Indian J. of Agroforestry Vol. 19 No. 1 : 48-56 (2017)

Scope and potential of hortipastoral systems for enhancing livestock productivity in Jammu and Kashmir

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ABSTRACT: Agroforestry is one of the sustainable approaches to land-use management where both agricultural crops and tree crops combine into an integrated production system to get maximum benefits. Yield and quality of forage in agroforestry systems can be improved by introducing shade-tolerant grass (*Dactylis glomerata, Festuca arundinaceae, Phleum pratense, Setaria* spp etc.) and legume species (*Trifolium pratense, Trifolium repens, Medicago sativa* etc.) in appropriate mixtures. Management of these systems can present a challenge especially in the selection of proper grass and legume species as well as the maintenance of the optimum balance between the two species in the grass–legume stand. Livestock plays very vital role in the economic development of the state of Jammu and Kashmir and forms an integral part of state agriculture. However, the major challenge is to bridge the gap between forage production and requirement. The state produces around 64 lakh MT of green fodder and 35 lakh MT of dry fodder. However the requirement of green is 139.13 lakh MT and dry is 58.53 lakh MT. Therefore, increased production of fodder is essential to meet the nutritional requirements of the livestock. The resource base available with the farming community is limited. Limited land endowments make it further difficult for the farmers to earmark adequate land for fodder and forage cultivation. Estimates of Horticulture Department of Jammu and Kashmir state are more than 340 thousand hectares under orchards wherein there is a scope for the introduction of fodder crops as inter-crop. Hortipastoral system, therefore, seems to be the possible solution not only in meeting the continuous increase in the demand for fruit and fodder but also in improving the productivity and sustainability of the system as a whole. An attempt has been made to review the forage potential status, livestock resource and suggest the potential for augmentation of forage production.

Key words: Agroforestry, grasses, hortipasture, legumes and livestock.

Received on: 03.11.2016 Accepted on: 21.02.2017

1. INTRODUCTION

Agroforestry is a dynamic, ecologically based, natural resources management system that, through the integration of trees on farms and in the agricultural landscape, diversifies and sustains production for increased social, economic and environmental benefits for land users at all levels (Mead, 2004). It encompasses sustainable approaches to land-use management where both agricultural crops and tree crops combine into an integrated production system to get maximum benefits (Kidd and Pimentel, 1992; Nair, 1998). Griffith (2000) considers agroforestry as an ecologically sustainable land-use option alternative to the prevalent subsistence farming patterns for conservation and development. Allen *et al.* (2011) define agroforestry as, "land-use system in which trees are used for forest products (e.g. timber, pulp, fruits, rubber, syrup and browse) combined with agricultural crops including forage crops and/or animal production."Agroforestry provides valuable environmental services including soil fertility replenishment, water catchment protection, carbon sequestration, biodiversity conservation and land rehabilitation (Garrity 2004, Idol *et al.*, 2011). The last twenty years have witnessed an intensification and expansion of research relevant to smallholder agroforestry systems (Leakey *et al.*, 2012).

The state of Jammu and Kashmir, especially the valley of Kashmir has a rich diversity of traditional agroforestry models which are in existence since time immemorial. Several agroforestry systems have been identified in Kashmir valleys which include boundary plantations, agri-silviculture, horti-silviculture, horti-pasture, horti-silvi-agriculture and kitchen gardens. Adequate representation of all the components is lacking in these systems. In some of the models, tree component is far less and utilization of space in these systems is not efficient, besides the yield of agricultural crops is also less (Mughal and Bhattacharya, 2002).

Temperate horticulture has a special significance for economic development in hilly regions. In the fruit map of India, the state of Jammu and Kashmir accounts for 48% of the total temperate fruit production followed by Himachal Pradesh and Uttarakhand. Among these states, J&K has emerged as the leading apple yet it

producing state in the country and during the last decade the area under the crop has increased 16 times, production by about 60 times and productivity by about 5 times (Bhat *et al.*, 2013). Although, Jammu and Kashmir is the state where yield of commercially important apple varieties is the highest in the country (11.29 t ha^{-1}) yet it compares poorly to the yields obtained by advanced countries which is 60 t ha^{-1} (Anonymous, 2009). 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 the horticultural tree plantation. Having a slow growth initially or during formative years, the interspaces not only go without productive use but also become vulnerable to weeds. Hence, growing of intercrops which are compatible with the main crop seems to reduce weed invasion in the early stages of plant growth and increase the yield.The utilization of these orchards as a niche area for forage resource augmentation can give a big boost to livestock development.

Inspite of the abundance of the pastures, in mid-hills, sub-alpine and alpine areas, crop residues and grazing in the forests, common property resources (CPR) and wastelands, the total available biomass is insufficient to sustain the livestock population (Dev *et al.*, 2014). Grass-legume inter-cropping, besides increasing the biomass production also provides better quality forage which is rich in protein and carbohydrates that ultimately helps to improve milk production and animal health. Legumes usually maintain their quality better than grasses even at maturity and being rich in protein, enhance forage value and also add substantially the much needed nitrogen to the soil (Ram, 2008; Ram and Parihar, 2008). Grasses and legumes bring such changes in soil organic matter and biological activity that have been associated with improved orchard soil quality (Neilsen *et al.*, 2003; Canali *et al.*, 2009) and tree performance (Cline *et al.*, 2011).

In this backdrop, the present review was carried out to focus on: (i) fodder/livestock inventory of the state, (ii) fodder-fruit integration for sustainable fodder-livestock development of the state. The present study is an outcome of exhaustive review of an inter-institutional project between IGFRI Regional Station and CITH on development of hortipastoral systems in Jammu and Kashmir. Both primary and secondary data were used to interpret the results. The secondary data included (i) discussions with researchers and field functionaries associated with different aspects of horticulture/livestock/fodder development programmes of state, and (ii) consideration of selected reference works, books, and research and extension papers pertaining to horticulture, fodder and livestock of the state.

2. JAMMU AND KASHMIR

Jammu and Kashmir (33° 17′ – 37° 20′ N latitude, 73° 25′ - 80° 30′ E longitude) comprises 3 main physical regions *viz.* outer-Himalaya facing with sub-tropical and intermediate type of climate (Jammu region), lesser-Himalaya or temperate zone (Kashmir region) and Trans-Himalaya (Ladakh region) or cold arid zone (Wani *et al.,* 2007). The livestock production system is mainly extensive in Jammu and semi intensive in Kashmir and Ladakh regions although extensive farming is practised for Changthangi pashmina goat in Ladakh (Wani *et al.,* 2009). The climate of the region is determined by altitudinal gradient, the elevation increasing from 330 metres in Jammu to about 3305 meters in Ladakh. With increase in the elevation the rainfall decreases from 1052 mm in Jammu to 662 mm in Srinagar and only 92 mm in Leh with mean annual temperature of 24.5 °C in Jammu, 13.3 °C in Srinagar and only 5.3 °C in Leh, giving rise to sub-tropics, temperate and sub-arctic climates (Wani *et al.*, 2014). The length of the crop growing season also decreases as we proceed from south to north. In Jammu the crop can be grown round the year while in Kashmir valley double cropping is possible but in Ladakh region, crops can be grown during June to September only (Ahmad and Verma, 2011).

2.1 Livestock status

Livestock plays very vital role in the economic development of the State and forms an integral part of state agriculture. About 75% population of J&K State is dependent on agriculture as their main occupation. Livestock rearing is their subsidiary occupation as these two sectors are interdependent. The agricultural sector (including livestock) contributes 25.94% to the Gross State Domestic Product (GSDP) at constant prices. The livestock sector alone contributes 11% of the GSDP which is about 40% of the contribution of the agricultural and allied sector (Ahmad *et al.*, 2016). Livestock sector engages sizeable number of work force not only in rearing of animals but also in processing, transportation and sale of animal products. According to 18th livestock census (2007) there were 3.45 million cattle, 1.05 m buffalo, 3.68 m sheep and 2.07 m goats in the state. During the last decade, total cattle population has remained almost stagnant but the annual growth rate in crossbred cattle

was 4.49 percent p.a. Buffalo has also registered a growth rate of 2.94 percent p.a. during 1997-2007, whereas in sheep and goats it was 1.5 and 1.05 percent p.a., respectively (Table 1). The livestock species which contributed significantly in the output from this sector included the bovine species (cattle, buffalo and yaks), small ruminants (sheep and goat) and to a less extent the equines (horse, pony, donkey besides camel etc).The 18th Livestock Census revealed that 65, 29 and 6% population was supported by Jammu, Kashmir and Ladakh regions, respectively (Anonymous, 2008).

The density of livestock per sq. km of area of Jammu and Kashmir State was 98 animals against 90 animals for the 16th Livestock Census. The number of livestock per 1000 of human population as per 2003 census was 926 animals while as at the all India level the number of livestock per 1000 of human population works out to be only 457 animals. Average livestock per household, as per census figures of 2001, works out to six animals per household for Jammu and Kashmir State as compared to about three animals per household at the all India level (Anonymous, 2006). There is no shortcut to sustain livestock husbandry, without focusing the issues related to the development of fodder and feed resources (Datta, 2013).

2.2 Forage resources, production and deficit

Fodder production is primarily a land-use activity and depends on multiple factors like climate, irrigation, livestock number and type besides cropping pattern (Arya *et al.*, 2011). In Jammu and Kashmir, feed for livestock is available from cultivated as well as uncultivated lands (Wani *et al.*, 2014). The uncultivated lands, as a source of feed include 2 major sources, *viz.* common and private support lands. Common support lands (CPRs) include the barren line forests outside the forest area and the forest area maintained by forest department; barren and uncultivable land; cultivable wasteland; land under tree groups; permanent pastures and non-agricultural land (Ahmad *et al.*, 2016). These CPRs constitute the most important input for livestock production and subsistence for the poor. Private support lands for grazing include grasses from bunds in paddy fields; fallow lands and orchards. Available feed resources from cultivated lands can be classified into four important groups, *viz.* (i) cultivated fodder (most commonly oats, berseem and alfalfa) (ii) straw-I, (residues from leguminous crops including pulses), (iii) straw-II, (residues from coarse grain crops including maize and millets), and(iv) straw-III, (residues from fine grain crops like paddy, wheat and barley).

The productivity and health of livestock mostly depends on feeding practices and the quality of feed and fodder provided to the animals (Birthal and Jha, 2005). Limited land endowments make it difficult for the farmers to earmark adequate land for fodder and forage cultivation (Anonymous, 2012). The major challenge is to bridge the gap between forage production and requirement (Ahmad *et al.*, 2016). The state produces around 64 lakh MT of green fodder and 35 lakh MT of dry fodder. However the requirement of green is 139.13 lakh MT and dry is 58.53 lakh MT. Therefore, increased production of fodder is essential to meet the nutritional requirements of the livestock (Anonymous, 2013). Further, the agro-climatic condition of the major portion of the state also

Table 1. Livestock population and their growth rate in Jammu and Kashmir

Year	Crossbred cattle	Total cattle	Buffalo	Sheep	Goat
			Population		
1987	4,90,919	2,765,699	5,95,257	2,493,454	1,396,025
1997	1,083,000	3,175,000	7,87,000	3,170,000	1,864,000
2003	1,320,000	3,083,842	1,039,461	3,410,676	2,054,923
2007	1,680,724	3,446,150	1,051,490	3,680,232	2,068,653
			Growth rate (percent p.a.)		
1987-1997	0.79	0.14	0.28	0.24	0.29
1997-2003	3.35	-0.48	4.75	1.23	1.64
2003-2007	6.23	2.82	0.29	1.92	0.17
1997-2007	4.49	0.82	2.94	1.50	1.05

Source: (Anonymous, 2008)

warrants the need of cultivating even additional fodder that can be dried to hay or stored as silage for lean periods (Mir *et al.*, 2016). Balance sheet for the entire state of Jammu and Kashmir to feed a rapidly increasing population of livestock is presented in Table 2.

3. SCOPE AND POTENTIAL OF HORTIPASTORAL SYSTEMS IN J & K

Adequate availability of quality fodder is essential for enhancing livestock productivity (Anonymous, 2007). The productivity of ruminants in Jammu and Kashmir is below the national average although the state has abundant natural fodder resources in the form of pastures, orchards, aquatic vegetation etc. As per the estimates of Horticulture Department of Jammu and Kashmir, more than 340 thousand hectares of land is under orchards (Malik and Chourie, 2014). Scope exists in introduction of fodder crops as inter-crop in orchards, which has by and large remained untapped for fodder development.Appropriate strategies are needed for effective utilization of orchard interspaces for sustainable livestock development in the region (Wani *et al.,* 2014).

In most parts of the state, resource base available with the farming community is limited. With the rise in the population and no further scope for extending area under cultivation in the state, per capita availability of land is declining. The area under permanent pastures and other grazing lands has remained stagnant at 125 thousand hectares over the years, which is a cause of concern to planners due to increasing demand for grasses and fodder for livestock. The possibility of increased forage production by bringing additional area under fodder cultivation are limited and it is therefore, imperative that continuous efforts are made to augment forage resource availability through alternate land use systems (Mir *et al.*, 2016). Under this programme, it is envisaged to introduce high yielding temperate perennial grasses and legumes in phased manner to cover the available orchard land (Table 3). The state has the largest potential for the production of quality temperate horticultural crops. It has created a niche in production of apple, pears, and dry fruits i.e. almond and walnut. Among temperate fruits, apple, walnut and almond rank first, second and third, respectively in area and production, covering 64.05, 27.31 and 8.65% of area. The state has a variety of agro-climatic conditions and each agro-climatic region has its own potential to grow specific fruit, providing an opportunity to grow a variety of fruits during the major part of the year (Table 4). Introduction of grasses and legumes in the interspaces of fruit plants is useful not only for proper orchard floor management but also for supplying adequate and quality forage to livestock (Merwin, 2004; Wani *et al.*, 2014).

4. GRASSES AND/OR LEGUMES FOR ORCHARD FLOOR MANAGEMENT

The orchard floor represents a substantial portion of the orchard agroecosystem, but it has generally received less research and management attention than tree horticulture and pest management. Yet opportunities exist to improve orchard sustainability through manipulation of the orchard floor (Granatstein and Sanchez, 2009).

Proper orchard floor management is vital to the health and productivity of fruit trees, with management practices impacting tree growth, fruit yield, and fruit quality. Current recommended orchard floor management practices consist of maintaining a vegetation-free tree row and a grass cover crop in the alleyway (Parker *et al.*, 1993; Dabney *et al.*, 2001; Merwin, 2004). Kuhn and Pedersen (2009) showed that clover and grass mixtures increased shoot growth and yield in two varieties of apples. Cultivation of annual crops decreases soil organic matter and increases soil erosion potential, especially on sloping landscapes. Perennial crops maintain a continuous soil cover, increase water infiltration, reduce soil erosion, and improve overall soil quality. Therefore, planting forage species in the alleys may not only

Table 2. Fodder balance sheet on dry matter basis ('000 tonnes)

Region	Availability	Requirement	Deficit
Jammu	5545.58	8188.00	2642.42 (32.27)
Kashmir	1866.49	3635	1768.51 (48.65)
Ladakh	108.57	740	631.43 (85.32)
Jammu& Kashmir	7420	12563	5142.36 (40.93)

Figures in parenthesis represent percentage

Source: (Wani *et al.*, 2014)

protect the soil resource by improving soil quality but also provide a source of income during orchard establishment.

A recent report suggests that cover crops integrated in almond (*Prunus dulcis* L.) orchards improved soil quality relative to clean tillage by increasing soil organic C, soil aggregate stability, and microbial activity (Ramos *et al.*, 2010). A cover of mixed legumes established in an apple (*Malus domestica* Borkh.) orchard increased soil organic C and total N, soil biological activity, and potentially available N for trees over a two-year period (Hoagland *et al.*, 2008).

Yao *et al.* (2009) reported that apple roots grew deeper and survived longer beneath grass than pre-herb treatments. The study conducted by Bhat *et al.*, (2013) under Kashmir conditions revealed significant improvement in annual extension growth, plant height and plant spread in apple plants intercropped with legume crops in comparison to apple plants with heavy feeder intercrops (maize and oat). Bhat (2015) reported that yield, leaf nutrient status (N, P, K, Ca, Mg) and relative economic yield (system equivalent yield) of cherry trees intercropped with pea, red clover and french bean were greater than clean cultivation.

5. GRASSES AND LEGUMES FOR INCREASING FORAGE YIELD AND QUALITY IN HORTIPASTORAL SYSTEMS

Forage grasses and legumes are commonly grown in mixture because of their ability to increase herbage yield and to produce forage with a more balanced nutrition for livestock feeding compared with monocrop systems (Barnett and Posler, 1983; Giambalvo *et al.,* 2011; Geirus *et al.,* 2012). Orchard floor management practices involving grasses and legumes (hortipastoral systems) are important in fruit production to maintain soil tilth and fertility, reduce weed competition, moderate soil temperature and moisture extremes, provide a habitat for beneficial

Table 3. Area under Fruits in J & K (area in 000 hectares)

Year	Apple	Pear	Apricot	Cherry	Other fresh fruits	Walnut	Almond	Other dry fruits	Total fruits
2004-05	107.93	10.54	4.93	2.55	41.62	74.89	15.43	0.42	258.31
2005-06	111.88	11.00	5.16	2.59	43.60	77.22	15.55	0.41	267.41
2006-07	119.04	11.25	5.43	2.75	46.24	81.39	16.37	0.62	283.09
2007-08	127.80	12.10	4.78	3.14	48.32	82.05	16.40	0.55	295.14
2008-09	133.10	12.35	4.92	3.30	49.65	84.56	17.18	0.56	305.62
2009-10	138.19	12.55	5.00	3.41	50.57	87.28	17.54	0.60	315.14
2010-11	141.71	12.53	5.85	3.46	53.50	89.78	17.65	0.58	325.06
2011-12	154.72	13.21	6.05	3.48	54.11	83.61	16.41	11.19	342.78

Source: (Malik and Choure, 2014)

Table 4. Suitable fruit crops for different zones of Jammu and Kashmir

Zone	Districts	Fruit crop
Temperate zone (1500-3500 m)	Anantnag, Pulwama, Shopian, Budgam, Baramulla, Srinagar, Ganderbal, Kulgam, Kupwara and Budgam	Apple (*Malus domestica*), Almond (*Prunus amygdalus*), Pear (*Pyrus communis*), Cherry (*Prunus avium*), Walnut (*Juglans regia*) and Apricot (*Prunus armeniaca*)
Intermediate zone (800-1500 m)	Doda, Rajouri, Poonch and parts of Udhampur	Peach (*Prunus persica*), Plum (*Prunus domestica*), Apricot (*Prunus armeniaca*), Olive (*Olea europea*) and pomegranate (*Punica granatum*)
Sub-tropical zone (<500-800 m)	Jammu, Kathua, Samba and parts of Udhampur	Mango (*Mangifera indica*), Citrus (*Citrus* spp.), Ber (*Zizyphus mauritiana*), Aonla (*Emblica officinalis*)
Cold arid zone (> 3500 m)	Leh and Kargil	Apricot (*Prunus armeniaca*), Apple (*Malus domestica*)

Source: (Ahmad and Verma, 2011)

arthropods and minimize soil erosion (Atucha *et al.*, 2011). Yield and quality of forage in agroforestry systems can be improved by introducing shade-tolerant grass and legume species (Table 5) in appropriate mixtures. Management of these systems can present a challenge regarding selection of the proper grass and legume species as well as the maintenance of the optimum balance between the two species in the grass–legume stand (Kyriazopoulos *et al.*, 2013).

Misri (1988) conducted a study in the valley of Kashmir on green forage yield of various combinations of grasses and legumes in an apple orchard and reported that rye grass + red clover and *Dactylis* + red clover combination recorded green forage yield of 48.0 and 42.0 t ha^{-1}, respectively.

Singh (1995) reported that rye and orchard grass were found to be the best grass species and clovers and lucerne the best perennial legumes for introduction in apple orchards. Makaya and Gangoo (1995) reported that the average green fodder yield of *Dactylis glomerata*, red and white clover was 22.03, 24.96 and 24.58 t ha^{-1}, respectively as compared to the natural vegetation (14.64 t ha^{-1}) while working on the forage yield of grasses and legumes in an almond orchard.

Ram *et al.* (2005) while working on the performance of *Ziziphus mauritiana* based hortipasture system found that intercropping of Guinea grass with Carribean stylo resulted in significantly higher dry forage and crude protein yields compared to Guinea grass+Carribean stylo+Dinanath grass+Carribean stylo and natural pasture. Ram *et al.* (2006) conducted a study on Annona-based hortipasture system and found that total crude protein yield was significantly increased in intercropping of *Stylosanthes hamata* + buffel grass as compared to *Stylosanthes scabra.*

Ram and Parihar (2008) reported that intercropping of Dhawalu grass (*Chrysopogon fulvus*) with *Stylosanthes hamata* in 1:1 row ratio resulted in significantly higher total green forage (25.83 t ha^{-1}) and dry matter yield (6.73 t ha^{-1}) as compared to sole stand of legume and grass. In temperate regions, the use of improved legumes, particularly white clover (*Trifolium repens* L.) and red clover (*Trifolium pratense L.*) has long been considered an effective way of improving pasture production and soil N status. White clover has a stoloniferous growth habit and an adventitious root system. It is a perennial with rhizomatous, prostrate stems which are creeping and has rooting from nodes (Baker and Williams, 1987; Frame *et al.*, 1998). Red clover is a perennial with fusiform root and short stock having many stems that arise from basal leaves. It is

Table 5. Suitable grasses and legumes in various agroclimatic zones of Jammu and Kashmir

Zone	Grasses	Legumes
Temperate zone (1500-3500 m)	*Dactylis glomerata, Festuca arundinacea, Lolium perenne, Phleum pratense, Bromus unioloides, Phalaris spp., Poa pratensis, Lolium multiflorum, Agrostis* spp. *Avena sativa*	*Trifolium pratense, T. repens, Onobrychis viciifolia, Medicago sativa, Trifolium alexandrinum*
Intermediate zone (800-1500 m)	*Dactylis glomerata, Festuca arundinacea, Lolium perenne, Dicanthium annulatum, Chloris gayana, Chrysopogon fulvus, Heteropogon contortus, Setaria* spp., *Avena sativa*	*Trifolium alexandrinum, Stylosanthus hamata, Macroptelium atropupreum,*
Sub-tropical zone (<500-800 m)	*Dicanthium annulatum, Chloris gayana, Chrysopogon fulvus, Heteropogon contortus, Cenchrus ciliaris, C. setigerus, Paspalum notatum, Avena sativa*	*Trifolium alexandrinum, Stylosanthus hamata, Stylosanthus scabra,*
Cold arid zone (> 3500 m)	*Festuca arundinacea, Avena sativa, Phalaris* spp., *Dactylis glomerata,*	*Medicago sativa, Medicago falcate, Lotus corniculatus, Astragalus* spp., *Caragana* spp., *Melilotus officinalis, Cicer microphyllum*

Source: (Ahmad *et al.*, 2016)

drought tolerant compared to most forage species due to a deep taproot and provides high forage production that has a high acceptability and nutritive value as forage (Thomas, 2003).

Festuca arundinaceae (tall fescue) is a deep-rooted, perennial bunchgrass (Stephenson and Posler, 1988) that is productive and adapted to a range of environments (Charlton and Stewart, 2006). Its main features are water deficit tolerance, heat tolerance and summer growth (Reed, 1996) clover compatibility and responsiveness to irrigation (Lowe and Bowdler, 1995). *Dactylis glomerata* L. (orchard grass) is a widespread perennial grass species, which has been reported to be adapted to shaded conditions (Lin *et al.*, 1999; Devkota *et al.*, 2009). Orchard grass has been reported as one of the most tolerant grass species in temperate agroforestry systems (Peri *et al.*, 2007), and as a suitable species for introduction in silvopastoral systems (Koukoura and Kyriazopoulos, 2007; Kyriazopoulos *et al.*, 2013).

6. CONCLUSION

There is a great scope for expanding livestock oriented activities in the state of Jammu and Kashmir because significant quantities of the demand of livestock produce is met through import from neighbouring states. In view of fodder shortage and limitation to expand the area under fodder cultivation on account of demographic pressures, effective utilization of the interspaces of fruit orchards offer a unique opportunity to mitigate the fodder shortages up to greater extent. Information on tree and alley crop interactions in temperate agroforestry including contributions by intercropped herbaceous legumes to soil quality and conservation is inadequate; therefore, research aimed at exploring new species is needed to optimize production and sustainability of these systems (Jose *et al.*, 2004). Tree-pasture association needs to be explored and exploited by evaluating different plant species under a given soil and climatic condition.

In future, coordinated programme on establishment, development and management of hortipasture should be given importance by encouraging more farmers and educating the youth involved in animal husbandry sector, to establish hortipastoral models. This approach would enhance the supply of nutritious fodder thereby ensuring sustainable livestock production in the state.

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