CROP DIVERSIFICATION - KEY TO SOLVING PULSES CRISIS IN GUJARAT STATE

PATEL, B. S.,* B. M. PATEL, N. B. PATEL AND J.B.PATEL

AICRP ON INTEGRATED FARMING SYSTEMS
SARDARKRUSHINAGAR DANTIWADA AGRICULTURAL UNIVERSITY
SARDARKRUSHINAGAR-385 506, GUJARAT, INDIA

****E.mail: bspagron52@gmail.com***

Gujarat is situated on the west coast of India and boasts of a 1,600 km long coastal line. The Arabian Sea sweeps off the western and south western frontiers of the state. It is situated between 20^o 1' and 24^o 7' North latitudes and 68^o 4' and 74^o 4' East longitudes. Gujarat stretches from Kutch in the West to Daman in the South. In the East, lies the hilly region of the *Aravallis*, whereas lush green woods, hills, plains and rivers are found in the west. Rajasthan lies towards the Northeast of Gujarat, Madhya Pradesh to the east and Maharashtra to the southeast.

It even shares an international border with Pakistan, which lies on the Northwest side of the state. Apart from this, there is Gulf of Cambay, situated towards the Northeast of Gujarat. It exhibits a wide variety in the landforms. It has extensively fertile alluvial plains, semi deserts, marsh lands, grasslands, etc. the state has been also a major trade destination since the ancient times, due to its strategic location.

Gujarat state has been delineated into eight agro-climatic zones viz.,

(1) South Gujarat (heavy rainfall area)
(2) South Gujarat
(3) Middle Gujarat
(4) North Gujarat
(5) North West Gujarat
(6) North Saurashtra
(7) South Saurashtra
(8) Bhal and Coastal zone

State has an area of 1,96,024 km^2 representing 5.96 % area of the country. Total geographical area is about 196 lakh ha among this 105.57 lakh ha area is under cultivation accounting 53.68 per cent of total area. It is organized in 26 districts with 226 talukas. As per 2011 census, total population of 6,03,83,628 in the state represents about 4.99 % of population of India with a density of 308 as against the national average of 383 per km^2.

In terms of the standard climate types, tropical climate *viz.*, sub-humid, arid and semi-arid are spread over different regions of the state. The region in the extreme North comprising the district of Kachchh and western part of Banaskantha and Mehsana, the Northern fringe of Saurashtra and its western part have arid climate. The districts of Valsad and Dang in the extreme South of the state have sub-humid climate and rest of the state has semi-arid climate.

Present Scenario of Pulses in the State

Gujarat grows more than half a dozen of pulse crops on 7.84 lakh hectares area accounting for annual production of 6.09 lakh tonnes with a productivity of 777 kg/ha. Amongst these, pigeonpea, chickpea, greengram, blackgram, cowpea, mothbean and clusterbean are the important pulse crops grown in Gujarat. Mothbean, greengram and clusterbean are predominant pulse crops grown in arid region of North Gujarat, though other pulses are grown on sizable area.

Pulses are the cheapest source of protein and minerals (Ca, Fe, Cu & Mo) and compliment cereals proteins excellently particularly for lysine. Despite distinction of the largest producer, the availability of pulses is far from satisfactory, which is evident from the fact that per capita availability has not kept pace with the population increase and has attenuated to merely 28 g/capita/day as against the mandate minimum and optimum quantity of 80 and 104 g/capita/day, respectively, as per WHO standards (Panda, 2005). As a result, sharing 11 per cent of the world import, Gujarat is also the largest importer of the pulses. In Gujarat, the condition is still dismal (23 g/capita/day), though there are ample chances to improve the situation by inclusion of short duration of pulse crops in cropping systems. Rajmash, though it is an unconventional pulse crop introduced in North Gujarat has yield potential of around 35 q/ha. Similarly, Fieldpea is also a potential unconventional crop having yielding ability of around 40 q/ha. Hence, these new crops should be introduced in Gujarat as catch crop. Moreover, the farmers should be motivated to cultivate recommended high yielding varieties of each and every pulse crops, by means of transfer of technology (Acharya and Patel, 2010).

Trends of Pulses Production

Gujarat has diversified agriculture with good entrepreneur and business minding farming community with excellent policy support from the government. Gujarati as community is God fearing and predominantly vegetarian. The agriculture, in general, hovers around water availability and off late water resources have improved with linking of rivers and ambitious water recharging programmes like Sujalam Sufalam and construction of check dams as well as irrigation water availability from Sardar Sarovar Project etc. Still pulses that comprise about 9 per cent of the total cultivated area are predominantly grown as rainfed in *kharif* season. Productivity of pulses in the state hovers around 7 to 8 q/ha, that is more than India but far lesser than USA and China that harvest double around 15 q/ha (Acharya and Patel, 2010). The area under pulses is around 0.8 m ha. The area has shown increase particularly after 1980s and increase in production at present is around 0.6 million MT is primarily attributable area. Despite increase in area, the pulses have been marginalized to very poor growing situations. The major reason for the same is Bt cotton that has replaced pulses. The major concern is reduced cereals to pulses ratio that has come down to 15:1 from 5:1 in 1950s. Pigeonpea followed by green gram, chickpea, urdbean and mothbean are the major crops though cowpea, Indian bean and horsegram are also cultivated in some pockets. Cluster bean is cultivated in on around 0.2 m ha and Gujarat is the only state that has both sizable acreage and productivity. Limitation in the expansion of agricultural land suggests that increase in gross cropped area can come from multiple cropping. The state has well developed pulses and cluster bean industries apart from well established fair marketing system through APMCs.

Existing Cropping Systems of the State

In traditional cropping system practiced in Gujarat, there is yield stability at lower level adaptable to favorable and adverse agro-climatic conditions prevailing over the period of time. These cropping systems are adopted by the farmers considering the market price, family requirement and fodder requirement of the milch and draft animals. The existing cropping systems followed in Gujarat by the farmers are as under (Annual Reports, 2000-01 to 2010-11, AICRP on Cropping Systems, SDAU, Sardarkrushinagar).

North Gujarat Region

- Pearl Millet – Mustard (Predominant)
- Cluster bean – Wheat
- Castor – Fallow
- Cotton – Fallow

Middle Gujarat Region

- Tobacco-Summer Pearl Millet (Predominant)
- Pulses –Mustard/Wheat
- Tobacco-Fallow
- Paddy- Wheat
- Cotton – Fallow

South Gujarat Region

- Paddy- Summer Paddy (Predominant)
- Paddy- Summer Groundnut
- Sugarcane- Sugarcane ratoon (2 Years) - Banana - Vegetables (2 Years)

Saurashtra Region

- Groundnut- Wheat (Predominant)
- Groundnut- Onion / Garlic/ Coriander
- Cotton alone
- Groundnut- Pigeonpea / Castor relay cropping

The above mentioned cropping systems are widely adopted in different parts of Gujarat because of differential favorable agro-climatic conditions and socio-economic situation of the farmers, but yield level is low. Therefore, it is the need of the time to standardize and develop adaptable and sustainable alternate efficient cropping systems in existing agro-climatic conditions with high yield potential, system productivity, system profitability and water profitability under available natural resources at the farmer's disposal.

Crop Diversification:

It is a strategy of shifting less profitable crop to more profitable crop, changing of varieties and cropping system, increasing export and competitiveness in both domestic and international markets, protecting the environment and making condition favourable for combining different enterprises.

Advantages of Crop Diversification:

1. Pooling and sharing of resources/inputs
2. Efficient use of family labour
3. Conservation, preservation and utilization of farm biomass including non-conventional feed and fodder resources
4. Effective use of organics, regulation and soil fertility and wealth
5. Income and employment generation for many people
6. Increase in economic status by utilization of under-utilized resources in an efficient and remunerative manner
7. Overall upliftment of farmers

Efficient Alternative Cropping Systems Recommended for Different Zones of Gujarat

The major soil groups of Gujarat ranges from sandy to clayey and hence, due to this soil range, growing crop differs from pearl millet - low water requiring crop to paddy - high water requiring crop. Therefore, as far as land capability classification is concerned, the majority of soil comes under land capability class II and III, which require moderate management practices for taking good crops. Therefore, alternate cropping sequences identified in crop diversification / intensification experiments suitable as per land capability classification and resource position of the farmers of Gujarat state are as under (Patel *et al*., 2007).

The efficient alternative cropping systems recommended for North, middle and south Gujarat as well as Saurashtra region of Gujarat are as under;

North Gujarat Region

- Groundnut- Potato- Summer Pearl Millet
- Castor- Summer Greengram
- Castor-Summer fodder Sorghum
- Greengram / Cowpea – Mustard - summer Pearl Millet
- Pearl Millet – Mustard + Lucerne

Middle Gujarat Region

- Tobacco-Summer Pearl Millet
- Paddy- Wheat/ *rabi* Castor
- Cotton – Summer Pearl Millet / Summer Greengram
- Paddy- Lucerne fodder- Lucerne seed production after two cuts

South Gujarat Region

- Paddy- *Rabi* Castor
- Paddy- Summer Groundnut / Greengram
- Paddy- Sorghum- Sorghum Ratoon
- Paddy- Fennugreek Vegetable/Onion- Summer Okra Vegetable

Saurashtra Region

- Groundnut- Wheat
- Groundnut- Garlic/ Coriander
- Groundnut- Onion-Summer Greengram
- Groundnut- Pigeonpea/Castor relay cropping

These cropping sequences, if adopted by the farmers will be very helpful for increasing productivity, soil fertility status, nutrient profitability, water profitability, system productivity and profitability, employment generation, etc.

Yield Gaps in Present Pulses Production:

The yield gap of different pulse crops was computed based on yield of a crop in efficient cropping system/research station and average yield of Gujarat state and depicted in Table 1. Yield gap of 964, 834, 651, 1078, 529, 1124 and 1591 $kgha^{-1}$ were observed in greengram, cowpea, blackgram, mothbean, clusterbean, pigeonpea and chickpea, respectively in Gujarat state. If yield gap is considered in percentage, the gap was ranged from 97 per cent in blackgram to as high as 465 per cent in mothbean. This indicated that more scope of yield improvement in mothbean followed by chickpea and greengram.

Improved Varieties of Pulse Crops :

Improved varieties in various pulse crops released and recommended for the farmers of Gujarat with their characteristics are given in Table 2.

Production Technology of Pulses:

Production technologies for short duration *kharif* season pulse crops (greengram, cowpea, blackgram, mothbean and clusterbean) were given in Table 3, while of long duration kharif pulses crop, pigeonpea was given in Table 4. Similarly, production technologies for pulses grown during rabi and summer season were given in Table 5 and table 6, respectively.

Pulses Based Sequential Cropping Research in Gujarat (Research Recommendations Bulletin, 1980-2012, DOR, SAUs, Gujarat)

North Gujarat Region:

Castor- greengram

Farmers of North Gujarat Agro-climatic zone growing crops in light textured soil and assured irrigation facility are advised to follow castor-summer greengram with recommended doses of fertilizers for getting higher yield and net returns.

Chickpea –pearl millet

The *kharif* pearl millet growing farmers of North Gujarat agro-climatic zone are advised to follow the cropping system of *kharif* pearl millet after *rabi* chickpea and the *kharif* pearl millet crop should be fertilized with 90 kg N/ha.

Mustard based cropping sequences

Farmers of North Gujarat region growing mustard (Gujarat Mustard 1) with assured irrigation throughout the year advised to adopt any of the following cropping sequences.

Kharif	***Rabi***	**Summer**
Clusterbean (Guj-1)	Mustard (GM-1)	Pearl millet (GHB-235)
Greengram (K-851)	Mustard (GM-1)	Pearl millet (GHB-235)

Profitable crop sequence (crop rotation) in relation to castor wilt

Under North Gujarat Agro-Climatic region, the most profitable crop sequence in relation to castor wilt disease is pearl millet - mustard, clusterbean-wheat and sorghum-cumin. Castor (GCH-4) should not be sown in the same field every year, but it should be sown after every three years to avoid wilt disease infestation.

Groundnut as a preceding *kharif* crop to the *Rustica tobacco*

Farmers of Vijapur area are advised to take either clusterbean or sesame or groundnut as a preceding *kharif* crop to *Rustica* tobacco to get higher monetary returns.

Cropping system diversification and / or intensification

The Farmers of North Gujarat Agro-Climatic zone having assured irrigation facility are advised to adopt cowpea/greengram-mustard-pearl millet or castor-fodder sorghum/greengram (summer) instead of existing cropping sequences *viz*. pearl millet-wheat and clusterbean-wheat for getting higher yield and net realization.

***Ardu (Ailanthus excels)* based agri-silviculture system under rainfed condition**

The Farmers of North Gujarat Agro-Climatic zone are advised to adopt *Ardu (Ailanthus excels)* (at 6.0 m x 3.0 m spacing) based agri-silviculture system of agro-forestry with greengram as an inter crop. This system gives more economic return per unit area.

***Middle Gujarat Region* :**

Planting technique for Cotton - Gram cropping system (Sunken and raised bed planting for Cotton-Gram cropping system)

Farmers of Bhal and Coastal zone are advised to adopt raised (15cm above surface) and sunken (15cm bellow surface) bed system (6m width) of cultivation for getting higher benefit in terms of substantial yield of *kharif* and *rabi* crops. They are advised to grow cotton on raised bed during *kharif* and wheat or gram on sunken beds during *rabi* for securing higher income.

Cotton-clusterbean cropping system in *goradu* soil of middle Gujarat

The farmers of Middle Gujarat Agro-climatic Zone-III (AES-II) are advised to adopt cotton (*kharif*) - vegetable clusterbean (*summer*) cropping system to get higher yield and net profit.

***South Gujarat Region* :**

Paddy-gram cropping system

Farmers of South Gujarat heavy rainfall zone growing *rabi* crops on residual moisture after kharif paddy are advised to grow gram without fertilizers. *Kharif* paddy, of course, should be fertilized with 100 per cent of the recommended doses (120-30-00 NPK kg/ha).

Fertilizer management in paddy-gram cropping system

It is recommended to farmers adopting paddy-gram sequence in clayey soils of South Gujarat heavy rainfall zone that they should apply only 100 kg N/ha to Paddy var. IR-22 instead of the recommended dose of 120 kg N/ha.

Fertilizer management in chickpea - sorghum cropping system

The farmers of South Gujarat Heavy Rainfall zone growing *kharif* sorghum are recommended to follow chickpea-sorghum sequence. They are further advised to fertilize sorghum with 60 kg N/ha so as to obtain the higher net realization.

Fertilizer management in paddy-gram cropping system

The farmers of South Gujarat agro-climatic zone fallowing paddy-chickpea crop sequence are advised to fertilize each crop with 60 kg P_2O_5/ha to secure the highest total economic return. Marginal farmers, however, may reduce the phosphorus dose to chickpea crop as 30 kg P_2O_5/ha.

Paddy-gram and paddy-groundnut cropping system

The paddy growing farmers of South Gujarat heavy rainfall zone are advised that under conditions of constraints of irrigation water, they should adopt paddy- gram system in *rabi* instead of paddy-wheat. Similarly, during summer they should adopt paddy-groundnut system instead of paddy-sorghum. Further, the paddy yield after gram and groundnut will be higher by 25 and 30 per cent, respectively than those after wheat and sorghum.

Paddy-vegetable fenugreek-summer okra/paddy-onion-vegetable cowpea cropping system

The farmers of South Gujarat agro-climatic zone having assured irrigation facilities are advised to adopt paddy-vegetable fenugreek-okra and paddy-onion-vegetable cow pea instead of existing cropping sequence paddy-wheat for getting higher yield and net realization.

Saurashtra Region :

Groundnut (*kharif*)-onion (*rabi*)-greengram (*summer*)

The farmers of South Saurashtra Agro-climatic Zone having assured irrigation facility are advised to adopt groundnut (*kharif*)-onion (*rabi*)-greengram (*summer*) sequence for obtaining higher production and net returns.

Groundnut-wheat- greengram cropping system

For south Saurashtra zone, groundnut-wheat-greengram cropping system has been found to be the best viable groundnut based cropping sequence.

Pulses Based Intercropping / Mixed Cropping / Relay Cropping systems:

North Gujarat Region :

Inter cropping in castor with greengram under irrigated condition

The farmer of North Gujarat agro-climatic zone growing irrigated castor (GCH- 5) at wider spacing (120 cm X 60 cm) are advised to intercrop with greengram (GM- 4) or sesame (GT-1) in 1:1 row ratio to achieve about 30 % and 24 % higher yield and 34 % and 27 % more net return respectively over sole castor.

Agri.-horti System in class - IV sandy soils of North-West zone

The farmers of North-West agro climatic zone growing ber var. Gola (6.0 m X 6.0 m) on sandy soil are advised to take intercrop of greengram for getting higher monetary return (33 %) as compared to sole crop of ber to overcome the risk involved in dry farming.

Mixed cropping in pearl millet with mothbean

Farmers of North-West agro-climatic zone growing pearl millet are advised to adopt mixed cropping of pearl millet with mothbean in proportion of 3.0 kg seed of pearl millet and 4.0 kg seed of mothbean for getting higher yield and gross return under dry farming conditions.

Chickpea-mustard intercropping

Farmers of North Gujarat are advised to adopt inter cropping of mustard in chickpea (1:5) in light soil areas so as to have more stable returns.

Castor-groundnut/greengram intercropping

Although sole castor has been found to give higher net return in North Gujarat zone (Sardarkrushinagar and Talod) the farmers are advised to intercrop it with groundnut or greengram in 1:1 ratio as a safe guard against the vagaries of monsoon.

Ber-greengram/fodder sorghum

Farmers of North Gujarat zone growing ber (10 m x 6 m) on light textured soils are advised to take intercrop of either greengram or sorghum (fodder) for getting 27 and 16 % higher net return as compared to that obtained by growing ber as sole crop.

Tree- crop intercropping

Residual effect of tree species viz. *Acacia tortilis*, *Delbergia sissoo*, *Albazzia lebback* and *Prosopis juliflora* (Israel) on succeeding crops (castor, pearl millet, greengram and clusterbean) grown on sandy soils of North Gujarat agro - climatic zone was found economically beneficial while improving fertility and productivity of soils. The average increase in gross income over control was 52, 46, 40 and 22 % due to residual effect of the respective tree species.

Eucalyptus grown in sandy soils of North Gujarat agro-climatic zone improved the soil productivity. Percent increase in the gross income was 65% for greengram, 39 % for castor, 28 % for pearl millet and 28 % for clusterbean under irrigated conditions. This shows that 26 % increased profit can be obtained from field crops grown in eucalyptus.

Pearl millet-clusterbean intercropping

The farmers of North Gujarat agro-climatic zone growing pearl millet on light textured soil in *kharif* season are advised to follow intercropping (2:2) with clusterbean variety Malosan or HG- 75 for insuring the income under risk prone dry land agriculture.

To overcome the risk involved in dry land agriculture under light textured soils of North Gujarat agro - climatic zone the farmers are advised to take pearl millet + clusterbean (2:1) intercropping during *kharif*. It gives a higher net profit than that of sole pearl millet.

In the low rainfall areas of North Gujarat agro-climatic zone having light textured soils, the farmers are advised to take intercropping of pearl millet + clusterbean (2:1) at an inter row spacing of 45 cm. They should apply only 50 % of the recommended doses of N to the crops (pearl millet 37.5 kg N/ha and cluster bean 10 kg N/ha). However, P_2O_5 @ 25 kg/ha should be applied to pearl millet.

Cotton-greengram intercropping

Farmers of North Gujarat zone cultivating cotton (Hy. 8) are advised to intercrop it with greengram (1:2) to get 19 % more income.

Mixed cropping of greengram and pigeonpea with pearl millet

Cultivators of North Gujarat agro-climatic zone are advised to grow pearl millet (100% recommended seed rate) as mixed crop with greengram (20% recommended seed rate).The mixed crop of greengram and pigeonpea with pearl millet recorded 40% and 26 % higher return respectively as compared to the sole crop of pearl millet.

Mixed cropping of pearl millet, mothbean, cowpea and clusterbean

The farmers of North Gujarat agro-climatic region are advised to adopt mixed cropping of pearl millet, mothbean, cowpea and clusterbean with proportionate seed rate (0.940, 3.000, 5.000 and 3.750 kg/ha, respectively) for getting higher net return and BCR under rainfed situation.

Greengram-castor relay cropping

Farmers of North Gujarat agro-climatic zone growing greengram on light textured soils under rainfed conditions are advised to inter relay castor crop after first picking in order to make efficient use of available soil moisture and get higher returns. Castor should be line sown after every two rows of greengram.

Middle Gujarat Region:

Maize -pigeonpea Intercropping

The farmers of Middle Gujarat (AES II) practicing maize-pigeonpea intercropping system are advised to to perform three hand weeding at 30, 40 and 60 DAS or inter-culturing and hand weeding at 30 and 60 DAS. Under paucity of labours, pre emergence application of Alachlor @ 0.5 kg/ha or Oxadiazon @ 0.25 kg/ha is recommended for efficient weed management and better re

Pigeonpea + maize intercropping

Farmers of middle Gujarat zone adopting pigeonpea + maize intercropping system (2:1) in paired row method are advised to fertilize maize crop with 100 kg N and 50 kg P_2O_5 /ha and not apply any fertilizer to pigeonpea.

Maize + mid late pigeonpea intercropping

It is recommended that farmers of middle Gujarat zone are advised to intercrop mid late pigeonpea (BDN-2) in 1:1 ratio with maize (one row of maize in between two rows of pigeonpea planted at 120 cm) for getting higher grain yield as well as monetary realization.

Pigeonpea + blackgram intercropping

Farmers of the middle Gujarat zone are advised to intercrop pigeonpea (BDN- 2) with blackgram in 1:1 ratio (one row of blackgram in between two rows of pigeonpea planted at 90 cm) for getting higher seed yield as well as monetary realization.

Maize + pigeonpea intercropping

The farmers of Panchmahals district of middle Gujarat agro-climatic zone growing maize (Farm Sameri) are advised to grow pigeonpea variety BDN-2 as a intercrop in the ratio of 1:1 at a distance of 45 cm between two rows with the application of N and P @ 80 kg and 40 kg per ha, respectively. Entire dose of P_2O_5 and 50% of N should be applied as a basal dose. Remaining 50% of N should be applied one month after sowing (ICBR 1:2.93).

Cotton + greengram or blackgram intercropping

It is recommended that the farmers of Bhal region should adopt intercropping of green gram and blackgram in a paired row planting cotton for getting higher additional realization.

Sorghum + Cowpea

Farmers of Bhal and Coastal Agro-climatic Zone-VIII (AES-II) growing sorghum alone are advised to sow the *kharif* sorghum (SSG-59-3) with cowpea (GFC-3) intercropped in 2:1 row ratio and fertilize it with 40 kg N/ha and 15 kg P_2O_5/ha to secure higher forage yield with good quality and higher returns under rainfed condition.

Cotton + greengram or blackgram intercropping under rainfed conditions

The farmers of North-West Agro-climatic Zone-V (AES-VIII) growing cotton (G Cot 21) are advised to sow the crop at 2.4 m row spacing and 0.3 m intra row spacing. The farmers are advised to take greengram

(GM 4) or blackgram (T 9) as a inter crop at a row ratio of 1:1 to get higher yield and net realization.

South Gujarat Region :

Cotton + soybean or blackgram or greengram intercropping

For securing higher economic return, farmers of south Gujarat zone growing irrigated cotton G.Cot Hy-6 at a distance of 120 cm between the rows are advised to intercrop one row of Soybean (G-1) or blackgram (Zandewal) or greengram (GM-2) in between the rows.

Cotton or pigeonpea + blackgram or greengram intercropping

For securing higher profit, farmers of south Gujarat zone growing rainfed cotton G.Cot.-11 or Pigeonpea at a distance of 120 cm between the rows are advised to intercrop it with Blackgram (Zande wal) or Greengram (GM-2) in between the rows.

Saurashtra Region :

Mixed cropping in pearl millet

The farmers of North West Agro-climatic Zone growing pearl millet are advised to adopt mixed cropping of pearl millet with mothbean in proportion of 3.0 kg seed of pearl millet and 4.0 kg seed of mothbean/ha for getting higher yield and gross return under dry farming condition.

Pearl millet + pigeonpea intercropping

The farmers of North Saurashtra agro - climatic zone are advised to apply recommended doses to the base crop pearlmillet (80 kg N and 40 kg P_2O_5 /ha) while intercropping with pigeonpea for getting maximum monetary returns. The marginal farmers, however, may apply 40 or 60 kg N/ha to the intercropping system. Phosphorus dose, however, remained unchanged.

Sorghum + pigeonpea intercropping

The farmers of North Saurashtra Agro-climatic zone are advised to adopt intercropping system of Sorghum + Pigeonpea in 1:1 row ratio. They should apply recommended doses of fertilizers (90 kg N/ha and 30 kg P_2O_5 /ha) to the base crop for getting higher equivalent yield of sorghum and maximum monetary return.

Groundnut + pigeonpea intercropping

The farmers of South Saurashtra Agro-climatic Zone following bunch groundnut-pigeonpea intercropping system (2:1) under rainfed condition are advised to maintain 100 per cent plant density by keeping intra row spacing of 7.5 and 20 cm, respectively and apply 100 per cent RDF of groundnut (i.e. 12.5:25:00 NPK kg/ha) as basal dose to both the crops for getting higher gross and net return.

Groundnut-pigeonpea

The farmers of South Saurashtra Agro-climatic Zone interested in adopting semi-spreading groundnut + pigeonpea intercropping system are advised to open the furrow at 40 cm distance and sow two rows of groundnut (GG-20) and one row of pigeonpea (Vaishali). They are also advised to apply 4 irrigations at an interval of 10 days (1.0 IW/CPE) to pigeonpea after harvest of groundnut for realizing higher net return.

Groundnut-pigeonpea intercropping system (Integrated Weed Management)

The farmers of South Saurashtra Agro-climatic Zone following bunch groundnut-pegionpea inter cropping system (2:1) are advised to keep weed free crops through out the season where farm labours are adequately available. Under paucity of labours, pre-emergence application of pendimenthalin or fluchloralin @ 0.5 kg/ha along with 3 IC (25-40-55 DAS) + 2 hand weeding (30 and 45 DAS) is recommended for effective weed control and higher return.

Pigeonpea + groundnut

The farmers of South Saurashtra Agro-climatic Zone adopting pigeonpea + groundnut

relay cropping in medium black calcareous soils are advised to apply 40 kg sulphur (one month prior to sowing) and 50 kg K_2O per hectare as basal in addition to recommended doses of N and P to pigeonpea for higher yield and net return.

Intercropping in sesame

The farmers of AES-IX of North Saurashtra Agro-climatic Zone are advised to intercrop sesame (G.Til-2) with cotton (G.Cot-Hy-8) in 3:1 ratio or sesame with groundnut (GG-5) or sesame with greengram (K-851) in 3:3 ratio for getting higher yield as well as monetary returns.

Intercropping in cotton var. G.Cot Hy. 8 under rainfed condition

The farmers of agro ecological situation - 1(a), 1(b) and 3 of *Bhal* region growing hybrid cotton (G.Cot Hy.-8) at the distance of 120 cm are advised to adopt intercropping system with sesame (G.Til-2) or blackgram (T-9) or greengram (K-851) with the ratio of 1:1 for getting higher yield and net return under rainfed condition.

The farmers of North Saurashtra Agro-climatic Zone growing hybrid cotton (G.Cot.Hy-8) at the distance of 120 cm are advised to adopt intercropping with sesame (G. Til-2) or greengram (K-851) in the row ratio of 1:1 for getting higher yield and net return under dry farming condition.

Cultivation of Pulses in Non-Conventional Season/Area :

The Rajmash, though it is an unconventional pulse crop, has been introduced in North Gujarat has yield potentiality of around 35q/ha. Similarly, Field pea is also a potential unconventional crop having yielding ability of around 40 q/ha. Hence, these new crops should be introduced in Gujarat as catch crop. Growing of short duration (60-70 days) summer pulses like greengram and cowpea instead of growing summer pearl millet save precious irrigation water and increased soil fertility and also increases the profitability. In Gujarat, cotton and castor crops are grown as a sole crop. The area of cotton is 23.54 lakh ha while, 4.34 lakh ha for castor crop. The results of growing pulse crop as an intercrop in these two long duration crops, increased the yield with profitability and soil sustainability, ultimately it will help us in solving the pulse crises in Gujarat state as well as in the country. If we consider 50 per cent area under intercropping with pulses in cotton, it would gave production of 4.7 lakh M.T. and 0.4 lakh M.T from considering 50 per cent area of castor + pulses intercropping which will increase the total pulse production.

Future Thrusts

It is an era of integration and globalization in which technological advancement have linked and integrated every aspects of life along with this the impact of global warming is also being realized. Now days, global warming is a burning issue. Therefore, along with other crop production aspects, impact of global warming should also be taken into consideration for deciding the future line of action for realizing sustainable productivity of the pulses crops for feeding teeming millions. Important future line of actions for sustaining productivity of the pulse crops in different cropping sequences of Gujarat is as follow.

- Technologies generation and development in respect to weed, water and nutrient management must be based on system approach rather for individual crop for getting higher productivity of the system.
- Now a days, lot of varieties of diverse nature of crops under cultivation are available which need different agronomical package of practices. Therefore, future research should give focus on development of variety specific agronomical package

rather than to crop specific for getting higher resource use efficiency.

- There is a great diversity in response of crop with respect to nutrient depending upon fertility status of the soil. Therefore, in order to achieve high nutrient use efficiency, crop and variety specific response equations based on targeted yield must be developed.
- All over the world, health awareness is increasing and developed countries are framing stringent regulations with respect to quality parameters of agricultural product. Therefore, in order to promote or maintain export in these countries it is necessary to meet the standard of quality parameters.
- Social audit of research and extension system must be strengthened.

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Table 1: Yield gap of important pulses crops grown in Gujarat

S. N.	Name of crop	Maximum Yield (kg ha^{-1})	Average Yield ($kgha^{-1}$)	Yield Gap (kg ha^{-1})	Yield Gap (%)
1.	Greengram	1417	453	964	213
2.	Cowpea	1261	427	834	195
3.	Blackgram	1322	671	651	97
4.	Mothbean	1310	232	1078	465
5.	Clusterbean	879	350	529	151
6.	Pigeonpea	2111	987	1124	114
7.	Chickpea	2250	659	1591	244
8.	Fieldpea	2266	New introduction	--	--
9.	Rajmash	2716	New introduction	--	--

Source: Final forecast report of area, production and productivity, Directorate of Agriculture, Gujarat state (2008-09)

Table 2: Improved varieties of pulse crops with their characteristics

Sr. No.	Name of pulse crop	Released varieties	Days of maturity	Av. yield (kg/ha)	Remarks
1.	Pigeonpea	Gujarat Tur 100	145-155	1500-2000	Bushy, determinate and white seeded.
		Gujarat Tur 1	125-130	5000-6000 green pods	Spreading, non-determinate, white seeded, recommended for vegetable as green pods.
		Gujarat Tur 101	140-150	2000-2500	Spreading, non-determinate, white seeded.
		Banas	135-145	2100-2300	Spreading, non-determinate, white seeded.
		Gujarat Tur Hybrid 1	145-155	2800	Semi-spreading, nondeterminate, white seeded, 87 % dal recovery.
		Gujarat Tur 103	140-145	2000-2700	Semi spreading, non-determinate, green podded, white seeded, gave 19.93 per cent higher yield than GT 101.
2.	Chickpea	Dahod yellow	100-105	2000	For rain fed condition, susceptible to wilt.
		ICCC-4	115-120	2800	For irrigated condition, resistant to wilt.
		Gujarat Chickpea-1	100-105	2500	For irrigated condition, resistant to wilt, 30% higher yield over Dahod yellow.
		Gujarat Chickpea-2	90-95	2500	For rain fed condition, especially for Bhal region.
		Gujarat Junagadh Chickpea 3	98	2500	For rain fed condition, moderately resistant to wilt and stunt, yellow seed colour
3.	Greengram	K 851	65-70	1200-1400	Erect type, for *kharif* and summer, synchronize maturity, resistant to YMV.
		GM 3	60-65	1100-1200	Spreading type, for summer season, green lustrous seed and resistance to YMV.
		GM 4	61-68	1200-1500	Erect type for *kharif* and summer, synchronize maturity, green bold seeded.

4.	Blackgram	T 9	70-75	1000-1200	Semi erect, pods in bunch, blackish seeds.
		TPU 4	75-80	1200-1600	Pods in bunch
		Gujarat Urd 1	75-80	1500-2000	Greenish black seeds, more fuzz on pods, 24% higher yield than T-9.
5.	Mothbean	GMO 1	80-85	500-700	Spreading type, dual purpose indeterminate, brown seeded.
		GMO 2	65-70	800-1000	Semi spreading type, indeterminate, brown seeded.
6.	Cowpea	GC-3	70-75	800-1000	Erect type, indeterminate, seed color light white, for *kharif*.
		GC-4	67-70	900-1100	Spreading type, indeterminate, bold white color seed, for *kharif* and summer, dual seed and vegetable purpose.
		GC-5	65-70	1000-1300	Erect type, indeterminate, seed color light brown, for *kharif* and summer, suitable for inter cropping, resistant to moisture stress.
7.	Clusterbean	Gujarat Guar 1	100-110	800-1000	Spreading type, indeterminate, creamy white seed, medium resistant to bacterial blight, high gum per cent, synchronize maturity.
		Gujarat Guar 2	100-105	1000-1200	Spreading type, indeterminate, attractive pink seeds color, synchronize maturity, 31% gum content, 17% higher yield than GG-1, resistant to bacterial blight and root rot.
8.	Rajma	HUR 137	105-110	2000	Purple red seed color, synchronize maturity.
		Gujarat Rajmash 1	98-105	2500	Purple red seed color, synchronize maturity.
9.	Fieldpea	DDR-23 (Extra early)	65-70	1100	Extra early suited as pure as well as intercrop.
		HFP 4	105-110	2000	Medium height without vine.
		Gujarat Dantiwada Fieldpea 1	98-123	2500-3000	Green seeded, dwarf and erect plant type, green foliage, suitable for dual purpose.
10.	Indianbean	Kadva val 125-36	150	600-700	Grown after paddy in conserved moisture.
		Gujarat Val-1	135-140	900-1000	Grown after paddy in conserved moisture

Table 3 : Production technologies for short duration *kharif* season pulse crops

Cultural Operations	***G*reengram**	**Cowpea**	**Blackgram**	**Mothbean**	**Clusterbean**
1.Land preparation	Pulses needs fairly deep, well drained soil which should be free from salt. Land is prepared by 2-3 cross harrowing followed by planking. The seedbed must be free from stubbles and weeds. Apply 5 tones FYM/ ha before land preparation for better moisture conservation and microbial activity.				
2. Seed rate	18 kg/ha	15-20 kg/ha	18 kg/ha	15-20 kg/ha	15-20 kg/ha
3. Sowing management					
a. Seed treatment	Seed treatment with Carbendazim *Rhizobium* and PSB	Seed treatment with Carbendazim *Rhizobium* and PSB	Seed treatment with Carbendazim *Rhizobium* and PSB	*Rhizobium* and PSB	Seeds soaking in 250 ppm streptocycline for 15 minutes, *Rhizobium* and PSB.
b. Time	3rd week of June to 2nd week of July	3rd week of June to 2nd week of July	3rd week of June to 2nd week of July	3rd week of June to 2nd week of July	3rd week of July to 2nd week of August
c. Spacing	30cm x 10cm	45cm x 20cm	30cm x 10cm	45cm x 10cm	45cm x 10cm
d. Gap filling	10 DAS	10 DAS	10 DAS	10 DAS	10 DAS
e. Thinning	15-20 DAS	15-20 DAS	15-20 DAS	15-20 DAS	15-20 DAS
4. Fertilizer application	20-40-0 NPK kg/ha	20-40-0 NPK kg/ha	20-40-0 NPK kg/ha	20-40-0 NPK kg/ha	20-40-0 NPK kg/ha

5. Weed control and interculturing	1 kg/ha Pendimethalin as PE. Interculturing at 20 and 40 DAS	0.75 kg/ha Pendimethalin as PE. Interculturing at 20 and 40 DAS	1 kg/ha Pendimethalin as PE. Interculturing at 20 and 40 DAS	Interculturing at 20 and 40 DAS	1 kg/ha Pendimethalin as PE. Interculturing at 20 and 40 DAS
6. Water management	Life saving irrigation if dry spell is prolonged				
7. PP measures	For sucking pest, spray 0.03% dimethiate. For the control of pod borer, spray endosulfan 0.07%. To control powdery mildew disease spray Carbendanzim 50WP @ 0.07 % twice at 15 days interval after appearing disease.	For sucking pest, spray 0.03% dimethiate. For the control of pod borer, spray endosulfan @ 0.07%. To control powdery mildew disease spray Carbendanzim 50WP @ 0.07 % twice at 15 days interval after appearing disease.	For sucking pest, spray 0.03% dimethiate. For the control of pod borer, spray endosulfan @ 0.07%. To control powdery mildew disease spray Carbendanzim 50WP @ 0.07 % twice at 15 days interval after appearing disease.	For sucking pest, spray 0.03% dimethiate.For the control of pod borer, spray endosulfan @ 0.07%	For sucking pest, spray 0.03% dimethiate. For the control of bacterial blight, spray streptocyclin.

Table 4 : Production technologies of long duration *kharif* season pulse crop, pigeonpea

Cultural Operations	**Pigeonpea (Long duration *kharif*)**
1. Land preparation	Crops need fairly deep, well drained soil which should be free from salt. Land is prepared by 2-3 cross harrowing followed by planking. The seedbed must be free from stubbles and weeds. Apply 5 tones FYM/ ha before land preparation for better moisture conservation and microbial activity.
2. Seed rate	15-20 kg/ha
3. Sowing management	
a. Seed treatment	*Rhizobium* and PSB
b. Time	On set of monsoon (3^{rd} week of June to 2^{nd} week of July)
c. Spacing	60cm x 20cm (early), 90cm x 20cm (mid late)
d. Gap filling	10 DAS
e. Thinning	15-20 DAS
4. Fertilizer application	25-50-0 NPK kg/ha
5. Weed control and interculturing	1 kg/ha Pendimethalin as preemergence. Interculturing at 20 and 40 DAS
6. Water management	Life saving irrigation if rainfall prolonged
7. Plant protection measures	For sucking pest, spray 0.03% dimethiate. For the control of pod borer, spray endosulfan @ 0.07%

Table 5 : Crop production technologies for *rabi* season crops

Cultural Operations	Rajma	Chickpea	Fieldpea	Indianbean
1. Land preparation	Land is prepared by 2-3 cross harrowing followed by planking. The seedbed must be free from stubbles and weeds.			
2. Seed rate	120-140 kg/ha	60 kg/ha (Rainfed) 80 kg/ha (Irrigated)	40 kg/ha	50-60 kg/ha
3. Sowing management				
a. Seed treatment	Bavistin/Thirum 2-3 g / kg , *Rhizobium* (Raj 5) and PSB each 30 g/kg	Bavistin/Thirum 2-3 g / kg , *Rhizobium* (IC-86) and PSB each 30 g/kg	*Rhizobium* and PSB each 30 g/kg	*Rhizobium* and PSB each 30 g/kg
b. Time	2nd week of November	3rd week of Oct. (Rainfed), to 1st week of Nov. (Irrigated)	2nd week of Nov. to 3rd week of Nov.	Last week of October
c. Spacing	30 cm x 10 cm	30 cm (Rainfed) to 45 cm (Irrigated)	30 cm to 45 cm	45 cm to 60 cm
d. Gap filling	10 DAS	10 DAS	10 DAS	-
e. Thinning	15-20 DAS	15-20 DAS	15-20 DAS	-
4. Fertilizer application	120-60-0 NPK kg/ha	20-40-0 NPK kg/ha, 25kg/haZnSo4 in NG	20-40-0 NPK kg/ha	20-40-0 NPK kg/ha
5. Weed control and interculturing	1.0 kg/ha Pendi. as PE. Interculturing at 20 and 40 DAS	1.0 kg/ha Pendimethalin as PE. Interculturing at 20 and 40 DAS	1.0 kg/ha Pendi. as PE. Interculturing at 20 and 40 DAS	HW and IC at 30 DAS
6. Water management	Pre sowing irrigation 20 DAS , 35 DAS 45 DAS, 55 DAS and 65 DAS	Pre sowing irrigation 30 DAS 45 DAS 65 DAS	Pre sowing irrigation 20 DAS 35 DAS 50 DAS 65 DAS	Branching (25-30 DAS) Flowering (50-55 DAS) Pod development (70-75 DAS)
7. Plant protection measures	For control of sucking pest, spray 0.03% dimethiate.	For control of sucking pest, spray 0.03% dimethiate.For control of pod borer and green larvae spray 0.07% Endosulfan or	For control of sucking pest, spray 0.03% dimethiate.	For control of sucking pest, spray 0.03% dimethiate.For control of pod borer and green larvae spray 0.07% Endosulfan or dust 4%

		dust 4% Endosulfan,		Endosulfan

Table 6 : Crop-wise production Technologies for summer season crops

Cultural Operations	***Greengram***	**Cowpea**	**Clusterbean**
1. Land preparation	Land is prepared by 2-3 cross harrowing followed by planking. The seedbed must be free from stubbles and weeds.		
2. Seed rate	20-22 kg/ha	20-22 kg/ha	15-18 kg/ha
3. Sowing management			
a. Seed treatment	*Rhizobium* and PSB	*Rhizobium* and PSB	Seed soaking in 250 ppm solution of streptocycline, Rhiz. and PSB.
b. Time	3rd week of February to 2nd week of March	3rd week of February to 2nd week of March	2 nd week of February to 1 st week of March
c. Spacing	30 cm x 10cm	45cm x 15cm	45 cm x 15cm
d. Gap filling	10 DAS	10 DAS	10 DAS
e. Thinning	15-20 DAS	15-20 DAS	15-20 DAS
4. Fertilizer application	20-40-0 NPK kg/ha	20-40-0 NPK kg/ha	20-40-0 NPK kg/ha
5. Weed control and interculturing	1 kg/ha Pendimethalin as preemergence. Interculturing at 20 and 30 DAS	0.75 kg/ha Pendimethalin as preemergence. Interculturing at 20 and 30 DAS	1 kg/ha Pendimethalin as preemergence. Interculturing at 20 and 40 DAS
6. Water management	Pre sowing irrigation 20 DAS 35 DAS 45 DAS 55 DAS	Pre sowing irrigation 20 DAS 35 DAS 45 DAS 55 DAS	Pre sowing irrigation 25 DAS 40 DAS 55 DAS 70 DAS
7. Plant protection measures	For control of sucking pest, spray 0.03% Dimethoate, Metasystox or Dimecron. To control pod borer, Endosulphan should be sprayed at 50 per cent flowering.	For control of sucking pest, spray 0.03% Dimethoate. To control pod borer, Endosulphan should be sprayed at 50% flowering.	For control of sucking pest, spray 0.03% Dimethoate.

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