Forage Res., **47** (3) : pp. 257-263 (2021) **http://forageresearch.in**

FODDER BEET: A BOON TO IMPROVE LIVESTOCK PRODUCTIVITY THROUGH QUALITY FORAGE PRODUCTION IN ARID AND SEMI-ARID REGIONS OF INDIA – A REVIEW

DEEPAK KUMAR[1]*, RAJESH KUMAR MEENA[1], RAKESH KUMAR[1], HARDEV RAM[1], RAKESH KUMAR[1] AND GANESH KUMAR KOLI[2]

[1]Agronomy Section, ICAR-National Dairy Research Institute, Karnal-132001 (Haryana), India
[2]Department of Genetics & Plant breeding, CCS Haryana Agricultural University, Hisar-125004 (Haryana), India
**(e-mail : bhardwaj051238@gmail.com)*

(Received : 12 December 2021; Accepted : 29 December 2021)

SUMMARY

India has the world's largest livestock population and milk production, but the livestock productivity is very low due to scarcity of quality green fodder especially during the hot summer month. To improve the profitability of small and marginal farmers in terms of the livestock sector, fodder beet can be a strong contender compared to other fodder crops in arid and semi-arid regions. Fodder beet (*Beta vulgaris* L.) is a temperate crop now spreading towards subtropical countries, where it can be grown successfully during the winter season. It is a high yielding potential crop treated as forage concentrate and provides high-quality green fodder up to June. High energy, water, sugar, low to medium protein and low fiber content makes it more palatable and digestible, can be cultivated profitably even with saline water and in salt-affected soils. Under diverse environmental conditions, agronomic practices significantly influence the growth, yield, and quality of fodder beet. Its full potential is widely recognised in world and it could possibly be a high yielding forage option for the Indian farmers as well.

Key words : Fodder beet, livestock, nutritional aspects and agronomic practices

Indian agriculture is an economic symbiosis of crop production and animal husbandry. Livestock rearing is an essential source of income and a risk-mitigation strategy, particularly for small and marginal farmers in arid and semi-arid regions. Arid and semi-arid areas of India account for approximately 166.2 million hectares of the geographical area are the most prominent zones concerning size, human and livestock population, which are characterized by high evaporation, low and erratic rainfall, pasture land degradation, and coarse textured-salt affected poorly fertile soils (Ajai *et al.,* 2009 and Shankarnarayan *et al.,*1987).

Currently, livestock is one of the fastest-growing agricultural sub-sectors, contributing 25.6% of total agriculture GVP and 4.11% GVP to the country's economy (Annual Report, 2018-19). India holds first rank in terms of milk production; however, its productivity is low (1000 kg per lactation yield) as compared to the world average (2040 kg per lactation yield) and European countries (4250 kg per lactation) (Vision- IGFRI, 2050). The scarcity of high-quality feed and forages has been considered a significant constraint in harnessing India's livestock sector (Brithal and Jha, 2005 and Chaudhary *et al.,* 2014).

Moreover, dairy farming productivity and efficiency drastically decreases due to the unavailability of green fodder, especially during hot summer. India's livestock population has increased to over 535.78 million (Fig. 1), showing an increase of 4.6 percent over the Livestock Census-2012, which created colossal pressure on the available fodder resources (Anonymous, 2019).

The availability of feed and fodder remains a significant concern as there is a gap between demand and supply (Table 1). Today, the country has a net deficit of 36% green fodder, 11% dry crop residue, 44 per cent concentrate feed ingredients, crude protein (24.60%), and TDN (19.87%) (ICAR-IGFRI, 2018). Furthermore, the available quality of forage is low and short in energy, protein, and minerals. Moreover, the size of operational land holdings is shrinking, posing a severe menace to farming's profitability and sustainability (Behera and France 2016).

Improving fodder productivity per unit area is the only way to meet the demand. The use of

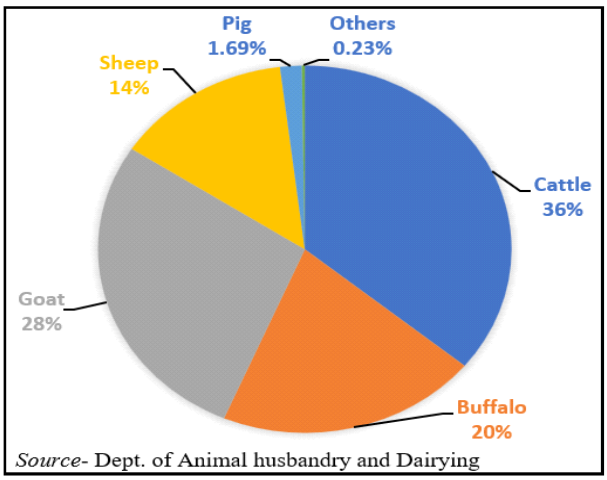

Fig. 1. Livestock population 2019 share of major species.

TABLE 1
Demand and supply of dry and green forages (million tonnes)

Year	Demand		Supply		Net % deficit	
	Dry	Green	Dry	Green	Dry	Green
2010	508.9	816.8	453.2	291.3	10.95	35.66
2020	530.5	851.3	467.6	260.9	11.85	30.65
2030	568.1	911.6	500.0	224.2	11.98	24.59
2040	594.9	954.8	524.4	193.0	11.86	20.22
2050	631.0	1012.7	547.7	186.6	13.20	18.43

(*Source* Vision-IGFRI, 2050).

appropriate high-yielding fodder crops and their varieties and following the best package of practices have been shown to intensify forage productivity by 75% at the farmer level (Ghulam *et al.,* 2008). Therefore, increasing the availability of quality green fodder meets the demands of an increasing livestock population and enhances their productivity, especially during the hot summer months.

Beet (*Beta vulgaris* L.) is a temperate crop, successfully grown in subtropical parts of the world for sugar, fodder, and vegetable purposes and is also known as sugar beet, fodder beet, and beetroot, respectively. Fodder beet is a high yield potential crop than any other arable fodder crop (Anonymous, 2006). It can yield more than 200 tonnes of green biomass per hectare in four months and be cultivated profitably even with saline water and salt-affected soils. During the hot summers when there is meagre availability of other fodder crops for *e.g.,* berseem, this crop win one's spur by satisfying the need for fodder. With the cost of production of less than 50 paise per kilogram of biomass produced, the crop has a very high-water use efficiency of 28-32 kg green biomass per m^3 water (ICAR-CAZRI, 2020).

Both the above and below the soil growth parts (leaves and roots) are feed for animals, but the primary source of feed are tuberous roots (Ibrahim, 2005; El-Sarag, 2013). The immediate use of fodder beet is feeding ruminants, though it can also be provided to pigs (Henry, 2010; Rees and Westmacott, 1956). The low fiber and high protein and sugar content make it a more palatable, nutritious, and energy-dense feed, it has good scope for India's livestock sector (Dulphy *et al.,* 2000). In India, its popularity is increasing as livestock feed, a few states, namley Rajasthan, Madhya Pradesh, Haryana, Chhattisgarh, Maharashtra, Kerala, and Uttar Pradesh are involved in its cultivation.

Fodder beet as a potential crop for fodder purpose

- High yield potential (20-30 t D.M./ha), so you need less land to feed the same number of animals.
- High metabolic energy value (12-13 MJ ME/ kg D.M.) and utilization (typically 90%) for improving animal performance
- The highest yield of net energy for lactation per hectare (NEL), and it is a good catch crop for nitrogen, too (De Brabander *et al.,* 2012).
- Fodder availability from January to May when there is meager availability of other fodder crops.
- Excellent crop for silage making with maize and oats, and for biofuel production (Henry, 2010).
- Relatively low cost of cultivation per kg dry matter production at high yields.
- Drought tolerant, profitably cultivation in salt-affected soils with poor quality water, and adaptive to harsh environmental conditions (Abdallah and Yassen, 2008; Tanwar *et al.,* 2013; and Khan *et al.,* 2020).
- Unaffected by most brassica diseases.
- It is a versatile crop.

Fodder beet cultivation may help overcome the problem of feed shortage, especially in arid and semi-arid regions of India during summers. Singh *et al.,* 2013 reported that fodder beet is a valuable crop for increasing milk productivity (180 kg to 450 kg extra milk) on smallholder farms with mixed farming during the lean period when no other fodder crop (even berseem crop) is available in the hot summer months.

Therefore, considering the significance and

potential of fodder beet, great efforts are needed towards its utilization and extension as a fodder crop among Indian farmers. The available reviews indicated that the scientifically well-managed fodder beet could be a good alternative for sustained green forage supply of high quality to fulfil the nutritional fodder requirement of the dairy animals, especially during hot summer months.

Nutritional quality of fodder beet : The crop contains 10-15% dry matter, and the roots have up to 60% sugars (mainly sucrose), low to medium crude protein (approximately 10%), and neutral detergent fiber (about 12%) contents (Matthew *et al.,* 2011). It has a relatively low dry matter content (12-20 %) and is mainly an energy feed due to the presence of high water-soluble carbohydrates content (55- 70 % of dry matter, main sucrose). The shoots account for approximately one-third of the total dry value of the plant (Clark *et al.,* 1987) and are distinguished by their high protein content, which ranges between 11.4 and 15.8 percent (Nadaf *et al.,* 1998). It contains high carbohydrate content on an average of 71.69 % of total dry matter (Abdallah and Yassen, 2008). The fodder-beet roots digestible and metabolizable energy contents were 13-15 and 11-12 MJ/kg DM, respectively (Clark *et al.,* 1987). The high sugar content, low fiber, and rich energy source in its fodder make them more palatable and digestible (Draycott and Christenson, 2003). The chemical composition of different fodder beet cultivars grown in Indian conditions by Singh *et al.,* 2013 shown in Table 2.

Anti-nutritional factor : Leaf portion of fodder beet cause digestive upsets in ruminants due to high oxalate levels in its shoots which bind to the calcium and form insoluble calcium oxalate during digestion and can results milk fever-like symptoms in ruminants (Duncan *et al.,* 1997). Diet supplemented with more than 80% of fodder beet also causes acidosis in ruminants (Waghorn *et al.,* 2017). The negative effect of consuming fodder beet, *i.e.,* acidosis, can be reduced by taking a transition period of 10-15 days and a proper diet plan, for example: (a) feed 40 % or less of total dry matter intake of fodder beet in case of lactating cows, and (b) feed 70 % or less of total dry matter intake of fodder beet in case of dry cows (Anonymous, 2021).

Improving dairy animals' performance : Fodder beet is a high-energy, low-protein, and low fiber feed, treated as a forage concentrate as it digests quickly in the rumen (Al Jbawi, 2014). Feeding dry cows with 65 % fodder beet and 35 % pasture silage provides adequate nutrition to the animal (Waghorn *et al.,* 2017). Cows wintered on fodder beet showed better reproductive performance and had more significant average milk solids, fat, and protein yield than kale (Dalley *et al.,* 2020). Diet supplemented with fodder beet increases the nitrogen use efficiency for milk production and lowers the nitrogen intake by the dairy cattle. It consistently lowers the urine nitrogen concentration, whereas oat is more likely to reduce milk production (Bozinviya, 2019). The milk production of Tharparkar cattle was boosted by 8 to 10% after feeding trials (Source: ICAR-CAZRI, 2020).

Commercially available improved cultivars :

Jamon is a mono-germ cultivar that has been evaluated in New Zealand. It is an orange-skinned cultivar with a bulb dry matter percentage between 16-18%, 50% of the bulb above the ground, excellent resistance to bolting, and a potential yield of 18-22 t/ha (Fig. 2).

Monro is a red beet with a large, rounded bulb shape and suitable in-paddock grazing (Fig. 3). It contains 13-15% bulb dry matter, a potential yield of 18-22 t/ha, good resistance to bolting, and 60% of the bulb above the ground (Anonymous, 2018).

TABLE 2
Chemical composition (%) of different fodder beet varieties

Varieties	TSS (root)	Dry matter		Crude protein		Crude fat		Crude fiber		Silica		Oxalic acid	
		Top	Root	Top	Root	Top	Root	Top	Root	Top	Root	Top	Root
JK Kuber	5.2	13.8	6.5	15.4	14.4	2.8	0.9	13.0	3.9	3.1	1.3	5.3	0.7
Jauna	6.3	13.6	8.4	16.9	11.6	2.5	0.4	11.8	2.5	1.8	0.9	5.6	0.8
Jamon	5.9	13.4	8.8	18.5	12.8	2.3	0.8	10.9	4.7	1.6	1.4	5.9	0.6
Monro	6.7	14.0	8.2	16.2	14.7	3.1	0.5	12.7	3.1	1.3	0.8	5.1	0.6
Splendide	5.2	13.8	6.5	15.4	14.4	2.8	0.9	13.0	3.9	3.1	1.3	5.3	0.7

(Singh *et al.,* 2013).

Fig. 2. Jamon cultivar.

Fig. 3. Monro cultivar.

Fig. 4. Geronimo cultivar.

Geronimo, a newly released mono-germ fodder beet that farmers can expect +/- 17% dry matter from, Geronimo's origins trace back to France. This variety is distinguished by its yellow-orange tankard-shaped bulb and is well-known for its resistance to diseases like rhizomania, ramularia, and mildew (Fig. 4). Versatile across various grazing applications, it can be grazed in-situ, lifted or fed whole, or chopped (Anonymous, 2020).

Others : Splendide (orange), Jauna (yellow), and multigerm hybrid JK Kuber (red).

Agronomic management practices : It is a halophytic and Na- salts scavenger C_3 plant with a high tolerance to salinity and alkalinity but performs poorly in acidic soils, which causes physiological yellowing (Lv *et al.,* 2019; Khan *et al.,* 2020; and Rozema *et al.,* 2014). Fodder beet is a 6-7 month crop, can be sown anytime in October-November months and harvested in April-June (Salama and Zeid, 2017). Sowing and harvesting dates are reported to significantly affect the crop's yield and quality (Matthew *et al.,* 2011). Multigerm varieties that give 3-4 seedlings from a single seed are sown at 2.0 to 2.5 kg per hectare to obtain an optimum population of 1,00,000 plants per hectare (Singh and Garg, 2012). Sowing is done by dibbling manually, the seed is placed on sides of ridges at a depth of 2 to 4 cm, and 20 cm distance between the plants or on raised beds in row-to-row distance of 40-60 cm and plant to plant distance 20-25 cm after sowing, light irrigation is given (Khan, 2013; Saini and Brar, 2017 and AL-Jbawi *et al.*, 2014). Fodder beet requires 150 kg N / ha + 60 kg P_2O_5 / ha + 60 kg K_2O, zinc Sulphate 25-30 kg, and borax 20 kg/ha applied in Zn and B deficient soils (Singh and Garg, 2012). About 25 tonnes FYM/ha + 100 Kg N/ ha + 75 kg P_2O_5 per ha is recommended. If FYM is unavailable, the fertilizer N dose should be increased to 150 kg/ha (Source: ICAR-CAZRI, 2020). Increasing nitrogenous fertilization increases the dry matter yield and crude protein content of fodder beet (Zamfir *et al.,* 2001).

Harvesting management operations : De-topping**:** The leaves of plants subjected to harvest during late May-June can be cut 5-7.5 cm above the root portion and fed to the animal from March to April. It provides additional fodder and helps in controlling damaging foliage insects. After de-topping, an extra 25 kg/ha N dose can give faster leaf re-growth.

Uprooting : Normally, the uprooting of the fodder beet can be started at 120 DAS (end of January month); at this stage, the average weight of root is around 1.5-2 kg/plant, and the crop can be maintained in the field up to mid-June. The crop roots can be harvested manually by pulling up and chopping into small pieces mixed with dry fodder. The dosages are 12 to 20 kg/animal per day to cows and buffaloes and 4 to 6 kg/animal per day to small ruminants. Start feeding with a small quantity with a progressive increase to reach the average feeding amount by ten days. It should not exceed 60% of the total dry matter requirement of the animal. Excess feeding may cause acidity in the animal (ICAR-CAZRI, Jodhpur). Salama and Zeid (2017) observed that the fiber fractions (NDF, ADF, and ADL) increase while digestibility (IVTD and NDFD values) decreases with plant age at harvest.

Productivity and Profitability analysis : Yields about 50-75 tonne of fresh roots/ha are familiar, and up to 100 tonnes of roots/ha can be obtained (Shalaby *et al.,* 1989; Al Jbawi *et al.,* 2009 and Singh and Garg, 2013). The crop also produces 10-20 t/ha of leaf material (Draycott *et al.,* 2003). Reported dry matter yields are typically around 20 tonnes (15 t/ha bulb DM

and about 5 t/ha leaf DM). With the recommended package of practices and prevailing conditions, the green fodder yield (root + foliage) of 150 to >200 t/ha can be achieved (Source: ICAR-Central Arid Zone Research Institute, Jodhpur, Rajasthan). An average yield of fodder beet cultivars under Indian conditions reported by Singh and Garg (2012) is shown in Table 3.

TABLE 3
Average yield (t/ha) of fodder beet cultivars under Indian conditions

Cultivars	16th March 2011			17th June 2011		
	Leaf	Root	Total	Leaf	Root	Total
Monro	27.0	97.5	124.5	11.0	130.0	141.0
Jamon	43.3	91.0	134.3	13.0	130.0	143.0
Splendide	46.5	81.0	127.5	8.0	120.0	128.0
Jk Kuber	27.5	81.0	109.0	8.0	50.0	58.0
Jauna	49.8	103.0	152.8	11.0	120.0	131.0
Average	38.8	90.8	129.6	10.2	110.0	120.2

(Singh and Garg, 2012).

Patel *et al.* (2019) studied the three-year average economics of fodder beet varieties grown during rabi season under coastal salt-affected soils, and J.K. Kuber secured the maximum net realization of Rs. 98,761/ha and BC ratio of 1.75 followed by J.K. Calixta with net realization Rs. 81,154/ha and BC ratio of 1.20. Patel *et al.* (2019) calculated the economic parameters of fodder sugar beet. They found that among two varieties, J. K. Kuber secured maximum net realization of Rs. 108353/ha and BC ratio value of 3.14, followed by J. K. Magnolia with the net completion of Rs. 98119/ha and BC ratio value of 2.94.

Environmental impact of Fodder beet :

- Beet crops are amongst the largest consumers of CO_2; they also release the highest amounts of O_2 (Kerten, 2003).
- It has the potential for vegetative bioremediation of salt-affected soils where water is scarce for leaching (Tarek *et al.,* 2008 and Tarek *et al.,* 2013).
- It is also a potential crop for biofuel production (Henry, 2010) and
- Recently, recommended as a source of biomethane due to its high fresh matter yield and digestibility (Laufer *et al.,* 2016).

CONCLUSION

Fodder beet is a high-yielding fodder crop that can be grown successfully under Indian subtropical climatic conditions on coarse texture salt-affected soils with poor quality water. It is a nutritious crop that can be treated as forage concentrate as it contains 10-15% dry matter, up to 60% sugars, high metabolic energy value (12-13 MJ ME/kg DM), a rich source of minerals (calcium and phosphorus) and water, low fiber and crude protein in its fodder makes them more palatable and digestible. Fodder beet cultivation has improved the milk productivity of small farms in arid and semi-arid regions of India during hot summer. It is a potential crop for silage making with maize and oats, biofuel production, and vegetative bio-remediation of salt-affected soils. It is recommended as a source of biomethane and the most prominent consumer of atmospheric CO_2. Many fodder beet cultivars are available worldwide and are mostly grown under temperate conditions. Cultivars like JK Kuber, Jamon, Monro, Splendide, Jauna and Geronimo are the most promising in India. Hence, there is a need to identify these cultivars' yield potential with good crop husbandry under subtropical Indian conditions. Therefore, considering the significance and potential of fodder beet, great efforts are needed towards its utilization and extension as a fodder crop among Indian farmers.

REFERENCES

Abdallah, E. F. and A. A. Yassen, 2008 : Fodder Beet Productivity under Fertilization Treatments and Water Augmentation. *Australian Journal of Basic and Applied Sciences,* **2**(2): 282-287.

ADBFM, 2009 : La betterave fourragère de A à Z. Association pour le Development de la Betterave Fourragère Monogerme, Paris.

Ajai, A., A. S. Arya, P. S. Dhinwa, S. K. Pathan and K. G. Raj, 2009 : Desertification/land degradation status mapping of India. *Current Science*, **97**: 1478-1483.

AL-Jbawi E. M., M. Bagdadi and Y. Nemr, 2014 : The effect of plant spacing on some quality traits of fodder beet (*Beta Vulgaris var. crassa*) varieties. *International Journal of Environment*, **3**(3): 286-293.

Al-Jbawi, E. M., S. Al-Jeddawy, M. Yabrak and S. Khuja, 2009 : Sugar Beet. Publications of the Directorate of Agricultural Extension, Ministry of Agriculture and Agrarian Reform, Syrian Arab Republic. No, (482), 33 pages.

Annual Report, 2017-18 : ICAR-Indian grassland and fodder research institute, Jhansi, India. 1-137.

Annual Report, 2018-19 : Department of Animal Husbandry, Dairying and Fisheries, Ministry of Agriculture and Farmers Welfare, Govt. of India.

Anonymous 2006 : http:// www. Seed 2 grow. Co. U.K./ acatalogy/Fodder-Beet- seed. Himl.

Anonymous 2019 : Department of Animal Husbandry and Dairying releases 20th Livestock Census. http:// pib.gov.in.

Anonymous 2018 : Fodder beet guide. Agricom.co.nz.

Anonymous 2020 : Agronomy guides & advice by Catalyst Performance Agronomy. https:// catalystag.co.nz/guides-and-advice/fodderbeat-varieties-best-practise.

Anonymous 2021 : Fodder beet. www.dairynz.co.nz.

Behera, U.K. and J. France, 2016 : Integrated farming systems and the livelihood security of small and marginal farmers in India and other developing countries. *Advances in Agronomy* **138** : 235-82.

Bozinviya, A., 2019 : Supplementing grazing dairy cows with crops: fodder beet and oats, to improve milk production and nitrogen utilization: A thesis submitted in partial fulfilment of the requirements for the Degree of Doctor of Philosophy at Lincoln University.

Brithal, P. S. and A. K. Jha, 2005 : Economic losses due to various constraints in dairy production in India. *Ind. J. Anim. Sci.,* **75**(12) : 1470-1475.

Chaudhary, D. P., S. L. Jat, R. Kumar, A. Kumar and B. Kumar, 2014 : Fodder quality of maize: its preservation. (in) maize: nutrition dynamics and novel uses, 153.

Claridge, J. H. and J. W. Hatfield, 1972 : Arable farm crops of New Zealand. Department of Scientific and Industrial research in association with A.H. and A.W. Reed, Wellington. pp. 345.

Clark, P., D. I. Givens and J. M. Brunnen, 1987 : The chemical composition, digestibility and energy value of fodder-beet roots. *Animal Feed Science and Technology,* **18**(3): 225-231.

Conference on Animals, fish and poultry production. Alexandria, Egypt, **13** : 133-143.

Dalley, E. D., J. P. Edwards and R. R. Woods, 2020 : Impact of winter fodder beet or kale allocation on body condition score gain and early lactation performance of dairy cows. *J. New Zealand Grasslands*, Vol. 82.

De Brabander, D., S. De Campeneere, I. Ryckaert, and A. Anthonissen, 2012 : Dairy cattle feeding. ILVO Announcement 101,112 p. In Dutch.

Draycott, A. P. and D. R. Christenson, 2003 : Nutrient for sugar beet production: Soil-Plant relationship. CAB International, Walling ford, U.K.

Dulphy, J. P., S. K. Moklet and C. Demarquilly, 2000 : Fodder beets in animal husbandry. Fourrages, **163** : 307-314.

Duncan, A., P. Frutos and S.A. Young, 1997 : Rates of oxalic acid degradation in the rumen of sheep and goats in response to different levels of oxalic acid administration. *Animal Science* **65**(3): 451-45.

E.F. Abdallah and A.A. Yassen, 2008 : Fodder Beet Productivity under Fertilization Treatments and Water Augmentation. *Aust. J. Basic and Appl. Sci.*, **2**(2) : 282-287.

El-Sarag, E. I., 2013 : Response of fodder beet cultivars to water stress and nitrogen fertilization in semi-arid regions, *American J. of Agric. & Environ. Sci.,* **13** : 1168-1175.

Fodder Beet : A high yielding green fodder crop gaining popularity in arid regions, 2020. ICAR-Central Arid Zone Research Institute, Jodhpur, Rajasthan.

Ghulam, M., 2008 : Enhancing land and animal productivity with cereal-legume combinations of improved fodder crop varieties under irrigation in Pakistan. International Centre for Agricultural Research in Dry Areas (ICARDA).

Henry, K., 2010 : Fodder beet. In: Bradshaw, J. E. Handbook of plant breeding, vol 7.

Hopp, W. J. and M. P. Oyen, 2004 : Agile workforce evaluation: a framework for cross-training and coordination. *Lie Transactions*. **36**(10): 919-940.

http://www.betteravefourragere.org/doc/Betterave%20Fourragere%20AZ%20V7.pdf.

Ibrahim, Y. M., 2005 : Ranges and forage (In Arabic). Dar Azza for Publication, Khartoum, Sudan. pp. 300.

Kerten, J.L., 2003 : La betterave fourragère, une culture oubliée? In: La betterave fourragère chez vous? Après-midi d'étude du 3 décembre 2003 consacrée à la betterave fourragère organisée par le Centre Agricole « Fourrages Mieux » à la ferme Expérimentale et Pédagogique de Ath, Belgique. http://www.fourragesmieux.be/betterave.htm.

Khan, M., 2013 : Sugarbeet production guide. NDSU Extension Service, North Dakota State University of Agriculture and Applied Science, and U.S. Department of Agriculture cooperating. Duane Hauck, Director, Fargo, North Dakota. pp. 9.

Khan, S. U., Z. A. Gurmani, W. Ahmed, S. Ahmed and A. Gul, 2020 : Production and salinity tolerance of fodder beet (*Beta vulgaris L. ssp. Maritima*). Book–Plant stress physiology.

Khogali, M. E., Y. M. I. Dagash and M. G. EL-Hag, 2011 : Productivity of fodder beet (*Beta vulgaris var. Crassa*) cultivars affected by nitrogen and plant spacing. *Agric. and Biol. J. North America*, **2**(5): 791-798.

Langer, R. H. M and G. D. Hill, 1982 : Agricultural plants. Cambridge University Press, Cambridge. pp. 344.

Laufer, D., O. Nielsen, P. Wilting, H. J. Koch and B. Märländer, 2016 : Yield and nitrogen use efficiency of fodder and sugar beet (*Beta vulgaris* L.) in contrasting environments of North-western Europe. *European J. Agron.*, **73** : 124-132.

Limagrain, 2011 : Fodder beet. http://www.limagrain.co.uk/products/fodder-beet.html.

Lv, X., S.Chen and Y. Wang, 2019 : Advances in Understanding the Physiological and Molecular Responses of Sugar Beet to Salt Stress. *Frontier in Plant Science*, https://doi.org/10.3389/fpls.2019.01431.

Matthew, C., N. J. Nelson, D. Ferguson and Y. Xie, 2011 : Fodder beet revisited. *Agronomy*, New Zealand, **41** : 39-48.

Nadaf, S. K., Y. M. Ibrahim, M. Akhtar, M. G. El-Hag and A. H. Al-Lawati, 1998 : Performance of fodder beet in Oman. *Annals of Arid Zone,* **37** : 377-382.

Niazi, B. H., J. Rozema, R. A. Broekman and M. Salim, 2000 : Dynamics of growth and water relations of fodder beet and sea beet in response to salinity. *J. Agron. & Crop Sci.,* **184** : 101-109.

Patel, K. R. and M. M. Patel, 2019 : Effect of integrated nutrient management on growth, yield, quality and economics of fodder sugar beet (*Beta vulgaris*) varieties. *Int. J. Curr. Microbi. and Appl. Sci.,* **8**(1).

Patel, M. M., H. K. Joshi, V. A. Patel and V. P. Usadadia, 2019 : Effect of irrigation schedules on growth, yield, wue and economics of fodder sugar beet (*Beta vulgaris* L.) varieties under coastal salt affected soils. *Forage Res.,* **45**(1) : 47-50.

Rees, D. H. and M. H. Westmacott, 1956 : The feeding of fodder beet to pigs. *J. Agric. Sci.,* **47** : 232-237.

Rozema, J., D. Cornelisse, Y. Zhang, H. Li, B. Bruning, D. Katschnig, R. Broekman, B. Ji1 and P. Bodegom, 2014 : SPECIAL ISSUE: Physiology and Ecology of Halophytes–Plants living in salt-rich environments comparing salt tolerance of beet cultivars and their halophytic ancestor: consequences of domestication and breeding programmes.

Saini, K. S. and N. S. Brar, 2017 : Sugarbeet ((*Beta vulgaris*) yield response to varying planting methods, densities and depth of sowing under subtropical conditions. *The Bioscan,* **12**(3): 1715-1720.

Salama Heba, S. A. and M. Zeid Mahmoud 2017 : Fodder beet (*Beta vulgaris* L.) yield and quality attributes as affected by sowing date, age at harvest and boron application. *Alexandria Science Exchange Journal,* **38**(1).

Shalaby, A. S., A. M. Rammah, G. M. Abdul-Aziz and M. G. Beshay, 1989 : Fodder beet, a new forage in Egypt. Productivity and the chemical analysis of some Fodder beet (*Beta vulgaris* L.) cultivars sown at different locations in Egypt. In proceedings of the third Egyptian British.

Shankarnarayan, K. A., L. N. Harsh and S. Kathju, 1987 : Agroforestry in the arid zones of India. *Agroforestry Systems,* **5** : 69-88.

Singh, D. and A.K. Garg, 2012 : Fodder beet- A promising fodder crop for dairy animals. *Indian farming,* **61**(10) : 10-13.

Singh, R. K., A. K. Sharma, R. K. Singh and B. Prakash, 2013 : Problems and prospects of sugarbeet cultivation as fodder crop in subtropical India. Souvenir 28 & 29th May, by-Nainital Organized by Indian Institute of Sugarcane Research (ICAR), Sugarbeet Breeding Outpost of IISR IVRI Campus, Mukteswar-263138.

Srinivasarao, Ch., B. Venkateswarlu, R. Lal, A.K. Singh and S. Kundu, 2013 : Sustainable management of soils of dryland ecosystems of India for enhancing agronomic productivity and sequestering Carbon. *Advances in Agronomy,* **121** : 253-329.

Tanwar, S. P. S., A. Singh, S. M. Deb, V. Khandelwal and B. S. Jodha, 2013 : Fodder beet – a nutritive and high yielding fodder crop suitable for salt affected soils of arid regions. *Annals of Arid Zone,* **52**(1) : 23-25.

Tarek, G. A., B. T. Alaedeen, H. M. Saoub, B. I. Hattar and Y. A. Al-zu'bi, 2008 : Salt removal efficiency as influenced by phyto-amelioration of salt-affected soils. *J. Food, Agric. and Envir.,* **6**(3&4) : 456-460.

Tarek, G. A., S. Al-Hiary and M. Al-Dabbas, 2013 : Reclamation of saline calcareous soils using vegetative bioremediation as a potential approach. *Archives of Agronomy and Soil Science*, **59**(3) : 367-375.

Vision 2050- IGFRI (ICAR), Jhansi. www.igfri.res.in.

Waghorn, G. C., K. Collier, M. Bryant and D. E. Dalley, 2017 : Feeding fodder beet (*Beta vulgaris* L.) with either barley straw or pasture silage to non-lactating dairy cows. N*ew Zealand Veterinary Journal,* **66**(4) : 178-185.

Zamfir, I., M. C. Zamfir A. Dihoru and E. Dumitru, 2001 : The long-term fertilization influence on both fodder beet yield and some features of argilluvial chernozem from Burnas plain. AnaleleInstitutului de Cercetari pentruCerealesi PlanteTehnice, Fundulea, **68** : 289-299.