SUSTAINABLE CROP PRODUCTION THROUGH CROPPING SYSTEM MANAGEMENT

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In all the major spheres of human influence, sustainability has emerged as the most appropriate paradigm of development. In sustainable developent, progress in any sector is gauged from the quatitative as well as qualitative angle.

When sustainability is applied to agriculture, the development is evaluated not only in terms of the crop and live stock outputs but also in terms of the social, economic and eclological appropriateness of the production processes adopted. While increase in agricultural production is important, the farming system as a whole will also have to satisfy the parameters of sustainability such as social acceptance, local adaptability, economic viability and ecological soundness.

It is well supposed that India has attained self-reliance in food production. However, to feed the ever growing up of country's food production. The highest priority should be given to raise the production to 250 million tones per annum during next five years. Due to population flush and decline in per capita availability of land, it seems that there hardly remains any scope for horizontal expansion of land for food, feed, fuel, fodder and fibre production. Only verticalexpansin is possible by intensifyling the production both in time and space, by developing appropriate and the efficient crops and cropping systems for rained agriculture.

Corpping system is an important component of farming system. It denotes the cropping patterns used on a farm and their interaction with farm resources, other farm enterprises and available technology which determine their make up. Thus it represents the yearly sequence and spatial arrangement of crops and fallows in an area.

Corpping system is are planned on the basis of soil type, climate and water resources, taking into account farmers requirements for the maximum production. Most of the dryland areas in India are molo-cropped , however, cropping intensity may be increased by adopting the suitable intercopping and double cropping systems with improved management practices. Similarly waste lands and uncultivated fallows can be well utilized by adoping different alternate land use system according to land use capability classification.

Potential cropping system in relation to rainfall and soil type : The concepts of rainfall pattern, effective growing season and soil type have been put fourth for deciding the cropping systems in differnt agro-climatic zones as given bellow:

Potential cropping system in relation to rainfall and soil type

Rainfall (mm)	Soil Type	Water Availibility	Potential cropping period (week) systems
350 - 600	Alfisols & shallow verisols	20	Single kharif cropping
350 - 600	Aridisols & Entislos	20	Single cropping in kharif or rabi
350 - 600	Deep vertisols	20	Single rabi cropping
600 - 750	Alfisols and Entisols	20 - 30	Intercropping
750 - 900	Entisols, deep vertisols, alfisols, inceptisols	More than 30	Double cropping with monitoring
900	Entisols, deep vertisols, deep inceptisols	More than 30	Double cropping

Rainfed land are generally monocropped, more so those cosvered by Aridiso Alfisols, Depending upon the soil type and rainfall distribution, the crop is grown either the monsoon season (June – September) or on conserved soil moisture during the post season (October- March). It has been established that, in region receiving 350 – 600 of rainfall and 20 weeks effective growing season, only single cropping is post Generally, the alfisols or red soils are kharf croppe, while in vertisols, the cropping done either during kharif or rabi. In unimodel rainfall region (mean annual rainfall 750 m is the any season cropping which dominates, whereas the bimodal rainfall regions concentrated with post-rainy season cropping on conserved (residual) siol moi Obviously, the productivity of monosoon crops fallows the distribution of rainy seasons ra while that of post-rainy season crops remains low because it has to grow on receding moisture and also faces moisture deficiency during maturity phase.

Alternate efficient crops suggested for various dryland regions.

Sr. No	Regions	Traditional Crops	Alternative crops
1.	Deccan rabi region	Cotton	Safflower
2.	Malwa Plateau	Wheat	Safflower, Chickpea
3.	Upland of Bihar plateau and Orissa	Rice	Finger milletw, Blackgram Groundnut
4.	South – East Rajasthan	Maize	Sorghum
5.	N – Madhya Pradesh	Kali Tur	Soybean
6.	E – Uttar Pradesh	Wheat	Chickpea
7.	N – W - India (sicrozem)	Wheat	Mustard, Turmeric

(Source : Singh and Singh,19)

Forms of crpping systems

Depending on the reources and the technologies available, different types of crops system are as mentioned below.

1) **Monocropping** : It refers to growing onnly one crop on a land year after year. The rea of monocropping is climatological and soci- economic condition or specialization of far in growing that particular crop. Under rainfed conditions, groundnut, cotton or sorghum are grown as mono crops due to limitations as rainfall, Paddy is grown in canal irrga area under water logged condition because it is not posssible to grow other crops there.

2) **Intercropping** : Intercropping is an art of growing two or more crops simultaneously the same piece of land with a definite row pattern. Thus the cropping intensity in sp demension is achieved. In intercropping, when one crop is grown with 100 % of recommmended population sole crop known as base crop and another crop cal intercrop is introduced in the base crop by adjusting or changning crop geometry. The stteamed as additve series. In the replacement series both the crops are cal comoponent crops. Hence another component crop is introduced by scarifying cer proportion of population of one component crop. Mixed simultaneously interming without any row arrangement. In thus, the seed of different crops are mixed in cer proportion and then sown. The main object of mixed cropping is to meet the fam requirements of cereals, pulses and vegetables. The introduction of short duration and high yield varities of crops has opened up a new arrey of inter cropping posibilities (Narwal and malik, 1986) among the different plant geomentry and row proportion 3:3 (Additive) series recorded significantily higher productivity (Singh *et al.*1991), (Halvankar *et al.*2000).

Major intercropping system along with crop line raito

Sr.No.	Cropping System	Croplines ratio
1.	Sroghum + Greemgram	3:3
2.	Sroghum +Blackgram	3:3
3.	Sroghum + Pigeonpea	3:3
4.	pearl millet + Pigeonpea	2:1
5.	Pigonepea + Greengram	1:2
6.	Pigonepea +Blackgram	1:2
7.	Pigonepea + Soybean	1:2
Sr.No.	**Cropping System**	**Croplines ratio**
8.	Pigeonpea + Sesamum	1:2
9.	Cotton + Greengram	1:1
10.	Cotton + Blackgram	1:1
11.	Cotton + Soybean	1:1
12.	Cotton + Pigenopea	6:2

Across many rainfall situtions, efficient utilization of resources and stability in yields are best achieved through intercroping system. Further, in terms of land use, the practice of intercropping is more productive than growing them peparately. However, the additional productivity due to intercsropping system is mainly depends on complementarly of component crops. In order to achieve maximun land use efficency, the dryland research centres developed efficent intercopping system for differnt agro – climatic zones.

3) **Double cropping** : It is defined as growing of two or more, crop in sequence on the same land a farming year. Thus depending on the number of crops grown in a year, it is called as double, triple and quadruple cropping, invlving two, three or four crops respectively. Relay cropping is another system in which succeeding crop is planted before harvest of processding crops. Whereas ratoon crop or rationing refers or raising a crop with regrowth coming out of roots or stalk after harvest or crop.

Factors such as total rainfall, soil type adn water avaiabiliuty decide a particular cropping pattern i a place region. Cropping system for differnt regions as suggested from the reults of AICARP (1970) are given below. (Normally only one crop is grown under dryland condtion and cultivation is restricted during the rainy seasons. Howere, the intensity of cropping can be increased through sequetial or intercropping depending on the rainfall adn moisture storage capacity of soils).

Cropping system for differnt regions of India under drylands:

Rigon / Soil types	Crops	
	Kharif	**Rabi**
Nothern regioon Samba (Jammu)	Maize Greengram Cowpea	Wheat Barley Wheat
Punajab	Sunflower Groundnut Pearl millet Sorghum	Wheat / Barely Barley Bengalgram Wheat
Hissar (Haryana) Arid soils (Sierozemic Soils) Central region Dehram(UP)	Maize Pearl millet (Monocropping is the rule)	Wheat / Potato / Barley Cluster bean / Chickpea

	Maize	Wheat
	Rice (upland)	Wheat / Bengalgram
	Gram	Mustard
	Pearl millet	Chickpea / Barly
	Rice	Chickpea / Mustard
Eastern region		
Ranchi (bihar)	Rice	Chickpea / Linseed / Barrley
Altisols (Red soils)	Maize	Repessed / Bengalgram
Bhubaneshwar	Rice	Linessed / Mustard
Madhyapradesh		
Rawa	Rice	Chickpea / Lentil
Vertisols (Black soils)	Sorghum	Bengalgram / Wheat
Jhansi	Sorghum	Bengalgram
Vertisols	Pearl millet	Bengalgram
Indore	Blackgram	Safflower
	Maize	Chickpea
Western region		
Udaipur (Rajastan)	Greengram	Safflower
Vertisols	Sorghum	Bengalgram
	Maize	Wheat
Anand (Gujarat)	Pearl millet	Wheat
Akola (Maharashtra)	Greengram	Safflower
Vertisols	Sorghum	Safflower
solapur (Maharashtra)	Greengram	Safflower
Vertisols	Pearl millet	Bangalgram
Southern region		
Anantpur (AP)	Sorghum	Safflower / Horsegram
Alfisols	Pearl millet	Cowpea
	Greengram	Pearl millet
	Cowpea	Pearl millet
Hyderbad	Pearl millet	Cowpea
Bijapur	Sorghum	Greengram / Blackgram
Vertisols	Greengram	Sorghum / Safflower
Bangalore (Karnatak)	Cowpea	Finger millet
Mysore	Groundnut	Sorghum
Bellary	Cotton	Sorghum
Kovilpatti (TN)	-	Cotton, Sorghum
Vertisols	-	Pearl millet, Cowpea

Soil fertility and corpping systems

Under intensive cropping, deffernt crops with varying roooting patterns are cultivated This heps to explore the soiil profile effectively for moistre and nutrients and prevent formation of compact sub-soil layers. Which often append in monculture. Adoping intensive cultivation in the marginal soils without adequate fertilizer may deplete the osil in course of time and decrease its productivity. Inter cropping and sequential cropping do not cause great varition in soil available N status. Continuous N application in cereal - basal system do not but up N status o soil.

In most of the intercopping, the quatity of added P through fertilizer is greater than the quantity removed. Hence there may be built up in P statua.But this may not reflected in the available P staus, sa most of the adsP is rapidly converted to insoluble form. In rice based cropping system, soluble P increases due to submergence and high temperature. Hence in rice- wheat system rice is found to make bette4r use of residual P than wheat. Hence a application is adovocated to what.

Majority of soils in India are well supplied with K. There is hardly sandy noticeble impact on soil avilable K even in continuous cropping. Because there exists equilibrium in various form of soil K. Even after depletion , the other forms release K slowly. But in coarse sols, with growing of high yielding varieties there maay be decline K.

Legumes effect

Legumes have a long standing histrory of being soil fertility restores due to thir ability to obtain N from the atmosphere in symbiosis with Rhizobaium and have cpacity to leave behind a good amount of N for the use of succeeding crop. It has been stimated that 0.668 million tonnes of N can be saved through the inclusion of legumes in the cropping systems and of the order of 0.746 million tonnes with intercropping by legumes. the clears that 1.414 million tonnes of nitrogen could be hrnessed by this way (Saraf et al. 1990). The N economy through various pulses is given below. The carry over N for succeeding crop (cereal) may be 20-60 kg in different kharif and Rabi pulses. Thus pulses crop plays a vital role of using as a source of renewable applied of N in pulse based cropping system.

Residul effect of proceeding legume on the folowing cereals.

Preceding legume	**Following cereals**	**Fertilizer N equivalent (kg N/ha)**	**Precending legume**	**Following cerals**	**Fertilizer N equivalent (kg N/ha)**
Chickpea	Maize	60 – 70	Lathyrus	Maize	36 – 48
Cowpea	Pearl millet	60	Pigeonpea	Pm	30
Chickpea	Pearl millet	40	Greengram	Pm	30
Lintil	Pearl millet	40	Pigeonpea	Maize	20 – 49
Peas	Pearl millet	40	Peas	Maize	20 – 32
Pigeonpea	Wheat	40	Lentil	Maize	18 – 30
Kharif					
Plgeonpea	Wheat	20	Cowpea	Wheat	20
Greengram	Wheat	20	Cowpea (F)	Wheat	60
Blackgram	Wheat	20			
Rabi					
Chlokpea	Maize (G-5)	60	Pear	Maize	10
Lentil	Maize (G-5)	20	Lathyrus	Maize	40
Summer					
Cowpea (F)	Maize (G-5)	40			
Greengram	Maize (G-5)	15			

Alternate land use system

Increasing emphasis is being placed on alternate land use system, viz, agro – forestry, agri – horiculture and silvi-pastoral system to stabilize and sustain the productivity of drylands.

1) **Alley cropping** : Alley cropping is essentially an agro-forestry system in which crops are grown in alleys formed by hedge rows of trees or shrubs. The tree component in n alley cropping system provides both leaves for fodder and green manure for component crops and addtionally serves as vegetative barriers for the conservation of moisture. Alley corpping has three versions viz, forage alley cropping, forage cum mulch alley

cropping and forage cum pole alley cropping . The hedge rows are cut bck at planting and pruned during the cropping season to prevent shedding and also to reduce competition with food crop.

The alley cropping experiments conducted at CRIDA with Jeucaen Iucocephas indicated that i) Short duration cereals or millets are more compatible compared with long duration crops like caster and Pigeonpea ii) wider alley with 7-8 m spacing and Leucaena paired at 60 cm is better for semi-arid tropics compared with narrow alley width of 3.6 m iii) nulching of leucaena leaves is better than using it as fodder iv) frequent cutting of leucena during the cropping period at a 15 cm cutting height is shpperior to a 60 m cutting hiegh.

2) **The studies of agro – horticulture system** : Comduted at CRIDA indicated that about 40 kg fruit / tree is possible to release from ber trees in addtion to get bonus yield of Greengram or Cowpea or Horsegram or 250, 450 and 1000 kg/ha, respectively. This ensures that fruit based alley cropping systems are essential for stabilizing income in drylands.

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