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Enhancing Forage Availability from Apple-based Agroforestry Systems: a case study of Jammu and Kashmir

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ABSTRACT

High yielding and nutritious fodder is essential for scientific and economic management of livestock. The production potential of Indian animals in general and those in Himalayan region is way below the global averages (about 50-60% less). Among the many factors limiting the productivity of livestock, inadequate availability of quality feed is the most important one. In view of scarcity of fodder and constraint of expanding the area under fodder cultivation, the effective utilization of interspaces of fruit orchards offer a unique opportunity to mitigate fodder shortages up to great extent besides aiding in better orchard floor management. Fruit tree-based agroforestry involves intentional simultaneous association of annual or perennial crops with perennial fruit producing trees on the same farm unit. Agroforestry system not only assures diversification but also provides higher economic returns in comparison to monocropping. The present study is an outcome of an inter-institutional project between ICAR-IGFRI regional research station and ICAR-CITH, Srinagar. In this project, the understory of apple trees was intercropped with perennial temperate grasses and legumes both under sole as well as in combination. The performance of fodder crops viz., tall fescue (IC-0615892), orchard grass (IC-0615914) and two legumes viz., white clover (IC-0615818) and red clover (IC-0615581) were tested under the 14 year old established apple orchard of ICAR-CITH, Srinagar, J and K, India. The utilization of these orchards as a niche area for forage resource augmentation can give a big boost to livestock development. However, the success of developing hortipasture land use system depends largely on selection of fruit plants and pasture species. Intercropping with suitable pasture species can bridge the gap of green and dry fodder deficits. It can ensure food and nutritional security by supplying quality fruits for human consumption and fodder for animal resulting stability in total system productivity

Key Words: Agroforestry, Apple, Forage availability, Jammu and Kashmir

I.INTRODUCTION

India being home to world's largest cattle population, animal husbandry plays a significant role in the economy of the people in general and more particularly in the regions where crop husbandry offers less remuneration. Crop farming in the plains and lower altitudes and livestock farming at higher altitudes is the accepted norm. The North Western Himalaya exhibit a great diversity in climate, landforms, ethnicity, resource availability and agricultural practices. The great mountain chain covers about 13% of geographical area in India and this vast hilly area provides ample opportunities for livestock rearing. But the production potential of Indian animals in general and those in Himalayan regions is way below the global averages (about 50-60% less). Among the many factors limiting the productivity of livestock, inadequate availability of quality feed is the most important one. High yielding and nutritious fodder is essential for scientific and economic management of livestock, especially cross bred. Livestock production is more efficient from cultivated fodder than from the degraded grazing lands but unfortunately the fodder cultivation has remained static and only 4% arable land in J&K is under fodder production [1]. There is acute shortage of fodder especially green nutritious fodder, which is the major cause of low productivity of the livestock, especially in hilly area [2]. In animal husbandry about 65-75% expenditure is incurred in feeds and fodder [3]. The regional deficits are more important than the national deficit, especially for fodder, which is not economical to transport over long distances. The pattern of deficit varies in different parts of the country. For instance, the green fodder availability in Western Himalayan, Upper Gangetic Plains and Eastern Plateau and Hilly Zones is more than 60% of the actual requirement. In Trans Gangetic Plains, the feed availability is between40 and 60% of the requirement and in the remaining zones, the figure is below 40%. In case of dry fodder, availability is over 60% in the Eastern Himalayan, Middle Gangetic Plains, Upper Gangetic Plains, East Coast Plains and Hilly Zones. In Trans-Gangetic Plains, Eastern Plateau and Hills and Central Plateau and Hills, the availability is in the range of 40-60%, while in the remaining zones of the country the availability is below 40%.

II.FORAGE SCENARIO OF JAMMU AND KASHMIR

Due to ever-increasing population pressure of human beings, arable land is mainly used for food and cash crops, thus there is little chance of having good-quality arable land available for fodder production, unless milk production becomes remunerative to the farmer as compared to other crops. Hence to meet the current level of livestock production and its annual growth in population, the deficit in all components of fodder, dry crop residues and feed has to be met from either increasing productivity, utilizing untapped feed resources, increasing land area (not possible due to human pressure for food crops) or through imports. Similarly in the state of Himachal Pradesh there exists a gap of about 35.0 and 57.0% from dry and green forages, respectively. Every year on an average about 7450 t of wheat straw is imported annually from the neighbouring states [4]. In the Practice of sheep and goat rearing has reduced drastically over the last decade due to the ban on free grazing in pasture lands and alpine meadow in Jammu & Kashmir by declaring them as protected areas. In such situation, the fodder obtained from arable land is insufficient to maintain the livestock. Therefore, the inhabitants largely

depend upon the forest based fodder resources. Forage cultivation is restricted to only about one per cent of the cultivated area in the entire Himalayan region. The state of Jammu and Kashmir produces around 64 lakh MT of green fodder and 35 lakh MT of dry fodder against a requirement of 139.13 lakh MT and 58.53 lakh MT of green and dry fodder, respectively. Besides oat crop, which is comparatively cultivated on a larger acreage (>20,000 ha), no fodder crop is cultivated intensively in the Kashmir valley. The majority of the fodder (62%) is extracted from forests (tree, shrub, leaves and herbaceous ground flora) and remaining (38%) is derived from agro-forestry systems, low altitude grasslands, degraded lands, high altitude grasslands and crop residues [5]. Beyond a certain altitude, the cultivation of fodder is not practical because of adverse climatic and geographic constraints. Due to extremes in climate, poor management and constant grazing, all types of grasslands have been degraded and these are found to be less productive. Consequently the livestock productivity is very low and all the Himalayan states have to import various livestock products from the plains.Besides grazing and fodder trees, the major local forage resource is the crop residue, which again is too inadequate to sustain the livestock [6]. Therefore, increased production of fodder is essential to meet the nutritional requirements of the livestock. But a host of factors like growing urbanization and shrinkage of agricultural land, preponderance of small and marginal farmers, climatic and geographicconstraints and social and economic aspects indicate that the chances of expansion of area under fodder cultivation are remote. This makes the exploration of alternatives even more important.

III.AGROFORESTRY AND FORAGE PRODUCTION

The state of Jammu and Kashmir, especially the valley of Kashmir endowed with multiple land forms has a rich diversity of traditional agro-forestry models which are in existence since time immemorial. These agro-forestry systems may provide for efficient fodder cultivation under existing systems. The area under different fruit plants in the state of J&K in 2016-17 was about 338528 ha (219723 ha in Kashmir and 118805 ha in Jammu) of which about 162971 ha (144825 ha in Kashmir and 18146 ha in Jammu) was under apple fruit alone. This vast area available under orchards and the inter spaces between fruit trees could be used for production of fodder by growing perennial grasses and legumes [7]. Among the fruit tree based agro-forestry system, the hortipasture systems have been recognized as sustainable land use option because of its high productivity and environmental benefits even under fragile agro-ecosystem [8] (Shukla *et al* 2014). Fruit tree based land use has been acceptable as a viable alternate land use system [9, 10]. Hortipastoral system is socially accepted, ecologicallyfeasible and economically viable for class IV and V types of lands, where fruit trees are grown in association with grass and legume [11,12]. The integrated approach of growing fodder grasses and legumes under agro forestry and silvi-pasture systems is one of the vital alternatives to augment fodder production. Agrosilvicultural (cultivation of trees yielding timber, fuelwood, and fodder along with agricultural crops), agrosilvihorticultural (cultivation of trees yielding timber, fuelwood, fodder, and fruit along with agricultural crops), silvopastoral (forest grazing), hortiagricultural (cultivation of agricultural crops along with fruit tree plantations), hortisilvicultural (cultivationof trees yielding fruit, timber, fuelwood, and fodder) and hortipastoral (fruit trees and forage crops) systems are the main forms of traditional agroforestry practiced in Himalayan region [13, 14].

Intercropping of perennial forage grasses and/or legumes with fruit crops is fruitful for high forage and fruit production [15]. Horti-pastoral system (orchards+ pasture+ livestock) where in the inter spaces between fruit tree species are utilized for cultivation of grasses and grass legume mixtures. Due to increased population, poor productivity of grassland resource and deficit in forage supply and farmer's inability to spare their cultivated land for forage production, it is essential to utilize the interspaces in these horticultural tree plantations. Having a slow growth initially or during formative years, the interspaces not only go without productive use but also become vulnerable to weedscausing trouble in the different orchard operations. Pasture component in the horticultural fruit crops has also reportedly been very promising intervention with respect to profitability and orchard floor management. Hortipastoral systems have been found to exhibit sustained or improved fertility by way of increased biomass, organic matter and other important nutrients, beneficial soil micro fauna, reduced run off and increased infiltration etc. The utilization of these orchards as a niche area for forage resource augmentation can give a big boost to livestock development. However, the success of developing hortipasture land use system depends largely on selection of fruit plants and pasture species. Intercropping with suitable pasture species can bridge the gap of green and dry fodder deficits. It can ensure food and nutritional security by supplying quality fruits for human consumption and fodder for animal resulting stability in total system productivity [16].

IV.MATERIALS AND METHODS

The present study was conducted at the Research farm of the ICAR-Central Institute of Temperate Horticulture, Srinagar, J&K, India. The experiment was established in the existing fourteen year old apple orchard (cultivar Red Gold) in 2012-13. The elevation of the experimental site is 1587 m above mean sea level and the climate of the region is moist temperate with mean annual precipitation of 730 mm received generally in the form of snow in winter and rains in March to April. The mean temperature of 13.3^{o}C with maximum reaching upto 35^{o}C in summer and may dip to -10^{o}C in winter is generally experienced. The soil of the experimental plot was clay-loam in texture with total N (0.012 %), total P (0.031 %), total K (0.312 %), organic carbon (0.67 %), pH (6.5-7.5) and bulk density (1.36 g/cc). The dominant clay mineral was illite, 2:1 non-expanding type (65 %) followed by kaolinite, 1:1 (22 %). The experiment was performed in three replications keeping the plot size 12m x 12m; spacing between plant to plant for apple was kept at 4m accommodating 625 trees/ha.. The rooted slips of tall fescue and orchard grass were transplanted in March, 2013 at 75 x 30 cm and where as red clover and white clover were sown @ 5 kg/ha in lines between two rows of grassesin theapple tree interspaces.Application of 5 kg FYM and 200 g N, 100g P_2O_5 and 150 g K_2O to each tree during both years was done and the dose was increased every year in same proportion. For pasture, 30 kg N and 60 kg P_2O_5 and 30 kg K_2O /ha of fertilizers were applied each year. Observations were taken using standard procedures and techniques.

V.RESULTS AND DISCUSSION

Fruit production

The intercropping of forage grasses and legumes had a significant influence on all the tree growth and yield parameters. The data in table 1 revealed that highest values for tree growth parameters in the apple variety Red Gold like trunk girth, trunk cross-sectional area (TCSA) and fruit yield were recorded in the apple + red clover treatments (39.20 cm, 122.34 cm^2 and 31.20 t/ha) followed by values of 38.20 cm, 116.18 cm^2 and 30.45 t/ha for trunk girth, TCSA and fruit yield, respectively in the apple + white clover treatment. Among other treatments, higher fruit yields were obtained in the combined (grass + legume) treatments as compared to sole grass treatments. However, grass/legume combination treatments were as good as legume treatments when comparisons were made with respect to yield efficiency. This improvement in the growth and yield parameters of apple may be attributed to the beneficial effects of legume introduction in the orchard.Forage legumes not only provide high-quality animal feed but also enhance soil fertility, improve soil structure and water infiltration, increase soil C accumulation and contribute to weed control and soil conservation [17]. So by way of additional production of quality forage and increased fruit production, the economic benefits of an apple based horti-pastoral system can be realised. Kinnow based sehima dominated horti-pastoral system gave maximum productivity when tree, grass and legume components were grown together [18]. Many research studies have revealed that the trees grown along with crops could give better economic returns as compared to agricultural crops alone [19].

Table 1: Growth and yield attributes of apple cv. Red Gold as affected by forage intercrops

Treatments	Trunk girth (cm)	Trunk cross-sectional area (cm^2)	Fruit Yield (Kg/tree)	Yield efficiency (kg/cm^2)
T_1: White clover+Apple	38.20	116.18	30.45	0.262
T_2: Red clover+ Apple	39.20	122.34	31.20	0.255
T_3: Tall fescue+ Apple	37.10	109.59	27.45	0.253
T_4: Orchard grass+ Apple	37.20	110.18	27.78	0.252
T_5: Tall fescue + white clover+ Apple	38.00	110.97	28.75	0.256
T_6: Tall fescue + red clover+ Apple	37.20	110.18	28.65	0.260

T_7: Orchard grass + white clover+ Apple	37.40	111.37	28.46	0.256
T_8: Orchard grass + red clover+ Apple	37.20	110.18	28.84	0.262
T_9: Control (Clean cultivation)	36.10	103.76	26.45	0.254
$CD_{0.05}$	0.06	0.33	0.09	0.001

Pasture production

The incorporation of pasture component in the apple orchard returned benefits in terms of adequate amounts of high quality forage in all the intercropped treatments. However, significant differences for forage production were observed between the treatments (table 2). Highest values for green fodder yield of 26.20 t/ha and dry fodder yield of 9.34 t/ha were recorded in the tall fescue+ red clover treatment followed by orchard grass+red clover treatment which recorded values of 23.70 t/ha and 7.94 t/ha for green and dry fodder yield, respectively. The pasture production across treatments was generally higher in the combined treatments (grass + legume) and lower in the sole legume treatments. However, significantly higher values for quality parameters like crude protein were recorded in the combined treatments (grass + legume) as well as sole legume treatments compared to sole grass treatments. The reason for this may be because of the legume component (red clover, white clover) which increased the overall crude protein content. The introduction of fescue in apple orchards gave 83.5% higher fodder yield over local grasses in Shimla hills of Himachal Pradesh [20]. The rhizobium inoculation of the pasture legumes provide synergistic effect for better establishment and obtained 59% and 72% higher green and dry herbage yield as compared to control [21].

In addition to fruits and forages, hortipastoral systems also provide valuable outputs like pruned wood and leaf. These are used as fuelwood during the harsh winter months in a specialized firepot, locally known as ‘kangri’. The leaf of apple is also used as fodder and bedding material in livestock sheds.

Table 2: Forage yield of grass/legume combinations

Treatments	Green fodder yield (t/ha)	Dry fodder yield (t/ha)
T_1: White clover+Apple	13.20	4.63
T_2: Red clover+ Apple	16.10	5.82

T_3: Tall fescue+ Apple	21.24	7.63
T_4: Orchard grass+ Apple	19.10	6.92
T_5: Tall fescue + white clover+ Apple	21.40	8.1
T_6: Tall fescue + red clover+ Apple	26.20	9.34
T_7: Orchard grass + white clover+ Apple	21.40	7.81
T_8: Orchard grass + red clover+ Apple	23.70	7.94
T_9: Control (Clean cultivation)	0.00	0.00
$CD_{0.05}$	0.04	0.031

VI.CONCLUSIONS

Hortipastoral systems can go a long way in enhancing forage as well as fruit production. Tree-based farming may also be useful as tree crops have the ability to withstand the vagaries of nature, provide year round employment and protect soil from erosion. Income from sheep production under apple based hortipastoral systems seems to be quite emunerative in addition to better utilization of orchard floor. In Jammu and Kashmir, forage production potential could be doubled by establishment of suitable hortipastoral systems as this approach would enhance the supply of nutritious fodder and meet the feeding requirements of sheep and other livestock and result in higher production and maximum returns to the farmer. Hortipastoral systems integrate fruits and forages and therefore are a self-sustainable system where solar energy can be harvested at different heights, soil resources can be efficiently used and cropping intensity is increased.

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