Table 4. Evaluation of water components of various cropping sequences

Cropping sequence	Irrigation water applied (cm)	Profile water use (cm)	Rainfall (cm)	Water expense (cm)	Water productivity (kg m^{-3})
Cotton-wheat	67.5	-10.88	43.56	100.18	0.327
Guar-wheat	45.0	7.59	32.19	84.78	0.358
Moong-wheat	52.5	-3.97	30.81	79.34	0.273
Cotton-barley	60	8.94	43.56	94.62	0.286
Guar- barley	37.5	9.51	32.19	79.20	0.323
Moong-barley	45.0	-1.8	30.81	74.01	0.227
Cotton-*raya*	60.0	-8.39	43.56	95.17	0.271
Guar- raya	37.5	8.84	32.19	78.53	0.333
Moong-raya	45.0	-1.6	30.81	74.21	0.242

Table 5. Effect of various cropping sequences on soil properties (0-15 cm) after completion of the experiment

Crop Sequence	pH (1:2)	EC (1:2) (dSm^{-1})	OC (%)	Av. N ($kg\ ha^{-1}$)	AV. P $kg\ ha^{-1}$)	Av. K ($kg\ ha^{-1}$)
Cotton-wheat	8.49	0.213	0.30	107	16.8	312
Guar-wheat	8.46	0.173	0.37	121	18.9	332
Moong-wheat	8.40	0.167	0.33	117	18.0	330
Cotton-barley	8.48	0.187	0.30	111	16.6	315
Guar-barley	8.43	0.147	0.38	123	18.4	339
Moong-barley	8.36	0.148	0.35	118	17.8	337
Cotton-*raya*	8.45	0.206	0.29	108	16.3	312
Guar-raya	8.34	0.149	0.35	118	18.5	325
Moong-raya	8.40	0.148	0.33	117	18.2	320
SEm ±	0.81	0.006	0.012	1.12	0.95	2.1
CD (5%)	-	-	0.06	5.2	-	7.7

Table 6. Economics of the various cropping sequences in comparison with existing sequence

Cropping sequence	Variable cost ($Rs\ ha^{-1}$)	Gross returns ($Rs\ ha^{-1}$)	Net returns ($Rs\ ha^{-1}$)	Increase/ decrease over cotton-wheat sequence ($Rs\ ha^{-1}$)	Benefit : cost ratio
Cotton-wheat	70901	97192	26291	-	1.37
Guar-wheat	37772	90063	52291	+26000	2.36
Moong-wheat	47777	64266	16489	-9802	1.34
Cotton-barley	62427	80298	17871	-8420	1.29
Guar- barley	29298	75884	46586	+20295	2.56
Moong-barley	39303	49848	10545	-15746	1.27
Cotton-*raya*	62819	76505	13687	-12604	1.22
Guar- raya	29690	77589	47900	+21609	2.59
Moong-raya	39695	53299	13604	-12687	1.34

sequence. The potassium content deceased in cotton based crop sequence (312 kg ha^{-1}) from initial status (326 kg ha^{-1}) but, slight increase in available K was noticed in *guar*-barley (339 kg ha^{-1}), *moong*-barley (337 kg ha^{-1}), *guar*-wheat (332 kg ha^{-1}) and *moong*-wheat (330 kg ha^{-1}) cropping systems. Sharma and Jain (2014) also reported highest available K status and actual K status in *guar*-wheat cropping system compared to maize-wheat and groundnut-wheat system.

Economics

The economic analysis of cropping system as a whole (Table 6) revealed that the highest cost of cultivation (Rs.70901 ha^{-1}) was recorded in cotton-wheat cropping sequence followed by cotton-*raya* (Rs.62819 ha^{-1}) and lowest was obtained under *guar*-barley (Rs.29690 ha^{-1}). The gross returns were also highest in cotton-wheat (Rs. 97192 ha^{-1}) followed by *guar*-wheat (Rs.90063 ha^{-1}) cropping pattern. Nevertheless, the net returns were lower in cotton-wheat than *guar*-wheat crop sequence. Jain *et al*. (2015) also reported the lowest input cost and higher (3.18:1) benefit: cost ratio in *guar*-wheat cropping system mainly due to lower fertilizer requirement and lower cost of cultivation. Sharma and Jain (2014), also reported highest benefit : cost ratio (3.66) in clusterbean-wheat cropping system compared to maize-wheat (3.43) and groundnut-wheat (3.48) cropping sequences. Cotton crop requires higher dose of nitrogen, more number of pesticides sprays and other inputs like cotton picking besides costly *Bt* seed etc., which leads to higher variable cost. The lowest net returns were found in *moong*-barley crop sequence. It may be due to lower potential yield of both *moong* and barley. Chauhan (2011) also found *guar*-wheat cropping sequence more profitable due to higher gross and net return and low input cost among *guar*-gram and *guar*-mustard crop sequences. When compared the increase or decrease over existing crop sequence (cotton-wheat), *guar* based crop sequences showed a positive increase than cotton and *moong* based crop sequences in terms of rupees ha^{-1}. Disparity in economics of various crop sequences has also been reported by Gawai and Pawar (2006).

Based on net returns and cotton equivalent yield it may be inferred that, *guar*-wheat crop sequence was more remunerative as compared to other rotations if there is assured marketing and lucrative price (more than Rs 3000 q^{-1}). The crop sequence may be practiced where there is scarcity of water, as it needs lesser irrigations (1-2) than cotton (5) and can also be helpful in the formulation of contingent plan depending upon availability of water. Furthermore small or marginal area if replaced with existing cotton-wheat crop sequence may help to conserve water resources as well help in soil sustainability.

REFERENCES

Chauhan, R. P. S. 2011.Studies on the crop diversification of existing cropping system in North-West Rajasthan. J. Prog. Agric. **2** (2)**:** 39-40.

Gawai, P. P. and V. S. Pawar, 2006. Integrated nutrient management in sorghum (*Sorghum bicolor*)-chickpea (*Cicer arietinum*) cropping sequence under irrigated conditions. Indian J. Agron. **51:** 17-20.

Gomez, K.A. and A. A.Gomez, 1984. Statistical procedures for agricultural research. John Wiley & Sons, New Delhi.

Jain, N. K., H. Singh, L. N, Dashora and S. L. Mundra , 2015. Maize (*Zea mays*)-wheat (*Triticum aestivum*) cropping system: Intensification through introduction of pulses. Indian J. Agron. **60** (3)**:**347-351.

Kadian, V. S., S. K. Thakral and S. Kumar, 2009. Evaluation of different crop sequences in south-west Haryana. Haryana J. Agron. **25** (1&2)**:** 4-6.

Sharma, S. K. and N. K. Jain, 2014. Nutrient management in wheat (*Triticum aestivum*)-based cropping systems in sub-humid southern zone of Rajasthan. Indian J. Agron. **59** (1): 26-33.

Sidhu, R. S., Sukhpal Singh and A.S. Bhullar, 2011. Farmers' Suicides in Punjab: A census survey of the two most affected districts. Eco. and pol. weekly. **XLVI** (26 & 27)**:**131-37.

Singh, Sukhpal., H. S. Kingra , R. Singh, 2013. Input utilization and constraints of cotton production in Punjab. J. Cotton Res. Dev**. 27** (1) : 144-148.

Singh, N.B. and K. K .Verma, 1998. Production potential and economic analysis of rice (*Oryza sativa*) based cropping system. Indian J. Agron. **43:**199-203.

Usadadiya, V. P. and R. H. Patel, 2013. Influence of preceding crops and nutrient management on productivity of wheat (*Triticum aestivum*)-based cropping system. Indian J. Agron. **58**(1)**:**15-18.

Varvel, G. E. and W.W. Wilhelm, 2003. Soybean nitrogen contribution to corn and sorghum in western corn belt rotations. Agron. J. **95:**1220-25.

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