Hortipastoral based land use systems for enhancing productivity of degraded lands under rain fed and partially irrigated conditions

S. K. Sharma
Indian Grassland and Fodder Research Institute, Jhansi (India)
Present postal address: Indian Agricultural Research Institute, Regional Station, Agricultural College Estate, Shivajinagar, Pune – 411 005, India

Abstract
Hortipastoral based land-use systems were developed for sub-tropical degraded lands in the central India under rain fed and partially irrigated conditions through long term trials (1991-98) at the Indian Grassland and Fodder Research Institute, Jhansi (India). Under rain fed condition, jujube (Ziziphus mauritiana Lamk.) based hortipastoral system, incorporating perennial rain fed fodder grass - buffel (Cenchrus ciliaris L.) and legume - stylo (Stylosanthes hamata (L.) Taub.), was developed to optimize productivity of the system. Major products of the system were fodder and fruits. The combination of buffel and stylo as mix crop when intercropped with jujube trees gave higher fodder production (4.63 DM t ha$^{-1}$) than buffel (3.62 DM t ha$^{-1}$) and stylo (3.26 DM t ha$^{-1}$) when intercropped separately with jujube trees. Growth and production of fruit trees (5.98 and 5.88 t ha$^{-1}$ average fruit production in the 5th and 6th years respectively) were not affected significantly with various tree-pasture combinations as compared to control (trees alone). Among all treatment combinations, the system gave maximum productivity when buffel and stylo were intercropped with jujube trees as mix crop. Under partially irrigated (drip irrigation) condition, productivity of natural sehima (Sehima nervosum (Rottl.) Stapf.) pasture was enhanced from 4.01 to 4.50 DM t ha$^{-1}$ by introduction of fruit trees (Kinnow mandarin, Citrus nobilis Lour x C. deliciosa Tenora) and stylo. Maximum Kinnow production (6.91 t ha$^{-1}$) was obtained in the 4th year. Maximum system productivity was obtained when both Kinnow and stylo were introduced in the natural sehima system. There was no adverse effect of tree and fodder components on each other in the long run. Hortipastoral systems offer viable alternatives to the present land uses on degraded lands of central India.

Key word: Central India, forage production, sub-tropical fruits

Introduction
Vast area in India (about 157 m ha) is classified under various types of degraded land where one or more limiting factor(s) render the cultivation of crops economically unviable. As an outcome of untiring efforts of pioneer workers in the field, fruit tree based land use systems have been accepted as an alternative land use option for degraded lands in India (Pareek and Chadha, 1993; Pathak, 1993 and 1999; Pathak and Pathak, 2000 and Saroj et al., 1994). Hortipastoral system is a promising land use system in which fruit trees are grown in association with fodder crops in which there exists, both ecological and economic interactions among different components. Among various fruit trees suggested for hortipastoral systems under rain fed condition, jujube (Ziziphus mauritiana Lamk.) is a preferred species because of hardiness and its ability for profitable production under harsh edaphic and climatic conditions, and limited external resources (Sharma and Saran, 1999). While under partially irrigated conditions, cultivation of Kinnow mandarin (Citrus nobilis Lour x C. deliciosa Tenora), has become popular because of its adaptability to different agro-climatic conditions, heavy bearing potential, reasonable shelf life, and excellent juice quality (Chopra and Joshi, 1971; Jawanda, 1976; Jawanda and Bhambota, 1979, Jawanda and Singh, 1973; and Jawanda et al., 1972). Natural grasslands are main source of fodder to about 500 million animals in India (Swaminathan, 1989) mainly because the area under fodder production is low (4.4% of total cultivated area). According to the latest census (GOI, 1998), the area under fodder crop (6.186 Ha) has further reduced to 3.5% of total cultivable area in India. Most degraded lands falls in the areas of acute fodder shortage. The introduction of pasture component in the fruit tree based land use systems (hortipastoral systems) makes them more attractive to farmers. Buffel (Cenchrus ciliaris L.) and sehima (Sehima nervosum Rottl. Stapf) are popular pasture grass species. Sehima is highly palatable at all stages of growth, quite nutritious and gives high yield in a well managed natural grasslands (Kanodia et al., 1993). Stylo (Stylosanthes hamata (L.) Taub.) is a perennial,
rain fed pasture legume species. Introduction of stylo in natural grasses is a common practice to enhance the pasture production and nutritional quality of the fodder (Rai and Pathak, 1985). Therefore, this study was aimed at optimizing the productivity of hortipastoral systems under rain fed and partially irrigated degraded lands in central India.

Materials and methods

Area description
Central Research Farm, Indian Grassland and Fodder Research Institute, Jhansi (78° 27' E Longitude and 25° 27' N Latitude, about 275 m above msl) falls under semi-arid region with average rainfall of 850 mm. Soil of the experiment site under rain fed condition was sandy-clay with neutral reaction (pH 6.74 and Electrical Conductivity, EC, 0.025 dm s⁻¹), low in organic carbon (0.184%) and available nitrogen (149.69 kg/ha) and medium in available potassium (152 kg/ha). While the soil of the experiment site under partial irrigation was sandy-clay-loam, neutral in reaction (pH 6.62) and low in EC (0.01 dm s⁻¹), with low organic carbon (0.28 %) and available nitrogen (172.9 kg/ha). Available potassium was in normal range (112 kg/ha).

Treatment and experimental Layout. Four jujube (Ziziphus mauritiana Lamk.) cv. Gola plants per treatment combination were planted at 6x6 m spacing in April 1991 in the relevant treatment combinations. Total experimental area was 36x120 m. Fruit trees and pasture components were planted in the following seven treatment combinations, viz., (i) Jujube alone (T1, control); (ii) Jujube+Buffel (T2); (iii) Jujube+Stylo (T3); (iv) Jujube+Buffel+Stylo (T4); (v) Buffel sole (T5); (vi) Stylo sole (T6); and (vii) Buffel+Stylo (T7). Treatment combination number T5, T6 and T7 were raised without jujube trees.

The field of natural pasture of sehima (Sehima nervosum (Rottl.) Stapf.) was divided into 12 plots of 18x18 m each. Total experimental area was 48x120 m. Nine Kinnow (Citrus nobilis Lour x C. deliciosa Tenora) saplings were planted per treatment combination in July 1992 in the relevant treatment combinations at a spacing of 6x6 m. The following four treatment combinations, viz., (i) Natural Sehima pasture (T1, control); (ii) Kinnow alone (without Sehima/stylo) (T2); (iii) Sehima+Kinnow (T3); and (iv) Sehima+Kinnow+Stylo (T4) constituted the experiment.

Establishment and management of trials. Jujube scion were patched budded in situ on three months old seedlings of jharter (Z. nummularia (Burm. F) Wight and Arn.). The inter-space among jujube trees was utilized for the cultivation of buffel grass (Cenchrus ciliaris L.) and stylo legume (Stylosanthes hamata (L.) Taub.). Rooted slips of buffel grass were transplanted at a spacing of 50 cm in lines, and lines being 1 m apart. All plants were maintained under rain fed condition. Saplings of Kinnow mandarin were raised on Jatti Khatti (Citrus Jambheri) rootstock. All Kinnow plants were irrigated through drip irrigation system. For the maintenance of fruit trees, standard orchard management practices were followed for the application of fertilizers, irrigation (Kinnow only) plant protection chemicals, training and pruning, and other operations. All pasture plots were applied with nitrogen (N) at the rate of 40 kg N ha⁻¹ annum⁻¹. Boiling water treated seeds of stylo were broadcasted in respective treatment combinations.

Data collection and analysis
Growth (plant height and collar diameter) and yield data were recorded annually for fruits and fodder crops (on dry matter basis). Harvest method was adapted for recording plant biomass of pasture (Odum, 1960). Entire plot was harvested and weighed in the field itself for fresh weight. Samples of 100 g pasture were oven dried for dry matter content. A randomised block design was adopted for statistical analysis of data using standard procedure.

Results and discussion

Rain fed condition

Fruit production
Jujube plants showed a steady growth with age in terms of plant height and collar diameter. The plant height varied from 0.87 to 0.92 m in the 1st year (1991). The variation in the 5th year (1995) was 3.14 to 3.54 m (Fig. 1). The collar diameter had variation of 0.87 to 1.01 cm in the 1st year (1991). The variation was raised to 7.69 to 8.48 cm in the 5th year (Fig. 2). During first five years, the plant growth was not affected significantly by cultivation of fodder crops. Trees started yielding fruits from 3rd year onward (1993, 0.125 to 0.164 t ha⁻¹ under various treatment combinations having fruit component). There was a steady growth in fruit yield during experimental period, except in 1997 (2.57 to 2.86 t ha⁻¹) due to bad weather. In 1997, the total rainfall (827.9 mm) and number of rainy days (47 days) were less than the preceding year (850.4mm and 52 days, respectively) and the following year (986.4 mm and 52 days, respectively). Unfavourable weather conditions resulted in a severe fruit drop, and the quality of fruits was inferior due to attack of powdery mildew and fruit borer. The yield was raised to 5.37 to 6.55 t ha⁻¹ in the 8th year (1998) (Fig. 3). The fruit yield was not affected significantly by growing intercrops in the inter-space. Similar trends of production were obtained by other workers. Raturi and Hiwale (1998) (Fig. 3). The fruit yield was not affected significantly by growing intercrops in the inter-space. Similar trends of production were obtained by other workers. Raturi and Hiwale (1998) obtained fruit yield of 1.61 and 4.9 t ha⁻¹ in the 1st and 3rd years respectively on Horti-silvi-pasture system at Godhra (Gujarat, India). Singh and Osman (1995) harvested 919 kg fruit ha⁻¹ under jujube based Hortipastoral system at Hyderabad.

Pasture production. In the first year, the fodder production was low in all treatment combinations, e.g., buffel (1.71 DM t
Table 1. Fodder production of buffel and stylo (DM t ha\(^{-1}\)) as influenced by jujube trees

<table>
<thead>
<tr>
<th>Year (Age)</th>
<th>Buffel Without jujube</th>
<th>Buffel With jujube</th>
<th>Stylo Without jujube</th>
<th>Stylo With jujube</th>
<th>Buffel+Stylo Without jujube</th>
<th>Buffel+Stylo With jujube</th>
<th>CD at 5%</th>
</tr>
</thead>
<tbody>
<tr>
<td>1991 (1)</td>
<td>1.71</td>
<td>1.39</td>
<td>1.86</td>
<td>1.35</td>
<td>2.22</td>
<td>2.82</td>
<td>NS</td>
</tr>
<tr>
<td>1992 (2)</td>
<td>0.64</td>
<td>1.15</td>
<td>4.50</td>
<td>5.32</td>
<td>7.83</td>
<td>7.10</td>
<td>NS</td>
</tr>
<tr>
<td>1993 (3)</td>
<td>3.03</td>
<td>4.30</td>
<td>4.31</td>
<td>4.21</td>
<td>5.17</td>
<td>5.14</td>
<td>NS</td>
</tr>
<tr>
<td>1994 (4)</td>
<td>4.59</td>
<td>4.17</td>
<td>3.23</td>
<td>2.34</td>
<td>4.27</td>
<td>4.77</td>
<td>0.47</td>
</tr>
<tr>
<td>1995 (5)</td>
<td>4.53</td>
<td>6.08</td>
<td>4.36</td>
<td>4.32</td>
<td>3.34</td>
<td>3.46</td>
<td>NS</td>
</tr>
<tr>
<td>1996 (6)</td>
<td>3.50</td>
<td>4.80</td>
<td>3.61</td>
<td>3.22</td>
<td>3.08</td>
<td>4.20</td>
<td>NS</td>
</tr>
<tr>
<td>1997 (7)</td>
<td>2.46</td>
<td>3.46</td>
<td>2.86</td>
<td>2.06</td>
<td>2.81</td>
<td>3.68</td>
<td>NS</td>
</tr>
<tr>
<td>Average</td>
<td>2.92</td>
<td>3.62</td>
<td>3.53</td>
<td>3.26</td>
<td>4.10</td>
<td>4.63</td>
<td></td>
</tr>
</tbody>
</table>

Table 2. Pasture production (DM t ha\(^{-1}\)) of Sehima dominated natural pasture under various treatment combinations

<table>
<thead>
<tr>
<th>Treatment combinations</th>
<th>Sehima dominated natural pasture</th>
<th>Sehima + Kinnow</th>
<th>Sehima + Kinnow + Stylo</th>
<th>C. D. at 5%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age of the system (Year)</td>
<td>Control</td>
<td>(Control)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 (1993)</td>
<td>2.87</td>
<td>3.18</td>
<td>2.09</td>
<td>NS</td>
</tr>
<tr>
<td>2 (1994)</td>
<td>5.87</td>
<td>5.15</td>
<td>5.74</td>
<td>0.70</td>
</tr>
<tr>
<td>3 (1995)</td>
<td>4.95</td>
<td>6.12</td>
<td>7.38</td>
<td>NS</td>
</tr>
<tr>
<td>4 (1996)</td>
<td>4.02</td>
<td>3.78</td>
<td>3.63</td>
<td>NS</td>
</tr>
<tr>
<td>5 (1997)</td>
<td>2.83</td>
<td>2.75</td>
<td>3.95</td>
<td>NS</td>
</tr>
<tr>
<td>6 (1998)</td>
<td>3.51</td>
<td>3.14</td>
<td>4.19</td>
<td>NS</td>
</tr>
<tr>
<td>Average</td>
<td>4.01</td>
<td>4.02</td>
<td>4.50</td>
<td></td>
</tr>
</tbody>
</table>

Figure 1. Growth (plant height) of jujube trees under various pasture combinations

Figure 2. Growth (collar diameter) of jujube trees under various pasture combinations
Figure 3. Production of jujube fruit under various pasture combinations

Figure 4. Growth (plant height) of Kinnow plants under various pasture combinations

Figure 5. Growth (collar diameter) of Kinnow plants under various pasture combinations

Figure 6. Production of Kinnow fruits under various pasture combinations
Pasture production

Pasture production was low in the first year, 1993 (2.09 to 3.18 DM t ha⁻¹). There was continuous increase in pasture production in first three years. It ranged between 4.95 to 7.38 DM t ha⁻¹ in the third year (1995). Thereafter, there was a decline in pasture production in all treatment combinations. It varied from to 3.14 to 4.19 DM t ha⁻¹ in the sixth year (1998) (Table 2).

Land degradation is an environment and social menace. Hortipastoral systems have a great potential for assuring conservation and land sustainability for degraded lands. The socio-environmental challenges of areas falling under degraded lands. Such as rapid increase in human and cattle population, decreasing land-man ratio, widespread deforestation, excessive grazing, soil erosion, environmental deterioration, etc., can be encountered by encouraging hortipastoral systems for different agro-climatic niches.

Conclusion

Based on a long-term trial, it has been established that jujube trees when grown with buffel and stylo as intercrops, gave maximum system productivity when compared with other combinations. Kinnow based sehima dominated Hortipastoral system gave maximum productivity when tree, grass and legume components were grown together. There was no significant adverse effect of tree and pasture on each other in the long run. Hortipastoral systems have much to offer in checking land degradation trend and in providing much needed products, like, fruit, fodder, fuel wood, etc. Hortipastoral systems being site specific in nature, need to be developed according to the location and people’s requirements. They are also governed by the extent of resources at the disposal of an individual farmer. Therefore, emphasis should be there on developing a few generic technologies and leaving ample scope for the individual farmers to innovate.

Acknowledgement

The author is highly indebted to the Director, IGFRI, Jhansi for providing encouragement and other necessary resources during the project period.

References


