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MAIZE FODDER PRODUCTION UNDER CHANGING CLIMATIC SCENARIO FOR NUTRITIONAL SECURITY OF LIVESTOCK– A REVIEW

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SUMMARY

The scarcity of fodder availability along with increasing demand of livestock products when integrated with ill effect of climate change, further decreasing fodder productivity in response to increasing emissions of green house gaseous. In future, these threats will raise challenges in quality fodder production. To meet out the desired level of livestock production and its annual growth, the deficit in components of fodder, crop residues and feed has to be solved out either by increasing productivity, utilizing untapped feed resources, increasing land area or through the adoption of some innovative strategies. Maize, being one of the most adaptable emerging crops having wider adaptability under varied agro-climatic conditions, has been proved superior in terms of green fodder quality and silage making, as it provides very palatable, highly succulent and nutritionally rich fodder to livestock which is free from anti-metabolites. Despite technological advancement in breeding programmes, fertilizers and irrigation management systems, the climate is a key aspect in quality fodder production. To mitigate the ill effects of changing climate, conventional approaches of crop production needs to be altered and inventive adaption policies required to be in place. Potential adaptations can be achieved by improving irrigation efficiency and altering sowing time or introducing new genotypes with higher thermal accumulation efficiency. Hybrids with resistant traits to various biotic stresses have been identified and evolved. Furthermore, genotypes adaptable to new geographical area with different environment conditions have to be identified and explored to withstand with climate change.

Key words : Maize, quality fodder, nutrition, climatic scenario, adaptation

The agricultural production systems are based upon mixed farming in which the two major enterprises are crops and livestock. Farmers combine these two enterprises to diversify the use of available resources for maximizing family income. Livestock production is a source of employment and backbone of country contributing 4% to National GDP and in rural areas a fountain of livelihood for 70% of the population. Global population is projected to be 9.7 billion and more than half of this projected increase in the world population will be concentrated in just nine countries, maximum being in India, which is expected to add nearly 273 million people by 2050. Current projections indicate that India will surpass China as the world's most populous country around 2027. After this re-ordering, India is expected to remain the world's most populous country with nearly 1.5 billion inhabitants (Anonymous, 2019). The demand for livestock products was increased due to marked shift in the lifestyle of people in feeding habits towards milk products. The production as well quality of fodder is to be enhanced to cope up with the ever increasing demand of the livestock products. Although, the increasing demand and cultivation of cereal and other cash crops has, in fact, assisted towards a decline in the area under fodder crops. Hence, there is a tremendous pressure of livestock on available feed and fodder, as horizontal expansion seems difficult for more fodder production. To meet the desired level of livestock production, the deficits in fodder components that is to the tune of 35.6, 11.0 and 44.0 per cent for green fodder, dry crop residues and concentrate feed ingredients has to be fulfilled either by increasing productivity potential, managing untapped feed resources, horizontal expansion or through implementation of some innovative approaches. Green fodder is the rich and cheapest source of protein, vitamins, carbohydrates and minerals for livestock (Anonymous, 2013). In our country significance of fodder is well recognized as over 60% of the cost of milk production alone accounts by its feeding. Hence, the cost of milk production can be significantly reduced by providing adequate quantities of fodder as a substitute to the costly concentrates and feeds.

Maize (*Zea mays* L.) is one of the most adaptable emerging crops having wider adaptability under varied agro-climatic conditions. It is commonly referred as 'Queen of Cereals' or the miracle crop due to its higher yield potential which is far better than any other cereal crop. It is an important *kharif* and summer forage crop grown throughout the country which provides very palatable, highly succulent and nutritionally rich fodder to livestock. As green forage, particularly when it contains the leaves and ears, stalks, it is an energy-rich source of feed for ruminant livestock, while maize forage is usually ensiled in cooler regions, year-round maize production in the tropics may allow the continuous harvesting of green forage, making ensiling unnecessary (Brewbaker, 2003). It is quick growing high yielding and supplies essential nutrients which can be fed at any stage of growth without any risk to animals as it is free from anti-metabolites. It can be fed as green or dry and is most favourable for silage making. It produces good quality herbaceous fodder with high palatability. On an average, when it was harvested at milk to the early-dough stage, it contains 9-10% crude protein (CP), 60-64% neutral detergent fiber (NDF), 38-41% acid detergent fiber (ADF), 23-25% hemi-cellulose, and 28-30% cellulose on the dry matter basis. Grazing whole maize plants also contribute as a source of green fodder to livestock in scarcity periods (Potter, 2012; Newport, 2006). In areas where conditions are unsympathetic and forage is scarce, maize is a valuable source of nutritional fodder for smallholder owned stock (Methu *et al.*, 2006). Maize is an energy-rich feed, better than most other tropical forage crops, of which the dry matter is often below 40% digestible. In tropics, although grass forages must be harvested almost monthly, maize forage matures within three months, is harvested only once, and does not require much labour and high machinery costs (Brewbaker, 2003). Fresh green fodder yields of maize range from 10 to 50 t/ha (FAO, 2016) whereas, yields obtained from baby corn crops range from 31 to 46 t/ha (21-25 t DM/ha) (Chaudhary *et al.*, 2012).

Recently, advances in plant and animal breeding, scientific innovation and introduction of new genotypes with the adoption of improved management practice has made it possible to improve livestock performance. Despite, for this to be realised, there must be an extra focus on fodder quality with additional nutritional values. Forage quality is the most important but is usually poorly understood. Although imperative, forage quality usually receives far less attention than it deserves. It is the extent to which forage has the capability to produce the desired animal response. Adequate animal nutrition is pre-requisite for high rates of weight gain, ample milk production, efficient reproduction and adequate returns. However, the quality of green fodder varies significantly between different fodder crops. Many factors are responsible for forage quality. These comprises of palatability, digestibility, intake, nutrient composition, anti-nutritional components like tannins, nitrates, alkaloids, oxalates, estrogens and mycotoxins etc. and lastly but more importantly animal capacity, a test of forage quality (Ramteke *et al.*, 2019). The cost of milk production is largely depends upon the quality of nutritious fodder fed to animals. Maize having higher yield potential with biomass yields of 400-500 quintal per hectare as one of the most crucial non-legume fodder crop which is highly nutritious, palatable, digestible and free from anti-nutritional components. It is a rich source of protein for livestock with constitutes sufficient quantities of soluble sugars critical for proper ensiling. In this review, maize as a quality fodder for its nutritional security of livestock and potential to withstand climate change is discussed.

Fodder production

In livestock production fodder production is the most crucial part. It not only decreases the feeding cost but also keeps livestock healthy, meets micronutrient requirements and ultimately enhances milk production. They usually contain considerably higher quantity of cellulose, hemicelluloses and lignin with variable amounts of non-fibrous carbohydrates and proteins. These crops are require by livestock to get energy as well as nutrients *viz.* protein, vitamins, minerals, fibre and water for their proper growth and maintenance, and optimum performance. There are many legume and non-legume fodder crops available for cultivation. Genotypes having characteristics like short duration, leafy with higher biomass accumulation, tasty, palatable and highly nutritious, suitability for preservation and free from anti-nutritional compounds are the prerequisite for ideal fodder.

Maize as a quality fodder

Maize considered as third most important food crop after rice and wheat with highest per day productivity. In terms of biomass production it is a fabulous crop as the production and productivity of maize is increases, its biomass is also increase in same proportion. The fodder quality of maize is considered superior among different non-leguminous forage crops (Table 1). It is considered ideal due to several characteristics like quick growing nature, higher yield potential, palatability, rich in essential nutrients, and helps to stimulate growth and milk quality in cattle (Sattar *et al.,* 1994). As a fodder for livestock, it is excellent source of higher nutritive value and sustainable for livestock production (Hukkeri *et al.,* 1977, Iqbal *et al.,* 2006). In India, it is commonly grown as a kharif fodder crop in the north-western regions. Its posse's quality which is superior than sorghum and pearl millet, as both crops having anti-quality factors such as hydrocyanic acid and oxalate, respectively (Nkhata *et al.,* 2018).

Nutritive value of maize

Maize grain contains high energy value due to its high starch and oil content with low fibre. It contains 85 to 90% total digestible nutrients, 8 to 12% protein, 4% oil and 70% starch content. Maize starch composed of 75% amylopectin and 25% amylase. The starch in maize grain is digested easily as compared to other grains by rumen and a proportion of which digested and absorbed in the form of glucose. It is also contains vitamin E, while low in B complex vitamins and vitamin D (NDDB, 2012).

Fodder quality of maize

Higher biomass accumulation with significant concentration of protein are the desirable characteristics for ideal forage which include higher digestibility, optimum intake potential *i.e.* low fibre content, and higher dry matter production for adequate fermentation potential (Carter *et al.*, 1991). Due to its identified potential as quick growing, high production, palatability and sufficient nutrient content it is referred as ideal quality fodder crop. It is the most valuable fodder crop without any anti-quality factors which can be grown throughout the year in both seasons. It is commonly grown as a *kharif* fodder in the north-western regions of India. Its quality is much better than sorghum and pearl millet, since both sorghum as well as pearl millet possess anti-quality components such as hydrocyanic acid and oxalate, respectively (Chaudhary *et al.*, 2014). It contains high concentrations of protein and minerals and possesses high digestibility.

The speciality of maize as fodder

Maize is also cultivated for some special purpose is called speciality maize *viz.,* sweet corn, baby corn and popcorn besides for grain and fodder purpose. The area of this is gradually increasing, mostly in the peri-urban regions of the country. Baby corn is very delicious and nutritious food, considered to be a very high-value agriculture produce for the country. The export potential of baby corn provides a boost to its cultivation further. Many other valuated products prepared from sweet corn and baby corn is being utilised for market consumption. A considerable amount of biomass production is attaining from speciality maize cultivation that can effectively be utilised as livestock food. Productivity and nutritional quality of some potential varieties *i.e.* JH-3459, PMH-2 and Parkash cultivated for baby corn, compliment its uses as fodder along with most favourable maize

TABLE 1
Comparative nutritional quality of non-legume fodders

Name of Fodder crop	Physiological stage	Harvesting stage-days after sowing (DAS)	Crude protein content (%)	IVDMD content (%)
Maize	Silk to milk stage	55-65	8-11	52-68
Pearl millet	Boot stage	45-55	7-10	55-62
Sorghum	Initiation of flowering to 50% flowering	70-80	7-8	57-60
Teosinte	Pre-flowering	80-85	7-9	58-62
Sudex	Subsequent cutting after 30 days	65-70	7-11	55-60
Napier Bajra Hybrid	1 m height and subsequent cutting after 30 days	55-60	7-11	55-60
Guinea grass	1 m height and subsequent cutting after 25-30 days	55-60	8-10	57-60

Source: Gupta *et al.* (2004).

genotypes, *viz.*, Vijay composite, African Tall, Moti composite, Ganga-5 and Jawahar for fodder production. Maize varieties namely J-1006 (PAU, Ludhiana), African tall (MPKV, Rahuri) and APFM 8 (ANGRAU, Hyderabad), Pratap Makka Chari-6 (MPUAT, Udaipur) are identified and released for economical cultivation in country. The nutritional quality of baby corn stalks is almost the same as with the maize grown for fodder purpose. Although biomass production from baby corn stalks was reduced as compared to fodder maize J-1006 and African tall. Baby corn is as important as fodder maize in terms of fodder value when compare (Chaudhary *et al*., 2016).

Ensiling of maize

Maize is an admirable crop potentially utilized for ensiling having high energy value. The crop might possess adequate quantities of soluble carbohydrates and moisture that are converted into lactic acid through fermentation process. Maize is most suitable for ensiling as it grown for fodder and baby corn purpose have the desired level of moisture and soluble sugars. Maize silage is very important for dairy animals. Maize is an important fodder crop due to its higher yield outcome and aptitude to compose admirable silage. Higher milk production was recorded with better silage dry mass consumption when cows take corn silage as compared to the cows which used sorghum silage (Lance *et al*., 1964). Lactating dairy cows which need high energy food for enhanced milk production need corn silage (Marsalis *et al*., 2010; Irlbeck *et al*., 1993). Griffiths *et al*. (2004) used Milk line score (MLS) to determine the proper stage of harvesting of maize crop. The MLS varies from 0 (no visible milk line at the tip of kernel) to 5 (the milk line reaches the base of the kernel and a black or brown layer forms across it). Maize is best suited to be ensiled when the grains are in the milking stage or at 2.5 milk line score (MLS) *i.e*. the milk line is halfway down the grain, is considered best stage to harvest maize for silage (Kumar *et al*., 2019). Brar *et al.*, (2017) reported that for making good quality silage, harvest the crop at proper stage, when the nutrient contents are at peak *i.e*. when the grains are in dent stage or near 2.5 MLS.

Silage quality

The physical state is a measure of silage quality *viz.*, colour and aroma. The colour of superior quality silage should be light brown with smell of vinegar. Due to synthesis of butyric acid in scantily fermented silage it will be dark in colour with foul smelling. Quality silage should have the subsequent features chemically (a) pH < 4.2 (b) Ammonical nitrogen of total N < 10.0 % of total N; (c) Butyric acid < 0.20 %; and (d) Lactic acid 3.0-12.0 %. Thus, it is a nutritional rich crop having potential to be used as livestock food. Maize silage has the capability for decreasing fodder scarcity and provides essential nutrient that will expand the dairy farming in the country. The possibility of reducing dry matter (DM) and quality losses during the ensiling process requires knowledge of how to measure losses on farm and establish the status of the silage during the feed-out phase, implementing the most effective management practices to avoid air exposure during conservation and reduce silage aerobic deterioration during feeding (Borreani *et al*., 2018).

Deleterious effect

Maize is free from anti-nutritional and toxic components. However, it contains some mycotoxins which are problematic in livestock feeding. Aflatoxin is the major mycotoxins formed by the mold Aspergillus flavus. They infect maize in the field as well as in storage. Insect and other stresses attacks further aggravate the infection. Ruminants such as cattle, sheep and goats are less known for their sensitivity to the negative effects of mycotoxins than are non-ruminants. However, production, reproduction, and growth can be altered when ruminants consume mycotoxin-contaminated feed for extended periods of time (Hussein and Brasel, 2001)

Fodder production under changing climatic conditions

Fodder production is largely dependent on local environmental conditions determined by a set of meteorological parameters. Thus, assessing the impending impact of climate change and variability on forage-based cropping systems has become vital. Despite technological advancement in breeding programmes, fertilizers and irrigation management systems, the climate is a key aspect in agricultural fodder production. To ensure feed availability in future, it is required to find underperforming regions to perform better and assess change in fodder productivity in high-performing regions in response to climate change and variability. Anthropogenic and naturogenic emissions of greenhouse gases will continue to accelerate climate change and impact on fodder production as a whole. Acknowledging the existence of regional differences in climatic, geographic, and socioeconomic conditions, understanding the overall potential and the magnitude of the climate change effects on maize fodder production and proposing advanced risk mitigation strategies are essential for national livestock security. The cost-efficient risk mitigation and management strategies to combat the potential reduction in fodder maize production contribute to the availability of quality fodder.

It is essential to understand the mechanisms of the impacts of climate change and the effectiveness of adaptation measures to withstand fodder maize production. The adaptation appraise *i.e.*, date of sowing, switching to late-maturing cultivars, and improvement in cultivars traits with high thermal requirements could be prerequisite to withstand under climate change impacts to varying levels; switching to the desired genotype may exert the most significant effect on increasing fodder maize yields.

Fodder maize under changing environmental

As a C_4 plant, maize is characterized by a specific photosynthetic pathway as a CO_2 concentrating pump. It is typically CO_2 saturated in the current atmosphere, which results in almost saturated photosynthesis due to the current high CO_2 concentration (Ghannoum, 2009; Kimball *et al.*, 2002). The increased atmospheric CO_2 concentration is well known to decrease stomatal conductance for all plants (Kimball *et al.*, 2002; Leakey *et al.*, 2006; Tebaldi and Lobell, 2008) and hence reduce transpiration, which could help to improve water use efficiency and to resist drought stress. All these indicate that increased CO_2 could not exert a direct influence on maize photosynthesis. If water is a limiting factor for maize production, increased CO_2 concentration would increase yield; when water is not a limiting factor, the CO_2 fertilization effect would not be significant (Babel and Turyatunga, 2014). However, increased temperature leads to an increase in the rate of crop development and as a result shortening in the growth period, which would lead to reduction in yield (Abraha and Savage, 2006; Moradi *et al*., 2012; Xu *et al*., 2017).

The negative impacts of climate change on crop production could be reduced by adaptation measures such as changing planting date (Babel and Turyatunga, 2014; Lashkari *et al*., 2012; Soler *et al*., 2007), switching cultivars (Wang *et al*., 2011; Tao and Zhang, 2010), breeding new cultivars (Xu *et al*., 2017), irrigation management (Babel and Turyatunga, 2014; Moradi *et al*., 2012), and soil nutrient management (Bryan *et al*., 2013). Increased the atmospheric CO_2 concentration is well adaptation is a key factor in mitigating the negative impacts of climate change on crop production in the future (Porter *et al*., 2014; Tao and Zhang, 2010). The other possible adaptations are the selection of planting method, identifying acquired varietal traits under the prevailing situation, improvement in machinery, plant protection measure, resource management, need based application of inputs, residue management, seed hardening etc. Breeding new cultivars with higher thermal requirements could be considered an effective adaptation measure to extenuate the negative effects of climate change on maize fodder yield. The three adaptation measures, switching the local cultivar to a later-maturing one with a longer growing period was the most effective measure to cope with the adverse impacts of a future warming climate. Additionally, under permitting conditions, a combination of several adaptation measures would generate a more significant increase in crop yield (Jin *et al*., 1998; Porter *et al*., 2014). It is not possible that a single factor control fodder production but, the combination of factors like genotype, management practices, weather conditions, and soil types that will make a forage system productive or non-productive.

A switch from crops and crop varieties are currently grown to others that are better adapted to

TABLE 2
Environmental impact of maize crop

Photosynthesis Pathway	Irrigation (mm)	Temperature (°C)	Sunshine (hour/day)	Duration of Growth (day)	Global Warming Potential (kg CO_2 eq./ha)	Carbon Equivalent Emission (kg C/ha)
C4	40-50	11-30	6-7	90-110	3427-17600	935-4800

(Source : Wang *et al.,* 2018).

new environmental conditions has been suggested as one possible adaptation strategy. The temperature of the earth's atmosphere will continue to increase in response to rising emissions of greenhouse gases. This will result in the uncertainty of rainfall, melting of glacial mass and extreme weather events (Raza *et al*., 2019; Kang *et al*., 2009). The alarming speed of climate change, combined with depletion of natural resources and increasing population intimidate food security.

Impact of climate change on crop production

The Intergovernmental Panel on Climate Change (IPCC, 2007) described the overall impact of climate change on agriculture which is as follows:

1. Rise in average temperature (Kang *et al*., 2009) :

a. Enhanced yield outcomes in response to the lengthening of the growing period in high latitude temperate regions
b. In low latitude subtropical and tropical regions where summer heat is already limiting productivity, it further reduced it.
c. Lower productivity due to an increase in soil evaporation rates.

2. Change in the amount of rainfall and patterns (Kang *et al*., 2009) :

a. It will influence soil properties like moisture and soil erosion rates which are of higher concern for crop productivity.
b. Rainfall will decrease in subtropical low latitude, whereas increase in high latitude regions. It will decrease by 20% leading to the occurrence of moisture stress and long drought spells in these regions.

3. Increasing CO_2 concentrations in the atmosphere (Raza *et al*., 2019)

It will increase the growth rate of some crops. The growth rate of these crops will be enhanced in response to beneficial effect of increase in level of CO_2. But it may be overcome by the other aspects of climate change *i.e*. increased temperatures and altering pattern of precipitation.

4. In tropospheric ozone degree of pollution (Raza *et al*., 2019) : The higher levels of CO_2 emission leads to rise in temperatures that will overcame the effect of enhanced growth behaviour of the crops due to higher CO_2 emission.

5. Alteration in severity and frequency of floods, heat waves, drought and hurricanes : It remains an important uncertain issue that may severally influence agriculture production and finally the overall outcome.

6. Agricultural systems affected by climatic changes : It may leads to increase occurrence of new diseases and insect-pests. Development of resistant in some existing pest in response to climate change.

Mitigation strategies for successful maize fodder production under climate change

To mitigate the ill effects of changing climate, conventional approaches of crop production demands to be changed and improved with inventive and novel adaption policies. There is a need to give attention for more efficiently production of food and fodder in unfavourable situations with improved agronomic practices and reduction in emission of greenhouse gases.

A. Maize phenology

Climate change also has an impact on maize phenology, as temperature changes influence the schedule of maize sowing, flowering, maturity days, CO2 fertilization effect and grain filling (Moradi *et al*., 2013; Wang *et al*., 2011; Wolf and Diepen, 1995).

1. Date of sowing

Spatially, the sowing date of maize will slightly advance in the future due to the warming trend in spring. Phenologically, the early sowing helps to prolong the maturity period of the current early genotypes and is a favourable change for achieving potential the yield of maize (Marcinkowski and Mikolaj, 2018; Liu *et al*., 2013).

2. Time of flowering

Similar to the changes in sowing date, there was also advancement in flowering time but with a more homogeneous pattern for the whole province (Craufurd and Wheeler, 2009).

3. Maturity days

Distinctive from the changes in sowing and flowering phases, the entire number of maturity days from sowing to harvest was predicted to shrink or lengthened depending on prevailing environment condition of particular site (Wang *et al*., 2011).

4. Grain filling period

Despite the advance in both sowing and flowering dates, the changes in the reproduction phase (periods after flowering, including tasseling and grain-filling) may contribute to most of the changes in maize phenology. It is likely that the length of reproduction period may be related to yield outcomes. The period of grain filling will bear direct effect on grain yield. As yield increases and quality improves with increase in the length of grain filling by fulfilling the time requirement of grain to grow and attain bolder size. While, decreases with decrease in the length of grain filling as plants will avoid the stress period by rapidly completing their life cycle which will force the plants to mature and the result of that grain remains shrinkled in size and inferior in quality and so on decrease the total productivity (Hatfield and Dold, 2018; Aprakut *et al*., 2011).

5. Effect of CO_2 fertilization

The increasing atmospheric CO_2 concentration was hypothesized to have positive influences on C_4 crop growth, due to the fact that it accelerates potential photosynthesis production (Kimball, 1983) and increases leaf stomatal resistance, which in turn reduces the evapo-transpiration (Hoogenboom *et al*., 1995). However, such a hypothesis of CO_2 fertilization was not supported by some studies based on open-air experiments (Leakey *et al*., 2006), and even in some confirmed cases, the observed yield increase was much smaller than expected (Leakey *et al*., 2009).

B. Potential adaptive strategy

The changes in dry spells and length of grain filling are the two main reasons for declining maize yield in response to climate change. Therefore, potential adaptations can be achieved by improving irrigation efficiency and changing the sowing time or introducing new genotypes (Wang *et al*., 2011; Zunfu *et al*., 2011) that require longer thermal accumulation in response to the predicted increases in the maize growth season.

1. Improved irrigation efficiency

It is obvious that the increase in effective irrigation helped to maintain the current maize yield in the future with response to climate change. The water required to keep yields at the baseline level can only be achieved with increasing irrigation efficiency by applying sprinkler/drip/hose irrigation system. Use of water efficient technologies like sub-surface irrigation system with minimum water looses will bear a great potential to withstand under changing climate. Other possible adaptation was achieved by giving life saving irrigation where there is limited irrigation water is available and more efficient use of water by adapting furrow system of irrigation based on evapo-transpiration (Moradi *et al*., 2013; Wang *et al*., 2011).

2. Altering sowing time and introducing alternative genotypes

In response to the warmer climate in future, shifting to an earlier sowing date may lessen the negative effects of high temperature on grain filling period, but its effect on maintaining production was not as high as expected. However, if postponing the sowing date to delay grain filling until late summer or early autumn with the optimal temperature for grain formation, the yield loss could be considerably reduced. In addition, the possibility of introducing new maize genotypes with a longer growing period than the existing ones will have potential to withstand changing climate. This indicates that changing sowing time and introducing new genotypes with desired traits is probably a better adaptation option to alleviate the anticipated reduction in maize production with response to warmer climate in future (Moradi *et al*., 2013; Zunfu *et al*., 2011).

C. Biotech crops for mitigating climate change:

To decrease the emission of greenhouse gases, biotechnology provides a solution to the problems. Hence, it overcomes the ill effect of climate change. These crops have been contributing by the reduction of CO_2 emissions for the last sixteen years of commercialization. They allow farmers to efficient and environmental friendly use of energy and fertilizer and practice soil carbon sequestration which built up soil organic carbon (Aslam *et al.*, 2020; Brookes *et al.*, 2018; Mtui, 2011).

Herbicide tolerant biotech crops that promotes residue retention with zero or no till will leads to decrease CO_2 emissions, loss of soil carbon and use of fossil fuel which ultimately reduce its erosion and save energy by sustainable use of available resources (Brookes *et al.*, 2018; Tesfahun, 2018; Mtui, 2011).

Biotech crops with insect resistant trait require less pesticide which significantly reduces the fossil fuel consumption with less emissions of CO_2 and have potential to withstand in changing climate (Brookes *et al.*, 2018; Tesfahun, 2018; Mtui, 2011).

D. Biotech crops as adaptive measure to climate change :

Crops trait can be modified rapidly by biotechnology means than conventional breeding, hence accelerating the practice of modification to fulfil the requirement under severe climate changes. Disease and pest resistant new biotech crops have been identified and evolved. These varieties require no or very less amount of pesticide which ultimately reduce emission of CO_2. Crops resistant to different types of biotech stresses have been identified and promoted in response to changing climatic scenario (Aslam *et al.*, 2020; Tesfahun, 2018; Mtui, 2011).

1. Salinity tolerant potential crops

The biotech crops with salt tolerant potential have been developed. Special genes are responsible for enhancing and development of tolerance to several types of biotic stresses (Pareek *et al.*, 2020; Raza *et al.*, 2019; Tesfahun, 2018; Mtui, 2011) including cold, salt, drought and low phosphorous. Several genes observed in different plants are responsible for salt tolerance. Developing salt tolerance in maize some of these genes may prove feasible.

2. Drought resistant traits in crops

Transgenic plants have been developed for water stress situation (Pareek *et al.*, 2020; Raza *et al.*, 2019; Tesfahun, 2018; Mtui, 2011). Several key enzymes or structural genes are being used for osmolyte biosynthesis. Transgenic crops having genes for drought resistant are being identified and promoted. An important inventiveness for identifying water efficient maize for the limited irrigation facility areas where crop entirely dependent upon rainfall. The genotypes with drought tolerant characters having protection against insect pest will be identified using marker assisted breeding and biotech modification could be accessible to the farmers.

3. Cold tolerance biotech crops

A numbers of related genes have been developed, promoted and utilized by using genetic and molecular advancement. The genes controlling *CBF* cold responsive pathway with *DREB1* genes when assimilate or unify several compounds of the cold acclimation due to tolerance of low temperatures (Tesfahun, 2018; Mtui, 2011).

4. Heat stress biotech crops

The recovery of crop plants during heat stress and drought period was related to the expression of heat shock proteins. These will stabilize and bind the proteins which undergo denatured under stress situation. This gave stability to restrict protein aggregation. The transgenic plants maintained higher photosynthetic capacity and elevated levels of photosynthesis related enzymes (Pareek *et al.*, 2020; Tesfahun, 2018; Mtui, 2011).

E. Other mitigating strategies to cope up with climate change

1. Adapting agriculture to climate change: the potential role of crop shift : The adoption of crops and crop cultivars more suited to new environment condition has been suggested as one possible adaptation strategy (Easterling *et al.*, 2007; Ortiz, 2011). Whereas, another potential but less explored strategy is the shift of already existent crop cultivars into adjacent geographic areas. Global warming has already responsible for latitudinal and altitudinal changes in the ranges of many wild species during the last decades (Parmesan, 2006; Parmesan & Yohe, 2003); yet research on corresponding shifts for agricultural species and cultivars remains more limited. A limited number of research studies have estimated geographical shifts in the suitability of growing situation for different crops under future climate scenarios. These suggest that the latitudinal growing ranges of different crops are likely to change in decades to come. It needs empirically based research on spatiotemporal changes in crop selection in relation to changes in climatic footprints. The study that clears altitudinal shifts in crops and crop cultivars through a case study of maize cultivation in different parts of the country.

2. Upward the shift in maize cultivation : Inter-communal variation in the previous and present limits of maize cultivation indicates that site-specific variation in climate and topography also influences the elevation range for growing maize. Maize has not completely replaced the crops already grown in the high zone, but rather presents an important addition in response to increment in the average temperature due to global warming.

3. Spatial shifts through time : The upward movement of maize has taken place in a stepwise fashion. Temperature is a limiting factor in the growth of different maize races (Brandolini *et al*., 2000), the elevation is an important regulator of their distribution in any particular area (Eagles & Lothrop, 1994; Timothy *et al*., 1963).

4. Seed sources and varietal adaptation : Farmers have procured seeds locally for growing maize at high elevations, either from their own or neighbouring communities at an intermediate elevation. Several farmers noted that it was necessary for the seed to get "accustomed" or "acclimatized" to grow in the high zone. Future research on local and regional patterns of seed provisioning as climate change proceeds will broaden our understanding of the capacity of existing seed systems to allow the movement of crops and crop varieties along with altered agro-climatic gradients. Second, farmers' observations of changes in seed performance at different altitudes over time bring attention to responses within populations, suggesting that the maize populations in question have been able to rapidly respond to new environmental parameters after being moved uphill. There is still limited scientific understanding of maize landraces' potential to adapt evolutionarily to climate change (Mercer & Perales, 2010). Yet, a growing body of research documents that plant populations across a number of other species has responded to climate change during recent years through phenotypic plasticity or evolution (Franks *et al*., 2014). Farmers' emphasis on the importance and effect of seed selection might suggest that at least some element of selection driven adaptation is at work. These migrated maize populations could yield interesting insights into possibly occurring plastic or evolutionary processes, advancing our understanding of the capacity and speed of adaptive change among maize landraces under climate change.

CONCLUSION AND FUTURE PROSPECTS

Maize is always praised for its several benefits as fodder, feed and food to livestock and human, which are directly related to ecological and economical upliftment of society. Besides serving as high-quality food and feed worldwide and allowing wider adaptability to varied agro-climatic conditions, fodder maize offers a host of other benefits. It is fast growing high yielding crop and supplies essential nutrients to the livestock. The current progress in quality fodder production does not really cater to the need of the livestock population, requiring increasing in the production as well as productivity of maize as a quality fodder. However, the increasing cultivation of cereal and cash crops has, in fact, contributed towards a decline in the area under quality fodder crops. Therefore, potential of maize as a quality fodder crop has been realised, which needs to be explored under different environment condition. To cope up with desired level of livestock production and its annual growth, the deficit in components of fodder, crop residues and feed has to be meet from either increasing productivity, utilizing untapped feed resources, increasing land area under quality fodder crops, efficient use of available resources, improved agronomic practices or through the adoption of some innovative approaches and adaptation and mitigation strategies to withstand the climate change. The emerging role of fodder maize crop becomes evident in enhancing crop productivity along with retaining nutritional and environmental quality.

Additionally, the importance of fodder maize in crop rotation, cultivation in summer season when other fodder crop is not available, cropping system intensification and diversification has also been explained in the text. Summing up, this article points out that maize have potential as green fodder crop with ample nutritional quality to withstand the changing climatic conditions.

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