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Forage Production in India: Bottlenecks and Opportunities by Opening up New Way with an Increase in Fodder Oats Demand: A Review

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ABSTRACT

In India, mixed farming and cattle raising is an essential elements of rural life and these practices are connected with the social structure in cultural, religious and economic ways. India's production of fodder is very unevenly distributed and how this resource is used depends on the breed of cattle raised, the climate, the socioeconomic context and the crop-growing patterns. Fodder from cultivated regions is regularly fed to cattle and buffalo, with some harvested grasses and top feeds added as supplements. On the other hand within the land area of just 2.3 per cent, India is home to 16.8 per cent of the world's population and nearly 20 per cent of the world's cattle. India homes cattle (16%), buffalo (55%), goats (20%) and sheep (5%) of worlds total livestock population respectively. This fact makes it more cumbersome to meet the forage demand by livestock, thus shift in paradigm and opportunity in near future is about to hike for fodder crops with their potentiality in production per unit area. The present Indian scenario of fodder crops in comparison with the livestock population is being described in this article along with the net deficit and surplus availability of green and dry fodder. Further, this review also includes the opening of a new way for oats to contribute to fodder production. The challenges facing India for fodder production and its near opportunity to open up and evolve with various methodologies to tackle the present fodder demand by enhancing the production is described in detail in an article.

Key words: Fodder, Livestock, Oats, Opportunities, Present scenario.

On just 2% of the planet's total surface area, India is home to about 17% of the world's population of humans and 15% of its animals, which suggests a significant biotic pressure on the environment. Indian livestock population currently stands at 536.76 million, with a 4.8% increase from the 2012 livestock census (IGFRI Vision). Fodder crops will undoubtedly play a crucial part in maintaining this enormous animal population as well as in meeting the rising demand for milk and meat from the constantly growing human population (Jitendra 2017).

The nation now has a net deficit in concentrated feed ingredients (28.9%), dry crop residue (23.4%) and green fodder (11.24%) (Roy *et al*., 2019).

A net deficit of 11.24 per cent in green fodder, 23.4 per cent in dry crop residue and 28.9 per cent in concentrated feed ingredients currently exists in the nation. The establishment, productivity and durability of grass and forage crops are significantly impacted by pests and diseases in addition to the issues outlined above. Due to the restricted amount of land available for forage crops, intensive fodder production strategies are used to produce the most forage per unit area, which creates more favourable conditions for pest proliferation. Furthermore, as a result of climate change, these pests' reproductive and developmental conditions are getting even better. Different feed crops, which vary depending on the agroecological conditions and season, are grown in various regions of the nation. For the benefit of farmers, it is crucial to design practical crop protection solutions that are appropriate for both the site and the region.

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The scenario of the area under fodder in India

India has a very uneven distribution of fodder production and the usage of this resource is influenced by the type of cattle raised, the climate, the socioeconomic environment and the pattern of crops. Cattle and buffalo are frequently fed fodder from cultivated areas, with some gathered grasses and top feeds added as supplements (Shashikala *et al*., 2017). Animals are fed fodder crops in the form of hay (dehydrated/dried green), silage (kept under anaerobic conditions) and forage (cut green and provided fresh). In the *Kharif* and *Rabi* seasons, respectively, sorghum (2.6 Million hectares) and Egyptian clover (1.9 Million hectares) make up around 54% of the total planted area under fodder (Dagar, 2017)

In various places, farmers grow a variety of grasses and legumes, such as hybrid Napier, guinea grass, para

grass, velvet bean, stylo, *etc*. In times of scarcity, farmers with small ruminants in particular choose tree-top fodders. According to the Directorate of Economics and Statistics, DACandFW, 2020, the area used for permanent pastures and other grazing land is 10.34 M ha. This area has been declining over time and the trend is projected to continue. Due to overgrazing, pasture productivity has also been declining (Pathak and Dagar, 2015). Crop residues are anticipated to offer 54 per cent of all fodder, while rangelands will contribute 18 per cent and cultivated fodder crops will only supply 28 per cent (Hegde, 2010).

The scenario of forage demand and supply availability in different states

The shortage and surplus growing of various green and dry fodder crops are depicted in Fig 1 and 2 (Indian Grassland and Forage Research Institute-IGFRI, Jhansi, 2020). For green fodder availability, states like Uttar Pradesh Assam, Karnataka, Nagaland, Kerala, Tamil Nadu, Goa, Chhattisgarh, Rajasthan, Bihar, Sikkim, Odisha, Meghalaya, Manipur, West Bengal, Jharkhand, Andhra Pradesh, Tripura, Uttarakhand and Jammu Kashmir have a shortage of green fodder content in respective states ranging up to 50%. Whereas, states like Gujrat, Arunachal, Maharashtra, Himachal, Madhya Pradesh, Haryana, Punjab and Mizoram have surplus green fodder production ranging up to 50 %. Similarly, in dry fodder production, states like Assam, Karnataka, Tamil Nadu, Chhattisgarh, West Bengal, Bihar, Rajasthan, Jharkhand andhra Pradesh, Maharashtra, Telangana and Gujrat are still having a shortage of various percentages in their dry fodder production. States like Tripura, Odisha, Haryana, Jammu Kashmir, Chhattisgarh, Madhya Pradesh, Arunachal Pradesh, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim, Punjab, Kerala, Goa, Himachal Pradesh and Uttarkhand are high in producing the dry fodder. The Figures explain the percentage of deficit or surplus

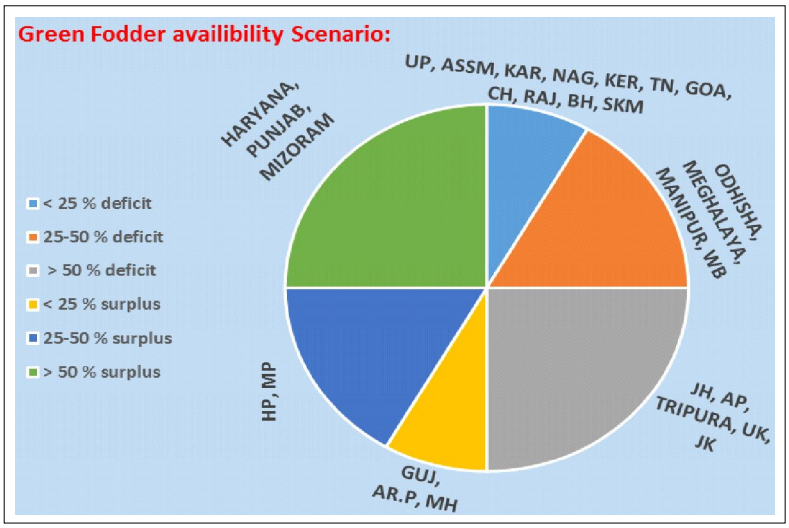

Fig 1: Scenario of green fodder availability in India.

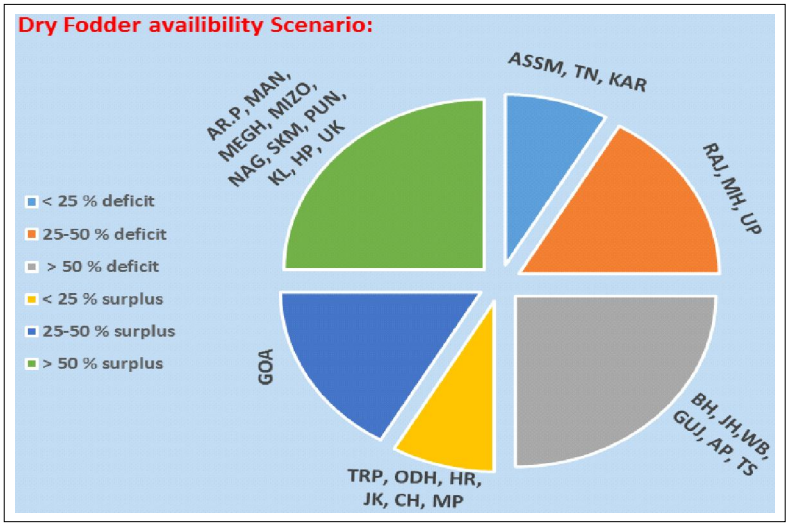

Fig 2: Scenario of dry fodder availability in India.

green and fodder availability in different states. This explains that more than 50 per cent of states are still lagging in the area and production of forage crops which might cause a drastic blow in near future to livestock feed.

Livestock feed from cereals and forage crops

Coarse grains play a significant part in the supply of animal feed and four primary cereals-corn, barley, sorghum and bajra-account for almost 44% of the total amount of cereals. Around 30 million tonnes per year are still produced of these grains. Maize makes up about three-fourths of all coarse grains, whereas barley makes up 15% (Agrawal *et al*., 2008). Sorghum and millets make up about 11% of the total. Less than 3% of the global production of these cereals, or 30 million tonnes, is produced in India each year. In affluent nations, the majority of coarse grains are primarily used as cow feed, while some grains, like barley, are also used in brewers. However, their primary use in India is for direct consumption, primarily by the underprivileged in rural areas. Numerous other millet varieties, such as Kodo millet, finger millet, little millet, foxtail millet, barnyard millet, proso millet and savan millet, are crucial for fodder. It is unnecessary to emphasise the importance of dietary grains, particularly coarse cereals, in giving animals a balanced diet to ensure increased productivity.

The tremendous increase in livestock population

According to the *indiastat* livestock survey over two decades, India's cattle population increased by 0.84 per cent during the last census (2010), from 190 million in 2010 to 192 million in 2020. And there are now 109.85 million buffaloes in the nation, up from 108.70 million in 2010. On the other side, the number of goats climbed by 9.1% since the last census, reaching 148 million. The limited land resources needed for the production of green fodder are stressed by the growing cattle population making it more tedious to get animals fed properly.

The area under fodder crops in India

Fodder crops are grown and harvested for use as animal feed in the forms of hay, silage and forage, which are all kept under anaerobic conditions (dehydrated green fodder). According to individual crop basis, there are 8.3 million acres of cultivated fodders. About 54 per cent of the entire area of farmed fodder crops is made up of sorghum (one of the *Kharif* crops) (2.6 million ha) and berseem (one of the *Rabi* crops). Similarly few major fodder crops taken up in India are depicted in Fig 3 with their respective areas. Together fodder area making up to 8.3 million hectares can nowhere be compared to the alone rice cropped area accounting for 48 million hectares in India. The present future is to be taken into account neglected crops having a vast area of research and studies gap in order to consider and meet the increasing livestock population (agristat).

Bottlenecks in fodder production

The production of forage crops has its constraints. An integrated approach needs to be used to properly address a number of issues relating to fodder breeding, genetic resources, plant protection strategies, forage quality, palatability and seed production (Halli *et al*., 2018). The following are some general limitations/constraints on feed crop production and improvement: Lack of dual-purpose varieties and the inability to obtain a sufficient amount of high-quality fodder seeds, the abscission of spikes after reaching maturity and the presence of a large number of sterile glumes, overlapping of vegetative and reproductive growth phases, uneven seed/pod setting, non-synchronous maturity and apomictic nature of most of the tropical forage crops that limit their genetic improvement.

The other important factor affecting production is the stress factor which negatively affects crops in the form of either abiotic (related to soil and environment) or biotic (weeds, diseases, insects and so on). But majorly accounted

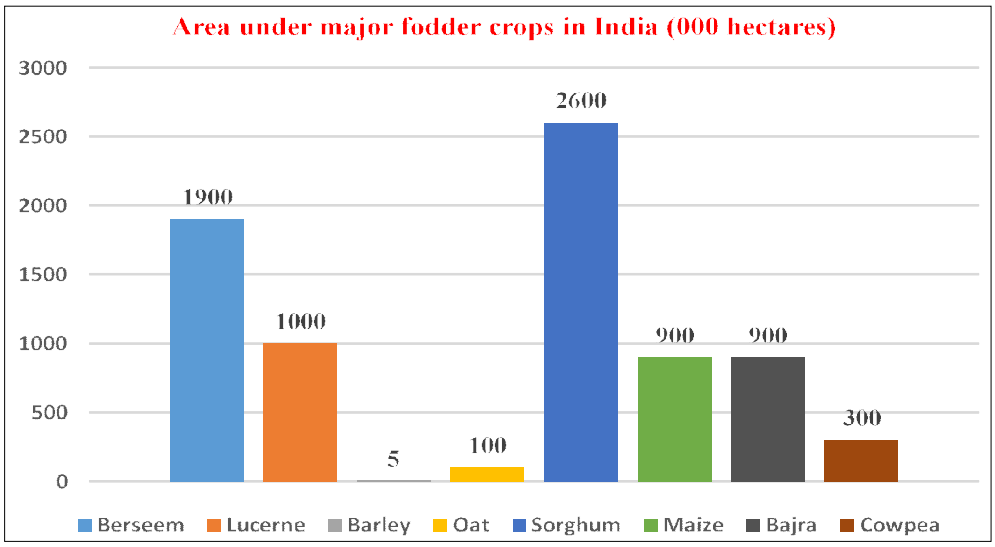

Fig 3: Area under fodder crops in India.

Table 1: Major Pests and diseases of forage crops.

Major forage crop	Major diseases	Major pests
Berseem	Stem rot	Hairy caterpillars, Semilooper, Pod borer, Red pumpkin beetle, Red cotton bug, Aphid, Stunt nematode
Oats	Leaf blotch, Crown rust, Stem rust, Powdery mildew	Aphid, Cyst nematode, Root-knot nematode, Stunt nematode
Lucerne	Downy mildew, Rust, Common leaf spot, Anthracnose, Crown wart, Leaf spot, Powdery mildew, Mosaic, Wilt, Crown and root rot, Damping off or Root rot	Leaf hoppers, Alfalfa weevil, Grey weevil, Alfalfa caterpillar, Tobacco caterpillar, Semilooper, clover cyst nematode
Cowpea	Anthracnose, Bacterial blight Root rot, Seedling rot, Cowpea mosaic virus, Powdery mildew	Leafhoppers, Flea beetle, Tobacco caterpillar, Semilooper, Aphid, Grasshoppers, Blister beetle
Bajra	Downy mildew, Ergot, Blast	Shoot fly, Stem borer
Guar	Leaf spot, Blight, Powdery mildew, Root rot, Anthracnose	Flea beetle, Leaf roller, Leafhoppers, Root-knot nematode, Reniform nematodes
White clover	Powdery mildew, Clover rot/crown and Stem rot	-
Sorghum	Anthracnose, Sooty stripe leaf spot, Downy mildew	Shoot fly, Stem borer Aphids, Sorghum midge, Armyworm, Sorghum cyst nematode
Maize	Brown stripe downy mildew, Turcicum leaf blight, Maydis leaf blight, Bacterial stalk rot	Shoot fly, Fall armyworm Stem borer, Aphids, Maize cyst nematode

Table 2: Varieties of major forage crops with their average yield potential.

Major crop	Variety	Fodder yield (tonnes/ha)
Berseem (*Trifolium alexandrinum*)	BL-1	95.0
	BL-10	102.5
	BL-22	70.0
	BL-2	42.2
	BL-42	110
	BL-180	62.5
Lucerne (*Medicago sativa*)	LLC-5	70.0
	LLC-3	78.0
Oats *(Avena sativa)*	Kent	52.5
	OL-9	57.5
	OL-125	50.0
	OL 10	68.0
Bajra (*Pennisetum glaucum*)	PCB-141	50.0
	PCB-16	52.5
	FBC-16	57.5
	PHBF-1	64.0
Cowpea (*Vigna unguiculata)*	CL-74	20.0
	Cowpea-88	25.0
	CL-367	27.0
	SL-44	60.0
	PSC 1	120.0
	PSC 4	97.5
Maize (*Zea mays*)	J-1006	40.0

by biotic stresses with varied durations of effect with various stresses (Tsao *et al*., 2003). Thus the major threats including pests and diseases affecting the production (Table 1) and productivity of various forages are addressed in Table 2.

The biggest drawback in the forage system is a regional imbalance of its availability. Since it is more expensive to transport fodder across large distances, regional deficits are more problematic than the national deficit. Varied regions of the nation have different deficit patterns. For instance, more than 60% of the actual need for green fodder is met in the Western Himalayan, Upper Gangetic Plains, Eastern Plateau and Hilly Zones (Hilli 2022). The availability of feed is between 40 and 60 per cent of what is needed in Trans Gangetic Plains and it is less than 40 per cent in the other zones. In the Middle Gangetic Plains, Upper Gangetic Plains, Eastern Himalayan, East Coast Plains and Hilly Zones, there is a greater than 60% availability of dry feed. The availability is between 40 and 60 per cent in the Trans Gangetic Plains, Eastern Plateau and Hills and Central Plateau and Hills, whereas it is less than 40 per cent in the remaining zones of the nation (Jitendra 2017).

Enhancing fodder productivity

One possible strategy for supplying the need for livestock fodder is to increase the productivity/yield of fodder crops per unit land area. As a soil-based production system that mines nutrients from the soil, forage cropping needs effective methods for reintroducing the minerals to the soil to maintain productivity (Palsaniya *et al*., 2008). Since the bulk of fodder crops are Poaceae and have high nutrient needs, proper nutrient management strategies should be given top priority in order to enhance forage production and maintain animal productivity. Therefore, the management of nutrients during the fodder-based cropping sequence is essential for increasing productivity and maintaining soil fertility. In recent years, it has become clear that integrated nutrient management (INM) is the best method for increasing system

productivity and sustainably preserving soil health (Antil and Raj, 2020; Babu *et al*., 2020; Antil *et al*., 2021; Yadav *et al*., 2007). In an integrated farming system involving crops and livestock, INM has no trouble finding organic manure. As a result, it can be used as a successful approach to increasing the productivity of the fodder (Yadav *et al*., 2007).

A significant issue in the nation is the year-round supply of green fodder. Continuous cultivation of rice-wheat degrades the health of the soil, ultimately leading to diminished production. As stated by several researchers (Banjara *et al*., 2021; Bohra *et al*., 2007, Kumar *et al*., 2018, Singh *et al*., 2019), diversification of wheat-paddy systems with fodder crops on a rotational basis can therefore be used as a technique to provide year-round fodder availability in India. Several workers have also stated that the traditional rice-wheat cropping methods need to be diversified (Bohra *et al*., 2007; Singh *et al*., 2019). Given that the majority of households (71 per cent) engage in crop + animal farming, the year-round supply of green fodder will be a benefit to farmers for enhancing their farm production and profitability. With its incredible ability to produce more biomass, Sudan grass is a suitable choice in the summer and wet seasons (Hazary *et al*., 2015; Yadav *et al*., 2007).

Berseem, multi-cut oats and dual-purpose barley are the available green fodder crops for the upcoming Rabi season (Kaur *et al*., 2018). As a perennial fodder crop, Napier grass (*Pennisetum purpureum Schumach*.), which grows quickly after being chopped, is an excellent choice (Negawo *et al*., 2017; Rusdy, 2016; Saxena *et al*., 2002). Crops can be chosen to assure year-round fodder availability depending on the area under fodder crops and the makeup of the crop + livestock integrated farming system. Due to its more effective resource use, the cropping system/rotation with fodder crops offers a potential solution to the fodder issue. It also provides a balanced diet to the animals, due to the inclusion of legume and cereal fodder crops together (Kadam *et al*., 2017).

Highlighting the forage value in oats alternatively to meet increasing fodder demand

Around 27 million hectares and 40 million tonnes of oats are produced worldwide, respectively. Russian Federation, the United States, Canada, Poland, China, France and Australia are nations that cultivate oats extensively. States that grow oats in India include Punjab, Haryana, Uttar Pradesh and a small portion of MP, Orissa, Bihar and West Bengal**.** Oats make for tasty cookies, good-quality grain for human meals and excellent cow feed. Seven haploids (14 chromosomes), fourteen haploids (28 chromosomes) and twenty-one haploids are three cultivable forms (42 chromosomes) (Hilli *et al*., 2021). Eighty per cent of the total oat area is covered by common oats (*Avena sativa*). Short oats, or *Avena brevis,* are grown in South Europe as green fodder. Oats suits to a wide range of soil with good water holding capacity but high N content in soil is not a desirable condition as it may lead to lodging (Hilli and Immadi, 2022; Hilli, 2021; Hilli and Immadi, 2021). It grows best in cool and moist climates which is important during grain filling for high yield. Oats are marginally more tolerant to salt than sorghum but significantly less tolerant than barley (*Hordeum vulgare* L.), wheat, or rye (Richards, 1954; Bresler *et al*., 1982). Oats are less susceptible to sodium than wheat or barley under non-saline circumstances, similar to rice (*Oryza sativa* L.) (Pearson, 1960).

Increasing the quantity of green fodder can be accomplished in several ways, including (1) expanding the area dedicated to the cultivation of feed crops, (2) raising already planted fodder crops by implementing better and by utilising novel cultivation techniques and increasing availability fodder crops in cropping systems on a rotational basis, (3) the use of high-quality seeds and planting materials for fodder crops and (4) fodder marginal land production, (5) hydroponic fodder production and (6) looking into alternative feed sources like Azolla (Bartl *et al*., 2007 and Contreras *et al*., 2019).

Nutritional value of oats as a fodder crop

Oats are strong in oleic and linoleic acids and contain a large amount of fat. It include vitamins B1, B2 and B6, as well as A, K and E. They also include beneficial minerals, vitamins, antioxidants and sterols. Compared to other cereals, oats have a higher beneficial fatty acid concentration. Oats contain 1%-3% more crude protein than barley (*Hordeum vulgare*) or maize (*Zea mays*). Also, when compared to the other cereals, oats have a balanced amino acid composition and a higher concentration of essential amino acids, such as lysine, making it one of the most preferred feed ingredients by livestock farmers. Dehulled oats and whole oats are the two forms in which it is available (Luis *et al*., 2020). Since dehulled or naked oats are suitable for chickens, horses, piglets and lactation cows due to their high energy content, they considerably increase feed value and palatability. Oats are the cereal with the highest fat content. The fat content of the kernels can range from 2% to 12%. 95 per cent of the fatty acids in oats are composed of palmitic, oleic and linoleic acids; myristic, stearic and linolenic acids are only present in trace amounts. Compared to wheat and barley, oats contain more oleic acid and less linolenic acid. Oats high-fat content boosts their energy level, which is a crucial component of horse diets. Oats reduce gastrointestinal discomfort and allergies in pet meals. Oats make your fur shine better, lessen diarrhoea and are excellent for preventing gluten absorption difficulties (Noli *et al*., 2004). Thus expanding knowledge among farm producers of the advantages of oats as a feed ingredient in the global animal feed ingredients market is credited with the rising demand for oats (Nair *et al*., 2018). Oats are increasingly in demand as a feed ingredient for a number of reasons, including their usage as a substitute for barley and wheat feed, their high nutritional value and the availability of both naked and whole oats. They lessen environmental greenhouse gas emissions as well.

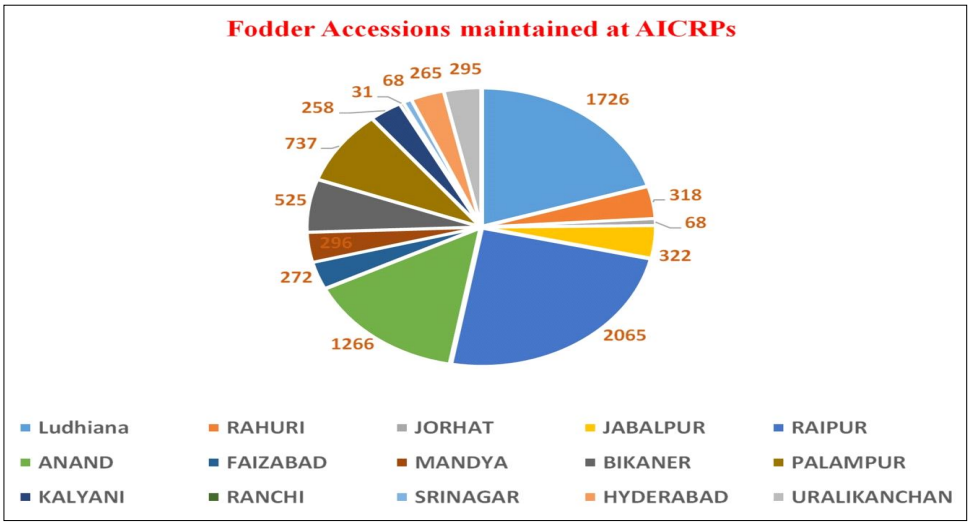

Fig 4: Accessions maintained by AICRPs in India.

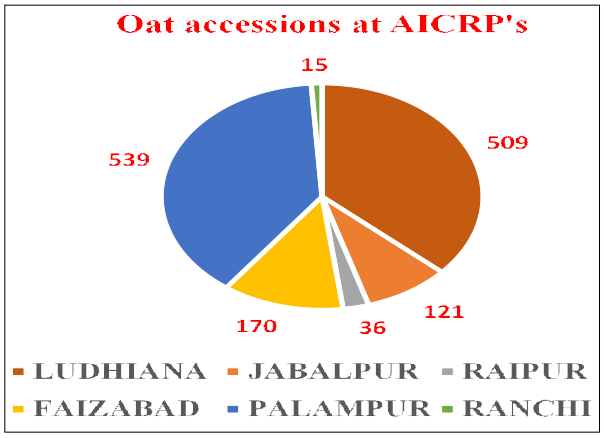

Fig 5: Oat accessions maintained by AICRPs in India.

Fodder accessions maintained at different All India Co-ordinated research projects (AICRP's) in India

Native grasses and legumes have a rich genetic diversity in the Indian gene centre. Graminae include 245 genera and 1,256 species, of which 139 species and around 21 genera are endemic. The value of Indian grasses as feed is thought to be one-third of the total. The Andropogoneae (30 per cent), Paniceae (15 per cent) and Eragrosteae tribes make up the majority of the grass species (9 per cent). Similar to this, 21 genera of the approximately 400 species in 60 genera of Leguminosae are said to be helpful as forage. Peninsular India (for tropical kinds) and the North-Eastern Region (for sub-tropical types) are the main centres of genetic diversity, along with a few micro-centres for specific species. Legumes like Vigna, Desmodium, Lablab, Macroptelium, Stylosanthes, Centrosema, grasses like Bothriochloa, Dichanthium, Panicum, Pennisetum, Cenchrus, Lasiurus, *etc*. and browse plants like Leucaena, Sesbania, Albizia, Bauhinia, Cassia, Grewia, etc. are some examples of major forage genera that exhibit for Along with many other genera, these are essential components of the nation's feed and fodder resources (Dagar *et al*., 2017). The nation also benefits from a long tradition of traditional knowledge regarding the cultivation, maintenance and utilisation of fodder, feed and animal resources. Several disciplines, including crop breeding, agronomy, genetics, nematology, entomology, pathology, physiology, biotechnology and animal nutrition, must work together over a lengthy period of time to develop forage crops. For the breeding programme, a full understanding of species relationships, chromosomal constitution, genomic structure, putative parentage, potential degree of gene exchange/recombination and polyploidy is also necessary. Depending on the issues that a given species of crop encounters, different crops have different strategies.

The present status of accessions available or maintained at different AICRP centres is depicted in the Fig 4 and 5. Among the 15 AICRP centres on forage crops, AICRP at Raipur maintains the maximum number of forage accessions with more than 2000 accessions, followed by Ludhiana with 1700 accessions on average and so on (Fig 4). Similarly, when it comes to oats accessions, Palampur and Ludhiana AICRP centre maximum of oat accessions as shown in Fig 5. Also when it comes to the varieties released, forage crops including oats cover a limited number when compared to other cereals, list of important forage and specifically oats varieties released by different centres to different climatic zones with their characteristics are shown in Table 1, Table 2, Table 3 and Table 4. Thus by comparing other cereals and oats or forage crop scenarios, it can be seen that the work has been done limited in later crops. This provides a new way for researchers to come up with modern and improved practices by increasing the production and productivity of such forages and oats in order to meet the present rising demand of livestock population (Census depicted in Fig 6).

Opportunities in fodder production

The value of the livestock sector's contribution to the Indian agriculture and allied sector's overall output, at current prices, is roughly 28.63 per cent. The cattle industry generated 4.19 per cent of GDP overall in the fiscal year 2018-19. (Anonymous, 2019). Over the past few decades, milk production has increased significantly, with India now producing more milk than the US (187.7 million tonnes in 2018-19; Economy Survey 2020-21, 2021). Given that our livestock productivity has remained among the lowest (Jitendra, 2017) of all major milk-producing nations, the increase in milk output has mostly been attributed to an increase in the population of cattle. While cows in Europe and the rest of the globe produce an average of 2238 and 4250 kg of milk every lactation, respectively, cows in India only produce an average of 1538 kg of milk per lactation

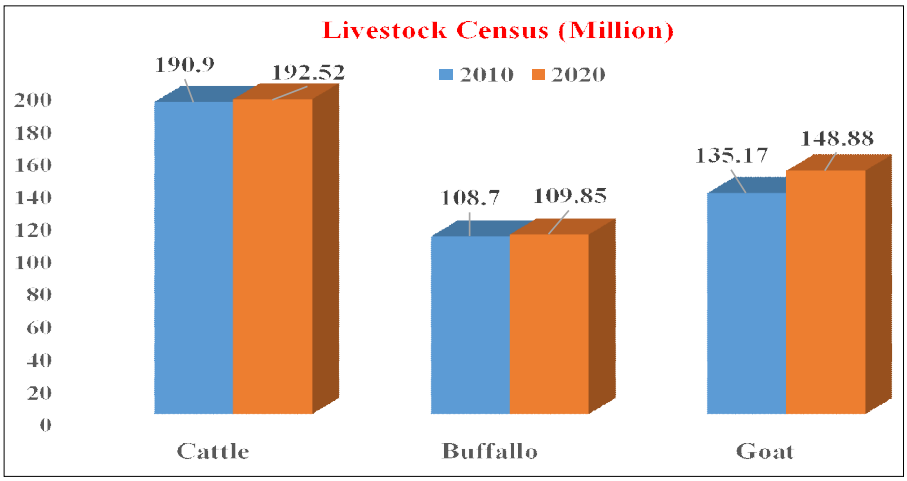

Fig 6: Livestock census of major animals between 2010 and 2020.

Table 3: Special features of certain oats varieties released in India.

Varieties	Characteristics
HFO-114	Early sowing, two cuts, good tillering, synchronous flowering, tall, resistant to lodging, tolerant to diseases
FOS 1/29	Single cut crop
KENT	Resistant to lodging and shattering
PLP-1	Profuse tillering and lodging resistant
UPO 94	Resistant to smut, rust and blight
OL-9	Leafy with profuse tillers and medium-sized seeds.
UPO 212	Seed shattering resistance
HJ-8	For two cuts, fast growth, broad and light green leaves, tolerant to diseases
OS-6	Early sowing, with two cuts, Early vigour, tall, broad leaves, light green colour, medium bold seeds, erect flag leaf at panicle emergence, tolerant to diseases
OS-7	For single cut, early vigour, tall, broad leaves and light green colour, medium bold seeds, Tolerant to diseases
JHO 851	High regeneration capacity
SABZAR	Profuse tillering, dual purpose
JHO -99-2	High quality and digestibility
JHO 2001-3	lodging resistant and shattering resistant
RO-19	Leaf spot resistant
JHO 2000-4	Wider adaptable
JHO 99-1	Resistance to aphids and grasshoppers
NDO-1	Highly palatable
JO-93-1	Resistant to blight, root rot, powdery mildew and root-knot nematode
SKO-90	Resistant to blight, root rot, powdery mildew and root-knot nematode
OS 346	For single-cut, Bold seeded, high per-day productivity, better nutritional quality, Highly resistant to leaf blight
JHO-2010-1	Mod resistant to blight and nematodes, high crude protein yield
OS 377	For single cut, better nutritional quality, bold seeded and good seed yielder, Moderately Resistant to leaf blight disease
OL 10	Leafy with profuse tillers

(IGFRI). Malnutrition or under nutrition brought on by a significant mismatch between the nation's demand and supply for feed and fodder is the primary cause of our livestock's low production (Prajapati *et al*., 2019). Dairy farmers have been feeding their cows an excessive amount of concentrates to sustain milk output due to a lack of green forage, especially during the summer months. In order to meet the nutritional needs of milch cows during the early lactation phase, feeding of concentrates is necessary, according to a 2018 study published in the Archives of Animal Nutrition.

In spite of the fact that concentrate feeding enhances milk output, it also causes rumen acidosis and other serious health issues in dairy cows. This method damages the liver by upsetting the equilibrium of the gut bacteria, which releases more toxins. To reduce these dangers, proper balancing of livestock feed is required. Forage is considered to be the most nutrient-dense and economical feed for dairy animals (Hilli *et al*. 2022; Kapoor *et al*. 2022; Iqbal *et al*. 2015). As a result, the availability of green fodder is essential for animal productivity and health, especially in the case of dairy operations where a reliable supply of green fodder is necessary for the long-term production of milk. Green fodder provides vitamins and minerals along with energy and improves digestion. The green revolution has expanded Indian agriculture, but the livestock industry has only been able to provide veterinary services and artificial insemination

Table 4: Zone-wise oats varieties in India released by various institutes.

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SABZAR	Profuse tillering, dual purpose
JHO -99-2	High quality and digestibility
JHO 2001-3	lodging resistant and shattering resistant
RO-19	Leaf spot resistant
JHO 2000-4	Wider adaptable
JHO 99-1	Resistance to aphids and grasshoppers
NDO-1	Highly palatable
JO-93-1	Resistant to blight, root rot, powdery mildew and root-knot nematode
SKO-90	Resistant to blight, root rot, powdery mildew and root-knot nematode
OS 346	For single-cut, Bold seeded, high per-day productivity, better nutritional quality, Highly resistant to leaf blight
JHO-2010-1	Mod resistant to blight and nematodes, high crude protein yield
OS 377	For single cut, better nutritional quality, bold seeded and good seed yielder, Moderately Resistant to leaf blight disease
OL 10	Leafy with profuse tillers

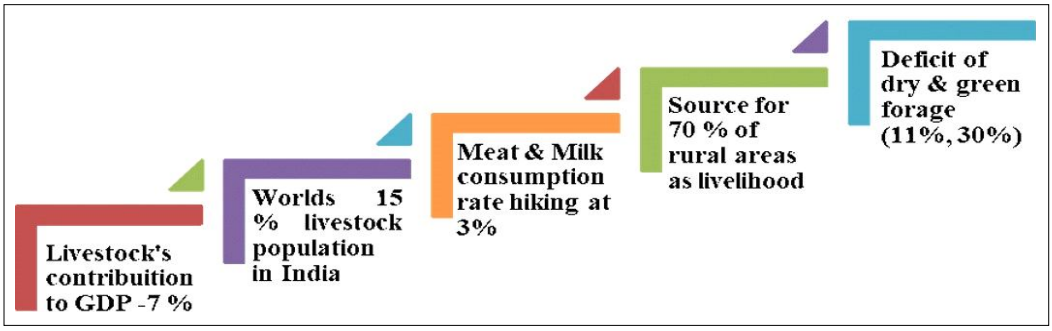

Fig 7: Increasing scope for forage production.

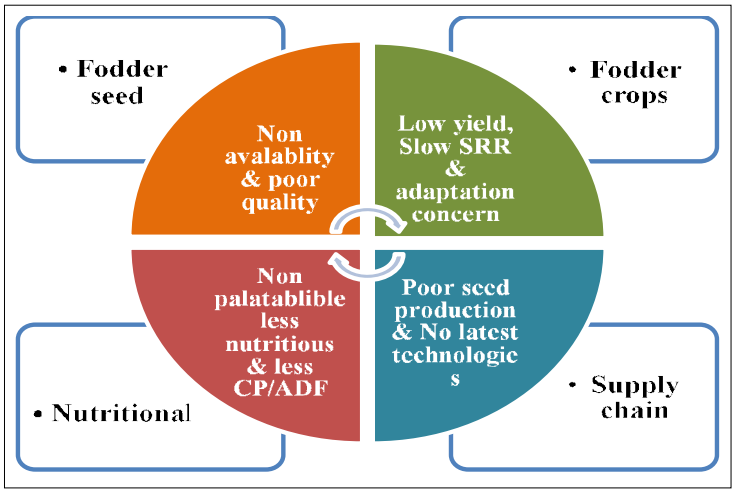

Fig 8: Major concerns in fodder production.

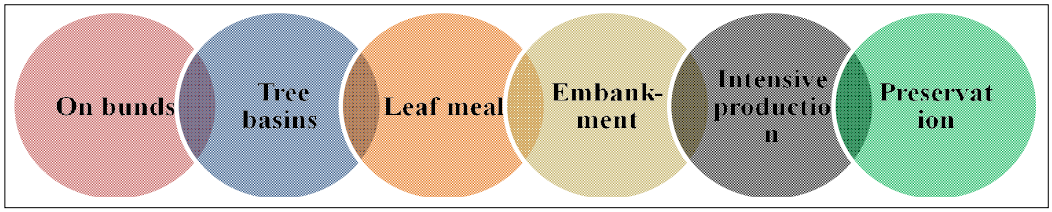

Fig 9: Fodder technologies practised in India.

(AI), remaining a supplementary activity. Forage resource development is a trickier problem than food and commercial crop production. Due to the non-commercial character of fodder crops, farmers are also not particularly interested in producing them. Degraded and marginal lands are typically used for forage production with minimal inputs of fertiliser, water, and human resources. Therefore, there is a big possibility for development in the livestock industry (Fig 7 shows scope of forage crops for livestock population, Fig 8 depicts concerns in Forage production and Fig 9 about the newer technologies that can be used) by boosting fodder production in India given the low productivity of farm animals and the enormous imbalance in demand and supply of green fodders.

CONCLUSION

Improving cattle and their productivity is necessary given the rising demand for animal products. Additional cropland acreage for fodder production is unlikely to be available under the current land use alternatives driven by the expanding human population. Thus the green forage supply situation has to grow at the rate of increasing human and livestock populations.

Conflict of interest: None.

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