INSTITUTION OF AGRICULTURAL TECHNOLOGISTS,

BENGALURU

EVALUATION OF RKVY PROJECTS

OF

UNIVERSITY OF AGRICULTURAL SCIENCES,

RAICHUR

"PRECISION FARMING TECHNIQUES
IN
SELECTED FIELD CROPS"

INSTITUTION OF AGRICULTURAL TECHNOLOGISTS,

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CONTENTS

"PRECISION FARMING TECHNIQUES IN SELECTED FIELD CROPS"

EXECUTIVE SUMMARY

India has moved from an era of chronic food shortage during the 1960s to food self-sufficiency and even food exports from the 1990s. Demand for food and agriculture commodities in India is rising at a much higher rate than the growth in population of the country. Hence, with the sole pursuit of high productivity in order to meet the ever growing demand for the agricultural products, it has resulted in indiscriminate utilization of resources which in turn resulted in neglecting the critical linkage between agriculture and environment and has posed a threat to the future of Indian agriculture on sustainable basis.

As the world's population grows, farmers will need to produce more and more food. Yet arable acreage cannot keep pace, and the looming food security threat could easily devolve into regional or even global instability. There are many risks that are impacting our ability to generate food today including plateauing crop yields in some regions, climate change and the increase in population growth. Currently, agriculture production is facing significant challenges such as escalating costs of production, shortage of irrigation water and increased public concern about the impacts of agricultural production on the environment.

The focus on enhancing the productivity during the green revolution coupled with total disregard of proper management of inputs without considering the ecological impacts has resulted in environmental degradation. Traditional farming relies on managing entire fields—making decisions related to planting, harvesting, irrigating, and applying pesticides and fertilizer—based on regional conditions and historical data.

Precision agriculture is the application of technologies and principles to manage spatial and temporal variability associated with all aspects of agricultural production for improving production and environmental quality. The success in precision agriculture depends on the accurate assessment of the variability, its management and evaluation in space-time continuum in crop production. The agronomic feasibility of precision agriculture has been intuitive, depending largely on the application of traditional management recommendations at finer scales. The biggest benefit of precision farming is that it gives producers the ability to manage their farm on a production zone basis rather than a whole field basis. This shift allows farmers to save time and money and helps them offset the rising cost of chemicals, nutrients, fuel and fertilizer.

Though it is widely adopted in developed countries, the adoption of precision farming in India is yet to take a firm ground primarily.

Although India has made considerable advance in agricultural research, but still the blanket recommendations of fertilizers for adoption over larger areas are in vogue. These blanket recommendations are no more useful to enhance productivity gains, which were witnessed between 1960's and 1980's. Now, to enhance growth rate in productivity, precision agriculture technology has to be developed. Precision agriculture is important because of the following points:

i. nutrient variability within a field can be very high affecting optimum fertilizer rates
ii. yield potential and grain protein can also vary greatly even within one field, affecting fertilizer requirement
iii. increasing fertilizer use efficiency will become more important with increasing fertilizer costs and environment concerns
iv. irrigation at critical stages is very important and
v. pest and stress management at the early stages of the crop helps the farmer to get maximum yield

Popularization of soil test based nutrient application in other words optimum input application may save cost on inputs, improve quality of agriculture produce apart from addressing the environment pollution issues associated with over use of agricultural inputs particularly in irrigation commands which are obsessed with high input intensive practices.

Keeping this in view the project, "**PRECISION FARMING TECHNIQUES IN SELECTED FIELD CROPS**" was sanctioned under Rashtriya Krishi Vikas Yojane (RKVY) during 2010-11 to take up large scale demonstration at farmers' fields. The adoption of precision farming tools and techniques in selected field crops through large scale demonstrations were taken at different villages under farmers' participatory approach in Raichur, Gulbarga and Koppal districts, covering approximately an equivalent of 100 acres each in Cotton, Pigeon Pea and Paddy crops respectively during 2011-12, 2012-13, & 2013-14. Apart from this, research demonstration plots [5.00 acres in each crop] at different research stations [Kalaburgi, Raichur and Gangavathi] of University of Agricultural Sciences, Raichur were also undertaken to assess the feasibility of Precision Farming Techniques in small scale land holdings during these years. However, during the year 2014-15, only research demonstration plots [5.00 acres in each crop] at three different research stations of University of Agricultural Sciences, Raichur were undertaken owing to several constraints. Finally, Precision Farming techniques were demonstrated in large areas of farmers' fields accounting to a total of 92.49 Acres in Cotton in Merchatal village, Raichur taluk & district, 78.125 Acres in Paddy in Jangamara Kalgudi village, Gangavathi taluk, Koppal district and

137.48 Acres in Pigeon pea in Chinamgera (73.74 acres), Ingalgi (48.12 acres) and Chowdapur (15.62 acres) villages, Afzalpur taluk, Kalaburgi district under the RKVY sponsored project.

The details of the project were as under:

1.	**Title of Project**	**:**	"**PRECISION FARMING TECHNIQUES IN SELECTED FIELD CROPS**"
2.	**Nodal officer and Principal Investigator**	**:**	**Dr. M. B. Patil,** Professor of Plant Pathology, Head AEEC, Koppal **Dr. Veeresh H.**, Asst. Professor of Soil Science, College of Agriculture, University of Agricultural Sciences, Raichur (In charge PI) **Dr. Masthana Reddy**, Professor of Agronomy, Chief Scientist & Head, ARS, Gangavathi (Co-investigator) **Dr. Pandith Rathod**, Associate Professor of Agronomy, Senior Scientist, AICRP on Chickpea, ARS, Kalaburgi (Co-investigator)
3.	**Implementing Institution (S) and other collaborating Institution (s)**	**:**	College of Agriculture, Raichur, ZARS Raichur, ARS Kalaburgi, Gangavathi
4.	**Date of commencement of Project**	**:**	2010-11
5.	**Approved date of completion**	**:**	2015-16
6.	**Actual date of completion**	**:**	2015-16
7.	**Project cost**	**:**	Rs. 110 lakhs

The objectives of the project were to adopt and demonstrate precision farming techniques for cotton, pigeon pea and paddy crops by emphasizing soil test based nutrient application to optimize soil input application.

The focus of Evaluation is:

i. To study the impact of soil test based nutrient application on crop yield in different crops.
ii. To study the impact of demonstration of precision farming techniques for cotton, pigeon pea and paddy crops in farmers' fields.

iii. To study whether the farmers who have benefitted from demonstrations of precision farming techniques are able to obtain sustained production by following the recommendations of the project scientists.

iv. To study the constraints in successful implementation, adoption and popularization of Precision Farming Techniques from the point of Indian Scenario.

FINDINGS AND DISCUSSION

The studies in research plots at the research stations and in farmers' fields revealed that:

1. Farmers were following blanket fertilizer application of major nutrients without any assessment of the soil fertility status and specific crop requirement.
2. It was clearly evident from the data observed and recorded from the experimental plots either in research farms or in farmers' fields that spatial variability of many factors of soil and crop did exist.
3. Farmers are convinced that by adopting the practices such as soil test based input application can save the unnecessary cost on fertilizer inputs, timely management of pests as per standard package of practices can control pest and disease occurrence better in crops, intervention through amendments and foliar nutrition can fetch higher crop yields etc.
4. Paddy farmers in Gangavathi taluk and cotton farmers' in Afzalpur taluk were more enthusiastic as they have found significant reduction in application of inputs and apart from fetching higher crop yields.
5. Increase in yield of pigeon pea in farmers' fields coincided with shift in variety of pigeon pea grown from the native Guliyal variety to TS3R.
6. The participatory approach in adoption of precision farming techniques by farmers resulted in application of other nutrients like Zinc, Iron and Potassium in addition to Nitrogen and Phosphorus that the farmers were using before introduction of the techniques.

Farmers used to apply blanket application of fertilizers to the crop based on their own indigenous knowledge. After, the intervention of project implementing team

1. Farmers have understood that soil fertility differs from field to field as well as varies within a given field.
2. Blanket application may not be the best way of fertilizer application
3. Different crops require different quantum of application
4. Optimum dose of fertilizer application can be satisfactorily achieved by interpreting

soil testing results.

5. Fertilizer application after every irrigation is not a good practice
6. Higher application of fertilizer will not always fetch higher profit even though higher crop yields are realized.
7. Application of soil test based fertilizer ensured good crop stand, low pest and disease occurrence and saved the money on pesticides.
8. Standing crop can also be effectively monitored by using crop sensor observations.

As a whole, the large scale demonstrations at farmers' field under precision farming techniques were successful in building the confidence among the farmers about the techniques of modern agriculture. They are convinced that by adopting the practices such as soil test based input application can save the unnecessary cost on fertilizer inputs, timely management of pests as per standard package of practices can control pest and disease occurrence better in crops, intervention through amendments and foliar nutrition can fetch higher crop yields etc.

REFLECTIONS AND CONCLUSIONS

1. Although the title of the project indicates adoption of Precision Farming Techniques in selected field crops, the study was mostly confined to soil test based application of fertilizers with focus on major nutrients and to some extent zinc and iron. Precision farming involves the application of technologies and principles to manage spatial and temporal variability associated with all aspects of agricultural production for improving crop performance and environment quality. Precision farming calls for an efficient management of resources through location-specific hi-tech interventions. The advance crop production encompasses a variety of interventions such as micro irrigation, fertigation, protected greenhouse cultivation, soil and leaf nutrient-based fertilizer management, mulching moisture conservation, micro propagation, genetically-modified crops, use of bio fertilizers, vermin culture, high-density planting, hi-tech mechanization, green food, soil-less culture and biological control. The present study has, however, been confined to Soil Test Crop Response (STCR) as a major precision farming technique.
2. Grid based soil variability maps and variability zones for Soil pH, Soil Electrical Conductivity, Soil Nitrogen and Soil Phosphorus have been developed for the fields in the research stations and prescription maps for application of nitrogen as urea, phosphorus as Diammonium phosphate have been developed and application of fertilizers have been made according to soil variability maps. Similar grid based soil variability maps and variability zones for the nutrients for the various farmers’ fields should have been made to educate the farmers on the need for site specific application of nutrients.

3. The results have indicated that there was an increase in yield by 15-20% in cotton, 20-25% in paddy and 15-25% in pigeon pea over the farmers' method and there was also significant reduction in the amount of fertilizer input consumption by 10 - 15% in cotton and 25-30% in paddy when compared to the farmers' method of fertilizer application during the previous years. The increase in yield on account of adoption of soil test based fertilizer application was more in research station experimental plots as compared to farmers' fields. While the exact reason for this variability was not evaluated, it may be due to higher soil variability in the grids and application of site specific nutrients in bigger grids of 50 m x 50 m in farmers' fields vis a vis 10 m x 10 m grids in research plots.
4. The experiments during 2014-15 at MARS, Raichur are affected due to the vagaries of climate, i.e., heavy rainfall on August 25th, 2014 and continued incessant rain afterwards that affected the crops so much that Pigeon pea experiment had to be discarded. On the other hand, the yield of cotton crop in both precision and non precision experimental plots was below the normal.
5. During 2015-16, the demonstration trials at Farmers' field on pigeon pea at different villages of Kalaburgi district were abandoned and the trials were discontinued owing to severe drought. Bt cotton yield from the farmers' demonstration fields undertaken at Raichur district was much below the targeted yield due to prevalence of drought like situations as well as severe attack of pink boll worm during the experimentation.
6. The adoption of grid based soil tests at yearly interval and application of test based nutrients were found to be tedious and time consuming. Better precision farming techniques like use of satellite data, use of tractor mounted or hand held sensors could reduce the drudgery of the work. In recent days, there are a number of innovations that are contributing greatly to the concept of precision farming. Satellites, drones and even self-driven tractors with precision seeders are changing the way farmers are producing crops.
7. Inadequacy of plant growth observations on all the three crops studied was observed and hence scientific reasoning for the achievements are not given.
8. The economics and production and impact of technology on the productivity are missing.

ACTION POINTS

1. While commendable work has been done by the project coordinators in educating the farmers to adopt precision farming techniques for site specific application of nutrients, wide climatic and soil type variability are observed within the area of operation of the University for the same crops. Systematic study of the precision farming techniques for the same crop in different soils and climates could give interesting information on adoption of these techniques.

2. The precision farming techniques in farmers' fields were supervised by the project coordinators during the project period. After the project was completed, there does not appear to have been any follow up visits by project coordinators except in Kalaburgi district. As a result, most of the farmers have gone back to the traditional practice of blanket application of fertilizers. Grid based soil tests have not been done after the project period was over. Only in Gangavathi, general soil test was done for one year. Thereafter, no soil tests have been done. The purpose of educating the farmers for adopting the techniques has been lost as the practice has been abandoned. Follow up visits could have ensured continuation of adoption with better results.
3. Interaction with pigeon pea farmers at Chimagera in Afzalpur taluk and paddy farmers at Jangamara Kalgudi revealed that, as a whole, the large scale demonstrations at farmers' field under precision farming techniques were successful in building the confidence among the farmers about the techniques of modern agriculture. They are convinced that by adopting the practices such as soil test based input application can save the unnecessary cost on fertilizer inputs, timely management of pests as per standard package of practices can control pest and disease occurrence better in crops, intervention through amendments and foliar nutrition can fetch higher crop yields etc. There is need to upscale these for adoption by other farmers with focused attention on economics and pollution.
4. The adoption of grid based soil tests at yearly interval and application of test based nutrients were found to be tedious and time consuming. Better precision farming techniques like use of satellite data, use of tractor mounted or hand held sensors could reduce the drudgery of the work. In recent days, there are a number of innovations that are contributing greatly to the concept of precision farming. Satellites, drones and even self-driven tractors with precision seeders are changing the way farmers are producing crops.
5. Precision agriculture is not economically viable in Indian context owing to small, marginal and fragmented land holdings, which invalidate the benefits of higher crop return and savings on fertilizer inputs. Moreover, most of the precision agriculture tools and techniques are yet to be standardized for better adoptability even in developed nations with large land holdings.
6. Convergence of line departments in implementation of the technology may benefit the farming community in the long run in releasing of fertilizer subsidy as well as correction of imbalanced use of fertilizers by farmers which may lead to low productivity.
7. Multidisciplinary participation in developing and implementing recommendations is needed.

"PRECISION FARMING TECHNIQUES IN SELECTED FIELD CROPS"

INTRODUCTION

Agriculture sector has evolved from being a basic food gathering (hunting and fishing) activity to an intensive production system due to population growth, increase in income, urbanization, technological revolution, and liberalization of international trade. The long-term development process indicates to begin with the agricultural sector that accounts for the bulk of the country’s economic output and a large share of the labour force. Growth in the overall economy depends on the development of the agriculture sector (Schultz, 1964). India has moved from an era of chronic food shortage during the 1960s to food self-sufficiency and even food exports from the 1990s. Demand for food and agriculture commodities in India is rising at a much higher rate than the growth in population of the country. Hence, with the sole pursuit of high productivity in order to meet the ever growing demand for the agricultural products, it has resulted in indiscriminate utilization of resources which in turn resulted in neglecting the critical linkage between agriculture and environment and has posed a threat to the future of Indian agriculture on sustainable basis.

As the world’s population grows, farmers will need to produce more and more food. Yet arable acreage cannot keep pace, and the looming food security threat could easily devolve into regional or even global instability. There are many risks that are impacting our ability to generate food today including plateauing crop yields in some regions, climate change and the increase in population growth. Currently, agriculture production is facing significant challenges such as escalating costs of production, shortage of irrigation water and increased public concern about the impacts of agricultural production on the environment. The focus on enhancing the productivity during the green revolution coupled with total disregard of proper management of inputs without considering the ecological impacts has resulted in environmental degradation (Singh, 2010). Traditional farming relies on managing entire fields—making decisions related to planting, harvesting, irrigating, and applying pesticides and fertilizer—based on regional conditions and historical data.

The idea of increasing crop yields using scientific method dates back to at least the 1730s. Since then, there have been many other scientific developments in agriculture including the application of synthetic fertilizers and growing plants using hydroponics and in recent decades enabling development and the infusion of appropriate technologies. This concept envisages precision farming.

Precision agriculture first appeared in 1970s in the United States. As the conditions of different farm lands are quite different in different places. Precision agriculture can effectively save input, reduce cost and abate the after effects to environment. The object to be controlled in precision farming is the soil and plant. Up to now, about 8 per cent farms have adopted the Precision agriculture system in US. Precision agriculture has showed the potential, wisdom and power of mankind in utilizing natural resources and protecting environment. Precision agriculture is the application of technologies and principles to manage spatial and temporal variability associated with all aspects of agricultural production for improving production and environmental quality. The success in precision agriculture depends on the accurate assessment of the variability, its management and evaluation in space-time continuum in crop production. The agronomic feasibility of precision agriculture has been intuitive, depending largely on the application of traditional management recommendations at finer scales.

Precision agriculture is not a single technology, but rather a set of many components from which growers can select to form a system that meets their unique needs and operation size. However, the main components are: Yield monitoring / mapping, Remote sensing and Variable rate technology. These components help us to meet the demands of precision agriculture practice i.e. application of Right Input, in Right Quantity, at Right Place, at Right Time and by Right Method. Different approaches are being followed in the adoption of precision farming throughout the world depending upon the availability tools and techniques, expertise, skilled human resources and machinery.

According to Robert *et al.* (1995), precision farming is defined as information and technology based agricultural management system to identify, analyze and manage site-soil, spatial and temporal variability within fields for optimum profitability, sustainability and protection of the environment. The biggest benefit of precision farming is that it gives producers the ability to manage their farm on a production zone basis rather than a whole field basis. This shift allows farmers to save time and money and helps them offset the rising cost of chemicals, nutrients, fuel and fertilizer (Subrata and Atanu, 2013). In recent days, there are a number of innovations that are contributing greatly to a concept called precision farming. Satellites, drones and even self-driving tractors with precision seeders are changing the way farmers are producing crops.

Though it is widely adopted in developed countries, the adoption of precision farming in India is yet to take a firm ground primarily.

Precision Agriculture (PA) is an innovative, integrated and internationally standardized approach aiming to increase the efficiency of resource use and to reduce the uncertainty of decision required to control variation on farms (JurgenSchellberg et al. 2008). In other words, right input at the right amount at the right place in the right time used for crop cultivation with the efficient agricultural farm management the concept was called Precision Agriculture (PA).

According to the US Congress Precision Agriculture is "an integrated information- and production based farming system that is designed to increase long term, site-specific and whole farm production efficiency, productivity and profitability while minimizing unintended impacts on wildlife and the environment"

The Precision farming could be defined as application of a holistic management strategy that uses information technology to bring data from multiple sources to bear decision associated with agricultural production, marketing, finance and personnel (Jose C. Samuel and H. P. Singh, 2003).

Precision agriculture or site-specific management has been defined as a knowledge-based technical management system that can help optimize farm profits and minimize agriculture's impact on the environment. This technology has been on the market for more than 20 years with new applications each year. Information about a field can be obtained and continuously updated to refine management strategies. Precision farming involves using what we know about fields and correlating that to responses from specific management decisions under those conditions. Precision farming uses data to better manage the field for an improved economic response. Stated another way, it is the determination of inputs needed for profitable management decisions. Growers who get involved in precision agriculture have more information at their disposal and usually spend more time thinking about crop management and how yields and profits may be influenced.

Precision farming involves the application of technologies and principles to manage spatial and temporal variability associated with all aspects of agricultural production for improving crop performance and environment quality. Precision farming calls for an efficient management of resources through location-specific hi-tech interventions. The advance crop production encompasses a variety of interventions such as micro irrigation, fertigation, protected greenhouse cultivation, soil and leaf nutrient-based fertilizer management, mulching moisture conservation, micro propagation, genetically-modified crops, use of bio fertilizers, vermin culture, high-density planting, hi-tech mechanization, green food, soil-less culture and biological control. Some of the other terminologies used for precision farming are Precision Agriculture (PA), Site-Specific Farming (SSF), Site-Specific Management (SSM), farming-by-the-foot, Variable-Rate Technology (VRT). Utilization of these interventions orchestrated together having the aim of achieving higher output in given time period leads to precision farming, which is largely a knowledge driven.

Precision farming is the term given to a method of crop management by which areas of land or crop within a field are managed with different levels of input in that field. The potential benefits are:

(i) the economic margin from crop production may be increased by improvements in yield or a reduction in inputs;

(ii) the risk of environmental pollution from agrochemicals applied at levels greater than optimal can be reduced; and

(iii) greater assurance from precise targeting and recording of field applications to improve traceability.

These benefits are excellent examples of where both economic and environmental considerations are working together.

A summary of factors that could influence the yield of crops in a given location developed by Earl et al. (1996) is presented in Table 1. Whilst little control can be exercised over factors on the left of the table, they have to be considered as they can have major effects upon yield. The factors on the right, however, can be manipulated in a spatially variable manner and could lead to economic benefits from either (i) yield improvements due to changes in input or (ii) savings in inputs costs without an adverse effect upon crop yield.

Table 1
Factors influencing yield variation

Little control	*Possible control*	
Soil texture	Soil structure	pH levels
Climate	Available water	Trace elements
Topography	Water-logging	Weed competition
Hidden features	Macro nutrients	Pests and diseaes

The soil is a heterogonous mass. Its properties and thus its soil fertility varies spatially within a given unit area and it has influence on crop performance and yield. This variation is very much significant when comparison is done between soils of different farmers. Therefore, the quantum of application of inputs cannot be generalized and thus crop performance varies even with the standard rate of input use among farmers. This issue of soil variability can be addressed through soil test based input application and can achieve a given target yield in respective soil types provided soil fertility is the main constraint and limiting the crop yield in that concerned area.

This subject matter is challenging to both scientists and farmers. Farmers generally follow their indigenous method of input application, i.e., blanket application of fertilizers which doesn't have any scientific basis. On the other hand, scientist uses recommended dose of fertilizers for specific crop but are mostly generalized rates and are usually equated to medium fertility ratings of soils. Therefore, both the practices or approaches are not precise as they do not account for the native soil fertility and also other factors including the expected or targeted yield in other words nutrient required in kilograms to produce every quintal of yield from unit land. This challenge can be encountered by adopting some components of precision farming techniques by giving more emphasis to the soil test based nutrient application to optimize soil input application for higher crop yields. The application of input fertilizers based on soil test and crop nutrient requirement ensures the optimization of fertilizer applications in different soil types for different crops. This overcomes the chances of soils with high fertility receiving higher quantum of fertilizer which may be more than the crop requirement, one can save the cost on fertilizers and vice versa. On a long term basis, this may lead to economically and environmentally viable practice more particularly in regions of high intensive agriculture.

Although India has made considerable advance in agricultural research, but still the blanket recommendations of fertilizers for adoption over larger areas are in vogue. These blanket recommendations are no more useful to enhance productivity gains, which were witnessed between 1960’s and 1980’s. Now, to enhance growth rate in productivity, precision agriculture technology has to be developed. Precision agriculture is important because of the following points:

i. nutrient variability within a field can be very high affecting optimum fertilizer rates
ii. yield potential and grain protein can also vary greatly even within one field, affecting fertilizer requirement
iii. increasing fertilizer use efficiency will become more important with increasing fertilizer costs and environment concerns
iv. irrigation at critical stages is very important and
v. best and stress management at the early stages of the crop helps the farmer to get maximum yield

Popularization of soil test based nutrient application in other words optimum input application may save cost on inputs, improve quality of agriculture produce apart from addressing the environment pollution issues associated with over use of agricultural inputs particularly in irrigation commands which are obsessed with high input intensive practices.

Keeping this in view the project, "**PRECISION FARMING TECHNIQUES IN SELECTED FIELD CROPS**" was sanctioned under Rashtriya Krishi Vikas Yojane (RKVY) during 2010-11 to take up large scale demonstration at farmers' fields. The adoption of precision farming tools and techniques in selected field crops through large scale demonstrations were taken at different villages under farmers’ participatory approach in Raichur, Gulbarga and Koppal districts, covering approximately an equivalent of 100 acres each in Cotton, Pigeon Pea and Paddy crops respectively during 2011-12, 2012-13, & 2013-14. Apart from this, research demonstration plots [5.00 acres in each crop] at different research stations [Kalaburgi, Raichur and Gangavathi] of University of Agricultural Sciences, Raichur were also undertaken to assess the feasibility of Precision Farming Techniques in small scale land holdings during these years. However, during the year 2014-15, only research demonstration plots [5.00 acres in each crop] at three different research stations of University of Agricultural Sciences, Raichur were undertaken owing to several constraints. Finally, Precision Farming techniques were demonstrated in large areas of farmers' fields accounting to a total of 92.49 Acres in Cotton in Merchatal village, Raichur taluk & district, 78.125 Acres in Paddy in Jangamara Kalgudi village, Gangavathi taluk, Koppal district and 137.48 Acres in Pigeon pea in Chinamgera (73.74 acres), Ingalgi (48.12 acres) and Chowdapur (15.62 acres) villages, Afzalpur taluk, Kalaburgi district under the RKVY sponsored project.

The details of the project were as under:

1.	**Title of Project**	:	"**PRECISION FARMING TECHNIQUES IN SELECTED FIELD CROPS**"
2.	**Nodal officer and Principal Investigator**	:	**Dr. M. B. Patil,** Professor of Plant Pathology, Head AEEC, Koppal **Dr. Veeresh H.**, Asst. Professor of Soil Science, College of Agriculture, University of Agricultural Sciences, Raichur (In charge PI) **Dr. Masthana Reddy**, Professor of Agronomy, Chief Scientist & Head, ARS, Gangavathi (Co-investigator) **Dr. Pandith Rathod**, Associate Professor of Agronomy, Senior Scientist, AICRP on Chickpea, ARS, Kalaburgi (Co-investigator)
3.	**Implementing Institution (S) and other collaborating Institution (s)**	:	College of Agriculture, Raichur, ZARS Raichur, ARS Kalaburgi, Gangavathi
4.	**Date of commencement of Project**	:	2010-11
5.	**Approved date of completion**	:	2015-16
6.	**Actual date of completion**	:	2015-16
7.	**Project cost**	:	Rs. 110 lakhs

The objectives of the project were to adopt and demonstrate precision farming techniques for cotton, pigeon pea and paddy crops by emphasizing soil test based nutrient application to optimize soil input application.

HYPOTHESIS

The context of evaluation arises from the following facts:

1. Farmers generally follow their indigenous method of input application, i.e., blanket application of fertilizers which doesn't have any scientific basis.
2. Nutrient variability within a field can be very high affecting optimum fertilizer rates.
3. There is need to account for the native soil fertility and also other factors including the expected or targeted yield in other words nutrient required in kilograms to produce every quintal of yield from unit land.
4. The application of input fertilizers based on soil test and crop nutrient requirement ensures the optimization of fertilizer applications in different soil types for different crops. This overcomes the chances of soils with high fertility receiving higher quantum of fertilizer which may be more than the crop requirement, one can save the cost on fertilizers and vice versa. On a long term basis, this may lead to economically and environmentally viable practice more particularly in regions of high intensive agriculture.

OBJECTIVES AND ISSUES FOR EVALUATION

The scope of evaluation is to study the impact of scheme, "**PRECISION FARMING TECHNIQUES IN SELECTED FIELD CROPS**" sanctioned under Rashtriya Krishi Vikas Yojane and been taken up by University of Agricultural Sciences, Raichur at College of Agriculture, Raichur and ARS, Kalaburgi and Gangavathi. The project was implemented from 2010-11 to 2015-16 under the Principal Investigator, Dr. M. B. Patil, Professor of Plant Pathology, College of Agriculture, University of Agricultural Sciences, Raichur with **Dr. Veeresh H.**, Asst. Professor of Soil Science, College of Agriculture, University of Agricultural Sciences, Raichur as In charge Principal Investigator and **Dr. Masthana Reddy**, Professor of Agronomy, Chief Scientist & Head, ARS, Gangavathi and **Dr. Pandith Rathod**, Associate Professor of Agronomy, Senior Scientist, AICRP on Chickpea, ARS, Kalaburgi as Co-investigators. The total cost of the project was Rs. 110 lakhs.

1. Stake Holders

a) University of Agricultural Sciences, Raichur – Sponsorer
b) Rashtriya Krishi Vikas Yojane – as Monitoring Authority
c) Institution of Agriculture Technologists – as Consultant
d) Farmers / beneficiaries as target group of evaluation

2. Purpose of Evaluation

Evaluation Framework

The focus of Evaluation is:

i. To study the impact of soil test based nutrient application on crop yield in different crops.

ii. To study the impact of demonstration of precision farming techniques for cotton, pigeon pea and paddy crops in farmers' fields.

iii. To study whether the farmers who have benefitted from demonstrations of precision farming techniques are able to obtain sustained production by following the recommendations of the project scientists.

iv. To study the constraints in successful implementation, adoption and popularization of Precision Farming Techniques from the point of Indian Scenario.

LOG FRAME

The intention of the project is to encourage farmers to adopt Precision Farming Techniques for cotton, pigeonpea and paddy crops by emphasizing soil test based nutrient application to optimize soil input application.

Evaluation Subject

1. Whether the projects were demonstrated at farmers' fields or not?
2. Whether enlisted assets were procured or not?
3. Whether institute had necessary infrastructure to take up soil and plant analysis or not?
4. Whether necessary chemicals and glassware procured or not?
5. Whether soil samples from farmers' fields were analyzed or not?
6. Whether soil analysis data available or not?
7. Whether plant observation data were recorded or not?
8. Why the optimization of input application is very much important from the point of environment and sustaining farmers' income?
9. The approaches available for precision farming practices in India.
10. The positive impact of soil test-based input application in Indian context.
11. The constraints in successful implementation, adoption and popularization of precision farming techniques from the point of Indian scenario.

EVALUATION DESIGN

Evaluation design has a rationale of requirement of field level data (primary) that is required to study evaluation objective with respect to beneficiary farmers on one part and the projects taken up for study per se on the other part. The evaluation requires analysis of administration obligations under the two heads and hence a secondary data analysis becomes important and accordingly formats were designed to procure secondary data. The third obligation under evaluation is opinion of stake holders with respect to improvement of the schemes, which require group discussions and exchange of views both in the form of a format, as well as group discussions with the stake holders. The entire evaluation process required a central administration of all activities.

A core team of experts at the Institution level considered three methods to bring a meaningful evaluation of the subject, keeping in mind the scope, evaluation questions and sub-questions duly keeping its focus on the purpose of evaluation. The three methods are:

a. Accessing and analysis of secondary data from the implementing department.
b. Interaction with Principal Investigator and his team.
c. Actual visit to the project site to study and obtain necessary information to elicit answers to the evaluation questions.
d. Suitable questionnaire was designed to elicit response from farmers.

DATA COLLECTION AND ANALYSIS

PROGRESS REVIEW

The project was implemented by adopting precision farming techniques in selected field crops through the initiation of large scale demonstrations at different villages under farmers' participatory approach at Raichur, Kalaburagi and Koppal districts, covering 92.49 Acres in Cotton in Merchatal village, Raichur taluk & district, 78.125 Acres in Paddy in Jangamara Kalgudi village, Gangavathi taluk, Koppal district and 137.48 Acres in Pigeon pea in Chinamgera (73.74 acres), Ingalgi (48.12 acres) and Chowdapur (15.62 acres) villages, Afzalpur taluk, Kalaburgi district respectively during 2011-12. Apart from this, research demonstration plots [5.00 acres in each crop] at different research stations (Raichur, Kalaburgi and Gangavathi) of University of Agricultural Sciences, Raichur were also undertaken to assess the feasibility of Precision Farming Techniques in small scale land holdings during these years. Each hectare of land was divided into four grid areas of 50 m X 50 m and one composite soil sample was collected from each grid area after mixing 15-20 number of random soil samples collected under each grid. Each grid area was been made into a separate entity, which received a separate quantum of input fertilizers based on soil analysis (NPK) results and also based on the expected targeted yield for each crop. For this purpose, agency used Soil Test Crop Response Correlation equations developed under ICAR-AICRP project on STCR for different crops. The project lands at different research stations were divided into grids of 10 m x 10 m for collection of soil samples for testing the soil fertility parameters.

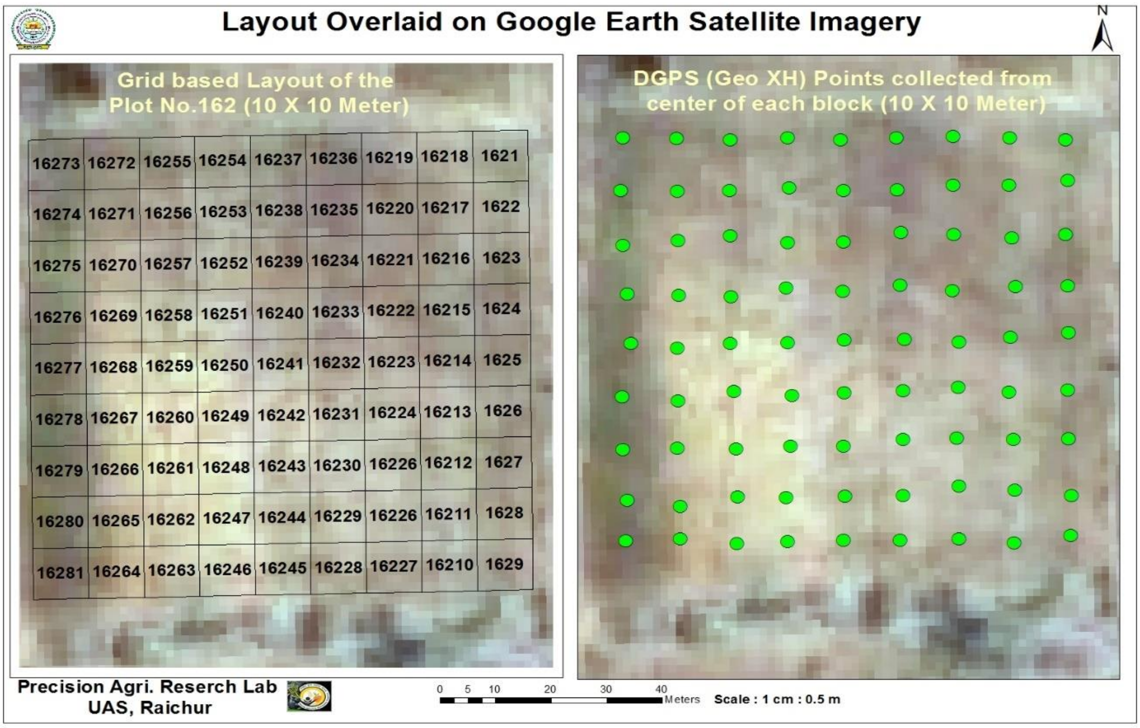
The project team constituted for the successful implementation of the project objectives involved faculties from different disciplines viz., Plant pathology, Agronomy, Soil Science, Crop Physiology, Entomology, Soil and water engineering, Farm machinery, Genetics and plant breeding, Agriculture Economics etc. for the smooth monitoring and evaluation of the project activities and outcomes.

Crop yield data and many other crop growth parameters were recorded grid wise to study the spatial variability. Recorded observations were used to understand and compare the spatial variability through GIS mapping. Further, efforts were made to understand and develop the Precision Agriculture Techniques in Indian context through series of capacity building workshops/interaction meets/ trainings/field days to educate the project scientists and farmers towards the use of important components of precision agriculture viz., GPS in the fields for geo-referencing their plots and GIS in the laboratory in understanding and quantifying the variability in crops and soils.

The details of experimental plots of the farm and farmers' fields are given below:

EXPERIMENTAL PLOTS' DETAILS

Sl. No.	Crop	Place	Farm/ Farmers	Village	Precision/ Non Precision	Plot No	AREA (Acre)	No Of Grids	Grid Size	No. of Farmers
1	COTTON	RAICHUR	FARM	RAICHUR	PRECISION	163	2.50	80	10 x 10 m	-------
					NON PRECISION	162	2.50	81	10 x 10 m	
		MERCHITAL	FARMERS	MERCHITAL	PRECISION	125	20.62	33	50 x 50 m	07
						125 A	16.25	36	50 x 50 m	
						126	18.12	29	50 x 50 m	
						126 A	37.50	60	50 x 50 m	
		B'GUDI	FARM	BHIMARAYANAGUDI	PRECISION	1	1.80	72	10 x 10 m	-------
					NON PRECISION	2	0.125	05	10 x 10 m	-------
2	PADDY	RAICHUR	FARM	RAICHUR	NON PRECISION	229	1.90	76	10 x 10 m	-------
		GANGAVATI	FARM	GANGAVATI	PRECISION	B-9	2.25	90	10 x 10 m	-------
					NON PRECISION	B-11	2.25	90	10 x 10 m	-------
			FARMERS	JANGAMARA KALGUDI	PRECISION	125	37.50	60	50 x 50 m	28
					PRECISION	126	27.50	44	50 x 50 m	
					PRECISION	127	13.125	21	50 x 50 m	
3	PIGEON PEA	RAICHUR	FARM	RAICHUR	PRECISION	136	2.50	90	10 x 10 m	-------
					NON PRECISION	146	2.50	90	10 x 10 m	-------
		GULBARGA AFZALPURA TALUKA	FARM	GULBARGA	PRECISION	B-4	1.25	50	10 x 10 m	-------
					NON PRECISION	C-2	1.10	44	10 x 10 m	-------
					NON PRECISION	C-3	1.10	44	10 x 10 m	-------
			FARMERS	CHINAMGERA	NON PRECISION	1	15.62	25	50 x 50 m	11
					NON PRECISION	2	30.00	48	50 x 50 m	
					PRECISION	3	13.12	21	50 x 50 m	
					PRECISION	4	15.00	24	50 x 50 m	
				INGALAGI	NON PRECISION	1	15.62	25	50 x 50 m	
					PRECISION	2	22.50	36	50 x 50 m	
					PRECISION	3	10.00	16	50 x 50 m	
				CHOWDAPUR	NON PRECISION	1	8.12	13	50 x 50 m	
					PRECISION	2	2.50	04	50 x 50 m	
					PRECISION	3	5.00	08	50 x 50 m	



- Soil samples and crop growth observations of all the experimental plots were taken on grid basis and analysed .
- The GIS maps of the variability were developed by using Arc GIS .
- Based on the analysis of soil parameters viz., fertility levels, the nutrients were applied with variable rates
- Further, based on the variability that exists with weeds and pests and diseases, plant protection chemicals were applied on variable rate techniques.
- Crops were harvested grid wise
- The creation of variograms and multiple regression analysis of the varying data in correlation to yield.
- The economics of the precision application of nutrients was worked out.
- The creation of GIS maps for various data of the project

FINDINGS AND DISCUSSION

The studies in research plots at the research stations and in farmers' fields revealed that:

1. Farmers were following blanket fertilizer application of major nutrients without any assessment of the soil fertility status and specific crop requirement.
2. It was clearly evident from the data observed and recorded from the experimental plots either in research farms or in farmers' fields that spatial variability of many factors of soil and crop did exist.
3. Farmers are convinced that by adopting the practices such as soil test based input application can save the unnecessary cost on fertilizer inputs, timely management of pests as per standard package of practices can control pest and disease occurrence better in crops, intervention through amendments and foliar nutrition can fetch higher crop yields etc.
4. Paddy farmers in Gangavathi taluk and cotton farmers' in Afzalpur taluk were more enthusiastic as they have found significant reduction in application of inputs and apart from fetching higher crop yields.
5. Increase in yield of pigeon pea in farmers' fields coincided with shift in variety of pigeon pea grown from the native Guliyal variety to TS3R.
6. The participatory approach in adoption of precision farming techniques by farmers resulted in application of other nutrients like Zinc, Iron and Potassium in addition to Nitrogen and Phosphorus that the farmers were using before introduction of the techniques.

Paddy Crop:

A target yield of 80 q per ha was fixed under precision farming techniques and based on soil test values for NPK and using STCR equation the quantity of NPK required was worked out. On the other hand, based on the farmers' survey at TBP command, the fertilizer rates generally applied by the farmers was found to be 330:150:100 kgs. of $N:P_2O_5:K_2O$ per ha and on an average the yield realized by them is around 70 q per ha. The average NPK inputs used under precision farming across grid areas was 254:51:68 kgs. of $N:P_2O_5:K_2O$ per ha. This works out to a saving of 76 kg N, 99 kg P_2O_5 and 32 kg K_2O per ha. The average fertilizer use efficiency (NPK) in precision farming worked out to be 17.2 kg of grain per kg of NPK against 12.07 kg grain per kg of NPK in non precision farming or farmers' method. The average cost of inputs in precision farming was Rs.6592 per ha while it was Rs.13062 per ha in the case of farmers' practice and thus resulting in a savings of Rs. 6470 per ha.

Moreover, the average savings on cost of pesticides and fungicides used under precision techniques was Rs.1200 per ha over the non precision farming.

The farmers of Tungabhadra Project Command area following intensive agriculture with high input applications since a long time. After the intervention of Precision farming project team and subsequent to soil sampling, soil analysis, soil test results and owing to field demonstrations with optimum input applications, farmers' have been convinced with the fact that the soils are enriched with phosphorus and potassium due to regular applications year after years that too in higher amounts. Therefore, fertilizer application based on soil test results saves unnecessary cost on extra quantity of fertilizers. Now, farmers are adopting use of bio fertilizers to re utilize the residual phosphorus.

Bt Cotton Crop:

The yield target was 35 q per ha and the average NPK application across the grids was @ 245:50:110 kgs. of $N:P_2O_5:K_2O$ per ha under precision farming technique. On an average the farmers apply NPK @ 260:100:110 kgs. of $N:P_2O_5:K_2O$ per ha and realize an average yield ranging from 28 to 31 q per ha.

The average Fertilizer Use Efficiency observed to be 8.56 % in Precision techniques compared to 6.38 % in farmers' practice. The average savings on cost of pesticides and fungicides use by precision techniques is Rs.900 per ha over the non precision farming or farmers' practice. The average savings on fertilizer inputs use by precision techniques (Rs. 8100/ha) is Rs.2200 per ha over the non precision farming or farmers' practice (Rs.10300/ha). Similar findings have been reported by Shruthi et al, 2017 who reported that though the cost of cultivation was marginally higher (1.47 %) in precision farming than non-precision farming, the yield obtained under management practices of precision farming (38.03 q/ha) were much higher than (26.48 q/ha) conventional farming situations. Hence there was a net gain of ` 35,898.82/ha under the adoption of precision farming. Returns per rupee spent was 2.03.

The tail end farmers of Tungabhadra Project Command area generally go for Bt cotton instead of paddy due to non availability of sufficient canal water. Farmers generally use inputs application on a regular basis as and when canal water irrigation given. The precision farming project team took the intervention through soil test based input application and standard package of practices for pest and disease control. The Bt cotton farmers have been convinced with the fact that the application of inputs on a regular basis matching number of irrigations is not necessary and it was higher than the crop requirement. Moreover, following standard packages that is application of Magnesium sulphate @ 50 kg per acre and a foliar spray of 19:19:19 plus $MgSO_4$ @ 1.0% can give best control of leaf reddening and fetch higher yields.

Pigeon pea:

The yield target was 18 q per ha and the average NPK application across the grids was @ 22:48:28 kgs. of $N:P_2O_5:K_2O$ per ha under precision farming technique. On an average the farmers apply NPK @ 25:50:00 kgs. of $N:P_2O_5:K_2O$ per ha and realize an average yield ranging from 7 to 8 q per ha.

The average Fertilizer Use Efficiency observed to be 12.36 % in Precision techniques compared to 10.25 % in Non precision farming. The average savings on cost of pesticides and fungicides use by precision techniques is Rs. 500 per ha over the non precision farming. However, under precision techniques on an average Rs.270 per ha extra cost on fertilizer inputs (Muriate of Potash) was incurred over the non precision farming. Therefore, on an average the net savings under precision farming was Rs.230 only over the farmers practice.

The farmers of Kalaburagi district generally take up rain fed Pigeon pea cultivation. Farmers generally use lower doses of inputs. The precision farming project team took the intervention through soil test based input application and standard package of practices for pest and disease control. The farmers of this region have been convinced with the fact that the application of a minimal dose of Muriate of Potash along with Diammonium Phosphate can be a good practice to realize good returns.

In summary, it was clearly evident from the data observed and recorded from the experimental plots either in research farms or in farmers' fields that spatial variability of many factors of soil and crop did exist. The project has proved that an increase in yield by 15-20% in cotton, 20-25% in paddy and 15-25% in pigeon pea over the farmers' method and also significant reduction in the amount of fertilizer input consumption by 10-15% in cotton and 25-30% in paddy when compared to the farmers' method of fertilizer application. Therefore, in general, paddy and cotton farmers were more enthusiastic as they have found significant reduction in application of inputs and apart from fetching higher crop yields.

Farmers used to apply blanket application of fertilizers to the crop based on their own indigenous knowledge. After, the intervention of project implementing team

1. Farmers have understood that soil fertility differs from field to field as well as varies within a given field.
2. Blanket application may not be the best way of fertilizer application
3. Different crops require different quantum of application
4. Optimum dose of fertilizer application can be satisfactorily achieved by interpreting soil testing results.
5. Fertilizer application after every irrigation is not a good practice

6. Higher application of fertilizer will not always fetch higher profit even though higher crop yields are realized.
7. Application of soil test based fertilizer ensured good crop stand, low pest and disease occurrence and saved the money on pesticides.
8. Standing crop can also be effectively monitored by using crop sensor observations.

As a whole, the large scale demonstrations at farmers' field under precision farming techniques were successful in building the confidence among the farmers about the techniques of modern agriculture. They are convinced that by adopting the practices such as soil test based input application can save the unnecessary cost on fertilizer inputs, timely management of pests as per standard package of practices can control pest and disease occurrence better in crops, intervention through amendments and foliar nutrition can fetch higher crop yields etc.

REFLECTIONS AND CONCLUSIONS

Precision agriculture is the application of technologies and principles to manage spatial and temporal variability associated with all aspects of agricultural production for improving production and environmental quality. The success in precision agriculture depends on the accurate assessment of the variability, its management and evaluation in space-time continuum in crop production. The agronomic feasibility of precision agriculture has been intuitive, depending largely on the application of traditional management recommendations at finer scales. The biggest benefit of precision farming is that it gives producers the ability to manage their farm on a production zone basis rather than a whole field basis. This shift allows farmers to save time and money and helps them offset the rising cost of chemicals, nutrients, fuel and fertilizer. The use of precision farming practices by small and marginal farmers helps in timely planting of crops depending on the spatial and temporal variability associated with the climatic aberrations. This would not only help the farmers to save time but also helps them to ensure optimum plant growth and yield.

i. Although the title of the project indicates adoption of Precision Farming Techniques in selected field crops, the study was mostly confined to soil test-based application of fertilizers with focus on major nutrients and to some extent zinc and iron. Precision farming involves the application of technologies and principles to manage spatial and temporal variability associated with all aspects of agricultural production for improving crop performance and environment quality. Precision farming calls for an efficient management of resources through location-specific hi-tech interventions. The advance crop production encompasses a variety of interventions such as micro irrigation, fertigation, protected greenhouse cultivation, soil and leaf nutrient-based fertilizer management, mulching moisture conservation, micro propagation, genetically-modified crops, use of bio fertilizers, vermin culture, high-density planting, hi-tech mechanization, green food, soil-less culture and biological control. The present study has, however, been confined to Soil Test Crop Response (STCR) as a major precision farming technique.
ii. Grid based soil variability maps and variability zones for Soil pH, Soil Electrical Conductivity, Soil Nitrogen and Soil Phosphorus have been developed for the fields in the research stations and prescription maps for application of nitrogen as urea, phosphorus as Diammonium phosphate have been developed and application of fertilizers have been made according to soil variability maps. Similar grid based soil variability maps and variability zones for the nutrients for the various farmers' fields should have been made to educate the farmers on the need for site specific application of nutrients.
iii. The results have indicated that there was an increase in yield by 15-20% in cotton, 20-25% in paddy and 15-25% in pigeon pea over the farmers' method and there

was also significant reduction in the amount of fertilizer input consumption by 10 - 15% in cotton and 25-30% in paddy when compared to the farmers' method of fertilizer application during the previous years. The increase in yield on account of adoption of soil test based fertilizer application was more in research station experimental plots as compared to farmers' fields. While the exact reason for this variability was not evaluated, it may be due to higher soil variability in the grids and application of site specific nutrients in bigger grids of 50 m x 50 m in farmers' fields vis a vis 10 m x 10 m grids in research plots.

iv. The experiments during 2014-15 at MARS, Raichur are affected due to the vagaries of climate, i.e., heavy rainfall on August 25th, 2014 and continued incessant rain afterwards that affected the crops so much that Pigeon pea experiment had to be discarded. On the other hand, the yield of cotton crop in both precision and non precision experimental plots was below the normal.

v. During 2015-16, the demonstration trials at Farmers' field on pigeon pea at different villages of Kalaburgi district were abandoned and the trials were discontinued owing to severe drought. Bt cotton yield from the farmers' demonstration fields undertaken at Raichur district was much below the targeted yield due to prevalence of drought like situations as well as severe attack of pink boll worm during the experimentation.

vi. The adoption of grid based soil tests at yearly interval and application of test based nutrients were found to be tedious and time consuming. Better precision farming techniques like use of satellite data, use of tractor mounted or hand held sensors could reduce the drudgery of the work. In recent days, there are a number of innovations that are contributing greatly to the concept of precision farming. Satellites, drones and even self-driven tractors with precision seeders are changing the way farmers are producing crops.

vii. Inadequacy of plant growth observations on all the three crops studied was observed and hence scientific reasoning for the achievements are not given.

viii. The economics and production and impact of technology on the productivity are missing.

DEVELOPMENTS / IMPROVEMENTS AFTER THE STUDY

The precision farming techniques in farmers' fields were supervised by the project coordinators during the project period. After the project was completed, there does not appear to have been any follow up visits by project coordinators except in Kalaburgi district. As a result, most of the farmers have gone back to the traditional practice of blanket application of fertilizers. Grid based soil tests have not been done after the project period was over. Only in Gangavathi, general soil test was done for one year. Thereafter, no soil tests have been done.

Procurement of scientific tools such as crop sensors, GPS, GIS software etc., have given opportunity to the scientists to gain the knowledge about their use in agriculture. Exposure of scientists to GIS and Remote sensing domain and its' utility in agriculture has enabled the scientists to learn new tools and become well versed with the data collection, storage, interpretation etc.

ACTION POINTS

1. While commendable work has been done by the project coordinators in educating the farmers to adopt precision farming techniques for site specific application of nutrients, wide climatic and soil type variability are observed within the area of operation of the University for the same crops. Systematic study of the precision farming techniques for the same crop in different soils and climates could give interesting information on adoption of these techniques.
2. The precision farming techniques in farmers' fields were supervised by the project coordinators during the project period. After the project was completed, there does not appear to have been any follow up visits by project coordinators except in Kalaburgi district. As a result, most of the farmers have gone back to the traditional practice of blanket application of fertilizers. Grid based soil tests have not been done after the project period was over. Only in Gangavathi, general soil test was done for one year. Thereafter, no soil tests have been done. The purpose of educating the farmers for adopting the techniques has been lost as the practice has been abandoned. Follow up visits could have ensured continuation of adoption with better results.
3. Interaction with pigeon pea farmers at Chimagera in Afzalpur taluk and paddy farmers at Jangamara Kalgudi revealed that, as a whole, the large scale demonstrations at farmers' field under precision farming techniques were successful in building the confidence among the farmers about the techniques of modern agriculture. They are convinced that by adopting the practices such as soil test based input application can save the unnecessary cost on fertilizer inputs, timely management of pests as per standard package of practices can control pest and disease occurrence better in crops, intervention through amendments and foliar nutrition can fetch higher crop yields etc. There is need to upscale these for adoption by other farmers with focused attention on economics and pollution.
4. The adoption of grid based soil tests at yearly interval and application of test based nutrients were found to be tedious and time consuming. Better precision farming techniques like use of satellite data, use of tractor mounted or hand held sensors could reduce the drudgery of the work. In recent days, there are a number of innovations that are contributing greatly to the concept of precision farming. Satellites, drones and even self-driven tractors with precision seeders are changing the way farmers are producing crops.
5. Precision agriculture is not economically viable in Indian context owing to small, marginal and fragmented land holdings, which invalidate the benefits of higher crop return and savings on fertilizer inputs. Moreover, most of the precision agriculture tools and techniques are yet to be standardized for better adoptability even in developed nations with large land holdings.
6. Convergence of line departments in implementation of the technology may benefit

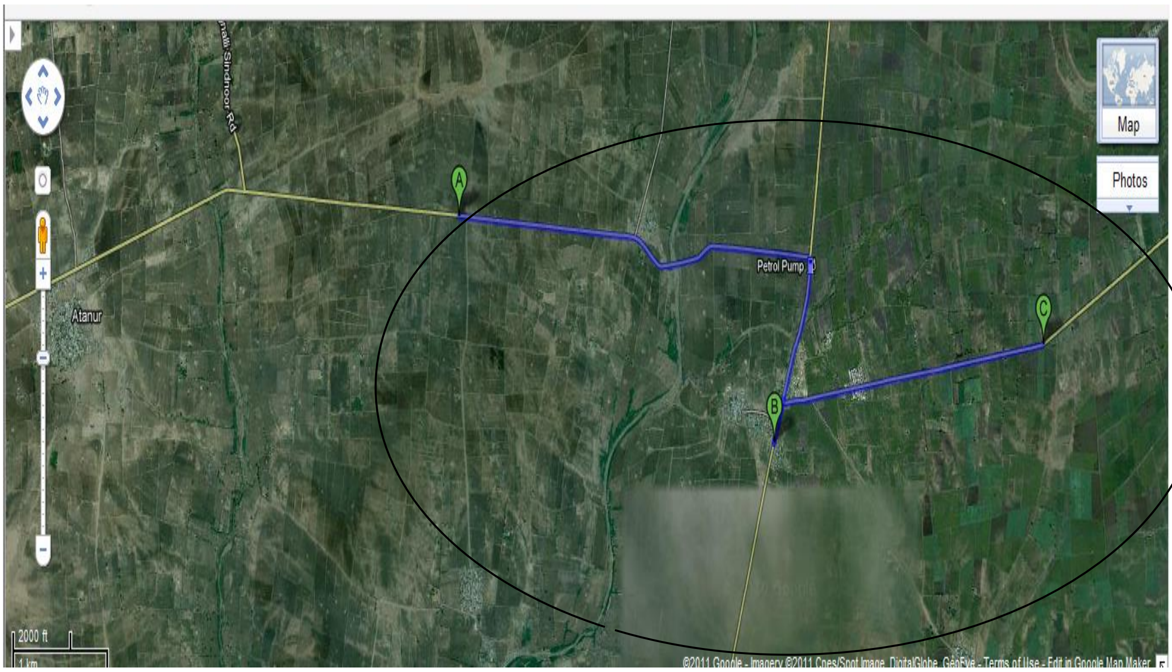
the farming community in the long run in releasing of fertilizer subsidy as well as correction of imbalanced use of fertilizers by farmers which may lead to low productivity.

7. Multidisciplinary participation in developing and implementing recommendations is needed.

RESEARCHABLE ISSUES

1. Resource use efficiency or savings in cost of production and economics of production and environmental impacts need to be assessed.
2. Human resource strengthening is the need of the hour in different agro climatic conditions for different crops.
3. Impact of dissemination of information on resource management strategies on real time basis through effective communication networks is to be assessed.

SATELLITE IMAGES OF THE FARMERS' FIELDS



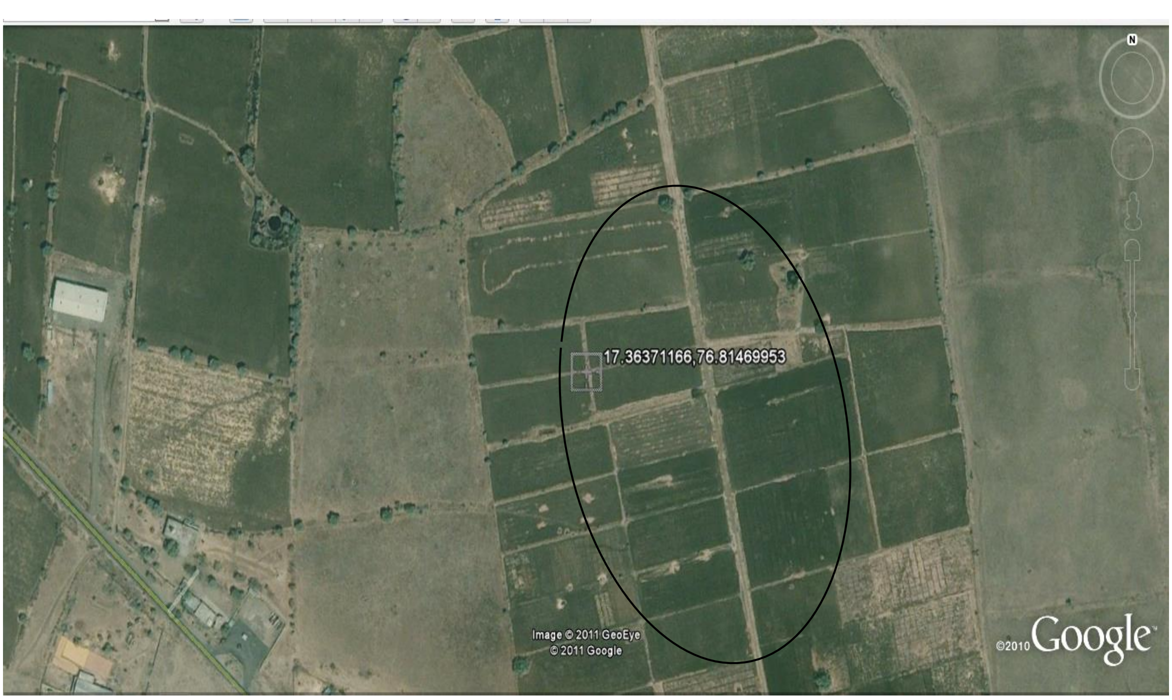
Ingalagi,Chowdapur and Chimanageri of Afzalpur Tq. In Gulbarga Dist.

Village Merchethal, RaichurTaluk

Village Jangamar Kalgudi, Gangavathi Taluk

Main Agricultural Research Station, Raichur

ARS,Gangavathi



ARS, Kalaburagi

PROJECT ACTIVITIES

PROJECT IMPLEMENTATION ON FARM TRIALS AT MARS, RAICHUR

CAPACITY BUILDING IN FARMERS FOR PFT

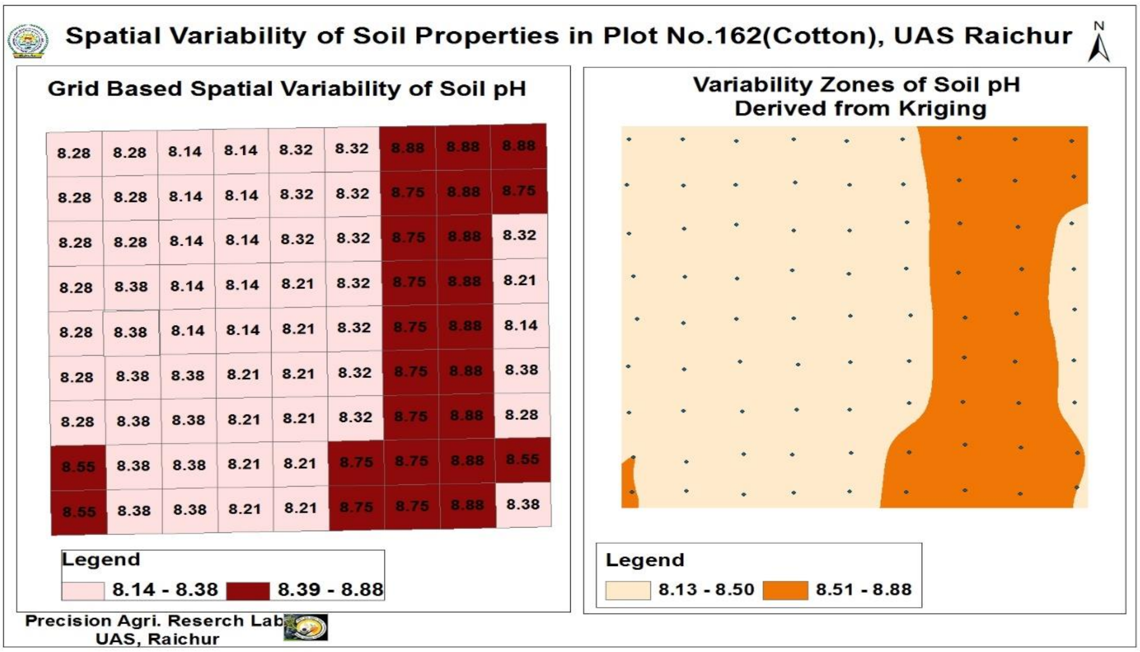


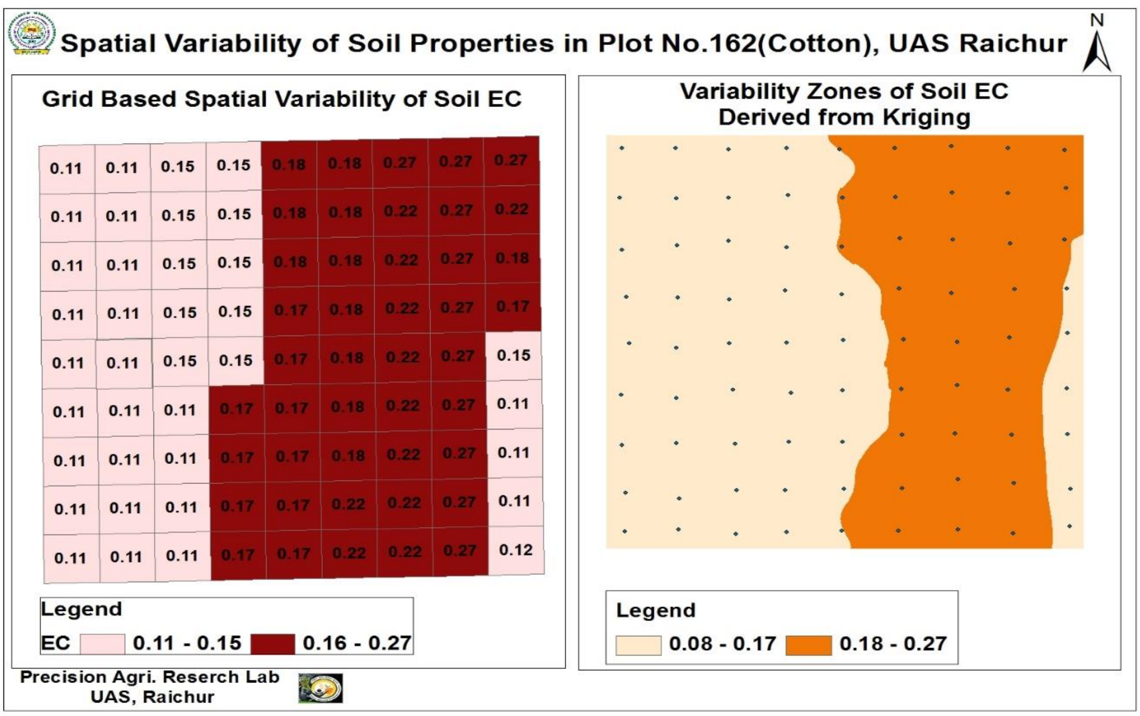
GRID BASED SOIL TESTING IN FARMERS' FIELDS

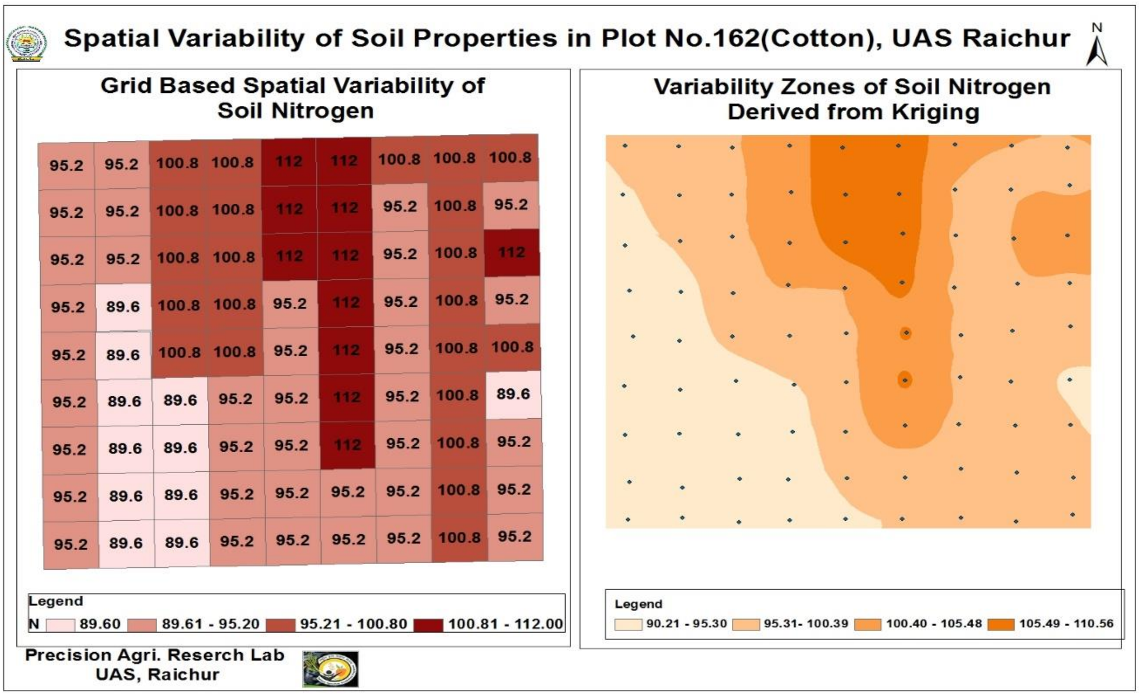

GRID BASED CROPPING IN COTTON AND PADDY

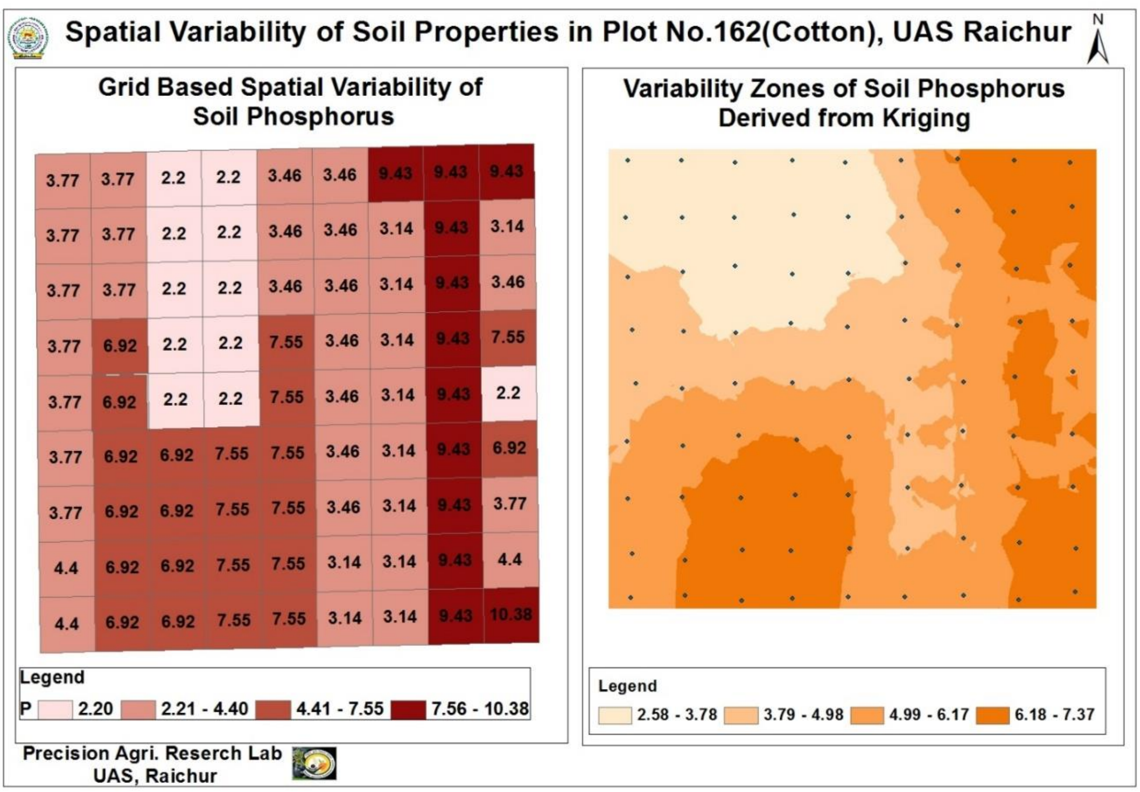
GRID BASED HARVEST AND PROCESSING OF CROPS

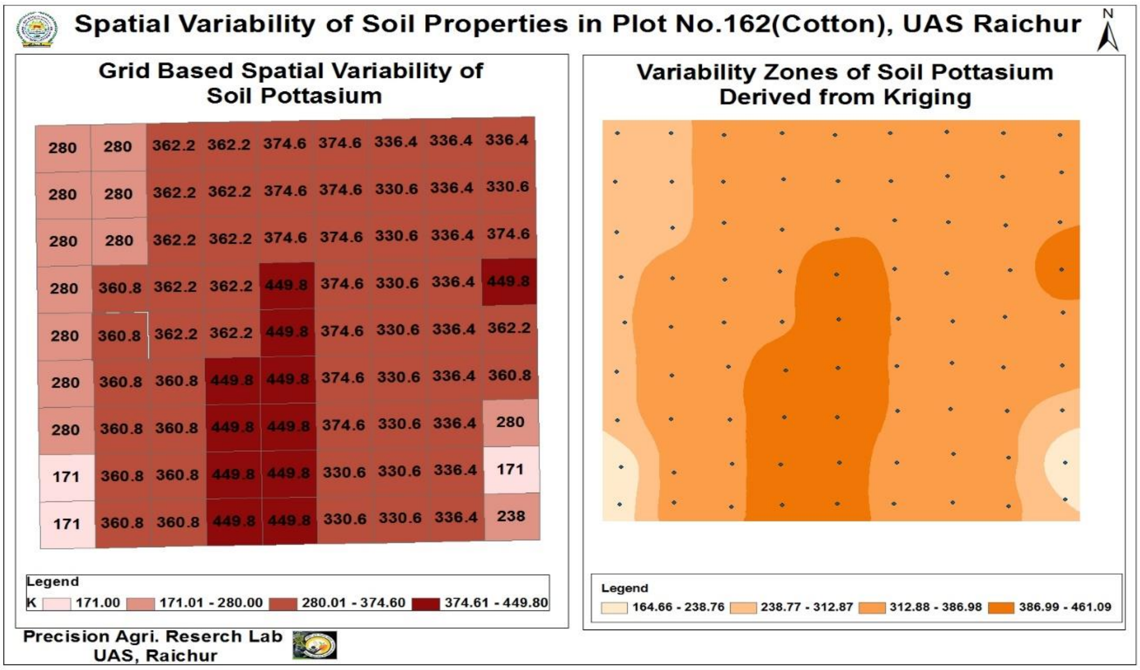
INTERACTION WITH FARMERS DURING EVALUATION

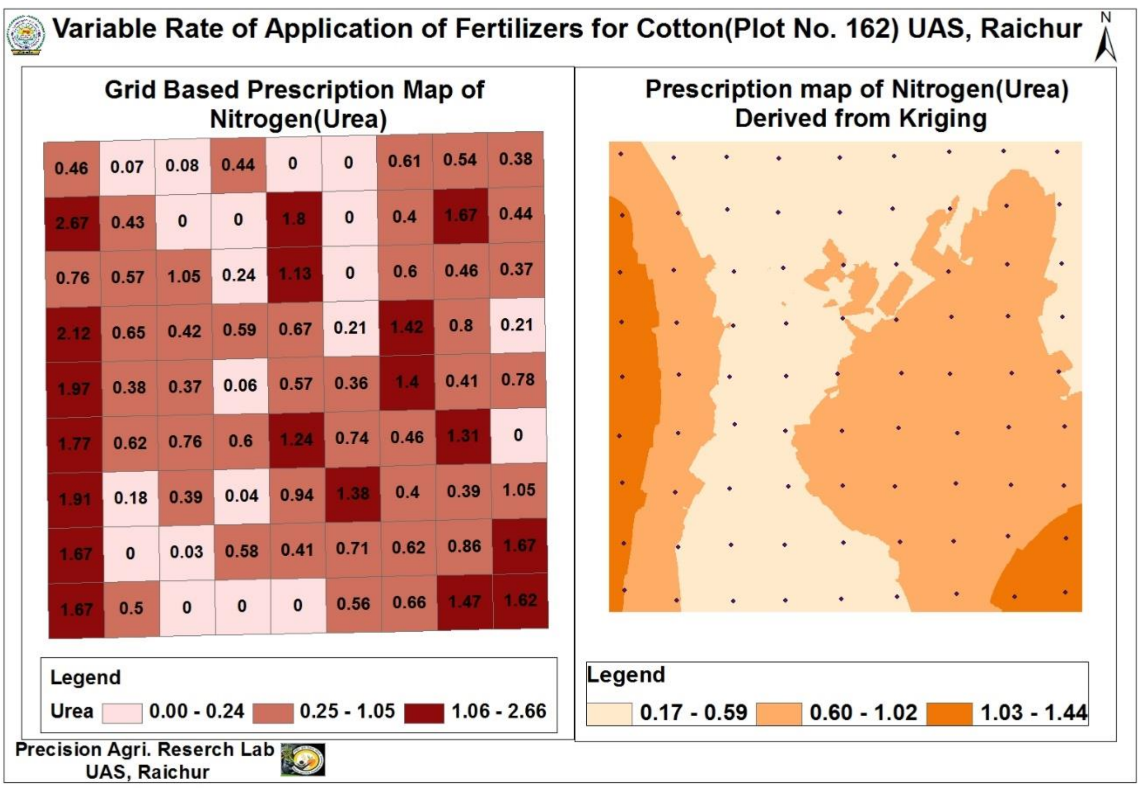

Spatial Variability of Soil Properties in Plot No.162(Cotton), UAS Raichur
N
Grid Based Spatial Variability of Soil pH
8.28 8.28 8.14 8.14 8.32 8.32 8.88 8.88 8.88
8.28 8.28 8.14 8.14 8.32 8.32 8.75 8.88 8.75
8.28 8.28 8.14 8.14 8.32 8.32 8.75 8.88 8.32
8.28 8.38 8.14 8.14 8.21 8.32 8.75 8.88 8.21
8.28 8.38 8.14 8.14 8.21 8.32 8.75 8.88 8.14
8.28 8.38 8.38 8.21 8.21 8.32 8.75 8.88 8.38
8.28 8.38 8.38 8.21 8.21 8.32 8.75 8.88 8.28
8.55 8.38 8.38 8.21 8.21 8.75 8.75 8.88 8.55
8.55 8.38 8.38 8.21 8.21 8.75 8.75 8.88 8.38
Legend
8.14 - 8.38
8.39 - 8.88
Variability Zones of Soil pH
Derived from Kriging
Legend
8.13 - 8.50
8.51 - 8.88
Precision Agri. Reserch Lab
UAS, Raichur

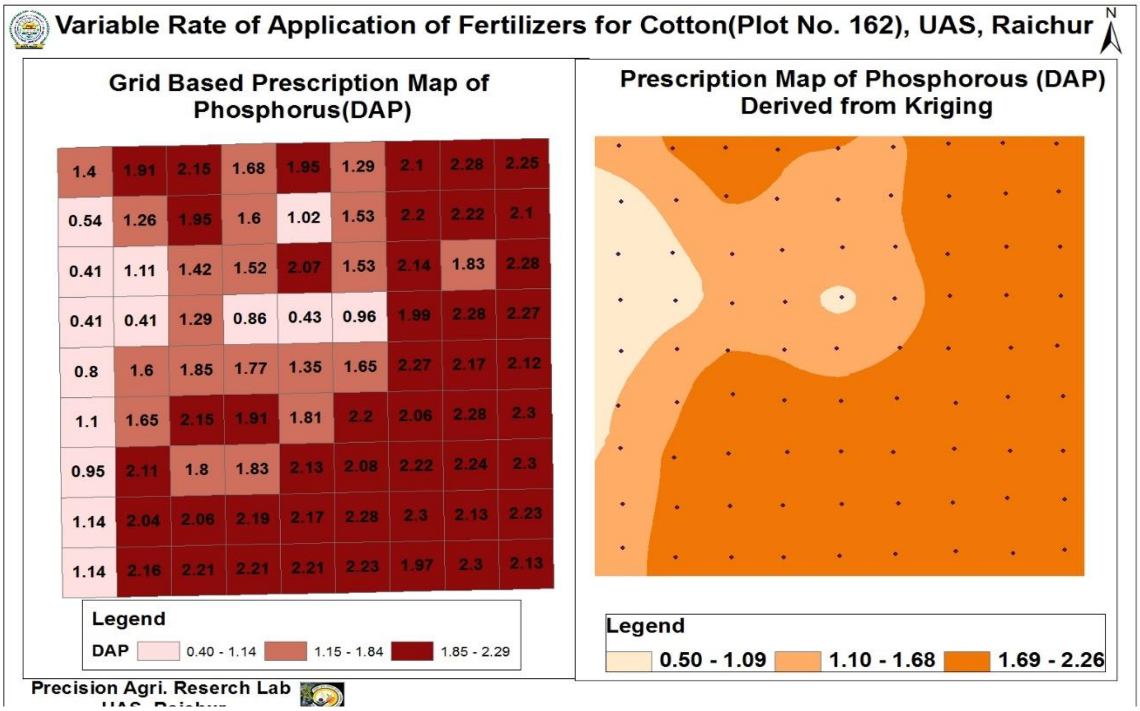

Spatial Variability of Soil Properties in Plot No.162(Cotton), UAS Raichur
N
Grid Based Spatial Variability of Soil EC
0.11 0.11 0.15 0.15 0.18 0.18 0.27 0.27 0.27
0.11 0.11 0.15 0.15 0.18 0.18 0.22 0.27 0.22
0.11 0.11 0.15 0.15 0.18 0.18 0.22 0.27 0.18
0.11 0.11 0.15 0.15 0.17 0.18 0.22 0.27 0.17
0.11 0.11 0.15 0.15 0.17 0.18 0.22 0.27 0.15
0.11 0.11 0.11 0.17 0.17 0.18 0.22 0.27 0.11
0.11 0.11 0.11 0.17 0.17 0.18 0.22 0.27 0.11
0.11 0.11 0.11 0.17 0.17 0.22 0.22 0.27 0.11
0.11 0.11 0.11 0.17 0.17 0.22 0.22 0.27 0.12
Legend
EC
0.11 - 0.15
0.16 - 0.27
Variability Zones of Soil EC
Derived from Kriging
Legend
0.08 - 0.17
0.18 - 0.27
Precision Agri. Reserch Lab
UAS, Raichur

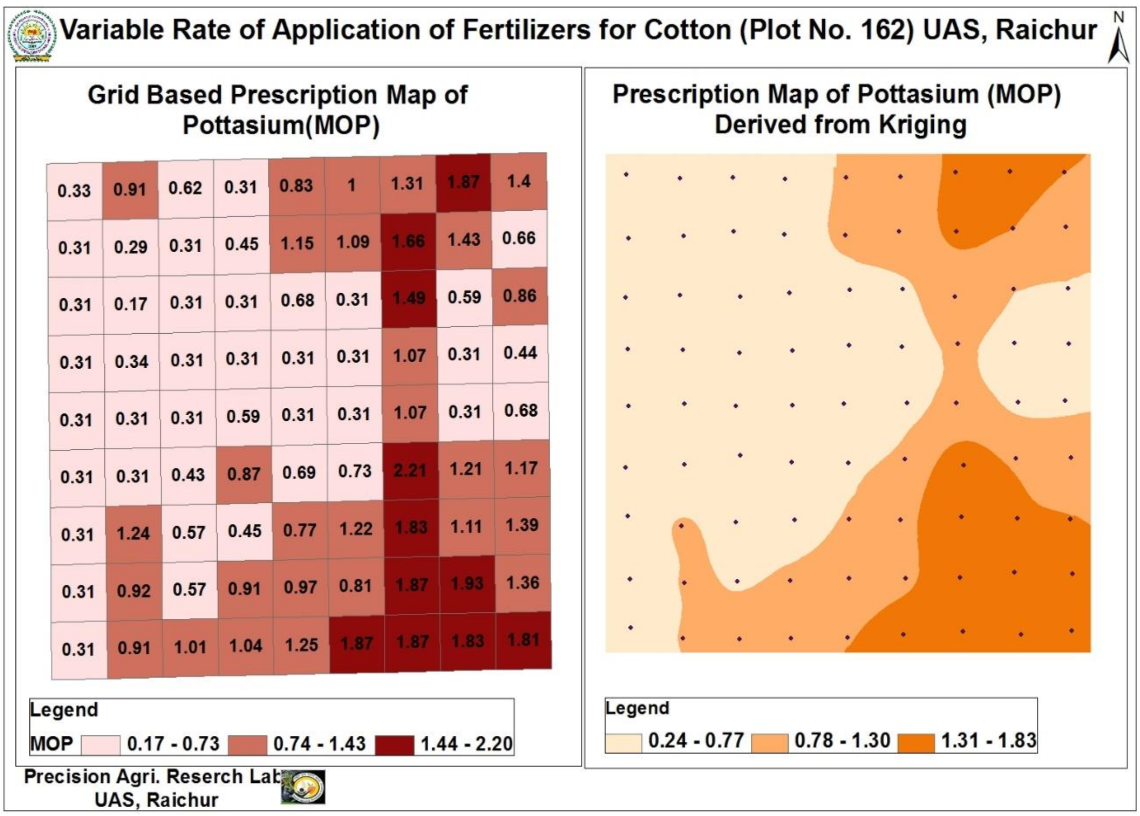

Spatial Variability of Soil Properties in Plot No.162(Cotton), UAS Raichur
N
Grid Based Spatial Variability of Soil Nitrogen
Variability Zones of Soil Nitrogen Derived from Kriging
Legend
N 89.60 89.61 - 95.20 95.21 - 100.80 100.81 - 112.00
Legend
90.21 - 95.30 95.31- 100.39 100.40 - 105.48 105.49 - 110.56
Precision Agri. Reserch Lab
UAS, Raichur


Spatial Variability of Soil Properties in Plot No.162(Cotton), UAS Raichur
N
Grid Based Spatial Variability of Soil Phosphorus
Variability Zones of Soil Phosphorus Derived from Kriging
Legend
P 2.20 2.21 - 4.40 4.41 - 7.55 7.56 - 10.38
Legend
2.58 - 3.78 3.79 - 4.98 4.99 - 6.17 6.18 - 7.37
Precision Agri. Reserch Lab
UAS, Raichur


Spatial Variability of Soil Properties in Plot No.162(Cotton), UAS Raichur
N
Grid Based Spatial Variability of Soil Pottasium
280 280 362.2 362.2 374.6 374.6 336.4 336.4 336.4
280 280 362.2 362.2 374.6 374.6 330.6 336.4 330.6
280 280 362.2 362.2 374.6 374.6 330.6 336.4 374.6
280 360.8 362.2 362.2 449.8 374.6 330.6 336.4 449.8
280 360.8 362.2 362.2 449.8 374.6 330.6 336.4 362.2
280 360.8 360.8 449.8 449.8 374.6 330.6 336.4 360.8
280 360.8 360.8 449.8 449.8 374.6 330.6 336.4 280
171 360.8 360.8 449.8 449.8 330.6 330.6 336.4 171
171 360.8 360.8 449.8 449.8 330.6 330.6 336.4 238
Legend
K 171.00 171.01 - 280.00 280.01 - 374.60 374.61 - 449.80
Variability Zones of Soil Pottasium Derived from Kriging
Legend
164.66 - 238.76 238.77 - 312.87 312.88 - 386.98 386.99 - 461.09
Precision Agri. Reserch Lab
UAS, Raichur


Variable Rate of Application of Fertilizers for Cotton(Plot No. 162) UAS, Raichur
N
Grid Based Prescription Map of Nitrogen(Urea)
0.46 0.07 0.08 0.44 0 0 0.61 0.54 0.38
2.67 0.43 0 0 1.8 0 0.4 1.67 0.44
0.76 0.57 1.05 0.24 1.13 0 0.6 0.46 0.37
2.12 0.65 0.42 0.59 0.67 0.21 1.42 0.8 0.21
1.97 0.38 0.37 0.06 0.57 0.36 1.4 0.41 0.78
1.77 0.62 0.76 0.6 1.24 0.74 0.46 1.31 0
1.91 0.18 0.39 0.04 0.94 1.38 0.4 0.39 1.05
1.67 0 0.03 0.58 0.41 0.71 0.62 0.86 1.67
1.67 0.5 0 0 0 0.56 0.66 1.47 1.62
Legend
Urea 0.00 - 0.24 0.25 - 1.05 1.06 - 2.66
Prescription map of Nitrogen(Urea) Derived from Kriging
Legend
0.17 - 0.59 0.60 - 1.02 1.03 - 1.44
Precision Agri. Reserch Lab
UAS, Raichur


Variable Rate of Application of Fertilizers for Cotton(Plot No. 162), UAS, Raichur
N
Grid Based Prescription Map of Phosphorus(DAP)
1.4 1.91 2.15 1.68 1.95 1.29 2.1 2.28 2.25
0.54 1.26 1.95 1.6 1.02 1.53 2.2 2.22 2.1
0.41 1.11 1.42 1.52 2.07 1.53 2.14 1.83 2.28
0.41 0.41 1.29 0.86 0.43 0.96 1.99 2.28 2.27
0.8 1.6 1.85 1.77 1.35 1.65 2.27 2.17 2.12
1.1 1.65 2.15 1.91 1.81 2.2 2.06 2.28 2.3
0.95 2.11 1.8 1.83 2.13 2.08 2.22 2.24 2.3
1.14 2.04 2.06 2.19 2.17 2.28 2.3 2.13 2.23
1.14 2.16 2.21 2.21 2.21 2.23 1.97 2.3 2.13
Legend
DAP 0.40 - 1.14 1.15 - 1.84 1.85 - 2.29
Prescription Map of Phosphorous (DAP) Derived from Kriging
Legend
0.50 - 1.09 1.10 - 1.68 1.69 - 2.26
Precision Agri. Reserch Lab


Variable Rate of Application of Fertilizers for Cotton (Plot No. 162) UAS, Raichur
N
Grid Based Prescription Map of Pottasium(MOP)
0.33 0.91 0.62 0.31 0.83 1 1.31 1.87 1.4
0.31 0.29 0.31 0.45 1.15 1.09 1.66 1.43 0.66
0.31 0.17 0.31 0.31 0.68 0.31 1.49 0.59 0.86
0.31 0.34 0.31 0.31 0.31 0.31 1.07 0.31 0.44
0.31 0.31 0.31 0.59 0.31 0.31 1.07 0.31 0.68
0.31 0.31 0.43 0.87 0.69 0.73 2.21 1.21 1.17
0.31 1.24 0.57 0.45 0.77 1.22 1.83 1.11 1.39
0.31 0.92 0.57 0.91 0.97 0.81 1.87 1.93 1.36
0.31 0.91 1.01 1.04 1.25 1.87 1.87 1.83 1.81
Legend
MOP 0.17 - 0.73 0.74 - 1.43 1.44 - 2.20
Prescription Map of Pottasium (MOP) Derived from Kriging
Legend
0.24 - 0.77 0.78 - 1.30 1.31 - 1.83
Precision Agri. Reserch Lab
UAS, Raichur

Input and output under PF and Non-PF in Cotton at Raichur[per ha basis]

Inputs	2011-12		2012-13		2013-14		2014-15*	
	Precision	Non precision	Precision	Non precision	Precision	Non-precision	Precision	Non-precision
Fertilizers (kg/ha)								
Nitrogen	88.75	63.00	366.31	150.0	244.59	150.0	280.0	150.0
Phosphorus	46.75	83.00	203.79	75.0	48.00	75.0	110.0	75.0
Potassium	42.75	50.00	314.33	75.0	482.02	75.0	320.0	75.0
Output (kg/ha)								
Target yield	3500	3000	3500	3000	3500	3000	3500	3000
Yield realized	2325	824.	4546	1457	3451	2100	1430	1571
% Yield realized	66.43	27.47	129.88	48.57	98.60	70.00	40.80	52.36
Cost and Returns (Rs./ha)**								
Total cost	25179	25902	46012	28784	38557	28816		
Gross returns	93535	33150	163647	52458	127687	77700		
Net returns	**68355**	**7248**	**117635**	**23675**	**89130**	**48884**		

REFERENCES

JurgenSchellberg et al. 2008, Precision agriculture on grass land: Applications, perspective and constraints, *European Journal of Agronomy*, Elsevier, Vol. 29, Pp. 59-71.

Jose C. Samuel and H. P. Singh, 2003, Perspective of Hi – Tech Horticulture and Precision Farming, *Precision Farming in Horticulture*, Pp. 21 – 35.

Robert, P.C., Rust, R.H. and Larson, W.E. Site specific management for Agriculture system. Proceedings of Site Specific Management for Agriculture System. 27-30, March 1994, Minneaports.

Schultz, T.W. 1964. Transforming Traditional Agriculture. New Haven, Yale University Press.

Shruthi K, G.M. Hiremath and Amrutha T. Joshi, 2017, An Economic Assessment of Cotton Production under Precision Farming in North Eastern Karnataka, *Economic Affairs,* Vol. 62, No. 4, pp. 633-639, December 2017

Singh, A.K. 2010. Precision farming. Water Technology Centre, IARI, New Delhi.

Subrata, K.M. and Atanu, M. 2013. Precision farming for small agricultural farm: Indian scenario. *American Journal of Experimental Agriculture*, 3(1): 200-217.

TERMS OF REFERENCE

FOR EVALUATION OF THE PROJECT ENTITLED "PRECISION FARMING TECHNIQUES IN SELECTED FIELD CROPS" IMPLEMENTED DURING THE PERIOD 2010-11 BY UNIVERSITY OF AGRICULTURAL SCIENCES, RAICHUR AT RAICHUR, KOPPAL AND KALABURGI DISTRICTS COMING UNDER THE JURISDICTION OF UAS RAICHUR

1. Title of the study:

"Precision Farming Techniques in Selected Field Crops"

2. Department/Agency implementing the scheme:

Department of Plant Pathology, College of Agriculture, UAS, Raichur

3. Project approval number: VI & 27.09.2010 KA/RKVY-AGRE/2011/152
& IX & 31.07.2012 KA/RKVY-AGRE/2012/321

Year of Start: 2010-11 and 2012-13
Year of Conclusion: 2015-16
Total budget of the project: 1.10 crore + 1.00 crore = 2.10 crore

4. Background and the context:

"Precision agriculture is not a single technology, but rather a set of many components from which growers can select to form a system that meets their unique needs and operation size." However, the main components are: Yield monitoring / mapping, Remote sensing and Variable rate technology. These components helps us to meet the demands of precision agriculture practice i.e. application of Right Input, in Right Quantity, at Right Place, at Right Time and by Right Method. Different approaches are being followed in the adoption of precision farming throughout the world depending upon the availability tools and techniques, expertise, skilled human resources and machinery.

The greatest challenge in precision agriculture is in interpreting information from yield data (maps), crop performance records (both historic and 'real-time') and soil analysis into practical strategies for the variable application of crop treatments for an individual field. If one overcome this challenge, then it is possible to develop management zones designating them as low, medium and high yield zone and devise the agronomic practices accordingly to achieve the maximum yield with optimum input application based on soil test values. Therefore, the soil test based input application had better advantages over the blanket application as for as the amount of savings in the cost of use of fertilizers and also getting higher crop yields. However, huge cost on soil sampling and analysis, which is tedious and time consuming is greatest hindrance in popularizing this approach.

Another key component i.e. Variable rate of input application which emphasizes the application of optimum fertilizer nutrients to the crop under each yield zone variably based on the expected yield and also considering the soil test values. Therefore, each yield zone area receive variable rate of NPK applications depending on the initial soil nutrient status, thus minimized the probability of areas with high soil test values receiving higher doses of nutrient inputs and vice versa which is a common impediment under blanket application of fertilizer inputs.

Popularization of soil test based nutrient application in other words optimum input application may save cost on inputs, improve quality of agriculture produce apart from addressing the environment pollution issues associated with over use of agricultural inputs particularly in irrigation commands which are obsessed with high input intensive practices.

Keeping this in view the project entitled "Precision Farming Techniques in Selected Field Crops" was sanctioned by Karnataka State Department of Agriculture (KSDA) during 2010-11 and again with additional grants during 2012-13 to take up large scale demonstration at farmers' fields under RKVY grants.

The adoption of precision farming tools and techniques in selected field crops through large scale demonstrations were taken at different villages under farmers' participatory approach at Raichur, Gulbarga and Koppal districts, covering approximately an equivalent of 100 acres each in Cotton, Pigeon Pea and Paddy crops respectively during 2011-12, 2012-13, & 2013-14. Apart from this, research demonstration plots [5.00 acres in each crop] at different research stations [03] of UAS, Raichur were also undertaken to assess the feasibility of Precision Farming Techniques in small scale land holdings during these years. However, during the year 2014-15, only research demonstration plots [5.00 acres in each crop] at three different research stations of UAS, Raichur were undertaken owing to several constraints. Finally, Precision Farming techniques were demonstrated in large areas of farmers' fields accounting to a total of 364.73 Acres in Cotton, 505.0 Acres in Paddy and 580.95 Acres in Pigeon pea under this RKVY sponsored project.

5. The objectives:

- To adopt and demonstrate precision farming techniques for cotton, pigeon pea and paddy crops by emphasizing soil test based nutrient application to optimize soil input application

6. The present status of the project: Closed

The project was concluded and closed in 2015-16 after the exhaustion of grants. As it was becoming difficult to keep and monitor the laboratory, it was dismantled and assets/ equipments were shared and distributed among different disciplines for the benefit of post graduate and doctoral students.

It should be noted that there is already inordinate delay and time lapse for the third party evaluation

7. Achievements/ Salient observations under the project:

- Soil test values indicated marginal to medium fertility variations within a field.
- The nutrient variability at field level was better interpreted through kriging maps
- Each grid area under each crop received different quantum of inputs based on soil test values which was aimed to achieve the targeted yield through input optimization
- The results have indicated that there was an increase in yield by 15-20% in cotton, 20-25% in paddy and 15-25% in pigeon pea over the farmers' method and there was also significant reduction in the amount of fertilizer input consumption by 10 - 15% in cotton and 25-30% in paddy when compared to the farmers' method of fertilizer application and soil test based nutrient application under precision farming technique.

8. Outcome of the project:

The large scale demonstrations at farmers' field under precision farming techniques were successful in building the confidence among the farmers' about the techniques of modern agriculture. They are convinced that by adopting the practices such as soil test based input application can save the unnecessary cost on fertilizer inputs, timely management of pests as per standard package of practices can better control pest and disease occurrence in crops, intervention through amendments and foliar nutrition can fetch higher crop yields etc.

In general, paddy and cotton farmers' were more enthusiastic as they have found significant reduction in application of inputs and apart from fetching higher crop yields.

9. Assets:

Sl. No.	Name of the Purchased Asset	Date of Purchase/ Received	Qty. (Nos)	Cost (Rs. In Lakhs)	Purpose of Purchase	
1	M - Tan (Harry)	25/6/2011	01	483=00	To carry out field operations	
2	Khodli	9/7/2011	04	320=00		
3	Bai Khodli	9/7/2011	02	180=00		
4	Kudagoal	9/7/2011	04	120=00		
5	Khurpi	9/7/2011	10	250=00		
6	9 Tyne Cultivator	25/7/2011	01	28000=00		
7	Leveller Blade	25/7/2011	01	19000=00		
8	5 Tyne Duck Foot Cultivator	25/7/2011	01	28500=00		
9	Blade Harrow	25/7/2011	01	16,000=00		
10	Canon Digital Camera	27/7/2011	03	56,985=00	To record experimentation activities	
11	Sony Handy Cam HDR	28/7/2011	01	24,990=00		
12	HP 8000 Series Computer Intel Core i5	1/8/2011	01	37,080=00		
13	Soil Sample Cabinate (wooden)	3/8/2011	01	25,000=00	To store samples	
14	Revolving Hydraulic Fibre Base Chair	4/8/2011	12	47,880=00	To office work	
15	Hp 7000 Series Computer Intel core i3	8/8/2011	10	3,50,763=00		
16	Pocket weather tracker	10/8/2011	02	78,750=00	To record observations	
17	APC UPS 600 VA	16/8/2011	01	2,330=00	Power backup to computer	
18	Computer Table	13/9/2011	12	28,500=00	Office work	
19	Hp M 1136 LaserJet printer (print/scan/copies)	13/9/2011	01	10,745=00	Office work	
20	T Screw Spanner	14/9/2011	01	180=00	Accessory	
21	DES Spanner 21 x 23	14/9/2011	01	45=00	Accessory	
22	Spanner 18 x 19	14/9/2011	01	35=00		
23	Backup with power strip	17/9/2011	01	6,520=00	Power backup to computer	
24	Cosmic 6 KV UPS	17/9/2011	01	53,203=00		
25	Luminous Batteries LT-500	17/9/2011	06	76,790=00		
26	Weighing Machine	22/9/2011	01	9,345=00	Weighing of samples	
27	Soil Sample Cabinet (wooden)	10/12/2011	01	25,000=00	Storing samples	
28	Scientific/ surveying instruments (GPS)	17/12/2011	10	5,14,500=00	Survey work	
29	Erdas imagine professional - Edu with modeller (DVD Pack)	27/12/2011	01	3,10,000=00	GIS & Mapping	
30	Aluminium Partition	9/1/2012	156.25 Sq ft	35,156=00	Office accessory	
31	Aluminium Door	9/1/2012	21 Sq ft	4,725=00		

32	Samsung make Split AC 2.0 ton capacity	6/12/2012	01	34,298=00	Office upgradation	
33	V-Guard Stabilizer	6/12/2012	01	2,886=00	Power backup	
34	3 - Speed with Osillation and pedestal Fan	16/2/2012	01	3,475=00	Office accessory & Upgradation	
35	Motorised screen	13/2/2012	01	16,400=00		
36	Hitachi multimedia LCD projector and Ceiling mount kit	16/2/2012	1+1	66,120=00		
37	Hp Folio - 13 Laptop Intel core i5	15/3/2012	01	69,930=00		
38	Digital Balance	21/3/2012	01	6,615=00	Weighing samples	
39	Spring Balance Cap 100 kg	26/3/2012	01	1,260=00		
40	Humidifier (Air Cooler)	11/7/2012	01	9,677=00	Lab accessory	
41	Green Seeker hand held battery	25/7/2012	01	8,500=00	To record plant observations	
42	Battery charger	25/7/2012	01	16,500=00		
43	NIKON Camera	3/9/2012	01	79,950=00	To record photo images	
44	Numeric 600 VA UPS	3/9/2012	01	2,000=00	Power backup	
45	20" LED Monitor Acer	3/9/2012	01	6,800=00	Computer accessory	
46	Digital copier with printer	19/11/2012	01	91,186=00		
47	Soil Moisture meter 1. TDR 300-6430FS 2. 2.8" (20mm) Stainless steel rod 3. Pilot Hole Maker	21/11/2012	01 set 01 01	85,000=00 5,000=00 6,500=00	To record field soil moisture observations	
48	Soil Compaction meter - 6120	6/12/2012	01	26,000=00	To record soil bulk density	
49	L.S. Soil Sampler Probe – 6519	6/12/2012	03	51,000=00	Soil sampler	
50	Spad Chiorophyll meter	7/12/2012	01	1,45,950=00	To record plant observations	
51	High power zoom AFS VK zoom Nikon	10/12/2012	01	32,450=00	To record photo images	
52	Closeup Micro Nikon	10/12/2012	01	54,450=00		
53	Automatic Voltage stabilizer	24/12/2012	01	3,500=00	Power backup	
54	Green Seeker	21/1/2013	01 set	65,812=00	To record plant observations	
55	IPM Scope Cam 2 2862 Make M.S Spectrum technology, USA	21/1/2013	01	50,000=00	To record plant observations	
56	Kudagol	6/2/2013	03	150=00	Field work	
57	Packet PEA (chlorophyll fluorescence system)	18/2/2013	01	4,050=00 (EUR Dollar)	To record plant observations	
58	Books Almirah with glass door	21/3/2013	01	9,300=00	Office accessory	
59	Leaf area index meter	31/3/2013	01	3,20,000=00	To record plant observations	
60	Taiwan sprayer	5/9/20113	01	10,339=00	Field work	
61	Honda power weeder	6/9/2013	01	32,000=00		
62	Trimble make green seeker	8/10/2013	01	52,500=00	To record plant observations	

63	HP color LaserJet printer	10/10/2013	01	23,895=00	Office accessory	
64	Trimble green seeker	19/10/2013	01	52,500=00	To record plant observations	
65	Trimble green seeker	8/11/2013	01	52,500=00		
66	Soil moisture EC & Temperature sensor 6470-20	26/11/2013	01	20,000=00	To record soil readings	
67	Data Logger (Basic software)	26/11/2013	01	38,000=00	Computer accessory	
68	Kyocera FS – C 2126 Color printer solution	26/11/2013	01	68,575=00	Office accessory	
69	Soil Sampler probe	28/11/2013	05	98,500=00	Soil sampling	
70	Trimble green seeker	14/12/2013	01	52,500=00	To record plant observations	
71	Apple I Pad	21/12/2013	01 Set	60,900=00	To record plant observations	
72	Trimble green seeker	31/12/2013	01	52,500=00	To record plant observations	
73	Elmo CRA-1 Wireless tablet slate	16/1/2014	01	42,995=00	To record plant observations	
74	Tractor drawn manual seed com fertilizer drill 6 types	10/2/2014	01	45,498=00	Field operations	
75	Bund farmer	10/2/2014	01	26,540=00		
76	Blade harrow /Cross 6.5” 3 blade	10/2/2014	01	18,957=00		
77	APC BR 1100VA UPS	11/9/2014	02	12,238=00	Power backup	
78	Trimble green seeker	6/10/2014	01	52,500=00	To record plant observations	
79	HP 1005 MEP LaserJet Printer	29/10/2014	01	12,850=00	Office accessory	
80	75mm HDPF Pipe with Accessories	26/3/2015	30	22,788=00	To irrigate the field experiments	
81	Systronics M Based spectrophotometer	13/10/2015	01	41,699=00	Soil testing for Phoshorus, sulphur etc	
82	M Based PH System with electrode & probe	13/10/2015	01	19,688=00	To measure soil pH	
83	M Based conductivity meter with cells	13/10/2015	01	26,888=00	To measure soil EC	
84	Bristal make boss table	6/11/2015	01	18,200=00	Office accessory	
85	Digital copier with printer	26/12/2015	01	73,332=00	Office accessory	

10. Where the project is undertaken/Demonstrated:

	Location /Address	Project
1	Merchatal village, Raichur Taluk, Raichur District	Demonstration of precision farming techniques in cotton Implemented by: Agriculture College, Raichur
2	Village Jangamara Kalgudi, Gangavathi, Koppal District	Demonstration of precision farming techniques in paddy

		Implemented by: Agriculture Research Station, Gangavathi
3	Village Chinamagera, Afzalpur Taluk, Kalaburagi District	Demonstration of precision farming techniques in pigeon pea Implemented by: Agriculture Research Station, Kalaburgi

11. Evaluation questions and minimum expectations:

1. Whether the projects were demonstrated at farmers' fields or not?

2. Whether enlisted assets were procured or not?

3. Whether institute had necessary infrastructure to take up soil and plant analysis or not?

4. Whether necessary chemicals and glassware procured or not?

5. Whether soil samples from farmers' fields were analyzed or not?

6. Whether soil analysis data available or not?

7. Whether plant observation data were recorded or not?

11. Evaluation methodology and sampling:

1. Interaction with the project coordinators and co-investigators of the project
2. Visiting the villages, interaction with the villagers
3. Checking the assets enlisted above

12. Deliverables:

13. Duration and time schedule for the study:

14. Quality expected from the evaluation report

The report should highlight the following:

1. Why the optimization of input application is very much important from the point of environment and sustaining farmers' income
2. The approaches available for precision farming practices in India
3. The positive impact of soil test based input application in Indian context
4. The constraints in successful implementation, adoption and popularization of precision farming techniques from the point of Indian scenario

15. Recommendations:

1. Specific recommendation in overcoming the constraints in adopting precision farming techniques in Indian agriculture
2. Guidelines and recommendations for university research to take up research involving modern tools and techniques such as green seekers, SPAD meters, chlorophyll meters, plant sensors in recording soil and plant observations and interpretation etc. This helps in standardization of modern tools and their utility in agriculture.

16. Cost and schedule of budget: No budget is available at our end

17. Minimum qualification of the consultant:

18. Providing oversight:

19. Contact persons:

Dr. M.B. Patil, Former Project Coordinator

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Dr. Pandith Rathod Co-investigator

Associate Professor of Agronomy,

Senior Scientist, AICRP on Chickpea, ARS, Kalaburgi

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EVALUATION TEAM MEMBERS

Sl. No.	Name	Designation
1	Dr. M. A. Shankar	Principal Investigator
2	Dr. B. C. Suryanarayana	Associate Investigator
3	Sri. Siddaraju	Associate Investigator

Dr. M. A. Shankar is a doctorate in Agriculture with specialization in Agronomy. He is former Director of Research, University of Agricultural Sciences, Bengaluru and presently the Executive Member of Institution of Agricultural Technologists, Bengaluru and Co-Chairman of Agribusiness Consultancy Subcommittee. He has implemented 51 research projects for the University funded by International organizations, Central and State governments, Private firms. He has guided 6 Ph. D. students and 15 M. Sc., (Agri) students. As Dean of College of Agriculture, Hassan, he has, with his administrative skills, streamlined accounting, financial, academic and administrative issues. He has been involved in review and evaluation of Technical Reports of 32 All India Co-ordinated Research Projects (AICRP) spread all over India. He has also evaluated 11 operational research projects for the technical feasibility and implementation. He has published 173 peer reviewed research papers. He has also penned 54 booklets and books for the University. He has vast experience in evaluation studies of projects.

Dr.Suryanarayana, B.C. is a doctorate in Agriculture with specialization in Agronomy and is a Certified Associate of Indian Institute of Banking (CAIIB), Fellow of Indian Institute of Valuers. He worked in State Bank of India from the year 1981 to 2014 as a Technical Officer and retired as Asst. General Manager (Rural Development). He is a practicing consultant in the field of Agriculture, Horticulture, poultry, dairy, fisheries and plant tissue culture and covered cultivation. He has about 35 years of experience in the field and has prepared several project reports for financial institution, written books in vanilla cultivation, anthurium, medicinal and aromatic crops, minor irrigation, poultry and dairy farming. He has appraised more than 6,000 proposals in agriculture and related fields for funding by the Bank and has also been involved in many studies relating to development of Agriculture and allied activities. He has served as a General Manager in a bio-fertilizer, bio-pesticides and organic manures manufacturing company and is also a Technical Director in a company involved in manufacture of agricultural implements and equipment.

Sri. Siddaraju is a Graduate in Agriculture with more than 35 experience in the field of Agriculture. He has served in the Karnataka State Department of Agriculture (KSDA) as Asst. Agricultural Officer in Farmers' Training and Education Centre, Soil Testing laboratory and as Subject Matter Specialist. He was Deputy Director of Agriculture (Commercial Crops) for 6 years, District Watershed Development Officer for 2 years. He has also been Joint Director of Agriculture (Inputs) for 5 years. He was involved in preparation of Annual Programme Planning booklets pertaining to Agricultural Inputs in Department of Agriculture. After retirement, he is serving as Chairman, Agriculture Consultancy Subcommittee, Institution of Agricultural Technologists, Bengaluru and has been actively involved in evaluation studies of projects.