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Strip cropping system as a climate adaptation strategy in semi-arid Alfisols of South Central India

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ABSTRACT

A two year (2013-2015) field experiment was conducted to assess the efficiency of rainfed strip intercropping of sorghum (S) and pigeonpea (PP) under 4:4 replacement series in comparison with 2:1 intercropping under additive series for system productivity, economic efficiency and farm family food security. There were three treatment combinations (S+ PP –relay horsegram (HG), S+ PP -ratoon S and S+ PP -sequence HG) accommodating an opportune crop of relay or sequence HG to be tested against checks of sole crops. S and PP strip system in a high rainfall year (2013) yielded 31% higher grain than 2:1 S and PP intercropping, but such advantages were not observed during a deficit rainfall year (2014). Significant PP yield increase during a high rainfall year in a strip system increased both water productivity (10.1 to 16.5 kg/ha/mm) and net returns (₹ 57490 to 71680/year). Similarly, during high rainfall year (2013), a superior diverse index (1.63 over 1.19) and production efficiency (19.6 over 13.5 kg/ha/day) was observed. Both relay/sequence cropped HG performed equally well while ratoon S performed poorly. Therefore, for changing climate, 4:4 strip intercropping of S and PP showed higher productivity and economic returns as compared to 2:1 intercropping system. Opportune cropping through relay or sequence HG can be successfully carried out in semi-arid regions during post monsoon season for climate change adaptation.

Key words: Crop diversification, Conservation cropping, Crop intensification, Efficient cropping system, Opportunity cropping, Sorghum+pigeonpea strip cropping

Intercropping of cereal and pulse crops is traditionally practised in Semi Arid Tropic (SAT) regions of India as a risk coping mechanism for minimizing drought impact especially for small and marginal farmers (AICRPDA 2010), which constitute 60% of farmers in rainfed areas. Sorghum (S) and pigeonpea (PP) intercropping is one of the established recommendations in SAT rainfed regions for the stability and productivity of the cropping systems (Subba Reddy *et al*. 2001). However, this cropping system suffered from low profitability due to low market prices of sorghum in India. As crop growth is rain dependant, accommodating more crops per unit area per unit time without obstructing cultural operations (Reddy *et al*. 2016) matching with weather variability is critical. However, to ward off the constraints and re-establish advantages of intercropping, it is necessary to facilitate improved cropping configuration both temporally and spatially. Undulating, slopy, erodible soils coupled with late monsoon do not support intensive cropping. Therefore, these conditions are pre-supposition for introduction of strip row intercropping (also called as conservation cropping) in the SAT regions to maximize rainfall utilization and intensive land use.

In order to survive intermittent dry spells during cropping period and capitalize on the extra rain events received, strip row intercropping systems need to be evaluated for its advantages. Strip cropping comprises growing crops in alternate strips like cereal of 100-120 days duration with pulse crop of 160-180 days duration across the slope. Although these two crops in strips interact agronomically, individual crop management in the strips is ascertained.

Sorghum (*Sorghum bicolor* (L.) Moench) is a predominantly grown cereal crop for dual purpose of grain and fodder. It has grain yield potential of 2-3 tonnes/ha with the harvest index of 0.35-0.4 and is drought tolerant. During the times of fodder scarcity, sorghum stover is of great consolation. However eroded, marginal soils produce poor crop of S, coupled with low market price results in poor profits, thus, preferred least by the farmers (Zalkuwi *et al*. 2015). Sorghum ratooning is one of the drought management practices tried earlier in rainfed areas (CRIDA Annual Report 1988), which could also be introduced and evaluated matching with the rainfall forecast.

Pigeonpea (*Cajanus cajan* (L.) Millsp.) is the most

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preferred legume intercrop for not only its initial slow growth, but also for its indeterminate habit, its tolerance to drought due to deep root system and medium to long duration life span. This is one of the cheapest sources of protein and consumed daily by most people in SAT regions of India.

Studies on field cropping and rainfall analysis in SAT rainfed regions for the last few years indicated a shift in the monthly rainfall distribution from June to July though the date of onset of monsoon was timely (CRIDA Annual Report 1988; CRIDA Annual Report 2010). Not only there seems to be a shift in rainfall distribution, but also there may be chances of receiving extra rain events beyond South West monsoon (SWM) season through the probability estimation. With the extra rain events, chance cropping of a pulse crop like horsegram (HG) can be considered for sowing in the S strips/rows of S+PP intercropping as a relay/a sequence crop or possibility of sorghum ratooning could also be evaluated. Horsegram (*Macrotyloma uniflorum* (Lam.) Verdc) is a contingent pulse crop grown mostly during late *kharif*/early *rabi* for grain and fodder purposes (AICRPDA 2010).

The probability analysis for monthly rainfall distribution beyond August may assist in planning for extended/intensive cropping by integrating the above chance cropping with both the cropping systems. Therefore, evaluation of 4:4 strip intercropping performance in comparison with performance of 2:1 S +PP intercropping and it's adaptability to varying climatic conditions was studied through this experiment.

MATERIALS AND METHODS

This study was conducted during *kharif* 2013 and 2014 at Hayathnagar Research Farm of ICAR-Central Research Institute for Dryland Agriculture (CRIDA), Hyderabad (14.41°N and 77.35° E and at an altitude of 334m). This region falls in SAT with a mean annual precipitation of 760mm. SWM rainfall is the major source for cropping. The monsoon spans from June to September and the cropping is mostly restricted to these four months. Soil water balance reduces with the withdrawal of SW monsoon season. However, it was observed that often some amounts of rainfall occurred during September second fortnight, October and November months which may be helpful to extend the cropping in the existing cropping systems.

The soil of experimental field is red sandy loam (Alfisol) with pH 6.3 and is low in organic carbon content (0.4%), low in available nitrogen (145 kg/ha), medium in available phosphorus (12.5 kg/ha) and available potassium (179.2 kg/ha).

The experiment included nine rainfed treatments comprising of an added third crop as relay HG/ratoon S/sequence HG in two types of S+PP intercropping (4:4 strip and 2:1 intercropping) along with the checks of sole S, sole PP and sole HG. These treatments were replicated thrice in Randomised Block Design. S+PP intercropping combinations (4:4 and 2:1) were sown during the first fortnight of June during both the years. In 4:4 strip, each strip of four rows of S (CSV 23) and PP (PRG 158) were alternated with each other and sown with the spacings of 45 × 15cm, 90 × 20cm for S and PP, respectively as a replacement series. 2:1 intercropping was sown in additive series with S planted at 45 × 15cm and PP was sown as an addition for every two rows of S. S received 40:20:0 kg/ha, whereas PP with 20:50:0 kg of N and P/ha as per the recommendation. Nitrogen (N) and phosphorus (P_2O_5) were applied in the form of diammonium phosphate and potassium in the form of muriate of potash, respectively. In S, nearly half of nitrogen, entire phosphorus, and potassium were applied basally at sowing and remaining nitrogen was top dressed at 45 days after sowing (DAS). In case of PP, entire nitrogen, phosphorus and potassium were applied basally.10 N + 20 kg P_2O_5 was applied for HG (CRIDA 18R) and 20 kg N for ratoon S. Cultural operations were carried out as per the recommendation. Pick axe sowing of relay/sequence HG was carried out at 20 days before the S harvest and after the S harvest respectively, while ratooning of sorghum was done at the time of physiological maturity.

Productivity observations included yields, water productivity, production efficiency etc. Profitability of the systems was also calculated. Production efficiency was calculated using the formula

$$\text{Production Efficiency (kg/ha/day)} = \frac{\text{Total production of the system}}{\text{Total duration of the crops in the system}}$$

Water productivity was calculated as yield per unit of effective rainfall. Effective rainfall was calculated on the basis of seasonal rainfall using USDA Soil Conservation Service method (1967) as given below.

$$P_{eff(dec)} = \frac{Pdec*(125-0.6*Pdec)}{125} \quad \text{If } P_{dec} \leq (250/3) \text{ mm} \qquad (2)$$

$$P_{eff\ (dec)} = (\frac{125}{3}) + 0.1*Pdec \quad \text{If } P_{dec} > (250/3) \text{ mm} \qquad (3)$$

P (dec) is rainfall in 10 days.

Statistical analysis was carried out for data as per ANOVA of Randomised Block Design (Gomez and Gomez 1984) after converting crop yields into sorghum equivalent yields using the farm gate prices of produce (Sorghum @ ₹1200/q, PP @ ₹4100/q and HG@ ₹1200/q prices considered for calculation of gross returns).Family food security was calculated as days the cereal and pulse requirement sufficient for a farm family of five (NNMB 2010).

Assessment indices were calculated for different systems taking mean yield of two years as recommended by Willey and Rao (1980). Land equivalent ratio (LER) was calculated to assess the advantage of intercropping over sole cropping, diversity index (DI) to assess the share of each crop contribution to the gross returns (Cheema *et al*. 1991) and cultivated land utilization index (CLUI) were used for assessing the systems. CLUI was calculated by summing the products of land area to each crop, multiplied by the actual duration of that crop divided by the total cultivated land times 365 days.

$$CLUI = \frac{\sum_{i=0}^{n} aidi}{A*365} \times 100 \qquad (4)$$

where, I = 1, 2, 3, n = total number of crops. A_i = area occupied by the i^{th} crop, d_i = days that the i^{th} crop occupied ai and A = total cultivated land area available for 365 days. Aggressivity (Ghosh 2004) for both the crops was calculated for main crop (Aab)= {(Yab/Yaa × Zab)- (Yba/Ybb × Zba)} and intercrop (Aba)= {9Yba/Ybb × Zba)-(Yab/Yaa × Zab)} upto S+PP intercropping.

The daily rainfall data of 38 years (1974-2012) were collected from the records of HRF, CRIDA, Hyderabad, India. The rainfall data was processed using Weibull distribution method for modeling the probability levels for monthly rainfall. Although rainfall varies with time and space, this is one probability distribution with which fairly accurate predictions are possible (Duan *et al*. 1995). The probability of the rainfall was calculated by using:

$$P=\left(\frac{m}{n+1}\right) \quad (5)$$

where, 'm' is the rank of rainfall, 'n' is the number of rainfall events.

RESULTS AND DISCUSSION

Probability analysis of rainfall

Long-term daily rainfall data of 38 years (1974-2012) of the experimental location was analyzed for prediction of monthly rainfall during post monsoon season at 50% probability. Fig 1 indicates 50% probability occurrence of >75mm rainfall during September month, >50mm during October, >10mm rainfall during November, and no rainfall during December. Probability of receiving a total rainfall of 135mm was predicted for the September, October and November months beyond SWM using Weibull model. Based on the probability of occurrence, matching relay or sequence crop systems were experimented and analyzed.

Rainfall received during field experimentation

During 2013, total rainfall received was 1046 mm while the rainfall received during crop season was 926 mm. SWM season rainfall was 663 mm in 31 rainy days and post rainy season rainfall was 359 mm in 19 rainy days. However, the SWM season rainfall during 2014 amounted to only 414 mm in 17 rainy days, was 38% less than the SWM season rainfall of 2013-14, while rains received during post monsoon season was 75% less in 6 rainy days.

Production and system productivity

Yields of sole crops of S, PP and HG were high during both the years (2013 and 2014) over the respective intercrops in 4:4 strip and 2:1 S+PP intercropping systems except that of strip intercropped PP recording 80 kg additional yield during a high rainfall year (Table 1) as evidenced by Land Equivalent Ratio (LER). Total yields from the strip system (4:4) were found to be significantly high (0.70 tonne/ha) during high rainfall year and insignificant (0.04 tonne/ha) during a deficit rainfall year suggesting that 4:4 strip system was able to capitalize on the additional rains received during post monsoon season. Although high rainfall significantly increased S yields in strip system by 0.58 tonne/ha over 2:1 intercropping, more or less equal yields were registered in both the intercropping systems during a deficit rainfall year. This might be attributed to the drought tolerant nature of sorghum crop (Sasaki and Antonio 2009). Similarly, strip intercropped PP outyielded

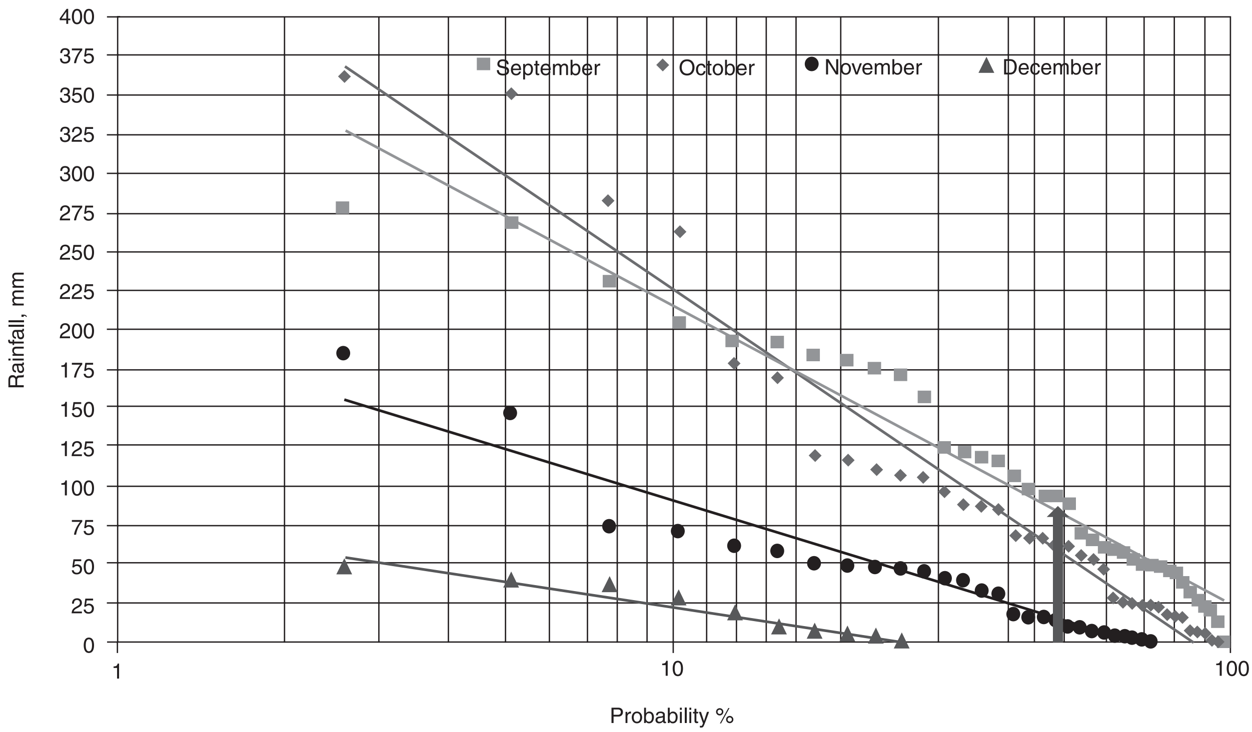

Fig 1 Extended rainfall probability after SWM during September, October, November and December months

Table 1 Yields of Individual crops in different Sorghum (S) + pigeonpea (PP) cropping systems (2013 and 2014) and Total System Productivity (TSP) as influenced by rainfall distribution

Cropping system	Yields of individual crops (t/ha)														TSP (Grain t/ha)	
	S				PP				Horsegram (HG)				Ratoon S			
	Grain		Stover		Grain		Stalk		Grain		Haulms		Stover			
	2013	2014	2013	2014	2013	2014	2013	2014	2013	2014	2013	2014	2013	2014	2013	2014
Sole crops																
Sole S	1.79	1.18	12.27	9.00											1.79	1.18
Sole PP					1.72	0.36	11.88	4.44							5.87	1.23
Sole HG									0.55	0.10	2.02	0.45			0.55	1.10
Ratoon HG													0.56	0.07		
Strip row intercropping (4:4)																
S+PP - Relay HG	1.61	1.14	11.2	8.15	1.80	0.24	11.09	4.79	0.45	0.05	1.42	0.40			8.21	2.11
S+PP - Ratoon S	1.67	1.07	8.5	6.19	1.66	0.22	11.24	4.67					0.92	0.07	7.34	1.82
S+PP– Sequence HG	1.73	1.07	10.7	8.20	1.77	0.20	10.39	4.70	0.49	0.04	1.44	0.39			8.26	1.79
Mean	1.67	1.09	10.13	7.51	1.74	0.22	10.91	4.72	0.47	0.05	1.43	0.40	0.92		7.91	1.91
Intercropping (2:1)																
S+PP - Relay HG	1.08	1.08	11.4	8.84	1.06	0.30	0.96	4.40	0.31	0.04	1.07	0.12			5.02	2.14
S+PP-ratoon S	1.02	1.00	8.9	6.65	1.01	0.24	0.90	4.25					0.34	0.05	4.47	1.82
S+PP - Sequence HG	1.16	0.95	11.2	8.83	1.06	0.25	0.95	4.57	0.29	0.04	1.31	0.19			5.07	1.84
Mean	1.09	1.01	10.50	8.11	1.04	0.26	0.94	4.41	0.31	0.04	1.19	0.16	0.34	0.05	4.85	1.93
SEM	0.02	0.005	0.12	0.11											0.10	0.03
CD(P=0.05)	0.12	0.09	0.77	0.68											0.66	0.17

2:1 intercropped PP by 7 q/ha during 2013, with a bonus from extended HG cropping of 130 kg grains HG/ha. This trend was missing during deficit rainfall year where similar grain production was obtained under different cropping systems. By accommodating opportune crop with extra rain events, 1-1.5 q fodder could be harvested additionally, but the difference lies in the way to utilize the extra rain events by growing either as a relay or sequence crop. Relay cropping may get the advantage, provided the sowings are mechanized. No significant difference in PP yields was observed during deficit rainfall year. This might be attributed to the reduced competition from the neighbouring PP rows for aerial space and light (1.8 m wide S strips on both the sides of PP strip were harvested) unlike 2:1 intercropping (additive series) due to which carbon in the microclimate must have been replenished with carbon dioxide (CO_2) with the gentle breeze as CO_2 gets depleted faster according to De Datta (1981) at leaf surface. Replenishment of air with CO_2 in this case might have enhanced leaf photosynthesis.

Although both the 4:4 and 2:1 cropping systems received similar amounts of rainfall, former system had luxuriant vegetative growth, capitalized on the extra rains and high yield with extra aerial space, whereas latter system failed to do so because of space congestion and side effect of intercropping (additive series). Extended cropping as a relay/sequence HG in these two types of systems was influenced positively by extra rain events during October, 2013 (359 mm) yielding 160 kg grains. This might be due to the avoidance of inter specific root competition for nutrients and water to the same soil depths (Craine and Ray 2013). But such significant differences in yield were not observed during deficit rainfall year. However, ratooning S in both the intercropping systems yielded additional stover of only 0.92 tonne/ha and 0.07 tonne/ha during 2013 and 2014, respectively. Extraction of nutrients and water continuously from same soil depths besides reduction in vigour at physiological maturity stage might have affected ratooned S performance (Vinutha *et al*. 2017).

Total system productivity (TSP) is an indicator calculated after converting the yields of crops into sorghum equivalent yields (SEY) and 4:4 strip system registered an average 45% superior TSP (Table 1) over the 2:1 intercropping system (4.85 tonnes/ha), during excess rainfall year, however, such advantage was missing during deficit rainfall year.

Under climate change conditions, not only rain deficit periods are frequently occurring but also the high rainfall events as well as shift in rainfall distribution towards farther end of SWM season is increasing (Reddy *et al*. 2014).Under high rainfall conditions, strip system performed best since it has got leverage for field operations due to the provision of sufficient space for crop growth expansion. The spatial plasticity was able to provide aeration and light for the luscious vegetative growth which elevated the performance of the strip system and stable prices of pigeonpea helped in attaining best economic advantage as well (Mukesh kumar *et al*. 2014). Strip systems performed at par with the 2:1 intercrop system during deficit rainfall conditions. Owing to these conditions, strip system with relay or sequence cropping system acted as an adaptive strategy for climate

Table 2 Effect of growing different sorghum (S) based cropping systems on water productivity

Cropping system	Seasonal rainfall (mm)		Effective rainfall (mm)		Water productivity for grain (kg/ha/mm)			Water productivity for fodder (kg/ha/mm)		
	2013	2014	2013	2014	2013	2014	Mean	2013	2014	Mean
Sole crops										
Sole S	573.3	209.1	344.8	168.3	5.19	6.9	6.05	35.5	53.4	44.45
Sole Pigeonpea (PP)	920.1	240.1	479.2	191.3	12.3	6.4	9.35			
Sole Horsegram (HG)	299.2	63.3	140.1	48.34	3.9	2.1	3	4.7	3.1	3.9
Ratoon S	299.2	63.3	140.1	48.34				3.9	1.45	2.68
Strip row intercropping (4:4)										
S+PP - Relay HG	920.1	272.7	479.2	216.4	17.1	9.8	13.45	24.3	38.2	31.25
S+PP-Ratoon S	920.1	267.7	479.2	211.4	15.3	8.6	11.95	19.6	0.3	9.95
S+PP-Sequence HG	920.1	272.7	479.2	216.4	17.2	8.3	12.75	23.3	38.4	30.85
Mean					16.5	8.9	12.72	22.4	25.6	24.0
Intercropping (2:1)										
S+PP - Relay HG	920.1	272.7	479.2	216.4	10.5	9.9	10.2	24.5	41.0	32.75
S+PP - Ratoon S	920.1	267.7	479.2	211.4	9.3	8.6	8.95	19.2	0.2	9.7
S+PP - Sequence HG	920.1	272.7	479.2	216.4	10.6	8.5	9.55	24.2	41.0	32.6
Mean					10.1	9.0	9.57	22.6	27.4	25.0
SEM					0.21	0.11	0.16	0.30	0.19	0.25
CD (P=0.05)					1.3	0.7	1.0	1.9	3.7	2.8

Table 3 Effect of different crops and cropping systems on economic returns for two years with forage value

Cropping system	Cost of cultivation (₹ × 1000)	Net returns (₹ × 1000)	Benefit cost ratio	Economic efficiency (₹/ day)	Production efficiency (kg/ha/day)	*Per capita food security for a family of five (days)			
						Cereals		Pulses	
						2013	2014	2013	2014
Sole crops									
Sole sorghum (S)	11.14	38.59	4.46	350	13.67	90	59		
Sole pigeonpea (PP)	17.61	25.03	2.42	139	19.72			430	90
Sole horsegram (HG)	1.55	3.59	3.31	32.9	3.04			138	25
Ratoon S	0.85	1.04	2.02						
Strip row intercropping (4:4)									
S+PP - Relay HG	15.29	75.97	5.97	308	20.89	81	57	562	73
S+PP - Ratoon S	14.54	64.09	5.41	267	19.08	84	54	415	55
S+PP - Sequence HG	15.59	74.97	5.90	281	18.82	87	54	565	60
Mean		71.68	5.76	285.3	19.60	84	55	514	63
Intercropping (2:1)									
S+PP - Relay HG	13.19	58.73	5.45	238	14.49	54	54	345	85
S+PP -ratoon S	12.44	52.81	5.24	220	13.10	51	50	253	60
S+PP -Sequence HG	13.19	60.92	5.62	228	12.94	58	48	338	73
Mean		57.49	5.44	228.7	13.51	54	51	312	73
SEM		0.96							
CD (P=0.05)		6.1							

Sorghum grain @ ₹12; Pigeonpea seed @ ₹41; Horsegram@ ₹12 and Sorghum stover @ ₹3; HG haulms @ ₹1. *As per National Nutrition Monitoring Bureau survey per capita requirements were considered.

change, though the farmers are not aware of the advantages and plasticity of the strip system are not yet popular due to non-availability of mechanization in these systems.

Water productivity and economic efficiency of the system

Water productivity (WP) is one of the indicators in assessing the efficiency of rainfed cropping systems. Cropping systems registered higher WP (11.2 kg/ha/mm) than the sole crop systems (6.1 kg/ha/mm).Between the cropping systems, strip system on an average produced 6 kg additional grain per ha-mm of effective rainfall over 2:1 system (Table 2). Either relay or sequence crops included systems recorded maximum WP except the ratooned S system. WP of different cropping systems was similar during the deficit rainfall year. Rainfed water productivity is linked to rainfall variability both temporally and spatially. Hence the above mentioned facts are attributed to the effective utilization of rainfall through spreading cropping and reduced competition for light and ground space for the extended crop growth of pigeonpea (Palaniappan and Sivaraman 2006) as well as to the relay/sequence HG crop sown in sorghum strips/harvested sorghum strips during or beyond SWM season by rainfed strip system. Further diversity index appears to have direct relation with WP while CLUI was same for both the cropping systems. Maximum utilization of received rainfall was made by strip system by altering space configuration of the crop rows. Aggressivity calculated for S and PP is applicable up to the harvest of S crop. Since, S was a fast growing crop intercropped with initially slow growing PP, dominated the cropping system but later PP was dominant.

A pooled analysis of monetary returns from two cropping systems in two years experimentation showed that though there was a marginal increase in cost of cultivation ranging from ₹ 750 to 1000 in 4:4 strip system over 2:1 system, however, additional returns increased by ₹ 14190/ha (Table 3). Although the superiority of intercropping systems is well established over sole cropping in terms of insurance against crop failure by Willey and Rao (1980) and others, strip cropping with simple space configuration further improved the returns during a high rainfall year. Therefore, it can be called as “opportunity cropping”. But during a drought year, both cropping systems performed equally. This was endorsed by BC ratio of 5.76, where a

Table 4 Indices for assessing the performance of different cropping systems

Treatment	Diversity index		CLUI (converted into %)		Aggressivity-sorghum	Aggressivity-pigeonpea	LER	
	2013	2014	2013	2014	Pooled	Pooled	2013	2014
Strip row intercropping (4:4)								
Sorghum (S) +pigeonpea (PP) - Relay horsegram (HG)	1.65	2.02	51	48	0.012	-0.012	2.77	2.13
S+PP - Ratoon S	1.53	1.91	48	44	0.014	-0.014	1.89	1.52
S+PP - Sequence HG	1.72	2.06	51	48	0.014	-0.014	2.88	1.86
Mean	1.63	1.99	50	47	0.013	-0.013	2.51	1.84
Intercropping (2:1)								
S+PP - Relay HG	1.00	2.08	51	48	0.009	-0.009	1.79	2.15
S+PP - Ratoon S	1.56	2.00	48	44	0.008	-0.008	1.16	1.51
S+PP - Sequence HG	1.03	2.04	51	48	0.010	-0.010	1.79	1.89
Mean	1.19	2.04	50	47	0.009	-0.009	1.58	1.85

benefit of ₹ 4 to 4.76 can be fetched with an investment of ₹ 1 and income of ₹ 285 was generated per day. Similarly, production efficiency obtained was 19.60 kg/ha/day in 4:4 system as compared to 13.51 kg/ha/day in 2:1 system (Table 3). Marked increase in net returns, benefit cost ratio, economic and production efficiencies are attributed to the enhanced yields of strip cropped PP due to its rainfall capitalization ability, stable markets and higher economic and production efficiencies.

Family food security

According to National Nutrition Monitoring Bureau (2012) standards, per capita diet requirements are 400 and 80 g of cereals and pulses, respectively. These standards were used to calculate the food security of a farm family of five in days and shown in Table 3. Though intercropping systems secured diet requirements of farm family (Singh 2007), strip system secured cereal and pulse needs of the family for 81-87 days and for 415-565 days, respectively while 2:1 intercropping system was able to fulfill dietary requirements only for 51-58 days and cereal and pulse requirement for 253-345 days. Overall analysis showed that drought year secured family for only 50-90 days leaving them dependent on income from other activities such as dairy and sheep rearing until the harvest of next season crop with a waiting period of more than 9 months.

Thus, it is concluded that by simple alteration of spacing, 2:1 intercropping system could be transformed into strip system (4:4) which can provide 22% improved crop yields that can be translated into an additional net return of ₹ 14910/ha with an added advantage of providing food security for cereal and pulse needs of the family of five for 81-87 days and for 415-565 days, respectively. At field level, in absence of foolproof rain prediction system, 4:4 strip system is advantageous over other cropping systems, in order to exploit the additional rainfall event. Augmented production efficiency, enhanced diversity index and water productivity are some additional advantages of strip system besides the indirect benefits of resource conservation and environmental protection. Relay or sequence cropping of horsegram for fodder may be a possibility, which could address food security through crop diversification and intensification. However, mechanization of the field operations is critical for operationalization of these systems as a climate change adaptation strategy.

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