Chapter 10
Crop Diversification Through Oilseeds in Eastern India

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10.1 Introduction

Among the countries in global oilseed economy, India ranks fourth, next to USA, China and Brazil in terms of vegetable oils (Rao 2008). In India, oilseeds represent the second largest agricultural commodity after food grains in terms of area, production and value (Reddy and Suresh 2009). However, the contribution of the country to the global oilseed production is still very low, which is mainly attributed to the extremely low productivity of different oilseed crops. This could be due to the fact that energy-rich crops are generally grown under energy-starved conditions. In fact, most of the oilseeds are raised on marginal and sub-marginal lands unlike cereals grown mostly under fertile soils with assured irrigation facilities. Besides, nearly 76 % of oilseeds area in the country is rainfed, which is often subjected to vagaries of monsoon (Hegde 2005b). This sort of disparity along with uneven distribution of irrigated area has made oilseed cultivation less productive and risky. Though the country made a record production of oilseeds (27.98 million t) during 2005–2006, it had to import a substantial amount of vegetable oils, thereby draining out a huge amount of its foreign exchange for purchasing vegetable oils in the world market. In this backdrop, there is a formidable challenge to increase oilseed production in order to feed the burgeoning population along with the maintenance of soil health in the long run (Bhowmick et al. 2006), especially in eastern India occupying about

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M. Ghosh et al. (eds.), *Diversification of Agriculture in Eastern India,*
India Studies in Business and Economics, DOI 10.1007/978-81-322-1997-2_10

28 % of country's total geographical area (Zaman 2012). The eastern region of the country is most backward in terms of per capita income, agricultural growth and infrastructure development. The yield levels are low because of the uncertain production environment and poor adoption of improved varieties and technologies. Overall, the region was food-based concentrating largely on rice, with little diversification. The humid atmosphere and high rainfall makes cultivation of rice more favourable in this region, which, however, has also gradually been emerging as an oilseed producing region with cultivation of crops like rapeseed-mustard, groundnut, sesame and soybean (Joshi 2005).

Considering economic viability, food and nutritional security, and long-term sustainability, particularly in the fast changing global scenario, it is, therefore, essential to achieve self-sufficiency in oilseed production of the country. This warrants immediate corrective steps to be taken towards diversification through oilseeds in traditional crops and cropping systems.

10.2 Conceptualizing Crop Diversification

Diversification is defined as diverting a sizeable acreage from the existing crop system to some other alternate crops, cropping systems or farm enterprises while maintaining a general equilibrium of meeting the needs for food, fodder, fibre and fuel, and while simultaneously taking care of basic soil health and productivity of agro-ecosystem of the area at large (Kalra 1990; Gautam and Sharma 2004). Thus, it is a strategy of shifting from less profitable to more profitable crops; changing of varieties and cropping systems; increasing exports and competitiveness in both domestic and international markets; protecting the environment; and making conditions favourable for combining different enterprises (Gautam and Sharma 2004).

Crop diversification is one of the major components of diversification in agriculture. It is an important tool for achieving the objectives of food security, nutrition security, income growth, poverty alleviation, employment generation, judicious use of natural resources, sustainable agricultural development and environmental and ecological improvement (Gautam and Sharma 2004; Sarkar 2005). The current thinking of diversification in the contemporary agriculture has, therefore, arisen so as to make it sustainable and profitable besides adding insurance against the disease outbreaks/insect epidemics/weed resurgence and socio-economic advantages. In addition, it is important to ensure that crop intensification goes together with crop diversification. If intensification enhances the productivity, diversification adds strength to the farmer in terms of sustainability (Siddiq 1999; Ali and Kumar 2002; Ali 2004). However, crop diversification in India is generally viewed as a shift from traditionally grown less remunerative crops to more remunerative crops (Reddy and Suresh 2009).

10.3 Need for Diversification in Cereals and Cereal-Based Cropping Systems

Among the cereal crops, rice is the most important and staple food crop for more than two-thirds of the Indians (Mishra 2005). It is cultivated in 44.8 million hectares (m ha) area in the country, of which eastern India, comprising Assam, West Bengal, Orissa, Jharkhand, eastern Uttar Pradesh and Chhatisgarh, accounts for 27.8 m ha (62 % of total rice area), contributing only 49 % of the total rice production. Based on the hydrology and topography of the land, rice area is divided into different ecologies: rainfed (uplands and lowlands), irrigated and hill rice. In all, 73 % of total rice growing area in eastern India is rainfed (20 % in upland and 53 % in lowland). The rainfed upland agro-ecosystem comprises of the soils poor in fertility and with low moisture retention capacity. The net economic return from this ecosystem also fluctuates from year to year due to vagaries of the southwest monsoon and traditional cropping system, dominated by rice. In such a situation, crop diversification and rice substitution with comparatively low water requiring crops like oilseeds may prove as an effective means to improve sustainability and rain water utilization efficiency, and in turn, productivity of watershed (Mahapatra 2002). The rainfed lowlands, where nutrient status and moisture availability is enough, may support, if managed properly, short-duration oilseeds for double cropping (Ali and Mishra 2002). On the other hand, rainfall being erratic and uncertain, expansion of oilseed area under irrigation is crucial for effective changes in cropping pattern, and adoption of profitable crops and technologies in the production systems to minimize risks considerably (Rai 2002).

Unfortunately, most of the high productivity systems are cereal-based, having high resource demand and continuously practiced in major parts of the country (i.e. rice-wheat in Indo-Gangetic plains (IGPs), rice-rice in coastal and high rainfall areas, and coarse-cereal-based systems in low rainfall areas) over the decades (Gangwar and Prasad 2005). Sustainability of these exhaustive systems is threatened owing to the emerging second generation problems viz. decline in factor productivity; depletion of soil fertility due to over-mining of native nutrient reserve; decline in fertilizer use efficiency and soil organic matter content; emergence of macro- and micro-nutrient deficiencies; lowering or rising of water table; water quality deterioration in coastal areas; soil degradation; increasing problems of salinity–alkalinity; resurgence of diseases, insects, and weeds; environmental pollution/degradation; formation of hardpan; stagnant farm incomes, etc. (Siddiq 1999; Ali and Kumar 2002; Gautam and Sharma 2004; Gangwar and Prasad 2005; Reddy and Suresh 2009). Crop diversification shows lots of promise in alleviating these problems through fulfilling the basic needs and regulating farm income, withstanding weather aberrations, controlling price fluctuation, ensuring balanced food supply, conserving natural resources, reducing the chemical fertilizer and pesticide loads, environmental safety and creating employment opportunity (Gill and Ahlawat 2006).

Today, the increasing demand for oilseeds to meet the requirement of ever-increasing population has brought the non-traditional and unutilized areas in sharp focus, as these crops can thrive well under such circumstances where other crops do not grow well (Ali and Mishra 2002).

Among all the states in the country, West Bengal continues to occupy the first position in rice production while the state has the second position in potato production and again the foremost position in vegetable production (Anonymous 2005). Even after this increase in the production of rice, potato and vegetables, there are still deficits in the production of certain other food grains and crops. The wheat production during 2009–2010 was 8.47 lakh t which is less than the present requirement of about 20 lakh t. Likewise, the production of pulses during 2009–2010 was 1.50 lakh t and of oilseeds 7.26 lakh t, which were again less than the present requirement of the state (Anonymous 2011). Therefore, some steps need to be taken for increasing production of the said important crops so as to reduce the deficits in such cases, and to ensure remunerative prices to the farmers because of excess demand for these crops.

All these call for crop diversification including partial substitution with oilseeds as well as adoption of other enterprises under specific situations for increasing oilseed production not only in the state of West Bengal but also in the eastern India as a whole. In addition, there is a need to develop suitable production technology of these alternative farming systems to make them equally or even more competitive with the existing systems. Besides, it is essential to use various resources rationally for sustained productivity and conserve biodiversity for achieving food and nutritional security (Bhowmick et al. 2006).

10.4 Options for Diversification and Area Expansion with Oilseeds

In respect of growth in oilseed production in India, nearly 55 % of the increase was achieved by area expansion and 45 % by productivity improvement (Hegde 2005a). Area expansion has occurred in favour of those oilseed crops, which have shown a higher growth rate of productivity due to technological development (e.g. rapeseed-mustard) or whose relative prices with competing crops have moved in their favour (e.g. sunflower) or whose total profitability has increased due to a combination of technological development and higher prices as in soybean (Hegde 2000a, 2000b, 2005a, 2005b). There is hardly any scope to bring additional area exclusively under oilseeds due to the increasing demand for all crops and commodities. Introduction of high-yielding varieties of oilseed crops (Table 10.1) can replace a number of traditional low-yielding crops because of their higher efficiency in utilizing rainfall and moisture, and ultimately, resulting in higher yields and returns (Reddy and Suresh 2009). Therefore, there is a need to find newer niches and situations where oilseeds can be introduced. The possible options available for crop diversification with oilseeds by going in for their area expansion (Hegde 2000a, 2002, 2004, 2005a, 2005b; Palaniappan and Jeyabal 2002; Sengupta and Das 2003) are as follows:

Table 10.1 Annual oilseed crops and their promising varieties/hybrids in West Bengal. (Source: Bhowmick et al. 2006)

Common name	Botanical name	Varieties/hybrids	Maturity (days)	Oil content (%)	Seed yield (q ha^{-1})
Groundnut	*Arachis hypogaea* L.	Varieties			
		AK 12-24	110–120	48.0–48.5	20–22 (Pod)
		Phule Pragati (JL 24)	100–110	50.7	20–25 (Pod)
		GG 2	110–120	49.0	20–25 (Pod)
		VRI 4	115–125	49.0	22–25 (Pod)
		ICGS 44	110–120	49.0	22–25 (Pod)
		J 11	115–120	49.0	18–20 (Pod)
Toria (Rapeseed)	*Brassica rapa* L. var. *Toria*	Agrani (B 54)	70–75	40.0	8–10 (R)
		Panchali (TWC 3)	80–85	40.0	10–12 (R) and 12–14 (I)
		T 9	90–95	40.0	12–15 (R&I)
		PT 303	95	43.0–44.0	9–11 (I)
Yellow sarson/ Swet sarson/ Colza (Rapeseed)	*Brassica rapa* L. var. yellow sarson	Binoy (B 9)	90–95	46.0	14–15 (I)
		Subinoy (YSB 19-7C)	95–98	46.0	14–16 (I)
		Jhumka (NC 1)	95–100	45.0	15–17 (I)
		NRCYS 05-02	113	42.9	14–15
		Narendra Sarson 2 (NDYS 2)	125–130	43.0	11–12
Gobhi sarson (Rapeseed)	*Brassica napus* L.	Kalyan (WBBN 1)	105–110	43.0	12–15 (I)
Rai/Indian mustard/ Brown mustard (Mustard)	*Brassica juncea* (L) Czern. & Cosson.	Seeta (B 85)	95–100	38.0	12–14 (R)
		Sarama (RW 85-89)	110–115	38.0	17–19 (I)
		Bhagirathi (RW 351)	110–115	38.0	16–18 (I)
		Sanjukta-Asech (RW 4C-6-3/II)	95–100	38.0	10–12 (I)
		Varuna (T 59)	120–130	43.0	20–22 (I)
		Pusa Bold (PR 45)	110–120	42.0	18–20 (I)
		Krishna (PR 18)	132	40.0	13–14 (I)
		Kranti (PR 15)	125–130	40.0	15–18 (I)
		RH 30	130–135	39.0	16–20 (R&I)
		JD 6	81–114	39–44	6–10
		Vardan (RK 1467)	120–125	40.0	10–16 (I)
Soybean	*Glycine max* (L.) Merr.	Bragg	112–115	22.4	15–20
		JS 80-21	105–110	–	25–30
		JS 2	90–95	–	18–20
		JS 335	95–100	–	25–30
		Birsa Soy 1	100–110	–	20–24
		Indira Soy 9	106	–	22–23
		MAUS 71	93–100	–	18–30

Table 10.1 (continued)

Common name	Botanical name	Varieties/hybrids	Maturity (days)	Oil content (%)	Seed yield (q ha^{-1})
		PK 472	100–106	–	25–30
		PK 564	105–115	–	30–35
		Pusa 16	105–115	–	25–30
		Pusa 22	110–120	–	25–30
		Pusa 24	110–115	–	25–30
		Pusa 37	110–115	–	25–30
		Shilajeet	100–105	–	20–25
		RAUS 5	96–104	–	30–35
Sunflower	*Helianthus annuus* L.	Hybrids			
		KBSH 1	90–95	42.0–44.0	12–16 (R) and 16–24 (I)
		KBSH 44	90–100	36.0–40.0	12–16 (R) and 16–25 (I)
		MSFH 17	90–95	36.0–38-0	13–16 (R) and 16–25 (I)
		DRSH 1 (PCSH 243)	95–105	40.0	13–16
		Jwalamukhi(PSCL 5015)	95–100	40.0–42.0	12–16 (R) and 16–24 (I)
		PAC 36	95–100	40.0–42.0	12–16 (R) and 16–24 (I)
		PAC 1091	95–100	40.0–43.0	12–16 (R) and 16–24 (I)
		Sunbred 212	109	–	15
		Sunbred 275	120	42.0	15–16
		MSFH 8	90–95	42.0–44.0	12–15 (R) and 15–18 (I)
		BSH 1	85–90	40.0–42.0	8–14 (R) and 15–18 (I)
		Pro Sun 09	90–95	42.0–44.0	12–16 (R) and 16–25 (I)
		MLSFH 47	92–98	40.0–41.0	12–16 (R) and 16–24 (I)
		Surya	90–100	38.0–40.0	8–10 (R) and 10–12 (I)
		Varieties			
		Morden (Cernianka 66)	80–90	38.0–40.0	6–7 (R) and 10–12 (I)
		Sidheshwar (LS 11)	85–88	40.0	10 (R)
		EC 68414 (Peredovik)	100–115	40.0–44.0	6–8 (R) and 12–15 (I)
		DRSF 108	95–100	37.0	12–14
		DRSF 113	90–98	40.0	12–14
		Morden (Cernianka 66)	80–90	38.0–40.0	6–7 (R) and 10–12 (I)

Table 10.1 (continued)

Common name	Botanical name	Varieties/hybrids	Maturity (days)	Oil content (%)	Seed yield (q ha^{-1})
Sesame	*Sesamum indicum* L.	Tilottama (B 67)	75–80	40.0	6–8 (R) and 8–10 (I)
		Rama (Improved Selection 5)	80–85	45.0	8–10 (R) and 10–15 (I)
		Krishna (RAUSS 17-4)	85–90	45.8–46.0	8–10 (R) and 10–11 (I)
		HT 1	65–70	50.0	5–6 (Post-*kharif*)
		PT 1	65–70	50.0	5–6 (Post-*kharif*)
		Uma (OMT 11-6-3)	80–85	51.0	9–11
		Savitri (SWB 32-10-1)	84–87	51.1	8–10
Safflower	*Carthamus tinctorius* L.	Hybrids			
		DSH 129	120–125	30.0	18–22
		MKH 11	130–135	31.0	17–18
		NARI NH-1(PH 6)	135–140	31.0	18–19
		Varieties			
		BLY 652	120–130	38.0	9–10
		Annigeri 1 (A 1)	115–125	29.0–35.0	9–10
		APRR 1	110–120	35.0	10–12
		Malvia Kusum (HUS 305)	165	36.0	15
		NARI 6	137	30.0	15
Niger	*Guizotia abyssinica* (L.f.) Cass.	Shyadri (IGP 76)	100–105	40.0	4.5–5.0
		No.71	95	42.0	4.5–5.0
		Bhawani (GA 5)	120–125	39.0	4.0
		Shiva (GA 10)	115–120	42.0	4.0–5.0
Linseed	*Linum usitatissimum* L.	Neela (B 67)	120–125	40.0	7–9 (R) and 9–10(I)
		Garima	125–130	42.0	12–14 (I)
		Shubhra	130–135	45.0	9–11 (R) and 11–13(I)
		Gaurav (LCK 152)	135–140	43.0	9.5 (fibre) and 10.5 (seed) (I)
Castor	*Ricinus communis* L.	Hybrids			
		GCH 4	150–180	50.0–51.0	11–13 (R) and 20–22 (I)
		GCH 5	180–240	52.0–57.0	18 (R) and 25 (I)
		GCH 6	210	48.09	30 (I)
		DCH 177	90–100	49.0	15 (R) and 20 (I)
		DCH 32	85–95	48.0	18 (R) and 28 (I)

Table 10.1 (continued)

Common name	Botanical name	Varieties/hybrids	Maturity (days)	Oil content (%)	Seed yield (q ha^{-1})
		DCH 519	105–110	50.0	17–21
		Varieties			
		B 1	120–130	45.3	3–5
		Jyoti (DCS 9)	90–150	49.0	10 (R)
		Kranti (PCS 4)	90–150	48.0–50.0	13–14 (R)
		Jwala (48-1)	130–220	48.0	10 (R) and 18 (I)
		Aruna	120–150	52.0	10 (R) and 20 (I)

I Irrigated *R* Rainfed

1. Extending cultivation in underutilized farming situations such as rice-fallows of eastern India where more than 15 m ha are under low land rice;
2. Intercropping of oilseeds in nearly about 45 m ha of widely spaced crops like sugarcane, maize, cotton, pigeon pea and plantation crops, and in less remunerative traditional staple food crops where replacement is not possible;
3. Substitution of existing low-yielding and high water requiring crops (*boro* rice, wheat, sugarcane, etc.) with high-yielding and less water intensive oilseed crops (sunflower, *Brassica*, sesame or groundnut) in tail-end of canals and in areas irrigated by wells and tanks where water availability is limited, and also in saline areas;
4. Cultivation of oilseeds in newer seasons e.g. expanding areas particularly under *rabi* groundnut cultivation as this crop registers high productivity during *rabi;*
5. Introduction of suitable oilseed crops through diversification of rice–rice and rice–wheat cropping systems;
6. Growing oilseeds (sunflower, sesame or niger) under contingency planning where the season for regular crops is not conducive or when these have failed;
7. Fitting the oilseeds (sunflower, sesame, etc.) as catch crops in the period left between two regular crops;
8. Value addition to some of the main and by-products of oilseeds which will increase their profitability, help expand the area and also arrest constant decline in area observed recently in linseed, safflower, etc.;
9. Growing of minor, non-conventional or tree-borne oilseeds in the forest areas, waste lands and marginal lands.

The diverse agro-ecological conditions in the country are favourable for growing nine annual oilseeds (Table 10.1), including seven edible sources (groundnut, rapeseed-mustard, soybean, sunflower, sesame, safflower and niger) and two non-edible sources (castor and linseed) apart from a number of minor oilseeds (Table 10.2) and perennial oilseeds (Table 10.3) of horticultural and forest origin, including coconut and oil palm in particular (Rai 2002; Hegde 2000a, 2005a; Reddy and Suresh 2009).

Table 10.2 Minor oilseeds of potential value and their distribution in India. (Sources: Rai 2002; Saxena et al. 2002)

Common name	Botanical name	Oil content (%)	Major producing states
Sal	*Shorea robusta*	12.5	Madhya Pradesh, Orissa and Bihar
Neem	*Azadirachta indica*	20.0	Andhra Pradesh, Gujarat, Madhya Pradesh, Tamil Nadu Maharashtra, Karnataka and Uttar Pradesh
Karanja	*Pongamia glabra*	30.0	Andhra Pradesh, Tamil Nadu and Karnataka
Mahua	*Madhuka longifolia*	35.0	Uttar Pradesh, Madhya Pradesh, Andhra Pradesh and Gujarat
Kusum	*Schleichera trijuga*	33.0	Bihar and Orissa
Kokum	*Garcinia indica*	40.0	Maharashtra and Goa
Rubber seed	*Hevea brasiliensis*	18.5	Kerala
Pinnai/Undi	*Calophyllum indophyllum*	60.0	Kerala
Khakan/Pilu	*Salvadora oboides*	33.0	Maharashtra and Gujarat
Mango kernel	*Mangifera indica*	8.0	Andhra Pradesh, Uttar Pradesh and Maharashtra
Tung	*Aleurities fordii*	–	Himachal Pradesh
Pisa	*Actinodaphne hookeri*	48.0	Karnataka and Maharashtra
Maroti/Kavathi	*Hydnocarpus wightianai*	33.0	Kerala
Nahor	*Mesua ferrea*	40.0	Tamil Nadu, Kerala, Andaman and Assam
Dhupa	*Vaterie indica*	17.0	Karanataka and Kerala
Tumba	*Citrullus colocynthis*	30.5	Rajasthan

Table 10.3 Perennial oilseeds with their oil yield potentials in India. (Source: Menon 1985)

Common name	Botanical name	% oil (Dry wt. basis)	Oil yield (t ha^{-1})
Coconut	*Cocos nucifera*	60 (kernel)	0.6–1.5
Oil palm	*Elacis guineensis*	47 (pulp) and 50 (kernel)	1.7–3.0
Macauba	*Acrochomia sclerocarpa*	61 (pulp) and 65 (kernel)	4.0–6.0
Tucuma	*Astrocaryum tucuma*	35–48 (pulp) and 45–48 (kernel)	1.5–2.0
Pinhao/Verendah	*Jatropha curcus*	60–65 (kernel)	1.5–2.3
Piqui	*Caryocar brasilience*	36.5 (kernel) and 6 (pulp)	2.3–3.5

The area expansion under oilseeds can further be promoted through ecological zoning. Delineating efficient zones for each oilseed crop helps realize potential yields with limited efforts and high input use efficiency. A serious effort must, therefore, be attempted to extend area where high oilseed productivity can be achieved (Sengupta and Das 2003). However, some potential regions for area expansion under different oilseed crops in eastern India have been presented in Table 10.4.

Table 10.4 Diversification of traditional crop base with annual oilseed crops in India. (Sources: Palaniappan and Jeyabal 2002; Hegde 2005a; Reddy and Suresh 2009)

Crop	Area suggested for diversification
Groundnut	As a replacement crop for minor millets in Bihar and Orissa
	As an intercrop with upland rice in north-eastern region and non-traditional areas in Uttar Pradesh (Bundelkhand, western Uttar Pradesh and *Tarai-bhabar* tract) and as a replacement crop of upland rice in Orissa, Tamil Nadu, Bihar and Andhra Pradesh during *kharif*
	As a *rabi*/summer crop on residual moisture of rice-fallows in Assam, West Bengal, Orissa and Chhatisgarh and as an irrigated crop in *Kosi* and *Tawa* commands in rice-fallows in Bihar and Madhya Pradesh
	As a second crop to substitute rice-rice with rice-groundnut system to prevent the build-up of insects and diseases in endemic areas where rice-rice system is prevalent
Rapeseed and mustard	As an introduction in *diara* tracts of northern and eastern India and Gujarat
	Mustard as an intercrop with autumn planted sugarcane, potato, wheat, lentil, chickpea, etc.
	As a rainfed *utera* crop in lowland rice-fallows in north-eastern states
	As a crop grown with brush fencing of fields to prevent cattles in upland rice-fallows in north-eastern hill states
Soybean	As a replacement crop for minor millets in Bihar and Orissa
	As an intercrop with maize, pigeonpea, pearlmillet, etc. in Madhya Pradesh, Rajasthan, Uttar Pradesh, Andhra Pradesh, Karnataka, Orissa and Tamil Nadu, and as a rotational crop in pest endemic areas of rainfed cotton
	As an introduction in non-traditional areas of north-eastern hills which are under agri-pastoral/ agri-silvicultural system
	As an intercrop with upland rice in north-eastern region and as a replacement crop for upland rice in Orissa, Tamil Nadu and Uttar Pradesh
	As a *rabi*/summer crop in rice-fallows in Assam and southern states
Sunflower	As a replacement crop of upland rice in Orissa, Tamil Nadu, Bihar and Andhra Pradesh
	As a crop in rice-fallows in most parts of rice growing areas
Sesame	As a summer crop under assured moisture condition after potato, rice etc. in eastern states and under limited water availability situation (three to four irrigations and shorter duration only) in central, peninsular and eastern India
Safflower	As a crop under limited moisture condition in traditional (Maharashtra, Karnataka and Andhra Pradesh) and non-traditional (Malwa plateau of Madhya Pradesh, Chhatisgarh, Udaipur region of Rajasthan and Bundelkhand region of Uttar Pradesh) areas
	As an intercrop/border crop/replacement sole crop for sorghum, coriander, dryland wheat, chickpea, linseed, etc. in the above states
	As an intercrop/border crop/replacement sole crop for sorghum, coriander, dryland wheat, chickpea, linseed, etc. in the above states
	As a replacement crop for desi cotton, minor millets and low-yielding pulses in the above states
Castor	As bund crop in all regions
	For replacing traditional varieties with high-yielding ones in Uttar Pradesh and Bihar

Table 10.4 (continued)

Crop	Area suggested for diversification
Linseed	As an intercrop of wheat, chickpea, lentil, coriander, etc. in linseed-growing areas
	As a *utera* crop in rice-fallows in eastern and north-eastern states
Niger	As a replacement sole crop/mixed crop for bajra, ragi, castor, groundnut and pulses under rainfed condition
	As an introduction in non-traditional areas under residual soil moisture and rainfed conditions

10.5 Strategies for Increasing Oilseeds Production

The state of West Bengal has much deficit in the production of oilseeds. Though the state has made remarkable progress in oilseed production in last few years (Table 10.5), it did not keep pace with the growing population as the estimated population of the state has risen from 802.21 lakhs (as per Census, 2001) to 913.48 lakhs (as per Census, 2011), which will further go high in the coming years. As such, the state has to produce a sufficient quantum of oilseeds for meeting the escalating demand vis-a-vis bridging the gap between requirement and production of oilseeds, for which the following strategies are to be taken up:

10.5.1 Area Expansion

1. Substitution of traditional crops with soybean and groundnut during kharif in the western red and lateritic zone;
2. Sunflower cultivation in rice-fallows in the coastal saline areas;
3. Cultivation of toria, linseed and niger after the harvest of autumn and winter rice;
4. Area expansion under sesame in all the three seasons in both traditional and non-traditional areas;
5. Expansion of area under rabi/summer groundnut in rice-fallows and on residual moisture in flood plains of Assam, West Bengal, Orissa and Chhatishgarh;
6. Intercropping/mixed cropping soybean with maize, sunflower with groundnut/pulses and linseed with wheat/pulses;
7. Cultivation of mustard in rice-fallows in north-eastern states;
8. More cultivation of sesame as a summer crop after rice in eastern states;
9. Cultivation of soybean and sunflower in upland areas of Orissa, Tamil Nadu, Bihar and Andhra Pradesh as these are more remunerative than upland rice.

Table 10.5 Area, production and productivity of total oilseeds in West Bengal. (Sources: Anonymous 2010, 2011)

Year	Area ('000 ha)	Production ('000 t)	Productivity (Kg ha^{-1})
2000–2001	598.55	570.67	953
2001–2002	604.15	493.04	816
2002–2003	568.39	475.83	837
2003–2004	685.05	651.74	951
2004–2005	673.15	556.82	827
2005–2006	643.47	623.30	969
2006–2007	703.41	645.38	917
2007–2008	707.43	705.71	998
2008–2009	703.68	582.62	828
2009–2010	681.99	726.19	1066

10.5.2 Improving Productivity

1. Replacement of varieties with newer ones;
2. Use of quality seeds with optimum seed rate;
3. Timely adoption of improved cultural practices;
4. Balanced fertilization including micronutrients and gypsum application as a source of sulphur;
5. Transfer of technology to the farmers;
6. Adoption of resource conserving technologies;
7. Exploitation of other non-traditional sources of oil (e.g. oilpalm).

The state of West Bengal is endowed with favourable agro-climatic conditions for the production of a variety of crops throughout the year. Though limited scope for crop diversification prevails during kharif, there is great scope of diversification both under irrigated and rainfed conditions during rabi and summer seasons in West Bengal (Samui 2005). Owing to huge deficit in the production of oilseeds in the state, there is a dire need to emphasize increased production of oilseeds through diversification in traditional cropping systems, introduction in non-traditional areas and non-conventional seasons utilizing residual moisture, and improving productivity with right application of available technology (Anonymous 2002). Similar strategies need to be adopted for other eastern states of the country.

10.6 Suitability of Oilseeds in Different Cropping Systems

The rainfall receipts in eastern India are usually high and some amount of rainfall is received during pre-kharif (March–May). A fairly good amount of moisture remains stored in the soil after the harvest of kharif crops. Further, the water table is sufficiently high, between 1–2 m below the ground level in the medium lands in many areas. All these facilitate in growing more than two crops in these predominantly rice-based mono-cropped areas, even without irrigation facilities. Oilseed crops have the potential for increasing cropping intensity and profitability in a wide range of cropping systems. These crops by nature are hardy, mostly grown under rainfed conditions, and impart stability of production system under harsh conditions (Reddy and Suresh 2009). As most of them have deep roots, they can tap very well the untapped resource of soil moisture (Chatterjee 1985). Moreover, these crops by virtue of their low irrigation requirement and better remunerative price are ideally suited to replace low-yielding other crops and become popular even in non-traditional areas (Palaniappan and Jeyabal 2002). Therefore, adapting cropping systems with oilseed crops in non-traditional areas and seasons can enhance the oilseed production substantially. But, these cropping systems require more balanced supply of inputs and effective crop management over mono-cropping because of the higher nutrient uptake by the crops and competition for light, water and nutrients (Palaniappan and Jeyabal 2002). Possibilities exist for expanding oilseeds cultivation both in irrigated and rainfed areas with the introduction of suitable oilseed crops, which can be intercropped, mixed cropped, relay cropped or grown as catch crop in multiple sequences (Bhowmick et al. 2006).

10.6.1 Sequential and Relay (Paira/Utera) Cropping

As the prices of oilseeds have gone high, the farmers can grow oilseeds as a cash crop. Time has come to provide them with cropping sequences, which can be stated as “oilseed-based cropping sequences” instead of “cereal-based cropping sequences”. These cropping sequences have profound influence on the productivity of succeeding crops (Chatterjee 1985).

Rapeseed being mostly taken as a catch crop enjoys the facility of being grown in solid stand (Sengupta and Das 2003). If grown after aman rice, long-duration varieties do not suit due to short and mild winter in West Bengal during rabi, and aman rice varieties also should be of shorter duration. Paira cropping of rapeseed-mustard in between two rice crops in rice–rice system is now gaining popularity (Samui 2005). Paira cropping of yellow sarson in the standing aman paddy has been found economic when the seeds of paira crop were sown broadcast before rice harvest. Broadcasting seeds of yellow sarson after land preparation in rice-fallow was found uneconomic due to severe infestation of aphid and diamond back moth and the prevalence of high temperature at later stage of crop growth due to delayed sowing in West Bengal (Samui 2005). Similarly, linseed can be grown as paira crop (Chatterjee 1985). Growing of mustard and linseed after rice was found remunerative (Yadav and Shukla 2002).The principle behind relay/utera/paira cropping is to take advantage of the residual moisture to raise two crops in a year by adopting an overlapped cropping system (Kempanna 1985). The areas in which this system is widely prevalent are West Bengal, parts of Orissa, Uttar Pradesh and Madhya Pradesh, Bihar and Chhatisgarh (Bhowmick et al. 2006).

Among the oilseeds, groundnut and sesame can be cultivated during summer season in aman fallow areas, where even restricted irrigation facilities are available. These two crops gave much higher yield with less disease incidence when grown in pre-kharif than during kharif. Groundnut and sunflower being fairly resistant to soil salinity have already become popular second crops in aman fallows of coastal tracts in West Bengal where cultivation of any second crop was earlier not possible (Chakraborty et al. 1973). Cultivation of rabi groundnut in river beds of West Bengal on residual moisture was found remunerative and cost-effective. The scope of groundnut cultivation is also replacing non-remunerative upland rice during kharif in upland and medium lands under red and lateritic zones of West Bengal (Samui 2005).

In West Bengal, pre-kharif sesame is mostly grown after harvest of potato, aman rice or jute. Potato being grown generally in light and fertile soils requires frequent irrigation, allowing a considerable amount of Nitrogen to leach down the root zone. The subsequent sesame crop having comparatively deeper root system is expected to draw nutrients from a deeper zone where potato roots cannot reach. When grown after potato, no fertilizer is therefore applied to sesame as the residual fertility seems to be enough for good crop growth (Chatterjee et al. 1992; Sengupta and Das 2003). However, in such rotation, sesame is found to be affected by Macrophomina disease due to high soil fertility status, encouraging profuse vegetative growth. Jute–sesame rotation is comparatively safer (Sengupta and Das 2003).

The usual crops preceding safflower are greengram, blackgram, maize, millets, sesame, upland paddy, groundnut, soybean and cowpea (Sengupta and Das 2003). Inclusion of leguminous oilseed in the cropping system has several advantages. Root nodules of legume release N during decomposition for the use of succeeding crops (Kailasam 1988). Prasad (1996) also reported that nitrogen fixed by the legumes not only meets their own N requirements but also a sizeable quantity (30–90 kg ha^{-1}) is left for the succeeding crops. Mustard being highly responsive to N-application yields more after leguminous crops, more particularly after cowpea taken as fodder. Studies also indicate that sunflower is a less exhaustive crop than maize, but a time gap of at least 2 weeks should be allowed between the two crops (Palaniappan and Jeyabal 2002).

In the new alluvial zone of West Bengal, cropping sequence of rice–wheat–groundnut was as highly productive as rice–potato–jute (Katyal and Gangwar 2001). Similarly, rice–potato–groundnut and rice–vegetables–sesame were found productive, profitable and efficient in irrigated areas (Samui et al. 2004; Samui 2005). Sharma and Rajput (1990) found rice–mustard–sesame and rice–mustard–greengram as more water-efficient systems at Memari (Burdwan) in West Bengal. In Bihar, rice–potato–sunflower system recorded higher rice-equivalent yield, net returns, benefit–cost ratio, land-use efficiency and production efficiency than traditional rice–wheat-green manuring (Reddy and Suresh 2009).

Under coastal rice-fallows, mainly rabi oilseeds like sunflower, safflower, linseed and castor are grown owing to mild temperature during winter (Ali and Mishra 2002). Again, instead of existing rice–rice system in coastal areas, rice–potato–sesame, rice–rice–soybean and rice–groundnut have been identified to be more suitable with high productivity, profitability and stability for the coastal areas of Orissa, Tamil Nadu and Maharashtra, respectively (Gangwar et al. 2003). Under the situation of limited irrigation availability in central India, soybean–wheat and soybean–chickpea were found most efficient and stable (Gangwar et al. 2004).

However, some cropping sequences, where oilseed crops can easily and profitably be nurtured, are (1) irrigated upland situation: (i) direct seeded rice (aus)/ jute–mustard–reengram/ sesame, (ii) groundnut/sesame–mustard–greengram, (iii) direct seeded/transplanted rice (aus)–rapeseed–groundnut; (2) irrigated medium and low land situations: (i) rice (direct seeded/ transplanted)/jute–rapeseed/mustard–boro rice, (ii) direct seeded rice–sesame (short duration)–wheat, (iii) direct seeded rice–wheat/potato/vegetables–sesame/groundnut; (3) other sequences suitable for irrigated condition: (i) groundnut-sesame/greengram, (ii) cotton–sunflower, (iii) rice–sunflower–greengram, (iv) sunflower–chickpea/soybean, (v) cowpea–sunflower–maize, (vi) sunflower–rice–sesame/blackgram/greengram, (vii) groundnut–wheat/maize, (viii) rice–niger (pre-rabi)/sunflower, (ix) rice–potato–sunflower, (x) soybean–sunflower; (4) rainfed upland and medium land situations: (i) jute–direct seeded rice–rapeseed/mustard/safflower, (ii) direct seeded rice (early)–niger/ safflower, (iii) jute–direct seeded/transplanted rice–linseed/mustard/safflower/sunflower; (5) rainfed lowland situation: (i) rice (late variety)–sesame, (ii) groundnut–sorghum/bajra/maize/sesame, (iii) millets/cowpea/kharif pulse–sunflower, (iv) sunflower–safflower.

10.6.2 Intercropping and Mixed Cropping

The underlying principle, regardless of crops and varieties, is to distribute/dilute the risk arising out of aberrant weather besides enhancing farm income. The basic objectives are crop intensification in both time and area, and raising productivity per unit of area and input by increasing the pressure of plant population. It also entails better utilization of soil moisture, nutrients and solar radiation than sole cropping of the base crop. The important criterion is not to sacrifice the main crop yield, but at the same time to have some additional yield. Some prominent examples are as follows:

Rapeseed-mustard Mustard is often mixed cropped or intercropped with sugarcane, wheat, potato and gram. In irrigated areas, mustard as companion crop of autumn planted sugarcane (Chatterjee 1985; Chatterjee and Pal 1988; Yadava et al. 2001; Palaniappan and Jeyabal 2002; Sengupta and Das 2003) in the sub-tropical region has been found to be more remunerative than pure sugarcane. Sugarcane is planted in 90 cm apart rows and two rows (30 cm apart) of mustard can easily be sown in between (Chatterjee 1985).

When shallow-rooted wheat was intercropped with deep-rooted mustard and chickpea, the consumptive use of water and combined intercrop yield increased because of more efficient use of soil moisture from the deeper zones (Mandal et al. 1986). One row of mustard after every ninth row of wheat proved to be the appropriate method (Chatterjee and Pal 1988; Yadava et al. 2001) under irrigated condition. The mustard variety Sanjukta-Asech (RW-4C-6–3/II) is suitable for mixed cropping with wheat in West Bengal.

Because of dissimilar growth, duration and canopy characteristics, intercropping of mustard (Varuna) with potato (Kufri Chandramukhi) in 1:3 proportion by border-ridger technique was found superior over pure crops (Chatterjee 1985; Yadava et al. 2001). Here, mustard should receive the first irrigation after earthing up of potato and subsequent irrigations to potato should be given after closing furrows from both the sides of the ridge on which mustard is planted. Intercropping of mustard (Varuna) and chickpea in a 1:2–3 row proportion has been found to be beneficial both under irrigated and rainfed conditions. Intercropping of lentil and toria in a 1:1 proportion was found suitable for rainfed areas of Uttar Pradesh (Yadava et al. 2001).

Sunflower It can profitably be intercropped with fingermillet, pigeonpea, groundnut, soybean, greengram, blackgram, horsegram and cowpea. Availability of high-yielding cultivars of sunflower with varied duration, photoperiod insensitivity and wide adaptability to varied soil and agro-climatic situations has made it highly suitable for intercropping. The drought tolerant nature of sunflower has made it better suited for the intercropping systems to exploit the resources over time (Palaniappan and Jeyabal 2002). Taking sunflower as an intercrop in groundnut in a 2:6 row proportion could bring higher returns and more income stability (Chatterjee and Bhattacharyya 1986; Chatterjee et al. 1989; Sindagi and Virupakshappa 1993). More sunflower yields with less disease incidence could be obtained by alternating sunflower with soybean (Palaniappan and Jeyabal 2002).

Soybean Soybean, when introduced as intercrop, exerts less competition to companion crop; it does not impose any allelopathic effects on companion crop and helps in fertilizer economy (Reddy and Suresh 2009). It offers much scope for intercropping in sugarcane by which the fertilizer N requirement could be cut down to some extent (Kailasam 1988). Intercropping of soybean sown 60 cm apart with two rows of direct-seeded rice (20 cm apart) in between is feasible and more remunerative. The mixture of soybean sown 60 cm apart with maize rows in between soybean out yielded pure crops in both dry and wet seasons. Similarly, the mixture of soybean in rows 45 cm apart and sorghum in between soybean rows out yielded pure crops in dry season (Chatterjee and Roquib 1977). Highest monetary returns were obtained when soybean was intercropped with maize in alternate rows where each of both the crops was spaced 60 cm apart (Sen 1982).

Groundnut Being a long-duration crop, groundnut can be grown along with sunflower so that early season rains benefit sunflower and late rains benefit groundnut, thereby giving some assurance to the dry-land farmers. Advancing sowing of groundnut by 15–30 days prior to sunflower reduces the competition due to the shading of sunflower. Research data recorded a net return of ₹ 12,615 ha^{-1} under sunflower + groundnut intercropping system in West Bengal (Reddy and Suresh 2009).

Yield advantages have been reported up to 81 % when one row of groundnut was alternated with one row of sunflower (Morden) and sown in June in the light sandy loam upland soils of IGPs. Similarly, when one row of sesame (B 67) established in June was alternated with two rows of groundnut (AK 12–24), the production per unit area increased appreciably in West Bengal (Chatterjee 1985).

In an intercropping of one row of pearlmillet and three rows of groundnut with inter-row spacing of each species in mono- as well as intercrop, Marshall and Willey (1983) recorded 28 % more total dry matter and lesser risk than growing the individual crops (Chatterjee and Bhattacharyya 1986; Chatterjee and Mandal 1992). In Sundarban area of West Bengal (coastal saline tract), yield advantage was found quite high when three rows of groundnut were alternated with three rows of chillies (Reddy and Suresh 2009).

Niger Intercropping of niger either with groundnut or sunflower has been found remunerative when sown at the later part of the rainy season in West Bengal. Intercropping of niger and sunflower in a 1: 1 or 2: 1 row proportion has been found to improve the seed filling of sunflower heads due to increased bee population (Chatterjee 1985). Niger can also be mixed cropped with bajra, ragi, castor, groundnut or pulses under rainfed situations during kharif and rabi (Anonymous 2001).

Linseed It can be grown as mixed crop/intercrop during rabi season with gram, wheat or lentil in a 1:3 or 3:1 proportion (Chatterjee 1985; Anonymous 1995). Inter- or mixed cropping of linseed with gram appeared to be more profitable than their sole cropping and this could appreciably reduce the wilt disease incidence and borer damage in chickpea (Chatterjee 1985; Chatterjee et al. 1992; Anonymous 1995). The fertilizer needs of chickpea and lentil are also minimized when they are intercropped with linseed. As far as possible, mixed cropping should be discouraged and intercropping should be popularized (Anonymous 1995). Moreover, intercropping of pulses and oilseeds with a recommended planting pattern after rice enhanced the net returns and improved soil health. The highest net return was recorded in rice-chickpea + linseed, closely followed by rice-linseed + mustard (Tripathi and Rathi 2003).

Sesame In West Bengal, a single row or twin row (20 cm apart) of sesame can easily be accommodated in the inter-row space of spring planted sugarcane. This practice might help in the harvesting of about 5 q additional seed yield of sesame ha^{-1} in addition to almost normal yield of sugarcane from the same piece of land. In the twin row system, the first row of sesame should be planted 35 cm away from the adjacent row of sugarcane. Similarly, a twin row of sesame (20 cm apart) can be successfully accommodated creating a space by skipping a row of spring/summer groundnut after every fourth row and such intercropping might give around 1.5 q additional oil yield ha^{-1} (Chatterjee et al. 1992).

Safflower Spices, legumes, oilseeds and cereals are the crops chosen for the intercropping of safflower. The ratio between the main crop and safflower varies from 2:1 to 3:1. In Madhya Pradesh only, the adopted ratio for intercropping safflower with either blackgram or linseed is 2:1 or 6:2 (Maity et al. 1988).

Castor Castor is usually raised either as sole or inter/mixed crop with kharif cereals/millets (sorghum, fingermillet, pearlmillet, maize)/grain legumes (pigeonpea, groundnut, mungbean, urdbean and cowpea) and sometimes with horticultural

Table 10.6 Remunerative intercropping systems with their row proportions. (Sources: Reddy and Pati 1998; Palaniappan and Jeyabal 2002)

Intercropping system	Main crop to intercrop ratio
Sugarcane + rapeseed-mustard (early)	1:2
Wheat + mustard	9:1
Potato + mustard/yellow sarson	3:1
Gram + mustard	3:1 or 2:1
Lentil/sugarcane/gobhi sarson + toria	1:1
Pigeonpea + sunflower	1:1 or 1:2
Soybean + sunflower	1:1
Groundnut + sunflower	6:2
Blackgram/greengram + sunflower	3:1 or 4:2
Direct seeded rice + soybean	2:1
Groundnut + pearlmillet	3:1 or 6:2
Groundnut + sunflower	2:1 or 3:1 or 6:2
Groundnut + pigeonpea/blackgram	4:1
Groundnut + sesame	2:1
Groundnut + castor	5:1 or 6:2 or 3:1
Niger + blackgram	2:2
Niger + sunflower	1:1 or 2:1
Niger + ragi	6:3
Niger + mungbean	1:1
Sesame + greengram/pearlmillet/groundnut	1:1
Linseed + lentil	1:3
Linseed + gram	2:1 or 3:1
Linseed + safflower	2:1
Linseed + wheat	1:3 or 3:1
Wheat + safflower	2:1 or 3:1
Coriander/chickpea + safflower	3:1
Castor + pigeonpea	1:1
Castor + greengram/blackgram	1:2
Castor + groundnut	1:3

crops like chillies, turmeric, ginger, Dolichos and cucumber (Raghavaiah et al. 2005; Reddy and Suresh 2009).

The above findings (Table 10.6) clearly indicate that with the remunerative intercropping systems, not only can more production be achieved, but production can also be more stable over the years, particularly where land and irrigation resources are limited (Bhowmick et al. 2006). Thus, oilseeds have an edge over other crops in price, wider adoptability and relative optimal production under environmental stress condition.

10.7 Conclusion

The present review clearly indicates the advantages of crop diversification with oilseeds in marginal ecosystems to make the cropping enterprise a profitable venture avoiding risks. Hence, crop diversification with oilseeds can be used as a tool for maximizing productivity and profitability leading to resource conservation, for which concerted efforts are required to step up oilseed production through both area expansion and productivity increase for making India self-sufficient in vegetable oils. Oilseeds, having the attributes to produce deep roots in order to tap the moisture from lower depths of soil, offer a great promise for their successful introduction in newer niches or non-traditional and unutilized areas. Rice-fallows, especially in eastern India, can easily be converted to double-cropped areas by introducing suitable oilseed crops like rapeseed-mustard, linseed, niger, sesame, groundnut, sunflower and safflower either as a sole or as an intercrop. Being fairly tolerant to soil salinity, cultivation of groundnut, sunflower and safflower can be expanded in the coastal areas, where other crops or other oilseeds do not grow so well. Increasing irrigated area is also worth considering diverting some cereal areas or low-yielding/less profitable crop areas in favour of oilseeds, the yields of which can be doubled or trebled through proper management under irrigated condition. Even in rainfed areas, the production of oilseeds can be sufficiently enhanced through better management practices. In the IGPs, where cereal-based cropping system is predominant, the potentiality of leguminous oilseeds like soybean and groundnut may be exploited. Exploitation of perennial sources of oilseeds including minor or non-traditional oil-bearing species, and development of strong and vibrant programmes for quality seed production and supply are some other avenues in this regard.

More research is, however, necessary to evolve location-specific, pest-resistant and short-duration varieties with high harvest indices to fit them well in different cropping systems and to introduce in non-traditional areas and seasons. Besides, there is a need to give greater impetus on refinement and/or upgradation of production technology. The development of cost-effective or high yield-low cost technology can change the scenario for oilseeds production in the country.

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