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Growing seed

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BROKPA: THE FOOD AND NUTRITIONAL INSECURE COMMUNITY, INDIA

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According to the Food and Agricultural Organization (2001), the food security defined as the "Food security is a situation that exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life". However, this definition is quite unfit for the community of *Brokpa* (A sub-community of *Monpa* tribe Arunachal Pradesh). As this particular community live at high altitude graze their animal under transhumance migratory system which is the prime cause of food and nutritional insecurity.

Evolution of word "Food Security"

This global concern word "Food security" concept originated only in the mid-1970s, in the consultations of international food problems at a time of global food crisis and how to ensure the food availability among the masses. The burning issues at that point of time such as famine, hunger, and poverty compelled international forum for this initiative. The initial focus of attention was primarily on food supply problems - of assuring the availability and to some degree the price stability of basic foodstuffs at the international and national level. The food security is first defined in the "World Food Conference" held in the year of 1974 as; "availability at all times of adequate world food supplies of basic foodstuffs to sustain a steady expansion of food consumption and to offset fluctuations in production and prices"[UN, 1975]. However, it is further redefined in 'The State of Food Insecurity' (2001) that "Food security is a situation that exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life" (FAO,2001).

Dimension of food and nutritional security

There are four basic dimension of food and nutritional security which includes food availability, access to food, utilization and stability (FAO, 2014) which are presented below;

A. Availability: Availability of food means the physical existence of products in a particular place. It could be further expressed in national level and household level. The national food availability comprised of domestic food production, commercial food imports and exports, food aid and domestic food stocks. On the other hand, household level food could be from own production or bought from the local markets.

B. Access to food: access to food is certified when all households have enough inputs to obtain food in sufficient quantity, quality and diversity for a nutritious diet. However, this is extremely depends on the amount of household assets and on prices.

Fig-1.1 A Brokpa pastoralist

C. Use and Utilization: it is related to socio-economic aspects of household food and nutrition security which is determined by the how-to- knowledge of individual. Utilizationis narratesability of the human body to take food and biological conversion of it. Example food and nutritional knowledge, food preparation and nutritional behaviour, hygiene etc.

D. Stability: It includes supply of food products, risk reduction, environmentally sustainable and viable, reproducible with respect to time frame.

Who is *Brokpa*?

Brokpa is the small trans human cepastoral community of ethnic *Monpa* tribe in Arunachal Pradesh. However, *Brokpa* is designated as one of the major ethnic tribe in Bhutan and Tibet region. *Brokpa* mostly resides in Tawang and West Kameng districts of Arunachal Pradesh follows non-vegetarian Buddhism. Their population is approximately 2500 to 3000 in numbers. They are highlander and follows migratory pattern of living. Yak is the major animal rear by them under free range management system at high altitude above 4500 m from mean sea level.

Their livelihood is depend on selling of yak milk products such as *chhurpi*, churkamchurtang, and butter. The above mentioned milk products use as a barter materials with *"Ungpa"*

community (crops growing community). There is no specific rules for bartering the materials. It's depend on their mutual understanding. Mostly the *Brokpa* bartered for rice, maize flour, salt and other household items.

Fig-1.2 A Lady *Brokpa* with symptoms of VitaminA Deficiency

How *Brokpa* is Food and Nutritional Insecure?

Brokpa follows transhumance migratory system in search of quality grasses for their animal i.e yak and yak-cattle hybrid. Yak is known as threatened species in all over India. They start their Journey during the month of mid-March to April to high altitude (more than 4500m from msl) and start getting down and settle during in the month of mid-October to mid-November to their base point for 3 months. Factually, their migration is depend on temperature and availability of grasses at particular place. During winter, the yak body weight loss from 25-30 percent due to feed and fodder scarcity. The same thing applied with the yak harder, during migration, they use to compromise with the food and nutritional diet. As they do not stay at a single place, therefore, they have to eat poor quality & dry vegetables, and other meat &meat products. The market distance from their base point is also one of the factor of poor quality diet. However, butter-salt tea, churkam, chhurpi and butter and dried meat supply some nutritional support but is it not sufficient and balanced. It has been also seen that the people have vitamin A deficiency leads to night blindness.

Table: 1.1 Climate Variation in Arunachal Pradesh

Istrict	Felt	Not felt	Undecided
Tawang	22 (36.67)	12 (20.00)	23 (38.34)
West Kameng	41 (68.34)	5 (8.34)	14 (23.34)

On other hand climate change playing their own role to have significant impact to affect their livelihood. The pasture land is decreasing, the river stream is drying, green cover of forest deteriorating, dumping of plastic bottles polluting organic places etc. further, study was conducted and questions were asked about felt of climate variation in Tawang and West

Kameng district, the following facts were found that the West Kameng (68.34%) people felt more climate variationthan the Tawang (36.67%). Similarly, Maiti *et al*. (2014) also studied on climate change and vulnerability in the costal and alpine region, he found the same that West Kameng people were more vulnerable than Tawang. The Indian Meteorological Department, New Delhi also identified the same that there is a deficit rainfall from actual in the West Kameng district of Arunachal Pradesh.

Conclusion

The livelihood and food & nutritional security is under compromised situation as per ethnic *Brokpa* community is concerned. The population of animal is reducing, less interest among the youth in brokpaism is seen, grazing pastures decreasing etc. However, Indian Council of Agriculture Research-National Research Centre on Yak and other state line department are working tirelessly to uplift the community economically and nutritionally sustainable. Still more continues innovative and adaptive interventions are required for unceasing growth and food & nutritionally security.

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CARBON SEQUESTRATION WON'T SOLVE CLIMATE CHANGE

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As a matter of fact the atmospheric concentration of carbon dioxide (CO_2) touched 400 ppm (NOAA, 2019) *i.e.* a total of 3124 giga tonnes of CO_2 is present in the atmosphere. However, there is increasing interest in controlling this growth in order to minimize the impacts on the global climate. Although major emphasis is focused on decreasing the rate of CO_2 emissions from fossil-fuel use, there is also increasing recognition that the hazard can be mitigated by transferring CO_2 from the atmosphere to the terrestrial biosphere (plant and soil system) as $CO_2$is absorbed by plants through photosynthesis and stored as carbon in biomass in tree trunks, branches, foliage and roots. This phenomenon has been termed as carbon sequestration, which is nothing but long-term storage of carbon in the biotic system to reduce the carbon dioxide concentration in the atmosphere.

It is evident that, tree plantation is very effective way to fight against global climate change (global warming). According to a recent report from a Swiss university, planting 1.2 trillion trees could suck up about 750 billion tonnes of CO_2 from atmosphere (Bastin *et al.*, 2019). This amount of CO_2 has been discharged during the past 25 years of anthropogenic activity. Though it seems very lucrative for obtaining a tangible (rather say readymade) solution of the climate change, it is never easy or sustainable. Obviously planting tree is beneficial for environment. However, unplanned forestation can harbor unwanted species of flora and fauna which may disturb the balance of the existing ecosystem. Whereas, aggressive plant species may spread the land very fast and may cause shift in biological diversity, dry up water bodies and make areas more prone to wild-fires. Nevertheless, it would be very much appreciating to stop the denudation of existing tree cover (mainly forest) from earth surfaces. Massive reforestation only works if the world's current forest cover is maintained and increasing; for example the clearing of the Amazon rain forest is in very alarming situation. However, there is no intension of discouraging the tree plantation programme, but when it would be conducted on a vast scale there are utmost chance of underestimating the local and regional ecological issues. Countries like Ireland and Japan are already witnessing the consequences of poorly planned tree plantation activities. Planting of just few tree species to replant in those countries has led to ecological disturbances.

On the other hand, agriculture has enormous role to play in improving the carbon dynamics of atmosphere not only by reducing green house gas emissions through adopting improved management practices, but also by enhancing the carbon stock of the soil. It is

estimated through several predicting models that soil organic carbon pool can be increased by soil restoration and the adoption of recommended agricultural practices. Carbon sequestration in agricultural system in particular has several ancillary beneficial roles, which includes reduced plant water stress due to enhanced available water in the soil, increased nutrient retention, enrichment of species diversity of soil biota, reduction in surface runoff and improve use efficiency of inputs. The ability of agriculture lands to store or sequester carbon depends on several factors, such as climate, type of soil, type of crop or vegetation cover and management practices adopted (Sundaram *et al*., 2012). Agriculture can positively influence the carbon sequestration by adoption of conservation agriculture, cover crops, perennial cropping systems and agro-forestry, restoration of degraded lands, rotational grazing, crop improvement and efficient management of manure and nutrient, water. However, the capacity of the soil to sequester and retain carbon is also finite as it reaches a steady state after sometime and the retention time is shorter in tropics than under temperate climates.

It must be understood that carbon sequestration through tree plantation and adopting sustainable agricultural practices is very much necessary butis short term way to fight against the climate change. Mature forests can store a lot of carbon, but this capacity is only reached after hundreds of years, not a couple of decades of new tree plantation. Also, there is great uncertainty regarding the size of the potential carbon sink of soil especially the agricultural soils. Carbon sequestration only buys us time during which alternatives to fossil fuel are to be developed and implemented. If anthropogenic CO_2 emission is not controlled through combustion of fossil fuels, it will be very difficult to mitigate climate change. Moreover, it is the overall awareness of people to nature and natural systems can mitigate the potential hazards of climate change.

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AGRO TOURISM: EXPLORING NEW AVENUES IN RURAL INDIA

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India being a land of agriculture, gifted with diverse panoramictopography and ecological landscape across the country, thus supporting the livelihood of more than 50 per cent of the farming community.Agro tourism is a recent offshoot of tourism sector that has grown up to be a potential business in its own space. Rural tourism is a form of nature based tourism that uncovers the rural life, culture, art and heritage at rural locations, thereby favoring the local communities socially and economically. Such form of tourism has created tremendous impact on the local economy and socio-cultural scenario of the concern area on one hand and carries a potential scope for the rural residents on the other hand. It can provide several advantages: income, employment, use accommodation, activities, natural resource conservation, recreation and education. But the main problem for many countries is the low level of farm income. Agro-tourism is a way of sustainable tourist development and multi-activity in rural areas aimed for enhancing higher standards of living for rural communities especially through increased income for people who work in agriculture.

The term agro-tourism emerged in the late twentieth century. It includes agricultural farms that are related to tourism. Agro tourism philosophy aims to increase farmers' incomes and the quality of life of rural society. The World Tourism Organization (WTO) defines rural tourism as tourism that gives to visitors a personalized contact, a taste of physical and human environment of the countryside and as far as possible, allows them to participate in the activities, traditions and lifestyles of local people (Aref and Gill, 2009). According to the Organization of Economic Co-Operation and Development (OECD), it is tourism that takes place in the countryside (Reichel *et al*., 2000).The Government of India (GoI) defines rural tourism as any form of tourism that showcases the rural life, art, culture and heritage at rural locations, thereby benefiting the local community economically and socially as well as enabling interaction between the tourists and the locals for a more enriching tourism

experience. Thus, rural tourism can be defined as tourism in country side which is intrinsically related to ecotourism, cultural tourism and agro tourism. Agro tourism educates people and society about agriculture and contributes to the local economy; it reduces the level of urbanization as people work and earn more from agro tourism; it promotes local products and create added value through direct marketing and stimulates economic activities in order to increase benefits in societies where the agro tourism is developed. Researcher Rilla clearly describes the reasons for the development of agro-tourism as: educate deliberately by maintaining links between sectors interested in the local society and visitors; the positive impact on improving the health of visitors; creating relaxation; it constitutes an adventure; it determines enjoying natural food; it could be a unique experience and it is a form of leisure tourism.

As it is well known fact that, urban population is increasing day by day in India, today the urban people's world is restricted in the closed door flats, offices, clubs, television, video games, spicy fast food, computer, internet, and so on. They can see nature only on television or screen of the computers. More over some people living in the cities do not have relatives in villages and they never visited or stayed in village. These people want to enjoy rural life but there is problem of such type of facilities. Hence, it is opportunity to the farmers for the development of the agro-tourism centres and it serves him and create additional income source.

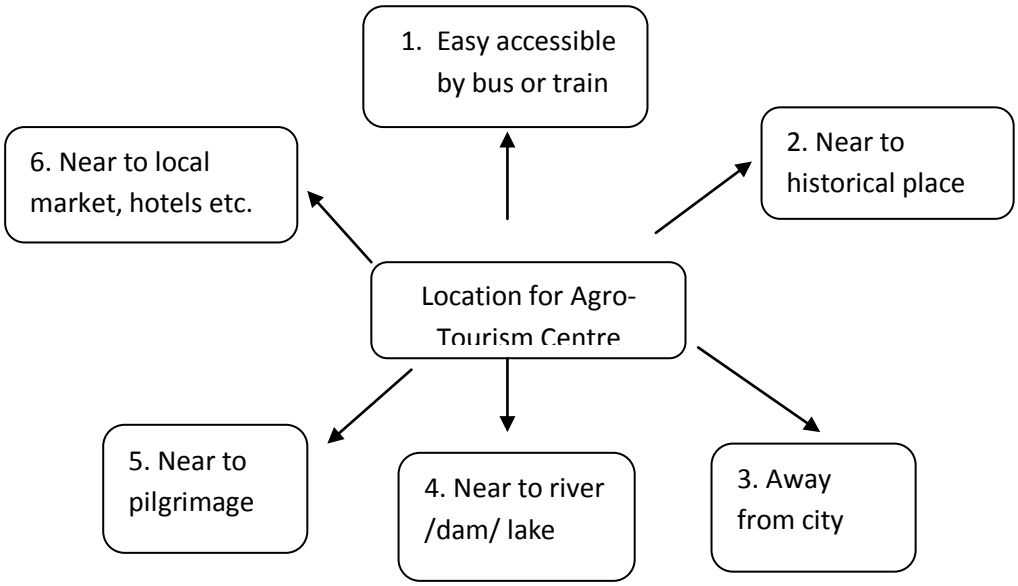

Fig1. Ideal location for Agro-tourism centres

There are three main forms of rural tourism which bring benefits both for tourists and for the local community

Ecotourism is a sustainable form of natural resource-based tourism that focuses primarily on experiencing and learning about nature, and which is ethically managed to be low-impact, non-consumptive and locally oriented (control, benefits and scale). It typically occurs in natural areas, and should contribute to the conservation or preservation of such areas (Fennell, 1999).

Fig a. Farm Stay Houses

Fig b. Animal Ride

Fig c. Dairy Tourism

Fig d. catering exotic foods

Fig d. Art and Craft

Fig e. Recreation in Sunflower field

Cultural tourism covers all aspects of travel where visitors can learn about another area's history and way of life. Thus, cultural factors in the context of tourism include the entertainment, food, drink, hospitality, architecture, manufactured and hand-crafted products of a destination, and all other characteristics of a destination's way of life (McIntosh and Goeldner, 1990).

Agriculture tourism is an enterprise which combines elements of agriculture and tourism. Example, retail markets, petting zoos, fee-fishing, festivals and fairs, tours, agriculture related museums, agriculture related festivals and fairs (Bruch *et al*., 2005). William *et al*. (2001) define agricultural tourism as a combination of natural settings and products of agricultural operations combined within a tourism experience. It includes providing tourists with opportunities to experience a broad spectrum of agriculturally based products and services ranging from fruit stand shopping to winery, from farm based bed and breakfast accommodation to tourist participation in cattle drives. According to Lamb (2008), agrotourism, farm tourism or agricultural tourism is the process of attracting visitors and travellers to agricultural areas, generally for educational and recreational purposes.

Benefits of Agro-Tourism Centers

Agro-Tourism has the potential to change the economic face of traditional agriculture. The benefits of agro-tourism development are manifold. It would bring many direct and indirect benefits to the farmers and rural people. Some of the benefits are following:-

- Employment opportunities to the farmers including farm family members and youth.
- Additional income source for the farmers to protest against income fluctuation.
- Cultural transformation between urban and rural people including social moral values.
- Farmers can improve their standard of living due to the contacts with urban people.
- Benefits to the urban people, they can understand about the rural life and know aboutthe agricultural activities.
- It supports and further promotes rural and agricultural development process.
- Help to the reduce burden on the other traditional tourist centres and attracts tourists.
- Agri tourism has the capacity to create a win win situation for both the farmers as well as the tourists.
- Employment generation through allied activities like Emu, organic and dairy farming.

Some barriers in Agro-tourism

1. **Language Problem**: Language problem in the locality have been found to be one of the barriers in the enhancement of the tourism potential. People are found to be lacking proper fluency in Hindi, English or even local dialect, for interaction with the tourists.

2. **Insufficient Financial Support:** Proper financial support can enhance the tourism potential of the region, which would help the folks to preserve the local culture, traditions, heritage, art forms etc. that showcases the uniqueness of the place in the proper manner.
3. **Communication Problem**: There should be proper transport and communication facility i.e. better road connectivity, mobile and telephone network for better commutation and convenience of the tourists.
4. **Lack of Trained tourist guide:** The whole tourism concept is very indigenous in the rural areas. Though initiative attempt have been taken by the local youths, yet the professionalism is lacking. They are lacking proper training to project in the manner from tourism perspective.
5. **Lack of business planning skill:** Some regions have great potential as an upcoming agro tourist spot. But, in order to bring it to a greater platform, sound business planning has to be made. The region needs proper enhancement of its beauty and resources skillfully to bring itself to light.

Socio-economic impacts of Agro-tourism

1. **Employment to youth:** Rural tourism contributes positively to the increase in employment and income levels of the youths.
2. **Boost to the Handloom and Cottage industry:** Traditional attires, especially of women are found to a delightful attraction for incoming tourist both domestic and outsiders. People, often found to be interested in purchasing the garments, which is helping in gearing up the production of local handloom products.
3. **Preservation of natural resources:** Tourism in local areas helps in preserving the rural eco system, since it forms the base to the tourism sector, also a part of the development funds are use in creating social forests and preserving existing forest**.**
4. **Exchange of revenue:** Employment avenues created by tourism demands help in earning domestic income.
5. **Exposure to their religion:** Tourism avenues have a given a due introduction to this almost hidden but old culture. Tourist interaction has provided the proper exposure to the world outside.

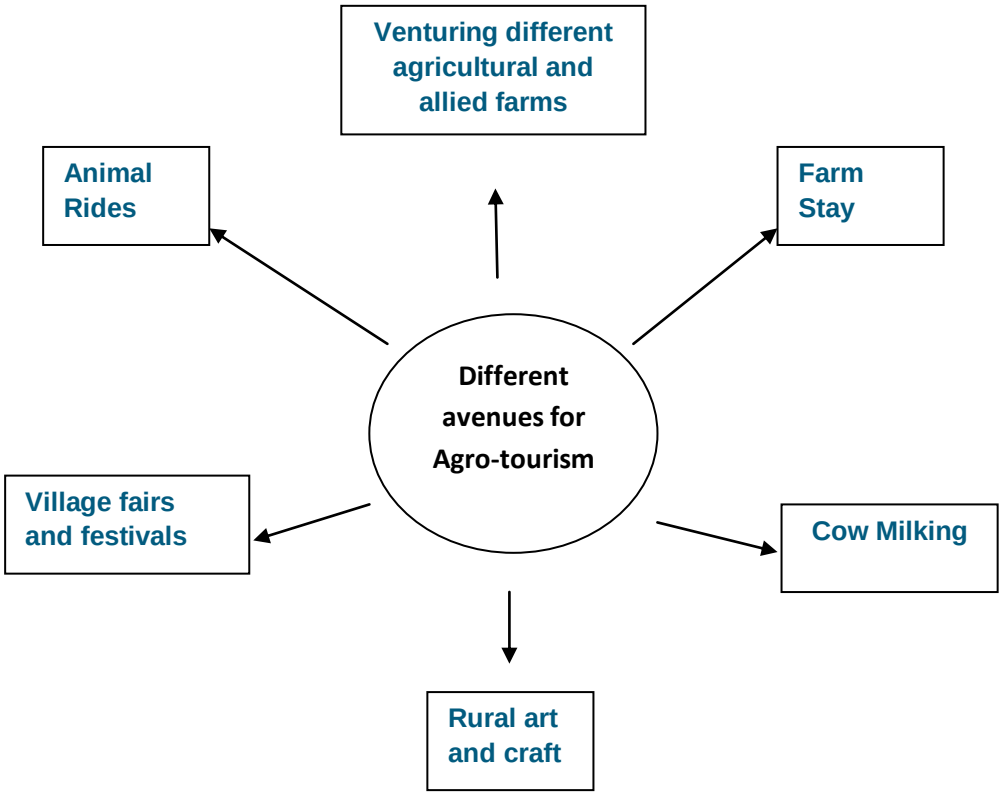

Fig 2. Different avenues for Agro-tourism

Key Strategy for Success of Agro-Tourism

Agro-Tourism is a one of the business activities. So, farmers must have commercialmindset and some marketing techniques for the success. For the better success in the agro-tourism farmers should follow the following things;

- Give a wide publicity of your tourism centre by newspapers, television etc. Use all possible advertisement means.
- Develop contacts with the schools, colleges, NGOs, clubs, unions, organizations etc.
- Train your staff or family members for reception and hospitality of the agro tourists.
- Understand about the customers wants and their expectations and serve them accordingly.
- Charge optimum rent and charges for the facilities/services on the commercialbase.
- Do the artificially use local resources for the entertainment / service to tourists.
- Develop your website and update time to time for attract foreign tourist.
- Take their feedback and comments about the service and suggestions to more development and modification.
- Develop a good rapport with the tourist for future business and chain publicity.

- Develop different agro-tour packages of for different type of tourist and their expectations.
- Maintain an address book and comments of the visited tourists for future tourismbusiness and reference.
- Small farmers can develop their agro-tourism centres on the basis of cooperativesociety.

Conclusion and Policy Implication

India basically being a rural economy, rural tourism and agri tourism significantly contributes to the GDP of any country and is a crucial tool for employment generation, poverty alleviation and sustainable human development. Indian tourism industry is growing at the rate of 10 %, which is two and a half times more than the growth rate at global level. In India of late the unique tourism arteries that have gained momentum are health tourism (medical tourism), religious tourism, sports tourism, educational tourism etc. Agri tourism is now an additional artery of the tourism sector in India. Though at present it is in nascent stage, with proper government incubation it can gain flight. There by introducing agro tourism concept all over India not only the present growth rate can be sustained but it is also a value addition and can accelerate further growth.

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CLIMATE RESILIENCE AGRICULTURE PRACTICES

Article Id: AL201904

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Climate change is going to present society with a variety of new challenges. Individuals, households, and communities around the world-but particularly in low-and middle income nations-will all be affected in the coming years and decades. Changes in mean temperature are going to affect food production and water availability, changes in mean sea level will increase coastal inundation, and more-frequent and more-intense extreme events will result in more damage and loss of life from floods and storms. On top of this, rising temperatures can increase the burden of malnutrition, diarrheal illnesses, cardio respiratory diseases, and infections. These challenges are felt particularly strongly in some of the poorest regions of the world.

Environmental changes may affect many different aspects of agricultural production. With greater climate variability, shifting temperature and precipitation patterns, and other global change components, we expect to see a range of crop and ecosystem responses that will affect integral agricultural processes. Such effects include changes in nutrient cycling and soil moisture, as well as shifts in pest occurrences and plant diseases, all of which will greatly influence food production and food security (Fuhrer, 2003). These changes are expected to increase abiotic and biotic stress, forcing agricultural systems to function under greater levels of perturbation in the future.

Resilience is defined as the propensity of a system to retain its organizational structure and productivity following a perturbation (Holling, 1973). Thus, a resilient agroecosystem will continue to provide a vital service such as food production if challenged by severe drought or by a large reduction in rainfall. In agricultural systems, crop biodiversity

may provide the link between stress and resilience because a diversity of organisms is required for ecosystems to function and provide services. Removing whole functional groups of species or removing entire trophic levels can cause ecosystems to shift from a desired to less-desired state, affecting their capacity to generate ecosystem services (Folke *et al*., 2004). This effect highlights the possibility that agricultural systems already may be in a less-desired state for the continued delivery of ecosystem services.

Biodiversity—which allows for the coexistence of multiple species, fulfilling similar functions, but with different responses to human landscape modification—enhances the resilience of ecosystems (Walker, 1995). This concept is linked to the insurance hypothesis (Yachi and Loreau, 1999), which proposesthat biodiversity provides an insurance, or a buffer, against environmental fluctuations because different species respond differently to change, leading to more predictable aggregate community or ecosystem properties. Such diversity insures the maintenance of a system's functional capacity against potential human management failure that may result from an incomplete understanding of the effects of environmental change (Elmqvist *et al*., 2003).

Advantages of diversified agroecosystems

Current knowledge suggests that climate change will affect both biotic (pest, pathogens) and abiotic (solar radiation, water, temperature) factors in crop systems, threatening crop sustainability and production. More diverse agroecosystems with a broader range of traits and functions will be better able to perform under changing environmental conditions (Matson *et al*., 1997), which is important given the expected changes to biotic and abiotic conditions. The following are a few of the major ways that the greater functional capacity of diverse agro ecosystems has been found to protect crop productivity against environmental change.

Pest suppression

In agricultural systems, as in natural ecosystems, herbivorous insects can have significant impacts on plant productivity. The challenges of pest suppression may intensify in the future as changes in climate affect pest ranges and potentially bring new pests into agricultural systems. It is expected that insect pests will generally become more abundant as temperatures rise as a result of range extensions and phenological changes. This abundance

will be accompanied by higher rates of population development, growth, migration, and overwintering (Bale *et al*., 2002). Changes in the distribution and abundance of species and communities are unlikely to occur at the same rates. Migrant pests are expected to respond more quickly to climate change than plants, and they may be able to colonize newly available crops and habitats (Bale *et al*. 2002). However, there are a variety of barriers to range expansions, including such biotic factors as competition, predation, and parasitism from other species (Patterson *et al*. 1999).Promoting such barriers to range expansion and pest viability will have an immediate negative impact on pest outbreaks and will help protect agricultural production.

Disease suppression

Losses caused by pathogens can contribute significantly to declines in crop production, and changes in climate potentially could affect plant disease distribution and viability in new agricultural regions. From 2001 to 2003, 10% of the global crop losses in wheat, rice, and maize were shown to be a result of pathogens (Oerke, 2006).

The diversity of crop species in an agroecosystem has a much less predictable effect on microbial pathogens compared with crop pests, as microclimatic conditions play an important role in the development and severity of a disease (Matson *et al*., 1997; Fuhrer, 2003).The effect of climate change on disease prevalence is therefore much less certain. Climate change could have positive, negative, or no impact on individual plant diseases (Chakraborty *et al*., 2000), but it is suspected that milder winters may favor many crop diseases, such as powdery mildew, brown leaf rust, and strip rust, whereas warmer summers may provide optimal conditions for other diseases, such as cercosporea lead spot disease (Patterson *et al*., 1999).Global change is also predicted to alter the distribution and abundance of arthropod vectors that distribute viruses, thereby affecting the rates of and chances for crop transmission (Anderson *et al*., 2004).

Climate variability buffering and mitigation

Diversified agro ecosystems have become more important for agriculture as climate fluctuations have increased. Research has shown that crop yields are quite sensitive to changes in temperature and precipitation, especially during flower and fruit development stages. Temperature maximums and minimums, as well as seasonal shifts, can have large

effects on crop growth and production. Greater variability of precipitation, including flooding, drought, and more extreme rainfall events, has affected food security in many parts of the world (Parry *et al*., 2005).

Agricultural vulnerabilities have been found in a number of important crop species. Studies of wheat have demonstrated that heat pulses applied to wheat during anthesis reduced both grain number and weight, highlighting the effect of temperature spikes on grain fill (Wollenweber *et al*., 2003). In maize, researchers observed reduced pollen viability at temperatures above 36 degrees Celsius, a threshold similar to those in a number of other crops.

Agro forestry systems are examples of agricultural systems with high structural complexity. Although the primary crop of interest (e.g., coffee, cacao) is sometimes grown in more intensively managed systems with little shade cover, the more structurally complex systems have been shown to buffer crops from large fluctuations in temperature, thereby keeping crops in closer-to-optimal conditions. The more shaded systems have also been shown to protect crops from lower precipitation and reduced soil water availability because the over story tree cover reduces soil evaporation and improves soil water infiltration.

Conclusions

It is abundantly clear that farmers are facing growing stress from climate change, and that the greater implementation of diversified agricultural systems may be a productive way to build resilience into agricultural systems. The challenges to increasing adoption of diversified agricultural management strategies are both scientific and policy based. In the scientific realm, the adoption of diversified agricultural systems could be bolstered if farmers had a better idea of how to optimize a diversified structure to maximize production and profits. Crop and landscape simulation models that can model a range of climate scenarios and landscape modelling with farm profitability scenarios would help farmers find optimal strategies for maintaining production and profit. Stakeholder-based participatory research would also be highly beneficial, as researchers could model strategies that seem plausible to farmers.

In the policy realm, diversification within agricultural systems could potentially increase in the United States through the adjustment of the farm income support systems to incentivize more diverse cropping systems that support small farmers. Internationally,

diversified agriculture can have a large role in protecting food security and production in regions where farmers have little access to chemical, structural, or technological resources.

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FUNCTIONAL DEVELOPMENT OF THE RUMEN AND RUMINANT SYSTEM

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Ruminant animals have a complex digestive system. They have a four-chambered stomach consisting of rumen, reticulum, omasum and abomasum. Among them, rumen is the largest one and gives the major characteristic features of the ruminant system. Without this rumen, cows and other ruminants wouldn't be much competent in converting grasses into milk. Actually, rumen acts as fermentation vat, where degradation of cellulose-containing fibers takes place, which is otherwise non-digestible for the monogastric animals. Interestingly, the digestive system of the ruminants is just like the monogastric at the time of birth. With the advancement of time, this system converts to a mature ruminant system. This transition occurs through step by step with simultaneous anatomical and physiological changes. There are different factors which influence the transformation. It is important to study these factors and the process of rumen development so that the ruminant digestive system can be modulated according to need. It will help in maintaining animal welfare as well as making more profit for the farmer through better production. For that purpose, the phases of rumen development and their stimulants have been described briefly in this section.

Structure and function of rumen

The rumen is the first chamber of the stomach. It is also the largest part of the digestive tract making 70% of the stomach. Many fingerlike projections called papillae covers the inner wall of the rumen. The rumen of an adult cow can contain up to 100 liters of undigested food. It contracts at a certain interval and helps in the movement of ingesta to the next chamber. Its major function is mechanical digestion through breaking the feed and fermentation with the help of microorganisms present in it. It also sends back the feed to the mouth for remastication and expels out the gases produced in the rumen, through eructation. Rumen can digest cellulose and hemicelluloses present in the leaves and produces volatile fatty acids as a final product. But, rumen itself can't secrete any enzymes for this digestion. It is the microbes present in the rumen which help in fermentation of the feed particles. The microbial population of the rumen is majorly consisting of bacteria, protozoa and fungus. They digest the feed taken by the animal and convert it into microbial products. The animal takes these products for further digestion in the later part of the digestive tract and fulfills their need. In the newborn animals, digestive tract is just like a monogastric animal and doesn't contain any microbes. At that time the rumen is also small in size consisting of only 25% of the stomach and abomasum 70%. With the progression of time, it gains its characteristic features and become fully functional at six to eight weeks of age.

Phases of rumen development

As already discussed above, a transformation of rumen takes place after birth with the progression of time. A newborn calf capable of taking only milk; transforms into an animal which can digest grass, leaves and other feeds. This process occurs through four stages namely newborn phase, pre-ruminant phase, transitional phase and ruminant phase. The events that occur in these phases are described below.

Newborn phase

This phase lasts for 24 hours after birth. The rumen is very comparatively small in size and contains no microbial population. The papillae present in the rumen are also rudimentary. At this period the only diet is colostrum (the first milk) which contains a high level of immunoglobulins. The abomasum also doesn't secret acid or pepsinogen to prevent digestion. This helps the immunoglobulins to pass undigested. The intestine also can't affect them due to the presence of anti-trypsin in colostrum. As a result, the antibodies present in

the colostrum are absorbed directly from the intestine and goes to the blood. This provides natural passive immunity to the newborn animal. This is very important as it helps in gaining disease resistant power. But, this direct absorptive capacity of intestine remains for only 24-48 hours after birth and disrupted if milk is provided. So, only colostrum should be fed to the newborn. If proper colostrum feeding is hampered, there will be a decline in immunity. It can result in acute infection like “joint-ill” and “naval-ill”.

Pre-ruminant digestion

This period lasts from one day to 21 days. The principal food for this period is milk, though in the later part of this phase solid feed is also taken. Suckling of milk promotes the secretion of saliva. Saliva contains an enzyme called esterase which promotes hydrolysis of milk lipids. But, this milk bypasses the rumen and reticulum and directly goes to the abomasum. It stimulates the secretion of the abomasum and further digestion of milk components.

Transitional Phase

Duration of this period is 3-8 weeks. In this period the large volume of milk is taken and digested as described above. But simultaneously, roughages are also taken in the large amount. They are responsible for the development of salivary gland as well as rumen and reticulum. The salivary gland starts increasing in size and rumen starts acquiring microbes. Microbial fermentation of feed particles especially roughage produces volatile fatty acids (VFA). These VFAs are necessary for the development of papillae of the rumen. Gases are also produced and eructation function is started. Bulks of the roughage are responsible for muscular development. At the end of this period, rumen will be quite developed capable of fermentation. Finally, the intermediary metabolism will also shift from glucose to VFAs and blood glucose level is also become less insulin sensitive.

Ruminant digestion

Starting from the transitional phase his phase lasts up to adulthood. With the decline in milk production by the cow, the calf becomes more dependent on other feeds. The stomach attains motility and fermentation starts at full phase. In a word, rumen acts like an adult one.

Ingredients to initiate rumen development

Rumen development is defined as the development of the epithelium and it is critical to successful weaning and good calf growth rates. There are five key ingredients that are required to initiate rumen development:

Bacteria

Rumen bacteria are absent when a calf is born and are introduced as the calf begins to eat calf starter concentrates. Bacteria help the digestive process. Bacterial end products of digestion (VFAs) cause significant changes in the rumen. The type of VFA produced is crucial. Calf starter contains carbohydrates in the form of starch which is fermented by bacteria that produce propionic and butyric acids. In contrast, when forages are digested the primary end product is acetic acid. Acetic and propionic acids are absorbed through the rumen wall and are converted into metabolites that the calf uses as energy sources. Butyric acid is not absorbed through the rumen wall and is instead converted into an energy source used by cells in the rumen wall (Fig.1). The production of VFAs lowers the pH of the rumen and establishes an ideal growing environment for bacteria, especially for bacteria that digest starch and produce propionic and butyric acids. Addition of yeast culture in a dairy calf starter at 2% enhances dry matter intake and growth and slightly improves rumen development in dairy calves.

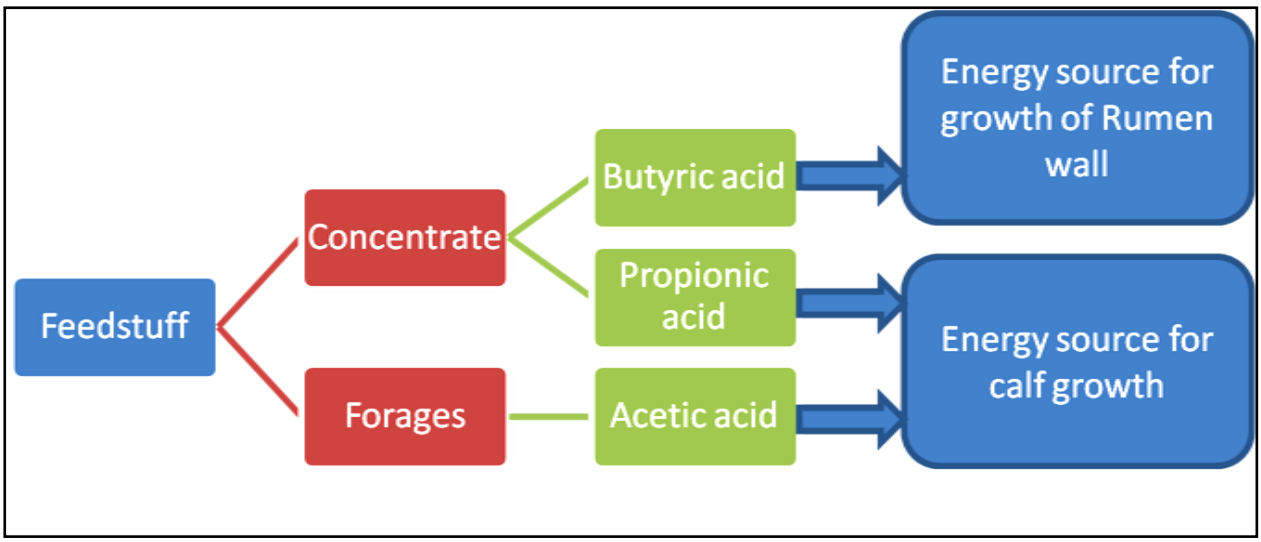

Fig. 1: Effects of VFAs in rumen development

Liquid in the rumen

Liquid in the rumen provides an ideal environment, combined with the absence of oxygen, for the rapid growth of bacteria. As milk bypasses the rumen, it does not provide enough liquid for optimal rumen development and therefore the calf must have access to 'free water'. Offering water from three days of age helps to increase calf weight gain, promotes starter intake and reduces the incidence of scour. Several studies have proved that rumen development may be affected by liquid feed type and composition.

Muscular movement

Feedstuffs that enter the rumen must be able to leave it. Therefore the development of rumen activity, such as contractions, pressure and regurgitation, is necessary. This muscular movement also helps mix the feedstuffs. When the calf is born, the rumen has little muscular activity, few contractions and no regurgitation. As the calf's dry feed intake increases, rumen contractions begin. If calves are fed milk, hay, and starter from shortly after birth, normal rumen contractions can be detected as early as three weeks of age. In contrast, if calves are only fed milk, normal rumen contractions may not be measurable for extended periods.

Absorptive ability of tissue

From a structural point of view, the rumen is made up of two layers: the muscular and the epithelial, the latter is responsible for the absorption of VFAs.

At birth, the epithelium does not have any ability to absorb. It is the production and subsequent absorption of VFAs in the rumen, from the fermentation of starter feedstuff that stimulates epithelium development by increasing the surface area through the development of the epithelium into finger-like projections called papillae. It has been seen that feeding greater amounts of non-structural carbohydrates increases the surface for absorption of the rumen epithelium in calves.

Availability of feedstuff in the rumen

The key factor to promote early rumen development, and thereby early weaning, is dry feed intake. As concentrates are fermented to propionate and butyrate, they are a good choice to ensure early rumen development. Offer clean, fresh, starter at three days of age which is both highly palatable and meets the nutrient recommendations for dairy beef calves.

Chopped hay provided to calf also help in the development of the rumen. The type of processed feed included in calf starters also affects intake, feed efficiency, growth, blood VFA concentrations, and rumen parameters in ruminally developing calves. The particle size of feed is also very important regarding this aspect.

Conclusions

Feeding of an animal should be taken care not only for the survival of the animal but also for better production and profit. Rumen plays an important function in digestion of ruminant animals and makes the difference from monogastric animals. Development of rumen is also a significant process through the animal gets its ruminant status. Factors affecting rumen development are important in the modification of rumen functions. It can be used for the benefit of the animal as well as the benefit of the farmer.

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MARKET LED EXTENSION IN AGRICULTURAL DEVELOPMENT

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Indian agriculture has made tremendous progress since the last half century, hence attaining the status of self-sufficiency in food grain production. Though the production has been increased significantly, yet it has failed to attract the farmers with remunerative incentives. With the globalization of commodity market, farmers have to transform themselves into producer cum seller to realize the optimum returns from the investments. Most of the production related technologies are being provided to the farmers by extension delivery mechanism. In present scenario it is the utmost need to change the focus of extension delivery mechanism from production oriented to market oriented to increase the farmers income. Market-led extension help the farmers to improve the quality of farm produce, increase the product value and marketability resulting in increasing of income to the farmers.

Concept of Market-led extension

In changing scenario of agriculture, the farmers should be provided with proper up to date information ranging from production technology to market oriented knowledge i.e What to produce? When to produce? How much to produce? When and where to sell? at what price? And What form to sell his produce. Basically market-led extension considers farmers as an agripreneur and enables farmers to get high returns (money to money) out of the entire farming enterprise. This also facilitates farmers with diverse baskets of package of practices suitable to local situations/ farming Systems.

Objective of market-led extension

- To identify possible areas of intervention of extension in agricultural marketing.
- To build up and use effective extension methodologies for providing need-based support to farming community in marketing of their produce.

- The present linkage among Research-Extension-Farmers is extended by market linkage.
- To identify and communicate innovation for value addition practices and post-harvest technologies.
- To develop network and action plans for extension to support marketing of the product at different level.

Role of Extension personals in light of Market-led Extension

- SWOT analysis of market for creating awareness among the farmers for planning of their production and marketing.
- Organization of Farmers' Interest Groups (FIGs) on commodity basis and building their capabilities.
- Enhancing the interactive and communication skill of the farmers to exchange their views with customers and other market forces (middlemen) for getting feedback and gain the bargaining during direct marketing.
- Establishing marketing and agro-processing linkages between farmers' groups, markets and private processors.

Extension strategies for creating awareness about Market-led Extension among the farmers

- Identifying the farmers/ group of farmers, interested in export of agricultural commodities.
- Creating awareness among the farmers regarding market-Led extension.
- Conduct training for farmers in cost reduction strategies of farming.
- Development model procedures in cultivation of crop for export purpose.
- Dissemination of financial and market related information to the farmers.
- Organising training for the farmers in grading and packing.
- Provide information through electronic mass media, TV, Internet etc.

Challenges of Market-led Extension

Public extension system is gigantic in size and heavily burdened with several activities. Now incorporating a new marketing dimension into this system may become an agenda with several difficulties to tackle. Again, extension personals need to be motivated to

learn various marketing skills before doing marketing extension. Developing accurate, relevant, comprehensive and timely market intelligence regarding product, market practices, customers and commodity prices will be the biggest challenge in market-led extension. There is a need to frame the information policy to make the farmers information rich with revamped websites. Moreover, the disparity of transport facility, storage and ware housing facility in different areas are some notable challenges.

Conclusion

Market-led extension is enabling the farmers to realize the high returns for their produce, minimize the production costs, improve the product value and marketability. The potential of information communication technology, electronic and print media need to be harnessed to disseminate the production and market related information to the farmers. Indian farmers have moved from subsistence to self-sufficiency due to advent of production technologies. In order to be successful in the liberalized market scenario, the focus needs to be shifted from ‘supply driven’ to market driven' and farmers should produce according to the market needs and earn high returns.

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NON-CONVENTIONAL FEED RESOURCES

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India is basically an agricultural country and about 70 per cent of its population live in villages. Their livelihood is dependent mainly on agriculture and animal husbandry. Though India has a huge livestock population of over 343 millions, besides poultry, yet the production of per animal milk and other livestock products is about the lowest in the world. It is evident that we are highly deficient in various livestock products, though we have about one-fourth of the total cattle population of the world. The analysis of this situation reveals that one of the main reasons for the low productivity of our livestock is malnutrition, under-nutrition or both, besides the low genetic potential of the animals.

Availability, vis-a-vis the requirement of green-fodder crops and concentrates, that there is a huge gap between demand and supply of all kinds of feeds and fodders. On the other hand, if we examine the land resources available for growing fodder and forage crops, it is estimated that the average cultivated area devoted to fodder production is only 4.4 per cent of the total area. Similarly, the area under permanent pastures and cultivable wastelands is approximately 13 and 15 million hectares respectively. Likewise, the total area under forests is 2.51 crore hectares and that open to grazing is 2.1 crore hectares. All these resources are able to meet the forage requirements of the grazing animals only during the monsoon season. But for the remaining periods of the year, the animals have to be maintained on the crop residues or straws of jowar, bajra, ragi, wheat, barley, etc. either in the form of whole straw or a bhusa, supplemented with some green fodder, or as sole feed. The crop residues are available mainly from wheat, paddy, bajra, jowar, ragi, sugarcane trash, etc. But now it is necessary to search and increase the nutrient utilization of crop residues as well as nonconventional feeds.

Non-conventional feed resources (NCFR)

The non-conventional feed resources (NCFR) refer to all those feeds that have not been traditionally used in animal feeding and or are not normally used in commercially produced rations for livestock. NCFR include commonly, a variety of feeds from perennial crops and feeds of animal and industrial origin. The term NCFR has been frequently used to describe such new sources of feedstuffs as palet oil mill effluent and palm press fibre (oil palm by-products), single cell proteins, and feed material derived from agro industrial by-products of plant and animal origin. Poor-quality cellulosic roughages from farm residues such as stubbles, haulms, vines and from other agro-industrial by-products such as slaughter-house by-products and those from the processing of sugar, cereal grains, citrus fruits and vegetables from the processing of food for human consumption also comes under category of NCFR.

Need of Non-conventional feed resources

There are serious shortages in animal feeds of the conventional type. The grains are required almost exclusively for human consumption. With increasing demand for livestock products as a result of rapid growth in the world economies and shrinking land area, future hopes of feeding the animals and safeguarding their food security will depend on the better utilization of unconventional feed resources which do not compete with human food. The availability of feed resources and their rational utilization for livestock represents possibly the most compelling task facing planners and animal scientists in the world. The situation is acute in numerous developing countries where chronic annual feed deficits and increasing animal populations are common, thus making the problem a continuing saga.

Thus non-conventional feeds could partly fill the gap in the feed supply, decrease competition for food between humans and animals, reduce feed cost, and contribute to self-sufficiency in nutrients from locally available feed sources. It is therefore imperative to examine for cheaper non-conventional feed resources that can improve intake and digestibility of low quality forages. Feedstuffs such as fish offal, duckweed and kitchen leftovers (i.e., potato peel, carrot peel, onion peel, and cabbage leftover), poultry litter, algae/*Spirulina*, *Leucaena* leaf, local brewery and distillery by-products, sisal waste, cactus, coffee parchment and coffee pulp are commonly used in India, and could be invaluable feed resources for small and medium size holders of livestock.

Advantages of NCFR

a) These are end products of production and consumption that have not been used.

b) They are mainly organic and can be in a solid, slurry or liquid form. Their economic value is often very less.

c) Fruit wastes such as banana rejects and pineapple pulp by comparison have sugars which are energetically very beneficial.

d) The feed crops which generate valuable NCFR are excellent sources of fermentable carbohydrates eg. cassava and sweet potato and this is an advantage to ruminants because of their ability to utilize inorganic nitrogen.

e) Concerning the feeds of crop origin, the majority are bulky poor-quality cellulosic roughages with a high crude fibre and low nitrogen contents, suitable for feeding to ruminants.

f) They have considerable potential as feed materials and their value can be increased if they are converted into some usable products.

Agro-industrial by-products

Appropriate use of relatively inexpensive agricultural and industrial by-products is of paramount importance for profitable livestock production. However, high cost and low availability of conventional livestock feedstuffs frequently demand consideration of by-products even if efficiency of utilization is low. Efficient use of by-products relies on their chemical and physical properties, which influence production system outputs. In developing countries, grain, which forms the bulk of concentrate feeds for livestock, is both in short supply and expensive due to direct competition with human food uses.

Natural pasture that is estimated to contribute to 80–90% of livestock feeds and whose quality is seasonally variable is the main source of feed in arid and semi-arid pastoral areas, while crop residues contribute up to 50% of the feed supply in mixed-farming system. Grazing lands are steadily shrinking by conversion to arable lands, and natural pastures are also restricted to areas that are marginal and have little farming potential. The reduction in natural pasture has led to overutilization and domination by undesirable forage species resulting in partial dependence on crop residues by most ruminants, which has reduced livestock

productivity. The increasing human demands for several foods (i.e. olive oil, vegetables, wine, fruit juices, etc.) led to a considerable increase of lands occupied by crops producing these feeds. Consequently, huge amounts of agro-industrial by-products are available in numerous developing countries (e.g. molasses, olive cake, winery marc, etc.), which are still not fully utilized in livestock feeding. Most of these AIBPs are low in main nutrients. Moreover, the difficulty of the use of these feed sources as fresh material for extended periods and the lack of efficient ways for their integration in feeding calendars may account for their under-utilization.

MAJOR BY-PRODUCT FEEDS FROM TREE AND CROPS

	Crop	**Scientific name**	**By-product feed**
Tree crops	Cocoa	*Theobroma cocoa*	Cocoa bean waste. Cocoa pod husks
	Coconuts	*Cocos nucifera L*	Coconut meal
	Oil Palm	*Elaeis uineensis*	Oil palm sludge (dry) Palm press fibre Palm kernel meal
	Rubber	*Hevea brasiliensis*	Rubber seed meal
	Sago	*Metroxylon_selo*	Sago refuse
Field Crops	Castor	*Ricinus communis L.*	Castor meal
	Cotton	*Grossypium spp*	Cotton seed meal
	Maize	*Zea mays*	Maize bran Maize germ meal
	Rice	*oryza sativa*	Broken rice Rice bran Rice husk Rice straw
	Sugarcane	*Saccharum officinarum*	Bagasse Green tops Molasses
	Cassava	*Manihot esculenta Crantz*	Tapioca waste
	Wheat	*Triticum aestivum L.*	Wheat bran Wheat straw

MINOR BY-PRODUCT FEEDS FROM VARIOUS SOURCES

	Crop/ Animal	Scientific name	By-product feed
Plants	Cassava	*Manihot esculenta Crantz*	Cassava leaves
	Dbupa	*Veteria indica*	Dhupa meal
	Groundnut	*Arachis hypogaea*	Groundnut vines Groundnut meal
	Guar	*Cyampsis psonaloides DC*	Guar meal
	Kakan	*Salvadoza oleoides*	Kakan meal
	Karaj	*Pohogomia pinnata)*	Karaj meal
	Kakum	*Garcinia indica chois*	Kakum meal
	Kusum	*Schleichara oleosa*	Kusum meal
	Mahura	*Madhuka indica*	Mahua meal
	Mango	*Mangifera indica*	Mango kernel
	Nahor	*Mesua ferrca linnn.*	Nahor meal
	Neem	*Azadirachta indica*	Neem meal
	Oak	*Obercus dilatata*	Oak meal
	Pineapple	*Annanas comosus*	Pineapple waste
	Pisa	*Actinedaphne hooberi*	Pisa meal
	Sal)	*Shorea robusta Gaerth*	Sal seed meal
	Sesame	*Sesammum indicum L.*	Sesame cake
	Soyabean	*(Glycine soya)*	Soya bean
	Sweet potatoes	*Ipomoea batatas*	sweet potato vines
	Tamarind	*Tamarindus indica*	Tamarind seed hulls Tamarind seed kernels
Animals	Poultry		Poultry litter (dry)
	Ruminants		Blood meal, Meat and bone meal] (dry), Rumen contents (wet)

Conclusion

The main reason for the poor animal production is the inadequate supply and low level of feeding due to serious shortage of feedstuffs. A major gap exists between the requirements and supplies of nutrients for feeding of animal, the non conventional feeds could partly fill this gap. More information is required on chemical composition, nutritive value and their utilization. Farmers are not aware of the nutritive value of some feed sources and the way for their efficient integration in livestock feeding. The involvement of local extension agencies in technology development for efficient use of NCFR, assessment and transfer is equally important. Several factors may account for their limited use, among which is their low nutritive value, Seasonal availability, high cost of handling and transportation from the production site to the farm, presence of anti-nutritional factors. It is essential to increase feeds by growing more fodders, propagating agro and social forestry, improving the nutritive value of crop residues and utilising other NCFRs. Crop residues, AIBPs and browse foliage are

certain an increasingly important role as feeds in the future, as human and livestock populations expand.

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MUTATION AND IRRADIATION: IMPORTANCE IN THE FIELD OF AGRICULTURE

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Mutation is defined as the sudden heritable change to an individual's genetic makeup, which results in new traits that are passed on from parent to offspring and thereby, leads to evolution. In nature, mutations are caused by errors in the replication of deoxyribonucleic acid (DNA).

Muller, 1927 demonstrated radiation caused mutations in fruit flies and in the crop plants maize and barley by Stadler, 1928 which followed the discoveries of X-rays by Roentgen in 1895; radioactivity by Becquerel in 1896; and radioactive elements by Marie and Pierre Curie in 1898. The subsequent rapid and widespread adoption of induced mutations as a crop improvement tool derives directly from these pioneering discoveries.

The plant materials are exposed to radioactive particle or chemical compound in mutation breeding experiments, which may change the genetic constitution of plants. The physical mutagens are comprised of ionized radiation viz., particulate (alpha radiation and Beta Radiation). Ionizing radiations such as X-rays and γ-rays are more preferred over any other mutagens because of their ease of application, good penetration and reproducibility, high mutation frequency and less disposal problems. During the last two decades, the use of ion beam irradiation has emerged as an effective and unique technique for inducing mutations in plants (Tanaka *et al*. 2010).

Mutation may be used to obtain superior mutant for different traits like high yield, drought tolerance, disease resistance, quality, color, taste etc. The efficiency of mutation breeding is dependent on the effectiveness with which useful variants can be recognized in M2 or M3 generation. The first step in the mutation breeding selection process is to reduce the population of potential variants to a sufficiently small fraction to permit more detailed

analysis and evaluation. In order to determine the optimal dose of gamma irradiation, subsequent growth rate is recorded from the treated population. The plantlet height is used to determine optimal dosage for mutation induction as growth reduction GR_{30} and GR_{50}. Determination of LD_{50}value helps to define exact mutation dose (Predieri, 2001). The plants sensitivity to irradiation varies according to species, cultivar and the plant's physiological conditions (Britt,1996)

Applications of irradiation in agriculture

Crop improvement

Plant breeding requires genetic variation of useful traits for crop improvement. Different types of radiation can be used to induce mutations to develop desired mutants' line that are resistant to disease, are of higher quality, allow earlier ripening, and produce a higher yield. American Scientist L.J. Stadler in 1930 using X-rays induced mutations in plants. Later gamma and neutron radiation were employed as ionizing radiations. This technique of utilizing radiation energy for inducing mutation in plants has been widely used to obtain desired or improved characters in number of plant varieties. It offers thepossibility of inducing desired characters that either cannot be found in nature or have been lost during evolution. A proper selection of mutant varieties can lead to improved quality and productivity.

Bhabha Atomic Research Centre (BARC) has developed number of high yielding varieties of green gram, black gram, groundnut, jute and rice by using radiation energy for inducing mutation (Sood *et al*., 2010).

Plant nutrition studies

Fertilizers are very expensive and their efficient use is of great importance to reduce the production cost of agricultural crops. It is essential that a maximum amount of fertilizer used during cultivation finds its way into the plant and that the minimum is lost. Radioisotopes are very useful in estimating the amount of phosphorus and nitrogen available in the soil. This estimation helps in determining the amount of phosphate and nitrogen fertilizers that should be applied to soil. Fertilizers labelled with radioactive isotopes such as phosphorus-32 and nitrogen-15 have been used to study the uptake, retention and utilization of fertilizers. Excessive use of fertilizers effects biodiversity and damages the environment.

These isotopes provide a means to determine about amount of fertilizer taken and lost to the environment by the plant (Harderson, 1990).

Insect pest management

Insect pests are responsible for significant reduction in production of agricultural crops throughout the world (Alphey, 2007). They not only reduce crop yields but also transmit disease to cultivated crops. Radiolabel pesticides were used to monitor the persistence of their residues in food items, soil, ground water and environment. These studies have helped to trace and minimize the side effects of pesticides and insecticides. There are concerns that continuous uses of pesticides have negative impacts on the environment and it also results into development of resistance against pesticides in many insect species (ANBP, 2005).

IAEA is using nuclear science to develop environmentally friendly alternatives for pest control. FAO and IAEA division jointly sponsors projects and conducts research on control of insects using ionizing radiations. They have placed considerable emphasis on the Sterile Insect Technique (SIT) proposed by Knipling in 1955. This technique relies on application of ionizing radiation as a means to effectively sterilize male insects without affecting their ability to function in the field and successfully mate with wild female insects. This technique involves release of large numbers of sterile male insects of the target species in the field crop. Sterile male insects compete with the regular male population during sexual reproduction and the eggs produced from their mating are infertile so they produce no offspring(Morrison *et al*., 2010). It is highly specific form of "birth control which reduces and eliminates the insect population after two or three generations. It has been effectively utilized in elimination of Mediterranean fruit fly from US, Mexico and Chile and screw worm infestation in the US and Mexico (Klassen and Curtis, 2005). It has been successfully used to eradicate several insect pests of agricultural significance throughout the world.

Conclusion

Radiations can be applied in a number of ways to solve many problems in the agriculture and allow the industry to be more efficient. These applications are especially important for developing nations or areas where resources are scarce and for preserving natural resources while meeting the challenges of food security.

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