

Effect of Mixed and Intercropping Systems on Dry Matter and Grain Yields of Component Crops in Arid Environment

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Abstract A field study on sole, mixed, intercropping and strip cropping of pearl millet [*Pennisetum glaucum* (L.) R. Br.] and clusterbean [*Cyamopsis tetragonoloba* (L.) Taub.] was conducted to identify the best suitable cropping system for the arid region. Pearl millet and clusterbean grown in alternate row (1:1) gave mean combined dry matter yields at par with sole cropping of pearl millet but significantly higher than mixed, intercropping and strip cropping. The increase was in the order of 42 to 194%. The 1:1 system also produced maximum grain yield among different intercropping systems. Better performance of 1:1 system was attributed to creation of more border rows that resulted in the least influence by shorter component crop through the formation of a two tier system. The highest gross (Rs. 7512 ha⁻¹) and net (Rs. 5844 ha⁻¹) returns accrued from alternate row intercropping system (1:1), followed by sole cropping of pearl millet.

Key words Pearl millet, intercropping, strip cropping, mixed cropping

Intercropping occupies an important place in the arid cropping systems. Numerous studies have shown that intercropping is advantageous from the point of view of increased yield (Panjab Singh & Joshi 1980), yield stability (Fisher 1976), better control of weeds (Rao & Shetty 1977), and pest and disease control (Crookston & Kent 1976). Shelter by one crop to another (Rathke & Hegstrom 1976), physical support (Aiyer 1949), lower soil temperature (Ghuman & Lal 1983), better use of growth resources (Andrews & Kassam 1976) and crop diversity are some other advantages of intercropping.

Intercropping often restricts choice of fertilizers, efficient mechanization, crop rotatability and practicability. Intercropping could be inferior to pure cropping if one crop fails because the component crop exerts competition but contributes nothing to yield. Plant competition may be more if intercrops and base crops are grown in close proximity. Inadequate supply of natural resource and simultaneous peak natural resources demand of crops in a system may also result in low yield or complete crop failure. The present investigation, therefore, aims at identification of an intercropping system that offers better choice of fertilizers and agrochemicals, and favours crop

diversity, less intercrop competition, crop rotatability, practicability and easy mechanization.

Materials and Methods

A field study on sole, mixed, intercropping and strip cropping of pearl millet and clusterbean was conducted during *Kharif* seasons of 1988 and 1989 under rainfed conditions at Central Arid Zone Research Institute, Jodhpur. The soils of the experimental site were developed from rhyolite and reworked by alluvial and aeolian activities. These are loamy sand in texture, with 85.5% sand, 4.8% silt and 9.7% clay. The rainfall during the growing seasons was about 10% less than the average seasonal normal of 305 mm (180.5 mm in 1988 and 182 mm in 1989). The crops faced terminal drought of about one month during both the seasons.

Treatments consisted of sole cropping of pearl millet and mixed, row intercropping, as well as strip cropping of pearl millet and clusterbean. The sole pearl millet crop was grown in a regular row system having rows 50 cm apart with 10 cm between plants. Mixtures consisted of 25, 50 and 75 per cent population of pearl millet and 75, 50 and 25 per cent population of clusterbean, respectively. In these mixtures seeds of

both crops were mixed and sown as in sole cropping of pearl millet.

Intercropping included: (i) pearl millet in paired row 25/75 cm (two rows of pearl millet 25 cm apart, two such pairs being 75 cm apart) with one row of clusterbean in interpair space, (ii) pearl millet in triple row 40/70 cm (three rows 40 cm apart, two such triplet sets at 70 cm apart), (iii) two rows of pearl millet alternated by one row of clusterbean, and (iv) alternate row intercropping, i.e., one row of pearl millet alternated by one row of clusterbean. Strip cropping had four rows of pearl millet alternated by four rows of clusterbean. In all the treatments, except the paired row and triplet row systems, a total of 0.2 million plants ha^{-1} were maintained. In the paired and triple row systems 0.3 and 0.26 million plants ha^{-1} , respectively, were maintained. Thus, nine treatments replicated three times in randomized block design. An additional treatment of pure clusterbean was also kept for rotating the pearl millet crop in 1989.

At the time of sowing 15 kg N and 30 kg P_2O_5 ha^{-1} were applied to all the treatments. An additional dose of 15 kg N ha^{-1} was top dressed to pearl millet about a month after sowing.

Both the crops in all the systems were sown simultaneously with the onset of monsoon, on 12 July in 1988 and on 27 July in 1989 by tractor drawn seed drill. The desired plant population was achieved by thinning the plants. In systems like pure cropping, strip cropping and in one of the intercropping systems, i.e., one row of pearl millet alternated by one row of clusterbean, pearl millet rows replaced the clusterbean rows and vice versa in 1989. In other systems no crop rotation was followed. Crops were harvested from net plot of 16x6 m for each treatment for evaluation of dry matter and grain yields.

Results and Discussion

Growing season rainfall

During the growing season a total rainfall of 180.5 mm from 24 showers was received in 1988 and 182.0 mm from 17 showers in 1989. Both the seasons had about 40 per cent less rainfall than the average of 305 mm. Besides low rainfall, its distribution was also erratic. A 26-day rainless period, beginning 44 days after planting, occurred in 1988. In 1989 the crops experienced two dry spells: (i) for 18 days just after sowing, and (ii) for 21 days at 35 days after sowing.

Table 1 Pooled dry matter and grain yield ($kg\ ha^{-1}$) of component crops under different cropping systems

Treatment*	Dry matter yield			Grain yield	
	Base crop	Intercrop	Total	Base crop	Intercrop
Sole Pearl millet	5400	—	5400	713	—
Sole Clusterbean	—	700	700	—	328
Mixed cropping					
Pm + C (25:75)	1680	80	1760	152	0
Pm + C (50:50)	2560	70	2630	123	0
Pm + C (75:25)	3140	30	3170	176	0
Row intercropping					
Pm + C (1:1)	4390	790	5180	640	40
Pm + C (2:1)	1890	590	2480	99	107
Pm(pr) + C	2830	210	3040	67	102
Pm(tr) + C	3630	30	3660	135	0
Strip cropping					
Pm + C (4:4)	2660	570	3230	360	127
CD 5%	510	—	510	49	—

*Pm = Pearl millet, C = Clusterbean, pr = Paired row, tr = Triple row

Dry matter yield

The system of intercropping where one row of pearl millet was alternated by one row of clusterbean (1:1), recorded the highest mean combined dry matter production of 5180 kg ha⁻¹ among the different intercropping systems (Table 1). This system of intercropping gave yields at par with sole cropping of pearl millet but significantly more than that of mixed, strip cropping and other row intercropping systems. The increase over different systems ranged between 42 and 194 per cent. The dry matter yields of pearl millet component also followed a trend similar to that of combined dry matter yield. Among the mixtures, the population ratio of 75:25 (pearl millet : clusterbean) resulted in maximum dry matter production (3140 kg ha⁻¹), while the ratio of 25:75 gave the lowest production. The taller and thicker stalks of pearl millet mainly contributed to this effect.

Grain yield

The alternate row intercropping system (1:1) produced the highest grain yield amongst different intercropping systems (Table 1). Better performance of this system could be attributed to creation of more border rows which resulted in the least influence by shorter component crop through the formation of a complete two tier system. The pearl millet component in the alternate system (1:1), having half the population as compared to that in the sole pearl millet, had only 73 kg ha⁻¹ less yield than that of sole crop. This indicated a strong compensation effect including border effect. Rao & Joshi (1986), while analyzing border effects, recorded a higher net radiation flux densities (Rn) in the sole crop system as compared to the skipped row and paired row systems involving border effect. This suggested more absorption of radiation in the systems having border effects, while sole crop system allows higher Rn to penetrate into the canopy. The net radiant energy partitioned for evapotranspiration (ET) is actually utilized for productivity purposes in skipped and paired row systems (Rao & Joshi 1986). Much of the net radiant energy in sole crop system, on the other hand, is utilized in ET process for maintaining equilibrium con-

ditions with the surrounding environment which is being heated by increased radiation penetration into the canopy due to variations in leaf area and its distribution. Ross & Harper (1972) observed higher plant growth in the border row as compared to that in the inner rows. Robinson (1984) and Joshi (1990) recorded 13 to 36 per cent higher yield of sunflower and pearl millet in the border rows as compared to that in adjacent inner rows.

The treatments, having triple row, paired row and 2:1 (Pearl millet : Clusterbean) geometries in the present investigation though had complete or partial border effects, but these gave lower yields than in the alternate row system which had full border effects. This could be attributed to the higher plant population in these systems and also to the absence of rotation effect. The alternate system had the benefit of rotation over preceding legumes.

In mixed cropping system with different ratios the intercrop component did not produce any grain, but in the row intercropping systems, intercrop component produced 40 to 107 kg ha⁻¹ besides base crop yields. Although mixed cropping (50:50) and row intercropping (1:1) had similar population of component crops, the latter per-

Table 2 *Relative profitability (Rs.) of different systems (pooled over 2 years)*

Treatments*	Total variable cost	Gross returns	Net returns
Sole Pearl millet	1694	6555	4861
Mixed cropping			
Pm + C (25:75)	1448	2115	667
Pm + C (50:50)	1513	2918	1405
Pm + C (75:25)	1529	3501	1972
Row intercropping			
Pm + C (1:1)	1668	7512	5844
Pm + C (2:1)	1517	3817	2300
Pm(pr) + C	1548	3746	2162
Pm(tr) + C	1584	3426	1842
Strip cropping			
Pm + C (4:4)	1578	5009	3431

*Pm = Pearl millet, C = Clusterbean, pr = Paired row, tr = Triple row

formed significantly superior to the former in terms of grain yield of component crops. This could be attributed to lower competition for resources owing to better geometry.

Relative profitability

The highest gross returns of Rs. 7512 ha⁻¹ and net returns of Rs. 5844 ha⁻¹ accrued from alternate row intercropping system, followed by sole cropping, strip cropping, 2:1 (Pearl millet : Clusterbean) and mixed cropping (Table 2). The present study indicates that alternate row cropping is practicable from the point of view of mechanization, rotatability and crop diversity.

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