Pearl Millet: Potential Alternative for Grain and Forage for Livestock in Semi-arid Regions of Mexico

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Article History

Manuscript No. 20
Received 27th April, 2010
Received in revised form 14th May, 2010
Accepted in final form 30th May, 2010

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Keywords

Pearl millet, germplasm, grain, forage, Mexico

Abstract

Researches undertaken on the introduction and evaluation of some tropical pear millet germplasms (91) and cultivars (15) revealed that tropical pearl millet could be a potential crop for production of fodder and grains for livestock/poultry in semi-arid north-east of Mexico. Crops were well adapted in semi-arid regions of north-east Mexico, and gave high yield of fodder and grain with good nutritional values.

1. Introduction

Pearl millet (*Pennisetum glaucum* L.) R.Br.) is a stable diet for the vast majority of poor farmers and also form an important fodder crop for livestock population in arid and semi-arid regions of India (Vetriventhan et al., 2008). The socio-economic development of a country depends greatly on the production of food and evolution of agriculture. Owing to the scarcity of precipitation occurring in large extensions of Mexico in arid and semi-arid regions, the production of food for mankind and feed for livestock is very low. In north-east of Mexico the main annual crops of great importance as food for human beings and animals are maize, bean, and sorghum, which are managed by different systems of production under completely mechanized and irrigated conditions, and few under rain-fed situations. The problems affecting the production of crops in the arid and semi-arid regions are mainly the nutrient deficiencies of soil, pH, alkalinity, soil crust and pebbles besides the climatic conditions such as drought, high and low temperature, frosts, depth of planting, salinity, insects and pests, diseases, etc.

Owing to the previous factors, especially erratic rainfall, there is greater extensions of the areas dedicated for production of cattle for meat. It leads to great demand of forage, grains and balanced feed for the livestock. Actually, a greater part of these feed, mainly sorghum are imported from Canada and United States. Therefore, there is an urgent necessity to look for alternative means for production of grains and forages in national territory which will help in earning by the farmers, and in better utilization of the land resources, thereby avoiding the migration of the population to big cities in the semi-arid tropics of Mexico.

Technologies more commonly utilized for increasing the agricultural production in the arid and semi-arid regions are stated as follows.

1.1. Crop management

Technologies used in the conservation of rain water, and harvesting of other sources of water through utilization of wooden or metal rollers in some arid regions, efficient use of water to avoid loss by evapotranspiration, management by better crop establishment, modification of agro-ecosystems, and protection of natural ecosystems, among others.

1.2. Genetic improvement

It is achieved by the evaluation and selection of improved varieties/cultivars of promising crop species resistant to biotic and abiotic stress factors such as drought, salinity, etc. Several studies have revealed that there is variability among diverse crops regarding resistance to various stress factors.

1.3. Biotechnology

Development of crops resistant to stress (drought, salinity, high and low temperature, etc.) through molecular basis, such as RAPD, QTL, SSR, cloning, gene transfer, and so on.

The main objective of the paper is to present the results of investigation carried out by the authors on the evaluation and adaptation of tropical pearl millet cultivars introduced from ICRISAT, India in semi-arid regions of Mexico. The results are promising, which reveal the potential of pearl millet as forage and grains for livestock in Mexico.

Pearl millet is a cereal well known in the arid and semi-arid regions of the world under rain-fed conditions. In Africa and some parts of India, the grains are consumed in different forms of preparations such as *chapatti*, bread, etc. The crop is adapted under different adverse conditions such as drought, salinity, and soil poor in nutrients for which the researchers of the world are motivated to introduce this crop in arid and semi-arid regions of their countries. In addition to its capacity of adaptation, pearl millet contains high nutritional value protein up to 21%, much higher than that of maize grain (8%), and is extensively used in different countries as forage of high nutritional quality.

2. Materials and Methods

About 250 germplasms and 15 pearl millet genotypes were introduced in Mexico and evaluated for their adaptation and agronomic traits in different locations of Nuevo Leon state (27°49' and 23°11' N; 98°26' and 101°14' W), Mexico, besides in different other states. In addition, forage production and forage values were estimated. Besides, nutritional value of pearl millet grains for broiler chicken was studied. All these studies were undertaken through undergraduate and graduate students´ thesis research. Results are presented and discussed as follows.

3. Results and Discussion

3.1. Adaptation, and forage and grain yield potentials

In order to test the adaptability of pearl millet, a large number of different genotypes of pearl millet were introduced in Nuevo Leon by Prof Maiti and evaluated for the production of forage and grain. The genotypes showed large variability in morpho-physiological characters with good adaptation in semi-arid regions of Mexico (Gomez-Soto, 1986; and Maiti et al., 1989). They reported that all 15 cultivars introduced from India showed adaptation in Spring with grain yield up to 15 mg ha^{-1}. Scientist also demonstrated that pearl millet was adapted to different agro-climatic conditions in Mexico.

The crop is sown during June-July in India and Africa but the growing seasons of this crop in Nuevo Leon is in February and July-August. So, the crop may be harvested two times in a year for grain as well as for green forage. Therefore, it was necessary to study the effect of climate on date of planting for growth and potential of the yield.

Maiti and Gomez-Soto (1990) undertook a study to determine the optimum yield of the cultivars in different dates of sowing (four dates) from July to September under gradual decrease of temperature and photoperiod. Although the effect of temperature on growth and development have been well documented (Fussel and Pearson, 1980; Maiti and Bidinger, 1981 and Ong, 1985), very little information is available related to the interaction of photoperiod and temperature on growth and development of pearl millet.

Findings of the present investigation revealed that the yield of pearl miller was affected by environmental variables such as temperature and day length. The crops sown in July grew under optimum temperature around 30^{o}C with prevailing photoperiod of more than 13 h with high rate of photosynthesis during grain filling period, and yielded up to 3 ton as compared to other dates of planting. Subsequently, the crops sown in August faced low temperature during the periods of grain filling, which reduced the grain yield. And low temperature during grain filling in the month of November affected the grain yield severely.

The decrease of temperature and photoperiod reduced the plant height, leaf area of the flag leaves, the number of tillers, and total grain yield. The results showed that there were highly significant differences among cultivars regarding the planting dates. Besides, interaction between genotypes x planting dates were significant for different parameters, revealing differential responses of the cultivars to different environments. Low temperature prevailing during grain filling period in October and November (24/12^{o}C) reduced grain yield substantially. Though no attempt was made to establish relation between temperature and photoperiod, it was observed that the progress of the development was delayed with gradual decrease of temperature and low photoperiod in the delayed planting dates. It may be mentioned that the day length in Nuevo Leon was more than 12 h, while in India it is lower. Moreover, the difference between day and night temperature was greater than that in India (Maiti and Gomez-Soto, 1990).

Further, it was observed that plant height of these pearl millet genotypes were less than 1.5 m, while in Nuevo Leon it reached more than 2 m which led to greater production of forage and grain in Mexico. During the growing season of pearl millet in India there is little difference between day and night temperature assuming greater loss of assimilates by photorespiration. It may be interpreted that the greater day length and large difference in day and night temperature contribute to higher forage and grain yield owing to greater translocation of assimilates in plants and grains. Grain yield was more than double in Mexico, which needs to be confirmed in future studies.

The yield of grain and fodder of pearl millet in Mexico is much higher compared to its place of origin in India and Africa. Under rain-fed conditions in the municipalities of Cerralvo and Pesqueria, Nuveo Leon, the plant height reached more than 2.5 m; while on the contrary, the same reached only to 1.5 m of height in India. Photoperiod of more than 13 h and the greater difference in day and night temperature may explain well the greater yield of both forage and grain of pearl millet compared to that in India, which may be due to lower respiratory loss at night and greater rate of photosynthesis during the day. Pearl millet population (bulked) have been tested in 14 municipalities of Nuevo Leon and some municipalities of Coahuila and Zacatecas under rain-fed conditions gave highly acceptable yield of fodder (Maiti-unpublished).

3.2. Fodder and grain nutritional value

Lopez Domínguez (1991) undertook a study on agro-biology of pearl millet with an objective to determine some factors which influence the production and fodder quality. Study revealed that factors which influence production and quality of fodder of pearl millet genotypes at different dates of planting, fertilization, irrigation and plant density influenced greatly genotypes and its chemical composition. Protein content was negatively correlated with plant height. Yield ha^{-1} was correlated with plant height, number of tillers and internodes and stem diameter. Yield also depends on genotype, humidity, fertilization, planting dates and crop season. On the other hand, Cuevas-Hernandez (1992) studied chemical composition, nutritional value, and toxicology of pearl millet grains as broiler feed in chickens. He found that compared to sorghum and maize, pearl millet grains contain more protein. In other study, related to metabolic energy, he found that there were significant differences between pearl millet and maize. Finally, results demonstrated that pearl millet could be a good substitute for fattening of broiler chickens in initial stage of their growth.

3.3. Advantages

Some advantages of pearl millet as fodder and grains are:

- High capacity of adaptation in soil poor in nutrients.
- High capacity in tillering which allows three cuttings per year for fodder, and finally leaving for grain.
- For its grains may be harvested in two and half months.
- Plant does not possess HCN. Therefore, not toxic to cattle unlike that possessed by sorghum at early stages of growth.
- Grains contain more protein than that of sorghum and maize.
- Plants may be cut during early milky stage, and can be packed. At this stage plant is high in protein content.
- Pearl millet has high capacity of compensatory growth in different spacing.
- In respect of grain yield production is much elevated in Mexico than that in its place of origin (Africa and India).
- In milling of grains, it has been proved that it has greater capacity of food conversion in fattening cattle for beef.
- Pearl millet is highly adapted to drought in field condition where sorghum and maize can not sustain their productivity.
- Farmers themselves can produce seeds without much difficulty protecting the crops from bird.
- It does not possess any anti-nutritional material.

5. Conclusion

In context of the above discussions it may be concluded that pearl millet offers a good opportunity for production of green fodder in places where precipitation is very scarce. Pearl millet can be sown dry under drought conditions similar to that in India and Africa. In this way, sowing can be undertaken in range lands. First plot can be sown under dry conditions, in which the seedlings start emerging with first shower of Spring to give forage under rain-fed conditions. In this manner, different plots can be sown sequentially to produce green fodder for livestock throughout the year at different stages of growth. It does not contain HCN as found in sorghum. It is non-toxic to the livestock. Besides, this species has great capacity of rooting once the plants are cut to supply fodder to the livestock continuously. After 45 days, it is possible to obtain forage with rainfall of 30-40 mm. It may be repeated for two or three cuttings depending on climatic conditions. In north-east of Mexico, rainy season falls in the months of May to June, and August to September. Owing to natural erratic conditions, sowing can be done during rainy season, thereby offering an opportunity for supplying forage at different stages of crop growth. Thus, it allows to feed livestock with green forage without the problem of HCN toxicity unlike that of sorghum.

5. References

Cuevas-Hernandez, B., 1992. Estudio nutritional del mijo perla (*Pennisetum americum* L). Leeke) y su utilización on alimentación de pollos. Tesis de Doctorado. Facultad de Ciencias Biológicas, UANL, Mexico.

Fussel, L.K., Pearson, J., 1980. Effects of grain development and thermal history on grain maturation and seed vigour of *Pennisetum americanum*. Journal of Experimental Botany 31, 635-543.

Gomez-Soto, H., 1986. Caracterización de germoplasma de mijo perla (*Pennisetum americanum*). Tesis Profesional, Facultad de Agronomía, UANL, Mexico.

Lopez Domínguez, R.U., 1991. Estudio agrobiológico del mijo perla (*Pennisetum americanum* (L.) Leeke) como alimento para ganado. Tesis de Doctorado, Facultad de Ciencias Biológicas, UANL, Mexico.

Maiti, R.K., Bidinger, F.R., 1981. Growth and development of pearl millet. Research Bulletin No. 6, ICRISAT, Patancheru, India.

Maiti, R.K., Gomez-Soto, G.L., 1990. Effect of four sowing dates, environments on growth, development and yield potentials of 15 pearl millet cultivars (*Pennisetum americanum* L.) during autumn-winter seasons in Marin, N.L., Mexico. Journal of Experimental Botany 41, 1609-1618.

Maiti, R.K., Landa, H., Gonzalez, H., 1989. Evaluation of ninety germplasms for morphological traits. Turrialba 39, 34-39.

Ong, C.K., Monteith, J.L., 1985. Response of pearl millet to light and temperature. Field Crops Research 11, 141-160.

Vetriventhan, M., Nirmalakumari, A., Ganapathy, S., 2008. Heterosis for grain yield components in pearl millet (*Pennisetum glaucum* L.) R. Br.). World Journal of Agricultural Sciences 4, 657-660.