Intercropping in Traditional Farming Systems

*by N. S. Jodha**

Though largely neglected by researchers and planners, intercropping is a key element of traditional farming systems. Its superiority over sole cropping in several respects has been indicated by different studies. The present paper, based on farm level data for three years collected under ongoing village level studies programmes of ICRISAT, clearly reveals the following: (1) Intercropping is essentially a system of small and dry land farmers. Hence research resource allocation favouring intercropping can help serve equity goals. (2) Traditional intercropping is highly complex and diverse. It is designed to meet the farmer's multiple objectives simultaneously. Scientists cannot and need not generate equally complex systems. They can help by generating more and better options regarding various components of intercropping systems and leaving their selection to the farmer.

INTRODUCTION

The practice of intercropping or growing crops in mixture, through seed mixing or through various spatial arrangements involving row or strip alternations or patches of different crops in the same plot at a time, is one of the important features of traditional farming systems in the tropics [*Aiyer, 1949: 4–15; Mathur, 1963: 38–43; Collinson, 1972: 174–8; Norman, 1974: 3–21; Ruthenberg, 1974: 325-351; Jodha, 1977: 101–126*]. However, notwithstanding its vast coverage and the strong rationale behind it, intercropping has received scant attention from the standpoint of research, policy, and planning. National and international reports of agricultural statistics seldom include details about intercrops; plan documents do not contain programme for intercrops, even at development block level; agricultural growth models seldom recognize intercropping as one of the variables. Researchers engaged in technology

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generation for agriculture have for the most part shown indifference to intercropping and consequently all high-yielding varieties were developed largely as sole crops. Extension activity for spreading new technology generally places little emphasis on intercrops. One reason is perhaps a general lack of awareness about its spread and potential.

The limited documentary evidence on intercropping that is available at present suggests that intercropping gave higher and more dependable gross returns per hectare than did sole crops in the Vidarbha region of India [*Mathur, 1963: 38–43*] and northern Nigeria [*Norman, 1974: 3–21; Norman et al., 1978*]. It gave higher gross returns per unit of labour employed during labour scarcity periods in northern Nigeria. Intercropping was found to ensure greater as well as more evenly spread employment of labour in Vidarbha and northern Nigeria. Intercropping, besides effectively serving the self-provisioning requirements of subsistence farmers, played an important role as insurance against risk. Traditional intercropping systems were found to be characterised by great complexity and diversity as indicated by the numerous crop combinations that may be involved in a single village. As many as 230 different crop mixtures were identified in study villages of northern Nigeria [*Norman et al., 1978*]. More than a hundred crop combinations of mixed crops in Vidarbha region were reported [*Mathur 1973: 38–43*]. About 60 different combinations characterizing intercropping in a single village were also found in peninsular India [*Jodha, 1977: 101–126*].

In relation to the extent of its practice and its enormous complexity, the effort devoted to the study of intercropping is insignificant. No doubt diversity and complexity make its study extremely difficult. But it must be understood if we are to explain farmers' crop choices. This in turn can generate information directly usable to those engaged in generating and spreading new agricultural technology.

INTERCROPPING IN PENINSULAR INDIA

This paper discusses only a few dimensions of intercropping in six SAT (semi-arid tropical) villages – two in each of three agroclimatic zones in peninsular India – where ICRISAT has conducted village-level studies since May 1975. My presentation is based on the plotwise cropping pattern of sample farmers for three agricultural years – 1975 to 1978.[1] Important characteristics of the villages and the extent of intercropping therein are summarized in Table 1.

As shown in Table 1, intercropping varied from 18 to 83 per cent among the six villages, This variability is due to differences in agroclimatic and related conditions, notably the extent of post-rainy season cropping, of irrigation, and of HYVs, as well as of some crops like paddy, castor bean, etc., that are rarely grown as mixed crops: all of these inhibit intercropping, and showed (Tables 2 and 3) high, significant positive correlations with sole cropping in the six villages. Why is this?

Reducing the weather-induced instability of farming through irrigation reduces the need for intercropping as a crop diversification strategy

TABLE 1

EXTENT OF INTERCROPPING AND RELATED DETAILS IN SIX VILLAGES IN SAT INDIA[a]

Village	Rainfall: Annual average	Rainfall: Variability (C.V.)	Soil type	Situation on sample farms (3-year average)[b]: Gross cropped area/ha	Proportion of GCA having: Inter-cropping	Proportion of GCA having: Irrigation	Proportion of GCA having: HYVs[c]	Proportion of GCA having: Specific crops[d]	Net sown area planted in: Post-rainy season	Net sown area planted in: Rainy season
	(mm)	(%)			(%)	(%)	(%)	(%)	(%)	(%)
Kanzara (Akola Dist. Maharashtra)	820	27	Medium deep vertisols	6.5	72.7	4.9	15.6	1.5	1.7	94.7
Kinkheda (Akola Dist. Maharashtra)	820	27	Medium deep vertisols	6.6	83.1	3.8	6.6	1.8	3.1	91.2
Kalman (Sholapur Dist. Maharashtra)	690	29	Deep and medium deep vertisols	9.0	47.4	10.4	1.0	3.5	60.8	31.5
Shirapur (Sholapur Dist. Maharashtra)	690	29	Deep vertisols	6.7	17.6	13.3	0.2	6.7	67.5	21.2
Aurepalle (Mahbubnagar Dist. Andhra Pradesh)	710	28	Shallow and medium deep alfisols	4.5	34.9	21.0	11.7	53.5	5.2	80.7
Dokur (Mahbubnagar Dist. Andhra Pradesh)	710	28	Shallow and medium deep alfisols	3.2	20.9	60.1	43.9	49.8	18.1	69.2

[a] Based on the details from sample farms in six villages. Village level studies have been conducted in these villages since May 1975 [Jodha *et al.* 1977].

[b] Number of sample farm selected in May 1975 was 30 in each village.

[c] High Yielding Varieties of crops include mainly hybrid sorghum and cotton in Akola villages and HYV paddy in Mahbubnagar villages.

[d] Includes crops like sugarcane, paddy, and castor bean which are seldom grown as mixed crops. See Table 3.

TABLE 2

PROPORTIONS OF POST-RAINY SEASON NET SOWN AREA (NCA) GROSS IRRIGATED AREA, AND HIGH YIELDING VARIETIES (HYVS) AREA DEVOTED TO SOLE CROPPING IN SIX SAT VILLAGES IN INDIA DURING 1975–76 TO 1977–78[a]

	Proportions of sole cropping in the total of:		
Village	*Post-rainy season NCA*	*Gross irrigated area*	*HYVs area*
	(%)	(%)	(%)
Kanzara	98.9	100.0	76.7
Kinkheda	100.0	73.7	73.3
Kalman	64.7	83.4	61.4
Shirapur	78.9	90.1	100.0
Aurepalle	100.0	93.8	100.0
Dokur	98.7	99.6	100.0
Coefficient of correlation[b]	.791**	.913**	.864**

[a] See Table 1, note [a].
[b] Coefficients of correlation (r) between the sole cropping and the above factors were calculated by using individual farm data for the six villages put together.
** r values significant at 1 per cent level.

TABLE 4

PROPORTION OF IMPORTANT CROPS/CROP MIXTURES IN GROSS CROPPED AREA (GCA) IN SIX SAT VILLAGES IN INDIA DURING 1975–76 TO 1977–78[a]

Crops/ Crop mixtures	*Proportion of crops/crop mixtures[b] in GCA in villages*					
	Kanzara	*Kinkheda*	*Kalman*	*Shirapur*	*Aurepalle*	*Dokur*
	(%)	(%)	(%)	(%)	(%)	(%)
Sorghum[c]	9.0	2.3	38.1	42.7	4.0	6.3
Sorghum mixtures[c]	18.4	35.6	20.3	11.8	30.0	7.6
Wheat	2.7	3.4	1.4	2.4	0.1	0.4
Paddy	1.1	1.0	2.5	1.7	16.6	48.1
Other cereals	0.1	–	1.6	2.1	0.3	4.4
Pigeonpea	–	0.8	1.2	6.8	–	–
Pigeon mixtures	–	–	19.4	0.5	–	–
Chickpea	2.0	4.9	2.3	4.6	–	1.2
Other pulses	1.0	1.4	1.5	8.7	1.1	1.6
Groundnut	2.1	1.5	1.6	2.1	0.7	17.0
Groundnut mixtures	9.1	2.1	0.8	0.2	0.1	12.0
Castor bean/cotton[d]	7.7	2.3	–	–	33.2	–
Castor bean/cotton mixtures[d]	45.9	43.6	–	–	3.7	–
Other crops	0.8	0.6	2.4	10.3	8.1	0.6
Other mixtures	0.1	0.5	6.9	6.1	2.1	0.8

[a] See Table 1, note [a].
[b] The crop mixtures have been named after the prominent crop of the mixtures.
[c] Sorghum crop and its mixture in Kalman and Shirapur villages are post-rainy season crops.
[d] Castor bean and castor bean mixtures relate to Aurepalle village; cotton and cotton mixtures relate to Kanzara and Kinkheda villages.

TABLE 3

PROPORTION OF INDIVIDUAL CROP AREAS DEVOTED TO INTER-CROPPING IN SIX SAT VILLAGES IN INDIA DURING 1975–76 TO 1977–78[a]

Crops	Proportion of individual crop's area devoted to intercrops in village[b]: Kanzara	Kinkheda	Kalman	Shirapur	Aurepalle	Dokur	Coefficient of correlation[c]
	(%)	(%)	(%)	(%)	(%)	(%)	
Sorghum (HYV)	46.7	33.6	15.0	–	0.0	0.0	.321**
Sorghum (Local-K)[d]	96.4	99.4	–	–	88.4	41.4	.879**
Sorghum (Local-R)[e]	–	–	35.4	21.6	–	–	−.853**
Pearl millet (Local)	100.0	–	100.0	–	99.3	–	.931NS
Wheat (HYV)	0.0	3.7	0.0	0.0	0.0	–	−.901NS
Wheat (Local)	0.0	11.2	72.6	49.5	40.0	0.0	.537*
Paddy (HYV)	–	–	–	–	0.0	0.0	−1.00**
Paddy (Local)	62.2	63.2	35.3	4.1	0.0	0.0	−.911**
Maize (HYV)	–	–	26.1	–	–	–	.371NS
Maize (Local)	–	–	59.2	32.1	–	–	.572*
Cotton (HYV)	44.6	84.4	–	–	–	–	.241*
Cotton (Local)	91.1	94.6	–	–	–	–	.897**
Sugarcane	0.0	–	6.6	9.0	–	–	−.843**
Pigeonpea	100.0	98.7	94.6	23.2	100.0	100.0	.961**
Mungbean	93.2	94.2	97.2	85.4	–	–	.875**
Chickpea	29.2	5.3	68.2	26.9	–	0.0	.792**
Groundnut	81.8	61.8	41.0	8.8	13.3	41.4	.851**
Safflower	0.0	0.0	100.0	85.7	18.3	–	.632*
Castor bean	–	–	–	–	9.9	–	−.877**

[a] See Table 1, note [a].

[b] For calculating proportions, the area of the concerned crop grown as sole as well as all mixtures containing the concerned crop irrespective of its actual share in the mixture was considered.

[c] Coefficient of correlation (r) between total area of each crop and the share of this area under intercropping was calculated by using individual farm data for the six villages put together.

[d] Local-K = Local variety of (kharif) rainy season crop.

[e] Local-R = Local variety of (Rabi) post-rainy season crop.

* Significant at 5 per cent level. ** Significant at 1 per cent level.

against risk.[2] Unlike rainy season (*kharif*) cropping, post rainy season (*rabi*) planting begins with a known state of soil moisture, and hence the need for intercropping to adjust to eventual fluctuation in moisture becomes less important.[3] The HYVs, requiring higher input costs, do not fit well to the farmers' intercropping systems. The farmer does not want to divert costly inputs meant for HYVs by interplanting non-HYV crops with HYVs.[4] Moreover, till recently, very little research was done on different aspects of intercropping involving HYVs. The phenomenon of unwillingness to divert costly inputs to unwanted crops also prevents mixing other crops with high water-requiring, high payoff crops like paddy and sugarcane. Besides ,the lack of technical complementarity of crops like paddy, castor, and sugarcane with other crops (Table 4) reduced intercropping. On the other hand, the villages with more crops such as pigeonpea, groundnut, cotton, and rainy season sorghum (largely grown as intercrops: Tables 3 and 4) had more intercropping.

While regional characteristics (broadly represented by villages) determine the overall pattern of cropping, the actual cropping decisions within that pattern are influenced by farm characteristics. An individual farmer's propensity to intercrop is influenced by his resource base – including land size, soil type, irrigation, family labour, etc., – as well as his other decisions such as those related to crop rotation.[5] Some of these influences on intercropping are discussed in the next section.

INTERCROPPING AND FARM SIZE

An important phenomenon, related to the risk-minimising potential of intercropping, is popularity with small farmers who (unlike large farmers) have neither enough capacity to take risk, nor enough land to conveniently diversify cropping by putting different sole crops on several plots. Several non-risk factors also tend to make intercropping a small farmers' system. Most importantly, intercropping is labour-intensive; small farmers, with ample family labour, are well placed to handle it.[6] Furthermore, depending on the nature of component crops and spatial arrangements of planting, the field operations, particularly weeding and harvesting, in intercrops call for a greater carefulness and sense of discrimination by labour; usually family workers do better on such criteria than hired workers.

Secondly, because of considerable flexibility offered by greater possibility of staggered or phased operations associated with intercropping, the system matches much better with the small farmers' means. For instance, the staggering of sowing operations, leading to 'patch cultivation', and the selection of crop components suited to soil moisture conditions of respective periods of staggered operation, prove convenient to small farmers, who often do not have adequate draft power and other means for completing sowing in a single spell.

Similarly, weeding and harvesting operations of some of the intercropping systems require labour on a staggered and piece-meal basis which cannot ensure fuller and efficient use of hired labour. The casual, part time and even odd hourly (i.e. during usually non-working hours) deployment of family workers by small farmers can meet such specific labour demand without much difficulty.[7]

The popularity of intercropping with small farmers is amply demonstrated by Table 5. The Table further confirms the earlier results from peninsular India [*Jodha, 1977: 101–26*] and corn growing areas of Colombia [*Colmenares, 1975: 49–50*] indicating the decline in intercropping with increase in farm size. This was the case in all villages except in Dokur and Shirapur, where small farmers were better endowed than large farmers in terms of the factors (proportion of area irrigated, post-rainy season net cropped area), which positively discouraged intercropping. The proportion of intercropping was consistently higher on small farms during all three years. The small and large farm differences in the proportion of intercropping were found statistically significant at one per cent level of confidence.

TABLE 5

EXTENT OF INTERCROPPING AND RELATED DETAILS ON SMALL AND LARGE FARMS IN SIX SAT VILLAGES IN INDIA DURING 1975–76 TO 1977–78[a]

Village	*Farm size groups*	*Proportion of gross cropped area devoted to intercropping***				*3-year average*	
		1975–76[d]	*1976–77*	*1977–78*	*Average*	*Irrigated area*[b]	*Post-rainy season cropping*[c]
	(Ha)	(%)	(%)	(%)	(%)	(%)	(%)
Kanzara							
Small	0.21–2.25	83.1	85.6	92.6	87.3	6.1	1.8
Large	> 5.60	68.6	65.6	75.2	69.7	5.4	1.6
Kinkheda							
Small	0.21–3.00	92.0	79.2	100.0	90.7	4.4	2.1
Large	> 5.60	79.6	78.4	85.4	91.8	4.6	2.7
Kalman							
Small	0.21–6.00	65.6	44.1	67.1	59.5	7.1	65.8
Large	> 10.75	34.5	41.0	46.5	41.1	10.7	58.6
Shirapur							
Small	0.21–2.50	3.1	14.1	15.7	11.2	21.9	77.1
Large	> 6.00	16.7	20.7	19.0	19.0	10.4	70.5
Aurepalle							
Small	0.21–2.50	49.3	27.4	57.2	44.4	4.5	5.4
Large	> 5.25	44.1	25.4	26.2	33.7	25.2	6.6
Dokur							
Small	0.21–1.00	12.3	0.0	0.0	5.1	74.0	7.9
Large	> 3.00	20.2	21.4	22.1	21.2	59.0	18.8

[a] See Table 1, note [a].

[b] Gross irrigated areas as proportion of gross cropped area.

[c] Net area sown during post-rainy season as proportion of total net sown area.

[d] The figures indicating proportion of intercropping on small and large farms differ slightly from those indicated by preliminary analysis [Jodha 1977] due to recategorization of farm size groups. See Ghodake and Asokan [1978].

** The small and large farms differences in the extent of intercropping were found to be statistically significant at one per cent level. Also see Table 2.

This result has an important implication. To the extent intercropping is largely a small farmers' system, any breakthrough in intercropping technology will benefit less endowed farmers more than relatively better endowed farmers. In the face of recent developments where HYV-based new technologies have tended to strongly favour better endowed farmers and areas, this offers an important opportunity of explicitly incorporating equity considerations in agricultural research strategy by allocating greater resources to intercropping research.[8]

As revealed by experimentation work, intercropping research in its broader sense includes screening of different crops and varieties for intercropping; performance evaluation of different crop combinations using different planting times, plant populations, spatial arrangements of crops, applications and rates of application of various inputs, methods of controlling pests, disease and weeds and finally to assess the relevance of the experimental results to the farmers' realities.[9]

TRADITIONAL INTERCROPPING SYSTEMS

As mentioned earlier, complexity and diversity is another important feature of a traditional intercropping system. This can be seen in the spatial arrangements, number of component crops and type of crop combinations characterizing the intercropping.

Regarding spatial arrangements, broadly three methods of intercropping were observed in the study areas. They are row or strip alternation, seed mixing and patch cultivation.[10] Though in varying degrees all the three methods were followed in all villages, row or strip alternation was the predominant form of intercropping in Akola and Mahbubnagar villages. Sholapur villages had a higher extent of patch cultivation. Seed mixing was the least popular method. It is difficult to determine the relative superiority of any method. While the well-known advantages of intercropping, e.g., risk minimisation, spread of labour requirement peaks, fuller exploitation of environment through interplanting crops of different maturity periods, are offered by all the three methods, each of them has some specific advantages, which induce farmers to adopt each of them in varying degrees.

For instance row or strip alternation, besides facilitating better monitoring of labour use, can (depending upon component crops) ensure benefits associated with micro-wind breaks (shelter belts). Patch cultivation on the other hand, offers better facility in terms of adjustment to early or mid-season vagaries of weather as well as the intra-plot variations in factors affecting crop suitability. Furthermore, to the extent patch cultivation is associated with staggering the planting operation, it aids those who do not have adequate resources for planting the plot at a stretch.

Seed mixing usually helps intercropping which involves a large number of crops as well as several small seeded crops. It is done on plots characterised by low fertility and poor moisture retention capacity. Seed mixing is also practised on plots usually nearer the homesteads and containing minor component crops like vegetables for mid-season self-provisioning and cash flow.

The diversity and complexity in terms of number of component crops in intercropping is partly illustrated by Table 6. Accordingly, the number of sole crops grown in six villages ranged from 17 (in Dokur) to 44 (in Shirapur), but the number of crop combinations used for intercropping exceeded the number of sole crops in most of the villages. Within intercrops, two-crop mixtures (i.e., intercropping of only two crops) were

TABLE 6

NUMBER OF SOLE CROPS, CROP COMBINATIONS IN CROP MIXTURES, AND THEIR (%) SHARE IN GROSS CROPPED AREA IN SIX SAT VILLAGES IN INDIA DURING 1975–76 TO 1977–78[a]

		Intercrops with mixture of				
Village	*Sole crop*	*2 crop*	*3 crop*	*4 crop*	*5–8 crops*	*Total*
	(no)	(no)	(no)	(no)	(no)	(no)
Kanzara	22 (27.5)[b]	17 (25.8)	13 (23.8)	11 (18.8)	4 (4.1)	67 (100.0)
Kinkheda	19 (16.9)	15 (23.8)	14 (41.2)	11 (17.3)	1 (0.8)	60 (100.0)
Kalman	34 (52.7)	40 (24.6)	28 (14.7)	13 (6.3)	3 (1.7)	118 (100.0)
Shirapur	44 (82.4)	23 (15.2)	3 (1.6)	1 (0.8)	–	71 (100.0)
Aurepalle	21 (64.3)	4 (5.5)	2 (9.8)	1 (1.5)	10 (18.9)	38 (100.0)
Dokur	17 (79.3)	4 (5.3)	3 (2.1)	2 (6.8)	1 (6.5)	27 (100.0)

[a] See Table 1, note [a].
[b] Figures in parentheses indicate the percentage share of crop/crop combination in gross cropped area during the 3-year period.

popular in most villages but mixtures (intercropping systems) involving five to eight crops were not uncommon. The proportion of gross cropped area occupied by two-crop mixtures ranged from more than 5 to about 26 per cent of gross cropped area in these villages. The corresponding proportions of three and four crop mixtures ranged from 2 to 41 per cent and 2 to 19 per cent, respectively. Of course, measured by their share in gross cropped area, the most important mixtures (identified by number and not type of crops involved) were different in different villages. Furthermore, in terms of seed rates and distribution of rows of different crops in the mixtures, no uniform pattern was found to prevail in all the villages. However, intercropping by mixing seeds (as against putting different rows of different crops) was not very common except in the case of minor components of the mixtures.

The inter-village differences (Table 6) could be further elaborated with the help of details in Tables 3, 4, providing additional information on cropping patterns in six villages. Cotton-dominated mixtures followed by sorghum-dominated mixtures were prominent in villages of Akola District (Table 4.)[11] In the remaining villages (except Dokur), sorghum-dominated mixtures were most important. In Dokur, groundnut-led mixtures were dominant. As reflected in Table 3, the bulk of the pigeon-peas, pearl millet, mungbean, and safflower were grown as mixed crops in most of the villages; but being subsidiary crops of the mixtures, they do not figure explicitly in most villages in Table 4.

The complexity of traditional intercropping as discussed above is partly an outcome of farmers' informal experimentation with crops which satisfy their requirements and also fit the agricultural environment of the region. In developing countries, the farmer is engaged in agriculture with multiple objectives. Since a single crop or a group of crops similar in their physiological, economic and other characteristics has a comparative advantage in satisfying a specific objective, the farmer with multiple objectives likes to grow several crops during the season. For instance his profitability objective can be satisfied best with high value cash crops like cotton and groundnuts while his subsistence requirements are best served by sorghum, pigeonpea, etc. While the maintenance of soil fertility is best achieved by leguminous crops, fodder requirements of farmers' animals are served better by crops like sorghum and pearl millet having enough crop by-products. Similarly, while trying to maximize crop output, a farmer has to guard against possible mid-season droughts. Crops like pigeonpeas with greater drought resistance and sorghum having salvage value (i.e., in the event of crop failure, at least fodder is available) satisfy his security requirements better.

The objectives of easing labour bottlenecks and lengthening gainful employment for family labour could be achieved by raising crops with distinctly different maturity periods (e.g., sorghum and pigeonpeas). The growing of such crops also helps to lengthen the farmer's period of liquidity, which usually coincides with post-harvest cash in-flows. Problems of patches of salinity, depression, gravelly infertile soils within the plots, as well as those created by mid-season weather vagaries or the staggering of patches of salinity, depression, gravelly infertile soils within the plots, suit the situation.

Most of the farmer's objectives can be achieved by diversification of cropping. The crop diversification in turn could be achieved by splitting the available land into several plots/sub-plots and planting them with different sole crops or by putting the land (with or without sub-plotting) under several crops raised as intercrops. Considerable seasonal splitting of operational holdings for crop planting was observed in the six villages.[12] However, in different villages 48 to 63 per cent of the newly created sub-plots were put under intercrops and 37 to 52 per cent under sole crops. Furthermore in the case of between 28 to 42 per cent of new sub-plots in different villages, the sub-plot had the same crop or inter-crop as the parent plot. The plot splitting in such cases was done largely as an attempt towards intra-farm rationing of scarce inputs such as irrigation, fertilizer, manure or draft power for summer ploughing, which would not have sufficed for the whole plot. This suggests that plot splitting was an important means of crop diversification, but this was attempted without minimising the importance of intercropping.[13] On the contrary, plot splitting was used for the extension of crop diversification through intercropping. This sort of clear preference for intercropping to achieve crop diversification and related objectives, which could also be met through sole cropping of different crops, could be explained in terms of advantages which are specifically associated with intercropping. To repeat, these advantages stem from the intercropping systems' potential for risk minimisation; their capacity to ensure fuller utilisation of environment affecting crop growth; technical complementarities of different crops when planted together; and depending upon the component crops and their density the impact of intercropping on incidence of weeds, conservation of moisture, regulation of light and wind effects, etc.[14] The farmers' practical awareness of some of these factors is reflected through their decisions about crop combinations used in intercropping. The crop combinations or crop mixtures classified under six categories are discussed below. A brief description of six categories is as follows:

A – *Special situation*:

This covers mixtures or crop combinations involving crops planted in order to use patches of problem-soils (saline soils, depression, etc.) within the plot. Combining paddy crop with sorghum or pigeonpea is one illustration of such mixtures. This category of crop mixture is intended to satisfy the objective of adjusting crops to features of the land-resource base. Patch cultivation resulting from staggered planting or mid-season corrections also falls under this category.

B – Self provisioning:

This category covers mixtures involving crops like seasonal vegetables, tobacco, fibre crops, and (in some cases) minor millets, pulses, and oilseeds, raised mostly for 'self provisioning requirements' of the family. Their insignificance is indicated by a very low seeding rate when compared with the seeding rate of other component crops of the mixture in a plot. Most of these crops – especially vegetables – are seldom harvested systematically. Leaves and fruits are picked up if and when need arises and time permits. These crops are different from other subsistence crops (e.g. sorghum, pigeonpea, etc.) raised as major components of mixtures.

C – Different maturity periods:

This category covers mixtures involving crops with different growth periods facilitating an even spread of peak period labour requirement and a lengthening of the farmer's liquidity period. Crops under this category help fuller utilisation of the environment because of technical complementarity between these crops. Combining sorghum or pearl millet with pigeonpeas is one example.

D – Drought-sensitive and drought-resistant crops:

This category covers mixtures involving drought-resistant and drought-sensitive or less drought-resistant crops such as pearl millet and groundnut or pigeonpea and cotton sown to guard at least partially against drought risk.

E – Cash crop – food crop:

This category covers mixtures involving crops conventionally described as cash crops and food-grain crops. Groundnut and pearl millet, or cotton and sorghum, or castor bean and pigeonpea are examples of this mixture designed to satisfy both profitability and subsistence requirements.

F – Legume – non-legume:

This category covers mixtures involving legume and non-legume crops to maintain soil fertility without sacrificing non-legume crops and also fulfil crop rotation requirements. Mungbean-sorghum mixture is an example.

It should be noted that the above categories of crop mixtures are not mutually exclusive. The proportions of mixtures qualifying for the above categories in different villages are presented in Table 7. Accordingly, the extent of intercropping (category A) induced by need for adjustment to features of the land-resource base or to mid-season contingencies

TABLE 7

PROPORTIONS OF DIFFERENT CATEGORIES OF CROP MIXTURES IN THE TOTAL AREA OF INTER-CROPPING IN SIX VILLAGES IN SAT INDIA (AVERAGE OF 1975–76 TO 1977–78[a]

Crop-mixture categories[b]	*Proportion of different categories of crop mixtures in total area of intercropping in*					
	Kanzara	*Kinkheda*	*Kalman*	*Shirapur*	*Aurepalle*	*Dokur*
	(%)	(%)	(%)	(%)	(%)	(%)
A. Special situation	2.1	3.4	15.4	12.2	2.6	1.8
B. Self provisioning	9.4	11.2	18.4	14.1	35.9	28.7
C. Different maturity periods	58.1	83.9	46.1	32.4	71.1	79.0
D. Drought sensitive – drought resistant	71.9	80.6	17.7[c]	24.6	12.5[c]	40.5
E. Cash crop – food crop	72.7	59.2	44.2	60.6	53.2	50.3
F. Legume – Non-legume	87.5	77.2	58.5	39.8[d]	84.4	37.7[d]

[a] See Table 1, note [a].
[b] The crop-mixture categories are not mutually exclusive. For the basis of crop-mixture categorization, see text.
[c] Bulk of the other mixtures consisted of only drought-resistant crops.
[d] Bulk of the other mixtures consisted of only legumes.

through patch cultivation was important only in Kalman and Shirapur villages. These villages belong to the region having the highest extent of heterogeneity of resource base created by types of soils, bunding, and very erratic rainfall in two phases. Staggered planting was also important in these villages. Intercropping induced by 'self-provisioning requirements' i.e., category B (different from subsistence requirements), ranged from 9 to 36 per cent of the total area under intercrops.[15]

Crop mixtures under category C, involving crops with different maturity periods accounted for 32 to 83 per cent of acreage under intercrops in different villages. However, in predominantly post-rainy season cropping villages, the proportion of crop mixtures of category C was relatively low as the cropping season did not offer enough scope for crops with vastly different maturity periods. Lack of mixtures of category C in post-rainy season crops influenced the overall proportion of these mixtures in both Kalman and Shirapur.

The lower extent of mixture category D (involving drought-resistant and less drought-resistant crops) in the above two villages was also partly due to the impact of post-rainy season intercrops. Crops in this season are grown on the basis of moisture stored in deep Vertisols and one does not have to plan crop mixtures that will guard against the impact of likely drought. Mixing of different drought-resistant crops only, also reduced extent of mixture category D in Kalman and Aurepalle villages. Intercropping induced by need for combining legume and non-legume crops was also very substantial in most of the villages, as revealed by crop-mixture categories E and F (Table 7).

While the analysis of data to quantify the extent to which a farmer could actually achieve his goals through six categories of crop mixtures is still in progress,[16] the above picture convincingly demonstrates that the traditional intercropping system is complex and varied because it embodies a conscious and rational attempt by the farmer to adjust his cropping pattern to his needs and his resource base. However, a close look at traditional intercropping raises an important question. Can one generate new intercropping technology which can satisfy the multiple goals of the farmers? The honest answer is 'no'. In the first place it is not possible for researchers to clearly perceive the diverse and multiple objectives of the farmer in raising intercrops. Secondly, even if the objectives are clearly understood, their incorporation into research strategy is more difficult, notwithstanding the availability of multi-location and multi-season trial facilities.

Indeed it could be argued that it is not necessary that scientists generate an intercropping system as complicated and diversified as witnessed in traditional agriculture. The best strategy lies in generating more and better options in terms of the variables that constitute the intercropping system and leaving their selection to the individual farmer. These variables are adopted crops or varieties, crop combinations, spatial arrangements or crop geometry and also the level and timings of different inputs used. With the available advanced knowledge about the genetics, physiology and agronomy of crops as well as about land and water management, it may not be difficult to multiply the options about various components of intercropping. In any case, new options in intercropping should be evaluated with reference to farmers' multiple objectives in doing intercropping *before* they are offered to the farmers.

CONCLUSION

Though neglected by both researches and agricultural planners, intercropping is an important feature of traditional farming systems. It embodies the traditional wisdom of the farmer as it relates to his crop decisions. The available documented evidence shows the superiority of intercropping over sole cropping in terms of gross returns per hectare as well as per man day used during the labour scarce period of the crop season. Intercropping ensures greater and more even distribution of employment of labour.

The present paper has highlighted two important features of the traditional intercropping system which have significant research and policy implications. Firstly, intercropping is less important on large farms and on irrigated farms compared to small farms and rain-fed farms respectively. Thus, any breakthrough in intercropping technology will help the poorly endowed farmers more than the well endowed farmers. Furthermore, due to its higher labour intensive nature, such technology will have favourable effects for agricultural labour. This suggests an important opportunity to incorporate an equity-bias in research resource allocation, by increasing funds for intercropping research.

Secondly, the traditional intercropping system is highly complex and diverse as indicated by spatial arrangements, number of crops and crop combinations involved. This is in order to satisfy the farmer's multiple objectives simultaneously. Researchers cannot and need not try to generate equally complex new intercropping systems. They should concentrate on generating more and better options related to the different variables that constitute the intercropping system. Modern scientific knowledge can help in this process. However, to make the prospective new options relevant to the farmer's conditions, they should be evaluated with reference to his multiple objectives in effecting intercropping.

NOTES

1. For methodology and other details of ICRISAT Village Level Studies see *Jodha et al.* (1977).
2. However it may be noted that, though very important, risk aversion may not be the sole reason behind crop diversification. Need for adjustment to the diversity in the land resource base, and efficient utilisation of fixed factors of production, e.g., family labour also induce crop diversification [Roumasset, 1976: 232–235]. The role of these factors in intercropping is discussed later.
3. Staggering or phasing of sowing operations which usually gives rise to intercropping through patch cultivation is also one of the strategies against risk. However in the case of irrigated cropping as well as post-rainy season cropping this strategy is not required.

4. The difficulty of incorporating HYVs into intercropping system could be one of the factors responsible for limited spread of HYVs in the areas as well as farming groups (i.e., small farmers) where intercropping gets higher priority (see Table 5). This strongly suggests the need for screening HYVs for their suitability in main inter-crops used by farmers.
5. Various aspects of crop rotation based on plot-use history for four years in the case of sample farmers in six villages have been discussed in a separate paper being prepared by the present author.
6. To provide quantitative evidence in this respect cropwise labour use data of ICRISAT village level studies are yet being processed. However, in northern Nigeria it was found that intercropping required 62% more labour than sole cropping. But the difference was reduced to 29% when labour scarcity peaks were considered [Baker and Norman 1975: 334–361].
7. Even large farmers are not precluded from reaping the aforementioned advantages of intercropping. But since the system favours those who have oversupply of family labour and deficiency of other resources the small farmer usually having such resource endowments stands to benefit more from intercropping.
8. There is yet another implication of the above result. To the extent intercropping complicates the business of proper monitoring, reporting and recording crop yields, this may give rise to a possibility of under reporting of yields particularly of subsidiary crops. If this reasoning is sound then crop yields on small farms (who have higher proportion of intercropping) get under reported. (I am thankful to JDS reviewer of this paper for suggesting this point.)
9. For details see various papers in [Monyo, *et al.* 1979], [ICRISAT, 1979], [IRRI, 1977].
10. Patch cultivation involving small patches of different crops in the same plot may not be called intercropping in the conventional sense of the term. However, functionally it serves the same purpose as intercropping; and the area of individual patch is too small to permit meaningful separate monitoring of input-output details even by the farmer. Therefore farmers themselves treat it as a form of intercropping. Both because of shape/size of the patch and purpose behind it the patch cultivation is different from systematically splitting or sub-dividing of the plot to raise different crops. For the present study the patches smaller than 0.05 hectares were treated as indicator of patch cultivation.
11. Mathur [1963: 38–43] also reported the similar phenomena for that region.
12. The per farm average number of fragments determined by physical and/or property boundaries ranged from 2.3 to 7.4 in different villages. The average number of plots/sub-plots in different villages resulting from splitting of holding for crop planting ranged from 4.8 to 14.2 per farm. For understandable reasons the number of plots/sub-plots was smaller on small farms compared to large farms in all the villages.
13. Further examination of the individual farm data on intercropping *vis à vis* fragmentation and plot splitting (which may facilitate crop diversification even without intercropping), revealed the following: The value obtained of coefficient of correlation between number of fragments and extent of intercropping was $r = -0.202$ and was found statistically insignificant. The comparison of extent of intercropping on 36 pairs of farms having equal land but a different number of sub-plots (including those with zero sub-plots) also failed to give any clear cut picture about impact of plot splitting on intercropping.
14. For experimental evidence on some of these technical aspects of intercropping see Willey [1978], ICRISAT [1978], Moody [1977: 281–293].
15. The highest extent of intercropping of Category B in Aurepalle and Dokur was partly due to the ritual that every farmer should plant nine crops in at least one of his plots. This practice known as Nava Dhanyam (nine grains) is guided by a belief that it is duty of every farmer to preserve the germplasm, which nature has provided. This practice – prevalent in several parts of the country – is now fast disappearing due to more and more specialized farming.

16. The biggest problem faced in such analysis is that of decomposing the mixture and judging the contribution of each component of the mixture in fulfilling different objectives.

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