Agronomic design: the bridge between researchers and farmers

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Abstract

Agronomic design is the process of establishing technical procedures for field management in crop production. It is a multi-disciplinary activity involving crop and soil sciences, ecology, and economics that seek to achieve an expected yield and to maximize long-term profit. A successful agronomic design can only be achieved by effective participation between researchers, extension workers, farmers, and related actors to establish a bridge between researchers and farmers who, only together, can forge technical expertise and achievements in science into practical crop production. This article presents an example of a successful agronomic design of a cereal production system of north China.

Media summary

Agronomic design utilizing a participative research approach is an efficient and effective tool for knowledge integration to improve field management practices that are adapted to farmers' conditions.

Key words

Crop production, agronomic design, agronomy, science, technology.

Introduction

Agricultural scientists and farmers have traditionally tended to work in isolation, with each following their own perceptions of what is needed to improve crop production. Scientists have often urged farmers to change the management of their enterprises without understanding the limitations that farmers experience, and limitations that explain why they are unable or unwilling to follow such recommendations. The reality of these limitations can explain why management practices result in low yield and profitability together with inefficient use of resources which still widely evident in crop production in many regions in the world even though research has identified practices that can improve crop performance under most conditions. The challenge to development in crop production is to identify simple and easy-to-apply field management practices that can increase the efficiency of resource use, yield and profit in a sustainable way. Agronomic design is an effective tool for that purpose, building a bridge for improved communication and collaboration between researchers and farmers that allows interchange of all available knowledge and experiences.

Definition of agronomic design

Agronomic design is the process of planning technical procedures for field management in crop production. It is a multi-disciplinary activity involving crop and soil sciences, ecology, and economics that seek to achieve an expected yield and to maximize long-term profit. It provides the essential bridge between research achievements and experience in farming operations and is also the ultimate destination of all development oriented agricultural research in crop production.

Objectives of agronomic design

- To match the resource supply with crop demand, and
- To maintain an appropriate balance between the various resource types in order to promote effectiveness and efficiency.

These objectives are achieved by:

- Eliminating existing limiting factors by attending to quantity and quality (e.g. ratio of nutrient elements) of inputs, and
- Providing resources in appropriate spatially and temporally appropriate amounts.

There are established laws and principles to guide this procedure, including; the law of limiting factor, the law of diminishing return, the principle of ecological adaptability, the principle of ecological-economic niche, the principle of stimulating effect, the concept of soil as a reservoir, the principle of critical stage and compensation effect, and the principle of self-adjustment of crops (Liang Weili and Wu Yuehong, 2002).

Methods

Procedure and approaches for agronomic design

The steps can be summarized as follows.

- Diagnosis. What are the existing limiting factor and/or problem/s? What are the causes and what technical improvements/alternatives exist for their solution? System analysis, participatory and multi-disciplinary analyses are all valuable at this stage to identify the farmers' problem/s and the possible potential solutions.
- Screening of optional solutions. The participation of scientists and farmers is critical at this stage to select and fine-tune the identified optional solutions.
- Testing and evaluation. This requires both on-station and on-farm trials.
- Technology transfer. This is a two-way process. Farmers are advised of management solutions but success also depends on evaluating the experiences of farmers during the implementation of chosen recommendations to allow continuous adjustment to the identified solutions.

The essential criterion of a good design is that it should be easy to follow, simple to implement, and capable of flexible adjustment.

Results

An example of agronomic design: improving management to increase yield and water-use efficiency of the wheat-maize double cropping system of north China

The wheat-maize sequence is the major cropping system of cereal production in the semi-arid North China Plain. The major problems identified in the system are:

1) Excessive application of nitrogen but inadequate applications of phosphorous and potassium fertilizers result in limited crop yields and low water-use and fertilizer-use efficiencies

2) Irrigation is inadequate around sowing in autumn but is applied in excess during spring. The result is poor establishment and subsequent small yield and low WUE due to water losses by both high soil evaporation and drainage.

3) Many field management practices recommended by researchers from the controlled conditions of on-station experiments are too complex and/or too demanding of experience and understanding to be widely adopted by the farmers. For example, while there has been much effort to popularize sprinkler irrigation, its application is unrealistic due to lack of capital in small households as well as unreliable supply of water and electricity. Furthermore, the advantage that sprinkler irrigation offers to water saving occurs mainly in distribution before the farm and not in the field. There is little benefit to the farmers and efficient water distribution can be achieved by other means.

The key points of a new agronomic design that was developed by active communication between researchers, extension workers, officials and farmers to solve these problems are as follows.

Cultivars: It is recommended to select winter wheat cultivars with high yield potential and maize cultivars with small leaf angle and medium–to-long growing period (Wang, 1991; Lan and Zhou 1995).

Sowing date and sowing density: It is recommended to sow wheat one to two weeks later than current practice (around Oct. 1) in order to manage the plant population more easily and also to allow more time for the preceding maize crop to mature and fill grain. The maize crop itself should be sown as early as possible after wheat harvest (around June 10) and at a higher sowing rate (around 60 kg/ha) than is currently practiced by most farmers (around 45 kg/ha). The higher sowing rate provides additional seedlings that facilitate thinning to the desired plant population. Thinning later than is currently practiced allows the establishment of a more even plant population(Lan and Zhou 1995; Shan, 2001).

Irrigation: Irrigation should be strategic according to crop needs rather than to a fixed schedule. It is recommended to irrigate once before wheat is sown to guarantee adequate soil water storage for seedling establishment and the development of a strong root system during winter growth. Further irrigation around stem elongation is required to achieve the desired ear size (kernel numbers per ear). The actual timing of this irrigation depends on soil moisture and population size. Irrigation after booting promotes grain filling. The timing and amount to be applied depend on current soil moisture content and rainfall forecast. Irrigation should be restricted after-booting. For maize, which grows in the rainy season, a maximum of three light irrigations are required one before sowing or at young seedling stage, a second at stem elongation, and a thirds at tasselling) depending on soil water regime and rainfall forecast (Liang and Wu, 2002).

Nutrient balancing fertilization: The principle is to match nutrient application to nutrient uptake by the crops. If all residues are returned to the field, 225 kg/ha N, 72 kg/ha P_2O_5 are necessary to achieve a wheat yield of 7.7 t/ha yield; while 240 kg/ha N, 93 kg/ha P_2O_5, and 150 kg/ha K_2O are needed for 9 t/ha yield of maize. For wheat, half of the nitrogen is applied before sowing (basal application) with the remainder at stem elongation (top dressing). All P_2O_5 is applied before sowing. For maize, apply all K_2O and half of the nitrogen is applied at the seedling stage (before stem elongation as possible) and prior to irrigation or rain. The remaining nitrogen is applied as a side dressing at the 12-leaf stage (Liang and Wu, 2002).

Other management practices: a) Well prepared land for sowing wheat (i.e. with a fine and flat surface without big maize stubbles). b) Maize to be sown directly into wheat stubble as soon as possible after wheat harvest. c) Maize seedlings to be thinned at 5 ~ 6 leaf stage, a little later than that currently adopted by most farmers. The result is easier thinning and a more even population. d) Maize to be harvested after physiological maturity. e) Fields and irrigation to be managed to avoid runoff after irrigation and after rainfall.

The design is acceptable to farmers because of its simplicity and flexibility, and because it achieves greater yield. The design achieved the following results in a two-year demonstration comparing to the neighboring fields managed by traditional methods:
Decrease in irrigation water applied: 30% (168 mm);
Decrease in nitrogen application rate: 20%;
Increase in annual crop yield: 10 %;
Increase in annual profit per hectare: 30%; and
Increase in crop water use efficiency: 40%.

Conclusion

The approach of agronomic design provides an effective and efficient tool to integrate theory and scientific knowledge with experience and know-how of farmers and other stakeholders for the purpose of developing improved relevant management practices in sustainable and profitable crop production.

On-farm demonstration plays an un-replaceable role in the design for several reasons including:

- It provides a forum for testing and adjusting the design in farmers condition;
- It involves farmer participation, which is important to draw their attention to the issue being addressed and to gain the experience and knowledge of farmers on the issue.
- It provides a forum for local farmers to observe and discuss the design, and make it their own business, hence create a better atmosphere for extending the design later.

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