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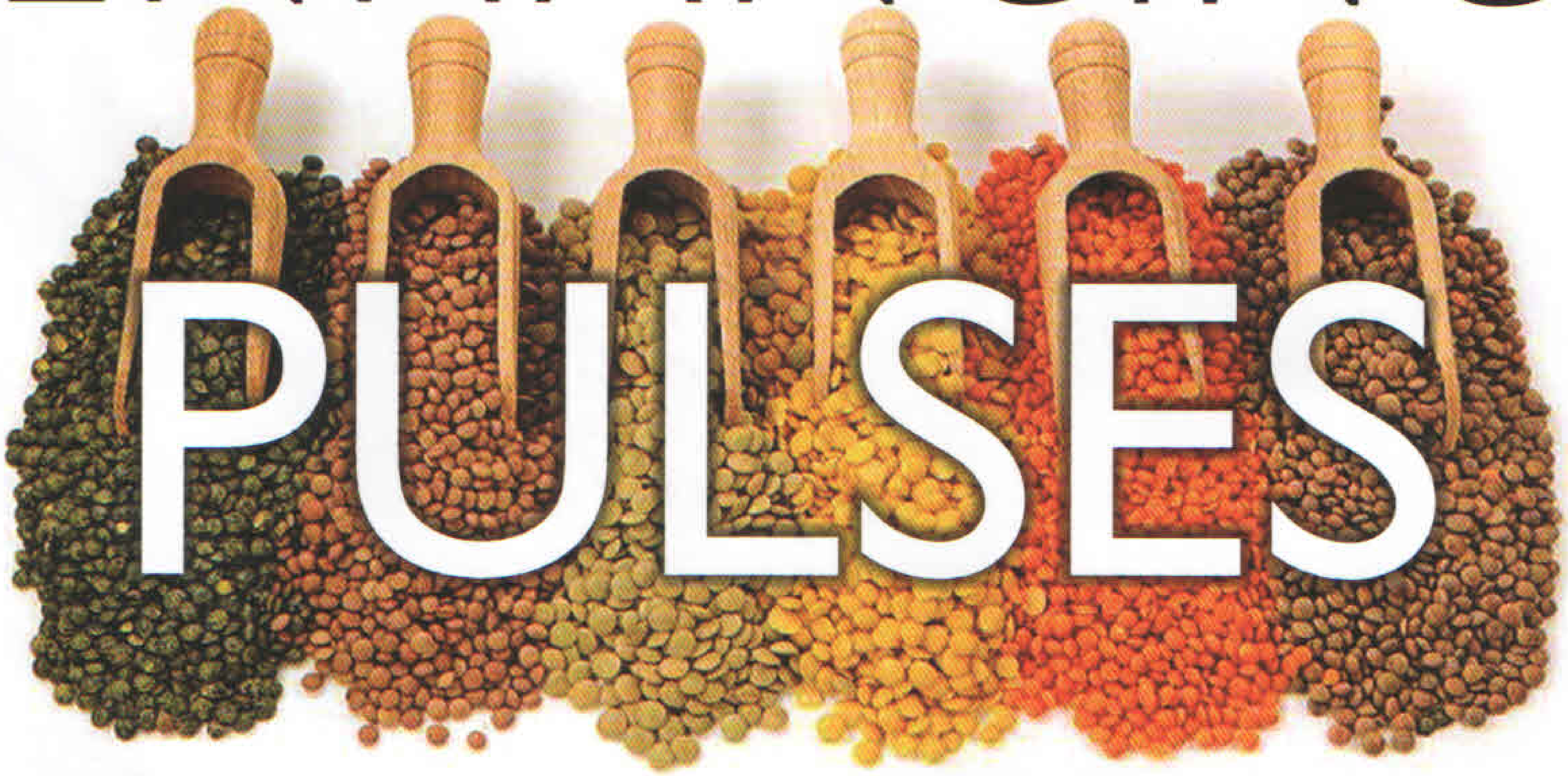

PULSES

PRODUCTION

Technologies & Strategies

Babooji Gangwar

Anil Kumar Singh

Enhancing Pulses Production

Technologies and Strategies

Edited by :

Babooji Gangwar

Project Director
Project Directorate for Farming Systems Research
Modipuram, Meerut -250110
Uttar Pradesh

and

Anil Kumar Singh

Vice Chancellor
Rajmata Vijayaraje Sciendia Krishi Vishvwa Vidhyalaya
Gwalior - 474002, Madhya Pradesh

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Islands

N. Ravisankar[1], B. Gangwar[2], T.P. Swarnam[3], S.K. Zamir Ahmed[4] and N. Bommayasamy[5]

[1]Principal Scientist (Agronomy), [2]Project Director, Project Directorate for Farming Systems Research, Modipuram, [3]Senior Scientist (Agronomy), [4]Senior Scientist (Agricultural Extension), [5]Subject Matter Specialist (Agronomy), Natural Resource Management Division, Central Agricultural Research Institute, Port Blair-744 101, A&N Islands

The geographical area of the union territory of Andaman and Nicobar Islands is 8, 24,900 ha with 86.9 % of it under reserve and protected forests. The humid tropical climate that prevails in the Andaman and Nicobar islands provides a unique opportunity to grow various crops. Owing to a number of factors, hardly 4.8% of the area is under cultivation. Maximizing the productivity and farm income mainly depends on effective management of natural resources like rain, soil, land as well as labour present in the Island ecosystem. On an average, the Islands receive 3074 mm of rainfall distributed over 8 months. The rainfall is intense from June to September and may have even up to 30 rainy days per month sometimes, however, from January to April, the rainfall is scanty or absent, particularly in March. The undulating terrain results in severe water crisis during the period which is aggravated by higher evapotranspiration. The Islands receive south-west monsoon from May to September and north-east monsoon during October to January. The topography of A&N Island is undulating with a stiff terrain exposed to soil erosion due to heavy rainfall. The crop growing season can be divided in to two major seasons *viz.,* wet and dry seasons. The wet season is usually from May to November receiving annual average rainfall of 2789.9 mm leading to water logging in the low lying areas. Even in the upland areas, the soil remains in saturated conditions throughout the season which forces farmers to grow only paddy crop in most of the area and sugarcane in limited areas. Dry season falls between

December - April which receives an annual average rainfall of 284.4 mm only in which pulses like blackgram and greengram are grown on the islands.

Soil Resources

The soil type of Andaman and Nicobar Islands ranges from sandy clay to sandy loam. These have developed under the dominant influence of vegetation and climate over diverse parent material. The uplands under forest cover are intensely leached, but runoff is very high, wherever forest cover has been removed completely. The valley floors comprise of depositional landforms and have been termed as low lands and have developed from the out wash of parent material from the surrounding hills. These soils are medium to heavy textured and moderately well drained and subjected to seasonal fluctuations in ground water. Most of the soils of these islands have medium to high organic matter status indicating that the organic carbon is >0.5% (Ganeshamurthy *et al.*, 2002). Parts of south and middle Andaman have low organic carbon status mainly because of severe erosion of the surface soil caused due to extensive deforestation and complete neglect of the deforested area. In general, soil fertility analysis indicates medium in available N, low in both available P and K.

Importance of Pulses in Islands

Indian diets are changing from grains to grams and greens. As stated earlier, Andaman and Nicobar Islands have heavy rainfall from May - December in which paddy is the main crop. Presence of light textured soil in islands leads to short time availability of moisture for rice fallow crops. Short duration pulses *viz.*, Black gram and Greengram can be grown successfully in the residual moisture. During the course of experimentation on pulses at Central Agricultural Research Institute, Port Blair, several technologies have been evolved which can lead to the increase in area, production and productivity of pulses. However, the productivity of the pulses remained almost static in the Islands (Table 1). The scope of increasing the productivity exists with the available technologies. The production can be increased by at least 1.5 times if proper post harvest practices and handling are adopted. The pulses produced from the Islands are not processed as such due to lack of processing facilities. The raw products are exported to either Kolkata or Chennai and then processed products are again imported to Islands. This causes two dimensional loss to the farmers as well as consumers due to cost of transportation of raw as well as processed products. Trend in production of pulses in the Islands during previous three years are given in Fig 1. Blackgram and Greengram are the two major pulses grown in the Islands. Projected demand of pulses in 2011 and 2021 are given in Table 2.

Table 1 : Area, production and productivity of pulses (Blackgram and Greengram) in Islands

Year	Area (ha)	Production (t)	Productivity (kg/ha)
2006-07	726	400	550
2007-08	2093	1369	650
2008-09	2119	1154	540

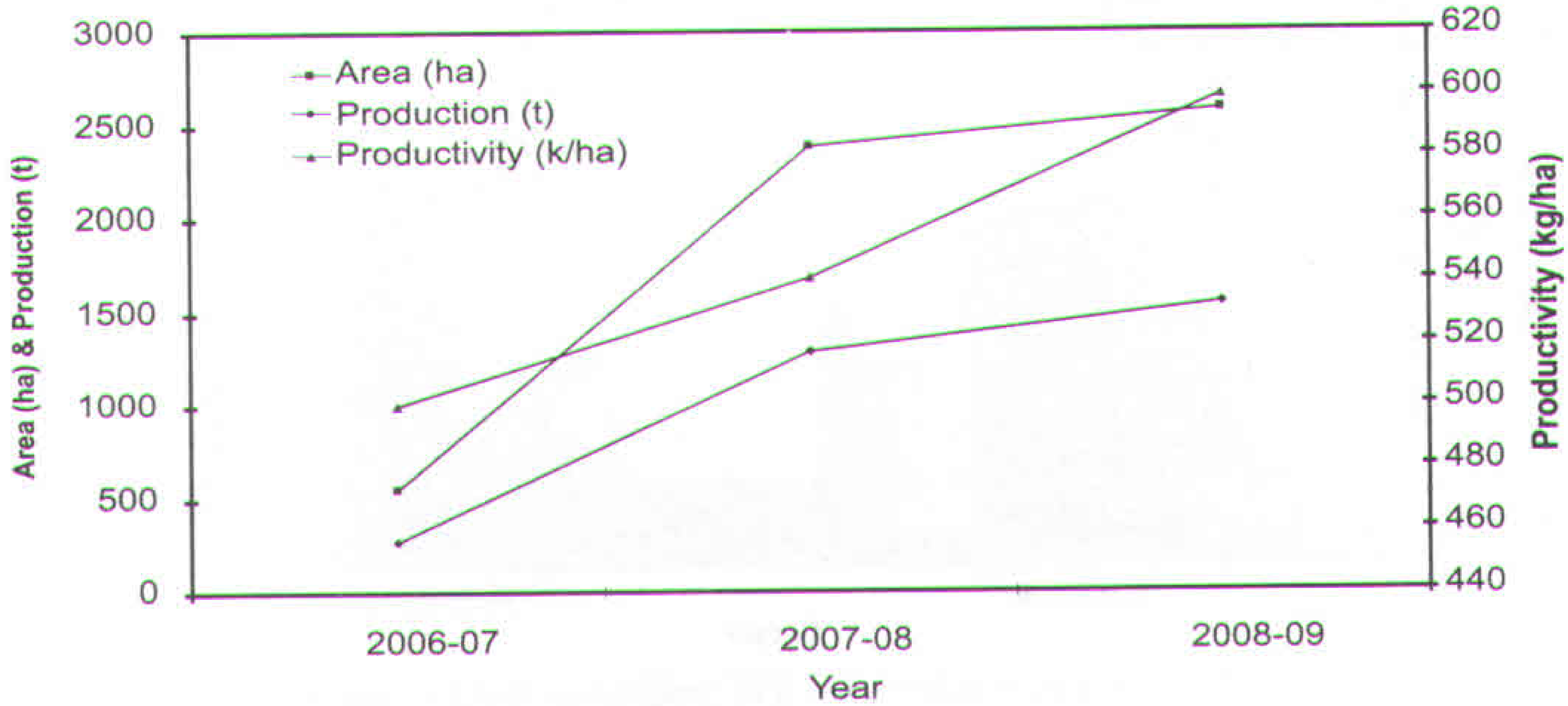

Fig 1 : Trend in pulses production in Island

Blackgram and greengram are highly suited for the Islands and at Central Agricultural Research Institute, Port Blair, several experiments have been conducted to develop package of practices for pulses under various cropping systems.

Table 2 : Projection of demand of cereals, pulses and oilseeds for Islands based on growth of population

Commodity	Present (2009-10)			Demand	
	Production (t)	Demand (t)	Deficit (t)	2011	2021
Cereals	13772	73295	59523	76596	95746
Pulses	280	4465	4185	4666	5832
Oilseeds	15	6150	6135	6427	8033

(Andaman and Nicobar Administration, 2005; 2006)

Yield gap in Blackgram and Greengram

Analysis of achievable and actual on-farm yield of blackgram and greengram indicates that there is a yield gap of 370 and 540 kg ha $^{-1}$ (Fig 2) in blackgram and greengram, respectively. It is expected that with the same area of cultivation (2119 ha), the production of pulses in the islands can be increased to 2118 t from the present level of 1154 t by bridging the yield gap through adoption of scientific package of practices.

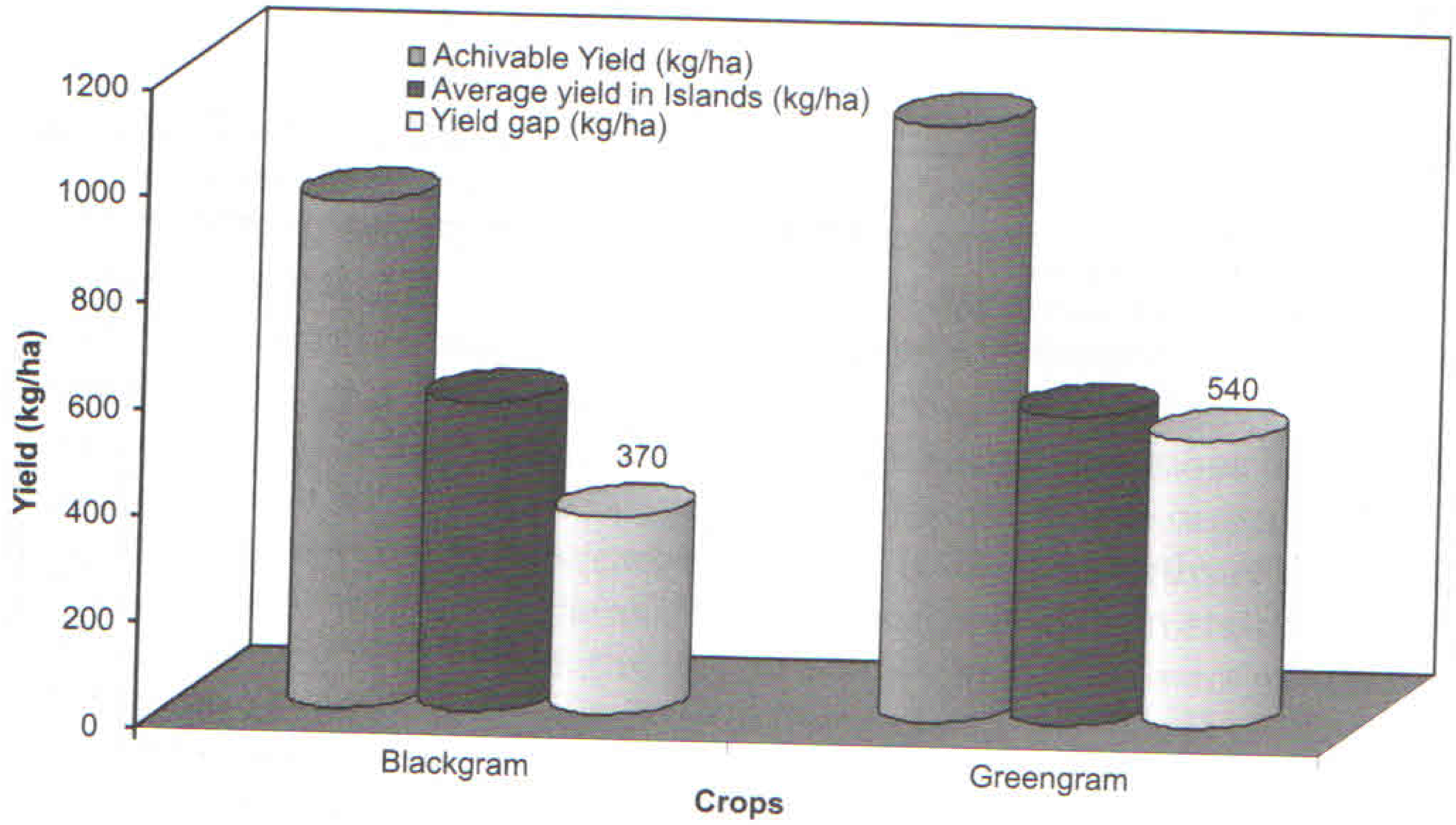

Fig 2 : Yield gap in blackgram and greengram in A&N Islands

Major Constraints

The major constraints in cultivation of pulses in Island conditions are

- Shorter length of growing period for pulses due to heavy rainfall for eight months (April to December)
- Extended period of rainfall in December does not allow soil to dry to take up the timely sowing
- Water stress during the peak and critical stages of the crop growth
- Unexpected and heavy downpour of unseasonal rainfall in dry season affects the growth and development of crops
- Timely availability of seeds of short duration varieties
- Unexpected early onset of rainfall in March or April when the crop is in maturity stage
- Maintenance of poor population due to broadcasting method of sowing
- Lack of proper intercultural operations like weeding, nutrient application etc
- Lack of post harvest processing facilities like Dal mills etc in the Islands
- Lack of procurement centres /policy in the Islands for pulses

Performance of Cropping Systems Involving Pulses

Performance of cropping systems involving pulses have been experimented from 1978 onwards at the Islands (Annual Report 1978 to 2006-07) and the gist of the same is presented. Six sequences of cropping *viz.*, Paddy (Jaya), Paddy (Ratna)-Pulse (Blackgram T-9), Paddy (Bala)-Rice bean (K_1), Paddy (CR-126-42-1)-Til (Vinayak), Paddy (Indira)-Mustard and Paddy (Jayanti)-Dhaincha were evaluated for yield potential. It is seen that crops like black gram, sesame, rice bean and dhaincha can be profitably grown after the harvest of first paddy crop under rain fed conditions. Among the varieties tried in first crop, the highest yield was recorded with CR-126-42-1 (32.3 q/ha) (Table 3). The yield of rice at different levels of nitrogen application after different preceding crops were estimated by using quadratic production function. The data revealed that there was significant increase in yield under different preceding crops over control. The maximum yield of rice was 44.4 q/ha followed by 42.5 and 42.0 q/ha when preceding crops were blackgram, maize and sesame, respectively. The optimum doses of nitrogen application for the rice were 87.4, 101.4 and 123.9 kg/ha when grown after black gram, maize and sesame respectively (Tables 4 & 5).

Table. 3 : Yield of different cropping sequences under rainfed conditions

Treatment	Yield (q/ha)	
	First crop	Second crop
Paddy (Jaya)- Monocrop	28.9	-
Paddy (Ratna)- Black gram	31.6	5.6
Paddy (Bala) - Rice bean (K_1)	31.6	450 (green fodder)
Paddy (CR-126-42-1)- Sesame (Vinayak)	32.3	3.5
Paddy (Jayanti) - Dhaincha	20.7	400 (green fodder)

Table 4 : Production functions of rice in relation to crop sequences and levels of nitrogen application

Name of previous crop	Production functions	R^2
Blackgram	Y =28.2584+3.3852X-0.1772X2	0.8936
Sesame	Y = 23.0708+3.0614X-0.1234X2	0.8008
Maize	Y = 26.9271+3.0903X-0.1506X2	0.8993

X = Rate of nitrogen (kg/ha), Y = Yield of crop (q/ha)

Table 5 : Total yield of rice (q/ha) under different preceding crops

N Levels (kg/ha)	Previous crops		
	Blackgram	Sesame	Maize
0	28.3	23.1	26.9
30	36.3	31.1	34.8
60	42.2	37.0	40.1
90	44.4	40.6	42.5
120	43.4	42.0	42.3

Significant increase in grain and straw yield of blackgram and cowpea were recorded where drainage was provided (Table 6). It is interesting to note that grain and straw yield of maize was less where black gram or cowpea were inter-cropped without providing drains. This is because the drainage and outflow of excess water from maize field was slowed down due to presence of legumes resulting into temporary water logging which had distinct harmful effect on maize. This was not true where drains were provided.

Table 6 : Effect of surface drainage on blackgram and cowpea

Treatment	Maize (q/ha)		Black gram (q/ha)		Cowpea (q/ha)	
	Grain	Stover	Grain	Stovr	Grain	Stover
Pure Maize without surface drains	10.3	53.0	-	-	-	-
Pure Maize with surface drains	22.8	67.5	-	-	-	-
Maize + Black-gram without surface drains	13.8	41.5	0.93	4.0	-	-
Maize + Black-gram with surface drains	31.9	81.5	4.28	10.0	-	-
Maize + Cowpea without surface drains	12.5	59.8	-	-	4.77	20.17
Maize + Cowpea with surface drains	21.2	77.8	-	-	5.16	21.00

Multiple cropping : Out of 56 farm families where emphasis was on field crops, 6 families were covered for multiple cropping. Rice was followed by Maize/Pulses/Oil seeds. The first short duration crop of rice (variety IET-4106) was transplanted in the last week of May and harvested in the last week of August. The second crop of rice (Variety-Bhavani) was transplanted in the same field in the middle of September and harvested in the last week of December. In the first crop, the average paddy yield was 42.7 q/ha while the second crop yielded 35.5 q/ha of paddy. Thus it was possible to obtain 78 q/ha from the same land under double cropping of rice. In upland areas, highest total grain yield of 98.7 q/ha was recorded in maize-rice-rotation followed by 89.3 q/ha in blackgram-rice-rice rotation. In lowland areas, after the harvest of rainy season long duration rice (CR-1009), maize, sorghum, greengram, sesame, and sorghum + cowpea (Forage) could be raised successfully in dry season with respective grain yield of 32.1, 15.8, 4.6, 6.0 and forage yield of 331.8 q/ha (Tables 7 & 8) (Gangwar *et al.*, 1991).

Table 7 : Highest, lowest and mean frequency distribution of yield and gross return over operating cost for various cropping sequence

Cropping sequence	No. of Demons -trations	Yield (q/ha)			Economics (Rs/ha)		
		Highest	Lowest	Mean	Gross Return Rs	Cost of produc -tion	Return over operating cost
Rice-rice-blackgram							
Rice	8	55.0	36.0	42.9	7224	3446	3778
Rice		48.8	30.0	37.3	6296	3390	2906
Blackgram		9.0	6.9	8.0	3168	1568	1600
	Total	112.8	72.9	88.2	16688	8404	8284
Rice-blackgram							
Rice	22	50.0	30.0	42.9	7182	3449	3733
Blackgram		9.0	6.3	8.2	3236	1563	1673
	Total	59.0	36.3	51.1	10418	5012	5406

Table 8 : Yield of pulses in various rotations

Crop rotation	Growing period	Yield (q/ha)	
		Grain	Straw
Rice-blackgram			
Rice	May-August	30.5	73.5
Blackgram	Dec / January- March / April	11.9	18.3
Rice-rice-blackgram			
Rice	May-August	33.9	69.2
Rice	September-December	29.8	67.0
Blackgram	January-April	13.2	22.4
Rice-rice-greengram			
Rice	May-August	37.9	77.1
Rice	September-December	38.2	79.3
Greengram	January-April	7.6	15.1

Another experiment involving 10 rotations using early, medium and long durations and C-14-8 as local check variety of rice with or without green leaf manuring before raising rice crop was repeated for the third consecutive year. In the experiment, instead of sorghum for fodder purpose and maize for grain purpose, were replaced with groundnut and maize for cobs respectively. All other treatments were same as during the previous years. On individual crop basis, maize for cobs purpose gave the highest net returns (Rs.16, 864/ha) closely followed by vegetable cowpea (Rs.15,600). Similarly the rotations involving these two crops gave distinctly higher returns (Table 9) mainly because of good market price. Though the cost of cultivation was comparatively higher in cases where three crops were raised during the year, the net returns were also good. However, the net returns can be increased considerably by raising vegetables in these rotations.

Table 9 : Yield of pulses q/ha in various rotations

Crop rotation	Rainy season		Dry season				Cost of cultivation	Net return
	1st crop (Rice) (May- August)		2nd Crop (Rice) (Sept. - Dec.)		3rd Crop (Jan.-April)		Rs/ha/yr	
	Grain	Straw	Grain	Straw	Grain	Straw		
Rice-fallow	43.3	80.2	-	-	-	-	2988	5111
Rice-Rice-Black gram	36.8	70.1	31.4	58.4	8.6	14.5	7656	9879
Rice-Rice-Cowpea (G)	43.0	81.3	36.0	61.6	18.7	34.6	7546	15680
Rice-Rice-Cowpea (veg)	45.8	87.2	36.6	62.2	30.0*	25.5	8206	16707
Rice-Rice-Cowpea (F)	42.0	78.4	32.1	56.4	-	261.7*	7106	9322
Rice-Rice-Greengram	36.8	85.6	34.9	62.3	8.3	16.1	7656	10690
CD at 5%	5.2	7.0	-	-	-	-	-	-

*Yield on fresh weight basis

Performance of Pulse Crops in Association with Sesame

Highest total grain was recorded when sesame was grown in association with blackgram in 2:2 ratio paired row system of planting (Table 10). On the other hand, it was found feasible to grow cowpea in alternate rows for forage purpose with minimum detrimental associative effect on sesame. Interestingly, considerable decrease in herbage yield of weeds was recorded when crops were grown in association. Even in case of main and associated crop of cowpea, where only one hand weeding was done at initial stages of crop growth, the herbage yield was less when compared with sesame alone. The weed infestation was found to be low when blackgram and greengram were grown with sesame in 1:1 ratio. Considering all the factors, raising of sesame with blackgram in 2:2 ratio for grain purpose and cowpea in 1:1 ratio for forage purpose appears to be better than other systems of intercropping (Gangwar and Singh, 1991).

Table 10 : Yield of pulses in association with sesame

Treatment	Yield (q/ha)		
	Sesame	Pulses (grain/forage)	Herbage yield
Sesame alone	2.24	-	5.80
Cowpea alone	-	96.53*	3.71
Blackgram alone	-	8.90	3.79
Greengram alone	-	3.42	3.70
Sesame + Cowpea (1:1)	2.04	91.15*	5.66
Sesame +Cowpea (2:1)	2.05	52.55*	5.70
Sesame + Cowpea (2:2)	0.98	59.36*	3.83
Sesame + Blackgram(1:1)	1.94	4.77	3.88
Sesame + Blackgram (2:1)	1.86	2.99	4.83
Sesame + Blackgram (2:2)	1.46	6.04	4.88
Sesame + Greengram (1:1)	1.76	2.18	3.33
Sesame + Greengram (2:1)	1.29	1.81	4.26
Sesame + Greengram (2:2)	1.14	1.85	3.63

*Fresh weight basis (harvested for forage).

Comparative performance of various cropping system involving pulses are presented in Fig. 3 which indicates that the net returns and B:C ratio were higher when blackgram was grown in residual soil moisture after either the traditional C14-8 variety of rice or improved high yielding long duration variety of rice namely Ranjit (Pramanik and Ravisankar, 2007).

Other General Observations on Cropping Systems Involving Pulses in Islands

- The agro-climatic conditions of the Islands are suitable for safely adopting rice based multiple cropping systems in valley areas.
- Rice–rice-pulse, particularly with cowpea for vegetable, was the most economic rotation giving more than Rs.10,000/- net return in a year. Rice-Rice-Blackgram with annual net return of about 8000/- was also good .
- Legumes in rotation with rice not only increased the productivity but reduced the nitrogen requirement (about 15 kg/ha) of following rice crop.

- Pulse and oil seed crops fit well in rice based cropping system and hence need encouragement.

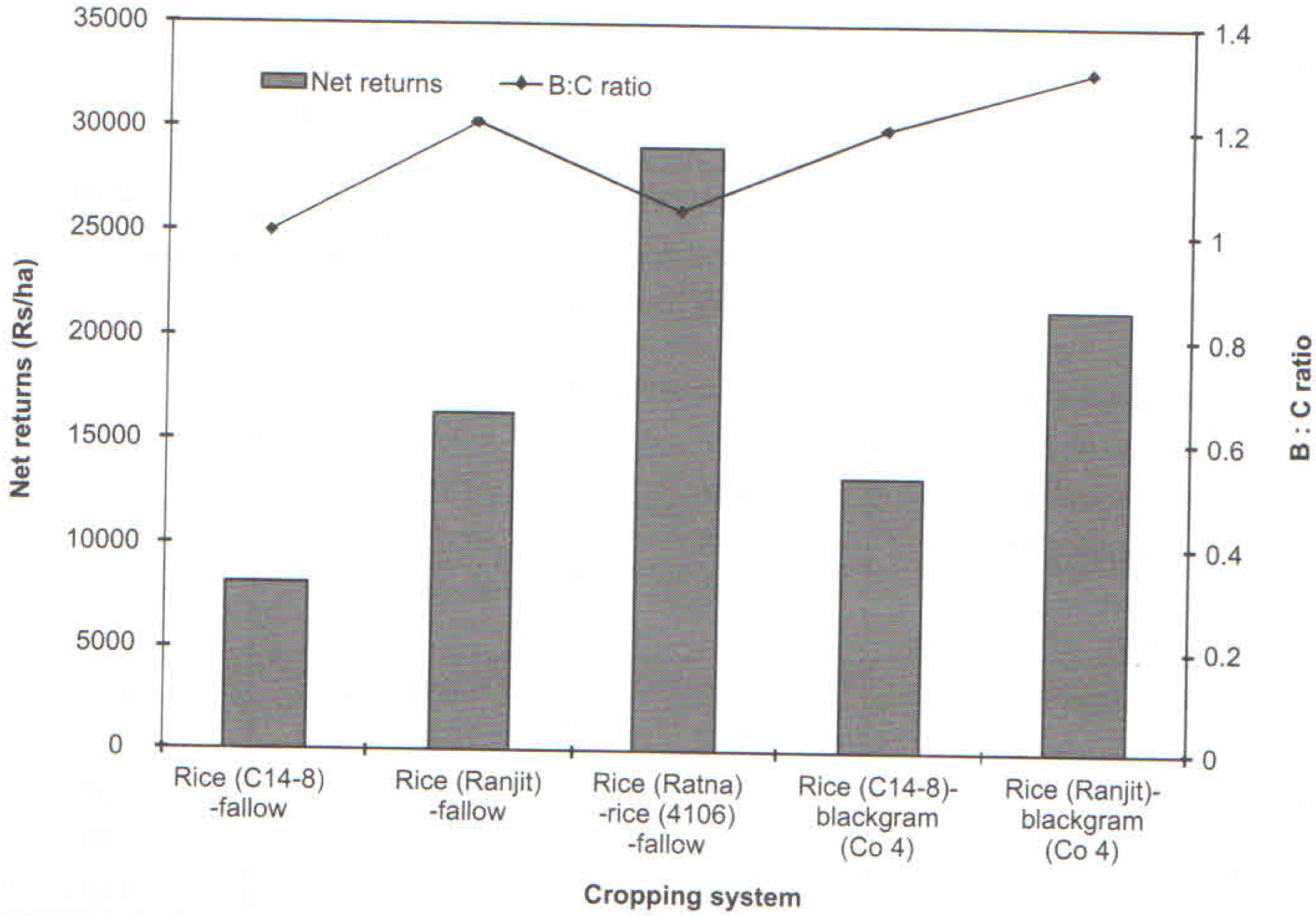

Fig 3 : Comparative performance of various cropping systems involving pulses

Package of Practices for Pulses

Blackgram

Varieties : There was a large variation in the yield of different black gram varieties (Table 11). Among the varieties evaluated, T9 registered significantly higher yield (0.95 t ha^{-1}) which is at par with TMV1 (0.94 t ha^{-1}). The other varieties namely, PDV1, Naveen and Co5, registered significantly lower yield compared to T9 and TMV1 under farmers field conditions. Significantly higher yield registered by T9 and TMV1 variety may be due to the tolerance of these varieties for drought in the later stages and short duration (< 80 days). Among the black gram varieties, T9 registered higher net returns of Rs. 19250.00 per ha, with B: C ratio of 4.24 followed by TMV1 registering the net return of Rs. 19150.00 with B:C ratio of 4.25. Higher net returns and B:C ratio of T9 and TMV1is attributed to higher grain yield recorded by these varieties. T9 variety of Black gram recorded higher out put energy of 13965 MJ followed by TMV 1. Energy efficiency was also higher with T9 in terms of conversion of input energy in to output energy. Specific energy is lower for T9 and TMV1 (0.78 and 0.79 MJ/kg) indicating that less energy is required by T9 and TMV1 varieties to produce one kg of grain. In another evaluation trial of four black gram varieties, viz. Pant U-30, Type -9 Pant U-19 and H-76-1 tried in R.B.D. with four replications under dry land conditions, the performance of Pant U-30 and Type -9 was observed to be better in visual estimation.

Table 11 : Yield and economics of black gram under participatory evaluation (pooled over 5 years i.e. 2001-02 to 2005-06)

Variety	Yield (t/ha)	Net Return (Rs./ha)	B :C Ratio
T9	0.95	19250	4.24
PDV1	0.87	17150	3.81
TMV1	0.94	19150	4.25
Naveen	0.85	16750	3.72
Co 5	0.77	14675	3.26
CD (P=0.05)	**0.02**	-	-

Seven cultivars of blackgram *viz* Co-3, Co-4, Co-5, KM-2, ADT-3, Type-9 and Pant-30, were sown after rice harvest in the second year of experiment in R.B.D and replicated four times. Among the six varieties compared, highest yield of 4.0 q/ha was recorded in Co-4 followed by Co-5 (Table 12). The lowest yield of 2.86 q/ha was recorded in variety KM-2. **The yield range of various varieties was low due to unusual cyclonic heavy rains in February, 1984.** In terms of productivity, highest grain of 5.05 kg grain/day/ha was recorded in variety Co-4 followed by Co-3 (4.1 kg/day /ha).

Table 12 : Yield of blackgram varieties

Variety	Yield (q/ha)	Days to maturity	Grain productivity (kg/day/ha)
Co-3	3.15	77	4.09
Co-4	4.04	80	5.05
Co-5	3.22	85	3.79
Km-2	2.86	76	3.76
ADT-3	2.98	76	3.92
Type-9	3.00	74	4.05

Planting density : Field experiments were conducted in rice fallows with greengram, black gram and cowpea using seed rate of 12, 20 and 28 kg/ha. Leaf water potential and net photosynthetic rate increased significantly up to a seed rate of 20 kg seed/ha in all the crops and ranged from 0.66 to 0.91 at 30 for blackgram (Table 13). Similarly the leaf water potential also varied from -6.2 to

-7.1 bars in blackgram at 30 days. In commensurate with these observations, the grain and straw yield of blackgram significantly increased up to a seed rate of 20 kg/ha and decreased further.

Table 13 : Effect of planting on yield and net photosynthetic rate of blackgram in residual soil moisture

Seed rates (kg/ha)	Relative leaf water content (-bars)		Net photosyn -thesis rate ($mg/m^2/sec$)		Yield (q/ha)	
					Grain	Straw
	30 DAS	50 DAS	30 DAS	50 DAS		
12	6.2	4.6	0.66	0.48	8.1	18.2
20	7.0	4.7	0.91	0.94	17.0	33.8
28	7.1	5.1	0.71	0.89	13.2	26.6
CD at 5%	-	-	-	-	3.3	3.6

Irrigation : The study on blackgram (T-9) comprised of seven irrigation treatments and four replications laid in a randomized block design. One and two irrigations of 2.5 and 5.0 cm depth were given at 25 and 45 days after sowing. The later irrigation corresponded with flowering and pod formation of the crop. Grain yield of blackgram, corresponding to different treatments, is given in Table 14. One light irrigation at 25 days after sowing or at flowering was at par with control. Significantly higher grain yields were obtained with one irrigation (5 cm depth) at flowering or 2 irrigations at 25 days and at flowering. Highest yield of 7.4 q/ha was obtained with one irrigation at flowering which is a critical stage in blackgram (Pramanik *et al.*, 2001).

Table 14 : Response of blackgram to depth and frequency of irrigation

Treatment	Grain yield (q/ha)
Control	5.8
One irrigation at 25 days with 2.5 cm depth	4.5
One irrigation at 45 days with 2.5 cm depth	5.2
One irrigation at 25 days with 5 cm depth	6.2
One irrigation at 45 days with 5 cm depth	7.4
Two irrigations at 25 & 45 days with 2.5 cm depth	7.2
Two irrigations at 25 & 45 days with 5 cm depth	6.6
C.D at 5%	1.8

Mulching : The experiment comprised of seven treatments in which black gram variety T-9 was evaluated. Three organic mulch materials equivalent to 10 q/ha were spread in between crop rows 10 and 30 days after sowing. The mulching treatment and grain yield of blackgram are given in Table 15. The data indicate that mulching at any stage invariably benefited the crop. However, early mulching had an edge over delayed application of mulch due to moisture conservation for longer duration. Control gave the lowest yield of 3.8 q/ha but yields of 6.2 to 6.6 q/ha were realized from mulching 10 days after sowing. The mulching materials did not differ significantly among themselves (Pramanik *et al.,* 2000).

Table 15 : Response of black gram to types of mulch and mulching time

Treatments	Grain yield q/ha
Control	3.8
Application of saw dust, 10 days after sowing	6.6
Application of forest leaves, 10 days after sowing	6.2
Application of paddy straw, 10 days after sowing	6.5
Application of saw dust, 30 days after sowing	6.8
Application of forest leaves, 30 days after sowing	5.8
Application of paddy straw, 30 days after sowing	4.7
C.D. at 5%	1.7

Nutrients : Application of 40 kg P_2O_5/ha along with 10 kg of N/ha was found to be better for obtaining higher yield of blackgram and also the yield of succeeding rice crop (Table 16).

Table 16 : Yield and yield attributes of black gram as influenced by NP levels

Treatments	No. of plants/m^2	No.of branches /plant	No.of pods /plants	Yield (q/ha)		Grain yield of succeeding rice crop (q/ha)
				Grain	Straw	
N_0P_0	9.0	1.6	19.4	6.1	17.0	16.1
N_0P_{90}	9.0	1.8	22.4	7.6	19.2	18.6
N_0P_{49}	8.5	2.2	22.5	7.8	20.6	20.0
$N_{10}P_0$	8.3	2.1	19.6	7.2	23.1	18.9
$N_{10}P_{20}$	7.8	2.0	21.9	8.4	20.0	18.6
$N_{10}P_{40}$	8.7	1.7	20.8	8.5	21.9	20.3
$N_{20}P_0$	7.8	2.1	22.4	6.7	18.3	19.2
$N_{20}P_{20}$	8.7	2.3	22.5	7.9	20.3	19.8
$N_{20}P_{40}$	8.0	2.1	22.9	8.2	19.2	22.2
C.D.at 5%	0.4	0.41	NS	0.76	NS	-

Greengram

Varieties : The performance of short duration high yielding greengram variety PDM 54 was evaluated on 10 farmer's field of South Andaman villages. Plant growth and yield attributes of greengram variety PDM 54 was higher than the local variety. PDM 54 recorded 66.7% (7.5 q/ha) higher grain yield than local variety (4.5 q/ha) (Table 17). The net return and benefit cost ratio was also significantly more with higher yielding variety. However, participatory assessment showed that variety with 60-75 days duration were more preferred by the farmers for safe harvesting of crop before onset of early monsoon (1st week of May) in these islands (Gangwar and Ahmed, 1991).

Table 17 : Performance of high yielding greengram variety in paddy fallows

Performance Indicator	Local variety	PDM 54
Plant height (cm)	32.5	50.5
Length of pod (cm)	5.3	7.8
Seeds per pod (no.)	9.0	11.0
Yield (q/ha)	4.5	7.5
Gross return (Rs./ha)	7200	12000
Net return (Rs./ha)	3700	7800
Benefit cost ratio	2.6	4.1

Pooled analysis of 5 years participatory evaluation of greengram varieties revealed the significant influence of varieties on yield under residual moisture. Among the varieties evaluated, PDM 54 registered significantly higher yield of 0.86 t ha^{-1} which is statistically at par with T44 (0.85 t ha^{-1}). Co5 also registered a yield of 0.80 t ha^{-1} compared to other varieties. Branching habit of PDM54 and T44 coupled with short duration (< 75 days) and stress tolerance mechanism of these varieties contributed to increased yield. Greengram varieties PDM 54 and T44 recorded higher net returns and B: C ratio (Rs. 17175 and Rs. 16850/ha and 3.81 and 3.74, respectively). Higher yield (farmers field conditions) registered by these varieties led to higher net returns and B:C ratio (Table 18).

Table 18 : Yield and economics of greengram under participatory evaluation trials (pooled over 5 years i.e. 2001-02 to 2005-06)

Variety	Yield (t/ha)	Net Return (Rs./ha)	B :C Ratio
T 44	0.85	16850	3.74
P 105	0.75	14250	3.16
PDM 54	0.86	17175	3.81
Co 5	0.80	15525	3.45
Narendra Moong	0.82	16100	3.57
PDM 11	0.73	13850	3.07
CD (P=0.05)	**0.03**	-	-

Eleven varieties of greengram, namely, Co-3, Co-4, ADT-2,PS-16,S-8, ML-65,ML-70,P-103,P-104 and P-105, were evaluated in R.B.D and 3 replications for two consecutive years. Among the varieties tested, P-105, ML-70 and Co-3 performed better in the order of their merit, with an average yield of 6.58, 6.29, 6.07 q/ha respectively (Table 19). The grain yield of these varieties was significantly higher to compared with varieties with non-significant difference among themselves. Lowest yield of 3.1q/ha was recorded in variety ADT-2. In terms of productivity, highest grain yield of 8.66 kg/day was recorded in variety P-105 while it was lowest in variety ADT-2 (4.04 kg/day).

Table 19 : Yield of greengram varieties

Variety	Grain yield (q/ha)	Days to maturity	Grain productivity (kg/day/ha)
Co-3	6.07	86	7.06
S-8	3.95	85	4.65
PS-16	3.86	76	5.00
ADT-2	3.11	77	4.04
ML-65	4.50	75	6.00
ML-70	6.29	75	8.38
P-101	3.95	90	4.39
P-103	5.12	76	6.74
P-104	5.76	90	6.40
P-105	6.58	76	8.66
CD at 5%	1.03	-	-

Planting density : Field experiments were conducted in rice fallows with greengram using seed rate of 12, 20 and 28 kg/ha. Leaf water potential and net photosynthetic rate increased significantly up to a seed rate of 20 kg seed/ha in greengram and ranged from 0.36 to 0.70 at 30 days in greengram (Table 20). Similarly the leaf water potential was observed to be –4.1 bars at 30 days. Corresponding to these observations, the grain and straw yield of greengram significantly increased up to a seed rate of 20 kg/ha and decreased further.

Irrigation : In order to optimize the supplemental irrigation (SI) schedule for different crops for getting maximum profit during dry season, field trials were taken up with different supplemental irrigation treatments (No irrigation, one, two, three and four supplemental irrigations and farmer's practice) and crops (maize, greengram, Sesame, chilli and okra). The supplemental irrigation had a significant effect on growth of greengram (Table 21). With respect to greengram, providing three supplemental irrigations (I_3) resulted in higher yield (340 kg ha^{-1}) compared to all other treatments.

Table 20 : Effect of planting on yield and net photosynthetic rate of greengram grown on residual soil moisture.

Seeds rate (kg/ha)	Ralative leaf water content (-bars)		Net photosyn -thesis rate ($mg/m^2/sec$)		Yield (q/ha)	
	30 DAS	50 DAS	30 DAS	50 DAS	Grain	Straw
12	4.1	3.6	0.36	0.74	8.9	26.8
20	4.4	5.0	0.70	0.93	11.2	42.5
28	5.6	5.2	0.51	0.86	10.1	33.8
CD at 5%	-	-	-	-	1.6	9.4

Table 21 : Yield of greengram with supplemental irrigation at critical growth stages

Supplemental irrigation stages	Yield (kg/ha)
Control	250
Flowering	276
Flowering and pod setting	295
Pre flowering (25 DAS), flowering and pod setting	340
Pre flowering (25 DAS), flowering, pod setting and early maturity	328
Pre flowering (25 DAS), flowering, pod setting, early maturity and maturity	304
CD at 5 %	25

Production technologies

Scientific packages developed and refined, can be adopted to realize higher yields and bridge the yield gap between on-station and on-farm conditions (Ravisankar *et al.*, 2008). The recommended package of practices for black gram and greengram in Island conditions are given in table 22.

Table 22 : Recommended package of practices for blackgram and greengram.

Cultural operation	Black gram	Greengram
Season	Dry season (Dec to April)	Dry season (Dec to April)
Sowing time	December or early January with in 10 to 15 days of cessation of rainfall	December or early January with in 10 to 15 days of cessation of rainfall
Varieties	Type 9	Pusa-105, Pusa-115 and ML-320
Soils	Well drained loamy and light soils	Well drained loamy and light soils

Contd.

Locations	South, Middle and North Andaman regions	South, Middle and North Andaman regions
Seed treatment	Treat the seeds with 5 g each of *Trichoderma viridie* and *Pseudomonas*/kg of seeds and or 3 g of Thiram or Captan /kg of seeds before sowing	Treat the seeds with 5 g each of *Trichoderma viridie* and *Pseudomonas*/kg of seeds and or 3 g of Thiram or Captan /kg of seeds before sowing
Seed rate	20 kg ha^{-1}	20 kg ha^{-1}
Spacing	30 X 10 cm	30 X 10 cm
Method of sowing	Line sowing	Line sowing
Intercropping	Sesame + blackgram in 2:2 ratio & Maize + blackgram in 1:1 ratio	Sesame + greengram in 1:1 ratio
Organic manures	12.5 t/ha of well decomposed FYM to be mixed with soil at least one week before sowing	12.5 t/ha of well decomposed FYM to be mixed with soil at least one week before sowing
Nutrient application	10:20:20 kg NPK ha^{-1} as basal application. Di Ammonium Phosphate (DAP) is preferred source for N and P.	10:20:20 kg NPK ha^{-1} as basal application. Di Ammonium Phosphate (DAP) is preferred source for N and P.
Weeding	One hoeing within 3 to 4 weeks of sowing	One hoeing within 3 to 4 weeks of sowing
Interculture operation	Small ridges and furrows after weeding to drain out excess water incase of heavy rain occurs during growth stage	Small ridges and furrows after weeding to drain out excess water incase of heavy rain occurs during growth stage
Mulching	Mulching with either paddy straw, saw dust and forest leaves at 10 DAS or 35 DAS to conserve soil moisture. Early mulching conserves moisture better.	Mulching with either paddy straw, saw dust and forest leaves at 10 DAS or 35 DAS to conserve soil moisture. Early mulching conserves moisture better.
Irrigation	One irrigation at flowering (45 DAS) with 5 cm depth should be give as it is the critical stage for the crop. If sufficient water is available, two irrigations at 25 and 45 DAS can be given with 2.5 cm depth of application.	Three irrigations at 25 DAS, 45 DAS (flowering) & 60 DAS (Pod setting) should be given as supplemental irrigation.
Foliar spray	2 % DAP (20 g/litre of water) at 55 & 65 DAS to improve the source-sink relationship	2 % DAP (20 g/litre of water) at 55 & 65 DAS to improve the source-sink relationship
Pest management	Hairy caterpillar and Jassids are major pests. Spray of 300 ml of Dichlorphos of 100 EC	Hairy caterpillar and Jassids are major pests. Spray of 300 ml of Dichlorphos of 100 EC in 400 lit of water ha^{-1} for

Contd.

	in 400 lit of water ha^{-1} for controlling aphids. Application of Carbofuran @ 10 kg ha^{-1} at the time of sowing is considered to be a preventive measure for checking major insects. If intensity of pest is more, 2 % Quinolphos can be applied.	controlling aphids. Application of Carbofuran @ 10 kg ha^{-1} at the time of sowing is considered to be a preventive measure for checking major insects. If intensity of pest is more, 2 % Quinolphos can be applied.
Disease management	Leaf spot and powdery mildew are major diseases reported in the Islands. Leaf spot can be controlled by 2 or 3 sprays of Zinc (2 %). The Powdery mildew can be controlled by 2-4 sprays of wettable sulphur @2-3 kg ha^{-1} in 100 litres of water.	Leaf spot and powdery mildew are major diseases reported in the Islands. Leaf spot can be controlled by 2 or 3 sprays of Zinc (2 %). The Powdery mildew can be controlled by 2-4 sprays of wettable sulphur @2-3 kg ha^{-1} in 100 litres of water.
Harvesting	The pods become black or brown on maturity in 75 to 85 days depending on variety. Staggered harvesting can be practiced by plucking the pods as soon as colour turns black or brown if no rainfall is expected during harvesting phase.	Plucking the pods can be done weekly or as soon as colour turns black or brown if no rainfall is expected during harvesting phase. After plucking of pods, plants should be ploughed in to the soil for enriching the soil fertility.
Yield	800 to 1200 kg ha^{-1} can be obtained with scientific package of practices	800 to 1200 kg ha^{-1} can be obtained with scientific package of practices

Contingency Measures

Delayed sowing due to excess moisture in soil

- Prefer early maturity varieties to avoid crop loss due to onset of rainfall during maturity
- Mulching with paddy straw

Excess rainfall during vegetative and flowering stage

- Excess standing water should be drained immediately after cessation of rainfall (draining of water will be easy if small ridges and furrows are made after first weeding)
- Application of starter dose of nitrogen @ 25 kg ha^{-1} should be done if yellowing symptoms are observed due to water logging.
- Spray of 2 % DAP can also be made to restore the crop from yellowing

Drought during vegetative and flowering phase

- Apply irrigation at critical stages (flowering) only depending upon water availability.,
- Reduce the plant population to 66 %.
- Mulching with paddy straw.

Rainfall during maturity phase :

- Uproot the entire plants and heap on elevated places.

Conclusion

Pulses play a critical role in food production and enhancement of soil fertility besides contributing towards reducing malnutrition. However, due to the various factors, production of pulses has reached plateau on the Islands. The present level of technologies available will make a significant contribution towards enhancement in production. In the Islands, black gram and greengram are fitting well with rice based cropping system and residual moisture. The production of pulses can be doubled by simply bridging the yield gap through scientific package of practices. The islands are having a deficit of around 3000 t at the present level of population which is going to increase to 5000 t in the next 10 years. Hence, proper policy on pulses needs to be developed for the islands with concerted efforts on technology demonstration, upgradation and refinement. The technology in terms of varieties and package of practices are to be developed with modern tools and equipments which can reduce drudgery in farming. Promotion of local small scale processing units in the islands are very much needed to enhance the farmer's profitability and encourage them to grow pulses.

Future Thrust

- Research efforts should be made to introduce perennial pigeonpea in the islands to harness excess moisture in the rainy season and moisture stress during dry season.
- Growing of pulses during rainy season in the bunds of rice field to be worked out with proper management practices.
- Identification of extra short duration (<50 days) varieties of pulses are required to be under taken to take benefit of shorter effective growing period in dry season.
- Small scale *dal* mills are to be introduced in the islands for post harvest processing and value addition.

- Scientific technology delivery through researcher managed experiments in farmers field.

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