A Study on Forage Sorghum (Sorghum bicolor L.) Production in Perspectives of White Revolution in Punjab, Pakistan: Issues and Future Options

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Abstract: Forage sorghum is considered to be the most heat and drought resistant summer forage with a fairly high green forage yield. Forage sorghum is more economical to grow as compared to forage maize with fairly high economic returns. The total area under forages in 2012 in Punjab was 1.82 million hectares with green forage production of 38.8 million tons. The land area of Punjab under forage sorghum in 2012 was 0.588 million hectares with production of 7.984 million tons. The average production of forage sorghum (13 t ha⁻¹) in Punjab province of Pakistan is much less as compared to potential of 50-70 t ha⁻¹. Seed with low yield potential, suboptimal plant population, drought, weeds infestation, suboptimal and unbalanced use of fertilizers, insect pest attack and marketing problems are major constraints in forage sorghum production in Punjab. A comprehensive breeding program to develop high yielding forage sorghum varieties and an extensive extension program to bring modern production technology into the knowledge of farmers at their door steps is the need of hour for sustainable milk and meat production to cater the needs of ever increasing population. The emerging dooming water scenario and phenomenon of global warming has necessitated the introduction of forage sorghum in irrigated tracks of Punjab and to develop modern production technology for rainfed areas. Forage sorghum intercropped with forage legumes has the potential to provide abundant and nutritious forage to dairy animals. Sorghum preserved as hay or silage may be fed to animals during forage scarcity periods to maintain milk production and for this provincial agriculture department as well as livestock department should strive to make farmers aware of fodder preservation technology to pave the way for a glorious white revolution in Punjab through milk production according to known genetic potential of large and small ruminants.

Key words: Animal feed · Fodders and forages · Cereal forages · Milk and meat · White revolution

INTRODUCTION

The term forage entails the utilization of plants in green succulent form for feeding domestic animals, while fodders are crops that are harvested and cured as hay or silage to feed during lean periods when there is scarcity of green forage. The history of forage crops can be traced back to about 1300 BC when alfalfa has been traced to be cultivated in areas of modern Turkey. Relatively widespread use of forage crops, however, appeared much later, around the beginning of the Christian era, when several species were cultivated in different continents, mainly in the countries of Mediterranean Europe. Little happened between the fifth and twelfth centuries, but the thirteenth to nineteenth centuries saw great advances in forage crops. They contributed to the development of mixed farming in the European agricultural revolution and spread globally with the expansion of Europeans into other continents. The mixed farming system works as shock-absorber in the wake of crop failure as livestock are comparatively less vulnerable to adverse climatic and weather upheavals as well as marketing fluctuations as compared to major and minor crops, along with contributing 53% to Pakistan’s national agricultural GDP [1]. Pakistan is endowed with 37.1 million cattle heads, 32.5 million buffaloes of precious breeds along with huge
treasure of small ruminants (28 million sheep and 68 million goat populations) with 50.9 million tons of gross milk production annually [1]. The major feed stuffs include residues of different crops particularly of cereals (44%) grazing in pastures and canal banks (28%) forage and fodder (15%) and concentrates (energy rich and protein rich) (3%) [2]. The matter of grave concern is that digestible protein and digestible nutrients are deficient by 33% and 24% respectively [3]. Since immemorial times, livestock has been providing milk, food security and daily cash income to small farmers in Pakistan and especially in Punjab province of Pakistan. Forages are the most palatable animal feed resource for livestock, however, forage shortage is increasing with each passing year and 2% land area under forage crops is skipping after each decade [4]. Pakistan witnesses two periods of forage scarcity (June-July and November-December), during which performance of the livestock particularly of dairy animals is hit the hardest [5, 6]. Due to greater number of animals of superior breeds, though Pakistan has attained 3rd position globally in terms of milk production but huge funds are going down the drain due to the bulk imports of dry milk in order to cater the needs of expanding population [7]. Livestock productivity is improved if forages in adequate quantities and with acceptable quality tag are being fed to animals [8, 9, 10]. In Pakistan, forage crops occupy 2.7 million hectares with a production of 53.5 M tons of green forage [11]. Average forage yield per hectare is about 19.4 tons. Despite the fact that cattle and buffalo breeds are known globally because of their superior potential for milk, there is a shortage of milk and other products which are processed from milk such as butter and cheese. In Pakistan, per capita meat consumption is just over 5 kg annually, while total daily protein consumption is hovering around 45-46 g [12]. Among forage crops in Pakistan, sorghum and maize constitute as major summer season forages, while some forage legumes as cowpea and cluster bean are also grown as an intercrop with sorghum and maize. Winter season in Punjab witnesses more forage production as compared to summer season because of more production potential of berseem and lucerne [13]. Sorghum (Sorghum bicolor L.) is one of the oldest cultivated cereals, having its origin in Africa [3]. Sorghum forage is usually grown in areas which witness extraordinarily higher temperatures with scarce rainfall and severe water deficiency [14]. More land area is under sorghum in Punjab which is the largest province of Pakistan in terms of population and also has the largest and fastest growing economy in the country compared to other provinces and administrative units. Punjab inhabits more than 64 million heads of Animals and forage sorghum fulfills 50% of Punjab rainfed areas feed requirement [13]. Sorghum is becoming an increasingly important forage crop in many regions of the world [8]. It has a good potential to tolerate adverse environmental conditions which makes it a suitable crop for semi-arid areas. Its rapid growth and high biomass production helps to overcome unfavorable environmental conditions [15] and the short maturity period favors successful cultivation of the crop on marginal soils with low soil moisture in temperate, tropical and sub-tropical climates [16]. Thus forage sorghum holds key in bringing white revolution in Pakistan by bridging the gap between availability and requirement of forages for milch animals. This forage crop holds the potential to be cultivated in all tracts of Punjab despite the extreme temperatures and severe deficiency of water. The present study has provided an assessment of area, forage yield and constraints of forage sorghum cultivation in Punjab province of Pakistan.

MATERIALS AND METHODS

In this case study, the data related to the cultivated area of Punjab under summer as well as winter forages, green forage production and yield of forage sorghum were collected and adapted from Economic survey of Pakistan [1], Food and Agriculture Organization (FAO) [12], Punjab development statistics [13] and different related published and unpublished scientific articles. Interviews with farmers, dairy farmers, forages seed wholesalers and retailers were conducted purposively during April 2012 to July 2013 in Pakpattan, Okara, Sahiwal and Faisalabad districts.

RESULTS AND DISCUSSIONS

Area, Production and Green Forage Yield of Summer and Winter Forages: Forages to feed domestic milch animals are grown by farmers throughout the Punjab province. The highest land area of Punjab under forages was recorded during 2006, when an area of 2.04 million hectares (winter + summer) was under forage crops (Fig. 1). This area was decreased to 1.87 hectares in 2011 and 1.85 million hectares during 2012. This shows an immense shifting from forage crops to other crops by farmers from 2005 to 2012. Total green forage production in Punjab during 2005 was 43.3 million tons and it increased to 45 million tons during 2006. Total green forage production in Punjab during 2012 was reduced to
Fig. 1: Total land area (million hectares) of Punjab under forage crops [13]

Fig. 2: Total green forage production (million tons) in Punjab [13]

Fig. 3: Punjab land area (million hectares) under summer forages as sorghum, maize and various forage legumes [13]

Fig. 4: Summer forages production (million tons) in Punjab [13]
38 million tons (Fig. 2) and it was due to reduction in area under forages and ultimately there was much less green forage production in Punjab during 2012 as compared to 2006. The total area under summer forages in Punjab in 2005 was 0.93 million hectares (Fig. 3), which decreased to 0.90 million hectares in 2012. The largest area under summer forages in Punjab was recorded during 2006 when there were more than 1 million hectares under summer forages such as sorghum, maize and various forage legumes. The highest green forage production of summer forages was recorded during same year and it was 12.7 million tons and it was decreased to 11.7 million tons during 2012 (Fig. 4). A variety of winter forages such as oat, maize, berseem, lucern etc. are grown in Punjab to sustain livestock production. The highest area of Punjab under winter forages was witnessed during 2006 that was 1.4 million hectares and it decreased to 0.91 million hectares in 2012 (Fig. 5). The reduction in area under winter forages from 2005 to 2012 was about 0.120 million hectares which speaks volume of immense shifting of farmers to other crops. Total production of winter forages in 2005 was 31.5 million tons and it was decreased to 29.8 million tons in 2012 (Fig. 6) and it was due to immense reduction in area under winter forage crops and ultimately much reduction in winter forages production was recorded.

Area, Production and Green Forage Yield of Forage Sorghum: Generally forage sorghum is being grown throughout the Punjab province but significantly higher area under forage sorghum and green forage yield is recorded in irrigated plains of Punjab rather than arid areas of Punjab. The maximum area under forage sorghum (0.62 million hectares) in Punjab was recorded during 2006 and it was decreased to 0.60 million hectares in 2012 (Fig. 7), while the forage sorghum production of 0.8 million tons was recorded during 2005 and it was increased to 0.81 million tons during 2012 (Fig. 8). The increased production of forage sorghum despite reduction in land area under forage sorghum was probably due to more advanced production technology and the use of forage sorghum varieties with more forage potential. As Figure 9 showed that sorghum green forage yield in 2005 was 13.04 t ha$^{-1}$ and it was increased to 13.58 t ha$^{-1}$ despite the fact that area under forage crops is decreasing with each passing year.
Fig. 7: Area (million hectares) under forage sorghum in Punjab [13]

Fig. 8: Forage sorghum production (million tons) in Punjab [13]

Fig. 9: Forage sorghum green forage yield (tons hectare$^{-1}$) in Punjab [13]

**Economics of Forage Sorghum and Maize Production:**

Forage sorghum is more economical than forage maize because its seed is much cheaper than that of maize and it requires less fertilizers as well as irrigation. The net income given by forage sorghum is higher (Rs.7500) as compared to forage maize (Table 1) and this is due to fact that there is less expenditure incurred on forage sorghum as compared to forage maize. Forage maize seed is much costlier in comparison with forage sorghum seed. Forage maize requires more fertilizers particularly urea while forage sorghum has the potential to give a reasonably high green forage yield with fewer use of fertilizers. Forage sorghum requires less number of irrigations than forage maize. Forage sorghum has more water use efficiency than forage maize because it allows comparatively less transpiration due to the presence of
Table 1: Economics of growing forage sorghum (*Sorghum bicolor* L.) and maize (*Zea mays* L.) on per hectare basis in Punjab (Pak. Rupee)

<table>
<thead>
<tr>
<th>Items</th>
<th>Forage Sorghum</th>
<th>Forage Maize</th>
</tr>
</thead>
<tbody>
<tr>
<td>Land Preparation</td>
<td>1200</td>
<td>1200</td>
</tr>
<tr>
<td>Seed</td>
<td>50×100 = 5000</td>
<td>80×100 = 8000</td>
</tr>
<tr>
<td>Fertilizers</td>
<td>4200+3200=7400 (Urea 2 bags + DAP 1 bag)</td>
<td>6300+3200=9500 (Urea 3 bags + DAP 1 bag)</td>
</tr>
<tr>
<td>Irrigations</td>
<td>1200×4= 4800</td>
<td>1200×6= 7200</td>
</tr>
<tr>
<td>Harvesting &amp; Transport</td>
<td>3000</td>
<td>3000</td>
</tr>
<tr>
<td>Total Expenditures</td>
<td>21400</td>
<td>28900</td>
</tr>
<tr>
<td>Green Forage Yield (t ha⁻¹)</td>
<td>14</td>
<td>14</td>
</tr>
<tr>
<td>Gross Earning</td>
<td>3×14000= 42000</td>
<td>3×14000= 42000</td>
</tr>
<tr>
<td>Net Earning</td>
<td>42000-21400=20600</td>
<td>42000-28900=13100</td>
</tr>
</tbody>
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thick cuticle on leaves as well as stem. Forage sorghum has the potential to sustain drought periods that makes it one of the most suitable option to be grown in irrigated tracts of Punjab on wide scale in the wake of emerging dooming water scenario. This is despite the fact that current production of forage sorghum in Punjab province of Pakistan is much less than the potential of forage sorghum, that is in the range of 50 to 70 t ha⁻¹.

**Forage Sorghum Seed Production and Sites of Production:** The availability of quality seed is one of the major factors which ensures successful cultivation and adoption of any crop in any region. There is a severe dearth of improved seed of forage sorghum for rainfed as well as irrigated tracts of Punjab [17]. The very reason is the least priority that has been conferred on forages by researchers and multinational seed companies. The vacuum created due to non-availability of certified forage sorghum seed, imported seed with unknown genetics has manifested local markets. Total forage sorghum seed production in Pakistan is about 7000 tons year⁻¹ which is much less than the requirement. Main areas of forage sorghum seed production in Punjab are Sahiwal, D.G. Khan and Bhaker.

**Constraints of Forage Sorghum Production in Punjab:** The matter of fact is that there is a severe dearth of forage sorghum quality seed because there is no wide scale genetic program on forage sorghum and neither has it seemed to be the priority of researchers. The improvement of forage crops through biotechnological approach has started in late eighties has made remarkable headway at the global level. The various biotechnological tools include molecular techniques for understanding the genetic structure of the plants, inserting foreign genes directly into the plant genome, in-vitro regeneration of plants from any plant part. A number of techniques such as embryo rescue, micro-propagation androgenic haploid plant production and creation of novel variations help at one or more steps involved in conventional breeding methods. These techniques save time and energy required for conventional methods. Genetic mapping and gene tagging in forage species have not been attempted much. Our markets including Sahiwal, Okara and Faisalabad are infested with Indian verities of forage sorghum that have not been thoroughly investigated for their response to local soil and climatic conditions and their rates are much high in the range of Rs. 50-70 and give low yield as compared to local verities such as Hegari, JS-88 and JS-263. Natural constraints such as drought in arid areas as well as in irrigated plains of Punjab have hindered forage production. Poor plant stand of forage sorghum reduces green forage yield to a great extent and ultimately results in loss of precious soil as well as environmental resources. The water availability in Pakistan at the time of partition in 1947 was 5600 m³ person⁻¹ year⁻¹ which has decreased to about 1066 m³ person⁻¹ year⁻¹ in 2012 [18]. So irrigation water shortage and its high price have forced the farmers to shift to other cash crops and let their livestock to feed on grazing alongside canal banks and already overused pastures. The extension services of Punjab agriculture department are directed and focused on the major crops such as wheat, rice, cotton and sugarcane and farmers are not being trained about the latest production technology and techniques of growing forages. The major disease that inflicts the forage sorghum in Punjab is red leaf spot which reduces the green forage yield as well as quality of forage. The shoot-fly and borer also attack the crop near heading stage and cause a serious loss the sorghum forage yield and quality. The lower number of animals also forces the farmers to purchase forage and opt to shift to cash crops. The large dairy farmers tend to grow forages but not small farmers having one or two heads. More competition with staple crops particularly with rice makes the forage sorghum out of competition in irrigated plains of Punjab, but in arid region of Punjab, farmers tend to grow forage sorghum and there is a sharp decrease in area under
forages in irrigated plains of Punjab. Suboptimal and unbalanced use of fertilizers, particularly nitrogenous fertilizers reduce the forage sorghum yield, because nitrogen is the most vital nutrient required for vegetative growth [19]. Weeds tend to reduce green forage yield particularly in early time until the crop has attained the knee height. Mostly suburban areas near Sahiwal, Faisalabad and Pakpattan cities provide supplies of green forage for livestock in city areas but the poorly developed infrastructure raises the cost of transportation which causes reduction in feed to livestock, disrupts economy of production and ultimately whole cycle of forage sorghum from production to marketing is drastically affected.

Future Strategies and Research Trends in Perspectives of White Revolution: The need of hour is to develop a comprehensive breeding program to develop forage sorghum varieties having fairly high potential for green forage yield and well suited to climatic and soil conditions for better utilization of soil and environmental resources. It is worth mentioning that future of white revolution in terms of milk production in Pakistan is closely and tightly bound with increased forage sorghum production in Punjab province of Pakistan, particularly in the wake current and emerging water scenario where irrigation water shortage is going to make its heavy toll in near future. A well designed extension program with wide coverage is needed to spread the awareness among the farmers about latest production technology as forage sorghum yield can be doubled in no time by adopting latest production technology keeping in view the production potential of verities such as Hegari that is 50-70 t ha\(^{-1}\). Proper insect pest management has the potential to increase the forage sorghum yield particularly by controlling the incidence of red leaf spot disease with the help of seed treatment. Forage sorghum is poor on nutrition scale with only 8-10% protein contents, so it’s intercropping with summer forage legumes such as cowpea and cluster bean has the potential to give mixed forage with higher protein contents [20, 21, 22, 23]. In this context, researchers and agronomists need to focus research on appropriate planting patterns, fertilizer doses as well as time of sowing of forage sorghum intercropping with forage legumes [24, 25, 26, 27, 28, 29]. Thus ensuring good and sustainable forage supplies throughout the yeas amount to a heft challenge to agronomists and researchers to cater the milk and meet demands of skyrocketing population.

REFERENCES