Integrated Practices and Sustainable Corn Production in Guizhou, China

Gu Ming[1,2] Hatsachai Boonjung[1]

ABSTRACT

Corn is one of the most important cereal crops grown in Guizhou with a total yearly output and growing area second only to rice. Corn production has increased significantly during the last 40 years, from 598 thousand tones to 3.42 million tones. While demand for food increases, the potential for meeting that demand decreases. The per capita availability of land and water are steadily going down, while biotic and abiotic stresses limiting crop production are increasing. Adverse ecological and socio-economic factors are hindering the further development of corn production. This paper describes the current situation, the importance of integrated practices in increasing yields, challenges and opportunities in improving sustainable development of corn production in Guizhou.

Key words: Guizhou, Corn production, Integrated practices, Sustainable development

INTRODUCTION

Description of the Province

Guizhou, one of the underdeveloped provinces of southwest China, is situated between north latitude 24° and 29°, east longitude 103° and 109°, covering an area of 176,128 km^2 with a population of 35.245 million in the year 2001. 87% of the area is mountainous, 10% is hilly and the remaining 3% is a flat plain. It mainly consists of small basins along the rivers or among the mountains. Guizhou has a varied topography, characteristized by sedimentary limestone rocks. Karst landform is geographically well preserved and covers 73% of the total area. The highest point is 2903 m while the lowest is 137 m above sea level, with the average of 1000 and 1200 m. The yearly temperature is 8-20 °C with 1000-1300 mm rainfall annually.

1. School of Crop Production Technology, Institute of Agricultural Production Technology, Suranaree University of Technology, 111 University Avenue, Nakhon Ratchasima 30000, Thailand
2. Agricultural College, Guizhou University, Guiyang 550025, Guizhou, Peoplel's Republic of China.

Correspondence: guming818@yahoo.com

Situation of corn production

Corn is one of the major cereal crops grown in Guizhou, exceeded only by rice in terms of quantity produced and area grown. Although Guizhou is one of the major corn production provinces, it still requires domestically imported cereal grains to feed its increasing population. In this province, corn is widely on from 250 m to 2200 m above sea level in different agroecological regions and has been given much attention among food crops. It is produced on 700 thousand hectares annually and plays an important role in the economy. Great changes have taken place in corn production since 1949 when P.R. China was founded.

In 2000, the total sowing area for food crops was 3.15 million hectares and the ratios for each major crop were rice 23.82%, corn 23.08%, wheat 18.01%, tubers 22.29%, soybean 4.47% and the rest 8.33%. The total growing area for corn and the average yield per hectare increased sharply from 660 thousand hectares to 727 thousand hectares and from 907.5 kg to 4718 kg respectively, giving a total production of 3.42 million tons from 598 thousand tons. Corn production was worth around $404 million in 2000. Trends of sowing areas and yields in Guizhou between 1950 and 2000 are given in Figure1.

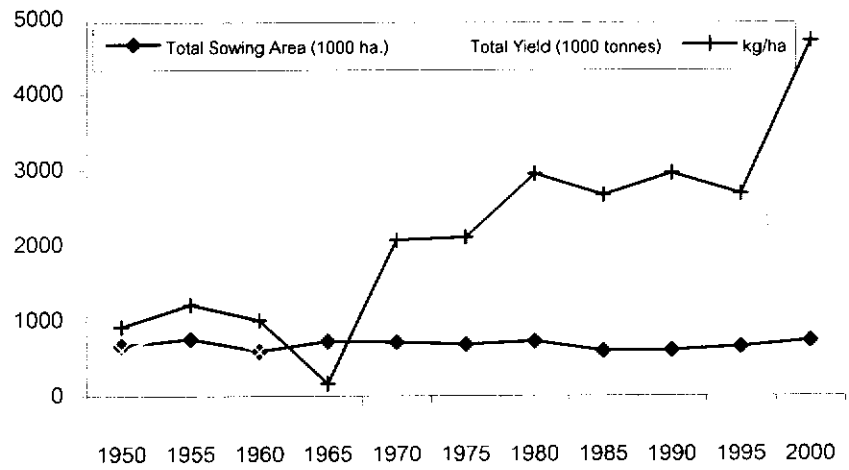

Figure 1. Trends of Sowing Area and Yield of Corn in Guizhou
Source: Guizhou agricultural statistics year book (2001)

CONSTRAINTS OF CORN PRODUCTION

One of the most typical features Guihzou is the scattered arable land, poor quality soil, and steep slope. In 2000, there was a total 4.7 million hectares of arable land in Guizhou and 15.98 % of it

was paddy, while the rest was dry land for growing corn, wheat etc. Most of the corn grown in Guizhou is under rainfed conditions with very poor soil fertility. Some farmlands in the Northwest even have slopes greater than 50%. Meanwhile, frequent droughts both in spring and summer have a serious impact on corn production.

Climate, soil and crops vary according to altitude of the planting area. Rice is mainly grown in the eastern part at low altitude, while upland crops are grown at the higher altitude of western part. Rice and upland crops are sometimes intersected in the middle part of the province. In the lower valley area, sugarcane and orange usually grow well. In the middle region, which is the major part of the province, two crops a year are usually grown. In the mountainous region, traditionally only one crop a year is grown. In some parts of the mountainous areas, where traditional practices are used to grow corn, it does not grow well or sometimes cannot even reach maturity because of low temperatures in the season. Only potato and buckwheat can survive in these places. However, if plastic sheeting is used to cover corn, the corn can grow well in these areas

In some parts of the province the crop management is poor and its output is considerably low. Farmers in remote villages still use old-fashioned methods to cultivate crops. Because of the poor economy, farmers' input of materials such as high yielding varieties, chemical, fertilizers and agricultural plastic sheeting are not sufficient to obtain the required yields. Nitrogen input was only 1/4 or less of the national average level (He, 1999).

POTENTIALS TO INCREASE YIELD OF CORN

Examples of high yields

Though corn production has achieved a good yield, it is still at the lower average of the national scale. Statistics showed that in 1999 the average yields of corn were 4620 kg/ha in Guizhou and 4944 kg/ha in the whole country. Data from some other advanced corn production provinces are given in Table 1, which shows that the average yield in Guihzou is much lower. In other words, there is a big potential for corn production increases in Guihzou.

Table 1. Average yields of corn from some advanced corn production provinces in 1998

Name of Province	Jilin	Ninxia	Liaonin	Xinjiang	Jiangshu
Average Yield (kg/ha.)	7950	6975	6375	6305	6045

Source: Agricultural statistics year book in P. R. China (1999).

Within the province itself, there are also many examples of high yields. The "*66.7 Thousand Hectare Corn Project*" carried out by Guizhou General Agricultural Extension (GGAE) across different ecological regions in 1997 got an average yield of 5271.6 kg/ha, 1086.6 kg higher than the average level of the province in the same year. "*10000 Hectare Corn Project*" carried out by former Guizhou Agricultural University in western Guizhou in 1998 obtained an average yield of 5362.8 kg/ha, 1118 kg higher than the province's average level and increasing yields by 20.84%. In smaller experimental plots, even higher yields were achieved. For example, in Fuquan city, 7131 kg/ha. was obtained on 0.5 hectares of land and in Anshun city 7534.5 kg/ha was obtained on 9.4 hectares in 1997; In Bijie prefecture, on an area of 6.98 ha., with the help of experts and professors from different institutions organized by the Department of Sciences and Technologies in Guizhou, an average yield of 10867.5 kg/ha. was achieved in 2001.

The potential yield of corn

With the best utilization of light, temperature, water supply and soil fertility in Guizhou, the theoretical estimated yield of corn is as high as 9255 kg/ha. (Wang, 1998), which is quite similar to the experimental results shown above. One of the most important reasons for the current lower yields of corn is that light energy is not efficiently utilized. Investigation showed that there were only 30000 — 37500 plants per hectare on farmlands, by contrast with high yield fields, where plant density was 52500-60000 plants per hectare. In some places, it even climbed to 61500 — 85500 plants per hectare with an average yield of 12510 kg (Zhao and Zhang, 2001).

The above data show the possibilities of achieving high yields of corn if practices are fully and properly integrated and applied.

INTEGRATED PRACTICES FOR SUSTAINABLE CORN PRODUCTION

With the explosion of population, decrease in arable land and development of animal production, growing corn is even more important than before. Retaining sowing land for corn and choosing the right hybrid varieties (varieties that are best adapted to local conditions), with a relevant package of integrated practices to increase yields, will be an important component in sustainable agriculture development in Guizhou.

Distribution of varieties

Varieties have an important role in increasing corn production. Correspondingly, their correct allocation is also important. Given the complex geography and vertical agro-ecological conditions, one or two varieties cannot dominate all the regions. With the development of breeding, more and more hybrid varieties have been successfully bred out since the end of 1960s, covering 73.38% of total corn growing areas in 1996, up from only 10%. For the moment, single-crossed, double-crossed, and tri-crossed varieties in combination with open-pollinated and some local varieties are widely grown across the region in different agro-ecological and socio-economic conditions.

To fully utilize the potential of hybrid varieties in increasing yields, it is necessary to distribute the varieties to their most suitable places for growing. Generally, in the middle of the province at the altitude between 1000-1200 m, single-crossed varieties such as Qianxi 4, Bidan 3 and 4 with high potential yield are highly recommended for regions with good natural and economic conditions. However, if the natural conditions are poor in this area, such as with shallow topsoils, poor soil fertility, and shortage of input, two-crossed and tri-crossed varieties like Guibi 303 should be selected. In the mountainous with altitude between 1200-1600 m, varieties with good adaptability like Hedan 4 and Bidan 4 should be chosen; and in the even higher regions (>1600 m), early maturing varieties with good resistance to adverse factors, such as Bidan7, Hedan 4, Bidan 8 and some open-pollinated or local varieties are recommended.

Integrated practices

The Chinese experience with agriculture has often been cited as an example of sustainability of land resources (John, 1994). Studies have shown that variety combined with relevant integrated practices is successful in increasing corn yields (Gu, 1999).

Green manure earth ridges are one of the features of Guizhou crop production, which can supply soil with organic matter continuously. The green manure is ploughed, formed into ridges and covered by soil along its planting rows when it reaches its highest biological yield; then corn is sown on the top of ridges. It can also protect sloping land from soil erosion and increase yields by 5.66-8.81% (He, 1999). Vicia sagetalis Thuill, *and* Lpomoea turbinata Lag are the main two types of green manure crops growing in Guizhou with intercropping mainly with corn, wheat and rice. The green manure area in 1997 were only 166.7 thousand ha., Green manure crops have not been widely grown in the past because they cost money and use land without providing any visible products, according to some farmers.

Seedling raising and transplanting is widely applied in the whole province accounting for 50.7% of the total corn area, giving an average yield of 5540 kg/ha, 1172 kg higher than the average provincial yield of the whole province in 1998. The reasons are that seedlings are stronger and grow evenly and completely under the well-controlled conditions. Early planting and transplanting can avoid drought in summer with 6000 to 9000 plants per hectare more than with direct sowing. In the middle of the province at the altitude between 1000-1200 m, the major cropping patterns are corn relay-cropped with rapeseed and wheat, to fully utilize the relatively good natural conditions and increase the cropping index. The practice of seeding raising and transplanting focuses on single or double plants transplanted in a certain direction, with all the leaves from each young plant stretching in the same direction when they are transplanted in the fields. Experiments proved that transplanting single and double plants obtained 24.54-37.24% higher yields than the normal transplanting method. In areas >1600 m above sea level, the corn can grow well if plastic mulching is used to keep the soil warm, humid and fertile. The practice can increase yields by 8.26 — 31.5% (GGAE.1998). If these practices are combined, the yield could be increased more significantly as the area altitude increases. Relative information on these practices is given in Table 2.

Table 2. Experiments on Covering Plastic Mutching and Raising Seedlings Transplanting

Year	Location	Altitude (m)	Practices	Areas (ha)	Average Yield (kg/ha)	Increase (kg)	Increasing %
1997	Panxian	2100-2200	CPS	205.6	7140	3390	90.4
1997	province	1200-1600	CPS	2948.6	6742.5	2040	30.26
2000	Weilin	2000-2400	CPS+RST	11.1	7911	2665.7	33.69
2000	Dafang	1400-1600	RST	213.1	7872.9	2627.6	33.38

Source: GGAE (1998); Zhao and Zhang (2001).

(CPS=Covering Plastic Sheet, RST=Raising Seedlings Transplanting).

Dividing land into sections and crop rotation is another feature of crop production in Guizhou because sequence crops are impossible to grow due to low temperatures. At the same time, this practice can control erosion (Clyde et al., 1999). In Guizhou, generally, crop rotation options decrease with lower temperatures. To fully utilize natural resources, farmers divide fields into sections, and crops are assigned to specific sites. The sites are changed in subsequent growing seasons; in the following year they grow crops in another belt before the previous crop is harvested. Crop rotation is the primary strategy for controlling pests and is used to create biodiversity in organic farming systems (Geogre, 2002). Because of food pressure, legumes are seldom grown alone and are often intercropped with corn, wheat or rapeseed. Cropping patterns are mainly corn/soybean, rape/pea or broad bean and wheat/pea or broad bean. Most farmers are aware of the benefits of rotation to control pests, but more research is needed to establish economically viable alternate crops.

Application of new technologies

Biotechnology has enormous potential as a tool in improving agricultural productivity. It will play an increasing role in developing sustainable agriculture. Guizhou Agricultural Academy of Sciences has developed several bio-fertilizers and bio-pesticides, such as "150 fungus liquid", which have been shown to be very effective and should be widely applied in corn production in Guizhou.

Treating seeds with special chemicals, nutrients, or natural substances extracted from plants is another way to prevent corn from being destroyed by insects and diseases both at the early stage and in the later growing season. It can also supply corn with nutrients, such as Membrane Juice P and C in the early stages. However, this technique has only recently been pioneered and it needs to be better developed before it is applied in the field. Some of the chemical —intensive practices in use today will not be acceptable in the future (Robert and Edgar, 1999).

Compact varieties of corn have compact shape and vertically-growing leaves, and are suitable for high density growing, with higher yields than normal hybrids. Experiments indicated that this could increase yields of corn by 7.9%, 7500 to 22500 plants more per hectare than normal hybrids (GGAE, 1998). However, since it needs relatively high inputs and intensive management, it is not widespread in the province. At the same time, since this type of variety comes from northern China, it is impossible for it to be grown throughout the region due to the complex agro-ecological conditions. Much more research work is needed in this area.

FURTHER SUGGESTIONS

1. Adjustment of crop production structure: To be sustainable, an adjustment of corn production structure is needed. Given the importance of corn in agriculture in Guizhou, further development of corn production should be based on keeping stable sowing areas, improving the lives of people in Guizhou, enlarging production for animal feed, and producing specialty corn for people's daily lives and for industry.

2. Using the right hybrid and increasing the use of integrated practices, as mentioned above: using right varieties with the relevant packages of integrated practices are important in increasing yields of corn. However, areas using such practices are not large compared to the total area of corn. Practices such as seedling raising and transplanting and plastic mulching only accounted for 60.7% of total corn area in 1998. Sparse plant density in farmlands is also a problem.

3. Extension service: Sustainable corn production is not only a matter of scientific knowledge, it is also political, economic and social. It is impossible to alter the present agricultural systems without additional structural changes in society as a whole. With appropriate policies to protect natural resources and mobilize human resources and capital for rational exploitation of existing lands, policy measures such as taxation of resource utilization and price regulation, sustainable corn production

can be achieved. The shortage of extension agents and support systems constrains corn production. Every 10,000 farmers share only 0.16 agents (average national level 0.43, and our neighbouring Yunnan province 3.8), Every agent shares 867 hectares, much higher than national level and levels in Yunnan and Sichan provinces. So, increasing the number of agents, improving their life quality and enhancing extension systems are another issue for crop production.

CONCLUSIONS

Corn is second only to rice as a cereal grain crop in Guizhou, in terms of total yearly output and growing area. Over the past 40 years great advances - from 598 thousand tones to 3.42 million tones — have been achieved in corn production. But still, as demand increases so do the difficulties of meeting it. Raising crop productivity to the extent of feeding a rapidly growing population without further damaging an already degraded ecosystem is a major issue, concerning which much debate has taken place in recent years.

Guizhou still imports grain food from other provinces. Yields of rice are at almost the same level as the national average. However, yields of corn are much lower than both the national level and the levels of other major corn production provinces, as mentioned before. To feed the increasing population, clearly, corn has a major role to play in Guizhou.

Traditional technologies have been used together with naturally rich resources in improving agricultural productivity. With natural resource deterioration it is necessary that more advanced technologies should be applied. Increasing corn yield without damaging environmental resources is possible if the right packages of integrated practices are used. The problem of food self-sufficiency for people in the region can be solved. Agricultural development, conserving land, water, plant and animal genetic resources, must be economically viable and socially acceptable.

REFERENCES

Acquaah, G. 2002. Principles of Crop Production. Theory, Techniques, and Technology. Prentice Hall, Upper Saddle River, New Jersey.

Agricultural Statistics Year Book in P. R. China. 1999. Agricultural Publishing House, Beijing.

Douglas, C.L. Jr., P.M. Chevalier, B. Klepper, A.G. Ogg Jr., and P.E. Rasmussen. 1999. Conservation Cropping Systems and Their Management. E.L. Michalson, R.I. Papendick and J.E. Carlson (Editors). In : Conservation farming in the United States. The method and accomplishments of the STEEP program. CRC Press

Guizhou Agricultural Statistics Year Book. 2001. Guizhou People's Publishing House.

Guizhou Division of Field Crops. 1989. Compilatory group of "Guizhou division of field crops". Guizhou People's Publishing House.

Guizhou General Agricultural Extension. 1998. Information of Agricultural technology extension. Guizhou Committee of Sciences and Technologies, Guihzou Agricultural Department.

Gu Ming. 1999. Sustainable corn production in Dafang county. Cropping Systems and Cultivation (Supplementary) : 86-86.

Tengbin, He, Mei Tao, Mao Guojun, Li Suwen, Yu Shihong and Ni Chenhou. 1999. Study on the functions of earth up of green manure and increasing crop yield. Cropping systems and cultivation (Supplementary) : 32-36.

John, P. 1994. Historical Perspective. In : J.L. Hatfield and D.L. Darlen. 1994. Sustainable agricultural systems. Lewis Publications.

Papendick, R.I. and E.L. Michalson. 1999. STEEP-A model for solving regional conservation and environmental problems. In : L.M. Edgar et al. (Editors). Conservation Farming in the United States. The Method and Accomplishments of the STEEP Program. CRC Press.

Tiansheng, Wang. 1998. New agricultural sciences and technologies vs food crop production in Guizhou. Pp. 58 - 69, in: Proceedings of Agricultural Sciences and Technologies vs Agricultural Development in Guizhou.

Zi, Zhao and Zhang Rong Da. 2001. Proceedings of Study on the Integrated Technological Application, Sustainable Development Theory and Technology of Corn. Guizhou Scientific and Technological Publishing House.