data were subjected to variance analysis accordingly and means were compared by using LSD technique at 5% probability level (Steel & Torrie, 1980).

RESULTS AND DISCUSSION

The composite soil samples were collected from each experimental site before crop sowing and were analyzed for their physical and chemical soil characteristics of the experimental sites (Table II). The meteorological data during study period is presented in Table III.

Soil moisture content (%) of different cropping patterns. At AAUR, ten cropping patterns differed significantly from one another for having average soil moisture content (Table IV). The CP-9 was found to be the best cropping pattern having the highest moisture content in the soil (13.62%), followed by CP-4 and CP-6, which had average moisture content (13.40% & 13.20%). The lowest soil moisture was found in CP-10, because in this cropping pattern, in contrary to all other cropping patterns, which were completely devoid of fallow from spring 2004 to Rabi 2005-06.

Under low rainfall condition of Pothwar plateau, CP-9 and CP-7 (groundnut based cropping patterns) were the best cropping patterns which conserved 9.88-10.32% and 8.38-9.06% moisture in the soil, respectively (Table IV). The lowest soil moisture was available in CP-5. Thus, groundnut based cropping patterns were found efficient for the utilization of available soil moisture under medium and low rainfall conditions of Pothwar plateau. David *et al.* (2002) have reported that continuous cropping or elimination of fallowing reduced soil moisture and higher wheat yield can not be achieved through any other cropping patterns except fallow-wheat under extremely dry conditions. Lal (1990) has concluded that introduction of legumes in cropping patterns in rainfed areas will provide organic matter, which improves soil structure and water holding capacity. Similar results have been reported by Ali (1998), Aslam (1995), Acharya *et al.* (1997), Sharda *et al.* (1999) and Juan *et al.* (2003). Frengrui *et al.* (2000) and Huang and Shao (2003)

Table I. Cropping Patterns under study

Cropping Patterns	Kharif 2003	Rabi 2003-04	Spring 2004	Rabi 2004-05	Kharif 2005	Rabi 2005-06
CP-1*	Fallow	Wheat	Fallow	Wheat	Fallow	Wheat
CP-2*	Maize	Fallow	Fallow	Wheat	Maize	Fallow
CP-3*	Fallow	Fallow	Groundnut	Fallow	Groundnut	Fallow
CP-4*	Fallow	Canola	Fallow	Wheat	Fallow	Canola
CP-5**	Fallow	Oats Fodder	Maize Fodder	Wheat	Fallow	Oats Fodder
CP-6**	Sunflower + mungbean	Fallow	Maize Fodder	Wheat	Sunflower + mungbean	Fallow
CP-7**	Fallow	Fallow	Groundnut	Fallow	Groundnut	Wheat
CP-8**	Fallow	Fallow	Sunflower + mungbean	Oats Fodder	Maize Fodder	Fallow
CP-9**	Fallow	Fallow	Groundnut	Fallow	Groundnut	Canola
CP-10**	Fallow	Fallow	Maize Fodder	Canola	Maize Fodder	Oats Fodder

Maize= Agati-2002, Sunflower= Parsun-2002, Mungbean= MN-92, Wheat= Chakwal-97, Oats fodder= PD-2 LV-65, Groundnut= Chakori. All the crops were sown at recommended seed and fertilizer rates.

* Existing cropping patterns, ** proposed cropping patterns. CP-1 was fallow-wheat based, CP-2 was maize(grain) based, CP-3, CP-7&CP-9 were groundnut based,CP-4 was canola based, CP-5 was oats fodder based. CP-6 & CP-8 were sunflower +mungbean (intercropped) based and CP-10 was maize fodder based treatments.

Table II. Physical and chemical characteristics of the experimental sites (0-15 cm)

Location	Clay (%)	Silt (%)	Sand (%)	Texture	Bulk density Mg m^{-3}	pH	EC (dS m^{-1})	Total N (%)	Available P (mg kg^{-1})	Available K (mg kg^{-1})
Rawalpindi (AAUR)	15	14	71	Sandy clay loam	1.45	7.7	0.25	0.046	3.50	131.38
Chakwal (BARI)	16.2	6	77.8	Sandy loam	1.2	8.0	0.42	0.041	3.43	129.21
Attock (GRS)	13	9	78	Sandy loam	1.1	7.03	0.23	0.031	3.00	122.73

Table III. The monthly average rainfall (mm) and temperature (^oC) regime at three locations during 2003-06

		AAUR			BARI			GRS		
Year	Months	Rainfall (mm)	Max. Temp. (^oC)	Min. Temp. (^oC)	Rainfall (mm)	Max. Temp. (^oC)	Min. Temp. (^oC)	Rainfall (mm)	Max. Temp (^oC)	Min. Temp. (^oC)
2003	Jul	185	34	28	106	39	20	95	44	18
	Aug	214	31	26	187	36	20	188	43	17
	Sep	93	30	23	71	36	24	64	39	16
	Oct	5	25	20	35	34	10	9	32	9
	Nov	17	20	11	13	30	2	3	22	11
	Dec	45	13	9	13	23	-0.7	0	15	7
2004	Jan	21	17	4	65	16	4	14	12	2
	Feb	37	22	6	19	21	4	23	16	4
	March	0	30	11	9	30	10	55	27	11
	April	92	32	17	62	33	16	8	35	18
	May	24	36	19	25	37	19	23	41	22
	June	132	36	22	126	36	22	44	42	21
	July	161	35	23	46	38	24	89	43	24
	Aug	174	33	21	169	33	23	105	37	19
	Sep	30	34	20	23	35	21	17	38	21
	Oct	67	27	12	34	28	13	60	31	17
	Nov	19	25	6	2	25	8	11	26	10
	Dec	29	20	4	30	19	4	22	19	6
2005	Jan	53	16	2	77	14	2	45	14	2
	Feb	191	16	4	145	15	5	20	16	4
	March	90	29	9	75	26	13	0	27	11
	April	12	29	12	12	29	12	75	34	15
	May	30	35	13	38	32	17	20	32	16
	June	14	45	18	51	42	29	31	34	17
	July	312	36	17	166	33	24	132	35	18
	Aug	267	35	20	93	34	23	112	39	21
	Sep	257	37	19	85	33	22	113	39	21
	Oct	54	35	8	14	31	15	14	34	23
	Nov	26	25	7	44	24	6	12	25	14
	Dec	0	21	1	0	20	-0.4	25	14	4
2006	Jan	63	18	3	42	17	14	30	13	2
	Feb	45	25	9	0	24	7	132	17	5
	March	65	26	11	60	24	10	55	30	8
	April	40	32	15	71	33	14	12	44	22

Sources: Agro meteorological Centers of AAUR, BARI and GRS reported higher cropping intensity of two crops in the third year had little effect on water content at wheat planting and subsequent grain yield. They opined that it is possible to utilize excessive summer rain water more efficiently by introducing cover crops in the fallow period.

Economic analysis of different cropping patterns. At AAUR, the benefit cost ratio of various cropping patterns was the highest BCR (2.90) in fallow-wheat cropping pattern, followed by sunflower + mungbean intercropping and canola based cropping pattern (Table V). The highest benefit cost ratio of CP-1 might be due to more grain yield, which resulted in more gross benefits and less total variable cost under fallow conditions. The groundnut based cropping patterns exhibited benefit cost ratio from 2.16 to 2.41, while it was the lowest in CP-2 and CP-10. The canola and groundnut based cropping patterns were superior to the rest of the treatments in terms of the highest benefit cost ratio ranging from 2.18 to 2.29 under medium rainfall conditions of Pothwar.

The perusal of data shown in Table V comparing different cropping patterns at GRS indicated that the highest benefit cost ratio of 2.23 was accrued in CP-1, followed CP-4 and CP-7 and this ratio was 1.80 to 2.04 in the groundnut based cropping patterns. The maize and sunflower based treatments appeared less efficient due to low remunerative returns and high cost of production (Zafar *et al.,* 1995; Aslam & Mehmood, 2003).

As regards partial budget of different cropping patterns, when the total gross benefit of different cropping patterns was compared at AAUR (Table V), CP-6 gave the highest gross monetary returns of Rs. 54077.00, followed by CP-1 (Rs. 46181.00). Total costs that varied were higher in CP-5 and followed by CP-6. Highest net benefit of Rs. 34738.00, Rs. 30283.00 was determined in CP-6 and CP-1, respectively which was followed by groundnut based cropping pattern i.e., CP-7 under high rainfall zone, while they were the lowest for CP-2 (Table V). Thus sunflower + mungbean intercropping may replace Kharif fallowing in high rainfall conditions of Pothwar tract to make it more efficient in terms of net benefits for farming community.

At BARI, CP-7 and CP-9 gave the highest gross monetary returns of Rs. 37758.00 and Rs. 36759.00, respectively (Table V). Thus groundnut based cropping patterns gave the highest gross monetary returns. Total cost was the highest in CP-5 and CP-6. The highest net benefits of Rs. 20765.00 and Rs. 19904.00 was found for CP-7 and CP-9, respectively. The lowest net benefit of Rs. 11046.00 was obtained in maize based rotation (CP-2). Thus groundnut based cropping patterns afforded the highest net benefit. In the low rainfall zone, the groundnut based cropping patterns gave the highest gross monetary returns at GRS (Table V). Fallow-wheat cropping pattern (CP-1) gave the highest net benefit, followed by CP-4 and CP-7. The lowest net benefits of Rs. 1583.00 and Rs.3237.00 were obtained in CP-6 and CP-8, respectively (Table V).

Dominance analysis of different cropping patterns. A cropping pattern was dominated, denoted by "D" by if its variable cost was higher but net benefit was lower than the preceding patterns. The results showed that at AAUR, CP-8, CP-10, CP-9, CP-7 and CP-5, at Barani Agricultural Research Institute, CP-1, CP-10, CP-6 and CP-5 and at Groundnut Research Station, CP-8, CP-6, CP-1, CP-10, CP-9, CP-5 and CP-7 were dominated by other cropping

Table IV. Volumetric (%) soil moisture content of different cropping patterns to soil depth of 0-30 cm during 2003-06 at three experimental sites

Cropping patterns	AAUR	BARI	GRS
CP-1	11.69 cd*	8.40 c*	7.33 de*
CP-2	12.28 bc	8.88 c	7.48 cde
CP-3	12.92 ab	9.62 b	8.04 bcd
CP-4	13.41 a	9.46 b	7.72 bcde
CP-5	11.56 cd	8.64 c	7.20 e
CP-6	13.20 a	9.59 b	8.13 bc
CP-7	11.33 d	9.88 ab	9.06 a
CP-8	11.86 cd	8.78 c	7.57 cde
CP-9	13.62 a	10.32 a	8.38 ab
CP-10	10.47 e	8.64 c	7.88 bcde

*Any two means not sharing a letter in common in a column differ significantly at 5% probability level
LSD (0.05) for AAUR= 0.7861; LSD (0.05) for BARI= 0.5585
LSD (0.05) for GRS= 0.7671

Table V. Net Benefits and Benefit Cost Ratio (BCR) of cropping patterns during 2003-06 at three experimental sites

Cropping patterns	Gross benefits (Rs. ha^{-1})	Total cost (Rs. ha^{-1})	Net benefits (Rs. ha^{-1})	Benefit cost ratio (BCR)
		AAUR		
CP-1	46181	15898	30283	2.90
CP-2	23288	10999	12289	2.11
CP-3	28021	12920	15101	2.16
CP-4	41248	15066	26182	2.73
CP-5	41870	19750	22120	2.12
CP-6	54077	19339	34738	2.79
CP-7	43190	17893	25297	2.41
CP-8	43198	16247	26951	2.65
CP-9	40368	17596	22772	2.29
CP-10	34096	16716	17380	2.03
		BARI		
CP-1	32525	14533	17992	2.23
CP-2	21904	10858	11046	2.01
CP-3	26694	12420	14274	2.14
CP-4	32648	14206	18442	2.29
CP-5	32258	17493	14765	1.84
CP-6	31746	17004	14742	1.86
CP-7	37758	16993	20765	2.22
CP-8	33323	14813	18510	2.24
CP-9	36759	16855	19904	2.18
CP-10	27808	14799	13009	1.87
		GRS		
CP-1	32551	14535	18016	2.23
CP-2	16227	10143	6084	1.59
CP-3	22081	12253	9828	1.80
CP-4	31064	14048	17016	2.21
CP-5	27242	16886	10356	1.61
CP-6	15841	14258	1583	1.11
CP-7	34816	16992	17824	2.04
CP-8	15337	12100	3237	1.26
CP-9	32916	16774	16142	1.96
CP-10	21362	15005	6357	1.42

patterns (Table VI), hence these were not included in calculating Marginal Rate of Returns (MRR).

Marginal analysis of different cropping patterns. The analysis of data for MRR of different cropping patterns for pooled data at AAUR site during 2003-06 revealed that if instead of CP-2 (maize based cropping pattern), CP-3 (groundnut based cropping pattern) is recommended then the marginal rate of return (MRR) is 146.38 percent (Table VII). This implied that for every 100 rupees invested in groundnut production, the farmers can expect to recover Rs. 100 and obtain an additional amount of Rs. 146.00. The MRR was higher in CP-1 with MRR of 367.30%, compared with CP-4 having MRR of 341.60%. This was due to the differences in costs that varied among these cropping patterns, but the differences in net benefits were substantial. However, the comparison of CP-2 with CP-6 indicated that the MRR was 269.17%. When CP-1 was compared with CP-3, CP-4 and CP-6 for MRR, an increase of 60%, 7% and 26.72%, respectively was found in former case. MRR of CP-6 was higher by 45.62% compared to CP-3. It is evident from economic analysis, if farmers in high rainfall zone of Rawalpindi (AAUR) do not leave their land fallow during Kharif, then they may replace it with sunflower + mungbean intercropping. Similar results have been reported by the several researchers (Watkins & Tesdale, 1999; William, 2002; Aslam & Mehmood, 2003; Andrew, 2006), while on the contrary, Pervaiz (2006) found 188% higher in maize fodder- wheat than fallow-wheat cropping system.

Under medium rainfall regime of Pothwar, the MRR was 220.91% for canola based cropping pattern and 147.71-206.66% for groundnut based cropping patterns compared to maize based rotation (Table VII). The MRR of CP-4 was higher than CP-3 probably due to more economic yield of canola than groundnut. The cropping intensity of CP-4 (100%) was higher as compared to CP-3, where cropping intensity was 66.67% and rainfall utilization was greater in canola based cropping pattern. Farooq and Bashir (2001) concluded that improved cropping patterns can harvest more economic returns without effecting soil moisture for succeeding crops. The economic analysis of the data revealed that, the farmers in medium rainfall zone may replace their fallow land preferably with groundnut or with maize fodder in terms of net benefits.

In low rainfall zone, CP-3 had MRR of 177.44% higher than CP-2 (Table VII). Similarly, canola based and fallow-wheat cropping patterns have higher MRR than maize based cropping pattern. The MRR of CP-4 (canola based cropping pattern) was higher than CP-3, because the cropping intensity was greater in CP-4 and rainfall water utilization was efficient in CP-4. The MRR of CP-4 was close to CP-1, but net benefit of CP-1 was more than that of CP-4. According to economic analysis, it seems better if farmers in low rainfall zone (GRS) may replace Kharif fallowing with groundnut or keep their land fallow in Kharif season for obtaining the higher net benefits, higher MRR and higher benefit cost ratio.

Table VI. Dominance analysis of different cropping patterns during 2003-06 at three experimental sites

Cropping patterns	Total cost that vary (TCV) (Rs ha^{-1})	Net benefits (NB) (Rs ha^{-1})
	AAUR	
CP-2	10999	12289
CP-3	12920	15101
CP-4	15066	26182
CP-1	15898	30283
CP-8	16247	26951 D
CP-10	16716	17380 D
CP-9	17596	22772 D
CP-7	17893	25297 D
CP-6	19339	34738
CP-5	19750	22120 D
	BARI	
CP-2	10858	11046
CP-3	12420	14274
CP-4	14206	18442
CP-1	14533	17992 D
CP-10	14799	13009 D
CP-8	14813	18510
CP-9	16855	19904
CP-7	16993	20765
CP-6	17004	14742 D
CP-5	17493	14765 D
	GRS	
CP-2	10143	6084
CP-8	12100	3237 D
CP-3	12253	9828
CP-4	14048	17016
CP-6	14258	1583 D
CP-1	14535	18016
CP-10	15005	6357 D
CP-9	16774	16142 D
CP-5	16886	10356 D
CP-7	16992	17824 D

Figures followed by "D" are dominated cropping patterns.

Table VII. Marginal analysis of different cropping patterns during 2003-06 at three experimental locations

Cropping patterns	TCV (Rs ha^{-1})	MC (Rs ha^{-1})	NB (Rs ha^{-1})	MNB (Rs ha^{-1})	MRR (%)
			AAUR		
CP-2	10999	----------	12289	----------	----------
CP-3	12920	1921	15101	2812	146.38
CP-4	15066	4067	26182	13893	341.60
CP-1	15898	4899	30283	17994	367.30
CP-6	19339	8340	34738	22449	269.17
			BARI		
CP-2	10858	----------	11046	----------	----------
CP-3	12420	1562	14274	3228	206.66
CP-4	14206	3348	18442	7396	220.91
CP-8	14813	3955	18510	7464	188.72
CP-9	16855	5997	19904	8858	147.71
CP-7	16993	6135	20765	9719	158.42
			GRS		
CP-2	10143	------------	6084	-----------	-----------
CP-3	12253	2110	9828	3744	177.44
CP-4	14048	3905	17016	10932	279.95
CP-1	14535	4392	18016	11932	271.68

TCV=Total cost that vary, MC=Marginal cost, NB=Net benefit, MNB=Marginal net benefit, MRR=Marginal rate of return

Aslam (1995) showed that net benefits and MRR were the highest in legume based cropping systems than non-legumes based ones. This is the confirmation that proposed cropping patterns are more efficient in utilization of rainfall water and are more remunerative in terms of benefit cost ratio, net returns and marginal rates of returns. Drinkwater *et al.* (2000) reported that improved cropping patterns with higher cropping intensity preserved more organic matter, reduced runoff and harvested more economic returns. Gadgil *et al.* (2002) reported that introduction of groundnut based cropping patterns in India provided higher benefit cost ratio and appreciable net returns and they cited that cropping patterns are location specific keeping in view its soil and climatic conditions.

CONCLUSION

Proposed cropping patterns are more efficient in harvesting rainfall water and soil moisture utilization and more remunerative than the existing cropping patterns. Thus these proposed cropping patterns should be practiced by the farmers and this study will have overall positive effect on rainfed agriculture. The summer fallowing should be replaced with sunflower + mungbean (intercropped) in high rainfall zone and with groundnut in both medium and low rainfall zones of Pothwar Plateau in order to conserve more soil moisture and accruing higher economic returns.

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