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Higher yields and profits from new crop rotations permitting integration of mediculture with agriculture in the Indo-Gangetic plains

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The results of a survey conducted in 100 villages of 7 districts located in Uttar Pradesh in the central Indo-Gangetic plains on the land cropping pattern and profits to the farmers per unit land and area are presented. It is shown that sugarcane is cultivated in about 19.5% of the land. Rice remains the principal *kharif* crop in the area, occupying about 76% of land. Conventional rice–wheat/*Brassica*/legume, rice–potato and rice–mint rotations benefitted farmers to the extent of roughly Rs 30,000 ha^{-1} year^{-1}. Introduction of new rotations based upon newly available short duration *Kosi* variety of mint is permitting practice of rice–wheat/*Brassica*/legume–mint and rice–potato–mint rotations, bringing a profit of approximately Rs 61,000 ha^{-1} year^{-1} to the farmers of the area. Future prospects of integration of short duration medicinal and aromatic crops (mediculture) between food grain crops (agriculture) like the above, for the development of agriculture, industry and employment are discussed.

THE Indo-Gangetic plains, through which Himalayan rivers, including Ganga and Yamuna flow, comprise one of the most agriculturally fertile areas of the world[1]. Before the advent of green revolution, food grains such as wheat, rice, *Brassica,* groundnut, lentil, pea and pigeonpea and the industrial plant sugarcane were the main crops of the area. Usually one crop, either in winter *rabi* or in summer *kharif* was taken in a year. In the era of green revolution, the practice of the rice–wheat rotation over *rabi* and *kharif* seasons proved to be highly productive and economically viable[2]. In this period, the cropping of sugarcane, oil seeds and legumes became less popular and area under them contracted. In the last decade, the economics of rice–wheat rotation turned less attractive and farmers began to adopt diverse crop rotations, involving seasonal vegetables and industrial crops, mostly in rotation with rice crop. Although these developments improved the income of the farmers and local employment opportunities, the area under *rabi* food grains decreased. New crop rotations that have been introduced in the last few years are expected to remedy this situation in future[3]. Reliable current statistics are not available on the land cropping pattern and related income/profit to the farmers in this important geographical region of Indian agriculture. In the present work a survey was conducted to elicit the above information in an area of the Indo-Gangetic plains spanning 7 districts of Uttar Pradesh (UP). The present studies have shown that in the Indo-Gangetic area surveyed, during the last three years about 76% of the cropped area was under rice. In the rice-cropped area, *rabi* grains occupied 52% of land, mint or vegetables 19% of land, *rabi* grains followed by mint 18% of land, and potato and other vegetables followed by mint 11% of land. The relative profits per hectare were Rs 24,000 (24 K) from rice–*rabi* grain rotation, 43 K from rice–mint/vegetable rotation, 58 K from rice–*rabi* grain–mint rotation and 74 K from rice–vegetable–mint rotation.

Three districts Barabanki, Lucknow and Sitapur in the southern part and four districts Udhamsingh Nagar, Rampur, Badaun and Moradabad in the northern part of

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Table 1. List of the villages surveyed in seven districts located in UP in the Indo-Gangetic plain

District	Village
Barabanki	Mati, Kurouli, Chadanpurva, Nargishmau, Moradabad, Akhchharipurva, Saihara, Raniganj, Bhaggamau, Raghai, Sadamau, Chhatauna, Rendua, Garahi, Naseerpur, Ramnagar, Akberpur, Gandouli, Dalyanpur and Bambhouralodi
Lucknow	Jainabad, Goila, Chinhat, Khandar, Kagikhera, Thakurpur, Badeha, Naseerpur, Utradhauna, Palia Rampurva, Semara, Tewaripur, Rajouli and Baggiroad
Sitapur	Shekhpur, Alhana, Manpur, Kalyanpur, Ameerpur, Gauria Ahrori, Kamalpur, Guerepara, Jodhpur and Mahmoodnagar
Udhamsingh Nagar	Chattarpur, Fauzi ka Matkota, Milak Nou, Baghwala, Ganeshpur, Motipur, Milak Navkharid, Barkheri Adarshnagar, Dineshpur and Malsa
Rampur	Hasalatpur, Padampur, Baggifarm, Milakkhanam, Similia, Majara Ameer Khan, Udairaj Mathiya, Jhuthiya, Murajpur, Sewar, Moga Farm Salehpur, Vilashpur, Isarpur, Lalpur, Magharanaina Nagla and Saraigate Rampur
Badaun	Daharpur, Papad, Lakhatpur, Dhaka, Beladandi, Tikra Kanakpur, Dalunagala, Shayamnagar, Kadarabad and Aamgaon
Moradabad	Majholi, Nagalasagar, Hariyana, Nagariyagatt, Pura, Raja ka Majoula, Joya, Samthol, Babai, Chandousi, Jatpura, Deengarpur,Amarpur Kasi, Faridpur, Kundarki and Rajabpur

Table 2. Percentage of district-wise area covered under different crop rotations in various districts surveyed in the Indo-Gangetic plains

	% of cultivated area covered in the district of							Mean % area covered over all the districts
Crop-rotation	Barabanki	Lucknow	Sitapur	Rampur	Moradabad	Badaun	Udhamsingh Nagar	
Rice–mint	1.5	1.2	4.2	29.2	21.5	9.3	5.6	10.4
Rice–wheat	35.5	40.5	38.7	42.1	25.4	43.5	31.7	36.8
Rice–wheat–mint	4.5	1.5	1.2	3.1	5.3	3.2	1.8	2.9
Rice–potato/other vegetables	5.1	8.0	11.3	0.8	–	1.9	1.7	4.1
Rice–potato–mint	21.5	19.5	12.2	1.7	1.5	2.0	1.1	8.5
Rice–*Brassica*	1.2	1.8	2.4	0.7	1.8	–	2.3	1.5
Rice–*Brassica*–mint	10.5	8.5	5.6	8.3	9.8	5.6	10.4	8.4
Rice–lentil/pea	2.0	2.5	2.9	–	–	–	1.4	1.3
Rice–lentil–mint	7.0	5.5	5.1	–	–	–	0.4	2.5
Millet–wheat	–	–	1.1	–	10.3	2.4	0.8	2.0
Millet–mint	–	–	–	–	1.6	–	–	0.2
Ocimum–wheat	–	–	–	–	–	0.7	–	0.1
Ocimum–*Brassica*–mint	–	–	–	–	–	7.1	–	0.7
Ocimum–*Brassica*–wheat	–	–	–	–	–	0.7	–	0.1
Ocimum–potato–mint	–	–	–	–	–	4.3	0.5	1.0
Sugarcane	11.2	11.0	15.2	13.0	10.2	19.3	42.3	17.5
Sugarcane + mint	–	–	–	1.1	12.6	–	–	2.0

UP were chosen for the survey which was conducted between June 1997 and July 2000. A total of 100 villages were surveyed (see Table 1). In each village up to 20 farmers were visited in their fields, on 3 to 5 occasions over a 3-year period, to collect information on their land area under different crops, varieties/cultivars of crops grown, crop rotation and intercropping patterns used and crop yields obtained, cultivation costs incurred and net return earned per ha. Samples of crops from randomly demarcated 1 sq m portions of fields were taken to independently assess the yield patterns. Market information on the retail rates[4] of agricultural inputs and wholesale selling rates of crops was used to determine the economics of the crops cultivated.

Table 2 gives summarized information gathered on the rotations and intercropping practices used in the 7 districts of central UP that were surveyed. The agricultural land in the area was being used in 17 distinct patterns of which 6 were being practised in all the districts surveyed, altogether over 84% of cultivated land. About

Table 3. District-wise net profit per hectare that accrued through different land cropping patterns used in the Indo-Gangetic plains

Crop-rotation used over one year period	Net profit (Rs ha^{-1} $year^{-1}$)[a] to the farmer in the district of							Mean net profit over all the districts (Rs ha^{-1} $year^{-1}$)
	Barabanki	Lucknow	Sitapur	Rampur	Moradabad	Badaun	Udhamsingh Nagar	
Rice–mint	49,726	43,621	41,691	42,471	50,231	51,139	49,000	46,839
Rice–wheat	25,743	22,973	21,773	24,743	25,163	28,135	24,370	24,700
Rice–wheat–mint	59,703	56,933	55,733	58,703	59,123	62,095	58,330	58,660
Rice–potato/other vegetables	42,762	37,932	36,722	36,912	–	42,947	41,885	39,860
Rice–potato–mint	76,722	71,892	70,682	70,872	73,820	76,907	75,845	73,820
Rice–*Brassica*	22,597	23,797	22,957	21,381	22,250	–	28,617	23,600
Rice–*Brassica*–mint	56,557	57,757	56,917	55,341	56,210	57,561	62,577	57,560
Rice–lentil/pea	24,654	22,848	22,818	–	–	–	–	23,440
Rice–lentil–mint	58,614	56,808	56,778	–	–	–	–	57,400
Millet–wheat	–	–	–	–	22,485	26,915	–	24,700
Millet–mint	–	–	–	–	45,990	47,688	–	46,839
Ocimum–wheat	–	–	–	–	–	24,400	–	24,400
Ocimum–*Brassica*–mint	–	–	–	–	–	57,260	–	57,260
Ocimum–potato–mint	–	–	–	–	–	73,520	–	73,520
Ocimum–*Brassica*–wheat	–	–	–	–	–	35,900	–	35,900
Sugarcane	32,873	26,202	30,328	32,782	33,468	33,893	42,331	33,125
Sugarcane + mint	–	–	–	67,521	68,207	–	–	67,864

[a]Based on the economics presented in Table 4; –, Crop rotation not used.

19.5% of the area was devoted to the sugarcane crop. The principal summer-monsoon *kharif* crops were rice in about 76%, millet in 2%, and *Ocimum* (basil) in 2% of the remaining area. In *rabi* winter season, about 56.4% of the cultivated land was being used to grow wheat, *Brassica* and legumes, in 53.4% after rice and in the remaining 3% after millet or basil. About 13.6% of the land in *rabi* season was cropped with vegetables (mainly potato), in 12.6% area after rice and in 1% after basil crop. The pattern of utilization of fields vacated from rice crop was such that the *rabi* grains (wheat : oil seed : legumes :: 28 : 1.2 : 1) were taken in 52% land, *rabi* grains (wheat : oil seed : legume :: 1.2 : 2.8 : 1) followed by *zaid* mint in 18% land, *rabi* mint or vegetables (potato : other vegetables :: 9 : 1) in 19% (mint : vegetables :: 1.6 : 1) land and *rabi* vegetables followed by *zaid* mint in 11% of the land. Most of the area after summer millet was occupied by wheat, only 9% of the millet area was devoted to mint crop in *rabi* season. Of the land vacated by *rabi* crop of basil, about 5% was used for *rabi* crops of wheat, 37% for short duration *Brassica* crop followed by *rabi* mint, about 5% for the above with mint in place of wheat, and in 53% potato was taken in autumn, followed by *rabi* wheat. In about 12% of the sugarcane area a companion short-duration crop of menthol mint was being taken, while sugarcane crop was in its early stage of development.

Based on the observations made on crop-wise yields and costs of cultivation and selling rates of commodities, estimates were made of net profits ha^{-1} $year^{-1}$ from land cropped. These are presented district-wise in Table 3. This analysis has made use of the observations summarized in the Table 4 on average yield, prevailing rates, gross return, cost of cultivation, net returns and cost benefit ratio of all the crops of this study grown in Indo-Gangetic plains during 1997–2000. The parameters of crop yields and economics were arrived at using information gained from the concerned farmers and that obtained from the market place. It will be observed that the cost benefit proportions were 1.0 : 1.0 to 1.2 in *Brassica,* potato, pea, wheat and rice and as high as 1.0 : 2.3 to 2.5 for menthol mint, *Ocimum* and sugarcane by taking the observations given in Tables 3 and 4 together. The conventional rotations currently used in the area could be arranged in the following order profit-wise, per hectare rice–vegetables (Rs 39,860 or 40 K ha^{-1}) > sugarcane (33 K) > millet–wheat, rice–wheat, rice–legume and rice–*Brassica* (25 K). Among the conventional rotations, in the rice growing area, rice–wheat, rice–legume and the rice–*Brassica* gave more or less the same level of profit to the farmers (about 25 K). The rice–mint rotation which has been in practice in the area for now about more than a decade gave a profit of about Rs 46,800 ha^{-1} (47 K). The sugarcane–mint intercropping which has also been in practice in certain pockets of Indo-Gangetic plains for about a decade gave profits in the range of Rs 67,800 ha^{-1} (68 K). In recent years, the introduction of two new varieties of mint[5,6], characterized by early maturity and wide disease tolerance, has permitted adoption of some new rotational patterns which have highly increased the profits to the farmers[3]. Some of these new rotations could be arranged

Table 4. Average yield, prevailing rates, gross return, cost of cultivation, net return and cost benefit ratio of various (sole) crops grown in Indo-Gangetic plains during 1997–2000

Crop	Average yield (q ha^{-1})[a]	Wholesale rate (Rs q^{-1})	Economics of production (Rs ha^{-1})			Cost: benefit ratio
			Gross return[b]	Cost of cultivation[c]	Net return	
Paddy (rice)	44.6	500	22,300	10,200	12,100	1:1.2
Wheat	42.0	550	23,100	10,500	12,600	1:1.2
Potato	273.3	200	54,660	26,900	27,760	1:1.0
Lentil	14.7	1200	17,640	6,300	11,340	1:1.8
Mustard	15.2	1400	21,700	10,200	11,500	1:1.1
Millet	25.5	800	20,400	8,300	12,100	1:1.5
Pea	20.0	1000	20,000	9,000	11,000	1:1.2
Sugarcane	625.0	85	53,125	20,000	33,125	1:2.5
Ocimum (basil)	0.84[d]	20,000	16,800	5,000	11,800	1:2.4
Menthol mint (transplanted)	1.38[e]	36,000	48,960	15,000	33,960	1:2.3
Menthol mint (sucker grown)	1.49[f]	36,000	53,640	18,901	34,739	1:1.8

[a]Average of yields reported by the farmers; [b]Gross return has been calculated taking into consideration the then prevailing market (*anaj mandi*) price(s) of the crop (s) and actual monies accrued of sale to the farmers; [c]Includes manday costs of both family and hired labour engaged, cost of tillage, weeding, irrigation, fertilizer, pesticide when applied and harvesting and post harvest value addition where applicable; [d–f]Although multiple cuts can be taken, values were based on single harvest by the farmer.

in the following order of profitability: *Ocimum*–potato–mint and rice–potato–mint (74 K) > rice–wheat/legume/*Brassica*–mint and *Ocimum*–*Brassica*–mint (57–58 K) > millet–mint (47 K). In the new systems being practised in this area in last 3 years, the farmers are taking rice or basil in the summer monsoon season, then short duration *Brassica* or potato in the *rabi* season, followed by mint in the *zaid* season, with profits in the range of Rs 55,000 to 75,000 ha^{-1} year^{-1} (55 to 75 K). Thus, the new crop rotations made possible by the availability of early maturing varieties of mints have more than doubled the yearly profits of farmers from a hectare of land from Rs 24,700 to 57,000 (25 K to 57 K). Further, the additional field work and need for field distillation of herbage harvested from mint and basil crops have substantially increased employment in areas of adoption of new crop rotational systems.

Future R&D and extension work should aim at development of rice, wheat and legume varieties that fit the new rotations suitably in wider areas of the Indo-Gangetic plains and at further spread of these technologies in the area. It appears that integration of a variety of short-duration medicinal and aromatic plants between the food grain crops can help in the production of high-value industrial raw materials for pharmaceutical, agri-chemical, food and cosmetic industries, in addition to the production of food grains in desired amounts. This kind of development is expected to sustain adequate food production, larger profits to farmers and promote growth of small-scale industries in larger numbers in towns and cities creating employment opportunities near the villages in large measures.

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