Theme 6 : Development of need based farming system models for different eco-systems

6.2 : Assessment and development of need based & site specific farming system models

6.2.1 Studies on cropping systems with emphasis on crop diversification for irrigated upland

(K.A. Singh(upto 19.01.2006) and A.K. Singh(w.e.f. 15.07.2006))

Studies on pre-rabi pigeon pea based cropping systems

Results revealed that mean yield of pre-*rabi* pigeon pea varied from 0.8 t/ha to 1.7 t/ha under different cropping sequences. Pigeon pea yield equivalence computed for 12 cropping sequences (treatments) showed highest values for wheat - elephant yam + black gram system (7.8 t /ha) followed by tobacco-maize - dhaincha (GM) system (7.1 t/ha). The highest net return was obtained in wheat - elephant yam + black gram (Rs. 83288/ha) followed by tobacco-summer maize - dhaincha (Rs.76747/ha). The highest benefit cost ratio was recorded under mustard - green gram - black gram (1.4) followed by tobacco - maize - dhaincha (GM) and wheat - elephant yam + black gram system.

Pre-rabi pigeon pea based cropping systems

Studies on winter maize based diversified cropping systems

Yield of winter maize varied from 2.3 to 5.2 t/ha under winter maize based cropping system. Winter maize yield equivalence computed for 15 treatments showed highest value for tobacco-summer maize - dhaincha (GM) system followed by maize + potato - green gram- sesame, maize + potato - black gram + elephant yam, and maize + potato - green chilies, respectively. Explicitly, it was observed that where highly priced tobacco, sesame, potato, green chilies, ladies finger and elephant yam were taken in the crop sequences, the equivalent yield was higher than the other treatments. The highest net return was observed (Rs. 71113/ha) from tobacco - summer maize - dhaincha (GM), followed by Rs. 69721/ha under maize + potato - green gram - sesame, Rs. 63477/ha under maize + musukdana and Rs. 61122/ha

under maize + potato - green chillies. The benefit cost ratio was highest (5.4) under winter maize intercropping with musukdana followed by 3.5 under maize + ashwagandha, 2.7 under maize + lemongrass, 2.2 under maize + *Menthe arvensis* and maize + pipli, respectively

Winter maize based diversified cropping systems

6.2.2 Development of diversified cropping systems for irrigated ecosystem in Bihar

(R.D. Singh, N. Chandra, Shivani and S.K.Singh)

A field experiment was conducted in randomized block design replicated thrice at Sabajpura farm during 2005-06 to develop a suitable cropping system by introducing pulse/oilseed/vegetables as second or third crop in ten rice based cropping systems. All the recommended management practices were followed during different cropping seasons.

Two-crop cycles for all the cropping systems have been completed and yield of different crops converted in terms of rice. Rice yield equivalence revealed that during second year of experimentation, there were significant variations among cropping systems. Maximum yield equivalence was recorded in rice-potato-onion (37.2 t/ha) followed by rice-carrot-cowpea (33.2 t/ha), rice-coriander-lady's finger (29.8 t/ha), rice-tomato-bottle gourd (29.4 t/ha) and rice-mustard-tomato (25.2 t/ha), respectively.

Diversified cropping system

Maximum net profit was recorded in rice-carrot-cowpea (Rs. 1, 20,144/ha), followed by rice-potato-onion (Rs. 1,14,508/ha), rice-coriander-lady's finger (Rs. 1,01,788/ha) and rice-mustard-tomato (Rs. 81,211/ha), respectively. Among rabi crops capsicum in rice-capsicum-cucumber could not bear fruit due to high temperature during winter months and similar was the case with bitter gourd during summer season in rice-cabbage-bitter gourd. This may be because of late sowing of bitter gourd and high temperature during cropping season. Vegetable dominated cropping systems were found to be more remunerative than the cereal and pulse dominated cropping systems (Table 18).

Diversified cropping system

Soil analysis indicated that there was increasing trend of average nutrient status such as EC, organic carbon, available nitrogen and available potash except available phosphorus after completion of second crop cycle as compared to first crop cycle but the variation was non-significant. There was only significant variation in available nitrogen after second crop cycle. It has been observed that there was buildup of organic carbon, available nitrogen, available phosphorus and available potash in most of the cropping systems after completion of second crop cycle because of added nitrogen, phosphorus, potash, litter falls and addition of organic matter through underground portion of rice and other crops in the systems. Generally, 10-15 per cent of top portion of dry matter per sq. meter is added to the soil every season. Apart from this, recommended dose of nitrogen is being added to all the crops but only 40- 50 per cent is made available to the crop and remaining nitrogen is fixed in the soil. This may be the reason for building up of organic carbon and available nitrogen in the soil. Available phosphorus and potash have decreased from initial status of soil in almost all the cropping systems because of vegetable dominated cropping system; whose phosphorus and potash requirement is more than cereals and pulses dominated crops in the system (Table 19).

In third crop cycle rice has been taken. Analysis of growth and yield parameters revealed that there was non-significant variation among different growth and developmental characters of rice. When pulses were taken prior to rice it had a beneficial effect on succeeding crop.

Table 18 : Yield equivalence in terms of rice, net-return, cost of production and benefit cost ratio in different cropping systems (2005-06)

Cropping systems	Yield equivalence of different crops (t/ha)			Rice yield equiv-alence	Cost of culti-vation (Rs./	Net return (Rs/ ha)	Cost of produce (Rs/ kg)	Benefit cost ratio
	Kharif 2005 2006	Rabi 2005-06 (t/ha)	Sum-mer ha)					
Rice - Wheat - Black Gram (C_1)	4.4	5.4	3.4	1.3	54445	18320	4.1	0.3
Rice - Capsicum - Cucumber (C_2)	4.3	Nil	9.0	1.3	61608	11872	4.6	0.2
Rice - Carrot - Cowpea (C_3)	4.3	15.5	13.4	3.3	62401	120144	1.9	1.9
Rice - Mustard - Tomato (C_4)	4.1	4.9	16.2	2.5	57664	81211	2.3	1.4
Rice - Potato - Onion (C_5)	4.3	17.7	15.2	3.7	89982	114508	2.4	1.3
Rice - Cabbage - Bitter Gourd (C_6)	4.2	11.8	Nil	1.6	53671	34164	3.4	0.6
Rice - Coriander - L. Finger (C_7)	4.6	5.0	20.2	3.0	62057	101788	2.1	1.6
Rice - Tomato - Bottle Gourd (C_8)	4.8	16.4	8.2	2.9	84536	77219	2.9	0.9
Rice - Pea - Green Chilli (C_9)	4.6	4.2	2.2	1.1	36629	24036	3.3	0.7
Rice-Lentil-Sponge Gourd (C_{10})	4.7	5.8	11.6	2.2	52605	68945	2.4	1.3
Sem (±)	0.2	0.5	-	0.5	-	-	-	
C.D. at 5%	0.5	1.4	-	1.5	-	-	-	-

Cost of rice considered as Rs. 5500/t for converting yield of different crops to the rice yield equivalence

Table 19 : Changes in chemical status of soil after second crop cycle (2005-06)

Treatment	pH	EC	Organic Carbon (%)	Available Nitrogen (kg/ha)	Available Phosphorus (kg/ha)	Available Potash (kg/ha)
Initial status of nutrients in the soil	**7.3**	**0.2**	**0.5**	**253.0**	**31.2**	**394.0**
Average nutrient status of experimental site after first crop cycle	**7.6**	**0.1**	**0.7**	**232.3**	**22.2**	**207.1**
Rice - Wheat - Black Gram (C_1)	7.6	0.2	0.5	324.0	24.5	224.0
Rice - Capsicum - Cucumber (C_2)	7.4	0.2	0.8	300.3	27.0	240.8
Rice - Carrot - Cowpea (C_3)	7.6	0.3	1.2	271.8	21.7	241.7
Rice - Mustard - Tomato (C_4)	7.5	0.2	0.8	292.7	22.8	223.6
Rice - Potato - Onion (C_5)	7.3	0.2	0.7	313.6	26.3	250.1
Rice - Cabbage - Bitter Gourd (C_6)	7.6	0.1	1.0	482.2	24.0	220.3
Rice - Coriander - L. Finger (C_7)	7.5	0.1	0.7	261.3	23.5	221.2
Rice - Tomato - Bottle Gourd (C_8)	7.7	0.2	0.6	324.0	23.0	205.0
Rice - Pea - Green Chilli (C_9)	7.7	0.1	0.5	303.1	21.3	236.1
Rice - Lentil - Sponge Gourd (C_{10})	7.5	0.2	0.8	318.8	20.6	223.1
Average nutrient status of experimental site after second crop cycle	**7.5**	**0.2**	**0.8**	**319.3**	**21.2**	**228.6**
SE m (±)	0.1	0.04	0.3	62.3	2.9	10.4
CD at 5%	NS	NS	NS	185.1	NS	NS

6.2.3 Development of sustainable agro-forestry model for acid soils of Chotanagpur plateau

(P. Dey, A.K. Sikka, S. Kumar, Bikash Das and R.K. Singh)

Growth of MPTs in acid soil

Maximum height (4.7±0.7 m) and diameter at breast height (DBH) (6.2±1.2 cm) was recorded in subabul. Minimum variation in height (CV=8.2 per cent) was recorded in *Flamingia semialata* whereas minimum variation in DBH (CV= 14.3 per cent) was recorded in siris. Among the MPTs planted in the border rows, *baken* (*Melia azetarach*) attained maximum height and girth. Incorporation of arhar (*Pigeon pea*) in the basin of chandan increased the survival of chandan significantly.

Growth of MPTs developed in 1st phase

	Gamhar *(Gmelina aeborea)*		Teak *(Tectona grandis)*		Shisham *(Dalbergia sissoo)*		Kala shisham *(Dalbergia latifoliaa)*	
	Height (m)	DBH (cm)	Height (m)	DBH (cm)	Height (m)	DBH (cm)	Height (m)	DBH (cm)
Average	4.0	5.4	3.4	3.5	3.6	4.5	2.3	3.3
SD	0.6	1.1	0.5	0.6	1.6	1.6	0.4	1.3
Range	2.1-6.0	2.9-7.4	2.5-4.5	2.3-4.6	1.1-5.3	1.1-7.2	1.5-3.3	0.3-5.1
CV (%)	22.0	20.4	15.2	17.5	34.9	34.9	16.6	40.7

	Soapnut *(Abutilon concinna)*		Siris *(Albizia lebbek)*		Aonla *(E. officinalis)*		Arjun *(Terminalia arjuna)*	
	Height (m)	DBH (cm)	Height (m)	DBH (cm)	Height (m)	DBH (cm)	Height (m)	DBH (cm)
Average	1.8	1.6	3.2	3.8	3.8	4.7	2.5	1.6
SD	0.4	1.4	0.4	0.5	0.4	1.0	0.2	0.4
Range	1.2-2.5	0.5-6.1	2.2-3.7	3.0-4.8	3.1-4.5	2.2-6.60	2.1-2.9	1.0-2.5
CV (%)	19.5	86.2	12.3	14.3	10.2	22.3	8.5	23.2

	Subabul *(Leucaena leucocephala)*		Karanj *(Derris indica)*		Chandan *(Santalum album)*		Neem *(Azadirachta indica)*	
	Height (m)	DBH (cm)	Height (m)	DBH (cm)	Height (m)	DBH (cm)	Height (m)	DBH (cm)
Average	4.7	6.2	2.4	1.7	3.1	3.8	2.7	2.7
SD	0.7	1.2	0.4	1.5	0.4	1.0	0.5	1.2
Range	3.6-6.0	4.1-8.7	1.7-3.4	0.1-7.3	2.5-3.9	2.2-6.2	1.9-3.6	1.2-7.6
CV (%)	14.5	19.8	16.8	89.1	13.5	26.6	17.7	45.6

	Mahua *(Madhuca indica)*		Bel *(Aegle marmelos)*		Ber *(Ziziphus mauritiana)*		*Flamingia semialata*	
	Height (M)	Girth (cm)	Height (m)	Girth (m)	Height (m)	DBH (cm)	Height (m)	DBH (cm)
Average	1.9	2.00	0.7	2.1	2.4	1.6	2.3	1.6
SD	0.3	0.7	0.2	1.3	0.2	0.7	0.2	1.5
Range	1.6-2.8	0.9-4.2	0.4-1.5	0.3-6.1	1.9-2.7	0.5-3.3	1.9-2.6	0.5-6.0
CV (%)	15.7	34.0	30.1	60.1	8.2	42.3	8.2	93.1

Growth of MPTs developed in 2nd phase

	Khirni (*Malinkara Hexandra*)		Imli *(Tamarindus indica)*		Mulberry *(Morus alba)*	
	Height (m)	Girth (cm)	Height (m)	Girth (m)	Height (m)	DBH (cm)
Average	0.7	2.0	0.7	1.4	2.6	1.4
SD	0.2	0.5	0.2	0.4	0.3	1.0
Range	0.4-1.2	0.1-2.9	0.4-1.5	0.7-2.2	2.1-3.1	0.1-6.1
CV (%)	25.4	27.1	30.1	30.0	10.1	71.6

Incorporation of pigeon pea in the basin of chandan

Lac-based agroforestry model

Feasibility trial on mulberry intercropping in aonla

Five mulberry cultivars (S_1, S_{1635}, C_{1730}, MR_2, RFS_{175}) were tested for their suitability as intercrop in grown up aonla orchard at 0.91x 0.91 m spacing (8 rows of mulberry in between two rows of aonla). Maximum average height was recorded in mulberry cv. MR_2 (3.6 m), followed by RFS_{175} (3.5 m). Average leaf weight of different mulberry cultivars followed the order: S_1>S_{1635}>MR_2>C_{1730}>RFS_{175}; the weight of fire wood including twigs followed the order: MR_2>S_1>RFS_{175}>S_{1635}>C_{1730}. The yield of aonla was not affected due to intercropping of mulberry. Organic carbon was higher in mulberry intercropped plots than that of solo aonla plot. Highest organic carbon (0.7 per cent) was observed in mulberry-intercropped plot (cv. MR_2). Lowest organic carbon was noticed in solo aonla crop (0.4 per cent). Available P and K did not show marked difference in mulberry intercropped or solo aonla plots.

Mulberry intercropping in aonla orchard

Collection, conservation and characterization of bamboo species

Total number of clums per clump was highest in *Bambusa tulda* var. Taral (*Taral bans*) followed by *Gigantochloa atraviolacea*. Circumference of clump was biggest in *Dendrocalamus membranaceus* followed by *Bambusa tulda* var. Taral. The average length between 5th and 6th node was also largest in *Bambusa tulda* var. Taral followed by *Bambusa balcoa* (*Guri Vulki*) and *Bambusa vulgaris* (*Basni bans*). Average total number of internodes and girth of culm between 5th and 6th node was highest in *Bambusa balcoa* (*Guri Vulki*) while it was lowest in *Gigantochloa atraviolacea*. Flowering was observed in *Dendrocalamus strictus* in the month of December, 2006.

Growth parameters of bamboo species								
Parameter	**Bamboo species**							
	Bambusa balcoa	***Bambusa vulgaris***	***Bambusa tulda var.* Taral**	***Dendroc-alamus membrana Ceous***	***Bambusa balcoa* (Plus tree)**	***Dendrocal-amus strictus***	***Gigantochloa atraviolacea***	***Unknown species***
Total no. of culms per clump	4.3	7.2	23.0	7.8	3.0	6.0	17.9	9.6
Circumference of clump (m)	1.4	1.4	1.7	2.0	1.1	0.9	1.0	0.9
Number of internodes in a culm	36.3	27.8	23.7	32.6	34.0	20.7	16.8	21.0
Average girth of culms (cm)	3.8	2.4	2.6	2.0	3.4	1.7	0.6	1.0
Length between 5th and 6th node (cm)	20.2	20.1	29.9	15.7	20.0	24.6	12.7	15.6