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Adaptability and Productivity of Forage Crop under Hortipastoral System

Kundan Singh[1], Mukesh Singh[1], Atul Singh[2], Anuj Kumar Singh[2] and A. K. Singh[3]

ABSTRACT

A survey was conducted in Faizabad district of eastern Uttar Pradesh, India was observed that farmers were cultivating comprehensively fodder crop with horticulture crop to bridge the huge gap between demand and supply of quality feed and forage required to be narrowed down. Research and development efforts made so far indicated that agroforestry played an important role in augmenting the supply of fodders especially in sodic land of eastern Uttar Pradesh, which is estimated to be one third of total area, reported. In order to raise the productivity of forage in more area of sodic land is to be brought under agroforestry and also cost effective technology is required to be developed. Adaptation of the forage cropping pattern in these area is very high because the soil structures is not suitable to propagate cash crop. In agro forestry systems farmers are using the intra spacing of the horticulture trees as under the canopy moisture and shade originate is suitable for growth and survival of forage crop during summer period. Out of 100 farmers reviewed, *Mangifera indica +Zea mays +Dicanthium annulatum* based horticulture system was adopted by majority of farmers in the study area.

Key words: Hortipastoral system, forage crop, sodic land, productivity and nutritive profile.

INTRODUCTION

Over the years, farmers have been integrating tree plus crop plus animal components for sustenance. With the passage of time, the agricultural component received priority over woody elements for sustaining self-sufficiency in food grains. The population pressure resulted in smallholdings and consequently lesser number of trees on the farms providing food, fodder, fibre, fuel, fertilizer, fruit, *etc.* The introduction of high yielding crops has no doubt resulted in self-sufficiency in food grains but its role in degrading topsoil by increasing salinity due to faulty loss of fertility and deposition of non-biodegradable agricultural chemicals in soil cannot be top soil.

Livestock production in India is largely dependent on crop residues and its by-products. Out of 445 million cattle in the country, nearly 270 million graze in forests. Forest Survey of India (FSI) has estimated (1996) that the requirements of green and dry fodder were 593 and 482 million tones, respectively. The requirement of green and dry fodder increased to 699 and 552 millions tons in 2001 (Planning commission government of India, 2001). It is estimated that the country faced a deficit of 570 million tones green fodder and 276 million tones dry fodders. The combined availability of green fodder from permanent pasture, other grazing lands, agricultural lands and forests was estimated at 434 million tones, whereas the minimum requirement was estimated to be 882 million tones (Solanki, 2005). Huge livestock population has resulted in unlimited and unrestricted grazing in forestlands. Forest has been an important source of grazing and for fodder in the absence of adequate pastureland. It is estimated that about 270 million livestock graze in forests. Additionally grazers collect an estimated 175 to 200 million tones of green fodder annually (Solanki, 2005). Overgrazing leads to forest degradation through their deleterious effects on soil compaction and poor regeneration of forest. In eastern part of Uttar Pradesh, livestock population particularly, buffalo and goat is increasing at the rate of 2 per cent per annum resulting into

[1] Pusa campus, IARI, New Delhi., [2] Directorate of Extension Unit , JNKVV, Jabalpur, Madhya Pradesh Department of forestry, JNKVV, Jabalpur, Madhya Pradesh

a tremendous pressure on the limited land resources (Pathak and Majumdar, 2002). Most of the livestock farming is of low productively. With the steady rise in animal, especially cattle population in the region pastures and grazing lands have been subjected to overuse. This has resulted in lose of vegetation and effected their regeneration potential leading to slow degradation of grazing land, which eventually become barren. There has been a steady decline in the area, quality and quantity of common property resources, because of increased human population and livestock pressure. Therefore, an experiment was conducted to investigate the alternatives to increase the forage production with different agroforestry systems by maximizing land use.

METHODOLOGY

Study area

The survey was conducted in Faizabad district of eastern Uttar Pradesh, situated between 26^{0}27' N latitude, 82^{0}12' E-longitude with an elevation of 113 msl. The climate of the area is sub-tropical and semi-arid with an average annual rainfall of above 1200 mm. Nearly 90 per cent of the total rainfall received from southeast monsoon during the months of July, August and September. Mean maximum and minimum temperature are 40^{0}C (May) and 7.7^{0}C (December), respectively. Soil is highly sodic and pH ranges between 8.5 to 10.2 and with high bulk density but low permeability and porosity. The soil contains low organic carbon and high ESP exchange complex and therefore, the exchangeable sodium and the nutrient status is impoverished (Table 1).

Identification of various agroforestry systems existing in the area

Agroforestry system has been classified using the criteria for classifying agroforestry systems and practices given by Nair (1985). Structure and function of the system have been used as the criteria for categorizing the systems (Lundgran, 1993). However, stratified classification of agroforestry practices has been name considering the major components. Whereas, system unit termed basic functional unit has been identified as combination of specific crop species within a component with the species from other components. Hence, functional units like food grain, vegetable or pulses in agriculture, specific fruit species in horticulture, grasses in pastures and tree species in forestry component have been described. Recognizing the structure and function of the various systems, primary and secondary components of each system type were identified. The forage yield was estimated by the harvest method, using 10 (1 X 1 m) quadrates randomly located at the time when the above ground biomass was at its maximum. The density derived for each crop species was based on 25 quadrates (1 X 1 m) per plot. Therefore, the economic yield per plant was determined in a plot as an average of 10 plants for each species. The yield per hectare in all cases was calculated based on the yield from the center plot as per described by Bhatt and Misra (2003). Yield of horticultural crop species was determined by harvesting all the fruits produced by tree and weight with the help of balance. The density, height, basal area and productivity were recorded for each species.

Awareness programme

This research focused the efficacy of project on farmers' information literacy in the study area. A participatory research design was adopted for the study for one to one interview with selected100 farmers among different framers group and key informants in study area. To fulfill the object 20 grass root training programs was organized in different area of Faizabad districts and took farmers opinion about the forage crop adoption including types of forage prefered to cultivate on different season of cropping and how they are supplementing the nutrient if the scarcity of forage crop.

Table 1. Physio-chemical properties of study sites.

Properties	Soil depths (cm)	
	0-30	30-60
PH	9.0	10.5
Organic carbon (%)	0.38	0.29
$CaCO_3$ (%)	7.2	8.8
Available N (kg ha^{-1})	140.3	125.4
Available P (kg ha^{-1})	6.3	5.2
Available K (kg ha^{-1})	235.7	120.1
Sand (%)	55	42
Silt (%)	30	26
Clay (%)	12	19
Texture	SL	SCL

SL= Silt loam; SCL= Silt clay loam.

RESULTS AND DISCUSSION

Perusal of table 2 shows that horticultural crop *Emblica officinalis, Zizyphus mauritiana, Psidium guojova, Aegle marmelos and Mangifera indica* are quite common in this region, while forage crop such as *Zea mays, Trifolium alexandrimum, Dicanthium annulatum, Sorghum bicolor Pennisetum pedicillatum, Pennisetum perpureum and Brachiaria mutica* were grown on the bunds of tresses or in between the fruit tree spacing. Farmer's practice cultivating fruit tree for commercial purpose and maintaining less spacing between lines and row to row this is the perfect example of maximum utilization of land.

They also undergo pruning of fruit tree species during the lean period for better growth and development of crown for maximum production.

It is well evident from the present study that varieties of forage crop are cultivated under fruit tree species that showed their perfection in plantation acquaintance. Based on indigenous knowledge system, the farmer's adopt the suitable tree crop combinations (Bhatt, 2003). In general hortipastoral system have been found most remunerative compared to other systems.

Table 2: Identification of important components under hortipastoral system.

Fruit trees	Forage crops
Zizyphus mauritiana	*Zea mays + Trifolium alexandrimum*
Mangifera indica	*Zea mays +Dicanthium annulatum*
Aegle marmelos	*Sorghum bicolor + Pennisetum pedicillatum*
Psidium guajava + Aegle marmelos	*Sorghum bicolor + Brachiaria mutica.*
Psidium guajava	*Zea mays + Dicanthium annulatum*
Psidium guajava	*Zea mays + Pennisetum perpureum*

Table 3 exhibited growth, density and yield of different components in hortipastoral system. Species density of fruit trees was found almost similar and varied from 200 tree/ha *(Mangifera indica)* to 285 tree/ha *(Zizyphus mauritiana, Psidium guojova, Aegle marmelos)*. Maximum growth was found in Mangifera indica (11.0 m height and 53.13 cm diameter) and rest of tree varied from 3.95 to5.40 m in plant growth and 8.59 to 23.67 cm in diameter.

Psidium guojova was produced maximum yield (28.76 q/ha), followed by *Emblica officinalis* (24.27 q/ha) while, *Mangifera indica* (17.66 q/ha) and *Aegle marmelos* (15.39 q/ha) were produced minimum yield as equated to other fruit tree species because heavy rainstorm accumulated during it's flowering stage as farmer informed during the data collection. Maximum density of forage crop was found in *Trifolium alexandrimum* (53044.9 p/ha) in interspacing of *Zizyphus mauritiana,* followed by *Sorghum bicolor* (39217.8 p/ha) under the plantation of *Psidium guojova.*

Pennisetum perpureum (327.37 q/ha) exhibited maximum green fodder yield, followed by *Pennisetum pedicillatum* (295.06 q/ha) under interspacing of *Psidium guojova* and *Aegle marmelos* heavy crown spread of these fruit tree species helped to protect for under story green forage crop through maintained moisture and reduced temperature.

The food energy in forage crop was determined highest in case of *Trifolium alexandrimum* (401.05 k. cal) and lowest in *Zea mays* (325.0 k. cal), while in fruit it was observed maximum in *Mangifera indica* (74.5 k cal) and *Zizyphus mautitiana* (74.3 k cal), respectively and rest of the species ranged in between these two extremes. The moisture content was very high (> 70%) in all the species as forage and fruit tree species as well and it was found comparatively more in fruit tree species as compared to forage crop.

The ash content in forage crop and fruit tree species varied from 9.7-18.2% and 4.6-8.4 % respectively. *Trifolium alexandrimum* (18.2 %) closely followed by *Pennisetum pedicillatum* (14.3 %) and *Brachiaria mutica* (13.8 %) indicated maximum deposition of mineral matter in forage crop.

Whereas, lowest ash content was recorded in fruit tree species as compared to forage crop, this might be more water contained in fruits of horticulture crop as compared to leaf of forage crop. Crude fibre content was recorded highest in *Dicanthium annulatum* (3.7 g/100g), followed by *Brachiaria mutica* (3.1g/100g) and *Trifolium alexandrimum* (3.0 g/100g)). Among various forage species, *Pennisetum pedicillatum* (1.4 g/100g) exhibited the lowest crude fibre.

While in horticultural crop species crud fiber was varied 0.9 *(Mangifera indica)* to 5.2 g/100g *(Psidium guojova)*. Fat content in forage crop was found highest (5.2 g/100g) in *Trifolium alexandrimum,* followed by *Pennisetum perpureum* (3.8 g/100g), and *Pennisetum pedicillatum* (3.4 g/100g). Among various species, lowest fat was noticed in *Dicanthium annulatum* and *Sorghum bicolor i.e.,* 1.9 g/100 g, respectively, however it was found very low in all the fruit tree species and ranged from 0.2-0.4 g/100g.

Carbohydrate content in forage crop is very high and ranged between 50.2 to 72.6 g/100g *Sorghum bicolor* possessed maximum carbohydrate content among all the species, followed by *Brachiaria mutica* and it was observed lowest in *Trifolium alexandrimum*.

The protein content determined for various forage species varied from 7.2 to 21.2 g/100g *Trifolium alexandrimum* contained maximum protein content, which was at par with *Dicanthium annulatum.* Out of 7 forage species, three contained the protein content more than 10, while in horticultural tree species, it was found very low (Table 4).

Table 3: Productivity of different components (±SD) in hortipastoral system

Fruit tree	Density (tree/ha)	Height (m)	DBH (cm)	Fruit yield (q/ha)	Forage crop	Density (p/ha)	Forage green yield (q/ha)
Zizyphus mauritiana	285.0	5.40 ±0.10 (5.3-5.5)	22.01 ±1.81 (20.6-23.7)	24.27 ±6.61 (18.1-31.3)	*Zea mays* *Trifolium alexandrimum*	21,271.7 53,044.9	80.36 197.86
Mangifera indica	200.0	4.30 ±1.01 (3.2-5.2)	8.59 ±3.53 (7.8-12.4)	21.27 ±3.21 (16.0-30.0)	*Zea mays* *Dicanthium annulatum*	27,711.5 20,217.3	69.84 225.39
Aegle marmelos	285.0	3.95 ±0.20 (3.7-4.0)	23.67 ±2.71 (21.3-26.5)	28.76 ±5.11 (24.8-35.0)	*Sorghum bicolor* *Pennisetum pedicillatum*	33,367.0 34,110.8	128.14 295.06
Emblica officinalis	250.0	3.99 ±0.41 (3.6-4.4)	15.19 ±1.68 (15.1-12.5)	15.39 ±0.84 (14.5-16.2)	*Zea mays* *Dicanthium annulatum*	22,538.1 17,183.3	85.51 196.18
Psidium guajava	285.0	11.00 ±0.50 (9.5-11.5)	53.13 ±8.27 (47.0-59.0)	17.66 ±3.59 (14.8-21.9)	*Zea mays* *Pennisetum perpureum*	23,353.6 23,218.4	76.93 327.37
					Sorghum bicolor *Brachiaria mutica.*	39,217.8 21,048.5	175.41 218.16

(Values in parenthesis are representing ranges of parameters).

Simple correlation (r) between density and yield of various components and with their respective environment (geographical, climatic and edaphic factors), irrespective of agroforestry system was evident in table 4. Yield of forage crop was highly influenced by geographical parameters and it exhibited significantly negative correlation (P= 0.01) with longitude. Density and growth of forage crops and horticultural, respectively was shown significant correlation (P=0.05 and P=0.01) with altitude. While climatic and ediphic factors are not influencing to growth and yield of hortipastoral components and shown non-significant correlation between them, because all the components are native to this region and cultivated in their natural habited.

Table 4: Simple correlation (r) between density and yield of components and with their respective environment (geographical, climatic and edaphic factors), irrespective of agroforestry system.

Parameters	Fruit tree			Forage crop	
	Density	Growth	Fruit yield	Density	Fresh yield
Latitude	-0.221	0.222	0.713	0.029	-0.002
Longitude	0.125	-0.158	0.086	-0.386	-0.966**
Altitude (m asl)	-0.639	0.819*	0.629	0.899**	0.396
Rainfall (mm)	0.640	-0.515	-0.500	-0.523	0.269
Temperature (°C)	0.545	-0.267	-0.264	-0.166	-0.096
Photoperiod (hrs/day)	0.132	-0.197	0.227	-0.609	-0.598
pH	-0.286	0.307	-0.076	0.427	-0.355
Bulk density (g cm^{-2})	0.197	-0.252	-0.677	0.084	0.315
Permeability (cc hr^{-1})	0.171	-0.099	-0.239	0.372	0.808*
Organic carbon (%)	0.225	0.103	0.469	0.280	0.062
Available N (kg ha^{-1})	0.431	-0.290	-0.519	0.084	-0.056
Available P (kg ha^{-1})	0.628	-0.700	-0.820*	-0.335	0.322
Available K (kg ha^{-1})	0.336	-0.204	-0.140	-0.355	-0.662

Significant at P=0.05*; P= 0.01**

Correlation coefficient (r) among different component, irrespective of agroforestry systems is shown that different parameters are not influencing each other except that of density of fruit tree influenced with growth of horticulture tree and found highly significant (P=0.01) relationship between them. Growth of horticultural tree is also influencing density of forage crop and exhibited significant correlation (P=0.05) with each other (Table 5).

Table 5: Correlation coefficient (r) among different component, irrespective of agroforestry systems.

Parameters		Fruit crop			Forage crop	
		Density	Growth	Fruit yield	Density	Fresh yield
Fruit crop	Density	-				
	Growth	-0.929**	-			
	Fruit yield	-0.614	0.705	-		
Forage	Density	-0.672	0.843*	0.560	-	
	Fresh yield	0.072	-0.046	-0.033	0.202	-

Significant at P=0.05*; P= 0.01**

Table 6 illustrate the adaptation rate of important forage components under hortipastoral system in the study area. Adaptation of the forage cropping pattern in these area is very high because the soil structures is not suitable to propagate cash crop and during the summer season due to high temperature food availability for the animal is very low and farmers are cultivating the forage crop in the bunds of their agriculture field where the irrigation facility is sound and under controlled. In agro forestry systems farmers are using the intra spacing of the horticulture tree as under the canopy moisture and shade originate is suitable for growth and survival of forage crop. Out of 100 farmers reviewed *Mangifera indica +Zea mays +Dicanthium annulatum* based horticulture system was adopted by major community of farmers (43) in the study area. The least Preferred was *Psidium guajava* + *Aegle marmelos* + *Sorghum bicolor* + *Brachiaria mutica* based horticulture system.

Table 6: Adaptation rate of important forage components under hortipastoral system

n=100

Fruit trees	Forage crops	Adaptation rate (%)
Zizyphus mauritiana	*Zea mays* + *Trifolium alexandrimum*	9
Mangifera indica	*Zea mays* +*Dicanthium annulatum*	43
Aegle marmelos	*Sorghum bicolor* + *Pennisetum pedicillatum*	07
Psidium guajava + *Aegle marmelos*	*Sorghum bicolor* + *Brachiaria mutica.*	04
Psidium guajava	*Zea mays* + *Dicanthium annulatum*	21
Psidium guajava	*Zea mays* + *Pennisetum perpureum*	16

CONCLUSION

Research and development efforts made so far indicated that agroforestry played an important role in augmenting the supply of fodders especially in sodic land of eastern Uttar Pradesh, which is estimated to be one third of total area, reported. In order to raise the productivity of forage in more area of sodic land is to be brought under agroforestry and also cost effective technology is required to be developed. Adaptation of the forage cropping pattern in these area is very high because the soil structures is not suitable to propagate cash crop. In agro forestry systems farmers are using the intra spacing of the horticulture trees as under the canopy moisture and shade originate is suitable for growth and survival of forage crop during summer period.

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