भाकृअनुप
ICAR

53rd Foundation Day

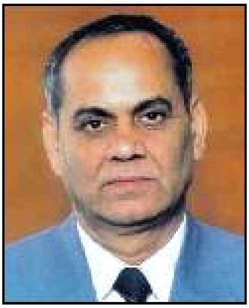
1st November 2014

Prof. Panjab Singh

Ex Secretary, DARE & Director General, ICAR

भा.च.चा.अ.सं.
IGFRI

ICAR-Indian Grassland and Fodder Research Institute
Jhansi-284003 (U.P.) India



Dr. Panjab Singh is an eminent educationist, researcher and able research manager and administrator. He was born in Anantpur, district Mirzapur, Uttar Pradesh on 10 December 1942. He was educated at Agra University, B.Sc. 1962, M.Sc. 1964 and Indian Institute of Technology, Kharagpur, Ph.D. 1969. Several universities have decorated him with D.Sc. (h.c.) including Banaras Hindu University, Varanasi, 2002; Tamil Nadu Agricultural University, Coimbatore; 2002; Poorvanchal University, Jaunpur, 2002; N.D. University of Agriculture and Technology, Faizabad, 2006; Rani Durgawati University, Jabalpur, 2008. His area of research included Agronomy, crop production, water management & agroforestry.

He has served in various positions like Asstt. Professor, Meerut University, Meerut, 1969-72; Senior Principal Scientist and Head of Division, CAZRI, Jodhpur, 1972-79; Assistant Director General, NARP, ICAR, New Delhi, 1979-85; Director, IGFRI, Jhansi, 1986-94; FAO Regional Plant Production and Protection Officer, FAO RAPA, Bangkok, 1991; Joint Director (Research), IARI, New Delhi, 1994-97; Vice Chancellor, JNKVV, Jabalpur, 1997-2000; Director (Vice Chancellor), IARI, New Delhi, 2000-01; Secretary DARE, GOI and Director General ICAR, New Delhi, 2001-02; Director, School of Agriculture, IGNOU, New Delhi, 2003-05; Vice-Chancellor, Banaras Hindu University, Varanasi, 2005-08; Scientific Advisor, Government of India, till 2009; Advisor, Agriculture and Plantations, ETA Star, Gurgaon, 2009 till date.

He is a fellow of several academic and professional societies which included NAAS, ISA, NIE and SEE. He was a recipient of number of awards like Krishak Bharati Barani Kheti Award, 1987; National Productivity Council Award, 1987; ISA Gold Medal, 1988; Rishabh Shree Award, 1992-93; Lok Vigyan Samman, 1999; K.N. Bahl Memorial Gold Medal, 1999; World Food Day Award, 2001; Ram Nath Singh Award; ISCA The Millennium Plaque of Honours, 2002; Dr. Dukhanram Vijnan Hindi Seva Samman, 2005; Observer Award, 2005; Dr. S.R. Bhargava Medal, 2006; Life Time Achievement Award, ISA, 2004-06; Distinguished Alumni Award, IIT, Kharagpur, 2007 and Agriculture Leadership Award 2009.

His scholastic contribution to agricultural sciences has been recognized by several professional societies and organizations. He has been actively associated with several professional societies like President, Range Management Society of India, 1986-1995; Indian Society of Agronomy, 1995-1998, 2001-03 & 2003-04; Indian Society of Agricultural Statistics, 2003-04; Indian Society of Plant Physiology, 2002-04; Indian Society of Agricultural Sciences, 2000-01 & 2002-03; Vice President, Indian Agricultural Universities Association, 2000-01; Indian Society of Tree Scientist, 2001-04; Indian Society of Forage Research; Society of Bio-sciences; Chairman/Member of about 100 Professional - International, National and State level Committees. He is President of Foundation for Advancement of Agriculture and Rural Development, Varanasi, 2008 to till date.

Forage Resources: Challenges and Way Forward

On this auspicious occasion of 53rd Foundation Day of Indian Grassland and Fodder Research Institute, I would like to congratulate and extend my good wishes to all the scientists, technical, ministerial and supporting staff of the Institute and also to those who have retired and have made significant contribution in bringing this Institute to such a glorious stage. Visit to IGFRI is always like a home coming and I always cherish the memories of my long association with this institute.

In the emerging national and international scenario especially in reference to ensuring livelihood security and changing climate, role of fodder linked livestock production has become a vital issue. IGFRI has a greater role to play to meet the challenges of ever increasing fodder demand through development and application of innovative forage production technologies.

Present Scenario

India with 2.3% of land area of the world, is maintaining nearly 17% of world human population and about 15-20% of livestock. The major feed resources for livestock in our country are grasses, community grazing, crop residues, cultivated fodder, edible weeds, tree leaves and agro-industrial by-products. Total crop residue available in our country is about 485 mt and green fodder about 504 mt. In terms of digestible crude protein, the deficit is nearly 50%. Although there is variance among different estimates of deficit, the huge deficit for availability of green/dry fodder as well as concentrate is well established. The production and productivity of the livestock is quite low due to inadequate and nutritionally unbalanced supply of feed and fodder. Recurring droughts, fodder scarcity during lean period, encroachment of grazing lands for other purpose, increasing pressure on cultivated lands for food crops and industrial uses, increasing livestock population has further widened the gap between demand and supply. About 4.9% of the gross cropped area in the country available for fodder crops is almost static for last 2-3 decades. Common grazing lands occupy 16% of the total geographical area and permanent pastures and grazing lands, a mere 3.2%, which has been declining steadily. The forest cover of 21.3% of (about 85 % protected) used to be a major grazing area for livestock rearing communities.

There is a shift in composition of livestock towards small ruminants due to natural resource degradation in arid and semiarid regions and high growth in meat sector. Buffaloes and goats are becoming more important in India. Global trend in animal production indicates a rapid and massive increase in the consumption of livestock products. It is predicted that meat and milk consumption will grow at 2.8 and 3.3 per cent per annum, respectively, in developing countries like India. Urbanization has brought a marked shift in the lifestyle of people in feeding habits towards milk products, meat and eggs with resultant increase in demand of livestock products. Peri-urban livestock farming and emerging fodder markets are indicators of fast changing economic scenario in livestock sector. Livestock population is expected to grow at the rate of 1.23% in the coming years. There is a need to meet the demand of increasing number of livestock and also enhance their productivity for which availability of feed resources has to be ensured.

The estimated demand for green and dry fodder is expected to reach 1012 and 631 mt by the year 2050. The seasonal and regional imbalances in the fodder production in the country further aggravate the situation. The complexity of the situation urgently calls for increased productivity per unit land area and also through integration of fodder crops in the existing farming systems. Apart from vertical expansion, utilization of non-cultivable areas for pastures is one of the most viable options to balance the demand. India possesses nearly 85 mha of grasslands/ rangelands which are mostly in degraded state. Revitalizing these denuded grasslands is the most plausible means to improve the availability of green fodder. These grasses also play pivotal role in the conservation of natural resources by preventing the denudation of degraded land mass and thus preventing soil erosion, enhancing bio-diversity and increasing carbon sequestration. Production technologies have made it possible for the farmer's to get sustainable round the year green fodder by adoption of conservation agriculture in forage based cropping system and inclusion of climate resilient fodder production strategies as per available resources, soil type and agro-climate.In the past, growth in livestock production was largely number driven. This may not sustain in the long run and may stress the resources. The future growth should primarily come from improvement in productivity. This will require overcoming feed and fodder scarcity and improvements in delivery of animal health and breeding services. Technology will be a key driver of growth and concerted efforts will be needed to generate and disseminate yield-enhancing and yield-saving technologies. Following paragraphs will deal with technology status and the future thrust for enhancing feed and fodder resources in different situations.

1. Crop Improvement

Responding to the emerging challenges, greater access to a range of varieties that can help farmers deal with biotic and abiotic stresses will be required. The focus of research and development should be to enhance use of genetic resources through subset approaches, pre-breeding to enhance the utilization of genetic resources in crop improvement programmes, further enrichment of forage crops genetic diversity by exploration and correspondence. To meet the increasing demand of feed and fodder, we would require improving productivity and quality of the existing forage crops utilizing biotechnological approaches. Forage crop improvement has its own limitations. Many aspects related to forage breeding, plant genetic resource, plant protection measures, quality, seed production and palatability need to be addressed in an integrated way. The pasture species pose more complex problems in genetic improvement compared to cultivated forages.

IGFRI, Jhansi since its inception is striving hard for the development of improved varieties having high yield, better nutritional quality coupled with resistance/ tolerance to biotic and abiotic stresses and suitability to specific niches. Both perennial and annual fodder resources are important in securing the fodder security in the country. More than 30 varieties of different fodder crops including annual crops like oats, cowpea, berseem, guar, fodder bajra and perennial crops such as Bajra-napier hybrids, guinea grass, *Cenchrus*, *Sehima*, *Heteropogon* and *Chrysopogon* have been developed. Most of these varieties are very popular among farmers in different regions of the country. However, with the changing time, objectives of the breeding crops have been modified and nowadays breeding programmes are not merely designed to fulfill the need of higher yield but its reorientation includes enhancing the nutritive value of range and cultivated grasses and crops, resilience to changing climate and more emphasis have been on pyramiding genes for multiple stress tolerance (biotic and abiotic). In recent times some major break-throughs *viz.,* development of new plant types of pearl millet for fodder, penta foliate type plants in berseem, sexual lines in guinea grass and cenchrus, multiple disease resistant lines in sorghum, varied ploidy level lines in guinea grass and development of new fodder plants through interspecific hybridization in pearl millet have more promise in meeting the challenges. Similarly to accumulate the desired genes across the species, new paradigm change in breeding programmes and pre-breeding efforts are under way for the transfer of lucerne weevil resistance from *Medicago scutellata* to *Medicago sativa,* tillering/ branching and tolerance to abiotic stress from *Zea mexicana* to *Z. mays*, late flowering and enhanced fodder quality and disease resistance from *Trifolium resupinatum* and *T. repens* to cultivated berseem.

Besides, we need to enrich and manage our forage plant genetic resources, and strengthen research on trait based germplasm identification, development of new plant types based on climate change parameters, stimulating pre-breeding efforts, development and utilization of male sterility systems in grain fodders, identification of genes for generating perennial grain fodder, fortification of fodder/dual purpose crops for enhanced nutrition, resistance to abiotic and biotic stresses and identification. Cloning and characterization of key regulatory genes for fodder traits like plant architecture, flowering time, foliage, adaptability and quality, biochemical/metabolic engineering to modulate quality components in fodders also needs priority research attention.

2. Crop Protection

Forage crops are impaired to a greater or lesser extent by pests including diseases, insects and nematodes. In the present situation, one of the ways to augment forage production is to minimize the losses imposed by various insect pests and diseases which altogether tolls 25-30 per cent of green forages. These pests and diseases hamper crop establishment, impair forage quality and reduce green fodder and seed yield. In cultivated forage crops and grasslands, various pest management practices have been evolved and recommended by the institute. Sources of resistance to important pest and diseases have been identified and are being utilized in resistance breeding. Efforts have been made to evaluate environmentally safe and economically viable pesticides, botanicals and their synthetic derivatives and bio-control agents. Plant protection aspects covers not only the sole fodder crop biotic stress management but also the pest suppression of various promising fodder crop production systems for round the year fodder production, resulting in higher forage production and are incredibly valuable for intensive dairy production units. Endeavour have been made for integrated pest management in various forage crop production systems and IPM modules have been demonstrated on farm and at cultivators fields and disseminated to the end users.

3. Forage Biotechnology

Biotechnology research at IGFRI was initiated in 1989 with *in vitro* plant regeneration and anther culture in *Dichanthium annulatum* with financial aid from the Department of Science and Technology, Government of India. The research work was further strengthened under Indo-UK collaborative research project in 1994 with initiatives on protoplast and genetic transformation of *Dichanthium,* embryo rescue in berseem (in 1997), and identification of molecular markers for apomixis in *Dichanthium* (in 1999). The strength of biotechnological approaches was demonstrated at this Institute in generating variability in crops with very narrow genetic base such as berseem. Utilization of wild species such as *Trifolium apertum* and *T. resupinatum* was demonstrated for alien gene transfer for stem and root rot resistance and increased longevity. Tissue culture protocols have been optimized for micro propagation and *in vitro* screening in grasses and legumes. Polyploidy research yielded development of alien introgressions in crops such as oats (quality traits), pearl millet (perenniality, multicut and apomixis) and berseem (morphotypes) either by enhanced genome dosage or through enhanced crossability with desired species. Molecular markers have been identified in fodder grasses, cereals and legumes, and were suitably tagged with traits of interest, and accordingly molecular maps have been developed. Genetic transformation has also been reported in *Cenchrus* and Lucerne.

Availability of diverse germplasm lines in wide variety of grasses is an asset to characterize the germplasm base for identification of obligate or facultative sexual lines in *Dichanthium*, *Heteropogon*, *Cenchrus* and *Panicum*. The institute has first time proposed a multi-gene model for apomixis regulation and had identified different pathways of seed development in apomictic grasses. Based on hybridization-supplemented apomixis-components partitioning approach (HAPA), they have generated worlds' largest ploidy series in a crop plant represented by eight ploidy levels, all derived from a single progenitor. Recently, genetic linkage maps of the chromosomal regions associated with apomictic and sexual modes of reproduction in *Cenchrus ciliaris* have been developed. Sequence characterized amplified region (SCAR) marker linked to apomixis and sexuality in *C. ciliaris* were identified.

4. Crop Management

Integrated Farming System

During and post green revolution era, policies emphasized commodity based isolated research efforts involving development of crop varieties, farm implements and machinery, fertilizer use and other production and protection technologies at the institute level which enabled the farmers to grow more but at the cost of over exploiting the resources. Now, it has largely been realized that dependence on single enterprise as a main income source is subjected to high risk. Such production systems also have poor employment potential. In this context, integration of various agricultural enterprises *viz*., cropping, animal husbandry, fishery, forestry, agroforestry, poultry, *etc.* have great potentialities in the agricultural economy. These enterprises not only supplement the income of the farmers but also help in increasing the family labour employment. The integrated system is the concept of judicious mixing of poultry, mushroom cultivation, fisheries, agroforestry, goat/cow rearing and sericulture along with the main agricultural crop cultivation on a unit area which could help bring prosperity to farming. In Integrated Farming System, one or other kind of animal is always associated and, for that, we need sound forage production strategies which ensure round the year availability of quality forage.

Climate Resilient Agriculture

Evidences from the Intergovernmental Panel on Climate Change (IPCC, 2007) is now overwhelmingly convincing that climate change is real, that it will become worse, and that the poorest and most vulnerable people will be the worst affected. While climate change is a global phenomenon, its negative impacts are more severely felt by poor people in developing countries who rely heavily on the natural resource base for their livelihoods. Rural poor communities rely greatly for their survival on agriculture and livestock keeping that are amongst the most climate-sensitive economic sectors. The IPCC predicts that by 2100 the increase in global average surface temperature may be between 1.8° C and 4.0° C. With increases of 1.5° C to 2.5° C, approximately 20 to 30 per cent of plant and animal species are expected to be at risk of extinction with severe consequences for food, feed and fodder security in developing countries. Responses to climate change include (i) adaptation to reduce the vulnerability of people and ecosystems to climatic changes, and (ii) mitigation to reduce the magnitude of climate change impact in the long term. The outcome will depend significantly on location, system and species. As temperature and CO_2 levels change, optimal growth ranges for different species also change; species alter their competition dynamics, and the composition of mixed grasslands changes. For example, higher CO_2 levels will affect the proportion of browse species. They are expected to expand as a result of increased growth and competition between each other. Legume species will also benefit from CO_2 increases and in tropical grasslands the mix between legumes and grasses could be altered. Rising temperatures increase lignifications of plant tissues and thus reduce the digestibility and the rates of degradation of plant species. The resultant reduction in livestock production may have an effect on the food security and incomes of smallholders. Interactions between primary productivity and quality of grasslands will require modifications in the management of grazing systems to attain production objectives.

Apart from production technologies, for responding to climate change and other production constraints, issues *viz.* fodder use, livestock, adaptation and mitigation need to be addressed. Research is required to understand, in particular, any changes in phenology that would make production systems more vulnerable to dry-season animal-feed shortages, and suitable alternatives for fodder production. In order to understand which fodder species is appropriate for promotion in particular location under future climate, there is a need to develop present-day and future suitability maps for a wider range of indigenous and exotic species. These then need to be related to production maps for alternative plant-feed sources.

5. Animal Feeding Systems

Forages are the most economical sources of nutrients and animals require good quality forages (which have many additional benefits) for expression of full genetic potential of milk production and growth performances. Accordingly forage based feeding systems have been developed keeping in mind the type of animals, species, breeds, level and stages of physiological production *etc.* It has been observed that milch cows sustained upto 17-18 kg milk yield/ day under forage based feeding system, besides sustaining 400-500g daily body weight gain in growing heifers. Different dietary combinations of grasses with tree leaves/shrubs were evaluated in sheep and goats and found 75:25 and 50:50 ratios optimum, respectively, for their better utilization.

Screening and identification of secondary metabolites like total phenolics and proanthocyanidines have been made in numbers of range shrubs and tree leaves, so that these can be exploited judiciously and economically in the ration of sheep and goats. Similarly, works are going on to develop technologies to conserve surplus green fodder of flushing season either as silage or hay in an efficient way to cater the needs of forage during lean periods.

In fact, in the recent past there was hue and cry from developed countries that Indian livestock being so large in number is creating problems by emitting large amount of methane in the environment. Microbial fermentation in ruminant animals invariably results in some methane production, to the tune of 5-7% of the calorific value of the dry matter consumed. This is wasteful and environmentally detrimental. Reduction in particulate size, higher concentrate or grain feeding, green forage feeding and introduction of propionic bacteria into the rumen along with the feed can control methane production. Use of ionophores and unsaturated fatty acids also helps in reduction in methane production. It has been observed that polyphenolic compounds available from Bel (***Aegle marmelos***) could reduce the methane production up to 32 % *in vitro* on addition to a straw substrate at 1 % level without affecting the feed utilization.

Food safety has also been a matter of concern recently. In view of these emerging food safety concerns, work on organic livestock production for milk is going on. Indigenous breeds of cattle have been raised solely on farm produced feeds and fodder following organic agronomic practices. Sahiwal, Gir and Tharparkar had an average daily milk yield of 12, 8.5 and 6 litres, respectively. Milk had no pesticide residues (below detection level) and contained 5.5, 5.4 and 5.1% fat in milk, respectively.

6. Conservation Agriculture

Increasing labour shortage is seriously affecting the availability of farm labour in India due to migration to urban areas. For these and other reasons, it is now becoming even more essential that farming methods that conserve resources, reduce human labour requirements and significantly improve food, feed and fodder security be adopted. Although there is much potential for the adoption of conservation agriculture systems in India, the issues like, awareness of the problem, general lack of knowledge concerning how best to introduce the techniques, need for appropriate equipment and inputs, land tenure influencing the adoption of conservation agriculture, lack of permanent soil cover as these are used for animal feed, uncontrolled grazing, organization of stakeholders etc. may limit its speedy implementation.

Since conservation agriculture emphasizes on minimizing soil disturbance and keeping soil covered at all times, it allows the soil to hold water far longer and facilitates deeper rooting of crops. This results in adaptation against drought as well as against excessive rainfall preventing floods through better water infiltration. Furthermore, live fences based on fodder trees and shrubs could be incorporated into the conservation agriculture system which, together with the minimum soil disturbance and integration of densely rooting grasses into crop rotations, would allow for many of the benefits of carbon sequestration as contribution to climate change mitigation, additional nitrogen, a source of soil cover and a management tool for controlling cattle movement as well as livestock feed.

7. Range Management

The rangelands have been very important in India since ancient times as is evident from Vedic literature, in which these have been projected as the ecosystems *i.e.*, the plants, the animals they support, and the soil supporting them. Grazing based livestock husbandry plays an important role in rural economy of the country. The very fact that total area available for grazing is about 40 per cent of land surface shows us the way to tackle of the problem of fodder for the livestock in the states like Rajasthan, Madhya Pradesh, Maharashtra and Karnataka where vast areas are in use for grazing. In states like Himachal Pradesh, Uttarakhand, Jammu & Kashmir, Meghalaya, Nagaland and Arunachal Pradesh, over 70 per cent of land area is utilized as grazing ground. The grazing intensity in the country is as high as 12.6 adult cattle unit (ACU) per ha as against 0.8 ACU/ha in developed country. Nearly 30 pastoral communities in northern and western part of country depend on grazing based livestock. The pastoral communities usually change the site of grazing. The example of such type of grazing system is Kharak in Uttarakhand and

Goals in desert area of Rajasthan. Based on migratory habits, the nomadic tribes are classified in four groups *viz.*, total nomadism, semi nomadism, transhumance and partial nomadism.

Through restoration / improvement of degraded rangelands following ecological management that include introduction of grass and legumes intervention of soil and moisture conservation along with protection have shown that production of range land improved quantitatively (from 0.1 t to 3.5 t dm/ha) and qualitatively within three years. The plant population of desired perennial grasses increased from 11 plants to 397 plant/ m^2 and undesirable forbs decreased from 1444 to 33 plant/ m^2

In Himalayan rangelands, rotational and deferred rotational grazing are not possible at many places, the local practices of enclosing rangelands for 5-6 months (June - October) followed by controlled grazing and later on cutting of grasses for stall feeding is recommended. In high altitude regions also the grazing pressure can be reduced by restrictive grazing on selected sites on yearly basis, rotation of grazing sites in different years.

8. Pasture Management

The long term study have shown that seedling of grasses like *Cenchrus*, *Chrysopogon* and *Sehima etc.* can double the production of pastures. Deferred rotational grazing system enhanced the production by about 1.5 times. Similarly introduction of pasture legumes like the *Stylosanthes*, *Siratro*, *Atylosia etc.* improved the productivity and nutritive value of sward. The crude protein content increased from 2-7 percent and productivity increased by 50 percent, equivalent to 40 kg N/ha application. Legume introduction in grassland prolonged the availability of quality forage up to the end of November. Satisfactory growth rate in young cross bred calves was recorded up to October and little concentrate supplementation was required thereafter for satisfactory growth. Intercropping of dry land forages in different grasslands along with protective irrigation during lean periods improved the productivity of *Cenchrus* and *Setaria* pasture from 15.0- 61.4 t green forage per year. The effect of natural pasture, sown pasture, improved pasture and three tier system was studied on various soil-water-plant and animals parameters. On an average of four years, it was found that bare plot had maximum runoff coefficient (0.41) followed by natural grassland (0.11), improved pasture (0.1), multi-tier (0.09) and sown pasture (0.08). The soil losses were 21.36, 2.92, 2.25, 1.90 and 1.52 t/ha in bare, natural grassland, improved pasture, multi-tier and sown pasture systems, respectively. In a study on established pasture, it was found that intercropping of *Stylosanthes seabrana* with Guinea grass produced maximum total dry forage (6.68 t/ha) followed by intercropping of *Clitoria* *ternatea* (5.41 t/ha), Siratro (5.60 t/ha) and *Stylosanthes hamata* (6.29 t/ha).

9. Silvipasture System

In view of increasing demographic pressure on land and concerns for productivity, resource conservation, environment and profitability, alternate land use system, especially on degraded land, are very relevant in the present context. Technologies like silvipasture that integrate multipurpose tree species (MPTS) either in special arrangement or in a time sequence, with pasture crop and livestock can fit here to produce more biomass per unit area and time.

Under poor soil, water and nutrient situation where cropping is not possible, such system can serve the twin purposes of forage and fire wood production and ecosystem conservation. Studies have indicated that tree growth in association with grass and legume was optimum and pasture production also did not decline up to 6-7 years of tree growth. Mean annual production ranged from 3-6 t dm/ha under different tree species on diverse habitats. At 8 years of growth, production of fodder and firewood from tree lopping has been found to vary from 1-2.5 t/ha of tree fodder per year. It has been possible to increase land productivity from 0.5-1.5 t/ha/yr-10 t/ha/yr on a rotation of 12 years through such interventions on degraded lands. The quality of forage supplied through such system increased substantially over the prevailing natural system subjected to unregulated grazing.

On saline soils, suitable tree/shrub species have been identified from the viewpoint of fodder-cum-fire wood production and also their ability to combine well with grass species. Several grass species like *Brachiaria mutica*, *Bothriochloa intermedia*, *Chloris gayana* and Karnal grass have been identified to provide assured high forage production (2.5-4 t/ha/yr) coupled with soil improvement. Thus, the lands that could hardly produce 0.5 t/ha in term of forage or brush wood were able to produce over 7 t/ha/yr. This quantum jump in the production of biomass is accompanied with higher nutritive value of the forage also.

In the present scenario, land degradation due to over grazing and illicit tree felling is a major environmental issue. Excessive runoff leading to soil erosion and nutrient loss could be effectively checked by development of silvipasture systems. Average soil loss from deforested land is reported to be 12-43 tonnes/ha in black soil and 4-10 tonnes/ha in red soils whereas soil loss from natural grassland has been only 3.2 tonnes/ha from a protected site. SilvIpastures are also better for soil conservation and the soil loss from these areas has come down to 0.9 t/ha.

In another study in *Hardwickia binata* based silvipasture system, intercropping of Guinea grass with *Stylosanthes hamata* in association with *H. binata* produced significantly higher dry forage yield (5.10, 8.09, 8.16 and 8.26 t/ha) as compared to intercropping of *Chrysopogon fulvus* (3.26, 5.40, 5.92 and 6.27 t/ha) and *Cenchrus ciliaris* with *S. hamata* (4.24, 6.80, 7.12 and 7.52 t/ha) during 1st, 2nd, 3rd and 4th years, respectively.

10. Hortipasture System

Integration of fruit trees with pasture species in the same unit of land acts as one of the best and economic alternative for class IV and V type of land. A number of experiments were conducted with different fruits *viz.* Ber (*Zizyphus mauritiana*), Aonla (*Emblica officinalis*), Custard apple (*Annona squamosa*), Guava (*Psidium guajava*), Tamarind (*Tamarindus indica*) and Bael (*Aegle marmelos*) based hortipasture systems under rainfed situation. On an average, production potential of these systems ranged from 7-15 t fruit/ha, 3-8 t dm forage/ha and 4-5 t fuel wood /ha, besides soil improvement and preventing soil erosion and reducing runoff. These systems were also recorded with higher cost : benefit ratio (1:3.7- 6.24) along with more employment opportunities (64.9 man days/ ha/year).

11. Forage Seed

Seed is the basic input of agriculture and 15-20% increase in production is possible by using quality seed. One of the reasons reported to stumble the green fodder production is non-availability of quality seed in sufficient quantities. In forages, availability of quality seed is only 25-30% in cultivated fodder and <10% in range grasses and legumes. Seed standards are not available for some of the crops. Similarly, variety specific seed production package of practices have not been thoroughly developed. The import of large quantities of forage seeds has been a cause of concern before the government. In forage crops, the seed chain is also not being properly maintained. The amount of breeder seed that is being produced by ICAR institutes or SAUs is sufficient to maintain at least 30% SRR in most of the crops, whereas in some crops it is many times higher than the required. Thus, it is clear the much of valuable breeder seed is being used directly for forage production only. The recent quantum jump in breeder seed demand indicates increasing interest of farmers in growing fodder crops. IGFRI with AICRP (FC) centres has been producing more than indented quantity of breeder seeds in addition to truthfully labeled seeds in good quantity.

There is huge demand by various agencies and the grass seed production is highly remunerative in view of present market value. However, the grass seed production is complicated and inconsistent involving several intrinsic problems. The range species are wild in nature and are not domesticated for large scale cultivation. This leads to difficulty in growing them as cultivated crops. Present state of grass seed production is also dismal. It is being undertaken at smaller scale by Public sector IGFRI, almost nil by Private Sector and negligible from SAUs.

Forage seed production is largely concentrated in the unorganised sector, where the quality of seed is always compromised. Organised fodder seed production chain is very limited. It is mainly because of a large number of forage crops and their suitability to specific niches. Each forage crop is suited to only specific area for forage and/or seed production such as *Berseem* in the northern plains and Lucerne in the north-west India. Similarly, pasture grass like *Lasiurus* is best adapted and productive under low rainfall situations of western Rajasthan and Congo signal grass and guinea grass in the highly humid regions of Kerala. Hence, there is a need to prepare a 'seed production atlas' for the entire country for commercial seed production and marketing. In this endeavour, disease free zones could also be identified and mapped.

With adoption of proper technology, optimization of quality seed harvest is possible. This requires proper action plan to address the important factors such as choice of harvest time, variation in flowering time even within inflorescence, upto 25-50% of the potential yield possible to harvest, develop visual indicators of physiological maturity, alternative methods to best but labour intensive hand picking the matured panicle/pod method, and to the not so effective sweating technique. Other constraints such as indeterminate growth, uneven maturity, seed shattering/shedding, blank seed formation, seed dormancy also required to be taken into account.

Strategies for Increasing Seed Production

- Creating awareness to use quality seed of improved varieties.
- Increasing the seed replacement rate from the present 2-3% to at least 20%.
- Seed chain should be followed to produce sufficient quantity of certified seed for farmers
- Seed production through farmer participatory approach
- Research to increase the ovule to seed ratio in forages
- In-depth studies on grass seed germination and dormancy problems.
- Research on development of cultivable pasture varieties.
- Channelizing the existing demand towards entrepreneurship development
- Establishing 'village seed banks' for ensuring seed availability.

12. Transfer of Technology

The real utilization of research efforts cannot be realized without understanding the extension aspects of forage production system, transfer of technology on forage production and utilization, strengthening linkages with various stakeholders in forage production and grassland management. Realizing the fact, IGFRI adopted the innovative approaches like 'Model villages development', Adarsh Chara Gram, fodder technology demonstrations (FTD), participatory seed production, On-Farm technology validation and evaluation. Besides these, National Initiative on Fodder Technology Demonstration (NIFTD) has been initiated on national level to promote and popularized modern fodder production technology suitable to various farm situations.

Adarsh Chara Gram is operating in three villages (Garera and Dhobi of Datia) and (Awas of Shivpuri) for five years with a sound strategy by a multidisciplinary team of scientist for scaling up of fodder technology at farmers field. The traditional crops such as groundnut which need more water has been replaced with alternate fodder crops which are drought tolerant and help feed livestock so that farmers livelihood is secured as contingent plan. The perennial fodders as boundary planting system at farmers field having life saving irrigation facility has been introduced as a contingent plan to supply round the year green fodder in deficit situations. A complete set of agriculture activities including weather advisory services through e-Chara Kendra, e-library, vermi-composting for soil health improvement, plantation of fodder purposes trees such as subabool and kala sirus on field boundaries, Vaccination, area specific mineral mixture, silage, subabool leaf meal and balanced feeding has been introduced on selected farms. Multimedia CDs has been developed on different aspect of fodder technologies and kept in e-library. Digital and hard copy of all farmers' friendly publication is kept in e-library and being issued to farmers of adopted villages.

The IGFRI is striving to develop 11 Model Villages (5 from Uttar Pradesh and 6 from Madhya Pradesh) of Bundelkhand region to address the issue of drought and long term perspective plan. The objectives include development of all aspects of agriculture and livestock specially fodder production, utilization and conservation, advisory services related to crop, fodder, livestock and weather *etc* and develop contingency plan and take appropriate action in case of natural calamities. In selected model villages, 22 on-farm trainings, 42 demonstrations of Hybrid napier grass (IGFRI-6 and IGFRI-10) and 11 demonstrations of Guinea grass (BG-2) have been conducted. Tribal Sub Plan has been implemented at Dhar and Jhabua districts of MP, Banswara district of Rajasthan, and Nandurbar district of Maharastra. Agricultural, animal husbandry, poultry and fodder related interventions were demonstrated to uplift the socio-economic condition of tribal farmers.

13. Strategies to Increase Fodder Production, Availability and Utilization

The above discussion sufficiently describes the magnitude of deficit and reasons for the same. Technologies exist for improvement of per unit area productivity from these areas, however, proper dissemination & expansion of technology is required with involvement of social institutions. Following interventions are needed to achieve the objective:

- Suitable forage ideotypes need to be sketched in terms of crop morphology, canopy, fertilizer and water efficiency for appropriate integration with existing systems as sole/mixed or intercrop
- The exploitation and evaluation of non-conventional forage resources for minimizing the growth and weight loss of livestock in lean periods.
- Blending knowledge for an inclusive approach towards innovation for demand led participatory technology development
- Development and adoption of crop-livestock integrated farming system models
- Rehabilitation of degraded lands, management of permanent pasture/ silvipasture cover, exploitation of forest resources, forest marginal lands and village common property lands, silvi pastoral systems.
- Controlled grazing practices by regulating grazing in tune with capacity will ensure sustainability of traditional pasture.
- Village common lands/ CPRs including those on forest sides are used for development of tree crops and fodder resources.
- Legume fodder crops like Sesbania, Subabul, *Desmenthus* etc. can be grown on all wasteland, canal banks, hillock slopes and field boundaries.
- Conservation and value addition of fodder including monsoon seasonal grasses
- Establishment of fodder banks near forest covers and bringing crop residues from surplus zones to meet the fodder requirement during natural calamities and scarcity is a good option.
- **Seed production of range grasses/legumes**
- Participatory seed production cultivated forages (berseem/ Lucerne/ Oat/ maize/ sorghum/ bajra/ cowpea)
- **Micro centre seed production unit**
- **Training and capacity building:**
- **Entrepreneurship -** seed marketing enterprises

14. Researchable Issues

Fodder conservation and utilization

- Crop residue: compaction, storability, value addition.
- Utilization of rice straw; wheat straw; maize, sorghum, pearl millet stover; groundnut haulms.
- Drying/baling of monsoon grasses.
- Conservation of non-conventional forages as silage.

Farming system adaptive research - Integration of forages in existing farming system

Estimation of forage resources- GIS/RS tools and ground estimation

Optimization of forage production in abiotic stress situations - light/salt/drought/flood

Forage/ feed quality assessment

Nutritional value

- Straw digestibility
- Feed pellet, leaf meal, top feed in hill and arid zone:
- Nutritional and utilization value of local forage
- Keeping quality processed fodder
- Mitigation of nitrate, oxalate toxicity -NxB hybrid
- Development of area specific complete feed block
- Utilization of horti/sugarcane Industry byproduct.
- Strategic supplementation, bypass nutrients
- Deconstruction of ligno-cellulosic biomass

Epilogue

The grassland and fodder crop production researchers need to orient themselves keeping in view the three major production sources *viz.,* cultivated land, vast waste and underutilized land and vast areas within the forest and their complex problem *vis-à-vis* socio-economic aspects of the users. Most of such areas, especially waste and forest degraded lands have poor soil fertility and often suffer from moisture deficit. In such situations, cultivation of forage plants which are complimentary to each other and not competitive in growth pattern and yield potentials with an ability to fulfill the nutritional deficiency of each other and also that they together yield balanced ration to livestock is important. Thus greater emphasis is to be given on inclusion of leguminous resources in the total forage production cycle. Intensifying forage cropping per unit area and time especially with legume crops without jeopardizing the yields from the main crop in the system needs to be researched. Crop residues, traditional source of forage, need to be improved in its quality with additives including fortification for enhancing their digestibility and utilization by animals. Herbage and grassland production assume greater importance than crop production, out of necessity, in desert (cold and hot) and extreme semi-arid zones receiving low and scanty rain fall and facing extremes of temperatures will continue to be the area of focus for both research and development. Good quality seed availability continues to be a serious concern both in cultivated fodder and herbages. The forages by virtue of their productive needs have been bred for herbage and as such these groups of crops are shy seeders and coupled with it the fact that the forage crops are harvested before they come to maturity makes it difficult to manage for seed production. This needs to be properly managed through suitable technologies. In tropics and subtropics the production is entirely dependent on the monsoon rains except in the limited area under irrigation net work. This poses the problem of surpluses in monsoon and severe deficit in other seasons. Role of conservation is imminent particularly during surplus month. Needless to say that production, quality addition and conservation and utilization of fodder and pastures has to be one stroke planning for assuring sustained availability of feed to livestock.