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INTERNATIONAL YEAR OF MILLETS 2023

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IGFRI

# Policy Paper : 1

# Forage Technologies for Enhancing Milk Productivity, Farm Efficiency and Farmers' Income in Bundelkhand

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झाँसी–284 003 (उ.प्र.) भारत

ICAR-Indian Grassland and Fodder Research Institute
Jhansi-284 003 (U.P.) India

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# FOREWORD

India accounts for 536 million livestock population (20th livestock census, 2019) and 210 million tonnes of milk production (2020-21); as a result of this, country is at the top in both of these aspects worldwide; however, the condition of India is not so satisfactory in terms of animal productivity. The sub-optimal productivity of animal husbandry sector is due to the shortage of quality animal feed and lack of proper animal health care. The area under fodder production in India is stagnated at 5% of the gross cropped area for the last four decades. The area (varying from 3.7 to 12% of total area) under natural grasslands/ pastures/common property resources are also on decline. Therefore, significant expansion of area under forage crops and scientific knowledge on fodder production, conservation and utilization technologies under different situations viz. rainfed, irrigated, problem soils, fodder conservation and utilization practices need to be disseminated at grassroots level. Besides, breed improvement programs and proper health care measures are also important for realization of potential animal productivity. Need based technological development and its effective extension at farmer's field is essential for successful bringing desirable changes in animal productivity and profitability.

ICAR-IGFRI, Jhansi; ICAR-CAFRI, Jhansi and ICRISAT, Hyderabad collaborative project 'Kisan Mitra Project for Doubling Farmers Income in Bundelkhand Region' has been a very successful project which intervened many well promised forage technologies in the existing agriculture and livestock system of Jhansi, Lalitpur and Jalaun districts of Bundelkhand, Uttar Pradseh. The linkage and amalgamation of different fodder production, conservation and utilization technologies with other agro-technologies of resource conservation and productivity enhancement has enabled the agro-ecosystem to perform in better and sustainable way. Improved forage technology intervention through the project has witnessed various desirable changes which include improvement in livestock productivity, optimum animal health and fertility status owing to balance nutrition and proper health care.

This policy paper on "Forage Technologies for Enhancing Milk Productivity, Farm Efficiency and Farmers' Income in Bundelkhand " is having the compilation of activities, results and outcome from the project 'Kisan Mitra Project for Doubling Farmers Income in Bundelkhand Region'. I am delighted that this booklet will not only reveal valuable information on success of forage and livestock technology intervention but also sensitize the issue of fodder production, conservation and utilization in more scientific ways for enhancing animal productivity and ensuring livestock nutritional security among the stakeholders of the institute.

**(Amaresh Chandra)**
**Director**

# PREFACE

Meeting the fodder demand and nutritional security under the existing resource base for ever increasing livestock population, which play a vital and catalytic role in livelihood and income of farmers, is an urgent need for the nation. Fodder production, conservation and efficient utilization in any way are of major importance for improving the productivity of animals and profitability of animal husbandry.

ICAR-IGFRI, Jhansi is such an Institute of national importance which undertaking development of efficient and successful technologies of fodder production, conservation and utilization which are helping the farmers to enhance the productivity and profitability of their livestock activity. ICAR-IGFRI, Jhansi in collaboration with ICAR-CAFRI, Jhansi and ICRISAT, Hyderabad has implemented a project 'Kisan Mitra Project for Doubling Farmers Income in Bundelkhand Region' in different villages of Jhansi, Lalitpur and Jalaun districts of Bundelkhand, Uttar Pradesh. Under this project, various crop based forage technologies such as fodder based crop diversification with new fodder crops (fodder oat, cowpea, guar), improved varieties of fodder crops, perennial grass (BN Hybrid) based round the year fodder production, non-traditional fodder sources (cactus, azolla) etc. have been intervened under improved and scientific package of practices. Besides, green fodder based ration balancing, mineral mixture supplementation; deworming and general health care interventions have been introduced as livestock based activities. For the efficient conservation of green fodder, silage technology has also been demonstrated. Apart from technology demonstration at field, capacity building programs have also been organized in the Institute for the capacity building of the farmers.

This policy paper on "Forage Technologies for Enhancing Milk Productivity, Farm Efficiency and Farmers' Income in Bundelkhand " is a masterpiece of compilation having information on the activities, results and impact of technologies intervened under the project in Bundelkhand region of Uttar Pradesh. The authors of this booklet are hopeful that the information contained in the booklet will be useful to the farmers and entrepreneurs engaged in animal husbandry sector.

**Authors**

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The compilation and publication of this policy paper on “Forage Technologies for Enhancing Milk Productivity, Farm Efficiency and Farmers' Income in Bundelkhand” has been possible with the sincere efforts and hard work of the members of the project and other concerned staff of the Institute. The authors of this bulletin are foremost expressing profound gratitude to the Dr. Amaresh Chandra, Director, ICAR-IGFRI, Jhansi for providing encouragement and guidance in compiling the bulletin. We are thankful to the members of the project including the scientists, technicals, Nitesh Kumar, Rajeev Gupta and Vijay Kant, SRF's and field staff which worked dedicative to bring desirable impact from the project which enabled the compilation of this informative and useful bulletin. Finally, and importantly, we would like to sincerely thank the members of publishing committee for providing timely inputs in publishing this bulletin.

**Authors**

# CONTENTS

# INTRODUCTION

The Indian livestock sector is on a rising spree with its annual record growth rate of above 8 per cent during 2014-15 to 2019-20 (at constant price). The sector, which contributed above 29 per cent to the agricultural and allied gross domestic product (Ag GDP) in 2019-20 (Economic survey, 2021-22), has established its vital role in cushioning agricultural growth and providing employment to over 20 million people, particularly to women folk, in principal or subsidiary status. Livestock is important in ensuring food and nutrition security and for providing promising livelihood option for poor households. The sector not only triggers equal distribution of income among farm households, but also is the best insurance against the vagaries of nature like drought, famine and other natural calamities (Saxena *et al.,* 2017; Choudhary and Singh 2019 ).

The livestock sector is both expanding and adapting in response to economic, technological, and environmental factors. Our country possesses the largest livestock population (over 535 million) in the world and the biggest flock of cattle and buffaloes (30.5% and 57.9% of the world population, respectively). However, productivity potential of our livestock is very low than the global average. To compensate low productivity farmers generally maintain more number of animals and hence, livestock production in our country is the best example for "production by masses rather than mass production."

Animal production systems in India are mostly based on low cost inputs drawn from crop residues and agro-by products, causing nutritional deprivation of the animals and thus impeding their productivity potential. Green fodder deficit, especially during the dry season has been widely recognized as one of the major factors for low animal productivity in the country (Sharma *et al.*, 2021). In India, land allocation to cultivation of green fodder crops is limited and has hardly ever exceeded 5 per cent of the gross cropped area. Therefore, the supply of feed and fodder has always remained short of normative requirement (Satyapriya *et al.* 2012), restricting realization of the true production potential of livestock. Fodder scarcity makes animal production system uneconomical and unattractive as an income generation activity among the poor farmers of the country.

Presently, the country faces a net deficit of 11.24% green fodder, 23.4% dry crop residues and 28.9% concentrate feed ingredients (Roy *et al.*, 2019). The scenario is more unnerving in 15 Indian states where the deficit is above 25%. With burgeoning livestock population and government focus on genetic upgradation of cattle by cross-breeding programmes, the demand-supply gap of green fodder will widen considerably, in absence of appropriate policy planning and its grass root level implementation.

Nonetheless, there exist regional and seasonal disparity in fodder production and availability, most of the deficient regions lie in the arid and semi-arid agroecological regions across the country. Seasonal inconsistency in forage availability accentuates the cost of feed there by menacing the sustainability of the livestock sector (Gachuiri *et al.* 2017). Moreover, seasonal scarcity of forages puts additional pressure on common property resources, particularly in the arid and semi-arid tropics; and has always added to the drudgery of farm households especially women in terms of time and energy spent for fodder collection (Dhyani *et al.* 2013). Therefore, ensuring quality and reliable availability of year-round fodder is prerequisite for enhancing productivity and economizing livestock production system in a country like India where around 80% of the livestock are with marginal and small holdings farmers.

During workshop on Agricultural development issues of Central Plateau & Hill region held on 30/11/2015 at ICAR-IGFRI Jhansi, farmers, scientists and development officers raised the following points as the matter of concern regarding livestock and social development.

- Need for focus on supplementary small enterprises like beekeeping, backyard poultry, small dairy units which may add to farmer's income and may be the insurance against natural calamities.
- Systematic promotion of fodder cultivation.
- Capacity building of farmers for production and marketing of value added products from fruits, traditional cereals and pulses.
- Strengthening the village level milk collection & processing centers.
- Bundelkhand has very large population of indigenous and very poor yielding cattle. The average yield of these cattle ranges from as paltry as 0.5 kg to 1.5 kg per cattle per day.
- The cattle holding are usually 4-10 adult bovine/household in the region. As the stall feeding cost is very high for such a large yet poor productive herd, farmer usually resort to make them free for grazing during rainy and summer seasons.
- Therefore, the large bovine population in the region needs to be considered as the opportunity and systematic breed improvement programme through upgrading and cross breeding on selective basis may be implemented.
- State Government sponsored Artificial Insemination (AI) centers are running non-functional in the region and there is tremendous load on private agencies like BAIF.

- The issue of developing rural youth as paravets was also realized.
- Timely and seasonal vaccination of livestock and castration of stray bulls are other critical issues in effective livestock management in the region.
- Small livestock like goat rearing and backyard poultry are another income generating options for the farmers of the region. Local Bundelkhandi breed of goat need to be systematically improved and popularized instead of other breeds which cannot adapt to the existing climate of the region.
- There is need to develop goshalas for holding back the stray animals and utilizing there byproducts (dung & urine) for crop production purpose.
- During off seasons, agriculture related employment may be created through the works of processing and making value added products from farm produces.
- Anna-pratha has become a serious problem for the farmers which are created by farmers themselves. In this pratha, most of the farmers leave their animals stray during rainy and summer seasons. As a result, farmers are not able to cultivate crops during these seasons.
- Necessary awareness camps, imposition of penalty by district administrations, turning the large unproductive animal herd to small and productive herd size, barbed wire fencing of crops, *etc.* are some of the potential intervention to mitigate the menace of this system also came during the course of discussion.

Improved animal husbandry practices have also played a major role in raising standards of living of rural population by providing self employment to households, besides providing nutritious food. In Bundelkhand, the animals are reared as insurance against crop failure due to low productivity of soils and unreliable rains. The drought generally occurs once in four year. Thus both frequency and severity of drought are high and create even drinking water crisis. In such situation, the disadvantaged groups such as farmers suffer most resulting in large scale migration. Animals are reared for milk, manure, draft and as wealth. Under dry land rain-fed conditions of Bundelkhand, mixed farming in which livestock are important component can sustain better. Such mixed farming would ensure round the year income, judicious use of resources, enhance soil organic matter and complete utilization of waste. In addition livestock based mixed farming will improve carbon sequestration and promote climate resilient agriculture. Several studies have recommended specialized dairy farming (SDF) or mixed farming over arable farming. The advantage can be summarized in an English proverb "A good farmer is one who diversifies, one who does not put all his eggs in one basket, one who rotates his crop."

About 2% land is spared for cultivated fodder (excluding sorghum and maize) thus the animals almost dependent on crop residues, which are in deficit resulting in free range grazing (Annapratha) of forest areas, on wastelands or the residues, which remains in the field after the harvesting of crops. The DMI was less than requirement of 6 to 8 kg (ICAR, 1985) in FRG system. The proposed interventions will help to reduce such problems.

The non-descript breed of cattle is poor yielder. Among buffalo breeds in Bundelkhand, Bhadawari along with some Murrah animals, are found. The crossbreds are very less in Bundelkhand. The problem of delayed conception, anoestrus, silent estrus and repeat breeding are very common in the animals especially in buffaloes mainly due to mineral deficiency.

Livestock provides food security through supply of milk, meat and self-employment and also plays an important role for poverty alleviation of smallholder livestock farmers. The livestock production system is low input - low output system. To make it more productive, there is need to enhance feed resources to meet the demand of increasing number of livestock. The transfer the potential technologies developed by various research organization to farmer's field can help to increase the production and reduce cost of milk production.

There are several reasons, which can be attributed to average low milk production by the Indian cattle and buffaloes. However, inadequate nutrition is the single largest factor responsible for poor milk production in animals in well-defined breeds. Several source indicated that there is deficiency of concentrate feeds, green fodder and dry fodder in the country due to which animals do not get adequate nutrients for expression of their genetic \potential for milk production. Efforts to increase feed resources during the last six decades have been offset by the bovine population increasing at an annual rate of 1.5 percent. Therefore, availability of feeds to the livestock remained unchanged during this period.

Feeding systems are primarily based on grazing of animals on native pastures of low productivity, which are steadily deteriorating in condition. Ruminants receive part or most of the feed requirements through grazing on natural grasslands in summer and rainy season. Large ruminants receive about 50-60 percent of dry matter requirement from crop residues (straw, stovers). This is supplemented with small quantity of grass, available through scanty grazing or cut and offered grass to animals. No concentrate is given to the growing, working, pregnant or dry animals. Only lactating animals are given better feeding through supplementation of by-product, concentrates (oilcake, brans, *Chunnies, etc.*), since the farmers receive immediate returns on this investment. Feeding systems in India are, therefore, based on straws/ stovers, little green and by-product concentrate.

In Jhansi district of Bundelkhand, regarding adoption of improved animal feeding, 73.5 per cent farmers were under medium category (29.62- 48.89%), followed by high adoption, having score more than 48.89 per cent (15.5 %) and low adoption, having score less than 29.61 per cent (11%). Even the adoption of low cost feeding technologies was less. In semi-arid, Jhansi district, in case of heavy and moderate activities the contribution of female farmers was higher than others *i.e.* 36.14 percent and 38.50 percent. Only in case of light type of activities male farmers were contributing more (38.5%). Regarding the participation of male and females farmers in decision making process, about half of the decisions were taken jointly by male and female farmers (49.21%), which should be encouraged.

The promotion of dairying and fodder among villages can be one of the viable options to address this problem. Policy makers conclude that livestock are an important component of the livelihood strategies of the rural poor in developing countries, and that a livelihood based approach to livestock development is more likely to have an impact on poverty than approaches that focus on increasing national food supplies and/or raising livestock GDP. The main focus of action component will be on low cost feeding strategy, breed improvement, increasing reproductive efficiency, increased lactation period, growth optimisation in goats, disease control, and sustainable input – output delivery system and developing “Dairy and Fodder Entrepreneurs” by capacity building and providing critical inputs. For rural based people self employment in dairying or goat production is most suitable.

In Bundelkhand, agriculture is mainly rain fed and mono cropping (either *Kharif* or *Rabi* crops) is practiced and have low return from the agricultural land due to recurring drought. Double cropping along with relevant interventions can help in reducing practice of Annapratha, enhanced food and livestock production which will bring desirable change in food and nutritional improvement at household level. The technological options include water harvesting and integrating crop & dairy and other remunerative practices like growing fodder in degraded lands and caring for grazing lands, vegetable growing, vermicompost, azolla, health care etc. will diversify the production, reduce the risk and stop migration.

The animal husbandry in Bundelkhand region is subsistence type and characterized by low productivity and profitability and high risk and result in insecurity of livelihoods and large-scale migration of the local population. In Bundelkhand not only availability of private pasture land is less but also the community land is fast shrinking due to land patta system. The fodder requirement as per calculation is very high (249.52 lakh tonnes), and the forest in can meet only 10% of the requirement, thereby a net deficit of 37%. Frequent drought in these region also make the situation worse as traditional drought coping mechanisms have under gone transformations due to technological changes with higher risks. The climate related challenges has led to farming uneconomic and unsustainable for livelihood of people. A shift from monocrops to double crop will enhance food- fodder security, prolonged fodder availability and making agriculture remunerative. With soil & water resource conservation measures & crop diversification, the whole production system will turn in to a energy saving, eco-friendly & sustainable production system in long run.

A brief reconnaissance of the area and interaction with the livestock farmers revealed following specific problems in the Bundelkhand region.

1. Limited livelihood options
2. Scarcity of green forage
3. Roughage (crop by-products) oriented milk production
4. Low milk yield of animals
5. Low genetic potential of lactating herd.
6. Severe mineral deficiency
7. High internal and external parasitic load
8. Lower return on milk yield
9. Free range grazing
10. Defects in input and output delivery system

Effective transfer of farm innovations and their practical application to the field situation is the key to the economic development of India. Extension service in the country has a huge network of professional extension workers at national, state, district, block and village level. Several programmes which are helping the farmers in adoption of new technologies are in operation throughout the country, still exists a wide gap between technology available with the researchers and its' adoption at farmers' field particularly in livestock feeding

Various efforts had been made by ICAR-Indian Grassland and Fodder Research Institute (IGFRI), Jhansi and other agencies to enhance the uptake of fodder technology among resource-poor smallholder farmers and to explore appropriate approaches to disseminate information on fodder technology to farming communities. Still, there is a critical technology gap regarding acceptance and potential adoptability of fodder technology especially by smallholder farmers. This technology gap of fodder production can be reduced by focused efforts with a sound strategy by a multidisciplinary team of scientist for scaling up of fodder technology at farmers field.

Keeping in mind the above discussed issues, KISAN MITrA (Knowledge-based Integrated Sustainable Agriculture Network Mission India for Transforming Agriculture) project, funded by government of Uttar Pradesh State (India), was started in the Bundelkhand region of Central India in the year 2017 by ICAR-Indian Grassland and Fodder Research Institute (IGFRI), Jhansi in consortia with ICRISAT Development Center (IDC) Hyderabad and ICAR-Central Agroforestry Research Institute (CAFRI), Jhansi and NGO partners. The targeted objectives for forage resource enhancement were: to demonstrate fodder production technologies for enhancing fodder availability round the year, demonstrating fodder conservation and its utilization techniques for enhancing livestock productivity, to establish participatory fodder seed production mechanism to develop entrepreneurship and capacity building and socio-economic impact analysis of fodder technologies.

# PROJECT AREA AND ACTIVITIES

Bundelkhand is an important region of Uttar Pradesh which comprises seven districts namely Jhansi, Jalaun, Hamirpur, Mahoba, Banda, Lalitpur and Chitrakoot. This region supports around 11.03 million of population (estimated census, 2020) in about 29, 41,800 ha of total geographical area out of which, about 20.5 lakh ha is net sown area. Bundelkhand region in central India is a hotspot of poverty, poor agriculture and livestock productivity. The region is characterized by a harsh climate, with temperatures reaching 47 ºC in May and June and annual rainfall ranging from 600-800 mm, with large temporal and spatial variability. The rainfall in Bundelkhand is mainly derived from S-W Monsoon. The monsoon arrives around 2nd to 3rd week of June and withdraws in around 4th week of September. The average of 10 years (2010-2020) of rainfall data reveals the variation in average annual rainfall of Bundelkhand districts of UP -Lalitpur (835 mm), Jhansi (619), Jalaun (579), Chitrakoot (817), Mahoba (592), Hamirpur (621) and Banda (713). The overall average of the average rainfall of all these districts indicates the average annual rainfall of 682 mm for whole Uttar Pradesh part of Bundelkhand. *Kharif*, *rabi* and summer seasons receives 88, 8 and 4% rainfall, respectively (Singh *et al.* 2002, Dev *et al.*, 2020; Garg *et al.*, 2020; Gupta *et al.*, 2014).

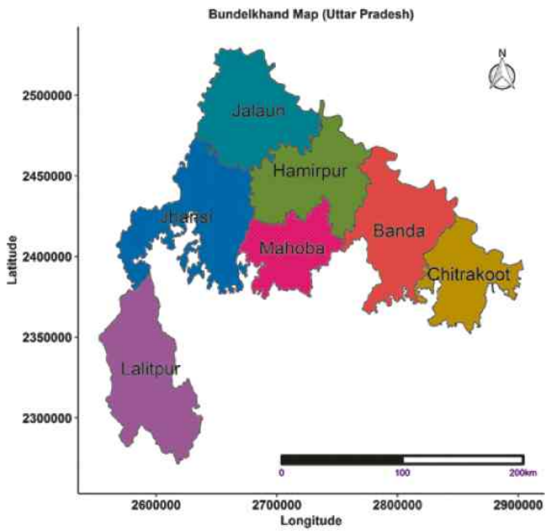

**Fig. 1: Bundelkhand region of India**

The soils of Bundelkhand can be divided into two broad groups, (1) red and (2) black soils. Four soil associations have been recognized in the area which includes (i) coarse grained-reddish brown soils, (ii) coarse grained-grey to greyish brown soils, (iii) clay loam black soils and (iv) fine clayey black soils. Locally these soils are termed as *rakar, parua, kabar* and *mar*, respectively (Kumar *et al.* 2021).

Major source of fresh water in Bundelkhand is available in the form of surface runoff and ground water. Total available surface plus ground water in Bundelkhand is 13692.91 MCM. Out of 29, 41,800 ha of total geographical area of Bundelkhand, 20, 57,967 ha (69.96%) is net sown and 13,70,662 ha (46.59%) is net irrigated area (http://planning.up.nic.in). The major sources of irrigation are canal (34%), private tubewells (28.5%), wells (23%), ponds (7.4%), and Govt. tubewells (4.3%).

Major crops of Bundelkhand are wheat, sorghum, pearl millet, minor millets among cereal; pigeonpea, mung, urd, chickpea, lentil, pea among pulses; groundnut, sesame, mustard, linseed among oilseeds; brinjal, potato, tomato, cole crops, radish among vegetables; aonla, mango, citrus, bael, jackfruit among fruits (Kumar *et al.* 2021). The agriculture of Bundelkhand is mainly based on livestock based production system where animal husbandry forms an integral component along with food, fruit and vegetable crops. Livestock-based mixed farming is common adaptive strategies against climate related risk on crop in Bundelkhand. Among livestock components, dairy production and goat farming are important for the entire region. By and large even the landless and small farmers maintain at least one cow/ buffalo or few goats as an ensured source of income and asset.

Project activities for promotion of improved fodder technologies under the "KISAN MITrA" were carried out in the 9 villages of three districts of Bundelkhand *viz*. Jhansi, Lalitpur and Jalaun (Table 1) from June, 2019 to March, 2022. Agro ecological features of these districts are presented in Table 1.

**Table 1. Agro ecological characteristics of project districts**

| S.No. | District | Latitude & Longitude | General physio-graphy | Soil types | Area (ha.) | Av. rainfall (mm) | *Kharif* crops | *Rabi* crops |
|---|---|---|---|---|---|---|---|---|
| 1. | Lalitpur | 24° 22' N (Lat), 78° 28' E (Long) | Undulated plains of black soil. Most area drained by rivers. In some area red soil tract are present. | Rakar, Parua, Mar, Kabar | 5,09,400 | 881 | Maize, urd, mung, sorghum, paddy, soybean and groundnut | Wheat, barley, pea, lentil, mustard and linseed |
| 2. | Jhansi | 25° 44' N (Lat), 79° 25' E (Long) | North eastern plains and South West Hilly Terrains | Mar, Mar, Kabar, Parua and Rakar | 5,02,400 | 848 | Urd, mung, groundnut, sesame, and sorghum | Wheat, barley, chickpea, potato, mustard and lentil |
| 3. | Jalaun | 26° 08' N (Lat), 79° 23' E (Long) | Ravinous, upland and center plain soils | Rakar, Parwa, Kabar and Mar | 4,54,400 | 862 | Urd, mung, sesame, sorghum, pearl millet, paddy | Wheat, pea, mustard, chickpea, barley, lentil |

**Source**: Tewari *et. al.*, 2018

**Table 2: Selected districts and villages for fodder based activities**

| S.N | District | Villages |
|---|---|---|
| 1 | Jhansi | Rajapur, Amarpur, Emaliya |
| 2 | Lalitpur | Birdha, Pura Birdha, Jhawar |
| 3 | Jalaun | Sadhara, Noorpur, Nasirpur |

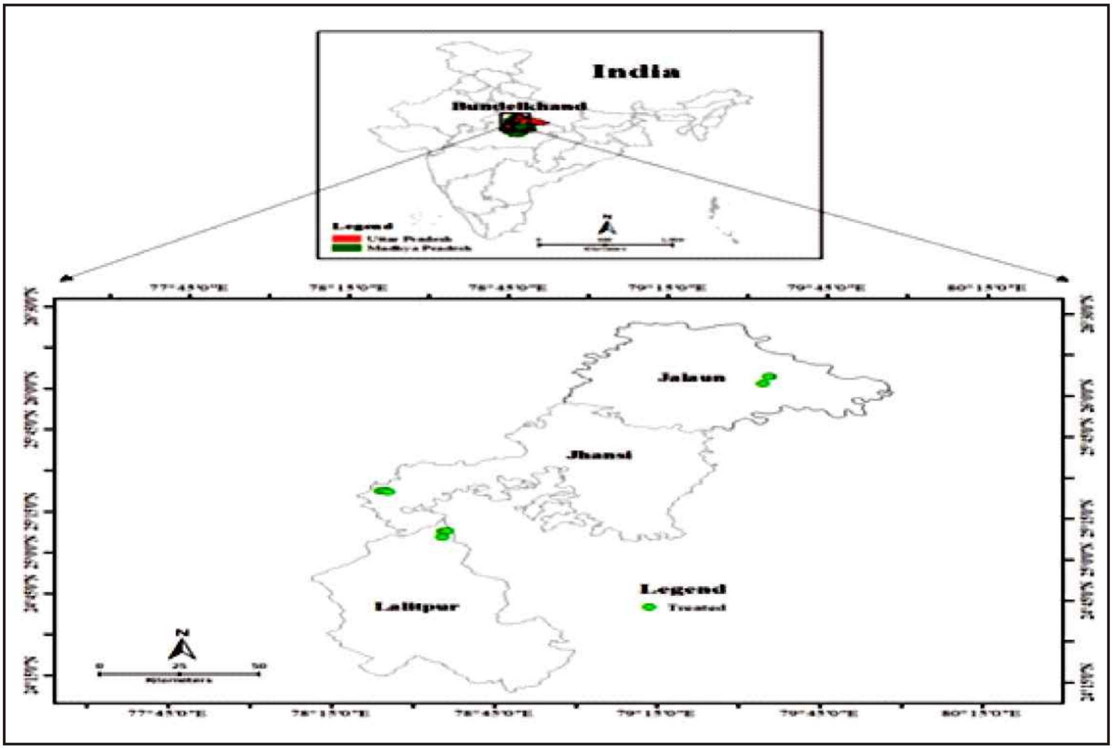


**Fig. 2: Location map of study area delineating treated and control villages**

## 2.1 Farmer-Scientist Interaction

Farmer-Scientist Interaction meetings have been an important way of transferring the technical knowledge and recording the feedback upon adoption of the technologies. Regular interaction meeting with the project clientele also helped in proper monitoring, evaluation and mid-term correction in technical interventions. A total of 38 (15-Jhansi, 12-Lalitpur and 11-Jalaun) on-site farmer-scientist interaction meetings have been conducted in different villages of the project. Besides, farmers of project villages have joined the weekly virtual farmer-scientist interaction meetings of the ICAR-IGFRI, Jhansi where more than 40 farmers connected weekly in the virtual meetings and interacted with the team of multi-disciplinary experts and resolved their queries related with all aspects of agriculture, natural resources management and livestock production management.

## Benefits of farmer-scientist interaction meetings

- Farmer-scientist interaction meetings provided first hand information on livestock/dairy production and feeding practices by the farmers. Such information reveals the animal production systems in the villages which were mostly based on low cost inputs drawn from crop residues and agro-by products, causing nutritional deprivation of the animals and thus impeding their productivity potential.
- As a solution to technical backwardness, farmers were then informed about various green fodders and perennial fodder crops suitable to their livestock and its potential benefits in terms of milk yield.
- All the aspects of forage production, conservation and utilization have been addressed in easy and farmers friendly way where expert scientist teams visited and conducted field days where exposure of technologies was given to the farmers by following 'learning by seeing' principle.
- From the interaction meetings, farmers understand the flaws in their traditional practice and thus, get convinced with the advantages of adopting the improved variety/technology.
- Doorstep service to the farmers by experts through providing solution to their problems related with agriculture and livestock.
- Technological implementation and real time monitoring, evaluation and feedback of adopting the new technology
- Motivation, encouragement and interest development in the adoption of new technologies.
- In case of inability to visit physically, the farmers and scientist interacted with each other through virtual platform which helped in achieving the targets of activities especially during the period of Covid pandemic.
- Farmers got motivated to actively participate in various fodder based training programs conducted by the ICAR-IGFRI, Jhansi, KVKs, NGOs and other state departments in the nearby vicinity to improve their livestock productivity and livelihood in the long run.

**Fig. 3: Interaction meetings at Noorpur, Naseerpur and Sadhara villages of Jalaun villages**

**Fig. 4: Interaction meetings at Birdha, Pura Birdha, Jhawar villages of Lalitpur**

**Fig. 5: Interaction meetings at Rajapur, Amarpur, Emaliya villages of Jhansi**


**Fig. 6: Virtual weekly farmers-scientist interaction meetings in zoom platform of ICAR-IGFRI, Jhansi**

## 2.2 Green Fodder-based Interventions

### Sorghum

Bundelkhand is having hot and semi-humid climate. In Bundelkhand region, sorghum is an major *kharif* and summer season fodder crop as it grows well under diverse soil and rainfall conditions. However, fodder productivity from sorghum crop is sub-optimal in the region owing to lack of scientific knowledge on package of practices. Therefore, improved fodder sorghum production technologies have been implemented in project. Cultivars (CSH-24 and PC-6) have been selected and 33.6 quintal seed of these varieties was distributed among the farmers. A total of 575 crop demonstrations of improved package of practices on sorghum were conducted covering 95.75 hectares area (Table 3). Findings of crop cutting experiment on sorghum revealed that, with the intervention of improved package of practices in sorghum crop, green fodder production was enhanced from 455 q/ha (farmers practice) to 568 q/ha (improved practice) during *kharif* season and 450 q/ha (farmers practice) to 545 q/ha (improved practice) during *zaid* season which indicates 19.8% improvement during *kharif* and 17.5% improvement during *zaid* season (Table 3). The adoption of multicut variety (CSH 24 MF) incurred some additional cost since it requires more labor and other resources for its long duration management owing to multi cut nature. The additional cost incurred under improved practice over the farmers practice was 12.7 and 8.7% during *kharif* and *zaid* season crop, respectively. Enhancement in green biomass production in sorghum was due to the introduction of improved multicut variety which enabled for extra number of cuts, quality treated seed free from any type of pathogens, good agronomic practices involving water, nutrient and weed management were other factors which resulted in better green biomass recovery. The extent of the distribution of different fodder crops seed (q) and root slips (no.) in the project villages is presented in Table 4.

**Table 3: Fodder sorghum production under farmers vs. improved practice**

| Practice | *Kharif* Sorghum (Variety- CSH 24) | | *Zaid* Sorghum (Variety- CSH 24) | |
|---|---|---|---|---|
| | Production (q/ha) | CoC (?/ha) | Production (q/ha) | CoC (?/ha) |
| Improved practice | 56.8 | 36660 | 54.5 | 42039 |
| Farmers practice | 45.5 | 32000 | 45.0 | 38400 |
| Impact (%) | 19.8 | 12.7 | 17.5 | 8.7 |

**Table 4: Fodder crops seed (q) and root slips (no.) distribution in the project villages**

| District | Sorghum | | | Cow-pea | Guar | BNH (no.) | Berseem | | | Oat | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2019 | 2020 | 2021 | 2020 | 2020 | 2020-21 | 2020 | 2021 | 2022 | 2020 | 2021 | 2022 |
| Jhansi | 4.7 | 7.4 | 0.70 | 0.5 | 0.5 | 21000 | 2.3 | 0.2 | 0.25 | 2.1 | 4.0 | 2.8 |
| Lalitpur | 0.65 | 7.0 | 0.80 | 0.5 | 0.5 | 20000 | 2.4 | 0.2 | 0.35 | 2.0 | 4.0 | 2.8 |
| Jalaun | 5.0 | 6.4 | 1.0 | 0.5 | 0.5 | 21000 | 2.3 | 0.2 | 0.25 | 2.9 | 4.0 | 3.8 |
| Total | 10.3 | 20.8 | 2.5 | 1.5 | 1.5 | 62000 | 7.0 | 0.6 | 0.85 | 7.0 | 12.0 | 9.4 |

**Fig. 7: Fodder sorghum (CSH-24 and PC-6) in the farmer's field**

## Cowpea and Guar

Cowpea and guar are leguminous fodder crops. These are usually feed to animals with cereal fodders and grasses to improve the nutritive value of the green herbage. To enrich the nutritive value of sorghum and bajra napier hybrid fodder in the year 2020 cowpea and gaur crop was introduced. 3 quintal seeds of these crops (cowpea 1.5 q. and gaur 1.5 q.) were distributed to three districts farmers to conduct 263 demonstrations on 9 hectares area. As per the crop cutting experiment, cowpea demonstrations have yielded an average green fodder yield of 326, 294, 261 and 294 q/ha in Jhansi, Lalitpur, Jalaun district and mean yield respectively. Similarly, guar demonstrations have yielded an average green fodder yield of 244, 256, 270 and 257 q/ha mean yield in Jhansi, Lalitpur, Jalaun districts, respectively. As per the feedback from the farmers, cowpea and guar based fodder cropping systems were noted as new intervention in the villages of Bundelkhand which was recognized as a highly successful and required fodder technological intervention for diversifying the non-leguminous sorghum fodder during summer and rainy season by adding leguminous fodder in animal feed which helps to balance animal nutrition and thus, enhances their health and productivity.

**Fig. 8: Demonstration on fodder production from Cowpea**


**Fig. 9: Demonstration on fodder production from Guar**

### *Berseem*

Berseem is a very common and popular legume fodder crop during *rabi* season in Bundelkhand region. Farmers prefer its cultivation as its fodder is highly palatable and milk multiplier in nature. It provides green fodder up to the end of May month to meet the longer duration fodder demand. However, farmers in the project villages were found to grow traditional/local varieties of berseem with minimal care and management which resulted in lower productivity. Therefore, inproved cultivar of berseem "*Wardan*" was provided to the farmers. Improved seed (7.45 q) of berseem was distributed to the farmers for conducting a total of 501 demonstrations which covered a total of 28.13 ha area. In field conditions from 5- 6 cuttings, the berseem green fodder production from improved practice was ranged between 889 – 1010 q/ha. Nonetheless, cost incurred by the adopter farmers were marginally high, but with an additional expenditure of around 9%, technological interventions have enabled to get above 20% more green fodder yield as compared to the traditional practices (Fig. 10). Crop demonstration view and crop cutting experiment on berseem has been shown in Fig.11

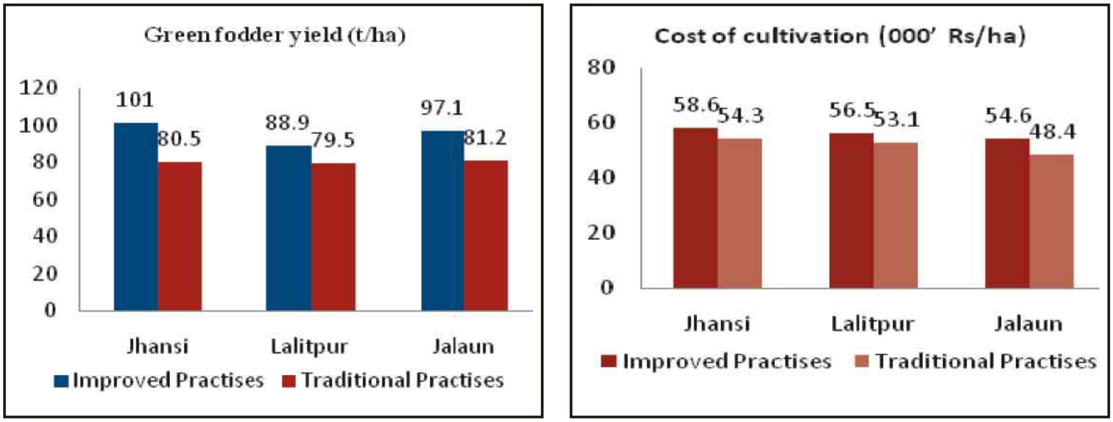


**Fig. 10: Fodder yield and cost of cultivation of berseem across the project districts**

The district wise demonstrations on different fodder crops is presented in Table 5 and the area (ha) covered through fodder crop demonstrations in Table 6

**Table 5: District wise demonstrations on different fodder crops**

| District | Crop | | | | | | |
|---|---|---|---|---|---|---|---|
| | Sorghum | Cowpea | Guar | BN Hybrid | Berseem | Oat | Total |
| Jhansi 155 | 42 | 42 | 30 | 138 | 166 | 573 | |
| Lalitpur | 197 | 44 | 45 | 74 | 214 | 329 | 903 |
| Jalaun 223 | 46 | 44 | 45 | 149 | 265 | 772 | |
| Total | 575 | 132 | 131 | 149 | 501 | 760 | 2248 |

**Fig. 11: Crop demonstration view and crop cutting experiment on berseem**

**Table 6: Area (ha) covered through fodder crop demonstrations**

| District | Sorghum | | | Cowpea | Guar | BNH | Berseem | | | Oat | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2019 | 2020 | 2021 | 2020 | 2020 | 2020-21 | 2020 | 2021 | 2022 | 2020 | 2021 | 2022 |
| Jhansi | 13.4 | 21.1 | 2.0 | 1.4 | 1.6 | 1.5 | 7.7 | 0.66 | 0.83 | 2.8 | 5.0 | 3.7 |
| Lalitpur | 1.9 | 19.9 | 2.29 | 1.4 | 1.6 | 1.5 | 8.0 | 0.66 | 1.17 | 2.7 | 5.0 | 3.7 |
| Jalaun | 14.3 | 18.2 | 2.86 | 1.4 | 1.6 | 1.5 | 7.7 | 0.66 | 0.83 | 3.9 | 5.0 | 5.1 |
| Total | 29.4 | 59.2 | 7.15 | 4.2 | 4.8 | 4.5 | 23.3 | 2.0 | 2.83 | 9.3 | 15.0 | 12.5 |

## Fodder oat

Looking to the severe wild oat weed problem in wheat, farmers of the project were having apprehension towards adoption of oat as fodder crop. However, exposure and scientific trainings have improved farmers understanding on fodder oat and as a result; farmers adopted the cultivation of oat as a new fodder crop during *rabi* season. A total of 760 technology demonstrations on fodder oat cultivation covering an area of 36.8 ha were conducted with the distribution of 28.4 q seed of improved oat variety "Kent". The crop demonstrations were provided with scientific package of practices on crop establishment, irrigation, nutrient and cutting management. Well monitored demonstration on fodder oat has yielded on an average 500-550 q/ha green fodder which became a good source of diversifying the berseem fodder during *rabi* season (Fig 12). The cost of cultivation of the oat in the field condition was estimated in the range of Rs. 52000 to 56000 per hectare (Fig 13).

**Fig 12. Crop demonstration view and crop cutting experiment on fodder oat**

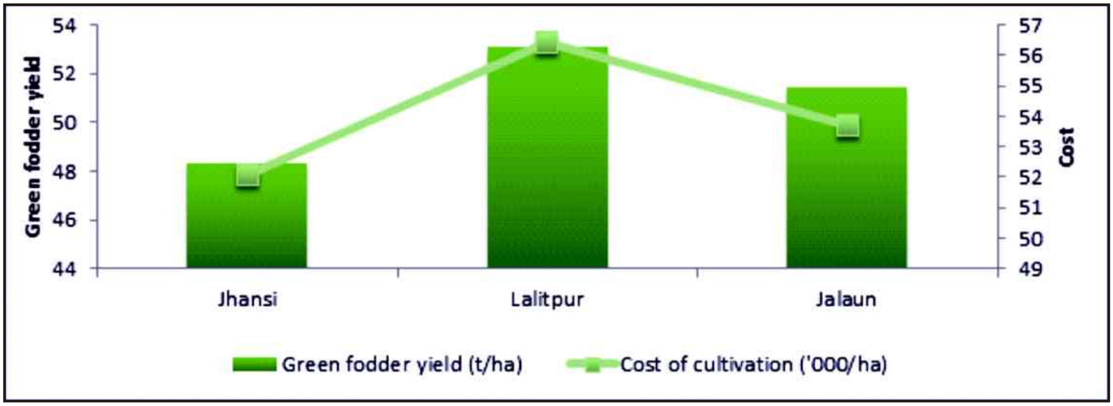


**Figure 13 Fodder yield and cost of cultivation of oat across the project districts**

## Bajra Napier Hybrid

The Bajra Napier (BN Hybrid) is a tropical and sub-tropical climate adapted, highly versatile, perennial, fast growing, vegetative propagated fodder crop which has immense potential for producing quality green fodder round the year throughout the country except, extreme cold areas. Despite of having great potential and ample opportunity for revolutionising the livestock sector, BN Hybrid area, unfortunately, is very low in the country. Considering the crop's fodder production potential and opportunity for its acreage expansion, the crop should be given due place in farming systems.

Under the project 'KISAN MITrA', more than one lakh rooted slips of BN Hybrid (cv. IGFRI-6) were planted in 149 demonstrations. The planting was done as pure, as intercrop and in bund areas. The post-demo survey and two years impact assessment of demonstrations revealed that the pre-demo knowledge of less than 10% regarding BN Hybrid was enhanced to more than 85% regarding crops's utility, fodder production potential and package of cultivation and feeding practices. Farmers were found very much interested in adopting the BN Hybrid since it was a new fodder crop in the area which offered more output with less input and risk. The average productivity of BN hybrid across the locations was recorded as 312 q/ha/cut. However, the number of cuts varied from minimum 6 to maximum 12 depending upon the resource availability and management level. The project beneficiaries' farmers harvested 174-189 tonnes per hectare green fodder that helped them to meet their green fodder requirement for livestock to the great extent. The cost of cultivation of the grass in the field condition was estimated in the range of Rs. 76000 to 84000 per hectare (Fig 14). BN Hybrid crop incurred relatively higher cost as compared to average cost by other fodder crops which was attributed to the cost of planting material i.e. rooted slips and cost of manual planting; moreover, more number of cuts required more labor which further increased cost of cultivation. However, despite of higher cost incurred, BN Hybrid has provided round the year fodder availability and thus reduced the cost of feeding by virtue of which, farmers were able to balance animal diets with the assured supply of green fodder which enhanced milk productivity by at least 15% and thus enhanced profitability by at least 24% as a whole. As per the impact study and feedback collected from the farmers, the perceived factors of its likeliness and popularity among farmers were round the year fodder availability (rank 1), higher production (rank 2), less management and risk of crop failure (rank 3) and various quality traits as other factors. The less availability of affordable planting material at local level (rank 1), injury of human labor engaged in manual harvesting (rank 2) and slow crop growth during extreme months (rank 3) are few weaknesses perceived. Apart from the factors of its success, some of the constraints also noted in which availability of assured irrigation resources (rank 1), crop loss by stray animals (rank 2) and farmers reluctance for accepting the desirable changes (rank 3). The adoption of BN Hybrid was identified as golden opportunity towards self-reliance in green fodder since there is lot of under-utilized space available in field bund areas, wastelands and community areas which can be utilized for cultivating BN Hybrid. Besides, BN Hybrid crop can also be integrated with other seasonal fodder crops, food crops or horticultural crops as intercrop or strip crop. This way, BN Hybrid offers the opportunity to reduce fodder deficit and cost of feeding by securing green fodder availability. Demonstrations on round the year fodder production from BN Hybrid is evident from the Fig. 15

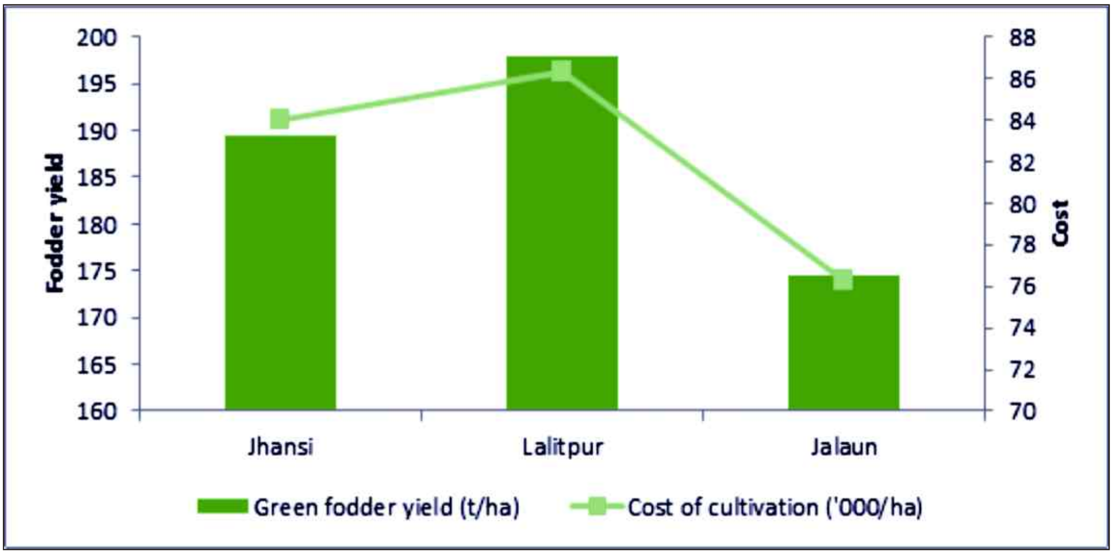


**Figure 14: fodder yield and cost of cultivation of BN hybrid across the project districts**


**Fig 15. Demonstrations on round the year fodder production from BN Hybrid**

## Constraints perceived by farmers in adoption of improved fodder production technologies

The impact analysis study on improved fodder production technologies in the project villages (Table 7) revealed that the most important constraints was 'Unavailability of improved seed at the time of sowing' which was perceived as very serious constraints with first rank (96.67%). Inadequate credit facilities for purchasing necessary inputs were found to be the second most important constraint (93.33%). Lack of scientific know-how about package of practice of improved fodder crop was found to be the third most important constraints (91.67%). Adulterated and sub-standard of inputs in market was the fourth most important constraints (88.33%) as perceived by farmers. Shortage of input/saplings of improved fodder tree and shrubs were perceived very serious constraints by respondents and rank fifth (85.00%). Water scarcity for fodder crop cultivation as perceived by respondent accorded sixth rank (83.33%). Other constraints as perceived by farmers was non availability of trained and expert human resource in fodder production; less priority to fodder crops; lack of awareness about improved fodder technologies; higher production cost of feed and fodder; lack of knowledge and skill for seed treatment; poor management practices; lack of on-farm guidance/ training from organized bodies; and small size of land holding was accorded seventh, eighth, ninth, tenth, eleventh, twelve, thirteen and fourteen with percentage of 81.67, 78.33, 76.67, 63.33, 61.67, 45.00, 38.33 and 26.67, respectively.

**Table 7. Distribution of respondents on the basis of perceived constraints in adoption of improved fodder production technologies (n=60)**

| Sl. No. | Constraints | Frequency | Percentage | Rank |
|---|---|---|---|---|
| 1. | Lack of scientific know-how about package of practice of improved fodder crop | 55 | 91.67 | III |
| 2. | Non availability of trained and expert human resource in fodder production | 49 | 81.67 | VII |
| 3. | Shortage of input/saplings of improved fodder tree and shrubs | 51 | 85.00 | V |
| 4. | Less priority to fodder crops | 47 | 78.33 | VIII |
| 5. | Adulterated and sub-standard of inputs in market | 53 | 88.33 | IV |
| 6. | Lack of knowledge and skill for seed treatment | 37 | 61.67 | XI |
| 7. | Small size of land holding | 16 | 26.67 | XIV |
| 8. | Inadequate credit facilities for purchasing necessary inputs | 56 | 93.33 | II |
| 9. | Higher production cost of feed and fodder | 38 | 63.33 | X |
| 10. | Lack of awareness about improved fodder technologies | 46 | 76.67 | IX |
| 11. | Lack of on-farm guidance/ training from organized bodies | 23 | 38.33 | XIII |
| 12. | Poor Management Practices | 27 | 45.00 | XII |
| 13. | Unavailability of improved seed at the timeof sowing | 58 | 96.67 | I |
| 14. | Water scarcity for fodder crop cultivation | 50 | 83.33 | VI |

## 2.3 Fodder Conservation: Silage Preparation

The availability of green fodder was noted more during the months from July to October and December to March in Bundelkhand. However, during the other period of the year i.e. November-December and April-June there is lack of green fodder availability. Therefore, if green fodder is conserved when available in plenty, livestock can be fed with conserved fodder during the lean period and thus productivity can be maintained throughout the year. Technology demonstrations of silage making using silage bags were conducted in the adopted project villages. Demonstrations (15 no.) were conducted during the month of February and March with the oat fodder crop (var. Kent). Importance of silage making and the major principles in the process of making silage were explained to the farmers. Around 50-60 farmers have attended the meeting. Oat fodder crop was cut from the farmer's field at milking stage. It was wilted for 6-7 hours to have proper moisture content (65-75%). Thereafter, chaffing was done by the farmers itself using the power operated chaff cutter available with the farmer. During filling of silage bag jaggery solution was sprinkled over the chaffed fodder and this process was completed in the presence of group of farmers (Fig 16). Fodder was compressed tightly by the feet of farmer in the bag. Around 1.5 quintal of chaffed fodder was filled in the bag. After the proper packing, the silage bags were sealed tightly and kept in safe place for about 45-60 days. Silage bags were opened after 1.5 to 2 months and checked for the physical parameters. Good quality silage looks golden brown in color, possess sweet odour and pH ranges between 4.2-4.5. After opening the bag, silage was fed to the milking cows and buffalos@ 5-6 kg initially and later gradually increased to 10-15 kg silage/day/animal. Feedback from the farmers was taken and it was noticed that the prepared silage was palatable for their animals, and hence their positive response towards adoption of silage preparation technology was quite satisfactory; moreover, feeding of silage can increase in milk yield by 8-12 percent per day after feeding silage for 30-45 days.

**Fig. 16: Demonstrations on silage in the treated villages**

## 2.4 Livestock based Interventions

Livestock are integral to the livelihoods of farmers especially for small holders. Most of the population in the project villages is dependent on crop/livestock-based activities. Among livestock components, dairy production and goat farming are important for livelihood. By and large even the landless and small farmers maintain at least one cow or buffalo or a few goats as an ensured source of income and asset. The project site typically represented traditional smallholder dairying areas within the semi-arid tropics in India.

As uptake of fodder based technology is entwined with livestock production system, the dairy farmers were also supported with animal health care services in the project villages. Deworming of the animals was done on mass scale (Fig 17). Besides, mineral mixture and feed supplement trail were also conducted on farm animals in each selected villages.

**Fig. 17: Deworming of farm animals in the project villages**

## 2.5 Capacity building

Capacity building of farmers is crucial to widen the horizon of improved agro/fodder based technology. It boosts credibility among farmers towards new technologies and counter balances the negative effect of poor formal education in the adoption decision. Farmers in the project villages were poor of resources, had low level or no formal education, and were often averse to adopt new technologies. Therefore, need was felt to motivate the farmers by exposing them to innovative fodder based projects and practices being implemented by various agencies and innovative farmers in their surroundings. Capacity building methods used included workshops, participatory research and extension, support in infrastructure and on-site trainings that centered on "learning-by-doing".

## Institute residential training cum exposure programs

In order to accelerate capacity building of farmers in area of scientific forage crop production and livestock keeping, well organized training cum exposure programs were organized at ICAR-IGFRI, Jhansi where farmers trained in aspects of fodder production, conservation and utilization. A total of 150 farmers including field staff and other stakeholders were trained in the training 'Improved fodder production and utilization in Bundelkhand' during the year 2019-20 and 'Training program on improved fodder crops, livestock practices and support services' during 2020-2021. Farmers were trained through classroom lectures as well as exposure visits to the ICAR-IGFRI, Jhansi, ICAR-CAFRI, Jhansi, ICAR-IISWC RC, Datia. Major areas under which capacity building of the trainees was done were as following:

**Fig. 18: Farmers training at IGFRI**

**Fig. 19: Farmers training at IGFRI**

- Major fodder crops and their production technologies, intensive fodder crop production systems and management
- Non-traditional fodder sources
- Livestock based Integrated farming system for sustainable livelihood and employment
- Entrepreneurship development through fodder seed production
- Nutrient management in fodder crops
- Agri-Horti-Pasture system
- Livestock production management techniques including common livestock diseases with their symptoms, vaccination and deworming schedule, identification of heat *etc.*

- Feeding management including crop residue enrichment, silage& hay making, concentrate and feed preparation
- Government schemes and program related to Agriculture and Animal husbandry.

The post training evaluation of the improvement in knowledge and feedback assessment of the trainee farmers on aspects of forage technologies and livestock production management was found satisfactory. The 'before and after' evaluation of answer sheets having basic questions on forage production and livestock management revealed 75% improvement in knowledge level from these trainings as compared to the level of knowledge before training. Interestingly, farmers were also found keen to disseminate the acquired knowledge and experiences to fellow farmers of the surrounding villages (Fig 20-23)

**Fig. 20: Training for capacity building of Lalitpur farmers**

**Fig. 21: Training for capacity building of Jhansi farmers**

**Fig. 22: Training for capacity building of Jalaun farmers**

**Fig. 23: Exposure visit of trainees from project districts to ICAR-IGFRI, Jhansi**

# SOCIO-ECONOMIC IMPACT OF FODDER INTERVENTIONS

Impact evaluation of promoted technologies through convincing analysis on livelihoods of targeted stakeholders (farmers) is imperative to justify the scarce public funding on such development projects. By generating a better understanding of how technology influenced the welfare of dairy farmers, impact assessment can improve targeting of research programs and help to adjust resource allocation across programs. Further, increasing productivity through the adoption and diffusion of improved technologies and practices has been considered one of the viable means for achieving economic growth and agricultural transformation in the face of natural resource scarcity and climate uncertainty. However, a farmer's decision to adopt a new technology is affected by the information gained as well as his or her cognitive level and attitude about technology. In developing countries like India there are often dramatic market variations in outputs, production factors, and information; the diffusion process, adoption potential, and effectiveness are thus likely to be heterogeneous across different types of technologies and farm households. It is therefore essential to assess the factors influencing adoption decisions besides appraising the returns of the wide range of promoted technologies.

## Drivers of fodder technology adoption

### *Empirical framework*

Following the theory of expected utility, we assumed that a farmer's adoption decision given the risk and uncertainty prospects, is based on the comparison of expected utility (Mercer 2004). Farmers will adopt and practise the promoted interventions if the expected utility from adoption (Ua) is greater than that derived from non-adoption (Un). As measurement of utility is difficult, profit can be used as a proxy and if combined with attitude to risk, farmers are described as maximizing the expected utility of profit rather than expected profit (Borges *et al.* 2015).

The utility derived from the adoption of improved forage based technology will have a binary choice component determined by observable characteristics $X_i$ and a stochastic error term $\varepsilon_i$

$I_i$ = ❂$X_i + \varepsilon_i$ ; $I_i = 1$ if $I_i^* > 0$ and 0 if otherwise.

Where, $I_i$ is a dichotomous variable for the adoption of the forage technologies and ❂ is a vector of parameters to be estimated.

Farmers will adopt forage technologies if $I_i^* = Ua - Un > 0$. The probability of adopting the technologies can then be estimated as follows

$$Pr(I_i = 1) = Pr(I_i^* > 1) = 1 - D(-\text{❂}X_i)$$

Where Pr ($I_i = 1$) is the probability of adoption and D represent the cumulative distribution function for $\varepsilon_i$

***Probit model estimated results***

Table 8 depicts the model estimates for factor influencing adoption decisions of improved fodder technologies. Concerning the household characteristics, we find that adoption is positively associated with longer formal schooling of the household head. The learning chances of educated farmers from exposure to technical advice, training and farm demonstrations may be higher. The direct relation between inclination towards adoption of improved agricultural technologies and education of household head has good literature support (Kumar *et al.* 2020). Additionally, households with large farm size are 4 % more likely to adopt the improved forage technologies. The larger landholdings accentuate the household's ability to take risks and thus increase the probability of adoption of new technology (Kabir and Rainis 2015).

Unsurprisingly, households with higher livestock units and having more buffaloes in their herd are more likely to adopt improved forage based interventions on their farm- the probability increases by 0.099 and 0.132, respectively for the present study area. The probable reasoning is that the households with higher livestock units utilized more crop residue as animal feed and thus more likely to adopt agricultural technologies that yield more forages. Kassie *et al.* (2018) also reported that ownership of productive breeds increases demands for feed requirements that result in farmers looking for more feed sources. Moreover, a positive and significant association between off-farm income activities by households and the probability of adoption of improved forage technologies was observed in the present study. Off- farm income relaxes liquidity constraints faced by the farm households and induces increased use of improved seeds (Choudhary and Singh 2019). A significantly higher adoption intensity of agricultural technology among households with off-farm income relative to their counterparts without off-farm income is well acknowledged (Mwangi and Kariuki 2015).

**Table 8: Regression results from probit for the driving factors of adoption of improved forage technologies/practices**

| Variables | Coefficients | Std. error | Marginal effect |
|---|---|---|---|
| Age of HH | 0.032 | 0.073 | 0.0083 |
| HH_Male | 0.078 | 0.139 | 0.0018 |
| Experience_HH | -0.019 | 0.027 | -0.0037 |
| Education_HH | 0. 371* | 0.016 | 0.0610 |
| HH Size | 0.0071 | 0.0273 | 0.0029 |
| Dependency Ratio | -0.1741* | 0.0331 | -0.0763 |
| Land holdings | 0.2382* | 0.0914 | 0.0413 |
| LSU | 0.082* | 0.0173 | 0.0991 |
| Buffalo to Cattle ratio | 0.6831* | 0.2976 | 0.1329 |
| Off-farm activities | 0.0247** | 0.0109 | 0.0571 |
| Training | 0.6179* | 0.1186 | 0.2312 |
| Credit | 0.3951* | 0.1049 | 0.0361 |
| Market access | 0.329* | 0.0791 | 0.1137 |
| Log likelihood | -241.36 | | |
| LR $\chi^2$ | 49.71* | | |
| Sample size† | 328 | | |

Source: Authors' estimates based on survey data
Note: *p<0.01, **p<0.05

All the three instructional factors considered in this study viz., training, credit and market access clearly have positive and significant effect on adoption of forage technologies. Exposure to training and demonstrations on improved forage practises increases the probability of adoption by 0.23. Training and demonstrations boost credibility among farmers towards new technologies and counter balance the negative effect of lack of formal education in the adoption decision.

A positive relationship between extension and training, and technology adoption among farm households has been unanimously supported in previous studies (Kumar *et al.* 2020). Additionally, being a recipient of formal credit and access to output market is correlated with household's-risk bearing ability and stimulates technology adoption (Ghimire *et al.* 2015). In the present study, we observed that due to the absence of efficient milk collection centre in the region, the milk vendors or middle men have strong presence for milk marketing and the farmers are not able to realise better price. However, few farmers disposes the surplus milk in form of dairy products like *Ghee* (clarified butter made from the milk) and *Khoa* (highly condensed milk), which undoubtedly fetches higher prices but also involves considerable drudgery and processing costs.

**Impact on milk production and feed sufficiency: evidence from Lalitpur**

***Empirical framework***

An empirical challenge in assessing causal impact is to examine the outcome and its counterfactuals on the same farmer i.e. what would have been the impact in absence of farmers being adopter. Ideally, the solution for this would be to randomly assign the treatment (forage based interventions in the present case) among farmers i.e. randomized control trial (RCT), however it is not feasible to implement it practically. Therefore, we relied on Propensity Score Matching (PSM) method, a quasi-experimental technique which is widely used in impact assessment studies to deal with the problem of the missing counterfactual (Imbens and Wooldridge 2009).

We also conducted sensitivity analysis using bounding sensitivity method proposed by Rosenbaum (2002), for the ATT that are significantly different from zero to test whether inference regarding impact were sensitive to 'hidden bias' due to unobservables.

***Data***

As matching technique used in the present study requires more number of observations from control units, preferably in the ratio of around 1:2 (Datta 2015), we collected information from 150 farm households in the treated villages and from 250 households from control villages (three contiguous villages, with no forage based interventions but having by and large close similarity with treated villages in their agro-climatic, infrastructural and socio-economic set up) in Lalitpur district. Household heads were stratified based on land size category in each village and then probability proportional to size method was used to draw sample households from each village. Finally, the respondent household heads were selected by using random sampling technique.

***Impact estimates***

The estimated causal impact of improved forage technologies, as average treatment effect on the treated (ATT), on selected outcome variables are presented in Table 9. The estimates of different matching algorithms are though quantitatively different, but qualitatively these are similar. These estimates control for the farmers' endogenous decisions on participating in the KISAN MITrA project and whether to adopt improved forage technologies.

We find that ATT is positive and statistically significant for most of the outcome variables. With regard to annual milk production, adopter households had a higher annual milk yield than non-adopters with matched characteristics and the treatment impact was over 950 litres. The corresponding annual gross return was estimated to hovers between INR 38000 to INR 39000 (Table 9). The impacts on milk productivity differ across dairy breeds. While daily milk yield of cows significantly increased by 1.15 to 1.97 litres; for buffaloes, the improved forage feeding raised daily milk productivity by 1.23 litres to around 2 litres. These findings are indicative of year round availability of quality feed and fodder in the treated villages.

**Table 9: Estimates of ATT: Impact of forage technologies**

| Outcome indicator | Average treatment effect on the treated | | | Gamma (Γ) |
|---|---|---|---|---|
| | NNM | KBM | RM | |
| Total milk production per household per year (litres) | 977.13** (467.11) | 959.54** (477.38) | 951.39* (423.32) | 1.25-1.30 |
| Cow's daily milk productivity | 1.97* (0.71) | 1.15* (0.342) | 1.25* (0.43) | 1.80-1.85 |
| Buffalo's daily milk productivity | 2.04* (0.81) | 1.23* (0.272) | 1.47* (1.34) | 2.15-2.20 |
| Daily hours spent to feeding (*kharif* season) | -1.12* (0.16) | -1.05* (0.25) | -0.95** (0.21) | 1.35-1.40 |
| Daily hours spent to feeding (*rabi* season) | -0.41 (0.29) | -0.39 (0.26) | -0.37 (0.21) | ------ |
| Daily hours spent to feeding (*zaid* season) | -1.80* (0.19) | -1.89* (0.26) | -1.79* (0.21) | 1.20-1.25 |

*p<0.01, **p<0.05

Note: Figures in parentheses indicates standard error

The assessment of the ATT of adoption improved on feed sufficiency revealed that the project interventions in the study area are associated with increased feed availability, particularly during feed stress periods. After matching, compared to the non-adopters the daily time spent by the adopters in sourcing feed significantly reduced by around 2 hours during the *zaid* season and around an hour during *kharif* season.

The establishment of perennial fodder grasses by the adopters in their forage plots was key sources of cut and carry grass during the *zaid* and *kharif* season that saved significant time in sourcing feed than non-adopters that reported spending around 3 to 4 hours sourcing green fodders, mainly weeds and shrubs, from fields and distant areas on a daily basis. In monetary terms, the feed sufficiency due to the project interventions benefited the adopters by reducing the imputed labour cost by around INR 10,000 (Table 10). We did not find significant impact on time saving in sourcing feed during *rabi* seasons due to the plenty availability of traditional feed sources such as crop bi-products and crop residues in these seasons.

**Table 10: Economic benefits of improved forage technologies**

| Parameters | Economic Gains (INR) | | |
|---|---|---|---|
| | NNM | KBM | RM |
| Annual gross returns* due to increased milk production | 39085.2 | 38381.6 | 38055.6 |
| Daily gross return per cow | 78.8 | 46.0 | 50.0 |
| Daily gross return per buffalo | 81.6 | 49.2 | 58.8 |
| Reduced imputed labour cost (*zaid* and *kharif* season)† | 10350.00 | 10158.75 | 9371.25 |

*Gross margin was calculated using milk procurement price (= INR 40/litre) in the study area.

†Imputed labour cost was calculated considering the prevailing labour cost of INR300 for 8 working hours in the study area.

The result of sensitivity analysis to examine the effect of uncontrolled confounders is also reported in Table 9 (column 5). The values of critical level of hidden bias ($\Gamma$) are well within the acceptable range as reported in previous literature (Mendola 2007; Keele 2010) and ranged between 1.20–1.25 to 2.15-2.20. The value of $\Gamma$ for daily hours spent for feeding during *zaid* cropping season (1.20–1.25) implied that the credibility of a positive impact of adoption on feed sufficiency during dry season would be questioned if households with similar characteristics differed in their odds of adoption by even 20-25%. The higher the value of $\Gamma$, the lower the hidden bias would be and the converse is also true. Therefore, we can conclude that the inference on estimated impact on milk productivity will not be changed even in the presence of large amounts of uncontrolled heterogeneity. In other words, impact of improved forage technology adoption on milk yield of dairy animals is less sensitive to the unobserved bias.

**Impact on technical efficiency of farms**

The scope for improving milk productivity and profitability also depends on the level of technical efficiency of dairy farmers. Technical efficiency implies the maximum attainable level of output that can be resulted from best production practices and optimal resource allocations (Girma 2019). Measuring and evaluating farm performance in terms of efficiency is imperative for supporting the development of sustainable dairy farming systems. Estimates of technical efficiency are useful in emphasizing practices like changes to the management (balance feeding, education and training programs for dairy farmers ) and structure of the farm for improving productivity levels (Bardhan and Sharma 2013).

Graphically examination of the relationship between the technical efficiency of dairy farmers in the project villages and proportion of green fodder area to gross cropped area (GCA) at their farm (Fig. 24) suggests a positive relationship the two, implying that farmers who diversified their farms with green fodder also tend to be more technically efficient. Since these findings are graphical and descriptive and only suggestive of the potential relationship between these variables, we provide more plausible empirical results estimated through roboust econometric framework.

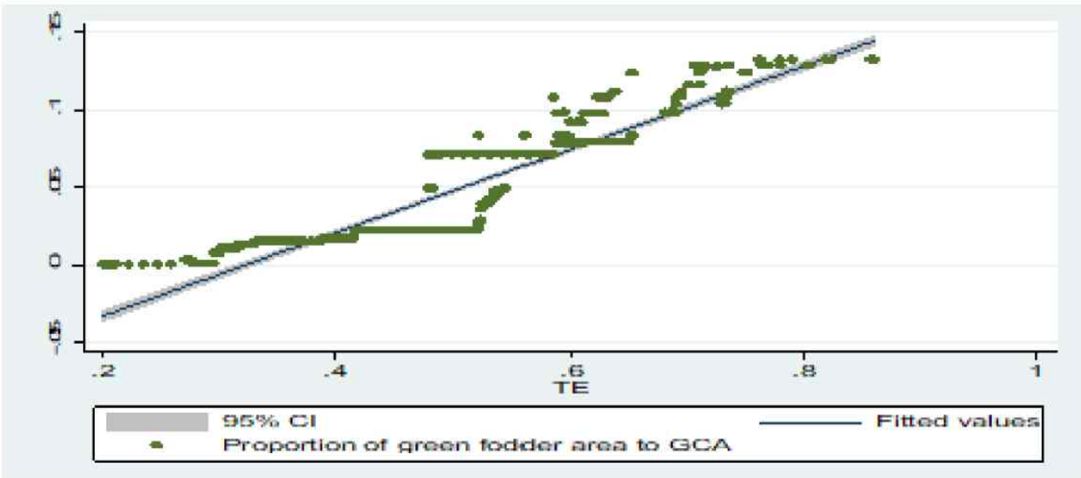


**Fig 24: Scatter graph of fodder acreage and technical efficiency (TE)**

### *Data and sampling*

The study used both purposive and random sampling approach for drawing sampled respondents. The first stage of the sampling approach involved purposively selecting 3 treated villages and randomly selecting three contiguous control villages in each district. The second stage involved randomly selecting dairy households within the physical boundary of these villages. A total of 700 respondents were surveyed in 2 visits (i.e., each farmer was visited 2 times) from June 2021 to March 2022. During each visit, information about the farmer's ongoing production and feeding practices was recorded to minimize recall bias.

### *Empirical techniques*

Reviewing earlier literature suggests that stochastic production frontier (SPF) analysis, an econometric assessment to analyze production relationships, is the main methodology in measuring efficiency (Ma *et al.*, 2018; Girma 2019). Few studies have also employed non-parametric approach like data envelope analysis (DEA) in estimating technical efficiency of farm (Gelan and Muriithi 2012). However the DEA method, due to its strong assumption of no sampling errors, is sensitive to outliers and attributes all deviation from the production frontier to inefficiency that reduces its relevance in agricultural studies where output is highly sensitive to random weather conditions (Koirala et al 2016). Therefore, in this study, to estimate farm level technical efficiency scores, we employed SPF model and specified as follows:

$$Y_i = f(X_i, d_i) + v_i - u_i \qquad \ldots(1)$$

Where, $Y_i$ indicate output of our interest for the $i^{th}$ farmer; X representing vector of input variables in the production frontier; d is dummy that captures the treatment status of the farmers under the project activities (1= treated, 0 = control); $v_i$ is stochastic error term [ $v \sim N(0, \sigma_v^2)$] and $u_i$ is positive (one-sided; $u_i \geq 0$) random error accounting for technical inefficiency in production. Among various possible distribution framework of $u_i$ i.e., half-normal, truncated normal, exponential or gamma, we assumed the commonly used truncated-normal distribution for the inefficiency component ($u \sim N[0,\sigma_u^2)$).

Farmers' decision to adopt any technology (fodder interventions in our case) depends on various observed and unobserved factors (Bravo-Ureta *et al.*, 2012; Wossen *et al.*, 2017) that may lead to self-selection in adoption. We used both PSM (kernel based matching algorithm) and selectivity bias corrected SPF model proposed by Greene (2010) to address biases from observed and unobserved factors. The KBM yielded a total of 676 matched observation, consisting 250 farmers from treated and 426 from control villages.

For estimating the production frontier, preliminary both the Cobb-Douglas and translog functional forms were compared by likelihood ratio test. Based on the test result, Cobb-Douglas function was used and specified as follows:

$$\ln(ADMP_i) = \beta_0 + \sum_{i=1}^{6} \beta_i \ln X_i + \delta_i d_i + \varepsilon_i$$

Where, the dependent variable ln(ADMPi) is log transformation of average daily milk productivity (in liters) of the animals of $i^{th}$ household. Independent variable ln(Xi) is log-transformed value of inputs (Table 1). $\beta_i$s are the production elasticity parameters to be estimated. $\varepsilon_i$ is random error which represents stochastic variations in milk output.

After confirming from Likelihood Ratio (LR) test that the parameters for the production frontiers differ for treated and control farmers, the SPF for the beneficiaries and non-beneficiaries was then estimated with following empirical specifications

Beneficiaries: $\ln(Y_i) = \beta_0) + \sum_{i=1}^{4} \beta_i \ln X_i + (1-\rho)\,\beta_i\,\lambda_i + e_i$

Non-beneficiaries $\ln(Y_i) = \beta_0) + \sum_{i=1}^{4} \beta_i \ln X_i + (1-\rho)\,\theta_i\,\lambda_i + \omega_i$

Where $Y_i$ and $X_i$ are as previously defined; ❐$_i$ is correction term, ❉$_0$ and ❑$_0$ are constant terms, ❉$_i$ ✌ ❉$_{i}$ , ❑$_i$ and ▼$_i$ are parameters to be estimated; and ✳ being a selectivity-correction term inclusion rule, takes value zero (✳ = 0 ) when unobserved selection bias issue is considered and one (✳ = 1 ) if not considered in estimating the SPF.

***Production frontier results***

Table 11 provides mean technical efficiency (TE) scores for bias corrected SPF model along with TE estimates from conventional SPF for unmatched sample. The average TE for treated group ranging from 55% to 59% and is higher than that of control group in all cases. The statistical difference in means indicates the prevalence of efficiency gap between beneficiaries and non-beneficiaries of the fodder centered project activities. However, this gap expectedly narrows down after implementing matching technique as PSM controls for selection bias stemming from observable variables.

**Table 11: Mean technical efficiency levels across SPF models**

| SPF Models | Overall | Treated | Control | Difference$ |
|---|---|---|---|---|
| Conventional SPF with unmatched sample (C-U)† | 0.49 (0.14) | 0.55 (0.13) | 0.41 (0.11) | 0.14* |
| Conventional SPF with matched sample (C-M) | 0.51 (0.19) | 0.55 (0.13) | 0.44 (0.09) | 0.11* |
| Sample selection SPF with matched sample (SS-M) | ----- | 0.59 ( 0.11) | 0.48 (0.04) | 0.10* |

Note: Standard errors are in parentheses.

$ t- test is used to determine if TE means are significantly different between the treated and control groups

*$p < 0.01$

† We also estimated mean TE for unmatched samples to present comparative results in Table 3.4.

Moreover, the sample selection SPF for the matched sample decreases the TE gap even further. These empirical estimates show that without the appropriate corrections for selection bias, technical efficiency tends to be underestimated and the gap in performance between treated farmers and their control counterparts would be overestimated. Our findings is corroborating with Bravo-Ureta *et al.* (2012) and Ma *et al.* (2018), who also reported the parallel evidence of bias correction on TE differentials between treated and control groups.

# POLICY IMPLICATIONS

KISAN MITrA (Knowledge-based Integrated Sustainable Agriculture Network Mission India for Transforming Agriculture) implemented in the Jhansi, Lalitpur and Jalaun districts of Bundelkhand region of Uttar Pradesh has shown crucial outcomes in form of improving fodder availability, enhancing knowledge on fodder production, conservation and utilization technologies through conducting 2248 fodder crop based and around 50 livestock based demonstrations.

Farmer-Scientist Interaction meetings, field visits, gosthi etc. have provided first hand information on baseline situation and thus, guided for better implementation of project activities. Moreover, a major period of project faced difficulties related with Covid-19 such as inability of physical visits hence, virtual meetings have helped a lot to maintain contacts with farmers which utilized for better implementation, monitoring and evaluation of technological interventions. Besides, well organized farmers training and exposure visits at ICAR-IGFRI, Jhansi were conducted where farmers trained in various aspects of fodder production, conservation and utilization.

Although sorghum crop was not a new fodder crop for the farmers however, demonstrations on improved package of practices based on multicut variety (575 no., covering 95.75 ha area) have enabled the farmers to improve the productivity of fodder sorghum. Improved multicut fodder sorghum crop cultivation has shown 17.5-20% more yield as compared to the existing farmer's practice.

Deficit of leguminous fodder during *zaid* and *kharif* season has been noted in Bundelkhand since there is no practice of growing leguminous fodder crops was found hence, in order to diversify non-leguminous fodder (sorghum, BN Hybrid), cowpea and guar as fodder crops demonstrated in 263 location covering 9.0 ha area. Both of these leguminous fodder crops have provided 250-300 q/ha green fodder which diversified animal diet, supplemented protein needs and improved productivity.

Demonstrations on scientific cultivation of berseem with improved package of practices has enabled the farmers to take 1-2 more cuts from berseem which provided 20% more fodder yield over the existing farmers practice.

Fodder oat has been a new fodder crop for the farmers of the project. Farmers acquainted with the utility and potential of fodder oat in form of diversifying berseem fodder during *rabi* season and securing better nutrition to the animals. Economic evaluation of fodder crop demonstrations revealed that with an investment of Rs. 50000 to 55000, farmers can harvest 500-550 q/ha good quality green fodder from oat.

BN Hybrid crop performed par excellence as per the data evaluation and feedback from 149 demonstrations conducted as pure, as intercrop and in bund areas. It has emerged as innovative, potential and feasible fodder source which provided digestible and palatable green fodder round the year. Farmers have harvested an average of 312 q green fodder /ha/cut. Economic evaluation of BN Hybrid demonstrations revealed that this crop requires Rs. 76000-84000 during first year of establishment and growth and provides 174-189 ton/ha green fodder from 6-12 cuts depending upon soil availability and management level.

Demonstrations (15 no.) of silage making using silage bags were done as fodder conservation interventions. As per feedback from the farmers, prepared silage was well palatable for animals, and hence their positive response towards adoption of silage preparation technology was quite satisfactory; moreover, feeding of silage can increase in milk yield by 8-12 percent per day after feeding silage for 30-45 days.

Various livestock interventions such as feed balancing, mineral mixture supplementation, deworming, general health care etc. have improved health and nutritional status of the livestock thus improved productivity status of the animals.

As per the impact analysis, the top three constraints perceived by the farmers regarding adoption of fodder technologies were unavailability of improved seed at the time of sowing, inadequate credit facilities for purchasing necessary inputs and lack of scientific know-how about package of practice of improved fodder crop.

The study established that the adoption of improved forages is positively influenced by level of education of household head and, various farm and institutional characteristics in a significant way. This necessitates a holistic approach for promoting the uptake of improved forage practises by livestock keepers.

Improving education status of farmers can go long way as it also have multiplier effect on economy, therefore strengthening public education system in rural areas should be the prime policy focus. Besides, mainstreaming practically oriented, participatory and interactive model like farmer field school (FFS) program and encouraging frontline demonstrations by local research institutes, to impart training to the dairy farmers on improved fodder production, conservation and utilization would be imperative to improve farmers' capacity and skills in forage and dairy management.

An urgent policy need in the studied region is to ensure parallel development of supporting market environment for surplus milk encompassing backward and forward market linkages. Promoting farmer's coalition through farmer producer organizations (FPOs) would be crucial in this direction for safeguarding the interest of small dairy farmers. Further, strengthening and streamlining the rural credit networks and other service providers who offer market and input support to dairy farmers will also be a key intervention for increasing the uptake of improved forage technologies.

The empirical estimates of stochastic production frontier models show consistently higher average technical efficiency for beneficiary farmers than their control counterparts, though the presence of selectivity bias cannot be rejected. Technical efficiency ranges from 0.55 to 0.59 for beneficiaries group and from 0.41 to 0.48 for non-beneficiaries depending on how biases were controlled. It is noteworthy that the average technical efficiency has increased for the both treated and control farmers and the gap between their mean TE scores narrowed down after correcting for selection bias stemming from observable and/or unobservable variables. Therefore, based on our results, we emphasize that unbiased estimation of the impact of development projects on technical efficiency of dairy production must take selection bias effects into account.

The kind of rigorous econometric analyses used in this study is crucial for understanding the actual field-level impacts of various sets of improved forage technologies and practices on milk productivity and socio-economic welfare of dairy farmers. Finally, the evidence from Bundelkhand region, with its typical agro-ecological conditions characterized by undulating topography and unique climatic challenges, can offer important lessons for the promotion of improved forage technologies for improving livestock productivity in arid and semi-arid regions around the world which face similar challenges. However, integrating farmer's choices with the suggested policy interventions will be more imperative as the ground implementation of strategies eventually governed by many socio-economic factors prevailing in a region.

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