IJFANS INTERNATIONAL JOURNAL OF FOOD AND NUTRITIONAL SCIENCES
ISSN PRINT 2319 1775 Online 2320 7876

Research paper © 2012 IJFANS. All Rights Reserved, **UGC CARE Listed (Group -I) Journal Volume 11, Iss 11, Nov 2022**

Crop Yield Potential, Soil Condition and Precision Farming

Shakuli Saxena, Assistant Professor
College of Agriculture Sciences, Teerthanker Mahaveer University, Moradabad, Uttar Pradesh, India
Email id- shakuli2803@gmail.com

ABSTRACT: Wheat, rice and maize contribute approximately two-thirds of the energy in human meals, and the basic foundations of human supplies are four main agricultural systems in which these grains are produced. In these systems, yield per unit time and land has risen significantly over the last 30 years as a consequence of stepped up crop management including better plasma, higher fertilizer inputs, cultivation of two or more crops year on the same piece of land and irrigation. The ongoing development of these four systems will rely mostly on meeting future food needs while limiting cultivated area growth. However, the ways in which additional intensification has been accomplished will vary significantly from the past, since the exploitable gap between average farm yields and genetic yield potential is narrowing. Today, the pace of growth in yield potential is considerably lower than anticipated. Thus, in each of these main cereal systems, average farm yields must approach 70%-80% of the theoretical production limit within 30 years. Consistent production at this high levels without causing environmental harm needs improved soil quality and accurate control of all time and space production variables. The extent of the scientific difficulty linked to these goals is addressed. In order to satisfies the anticipated rise in food demand, significant scientific discoveries must occur in fundamental plant physiology, ecophysiology, and soil science.

KEYWORDS: Agriculture, Crop Yield, Intensification, Irrigation, Production.

1. INTRODUCTION

This study examines biophysical limitations on global food safety in the next century. The focus is on wheat, rice and maize since these three plant species provide the bulk of calories in human diets and are expected to remain in the foreseeable future the primary feeding stuffs of human nutrition. Intensification of agricultural systems for wheat, rice and maize was mainly responsible for avoiding a food shortage in the previous three decades – the 30-year era which marked the beginning of the so-called 'green revolution. The most important characteristic of these intensified systems was a higher yield per unit country and time [1].

Although the government's policies and social circumstances were needed to encourage intensification, the higher output produced by farmers was mainly responsible for three production variables. Those were: (i) new miracle wheat and rice varieties released between the mid-1960s which had a higher harvest index, shorter stature, and increased stalk strength, which reduced the susceptibility to housing, and constantly improved maize hybrids; (ii) increased N fertilizer use, which allowed for greater net primary production without fear of lodging; and (iii) massive ii The following factors: The reduced period from planting to maturity of the new cultivars also allowed an increase in cultivation intensity. While just one harvest per year with landrace genotypes was feasible, the early maturity enabled for the same area of land to produce two and, occasionally, three grain crops each year. Annual rice, wheat and maize double crop systems have become the main agricultural system, where soil, climate and water are able to increase crop production. The potential for a further rise in cultivation intensity is thus restricted. The continuing development of irrigated land in recent years has slowed significantly, and future possibilities are restricted by the supply of water and environmental issues. The basis of global food security is currently based on four main cereal manufacturing systems, using contemporary agricultural techniques. The following systems include: (i) irrigated, double- and triple-crop, annual continuous rice systems in tropical and subtropical lowlands in Asia representing approximately 25% of world rice production; (ii) annual irrigated double-crop, primary cereal production in Northern India, Pakistan and Southern China; Smaller cropping systems identical to each of the main systems mentioned above are also present in other parts of the globe with similar natural resources [2].

1.1 Requirement of Intensifying the Environment:

A rise in profits from the growth in wheat, rice and maize systems accounted for 79-96% of the overall increase since 1967 in the worldwide supply of wheat, rice and maize. The area of wheat has stayed relatively steady while the entire area of maize grew by 30 million ha, 12% higher than the total area of maize in the United States in 1997. An extra 446 million ha land would be needed to produce wheat, rice and maize in 1997 at 1967 levels, which constitute 3-fold more than the current overall area of wheat, rice and maize combined in the United States and China. Increased grain production methods therefore avoided agricultural expansion to natural ecosystems and marginal areas prone to severe crop damage.

While intensification avoided the conversion to agricultural use of natural ecosystems, increased use of inputs and poor farming methods led to surface water contamination, biodiversity loss in agroecosystems and other ecosystems impacted by food production output systems. Furthermore, both intensification and development of the agricultural area contribute to human impacts on the biogeochemical cycles of the Earth. The question is, therefore, whether further intensification of the cereal production systems which meet the expected rise in food demand while fulfilling acceptable environmental quality requirements can be accomplished. This aim may be characterized as a greening of agriculture. Success will rely on sustained improvements in yields of the current main irrigated and favorable precipitation cereal systems since crop intensity and irrigation extension are restricted [3].

One key issue is how much more cereal production is needed. One of many econometric models used to predict the future food demand based on population and economic growth rates and other variables that impact supply and demand, is the International Agricultural Commodities and Trade Policy Analysis Model (IMPACT). A recent version of the model forecasts that demand for main grains increased by about 1.2 percent a year for wheat and rice between 1993 and 2020 and 1.5 per cent for maize. The extrapolation of these increases from 1997 to 2027 provides an estimate of 882, 827 and 916 million tonnes correspondingly for wheat, rice and maize demand. In the next 30 years' grain output will therefore rise by 44% for wheat, 43% for rice, and 56% for maize provides realistic goals for academics who focus on the variables controlling global food supply capacities. The aim of attaining this growth without net cultivation without additional loss of the rest of the natural ecosystems of the Earth also appears acceptable.

1.2 Favorable and Unfavorable Environments Intensification:

Rice yield patterns from 1967 show the connection between intensification, natural resources and the possible effect on world food supply in three Asian nations. All rice is grown using irrigation in South Korea. Returns grew significantly via modern agricultural techniques until 1980. Then yields have stalled since the average output of about 6.3 tonnes (t)·ha 1 is close to current output potential with the greatest available technology. In the rice season, South Korea has an average rice production potential of about 7.8 t· ha 1 during the summer monsoon environment with low solar radiation. With comparable production potential in South Korea, South Korean farmers have averaged rice yields at approximately 80 percent of the yield potential. Indonesian rice production gradually grew as irrigated areas expanded, better varieties adopted and fertilizers used. Roughly 70 percent of the rice land is now irrigated. The yield trend indicates that further gains are feasible in Indonesian rice yields. By comparison, Thailand's rice yields have only risen little since 75% of the rice is grown on low quality soils without irrigation. Drought, floods and barren soils impose serious limitations on the capacity to enhance yields even if farmers have access to better variety and fertilizer supplies. Despite these limitations, it is worth noting that Thailand is now the biggest rice exporter in the world, reflecting the vast area of rice cultivation rather than the high level of productivity [4].

Similar patterns with regard to natural resources are observed in wheat and maize yield trends. Modern crop management practices have had a major impact on yields in irrigated systems such as high-producing rice and wheat systems in Asia and in rain-fed environments, where both soil and climate quality are favorable for crop development, such as northwestern and central Europe's wheat systems and maize based systems in North America. In adverse precipitation and hard soil conditions, wheat and maize yields have been increasing slowly during the last 30 years.

The ecological intensification of crop systems in adverse rain-fed environments depends largely on decreasing dependence on the production of subsistence cereals, integration with farming companies, greater crop diversification and agro-forestry that provide more economic value and foster soil conservation. However, the amount of the gain in the food supply from this development is very modest, since current outputs are extremely low and water shortages are the main limitation. The quantity of water transpired is closely linked to all crop yields. The potential to enhance transpiration via genetic improvement in water-limited settings is thus very modest. Instead, an improvement in soil management and residue management that increases the quantity of plant-available water per unit of rainfall would have far larger effect on yield and yield stability than might be anticipated as a result of genetic enhancement. Examples of such techniques include no-till and low tillage systems established in the US. Applied research to adapt conservation tillage technologies for use in unfavorable rain-fed systems in developing countries in conjunction with research on integrated nutrient management would have significant positive implications for local food safety and an increased standard of living but they will have little impact on the global food supply balance [5].

At the opposite extreme are high-production systems in which the mean agricultural yields now exceed 70% of the yield potential. Rice output has reached this level in Korea, Japan and portions of the United States and China, and wheat production in certain regions in North West Europe. Further improvements in yield without an increase in the genetic yield potential of plant variants and hybrids will be impossible to accomplish. The highest possibilities for sustainable yields are found in irrigated and suitable rain-feeding systems with a mean agricultural yield of less than 70%. Indonesia's rice systems are an example of such systems, and this category covers most irrigated rice and wheat systems in Asian developing nations. The mean climate-friendly rice yield potential for this area is estimated to be about 8,5 t· ha 1, while the average irrigated rice yields now amount to 5,0 t·ha 1, or approximately 60% of the climate-friendly yield potential. The most advantageous plant systems for rainfed maize in North America, irrigated rice-wheat systems of Pakistan, North India, Ne-pal and China, rainfed wheat in central Europe, cereal production in favorable rainfed areas of Argentina and Brazil are also the major food production systems of this category.

1.3 Potential yield:

The gap between current farmers' average yields and yield potential is measured by the yield capacity of existing crop varieties or hybrids and the degree to which crop and earth management techniques enable this genetic potential to be manifested. Maintaining a significant difference in yield is essential for maintaining consistent improvements in average yields of rice in South Korea. Knowing the yield potential growth rates and the physiological foundation for these gains in the last 30 years offers insights into future possibilities. Researchers describe crop yield potential as the output of a cultivar under settings to which it is suited, without nutrients and water limitations, and with successfully managed pests, conditions, weeds, lodging and other stressors. Although this concept appears simple, the yield potentials under real field circumstances are challenging to quantify since all abiotic and biotic stressors cannot be eliminated. The yield realized is therefore a more useful description of the yield potential when an adapted cultivar is cultivated with the minimum feasible effort that optimal management techniques may accomplish. While the specifications of minimum stress and optimal management techniques are rather vague, crop simulation models may offer acceptable estimations of functional yield potential in a given environment based on the physiological connection which governs plant growth and development. In irrigated settings, solar radiation and temperature regime during crop development mainly influence the production potential. For rain-fed systems, a water-limited yield potential may also be approximated by taking into account the water balance of the system [6].

1.4 Quality of The Soil:

Soil quality is an elusive notion, as is yield potential, which is difficult to define and quantify. Soil quality definitions in contemporary research emphasize biological production capability, environmental quality, and plant and animal health promotion. Despite this wide definition, it may be claimed that particular soil characteristics, such as nutrient stores, water holding capacities and the favorable root-growth structure, promote crop production, are the same attributes as contributing to environmental services provided by soils. These soil properties include: physical features such as pore size and continuity, aggregate stability, and texture which jointly determine soil structure; chemical properties such as organic matter content and composition, nutrient inventory and accessibility, mineralogy and quantity of elements and compounds deleterious to plant growth;

A soil degradation may be described as soil deterioration as a consequence of human activity. The four main forms of soil degradation are water erosion, wind erosion, chemical degradation, and loss of physical characteristics. A recent research of 250 experts from 21 areas assessed worldwide soil deterioration, severity and causes. It has been calculated that the total area having some kind of soil deterioration is approximately 2,000 million hectares. Inappropriate techniques of agriculture, deforestation and overgrazing were the main reasons identified. It was calculated that

84% of the overall degraded area was damaged by water or wind erosion. In Africa, Asia and South and Central America, more than 80 percent of all degraded land was found. About 60 percent have been found to be poorly suitable for intensive agriculture in dryland areas. Since erosion-causing manufacturing methods and physical processes are widely known, technological solutions are provided to avoid this kind of deterioration. Adoption obstacles may include land tenure problems, availability to loans and inputs and other socio-economic constraints. Efforts to promote erosion management techniques are essential in order to enhance local food security and social security for individuals living in regions affected by erosion. Equally, avoidance of erosion in the upland watersheds, feeding large irrigation systems in highly productive lowland regions, may influence food production capacity through decreased sediments in reservoirs and irrigation systems. This sediment charge raises irrigation infrastructure maintenance costs and decreases the storage capacity of the reservoir, which may result in water shortages in highly productive irrigated regions [7].

Erosion in favorable rain-fed areas with excellent soils and sufficient precipitation for crops may also be a concern. Much of the cropland in the north-central United States belongs under this category, although techniques of soil conservation to avoid erosion have been developed. No-till and decreased tillage methods retain crop residues on the surface and shield them from the direct effects of raindrop and enhance the rate of infiltration. As a consequence, more rainwater is retained in the soil profile, and both rush and erosion are decreased. Long-term studies also show that such soil conservation techniques contribute to the preservation of soil quality by stabilizing organic matter at greater levels than traditional soil ploughing [8].

In addition to erosion, an estimated 555 million hectares of the study were subject to other types of chemical and physical deterioration not directly related to erosion. For most types of chemical deterioration, the preventive and restoration techniques and procedures are well known. Salinization and acidification come into this category as do the toxicities of soil caused by humans that are side effects of salinization, acidification and pollution. While deterioration of this type may be repaired, it might be prohibitive when degradation gets severe. Prevention is the most important thing. In agricultural systems which get little or no nutrient input such as fertilizer or manure, the depletion of nutrient and loss of soil organic matter are also easy to detect and to rectify access to nutrient sources, buying power or credit. In traditional slash and burn systems used by subsistence farmers, for example, soil degradation is caused by nutrient depletion in the forests and savannas of the tropics that decrease in fallows due to population pressure. Here again, technological solutions are accessible and significant social, political and economic limitations are the main ones [9].

Although flagrant types of deterioration occur mainly in low-soil or adverse climates, and technological remedies are available to avoid these issues, the conclusion that soil degradation is not a significant threat to food security would be an error. Instead, in some of the most productive agricultural systems in the world, subtle and complicated types of soil degradation may occur and these less evident forms of degradation may constitute an increasingly significant restriction on the capability of food production over the next century. In addition, prior soil degradation estimates are unlikely to account for subtle types of deterioration in high-production systems, since the magnitude and the causes of such degradation have been identified only lately [10].

2. DISCUSSION

Average farm outputs and prospective yield limits must decrease during the next 30 years as tropical rice and maize yield potential seems to remain static and the yield potential of wheat increases more slowly than anticipated. Consequently, obtaining consistent grain yields above 70 percent of the theoretical barrier to yield relies on smart land, water and input management. A precision farming strategy is needed to ensure that the necessary resources for crop development are accessible and crop protection requirements fulfilled at each point in time throughout the growing season without deficiency or excess. Precision management may be implemented consistently via accurate scheduling and placement of a given field activity, or it might include site-specific management to account for variations in soil characteristics, crop resource needs, pests and disease.

Site management based on a variable application of an input or management operation is particularly important for large-scale farming when field size and variation in the field are sufficient to justify the expense of required equipment. The technology is now accessible in most industrialized nations, which enables the administration of seed, nutrients, water and pest control methods to suit individual needs at each site in a field. In theory the efficiency of fertilizer usage is rising from site-specific vs uniform nutrient use, as the size or septicity of variation in the supply of native soil nutrients rises and as production levels approach the yield potential limit. Simulations also forecast a reduced efficiency of N fertilizer nitrate leaching with site-specific management.

In reality, it was difficult to validate theory. In one research, comparing site-specific N applications with irrigated maize, a substantial site-specific yield was observed in one of 12 site-year comparisons and a negative yield response in another. There was no difference in yield in the other 10 tests and the quantity of N applied by both techniques was comparable. The authors have attributed the lack of response to the inaccuracy of predicting the requirements for N fertilizers by present soil testing methods that do not meet dynastic controls on the availability of soil and fertilizer N or crop N conditions to the site-specific N application guidelines despite their detailed soil samples.

Theoretical economic and environmental estimates are broadly based on the site-specific deployment of variety or hybrid, but farmer successfully implements accurate data on the spatial variability of soils properties, pest and disease impact and crop physiology, as well as exact knowledge of soil conditions and pests. Remote sensing technologies are being developed that may enhance accuracy and lower the cost of real time spatial variability assessments of crop physiology and pest pressure. In contrast, a comprehensive understanding of the eco-physiological mechanisms controlling crop response to interacting environmental variables is not strong enough to provide reliable forecasts of site-specific input needs or anticipated results. This information gap is the key to site-specific management in big agricultural systems in industrialized nations.

Precision agriculture will also be essential in emerging nations to achieve improvements in grain yields that must be approaching potential yield levels in major production systems. As field sizes are usually lower than 0.5 ha, precision farming includes field-specific management techniques. Recent on-farm studies in many Asian nations of dual crop rice systems show enormous field to field variations in native soil N availability within limited production areas in which soil characteristics are comparable. For instance, the grain yields without N-applied varied from 2,400 to 6,000 kg/ha —1 in 42 distinct rice fields in one town in the Philippines, and variations in soil N availability were ascribed. Similar results were achieved in other major rice producing facilities in south India, Indonesia, Thailand and Vietnam, which are dominated by double and triple crop rice systems. In all instances there was no association of significant variation in soil N supply with variations in soil organic matter, total N or other measures of soil N availability that are consistent with the findings of long-term studies with rice systems with a double or a triple crop. Thus, in long-term studies, the same mechanisms that account for the minor changes in the composition of soil organic matter may potentially affect the supply of soil N to regions with continuous irrigated rice cultivation systems as the main cereal system.

Given a huge variance in soil N supply across soil types and plant management methods comparable to field-specific N fertilizer needs, yield and profit optimization will be required and N fertilizer losses minimized. Related investigations have found significant field-to-field variability in soil supply P and K. Field-specific management of these nutrients will also be required. As for the supply of soil N, existing techniques cannot forecast correctly the availability of soil P or K or the yield response from application P or K. Similar variations in the soil supply of N, P and K are expected in the rice-wheat irrigation systems of Asia since rice is also cultivated in the flooded soil in such systems.

Currently, most national and regional extension agencies in Asia provide clear fertilizer recommendations for broad areas of wheat and rice cultivation. In small regions with a similar soil type, the extent of the variance in field to field will lead to inefficient fertilizer usage and will reduce attempts to improve average farm returns due to nutrient shortages, excesses and inequalities. On the other hand, the requirement to control nutrients in hundreds of millions of tiny rice and wheat fields in low-income nations is an intimidating task. In order to protect crops from insect pests and diseases and minimize the use of pesticides, field-specific pest control will also be necessary. The frequency and severity of a number of key illnesses and insect pests increases when cereal plants have enough N to produce the luxuriant canopy needed for good yield. In these low-income countries that have high-production cereal systems, the development of scientific capacity, technology transferal mechanisms, and farmers' education for the diagnosis of limiting factors, the prediction of expected yields and input requirements and the realization of field-specific management will be a crucial compound in food security.

3. CONCLUSION

The anticipated rise in demand for food and the aim of limiting cropland expansion implies that cereals will reach the yield potential limit in many of the world's most productive crop systems during the next thirty years. In order to achieve food security, ecological intensification of these high-producing farming systems is essential for this scenario and presents many questions: What are the forecasts for rising wheat, rice and maize yields and how much? What are the direction and how will these changes impact the yield of the crops in major cereal production systems? Is it possible to enhance agricultural and soil management techniques in order to consistently produce high returns while satisfying acceptable environmental standards? It is claimed that despite the need for answers and the general application of this information in a reasonably short period, the current level of knowledge is far from adequate to address these issues. The conclusion was that global food security for 30 years would therefore depend on quick scientific advances in the comprehension of the physiological basis of plant yield potential, soil quality and crop productivity processes, and plant ecology linked to many interacting environmental factors that affect crop yields. These scientific breakthroughs are conceivable, but current investments in those particular fields of study, both in the US and abroad, are not sufficient to address the issue.

REFERENCES

[1] P. Tittonell and K. E. Giller, "When yield gaps are poverty traps: The paradigm of ecological intensification in African smallholder agriculture," *F. Crop. Res.*, 2013, doi: 10.1016/j.fcr.2012.10.007.

[2] S. Khanal, J. Fulton, and S. Shearer, "An overview of current and potential applications of thermal remote sensing in precision agriculture," *Computers and Electronics in Agriculture*. 2017, doi: 10.1016/j.compag.2017.05.001.

[3] M. Diacono, P. Rubino, and F. Montemurro, "Precision nitrogen management of wheat. A review," *Agronomy for Sustainable Development*. 2013, doi: 10.1007/s13593-012-0111-z.

[4] S. Khanal, J. Fulton, A. Klopfenstein, N. Douridas, and S. Shearer, "Integration of high resolution remotely sensed data and machine learning techniques for spatial prediction of soil properties and corn yield," *Comput. Electron. Agric.*, 2018, doi: 10.1016/j.compag.2018.07.016.

[5] M. Hakojärvi, M. Hautala, A. Ristolainen, and L. Alakukku, "Yield variation of spring cereals in relation to selected soil physical properties on three clay soil fields," *Eur. J. Agron.*, 2013, doi: 10.1016/j.eja.2013.03.003.

[6] R. Gaur, L. Mishra, and S. K. Gupta, "Modelling and Simulation of Diffusive Processes," *Model. Simul. Diffus. Process.*, 2014.

[7] M. H. Gerzabek, "Global soil use in biomass production: Opportunities and challenges of ecological and sustainable intensification in agriculture," *Bodenkultur*, 2014.

[8] M. Zhang, P. Hendley, D. Drost, M. O'Neill, and S. Ustin, "Corn and Soybean Yield Indicators Using Remotely Sensed Vegetation Index," 2015.

[9] G. S. Mupppavaram, "Leveraging Technology for Marketing Smart Farms," *Sansmaran Res. J.*, 2018.

[10] S. Phillips, "Precision Agriculture: Supporting Global Food Security," *Better Crop. With Plant Food*, 2014.