ROAD MAP FOR PRECISION AGRICULTURE IN THE PUNJAB, NORTH-WEST INDIA

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ABSTRACT

Agricultural experimentation is both expensive and time consuming. It is necessary to reduce site-specific research and capitalize on the agricultural experience gained elsewhere by using soil maps and GIS-GPS (Geographic Information System - Global Positioning System) technology. Since in an agro-eco-subregion, soils in the same family require essentially the same management practices, maximum production results obtained in one soil family can be used as production targets for all soils belonging to the same or similar soil families. Therefore establishing of benchmark soils with specific families in every agro-ecological subregion of the state for agricultural research, development and technology transfer is desirable. In the state of Punjab 17 benchmark soils have been established. Together these represent 55.86 per cent of the geographical area of the state. Research based on these 17 benchmark soils can be used to further fine tune the agricultural recommendations system. Depending upon the extent, major land use and economic importance, two benchmark soils have been identified in the northeastern undulating agro eco-subregion, which are Typic Ustorthents and Typic Haplustept. These soils should be used for future research and testing of agro-technology related to crops of this agro-eco- subregion. Seven benchmark soils covering 13.53 per cent of State in the north-eastern undulating agro eco-subregion. These are Typic Ustipsamments / Ustifluvents, five Typic Haplustepts and a Vertic Haplustept. Five benchmark soils represent the central alluvial plain agro-eco-subregion. These represent 25.64 per cent area of the state. These are two Typic Haplustepts, Typic Ustipsamment, Typic Ustifluvent and Natric Haplustept. In the South-western alluvial plain agro-eco-subregion, three benchmark soils cover 13.84 per cent of the geographical area of the state. These are Ustic Torripsamment, Ustic Haplocambid and Ustic Haplocambid. Instead of single blanket recommendation for the whole state, this should help in developing a separate set of recommendations one each for an agro-eco-subregion based on the results of experiments on the benchmark soils, which at later stage can be extended for each soil variant leading towards better precision farming. However, effective technology transfer will depend largely on horizontal information exchange among different departments and vertical delivery of appropriate technology to the farmers of the State.

(Key words: Road map, Precision farming, Agro-eco sub-regions, Benchmark soils)

Today's headlines in Punjab focus on the declining water table, deteriorating quality of irrigation as well as potable water, decreasing profits from the agriculture and increasing debtness of cultivators, decreased rate of productivity and deteriorating quality of natural resources (climate, water and soil). Another worrying scenario is of real estate, which is engulfing the prime agricultural lands of the State. Soil and water are the biggest reactors on this earth, where most physical, chemical and biological reactions take place. These are also the largest sinks, where most animal, human, agricultural and industrial waste is disposed off. Under such a scenario, where magnitude of negative processes is increasing and when sincere efforts of experts are not breaking the stagnation in agricultural productivity, it is worthwhile to provide tailor made solutions as per crop requirements based on quality of climate, water and soil.

Precision agriculture integrates a suite of technologies that retain the benefits of large-scale mechanization, which is essential to large fields, but recognizes local variation. By using satellite data to determine soil conditions and plant development, these technologies can lower the production cost by fine-tuning seeding, fertilizer, chemical and water use, and potentially increasing production and lowering costs — all benefiting the farmer. The generation of maps for crop and soil properties is the most important and first step in precision farming. These maps will measure spatial variability and provide the basis for controlling spatial variability. Data collection occurs both before and during crop production, which is enhanced by collecting precise location, coordinates using the global positioning system (GPS).

Precision farming in the context of Punjab agricultural scenario

Conventional agriculture is practised for uniform application of fertilizer, herbicide, insecticides, fungicides and irrigation, without considering spatial variability. To alleviate the ill effects of over and under usage of inputs, the new concept of precision farming has emerged. Site-specific management of spatial variability of farm is developed to maximize crop production and to minimize environmental pollution and degradation, leading to sustainable agro-ecological development. Precision agriculture is a newly emerging agricultural management concept. It is basically designed to optimize agricultural inputs viz., fertilizers, pesticides, water etc, in tune with micro-level/field requirements. Optimization is focused on increased yields, reduced cost of cultivation and to minimized environmental impacts through location-specific management. The success stories pertaining to precision agriculture have been mainly drawn from the developed countries; wherein very large field size is suitable for high end mechanization with automated systems, is driven by market forces and has been a professionally managed enterprise.

Though widely adopted in developed countries, the adoption of precision farming in India is yet to take a firm ground primarily due to its unique pattern of land holdings, poor infrastructure, lack of farmers' inclination to take additional onus of management including socio-economic and demographic conditions. Taking into account the predominance of fragmented and small land holdings, heterogeneity of crops and livestock, the model of precision agriculture representing the typical Punjab agricultural scenario is yet to evolve. While the ecological integrity of farming systems is an imperative need, it is equally important to extend the access of information and market to the small and marginalized farmers. The precision agriculture model for Punjab while addressing these issues should provide an innovative route for sustainable agriculture in the globalized and liberalized economy. The most improtant for any proposed precision agriculture model, is its own sustainability. This is possible only if it is more near the ground realities. It requires special tools and resources to recognize the inherent spatial variability associated with soil and water characteristics, crop growth and to prescribe the most appropriate management strategy on a site-specific basis. It offers a potential step change in productive efficiency. Considering this inherent variability, management decisions should be specific to time and place, rather than rigidly scheduled and uniform over a large area.

Road map for precision agriculture in Punjab

Precision agriculture involves advance decision making at the agricultural experts level as well as at the farmers level. This requires a comprehensive back up from the database about the basic resources being used in the agriculture. As discussed earlier there cannot be any further precision in agriculture without the availability of database pertaining to spatial and temporal variability in soil and water associated with different aspects of agriculture production system. In case of Punjab State, only small-scale maps are available about the variation in natural resources. Data base about variations in natural resources for most districts and agricultural development blocks in the form of large-scale maps are not available. Therefore, at present only blanket recommendations are given at the state level after proper testing at different locations of the state (Table 1). In such a scenario when proper database is lacking and state is eager to move further in the direction of precision farming, best course available is testing of agricultural technology on well-established benchmark soils and then transferring the same to similar soils occurring elsewhere in the suitably crafted agro-ecological subregions.

Table 1 **Status of natural resources data base and expert advice system**

Adminis-trative level	**Required resource data base**	**Availability of resource data base**	**Present expert advice system**	**Suggested expert advice system**
State	Small scale maps	Yes		Punjab State ↓ 5-agro-eco-subregions
Agro-ecological-subregions	Small scale maps	Yes	↘	↓ Test agro-technology

Agriculture development blocks	Large scale maps	No	Blanket package of practices for whole state	on 17 - Benchmark soils in the 5-agro-ecological subregions ↓ Transfer the five sets of agro technology to similar soils, one each for the 5 - agro-ecological sub regions of the state ↓ Transfer of agro-technology to individual farm based on soil and water health cards
Village	Very large scale maps	No		
Individual farm	Very large scale maps	No		

Agro-eco subregion based planning for precision farming

Land resources are limited and finite. Human population continues to increase, therefore, there is an urgent need to match uniform land types and land uses under similar climate, in the most rational way to maximise sustainable production and satisfy the diverse needs of the society while conserving the fragile ecosystem and our genetic heritage. This brings into fore the concept of agro-eco subregion based planning for precision farming. Such a planning is an extremely complex subject that combines physical, social and economic aspects of land use with an assessment of potential future needs. Out come of such plans are sometimes misunderstood as being a process where planners tell people what to do, i.e. a typical top-down situation. Agro-eco subregion based planning for precision farming means the systematic assessment of physical, social and economic factors (especially with respect to agricultural land use) in such a way as to help and encourage expert as well as users to select options that increase their productivity and meet the needs of the society. The driving force in such a planning process is the need and desire for change, the need for improved management or the need for a different pattern of land use as dictated by changing circumstances.

Agro-ecological-subregions are large areas of Punjab state, which are broadly uniform with respect to problems and potentials of the existing natural resources. The agro-ecological-subregion methodology involves delineating land units, which are homogeneous with respect to rainfall, temperature, vegetation, potential evapo-transpiration, soil moisture storage, soils and topography. The National Bureau of Soil Survey and Land Use Planning, Nagpur (NBSS & LUP) has established 20 agro-ecological regions and 60 subregions by superimposing the maps of bio-climate and length of crop growing period maps on the soil map of India (Velayutham *et al*., 1999). The maps are based on 50 years of climatic data from over 350 meteorological stations of the country and the available soil quality database. The boundaries of the agro-ecological subregions of Punjab have been delineated from the maps of the NBSS & LUP, Nagpur. As such, five agro-ecological-subregions (agro-eco-subregion) have been identified and named in simple language for the convenience of the users (Map 1).

1. **Sub-mountain (Siwalik Hills) agro-eco-subregion**
2. **North-eastern undulating agro-eco-subregion**
3. **Piedmont and alluvial plain agro-eco-subregion**
4. **Central alluvial plain agro-eco-subregion**
5. **South-western alluvial plain agro-eco-subregion**

In delineating sub-mountain (Siwalik Hills) agro-eco-subregion and Northeastern undulating agro-eco-subregion, relatively more weightage has been given to the topography than the rainfall, temperature, vegetation, potential evapo-transpiration, soil moisture storage and soils. In the remaining four agro-eco-subregions, all the criteria have been given almost equal weightage. Based on narrow range of length of crop growing period (less than 60 days) some parts of Abohar and Khuian Sarwar blocks of District Firozpur have been grouped under Marusthali hot, hyper-arid-eco-subregion (M9Eh1) by Velayutham *et al.* (1999). However, owing to small geographical extent of the parts of these blocks, these have been discussed along-with the M9Et2 subregion that in Punjab has been named as southwestern alluvial plain agro-eco-subregion. The precision farming in each of the agro-eco-subregion demands the identification of major soil-variants that dominate in a particular region around which the main inputs-management-response combi-nations be experimented and precise recommendations worked out.

Benchmark soils (BM) network for Punjab

Agricultural experimentation is both expensive and time consuming. It is necessary to reduce site-specific research and capitalize on the agricultural experience gained elsewhere by using soil maps and GIS-GPS (Geographic Information System - Global Positioning System) technology. Since in an agro-eco-subregion, soils in the same family require essentially the same management practices, maximum production results obtained in one soil family can be used as production targets for all soils belonging to the same or similar soil families. Therefore establishing of benchmark soils with specific families in every agro-ecological subregion of the state for agricultural research, development and technology transfer is desirable. In the state of Punjab 17 benchmark soils have been established (Table 2, Map 2). Together these represent 55.86 per cent of the geographical area of the state. Remaining 44.1 per cent area of the state is too heterogeneous and is represented by 104 associations of soil families. Research based on these 17 benchmark soils can be used to further fine tune the agricultural recommendations system. Instead of single blanket recommendation for the whole state, this should help in developing a separate set of recommendations one each for an agro-eco-subregion, which at later stage can be extended for each soil

Table 2 Distribution of Benchmark soils (BM) for testing of agro-technology in Punjab

Sr No.	Subregion	Number of benchmark soils (BM)*	Per cent area of Punjab covered by BM soils
I	Sub-mountain (Siwalik hills) agro-eco-subregion	-	-
II	North-eastern undulating –agro-eco-subregion	2	2.85
III	Piedmont and alluvial plain agro-eco-subregion	7	13.53
IV	Central alluvial plain agro- eco-subregion	5	25.64
V	South-Western alluvial plain agro-eco-subregion	3	13.84
Total		**17**	**55.86**

variant leading towards better precision farming. However, effective technology transfer will depend largely on horizontal information exchange among different departments and vertical delivery of appropriate technology to the farmers of the State.

1. Sub-mountain (Siwalik hills) agro-eco-subregion

This agro-eco-subregion comprises of only 2.4 percent of total geographical area of Punjab and there is a lot of heterogeneity from the agricultural production point of view due to hilly terrain. Due to uneven terrain and steep slopes, major emphasis in this subregion is on conservation of soils and water. Thus, no benchmark soil is suggested for testing of new crop production based agro-technology.

2. North-eastern undulating agro-eco-subregion

Depending upon the extent, major land use and economic importance, two benchmark soils have been identified in the northeastern undulating agro eco-subregion, which are Typic Ustorthents and Typic Haplustept (Map 2). These soils should be used for future research and testing of agro-technology related to crops of this agro-eco- subregion.

3. Piedmont and alluvial plain agro-eco-subregion

Seven benchmark soils covering 13.53 per cent of State have been identified in the northeastern undulating agro eco-subregion (Map 2). These are: Typic Ustipsamments/Ustifluvents, five Typic Haplustepts and a Vertic Haplustept These soils should be used for future research and testing of agro-technology related to crops of this agro-eco-subregion.

4. Central alluvial plain agro-eco-subregion

Depending upon the extent, major land use and economic importance, five benchmark soils represent the central alluvial plain agro-eco-subregion (Map 2). These represent 25.64 per cent area of the state. These are: two Typic Haplustepts, Typic Ustipsamment, Typic Ustifluvent and Natric Haplustept.

These soils should be used for future research and testing of agro-technology related to crops of this agro-eco- subregion.

5. South-western alluvial plain agro-eco-subregion

In the Southwestern alluvial plain agro-eco-subregion, three benchmark soils cover 13.84 per cent of the geographical area of the state. These are: Ustic Torripsamment, Ustic Haplocambid and Ustic Haplocambid. These soils should be used for future research and testing of agro-technology related to crops of this agro-eco- subregion. The location of benchmark soils of this agro-eco-subregion is indicated in Map 2.

Detailed physical and chemical characteristics of all these benchmark soils and their precise location in the respective agro-ecological sub-region are available in the book entitled ‘Planning for precision farming in different agro-ecological sub-regions of Punjab - role of natural resources in agricultural research, planning, development, & transfer of technology (Raj Kumar *et al.,* 2008)

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