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Productivity and economic efficiency of different cropping systems under various levels of irrigation

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Abstract
A field experiment was conducted at Mahatma Phule Krishi Vidyapeeth, Rahuri, to study the effect of irrigation levels on grain equivalent yield, economic efficiency and sustainability value index of different cropping systems. Irrigation given at all critical growth stages recorded significantly higher grain equivalent yield of *Kharif* (2002-03) crops, *rabi* crops and cropping system, economic efficiency which was followed by irrigation skipped at one critical growth stage and the lowest values were registered when irrigations were skipped at two critical growth stages. The pearl millet equivalent yield for *kharif* crops was found significantly highest in soybean, for *rabi* crops chickpea grain equivalent yield was recorded the highest value. Soybean-chickpea recorded highest grain equivalent yield and economic efficiency rest of the cropping systems remained at par. The lowest pearl millet equivalent yield was recorded in pearl millet-*Rabi* sorghum. Groundnut + Pigeonpea intercropping recorded the lowest economic efficiency during both the years.

Keywords: grain equivalent yield economic efficiency, irrigation levels, cropping system

Introduction
The general inadequacy of irrigation water and growing demand for crop production including remunerative cropping needs a efficient and economic use of water. When the arable land is large as compared to water available for crop growing, the objective of efficient water management would be to maximize crop production per unit of water, crop yields do not get drastically reduced if irrigation is given at most critical stages of crop growth and in this way crop productivity can be assured even under limited water condition. Benefit of crop production technologies such as high yielding varieties, fertilizer use, multiple cropping and plant protection can be derived only when adequate supply of water is assured. Hence, to assess the effect of irrigation levels on cropping systems in terms of grain equivalent yield and economic efficiency present study was planned.

Material and Methods
A field experiment was conducted during *Kharif* and *rabi* season of 2002-03 and 2003-04, Mahatma Phule Krishi Vidyapeeth, Rahuri. The soil was clayey in texture with pH 8.2 and EC 0.29 dSm^{-1}, low in available N (168.41 kg ha^{-1}) medium in available P (15.69 kg ha^{-1}) and high in available K_2O (497,15 kg ha^{-1}). The field capacity, permanent wilting point and bulk density of soil are 38.23 and 18.42 per cent and 1.28 Mg m^{-3} respectively. The treatments were kept in split-plot design in four replications. Three irrigation levels were kept in main plots *viz*. Each plot was further split into 8 subplots for cropping systems during *kharif* and *rabi* season. Irrigations were given according to the critical growth stages of crops. Grain and fodder yields of crops were recorded. The grain equivalent yield was calculated separately for kharif, *rabi* crops and then for cropping system using the following formulae as:

For *Kharif* crops

$$\text{Pearlmillet grain equivalent yield (q)} = \frac{\text{Grain yield of } \textit{kharif} \text{ crop (q/ha)} \times \text{Selling rate of } \textit{kharif} \text{ crop (Rs/q)}}{\text{Selling rate of pearlmillet (Rs/q)}}$$

For *Rabi* crops

$$\text{Chickpea grain equivalent yield (q)} = \frac{\text{Grain yield of } \textit{rabi} \text{ crops (q/ha)} \times \text{Selling rate of } \textit{rabi} \text{ crops (Rs/q)}}{\text{Market rate of chickpea (Rs/q)}}$$

For cropping system

$$\text{Pearlmillet grain equivalent yield (System) (q)} = \frac{\text{Chickpea equivalent yield q/ha)} \times \text{Selling rate of chickpea (Rs/ha)}}{\text{Selling rate of pearlmillet (Rs/q)}}$$

The economic efficiency was calculated by using following formula

$$\text{Economic efficiency (Rs/day/ha)} = \frac{\text{System net returns (Rs ha}^{-1})}{\text{Total duration of crop in systems}}$$

Results and discussion

Grain equivalent yield

Irrigation level

The effect of irrigation levels to *kharif* crops and *rabi* crops expressed in terms of total productivity as pearl millet equivalent yield (Table-1) and chickpea yield (Table-2) and grain equivalent yield of system (Table-3). It was revealed that the grain equivalent yield of *kharif* crops, *rabi* crops and cropping system differed significantly due to irrigations given at all the stages during both the years and when the data were pooled over the years. It was recorded significantly higher and more grain equivalent yield compared to the rest of the irrigations were skipped at two critical growth stages. Similar results were reported by Singh and Deo (1998) [3], Singh and Singh (2001) [4].

Table 1: Mean grain equivalent yield (q ha^{-1}) of pearl millet (*kharif* crop) as influenced by different treatments

Treatment	Pearl millet grain equivalent yield (q ha^{-1})		
	2002-03	2003-04	Pooled mean
Irrigation levels			
I_1: Irrigation at all critical growth stages	33.66	31.52	32.59
I_2: Irrigation skipped at one critical growth stage	26.90	25.18	26.04
I_3:Irrigations skipped at two critical growth stages	20.59	20.63	20.61
S.E. ±	0.42	0.29	0.70
CD at 5%	1.44	0.99	2.11
Cropping systems			
CS_1: Pearl millet – Wheat	27.65	26.95	27.30
CS_2: Sorghum – Wheat	31.48	35.90	28.69
CS_3: Pearl millet – *Rabi* sorghum	25.11	25.55	25.33
CS_4: Pearl millet – Chickpea	26.11	23.10	24.61
CS_5: Sorghum – Chickpea	29.62	26.69	28.16
CS_6: Pearl millet + Pigeonpea	27.89	22.20	25.05
CS_7: Groundnut + Pigeonpea	1.18	3.00	2.09
CS_8: Soybean – Chickpea	43.37	52.82	50.10
S.E. ±	0.98	1.00	1.91
CD at 5%	2.76	2.85	6.36
Interaction	N.S.	N.S.	N.S.
General mean	27.05	25.78	-

Table 2: Mean grain equivalent yield (q ha^{-1}) of chickpea (*rabi* crop) as influenced by different treatments

Treatment	Chickpea grain equivalent yield (q ha^{-1})		
	2002-03	2003-04	Pooled mean
Irrigation levels			
I_1: Irrigation at all critical growth stages	24.06	26.07	24.20
I_2: Irrigation skipped at one critical growth stage	21.61	24.20	21.79
I_3:Irrigations skipped at two critical growth stages	17.01	19.03	17.15
S.E. ±	0.14	0.51	0.37
CD at 5%	0.48	1.76	0.86
Cropping systems			
CS_1: Pearl millet – Wheat	15.95	20.09	18.02
CS_2: Sorghum – Wheat	15.11	20.16	17.64
CS_3: Pearl millet – *Rabi* sorghum	11.15	11.31	11.23
CS_4: Pearl millet – Chickpea	25.61	24.81	25.21
CS_5: Sorghum – Chickpea	23.56	24.14	23.85
CS_6: Pearl millet + Pigeonpea	26.21	21.16	23.69
CS_7: Groundnut + Pigeonpea	26.76	29.75	28.26
CS_8: Soybean – Chickpea	22.81	33.42	28.12
S.E. ±	0.14	0.68	2.33
CD at 5%	0.41	1.92	7.77
Interaction	N.S.	N.S.	N.S.
General mean	20.90	23.10	-

Table 3: Mean grain equivalent yield (q ha^{-1}) of pearl millet (system) as influenced by different treatments

Treatment	Pearl millet (system) grain equivalent yield (q ha^{-1})		
	2002-03	2003-04	Pooled mean
Irrigation levels			
I_1: Irrigation at all critical growth stages	100.30	99.60	99.95
I_2: Irrigation skipped at one critical growth stage	86.73	88.38	87.56
I_3:Irrigations skipped at two critical growth stages	67.71	70.33	69.02
S.E. ±	0.76	1.27	1.96
CD at 5%	2.62	4.39	5.93
Cropping systems			
CS_1: Pearl millet – Wheat	71.81	79.40	75.61
CS_2: Sorghum – Wheat	73.33	78.54	73.94
CS_3: Pearl millet – *Rabi* sorghum	55.99	55.08	55.54
CS_4: Pearl millet – Chickpea	97.01	87.87	92.44
CS_5: Sorghum – Chickpea	94.88	89.73	92.31
CS_6: Pearl millet + Pigeonpea	100.49	77.45	88.97
CS_7: Groundnut + Pigeonpea	75.27	80.67	77.97
CS_8: Soybean – Chickpea	110.55	140.09	125.32
S.E. ±	1.53	2.05	7.60
CD at 5%	4.33	5.80	25.36
Interaction	N.S.	N.S.	N.S.
General mean	84.91	86.10	-

Cropping systems

Significantly maximum grain equivalent yield (Table-1) was recorded in soybean (43.37 and 52.82 q ha^{-1}) rest of the crops remained at par among them during first and second year of experimentation. The minimum pearl millet grain equivalent was recorded in groundnut (1.18 and 3.00 q ha^{-1}) during 2002-03 and 2003-04. Similar trend was observed in case of pooled mean.

In *rabi* crops (Table-2) significantly maximum grain equivalent yield was recorded in pigeonpea (26.21, 21.16 q ha^{-1}) during 2002-03 while chickpea recorded significantly maximum grain equivalent yield (33.42 q ha^{-1}) followed by pigeonpea (27.75 q ha^{-1}) during 2002-04. In pooled mean maximum grain equivalent yield (28.26 q ha^{-1}) in pigeonpea followed by chickpea having value of 28.12 q ha^{-1}. *Rabi* sorghum recorded the lowest grain equivalent yield (11.15 q ha^{-1}, 11.31 q ha^{-1} and 11.23 q ha^{-1}) during 2002-03, 2003-04 and on pooled mean basis, respectively.

The grain equivalent yield of cropping system (Table-3) significantly higher yield was recorded in soybean-chickpea (110.55 and 140.09 q ha^{-1}) than those observed in rest of the cropping systems. Significantly lowest pearl millet equivalent yield (55.99 and 55.08 q ha^{-1}) was recorded by pearl millet + *Rabi* sorghum during both the years. The pooled mean pearl millet equivalent yield also showed the similar trend. These results are in conformity with those reported by Patel and Mehta (1991) [2], Misra *et al.* (1998) [1] and Sutaria and Patel (1996) [5].

Economic efficiency

Irrigation levels

Irrigation given at all the stages of crop recorded significantly maximum economic efficiency (209.27, 215.04 and 212.16 Rs/day/ha) followed by the irrigation skipped at one critical growth stage and irrigations were skipped at two critical growth stages during both the years and on pooled mean basis (Table-4).

Table 4: Economic efficiency (Rs day^{-1}ha^{-1}) as influenced by different treatments

Treatment	Economic efficiency (Rs day^{-1}ha^{-1})		
	2002-03	2003-04	Pooled mean
Irrigation levels			
I_1: Irrigation at all critical growth stages	209.27	215.04	212.16
I_2: Irrigation skipped at one critical growth stage	181.66	170.74	176.20
I_3:Irrigations skipped at two critical growth stages	129.16	117.02	123.09
S.E. ±	3.31	2.79	5.97
CD at 5%	11.46	9.64	17.30
Cropping systems			
CS_1: Pearl millet – Wheat	143.71	166.60	155.16
CS_2: Sorghum – Wheat	110.99	139.02	125.01
CS_3: Pearl millet – *Rabi* sorghum	114.27	114.42	114.35
CS_4: Pearl millet – Chickpea	241.75	209.55	225.65
CS_5: Sorghum – Chickpea	205.65	180.78	193.22
CS_6: Pearl millet + Pigeonpea	181.86	176.50	179.18
CS_7: Groundnut + Pigeonpea	100.01	107.69	103.85
CS_8: Soybean – Chickpea	288.66	246.25	267.46
S.E. ±	5.08	4.90	12.80
CD at 5%	14.37	13.85	42.71
Interaction	N.S.	N.S.	N.S.
General mean	173.36	167.60	-

Cropping systems

Significantly maximum economic efficiency (Table-4) was recorded in soybean-chickpea (288.66, 246.25 and 267.46 Rs/day/ha) during 2002-03, 2003-04 and on pooled mean basis and rest of the cropping systems were at par with each other. Lowest economic efficiency was recorded in Groundnut + Pigeonpea intercropping (100.01, 107.69 and 103.85 q ha^{-1}) during both years and on pooled mean basis.

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