Southeast Asian Studies, Vol. 19, No. 2, September 1981

Traditional Cropping Systems of Small Farmers in the Central and Southern Deccan Plateau Area*

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Introduction

The farming system in the central and southern Deccan Plateau area is characterized by cultivation of millets and pulses as the major crops. This system is one of three major agricultural systems in India. The other two are wheat cultivation in northwest India and wet rice cultivation in the Ganga basin area. The crops cultivated in the Deccan system include *jowar* (*Sorghum bicolor*), *bajra* (*Pennisetum typhoideum*), and *tur* (*Cajanus cajan*) in the states of Andhra Pradesh and Maharashtra, and *ragi* (*Eleusine coracana*), *tur* and *avare* (*Dolichos lablab*) in Karnataka State. This millet-pulse system is more subsistence-oriented than the other two systems mentioned above, and hence considered to be less productive. The improvement of this form of farming poses a major problem for Indian agriculture.

It can generally be said that the traditional farming system should be modernized to develop Indian agriculture. However, realization of this is not so simple. For instance, introduction of high-yielding varieties and other high-cost technology has been attempted, but it was found that the necessary pre-conditions existed only in limited areas. This was especially true in the case of wet rice cultivation [Farmer 1979: 316]. Attempts to replace the traditional system with a modern one modelled on a foreign system have not always proved successful. Rather, a more widely adoptable, though less significant, improvement of the existing systems should be aimed at as an alternative approach to agricultural development. The latter approach would be possible given a thorough understanding of the traditional technology. *Ragi* cultivation in Karnataka State is a good example [Ohji 1979: 27]. This highly intensive and elaborate farm practice should be thoroughly re-evaluated rather than simply replaced with so-called "modern" farming.

With this view in mind, a study of the traditional cropping systems of small farmers in central and southern India was carried out. The field survey was conducted from October to December in 1979.[1)]

* Some of the data in this paper were presented at the 170th Meeting of The Crop Science Society of Japan, Sept. 1980.

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1) This survey was conducted by a Grant-in-Aid for Overseas Scientific Survey from the Ministry of Education, the Government of Japan in the fiscal year 1979.

Outline of the Survey Area

The following three areas were surveyed: Mahbubnagar District in Andhra Pradesh State, Sholapur District in Maharashtra State, and Bangalore District in Karnataka State. One to six sample villages were chosen in each area: two (Aurepalle and Dokur) in the first, one (Shirapur) in the second, and six (Allalasandra, Thippagondanahalli, Dodderi, Padarhalli, Chennamanahalli, and Kodugurki) in the third area. The locations of the areas and the villages except Shirapur are shown in Figures 1 and 2, respectively. Shirapur is located approximately 13 miles northwest of Sholapur.

All the villages are situated on the Deccan Plateau. The elevation is approximately 500 m at Aurepalle, 430 m at Dokur and 500 m at Shirapur. The villages in Bangalore District are at elevations from 700 m to 1,000 m. As shown in Figure 2, all three areas are characterized by undulating plateau topography, consisting of gently sloping hills and arborescent river valleys which dissect the plain. Most of these rivers dry up in the dry season. Reservoirs are constructed on these rivers for irrigation, and they collect water during the rainy season. Figure 2 shows that this type of irrigation is used in Dokur and northern Bangalore District. The soils vary from one village to another: from deep red Alfisols in Aurepalle through medium Alfisols in Dokur, to medium-deep Vertisols in Shirapur [Jodha *et al.* 1977: 3]. In

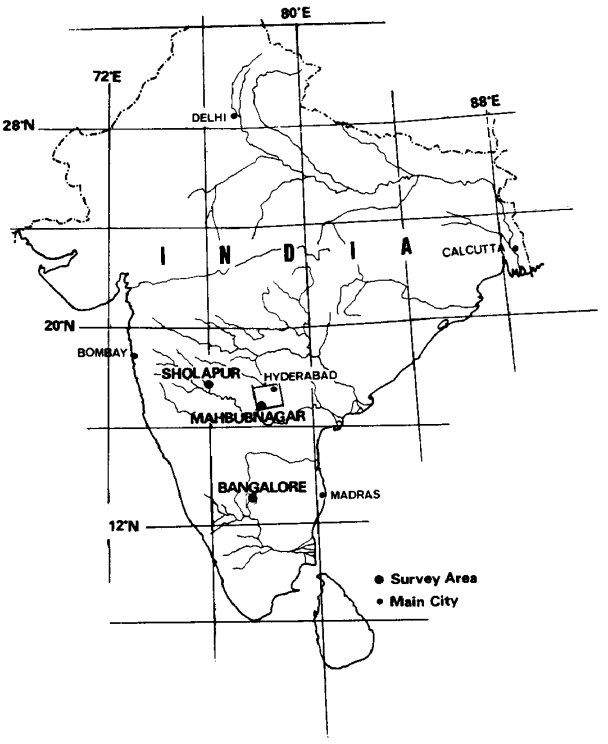


Fig. 1 Survey Areas

Bangalore District, red sandy soil is found in Padarhalli and Chennamanahalli, while red loamy soil is found in the others [Min. of Education and Youth Service 1972: Plate 8].

Seasonal precipitation data for Sholapur, Mahbubnagar and Bangalore are shown in Figure 3 [Virmani *et al.* 1978: 30, 94, 120]. As shown in Figure 3, the annual precipitation is about 800 mm at all three locations, with most of it falling between May and October. Thus, the survey areas are characterized by a semi-arid monsoon climate. The year-to-year variation in precipitation is also great. For instance, the annual precipitation in Aurepalle and Dokur was 522 mm and 759 mm in 1977, while it was 1,010 mm and 945 mm, respectively, in

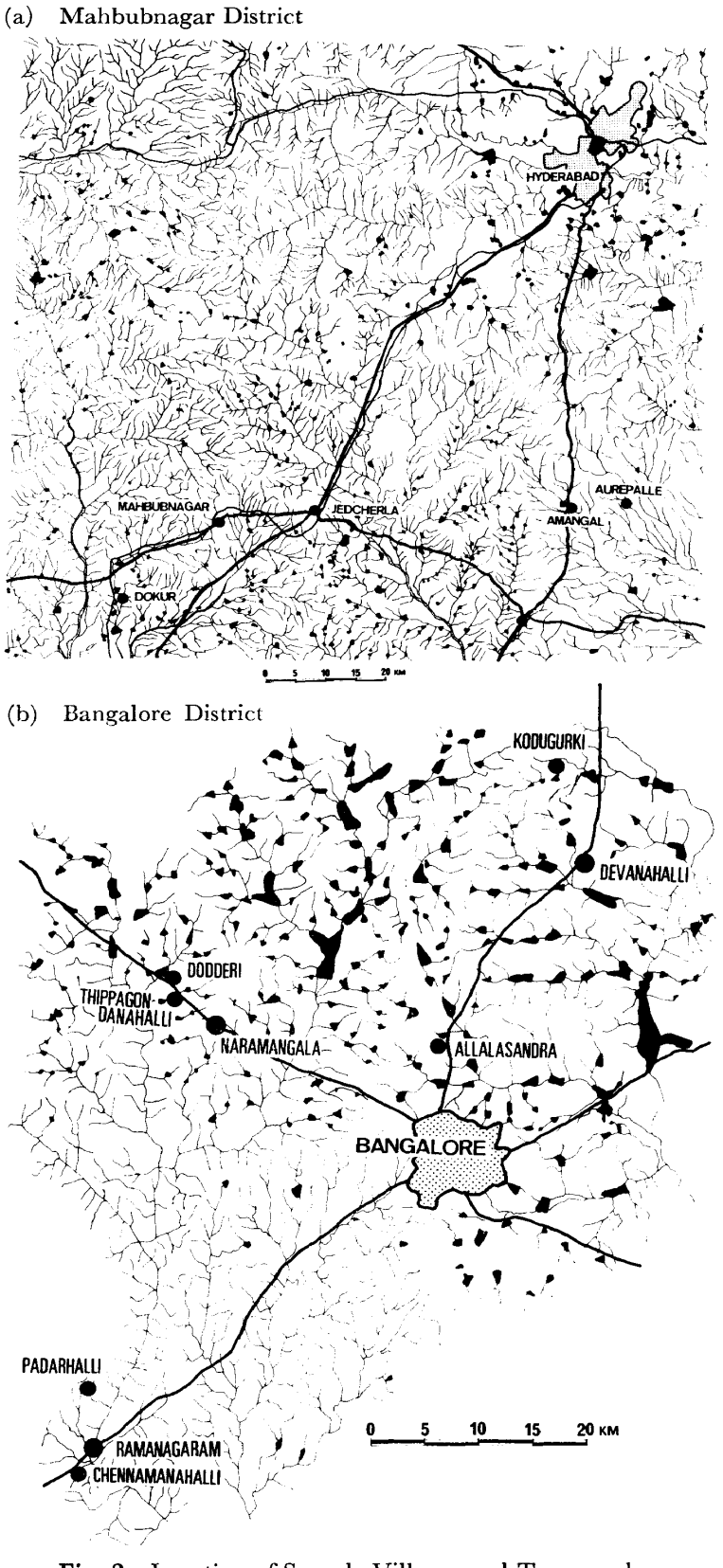


Fig. 2 Location of Sample Villages and Topography of the Survey Area

1978.[2] Such rainfall conditions clearly determine the cropping calendar in the area; i. e., there are the *Kharif* crop (rainy season crop) and the *Rabi* crop (dry season crop). The former is grown in the major crop season using the rainfall during the monsoon, which extends from May or June until October. The latter is cultivated from October to February or March.

The water balance was calculated for Bangalore by Thornthwait's method (Table 1). It shows that surplus water in the soil occurs only during the three months between September and November, while the soil suffers from a deficiency in moisture during the remaining nine months. Under such conditions, choosing crops resistant to drought and maintaining soil moisture become mandatory. Crops that require abundant water for their growth, e.g., groundnuts or wet rice, cannot be grown without irrigation.

2) According to the data collected in village-level studies by Economics Program, ICRISAT.

Table 1 Estimated Water Balance in Soil, Bangalore, Karnataka State[1)]

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
Temp. (°C)	21.0	23.1	25.7	27.3	26.9	24.3	23.2	23.3	23.3	23.2	21.8	20.5	23.6
PET[2)](mm)	117	130	166	158	157	127	116	114	109	105	98	103	1,500
RF (mm)	6	7	8	52	102	56	104	111	151	168	50	11	826
Dif. (mm)	−111	−123	−158	−106	−55	−71	−12	−3	42	63	−48	−92	−674
SMS (mm)	0	0	0	0	0	0	0	0	42	100	52	0	—
WS (mm)	0	0	0	0	0	0	0	0	0	5	0	0	5
WD (mm)	−111	−123	−158	−106	−55	−71	−12	−3	0	0	0	−40	−679

Notes 1) Calculated according to the Thornthwait's formula.
2) PET: Potential Evapotranspiration, RF: Rainfall, SMS: Soil Moisture Status, WS: Water Surplus, WD: Water Deficiency

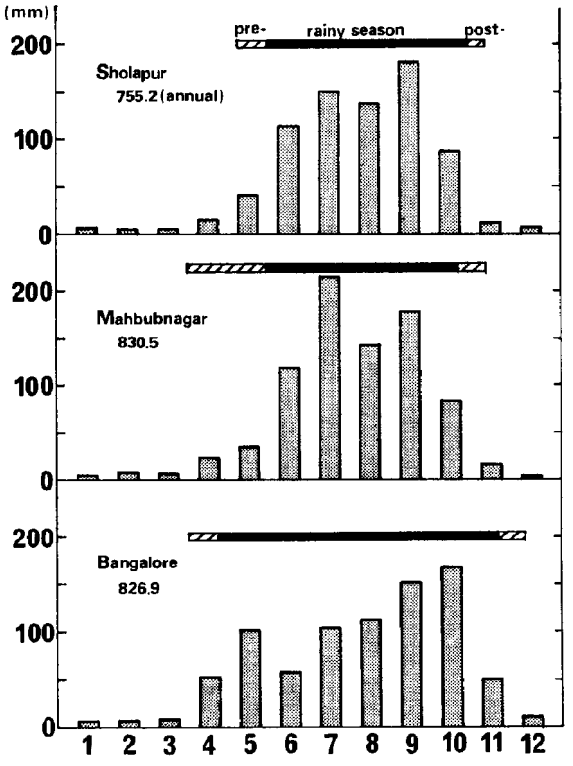


Fig. 3 Amount and Distribution of Rainfall and the Period of the Rainy Season at Three Locations in the Survey Area

Selection of Sample Villages and Method of Survey

The three villages of Andhra Pradesh and Maharashtra States are among the sample villages of the village-level studies of the Economics Program of ICRISAT (International Crops Research Institute for Semi-Arid Tropics), which have been carried out for several years. These particular villages were selected so that we could investigate different cropping systems corresponding to different soil conditions. The six villages in Bangalore District were selected on consultation with the Division of Extension of the University of Agricultural Science (Hebbal). Since similar cropping systems are practiced in most of the villages surrounding Bangalore, many villages, rather than many farmers in one village, were investigated.

The investigation was carried out by interviewing the farmers and observing the fields. Emphasis was placed on the farming practices of small farmers with little capital investment, since they would presumably practice a more traditional and subsistence-oriented cropping system. The questionnaire used in interviewing them appears at the end of this report as

Table 2 Size and Kinds of Operational Landholding and the Number of Main Plots of Individual Respondents in the Sample Villages

Name of Village and Respondent	Operational Landholding (ha)			No. of Main Plot	Acreage of Each Main Plot (ha)					No. of Family Members
	Non-irrigable	Irrigable	Total		A	B	C	D	E	
1. Aurepalle vil.										
A. Weerayya	2.12	—	2.12	1	2.12	—	—	—	—	11 (1)
N. Seenayya	2.63	—	2.63	1	2.63	—	—	—	—	3 (-)
K. Nagoji	1.01	1.62	2.63	2	1.42	1.21	—	—	—	11 (9)
C. Ramayya (78/79)	0.40	—	0.40	2	0.36	0.04	—	—	—	7 (4)
C. Ramayya (79/80)	0.81	—	0.81	3	0.36	0.04	0.41	—	—	
C. Guravayya	1.82	—	1.82	2	1.21	0.61	—	—	—	6 (4)
P. Chinnayya	0.81	—	0.81	1	0.81	—	—	—	—	6 (2)
A. Lingayya	1.42	—	1.42	1	1.42	—	—	—	—	8 (5)
2. Dokur vil.										
M. Kondanna	—	0.91	0.91	3	0.30	0.41	0.20	—	—	4 (4)
J. Sayanna	0.40	0.51	0.91	2	0.40	0.51	—	—	—	5 (3)
J. Karrenna	0.10	0.20	0.30	2	0.10	0.20	—	—	—	7 (1)
A. Linga Reddy	0.41	1.21	1.62	1	1.62	—	—	—	—	—
J. Tammanna	2.33	0.10	2.43	2	2.33	0.10	—	—	—	—
3. Shirapur vil.										
S. P. Patil	5.26	—	5.26	2	4.45	0.81	—	—	—	7 (1)
R. K. Pandhara	1.21	—	1.21	1	1.21	—	—	—	—	5 (2)
P. D. Kolakar	1.42	—	1.42	1	1.42	—	—	—	—	5 (2)
D. A. Roman	8.09	—	8.09	3	4.05	1.21	2.83	—	—	8 (2)
S. K. Takmoge	1.82	—	1.82	1	1.82	—	—	—	—	3 (2)
4. Allalasandra vil.										
Krishnappa	0.61	0.61	1.22	2	0.61	0.61	—	—	—	10 (5)
Krishna Reddy	1.54	0.12	1.66	2	1.54	0.12	—	—	—	13 (8)
Muniswamyppa	1.21	—	1.21	3	0.61	0.40	0.20	—	—	11 (2)
5. Thippagondanahalli vil.										
Siddappa	4.05	—	4.05	5	0.81	0.40	0.30	1.22	1.32	10 (2)
Rangappa Patel	1.82	0.20	2.02	5	0.20	0.81	0.40	0.40	0.20	5 (2)
6. Dodderi vil.										
Sattar Sahib	0.40	—	0.40	1	0.40	—	—	—	—	2 (2)
Paramashiviah	1.06	0.15	1.21	2	0.15	1.06	—	—	—	8 (2)
7. Padarhalli vil.										
Siddaiah	0.81	—	0.81	1	0.81	—	—	—	—	2 (2)
Meddaiah	0.81	—	0.81	1	0.81	—	—	—	—	10 (4)
Puttaswamingowda	1.42	0.20	1.62	2	0.20	1.42	—	—	—	7 (2)
Hanumaboviah	1.62	—	1.62	2	0.81	0.81	—	—	—	10 (6)
8. Chennamanahalli vil.										
K. Nagaiah	0.56	0.16	0.72	2	0.16	0.56	—	—	—	7 (2)
9. Kodugurki vil.										
K. Venkatappa	6.07	4.05	10.12	4	3.24	0.81	4.05	2.02	—	23(11)
R. Narayanswami	0.81	0.81	1.62	2	0.81	0.81	—	—	—	4 (2)

Note) The figures in parentheses indicate nos. of family members able to work.

an appendix.

Two items were investigated during the course of the field studies. One was the sequence of crops and farm operations as practiced by individual farmers; the other was the mixed cropping system. The study of the former requires a very precise record of the actual consecutive crop sequence for a particular field plot [Binswanger and Jodha 1978: 22–28]. With this in mind, when interviewing the farmers, special attention was paid to which particular plot the respondent was talking about.

The number of farmers interviewed in one village ranged from a minimum of one in Chennamanahalli to a maximum of seven in Aurepalle. The operational landholding size,[3] and the number and size of the main plots of each farmer interviewed are shown in Table 2. As stated previously, small farmers were of major interest in this study, but a few medium farmers were also included. In Kodugurki village, Bangalore District, a large farmer possessing about 10 ha of operational land was interviewed, but the results of this interview were omitted in the subsequent study. According to Jodha [1977: 108], the average operational landholding of small farmers is 0.8 ha in Aurepalle, 0.6 ha in Dokur, and 1.4 ha in Shirapur village, while that of the medium farmers is 2.3 ha, 1.7 ha, and 4.5 ha, respectively. Therefore, the farm size of the respondents in this study ranges from that of the average small-sized farm to smaller-than-average medium-sized farms.

3) Operational landholding size is defined as the area of owned land, minus the area leased or sharefarmed to someone else, plus the area leased or sharefarmed from someone else [Jodha *et al.* 1977: 10].

Land-use Pattern

The operational landholdings of the sample farmers were averaged for each village and are summarized in Table 3. The figures for the six villages in Bangalore District, Karnataka State, were averaged together instead of individually, since the number of sample farmers in each village was small, and no significant difference was found among them. Table 3 shows that non-irrigable land is the largest portion of the operational land in all villages, although the operational land of Dokur village in Mahbubnagar District is nearly equally divided into irrigable and non-irrigable land. Apart from the average operational landholding in Shirapur village which exceeds three ha, the averages are between 1.2 and 1.7 ha for the other villages.

The averages of land-use intensity (the proportion of the net sown area to the operational land area) range from 54 percent to 98 percent (Table 3). The relatively low intensity in Shirapur indicates that about one fourth of the total operational land lay fallow during both of the agricultural years under investigation. The lowest land-use intensity was recorded in Dokur in 1978/79, although in 79/80 Dokur was far from the lowest. Considering that there is a much

Table 3 Average Size of Operational Landholding, Land-use Intensity and Cropping Intensity (Average by Village of Sample Farmers)

Village	No. of Farmers	Agric. Year	Operational Landholding			Net Sown Area	Gross Cropped Area	Land-use[1] Intensity	Cropping[2] Intensity
			Non-irrigable	Irrigable	Total				
			(ha)	(ha)	(ha)	(ha)	(ha)	(%)	(%)
Aurepalle	(7)	78/79	1.46	0.23	1.69	1.60	1.60	95	100
		79/80	1.52	0.23	1.75	1.60	1.60	91	100
Dokur	(5)	78/79	0.65	0.58	1.23	0.67	0.91	54	136
		79/80	0.65	0.58	1.23	1.11	1.35	90	122
Shirapur	(5)	78/79	3.56	0	3.56	2.53	2.81	71	111
		79/80	3.56	0	3.56	2.63	2.63	74	100
Average of the Six Villages in Bangalore District	(13)	78/79	1.29	0.14	1.43	1.40	1.46	98	104
		79/80	1.29	0.14	1.43	1.40	1.44	98	103

Notes 1) Land-use Intensity=Net Sown Area/Total Operational Landholding
2) Cropping Intensity=Gross Cropped Area/Net Sown Area

greater area of irrigable land in Dokur than in any other village studied, this may be somewhat puzzling, but it was because a relatively large main plot happened to lay fallow during 1978/79. The intensity was nearly 100 percent in the villages of Karnataka State, indicating that most parts of the operational land were used for growing some crop at least once a year. Furthermore, the proportion of gross cropped area to net sown area, or the cropping intensity, is highest in Dokur. This can be explained by the high percentage of the irrigable land in this village [Jodha 1979: 2].

Table 4 shows the kind of crops cultivated, and the percentage of the total operational area planted with them in each village. The dominant crops are *jowar* (mixed-cropped) and castor bean in Aurepalle, wet rice and groundnuts in Dokur, *jowar* (sole-cropped) in the *Rabi* season in Shirapur, and *ragi* (mixed-cropped) in the villages of Bangalore District. In Dokur, where the irrigable land area is large, there is relatively extensive cultivation of wet rice and groundnuts. However, these are rare in the other areas, where rain-fed cultivation of millets is the basic form of agriculture. A characteristic feature in Shirapur is the cultivation of *jowar* as a *Rabi* crop. Furthermore, this *Rabi* crop is the main crop in Shirapur, while the *Kharif* crop is always the principal crop in the other villages. This is due to the heavy, clayey deep-black soil in Shirapur, which makes the land preparation for the *Kharif* crop impossible after a heavy rainfall during the early monsoon.

Table 5 shows the proportion of cropped and fallow areas to the total operational land area in each village for the different crop seasons. The cropped area is further

Table 4 Kinds and Acreage of Principal Crops in the *Kharif* and *Rabi* Seasons[1] (Average by Village of Sample Farmers)

Crop Season	Crops	Aurepalle		Dokur		Shirapur		Average of the Six Villages in Bangalore District	
		78/79	79/80	78/79	79/80	78/79	79/80	78/79	79/80
Kharif	Wet Rice	—	—	29.5	27.9	0.4	—	5.8	5.9
	Jowar (Mixed)	52.7	5.0	1.6	—	—	—	—	—
	Jowar (Sole)	—	3.3	6.5	—	—	—	—	—
	Ragi (Mixed)	—	—	—	—	—	—	80.9	77.9
	Groundnuts (Mixed)	—	—	—	44.2	1.1	—	—	—
	Groundnuts (Sole)	—	—	11.5	11.5	—	—	—	—
	Pulses[2]	—	4.9	—	—	8.6	—	6.5	5.5
	Castor Bean	28.2	74.3	—	—	—	—	—	—
Rabi	Wet Rice	—	—	4.9	4.9	—	—	0.9	—
	Jowar (Sole)	—	—	—	—	64.8	60.9	2.2	2.2
	Groundnuts	13.7	6.6	19.6	19.6	—	—	—	—

Notes 1) Figures indicate the percentage of cropped area to the total area of operational land of sample farmers.
2) Including green gram, black gram, horsegram, etc.

Table 5 Relative Acreage of Sole Cropping, Mixed Cropping and Fallowing in the Sample Villages in Different Seasons of 78/79 and 79/80[1] (Average by Village of Sample Farmers)

Village	78/79						79/80					
	Kharif			*Rabi*			*Kharif*			*Rabi*		
	Sol.[2]	Mix.	Fal.	Sol.	Mix.	Fal.	Sol.	Mix.	Fal.	Sol.	Mix.	Fal.
Aurepalle	12.8	68.1	19.1	13.7	0	86.3	37.9	49.6	12.5	6.6	0	93.4
Dokur	47.5	1.6	50.9	24.5	0	75.5	41.0	44.2	14.8	24.5	0	75.5
Shirapur	3.4	6.8	89.8	68.7	0	31.3	0	0	100	77.2	0	22.8
Allalasandra	17.8	82.2	0	0	0	100	22.7	77.3	0	0	0	100
Thippagondanahalli	4.0	89.4	6.6	0	0	100	4.0	89.4	6.6	0	0	100
Dodderi	24.8	75.2	0	0	0	100	34.8	65.2	0	0	0	100
Padarhalli	24.9	75.1	0	4.1	0	95.9	33.3	66.7	0	4.1	0	95.9
Chennamanahalli	22.2	77.8	0	22.2	0	77.8	36.4	63.6	0	0	0	100
Kodugurki	33.1	66.9	0	33.1	0	66.9	49.6	50.4	0	33.1	0	66.9

Notes 1) The figures indicate the percentage of the respective areas to the total area of operational land of sample farmers.
2) Sol. : Sole cropping, Mix. : Mixed cropping or intercropping, Fal. : Fallowing

divided into mixed- and sole-cropped areas. It can be seen that mixed cropping was more common than sole cropping in Aurepalle and the Bangalore District villages in both years. The area used for the mixed cropping in Dokur was smaller in the 78/79 agricultural year than in the following year. This was because a single large field plot lay fallow in the first year, as mentioned previously.

The areas used for mixed and sole cropping were about the same in 79/80. In Shirapur village, where the *Rabi* crop is the main crop, mixed cropping is not common at all except in a limited area used during the *Kharif* season in 78/79. It should be noted that mixed cropping is not practiced during the *Rabi* season in any village.

The percentage of fallow land area in Aurepalle was 19 and 13 percent in the *Kharif* seasons, and 86 and 93 percent in the *Rabi* seasons of 78/79 and 79/80, respectively. Fallowing in the *Rabi* season is due to the absence of rainfall and irrigation facilities. The natural replenishment of soil fertility during the fallow period is one of the reasons for fallowing in the *Kharif* season. However, there are also economic factors such as inability to purchase seeds and fertilizer or to hire laborers. The land-use pattern of Aurepalle, i.e., extensive cropping in the *Kharif* and fallowing in the *Rabi* season, is also practiced in the villages of Bangalore District. In Dokur village, the percentage of land left fallow in the *Rabi* season was exactly the same in both years, i.e., 75.5 percent. This reflects the high percentage of irrigable land in this village, as well as completely different land-use patterns in the irrigable and non-irrigable fields. Fallowing in Shirapur during the *Kharif* season is due solely to the particular soil conditions in this village. Heavy rainfall during the early monsoon makes the soil so muddy that cultivation is impossible. Thus, cultivation is concentrated in the *Rabi* season, utilizing moisture accumulated in the soil during the rainy season.

To summarize this section, the most basic and traditional farming system in the surveyed area is rain-fed agriculture using mixed cropping of millets and several other crops. However, there is diversity in crop sequence, intensity of cropping, and crop season among the villages in the area. This is the result of adaptation to the local conditions, among which soil condition and irrigability are particularly significant.

Mixed Cropping as a Traditional Cropping System

As described in the previous section, mixed cropping is the traditional cropping pattern adopted in non-irrigable fields during the *Kharif* season. The details of mixed cropping differ from one village to another, depending on the different main crops in each village. These different cropping patterns and their agronomical significance will be discussed here. As mentioned previously, the case of Shirapur will be omitted from the following discussion, because of the insignificant area devoted to mixed cropping.

The crop combination and the area used for mixed cropping by the individual farmers in Aurepalle, Dokur, and the Bangalore District villages in 78/79 and 79/80 are shown in Table 6. Two out of five sample farmers practiced mixed cropping in Dokur. This ratio is much lower than that in the other

Table 6 Kinds of Crop Combination in the Mixed Cropping System

Village	No. of Crops Combined	Crop Combination	No. of Field Plots	Area in Ha	Proportion to Total Mixed-cropped Area
Aurepalle	2	C+P	1	1.01	7.2
	3	C+P+CP, C+P+Me	2	2.43	17.2
	4	C+P+CP+Me	2	2.22	15.7
	5	J+B+P+CP+Cu	4	2.99	21.2
		C+P+CP+Cu+Me			
	6	J+B+P+CP+G+Me	2	1.02	7.2
		J+B+P+CP+G+Cu			
	7	J+B+P+CP+G+Cu+Me	2	1.82	12.9
	8	J+B+P+CP+G+Cu+Me+SH	1	2.62	18.6
		Total	14	14.11	100
Dokur	3	J+P+CP, GN+P+CP	2	0.50	17.7
	4	GN+P+CP+Me	1	2.33	82.3
		Total	3	2.83	100
The Six Villages in Bangalor District	3	R+J+A	11	6.32	21.4
	4	R+J+A+NS	2	3.08	10.5
	5	R+J+P+A+Mu, R+J+P+A+CP	4	1.95	6.6
	6	R+J+P+A+CP+C	16	10.84	36.8
	7	R+J+P+A+CP+C+NS	8	7.28	24.7
		Total	41	29.47	100

Note) J: *jowar* (*Sorghum bicolor*), B: *bajra* (*Pennisetum typhoideum*), P: pigeonpea (*Cajanus cajan*), CP: cowpea (*Vigna sinensis*), C: castor bean (*Ricinus communis*), Me: *mesta* (*Hibiscus cannabinus*), Cu: melon (*Cucumis melo*), G: green gram (*Phaseolus aureus*), SH: sunnhemp (*Crotalaria juncea*), GN: groundnuts (*Arachis hypogea*), R: *ragi* (*Eleusine coracana*), A: *avare* (*Dolichos lablab*), Mu: mustard (*Brassica* spp.), NS: niger seed (*Guizotia abyssinica*)

Plate 1 Mixed cropping of *jowar*, *tur*, fox-tail millet and others, Anantapur, Andhra Pradesh State

Plate 2 Mixed cropping of *ragi* and *akkadi* (intra-row mixed cropping of *jowar*, *tur*, *avare* and others) crops, Naramangala, Karnataka State

villages in Table 6. The number of crops which form a combination appears to be related to the popularity of mixed cropping in the vicinity; i.e., only a few kinds of crops are mixed in Dokur, while as many as eight different crops are mixed in the other villages.

The principal crop or crops in the mixed cropping system vary from one village to another. The most common combination was *jowar*+*tur*, or castor bean+*tur* in Aurepalle. In Dokur, groundnuts were the principal crop. *Ragi* was the most important crop in the Bangalore District villages, with *jowar* and pulses such as *tur* and *avare* mixed in occasionally.

The pattern of mixed cropping and the spacial arrangement of different crops within a community differs according to the different crop combinations. In the case of the combination of *jowar*, *tur* and others which is most common in Aurepalle, *tur* is grown in rows with four to six meter intervals. Between these rows of *tur* are several rows of many different crops, including *jowar* and others. Thus, as shown in Figure 4(a), a large number of crops can be accommodated in the same row of *jowar*. However, in the Bangalore District villages where *ragi* is the main crop in the mixed cropping system, the other crops are not grown in the community of *ragi*; rather, the other crops, such as *jowar* and pulses, are combined to constitute rows of their own called *akkadi*. These are arranged between the *ragi* community, with intervals of several meters. Thus, the patterns of mixed cropping in the two areas are quite different, as shown in Figure 4 and Plates 1 and 2. The pattern in Dokur, where groundnuts are the principal crop, is similar to that of the Bangalore District villages.

Tall cereals like *jowar* and *bajra* have comparatively large seeds and few tillers, and early growth is vigorous, while short-stem cereals like *ragi* have relatively small seeds and many tillers, and early growth is slow. The different growth characteristics of the main cereal crops in the combinations seem to determine the different patterns of mixed-cropped community. During the course of the survey trip, various types of mixed cropping were observed. They included the combinations in which the principal crop was *kodora* (*Paspalum scrobiculatum*) or fox-tail millet (*Setaria italica*). It is interesting to note that the pattern of mixed cropping in both cases was very similar to that of *ragi* shown in Figure 4(b). This can also be attrib-

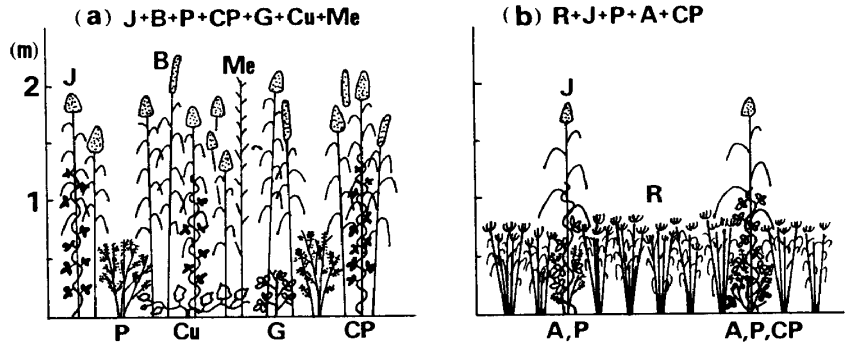


Fig. 4 Spatial Arrangement in Mixed-cropped Community (Abbreviation: the same as those in Table 6)

uted to the similarity in growth characteristics among these three crops.

From an agronomical viewpoint, the advantages of mixed cropping can be summarized as follows. First, the land is used effectively. As shown in Figure 4(a), for example, the space is multilayered, and the upper layer is occupied effectively by tall crops like *jowar*, *bajra* and *mesta* (*Hibiscus cannabinus*), while the lower one is occupied by short crops like *tur* and *mung* (*Phaseolus aureus*), and even by creeping crops like melon (*Cucumis melo*). Furthermore, vine crops such as *lobia* (*Vigna sinensis*) are able to coil up the stems of the tall crops, thus utilizing all possible space above the ground. The same could be said for the cultivation of mixed *ragi* in the Bangalore District villages.

The second advantage of mixed cropping is the effective use of time. For example, let us consider the case of *jowar*+*tur*+*lobia*. All these crops are sown at the same time in June but harvested separately. *Jowar* matures earliest. Its panicle is harvested in October, but the stem is left standing until the *lobia* twining around it is harvested. After the harvesting of *lobia* at the end of November, the stem of *jowar* is cut and used for fodder. At this point the *tur* starts to grow vigorously and fills out into the open space. This is harvested in February. Thus, the characteristics of *tur*, i.e., long growth period and drought tolerance, are successfully incorporated into the system to maximize the use of time and space. Such combinations of crops with different growth periods bring about the same result as multiple cropping of sole crops, in terms of productivity per unit area and unit time. This is the ingenuity of the mixed cropping system.

The third advantage of mixed cropping is that it can avoid or minimize the damage which might be caused by nutritional or water deficiency. This becomes possible by combining crops with different nutritional requirements and drought tolerance. The principal combination, which was observed in all the villages surveyed, was that of leguminous and non-leguminous crops. This is probably the product of the farmers' empirical knowledge of the effectiveness of such combinations.

Besides the agronomical advantages of mixed cropping, there are also economic advantages to small farmers. The mixed cropping with many crops observed in Aurepalle and Bangalore District seems to be an effective means for small farmers to maintain self-subsistence. Castor bean is an important commercial crop. If only the cash income from this crop were considered, the crop would be cultivated without being mixed with other crops. Such purely commercialized cultivation of castor bean is common in more advanced localities, where irrigation is possible. To the small, subsistence-oriented farmers, however, food crops for self-support are as important as the cash crops. Therefore, the mixed cropping of castor bean with some food crops is more advantageous to small farmers than the sole cropping of castor bean.

While mixed cropping has the advantages mentioned above, it may have some disadvantages, too. One possible disadvantage is a complicated working procedure which may adversely affect labor productivity. According to observations made in the villages surveyed, the procedure was certainly complicated, but at the same time very systematic. There are a variety of farm tools nicely designed to suit each step. The tools used for tilling, sowing and intertilling in the mixed *ragi* cultivation in Bangalore District are particularly noteworthy [Ohji 1979: 11–19]. They enable the user to act smoothly in order to attain great efficiency. In this sense, the work efficiency of the mixed cropping system appears to be not necessarily inferior to the mechanized farming systems.

Crop Sequence and Rotation System

The discussions in this section deal with the crop sequence during one rotational cycle, which may be as long as several years. Although the interviews were mainly concerned with the farming practices in the 78/79 and 79/80 agricultural years, some additional information was also collected for the preceding years. It is summarized in Table 7. The crop sequences representative of each village are shown in the table by order of the rate of crop accumulation. The rate of crop accumulation means the ratio of the number of crops to the number of years in one rotational cycle, in other words, it indicates the cropping intensity during one cycle of a crop sequence. If three crops are grown in two years, for example, the rate is 3/2 and the cropping intensity is 150 percent in the crop sequence.

Double cropping (the rate of crop accumulation being 2/1) is seen in Aurepalle, Dokur and the Bangalore District villages. It is always practiced in the irrigable rather than rain-fed areas of the respective villages, though sometimes only one crop is grown, either wet rice or groundnuts. In the rain-fed fields, one crop per year (the rate of crop accumulation being 1/1, 2/2, 3/3..., etc.) is the most common type. Such rain-fed single cropping includes the following two cases: a crop is grown in the *Kharif* season followed by the *Rabi* fallowing, and vice versa. The former is common in Aurepalle and the Bangalore District villages, while the latter is common in Shirapur, as mentioned previously.

The most common crop sequences in Aurepalle are the mixed *jowar* and mixed or sole castor bean systems. In one case, both crops alternate every year, while in another mixed *jowar* is cultivated for two successive years followed by castor bean grown for one year. As mentioned previously, these sequences which involve commercial and subsistence crops seem to be advantageous to small farmers with little capital. In Aurepalle, there are cases in which the rate of crop accumulation is either 2/3, 1/2, or 1/3. This means that there is at least a whole year of fallowing during one rotational cycle. Lack of rainfall may be the cause of involuntary

Table 7 Crop Sequence and Crop Accumulation Rate in Various Rotation Systems in the Sample Villages

Village	Crop Accum. Rate	Crop Sequence	Prop. to Total Operational Landholding
Aurepalle	2/1	(C-GN)	6.6*
		(J-GN)	3.3*
	3/3	Jmix-Jmix-C	3.3
		Jmix-C-C	23.3
	2/2	Jmix-C	37.6
	1/1	Jmix	5.0
		GN	3.3*
	2/3	Jmix-C-F	0.9
	1/2	Jmix-F, C-F	7.0
	1/3	Jmix-F-F	4.9
Dokur	2/1	(Pd-Pd)	4.9*
		(Pd-GN)	3.2*
		(GN-GN)	11.5*
	3/3	J-GN-R	6.5
	2/2	Jmix-GNmix	37.8
	1/1	Pd	18.2*
		GN	4.9*
	1/2	Pd-F	4.9*
Shirapur	3/2	J-(Pul. mix-J)	1.2
	2/2	J-Pul. mix	4.3
		J-Pul.	8.3
		J-W	0.6
		(Pul.mix-W)-F	1.2
	1/1	J	55.8
The Six Villages in Bangalore District	2/1	(R-J)	2.2*
	5/5	Rmix-Rmix-Rmix-Rmix-GN	1.1
	4/4	Rmix-Rmix-Rmix-GN(or HG)	4.4
	3/3	Rmix-Rmix-GN(or HG)	4.6
	2/2	Rmix-HG	1.1
		Pd-R	0.8*
	1/1	Pd	5.0*
		Rmix	70.2

Note) C: castor bean (*Ricinus communis*), F: fallowing, G: groundnuts (*Arachis hypogea*), HG: horsegram (*Dolichos uniflorus*), J: *jowar* (*Sorghum bicolor*), Pd: rice (*Oryza sativa*), Pul.: pulse crops, R: *ragi* (*Eleusine coracana*), W: wheat (*Triticum* spp.) *: rotation system with irrigation, mix: mixed cropping or intercropping, underline: the *Rabi* crops

fallowing, but in most cases the land is left fallow regularly in order to re-fertilize the soil.

Growing a single crop each year is common in rain-fed fields in Dokur also. Again, both cash crops and subsistence crops such as groundnuts and mixed *jowar*, respectively, are incorporated in order to suit the household economy of small farmers. The mixed cropping system alone can accommodate a variety of crops. By rotating two mixed cropping systems, as seen in Dokur, a great many kinds of crops can be produced.

The most widely practiced crop sequence in Shirapur is the annual cropping of sole *jowar* in the *Rabi* season. This is followed by the rotation of both sole *jowar* and pulses in the *Rabi* season. It is not known whether this type of annual cropping can be sustained over a long time span. We suspect that pulses may be grown only once in a while.

In the rain-fed fields of the Bangalore District villages, it is most common to grow a single crop of mixed *ragi* year after year. Less common are those types in which groundnuts or *kulthi* (*Dolichos uniflorus*) are rotated with mixed *ragi* every few years. Thus, rain-fed farming of this area is characterized by the predominance of this cropping system, and the annual cropping of the same principal crop, i.e., *ragi*. This suggests that mixed cropping may have a favorable effect on maintaining soil fertility, so that the same cereal crop can be grown annually without fallowing or rotating with other crops. If this is the case, it could be said that mixed cropping has an effect similar to inundation, which makes the continuous cropping of rice plants possible, in wet rice cultivation.

These various types of crop sequences in rain-fed fields, along with the mixed cropping system mentioned in the previous section, seem to form extremely practical rotation systems. They are based on the empirical wisdom of small farmers, and under the harsh conditions of little rainfall and meager capital they serve to maintain the fertility of the soil, diversify the risk in times of disaster, and enable self-subsistence.

Concluding Remarks

The traditional cropping systems practiced by small farmers in the semi-arid region of central and southern India were described and discussed. They are characterized by mixed cropping and numerous different crop sequences in crop rotation.

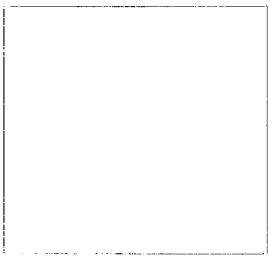
In evaluating these systems, it should always be kept in mind that the region receives only 700–800 mm of annual rainfall and the year-to-year variation is notoriously great. With this in mind, examination of the traditional systems reveals the efficiency with which the local farmers have adapted their way of farming to the physical and economic conditions under which they live. Their ingenuity, even sophistication, is particularly obvious in the choice of crops under various circumstances.

The future course of agricultural development should be sought within the framework of the traditional system. Recent efforts for varietal improvement, aimed at creating new varieties suited to mixed cropping, follow this line of thinking. The authors believe that similar approaches should be attempted in other aspects of agricultural technology, as well.

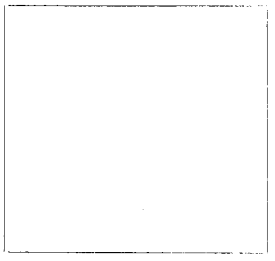
Appendix: Questionnaires to Farmers

1. Crop Sequence Research
   (1) Name of the village
   (2) Name of the respondent
   (3) How many acres is your total operational landholding?
      (3)-2 How many acres of irrigable area do you have?
      (3)-3 What is the soil type of your fields?
   (4) How many main-field plots do you have?
   (5) Write down your crop arrangement in each plot for the *Kharif* and *Rabi* crops in 78/79 and 79/80 on this note.

78/79 *Kharif* *Rabi*



79/80 *Kharif* *Rabi*



(6) Give the cultivation schedule of each crop in each main plot.
  (a) Timing of tillage, sowing, weeding, fertilizer application, harvesting, etc.
  (b) Amount of seeds, fertilizer, and yield.
(7) Remarks

2. Cropping Pattern Research
(1) Name of the respondent
(2) Field plot No.
(3) Crop season
(4) Crop combination (e.g., inter-row mixed, intra-row mixed, entirely mixed, or patch?)
(5) Patterns of sowing or planting
  (a) What is the distance between rows of mixed crops?
  (b) What is the height of plant canopy of the mixed-cropped community several months after sowing and at the harvesting time?
(6) Cultivation schedule of each crop
(7) What kinds of farm tools or instruments are used for intercropping or mixed cropping?
(8) Other questions
  (a) Why do you practice the intercropping system?
  (b) Why don't you grow those crops as pure stands?
  (c) What benefits do you get by intercropping?
  (d) If you had a greater acreage, would you practice the same cropping as you are now doing?

Acknowledgement

We would like to express our deepest gratitude to Dr. L. D. Swindale, Director of ICRISAT, and Dr. J. S. Kanwar, Acting Director of ICRISAT, for their thoughtful advice and help to our research program. We are also deeply grateful to Dr. K. Krishnamurthy, Director of Research, University of Agricultural Science (GKVK), and Dr. K. R. Kulkarni, UAS (Hebbal) for their thoughtful aid in arranging the field survey.

Village-level studies would have been impossible without assistance from the Economics Program of ICRISAT and from the Division of Extension of UAS (Hebbal). We would especially like to thank Drs. M. von Oppen and V. S. Doherty of ICRISAT for their kind guidance and arrangements. We owe a debt of gratitude to Mr. V. Bhaskar Rao and Mr. T. Balaramaiah of ICRISAT who helped us in the field study in Andhra Pradesh and Maharashtra States and to Drs. M. B. Channe Gowda and M. V. Kulkarni of UAS who did the same in Karnataka State. The data presented in this report were collected and translated with their cooperation. We also thank many persons in the villages, whose names cannot be mentioned here, for their kind help.

This report owes much to critical direction and constructive suggestions from Dr. Hayao Fukui, to whom deep appreciation is expressed.

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