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Research Article

SUSTAINABILITY OF UNPRODUCTIVE CLASS IV LANDS THROUGH TREE BASED FARMING SYSTEM APPROACH IN ARID REGIONS OF ANDHRA PRADESH

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Abstract: Though Ananthapuramu district of Andhra Pradesh falls under semi-arid tropics, the climate is arid with an aridity index of -72.3. This rain shadow district receives low, uneven distribution of rainfall besides prolonged dry spells during cropping season leading to frequent crop failures. There is a large area of Class IV lands (25% area) in Ananthapuramu district which is not suitable for arable farming and remained unproductive with thorny shrubs. There is a necessity to improve the productivity of such lands by designing a appropriate farming system module and thoroughly identifying suitable tree species which includes horticultural trees, pasture crops and animal component to make unproductive lands to productive and sustainable over a long period of time. In this direction, two experiments were conducted during 2000-01 to 2012-13 and one experiment during 2010-11 to 2015-16 at Agricultural Research Station, Ananthapuramu, Andhra Pradesh for identification of suitable tree species, to develop suitable farming system module and to evaluate Agri-Horti agroforestry system under the three experiments respectively. Four tree species *i.e.*, tamirand (*Tamarindus indica, Linn.*), ber (*Zizyphus mauritiana, Lamk*), custard apple (*Annona spuamosa L*) and soapnut (*Sapindus mukurossi L*) were planted during *Kharif* 2000. There was only 88% ,45% and 18% survival in soapnut,tamirand and ber plantation after a span of thirteen years. Hundred per cent mortality of plants was recorded in custard apple. Among all trees species, soapnut alone gave fruits with average yield of 1.180 kg per tree. It could be inferred that soapnut is the only tree that withstands harsh climatic (low rainfall) and even in Class IV soils which prevailed in Scarce rainfall zone of Andhra Pradesh. Tamirand trees came to fruiting only during well distributed rainfall years with mean net returns of Rs.4600/ha with horti pastoral (*Tamirand + Stylosanthes*) and integrated with sheep farming system. It could be opined that growing tamarind alone under rainfed conditions in class IV lands was not remunerative. However, positive net returns could be recorded only when sheep component was integrated in the system under Class IV lands

Keywords: Class-IV lands, tree based farming system, Agri-Horti agroforestry system

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Introduction

In the green revolution era of India, the rainfed agriculture received much less attention than the irrigated Agriculture. Considering vast potential of drylands, second green revolution may be seen through dry areas by concerted efforts of farmers, researchers and policy makers by enhancing and stabilizing their productivity. About 70% drylands are distributed in arid (21%) and semi-arid (49%) region and only 30% in dry sub humid regions. Arid ecosystem represents those environmental conditions of limited rainfall which is less than potential evapotranspiration (PET) almost throughout the year and supports sparse xerophytic vegetation. Indian arid ecosystems are confronted with 1500 to 2000 mm PET against annual erratic rainfall from less than 100mm to a maximum of 500mm.The area is represented by Thornthwaite's moisture index of more negative than -66.6 [1]. The agro-ecoregion with hot arid climate and mixed red and black soil comprises a part of the Deccan plateau that includes the districts of Bellary, SW part of Bijapur, Raichur of Karnataka and Anantapur of Andhra Pradesh. The region covers an area of 4.9 m ha, representing only 1.5% of the total geographical area of the country, characterized by hot and dry summers and mild winters. The rainfall is erratic and ranges from 400 to 500mm against annual PET of 1500 to 1600mm.The length of growing period is less than 90 days. The soils are represented by gently sloping, shallow and medium red loamy soils. The natural vegetation of the area comprises tropical thorn forest. The region faces frequent droughts. Overgrazing due to high animal population, wind and water erosion is very common. The geographic area of the district is 19.13 lakh ha. of which permanent pastures constitutes of 25968 ha (1.36%). As per the latest (18th) livestock census, the district had 7.3 % of cattle, 4.0% of buffaloes, 12.6% of sheep, 9.4% of goats and 5.4% of pig population of Andhra Pradesh. Ananthapuramu district ranks first in sheep and goat population in the state. About 57.6 % of the households in the district possess livestock. Sheep and goat constitute 73% of the total livestock population (58.10 lakh). In the district, 68% of the farmers come under marginal and small category. Most of the farmers are resource poor and practice rainfed farming. Smallholdings (< 3.0 ha) dominate (60%) the district. The district is more frequently prone to drought. Of the 133 years of record *i.e.*, from 1876-1877 to 2008-09, 66 years were drought years. Ananthapuramu district of Andhra Pradesh comes under arid zone and is one of the drought-prone districts in the rain shadow area of Andhra Pradesh. The annual average rainfall of the district is 542 mm. Red soils are dominant in the district and occupy 66% of total geographical area (TGA). Red sandy soils occur extensively in all mandals. In general, the depth of majority soils ranges from extremely shallow (10-25 cm) to shallow (25-50 cm). Deep soils (100-150cm) are also found in some parts of the district. In the district, about 47% area has very gentle (1-3%) slope, followed by 23% area with gentle (3-8%) slope, and about 12% area is moderately steep slope (15-30%). Land capability classification suggests that 43% of the lands are class III followed by class IV lands occupying 25% of the area [Table-1]. The landscape is undulating and largely arid, treeless with poor soils (NBSSLUP, 2005) [2]. Management of class IV soils is an important aspect in the district and the information about the suitable tree species is lacking. Based on these lines, experiments were taken up during *kharif* 2000-01 to 2012-13 with an

objective of identification of most suitable and economically viable tree crop for class IV lands. Agroforestry, evergreen agriculture, and smallholder production systems have attracted considerable attention around the world, of late, and tree-based production systems are being promoted, the worldover by Byerlee *et al*., (1982) [6]; Dhyani, *et al*., (2009) [3] and Gurbachan-Singh, (2012) [7]. Hence, it was felt necessity to improve the productivity of such lands by designing a suitable farming system which includes horticultural trees, pasture crops and animal component to make them productive and become sustainable.

Materials and Methods

Two experiments were conducted during 2000-01 to 2012-13 and one experiment during 2010-11 to 2015-16 at Agricultural Research Station, Ananthapuramu, Andhra Pradesh for identification of suitable tree species, to develop suitable farming system module and to evaluate Agri-hort agroforestry system respectively. Soils of land capability class IV consists of gravel sandy loam on very gently sloping lands with severe erosion. The details of soils for the three experimental sites are indicated in [Table-2]. These soils limit the root zone owing to their shallow depth (0-20 cm). Four tree species *i.e*., tamirand (*Tamarindus indic*a, Linn.at 9.0X9.0 m), ber (*Zizyphus mauritiana, Lamk at* 6.0X6.0m), custard apple (*Annona spuamosa* L at 4.5X4.5m) and soapnut (*Sapindus mukurossi L* at 6.0X6.0m) were planted during *kharif* 2000-01. The experiment was conducted in randomized block design (RBD) with five replications. Since the mean annual rainfall is 542mm and mostly confined to S-W monsoon only, initially drip irrigation was given for establishment later they were allowed to grow under rainfed condition. The varieties used were Balanagar in custard apple, Bala in ber, local in soapnut and PKM-1 in tamirand. The second experiment was carried out during *kharif* 2000-01 to 2012-13 to develop a suitable horti pasture based farming system for class IV lands and to improve the productivity of Class IV lands. Tamirand (*Tamarindus indica, Linn*.) trees were planted during *kharif* 2000 and stylosanthes was established in between. Ten ram lambs per hectare were introduced for grazing in the month of August 2007 and grazed for four months in the area specified and monitored their weight increments. The system productivity was calculated. Third experiment was carried during *kharif* 2010-11 to 2015-16 to evaluated different agroforestry systems under rainfed conditions. Simaruba, Mango, Amla, Jamun, Custard apple and Pomegranate plants were planted during *kharif* 2010 with a spacing of 6.0X6.0 m in randomized block design and with four replications. Initially from 2010 to 2013 during *kharif* groundnut crop was sown between the plants to improve the system productivity. After harvest of groundnut, the haulms were fed to ten ram lambs for four months (November to February). An amount of 887.6, 466, 446, 432, 375, 641 mm rainfall recorded in 48, 35,34,23,26,44 rainy days during 2010-11,2011-12, 2012-13,2013-14 and 2015-16 respectively.

Results and Discussion

After 12 years of experimentation (First experiment) 88 % in soapnut, 45% in tamarind and 18% in ber plants could survive. Hundred per cent mortality of plants was recorded in custard apple. Highest stem girth of 45.3 cm was recorded in tamarind followed by soapnut with 41.2cm. During 2008 (445 mm rainfall with 33 rainy days), only soapnut trees came to fruiting and average yield per tree was 1.180 kg. Even with 270 mm rainfall with 24 rainy days (2009) soapnut trees came to fruiting and average fruit yield per tree was 0.6 kg/tree. Among all the trees, soapnut alone gave fruits only during 2008-09 and 2009-10 with average yield of 1.180 kg per tree. While the rest of the trees (ber, custard apple and tamarind) have failed to bear any fruits. It could be inferred that soapnut is the only tree that withstands harsh climatic (low rainfall) and steep slopy soil with hard sub surface soils (Class IV) conditions which prevailed in Scarce rainfall zone of Andhra Pradesh. Arid regions are not ideally suited to crop production but can be better utilized for alternative land uses *viz*. agro forestry and tree farming [5]. In the second experiment, Tamarind trees came to fruiting only during well distributed rainfall years (980 mm in 2008) with mean net returns of Rs.4600/ha with horti pastoral (*Tamirand + Stylosanthes*) with sheep farming system. It could be inferred that growing tamarind alone under rainfed conditions in class IV lands was not remunerative. However, positive net returns could be recorded only when sheep component was introduced in the Horti-pastoral system. With the uncertain rainfall and frequent droughts that prevail in the desert region, it is increasingly realized that animal husbandry, tree and grasses intercropped with vegetables or fruit trees is the more viable model for arid, drought-prone region [4]. In the third experiment, among six species of trees planted in agroforestry system, Simarouba recorded higher survival % followed by custard apple, Jamun, Pomegranate, while Amla and Mango recorded lowest survival percent. Groundnut pod yield of 795, 555, 259 and 205 kg/ha were recorded during *Kharif* 2010-11,2011-12, 2012-13 and 2013-14 respectively in the agri-horti system. Groundnut cultivation along with 10 sheep rearing has given higher net returns on Rs.24,445/- compared to other faming systems and also created an additional employment generation of 75 mans days. Increase in sheep body weight with higher profits was observed when groundnut haulms+150 grams concentrates + Subabul was given compared to other treatments. Ram Newaj and Rai, (2005) [8] reported that the gross income from with Agri-Horti system with amla was less during initial years but when fruiting stated in amla, the gross income was increased and it went up to Rs.60,712 /ha at the age of 13 years. Agroforestry and agri-horticulture systems involving *Ziziphus rotundifolia* + mungbean/ mothbean /Clusterbean and *Z. mauritiana* + mungbean/ Clusterbean, respectively, have been found environmentally protective and economically viable systems even during drought years and are recommended in rainfall zone above 300 mm. Studies on integrated farming systems have shown that besides producing more fruits, fuel, fodder and timber, these could also result in improvement in livestock productivity and sustained economy [4].

Table-1 Land Capability Classes in Anantapur District of Andhra Pradesh

Land Capability Class	Area (in hectares)	Percentage of Area
I	Nil	Nil
II	65,082	3.0
III	831,895	43.89
IV	482,122	25.43
V	Nil	Nil
VI	177,453	9.36
VII	339,048	17.89
Total	18,95,600	100.00

Table-2 Details of soils for the three experimental sites.

Characteristics	Site I (Experiment 1 &2)	Site II (Experiment 3)
Topography	Steep	Moderate
Slope (%)	8-15%	<8%
Erosion	Severe	Moderate
Permeability	Poor	Moderate
Infiltration rate (cm/hr)	<0.5	0.5
Texture	Scl	S cl
Surface rock fragments	40-70%	40-50%
Sub surface fragments	30-50%	30-35%
Soil depth	Wavy	Wavy
Organic carbon	Low	Low

Table-3 Performance of different tree species in agri-horti system.

Tree species	No. of trees planted	Survival %	Per cent flowering plants	Fruit yield (Kgs per tree)
Simarouba	72	100	53.5	4
Custard apple	72	98.6	63.0	--
Jamun	72	88.8	--	--
Amla	72	58.0	50.0	10
Pomegranate	72	75.0	94.0	7
Mango	72	58.0	18.0	9

Table-4 Ram lambs weight as influenced by grazing methods over different intervals in agri-horti system

Treatments	1st week	3rd week	5th week	7th week	9th week	11th week	13th week	15th week	Increase after 15 weeks over initial weight
T1: Groundnut haulms	12.76	13.65	14.86	14.70	16.74	17.58	18.5	20.3	7.54
T2: G. nut haulms+150 grams Feed + Subabul leaves	14.38	16.07	17.08	17.36	20.73	22.98	23.7	26.65	12.27
T3: Grazing alone	11.82	12.24	13.12	13.31	13.97	16.01	16.3	17.54	5.72

Table-5 Economics of ram lamb rearing in agri-horti system

Treatments	Ram lambs (10 sheeps)	Feed cost	Total cost	Gross returns (after 10 ram lambs sale)	Profit from 10 ram lambs
T1: Groundnut haulms	23750	5570	29320	41525	12205
T2: G.nut haulms + 150 grams Feed + Subabul leaves	27020	8640	35660	50000	14340
T3: Grazing alone	23160	-	23160	35000	11840

Korwar, (1992) [5] reported that an ideal system for dryland arid regions should have a Judicious mix of crops, trees and grasses. Then only the natural resources will be judiciously utilized and returns maximized without any detriment to environment. The potential of agroforestry systems as carbon sink varies depending upon the species composition, age of trees, geographic location, local climatic factors and management regimes [9].

Conclusions

In class IV lands, soapnut is the only tree that withstands harsh climatic (low rainfall) and with slopy (8-15%) topographic soil conditions. Since tamirand comes to fruiting only in well distributed rainfall years, to make the unproductive class IV lands productive with tamirand species, it should be integrated with pasture (*Stylosanthes*) and sheep rearing components is viable horti pastoral system in slopy (8-15%) topographic soil (Class IV) conditions having limitations with respect to depth, wetness, slope, runoff and soil texture. Under agri-horti system Groundnut +Amla integrated with ram lamb rearing is appropriate system in class IV land for arid region of Anantapur for the best use of available natural resources.

Application of research: The ecosystems in hot arid region of the country are highly fragile and large liabilities cause severe impediments in development programs. Agroforestry systems combining tree/shrub, crop, grass and livestock have great scope and role in optimizing land productivity and environmental protection, more so from the angle of climate change. The appropriate combination and management of tree/shrub (both forest and fruit), crops, grasses and livestock units (in mixed herds) will make agriculture a profitable and risk free proposal in light of emerging climate change challenges in the region.

Research Category: Agro forestry systems

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