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SOUVENIR & ABSTRACTS

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C status and budgeting of prototype IFS models developed for different agro-climatic regions

Debashis Dutta[1],Anupam Das[2],Ravisankar, N[1]., Subash. N[1].,Shamim, M[1].andPanwar, A. S[1].

[1]ICAR-Indian Institute of Farming Systems Research, Modipuram , Meerut, Uttar Pradesh

[2]Department of Soil Science and Agricultural Chemistry Bihar Agricultural University,Sabour,Bhagalpur

Abstract

Atmospheric CO_2 level has increased to 391 ppm in 2011 (IPCC, 2013) from a pre-industrial concentration of around 28 ppm predicted to affect the human civilizations catastrophically on further increase in its concentration. Existence of huma being on the earth is at stake owing to global climate change associated with anthropogenic activities on account of greenhou gas (GHG) emissions due to unabated increase in population coupled with rapid industrialization. Agriculture is both source and a sink for greenhouse gases. Decision makers can take full advantage of agriculture's potential to slow clima change only by acknowledging the sector's dual role in decarbonizing the economy, and seeking both to minimize agricultur greenhouse gas emissions and to maximize carbon storage. Carbon-neutral farming or GHG-neutral farming is one whe the net greenhouse gas (GHG) emissions associated with activities within that economy's geographic area are zero (accordi to the EPA and the NESC Secretariat). The concept of carbon neutrality in a farming system refers to a scenario in whic national GHG emissions from agriculture are fully offset by carbon sequestration by grassland soils, forestry and oth landuse, thus put more emphasis from gross emissions to net emissions (i.e. the difference between gross emissions ar offsetting).

The integrated farming system is the best option for mitigating climate change and enhancing the quality of life of t marginal and small farmers. Integrated Farming System (IFS) is a participatory and comprehensive approach of developi location and situation specific farming systems harnessing the interactions among components of a farm for higher ar sustained agricultural production for environmental, social, economic and nutritional security.Integratedfarming systen are sustainable agricultural practice based on a simple concept: that crop yields can be maximized by recycling nutrien present in both animal manure and crop residues side by side reducing the carbon foot print in the farming systems. Th reduces the need for chemical fertilizers that release large quantities of greenhouse gases and thereby contribute to clima change. In an integrated cropping-livestock system, livestock may either graze the field crops directly or may be fed the cr after harvesting. Farmers then collect the manure from the livestock and use it as fertilizer, thereby returning many of t nutrients to the soil. Preservation of bio-diversity, diversification of cropping / farming and maximum recycling is the ba for success of the integrated farming systems approach.

Making agriculture climate smart through integrated approach is also an ideal solution to ensure the food security of t ever-increasing global population at a time when there are twin problems of land degradation and carbon emissions. today's time, climate change has become a most pressing issue. Though a natural process, anthropogenic activities ha speeded it up through more emissions of greenhouse gases, deforestation and burning of fossil fuels. Climate change h profoundly affected the environment as manifested in the vagaries of nature. It has also impacted agriculture and t natural resource base of the Earth. It is need of the hour to cope with the devastating effects of climate change and the on options for us are to adapt to it, lower our emission rate and increase carbon sequestration through suitable land use ar land use changes like afforestation. A multi-pronged strategy is required to check climate change and integrated farming one of the options to achieve it. It provides multiple benefits that are sustainable and can pave the way for Integrat farming system (IFS).

Carbon status of Soil

World soils play an important role in the global carbon cycle. The soil carbon pool comprises soil organic carbon (SO estimated at 1550 Pg and soil inorganic carbon (SIC) about 750 Pg both to 1-m depth (Batjes, 1996). Thus the total soil C po of 2300 Pg is three times the atmospheric pool of 770 Pg and 3.8 times thebiotic pool of 610 Pg. The atmospheric pool h steadily increased since about 1850, and is currently increasingat the rate of 0.5%/year or 1.8 ppmv/year (Lal, 2002). natural ecosystems, both SOC and N pools decrease exponentially with increase in temperature (Univ. of Missouri, 193 Similar relationships exist for soils of India (Jenny and Ray Chaudhary, 1960), New Zealand (Tate, 1992), and tropical Ameri (Rossell and Galantini,1998).Indian soils are in general low insoil organic carbon (1.0–10.0 g /kg).Soil organic carbon level 5–10 g kg^{-1} is desired for optimum ecosystem functioning in subtropical Indian soils. The critical limit of soil organic carb in different states of India are as follows

Ludhiana 4.46 Mg ha^{-1}, Almora 0.32,Pantnagar 3.16Mgha^{-1},Varanasi 2.47 Mg ha^{-1}, SK Nagar 4.03 Mg ha^{-1}, Coimbatore 3.4 Mg ha^{-1} respectively.

Climate Smart Farming Systems

Climate Smart Agriculture (CSA) is an integrated approach to develop technical, policy and investment conditions in su manner so as to ensure sustainable development for food security. The main aim is to achieve sustainable higher product ensure livelihood and food security, adapt to climate change and bring down emission of greenhouse gases. CSA ens increased productivity in a sustainable way which can strengthen the farming community against the consequenc climate change. It can also increase the mitigating potential of climate change through carbon stocking. There is an ur need to go for CSA. It is expected that the world population will increase by 1/3 of the present in 2050 which will put pressure on our existing resources. Climate change will affect food productivity across the world. We have to be read these challenges and ensure that there is enough food for our growing population. Being an integrated approach, includes soil/water conservation practices like watershed management, water harvesting and mulching and gr management, plantation of multi-purpose tree species, agronomic practices like crop rotation and multiple croppi legumes alternating with non-legumes, conservation farming, agroforestry, integrated farming, generation and use of clin smart varieties of crops, development and use of high-yielding genetic stocks of crops and livestock, forecasting wea and market risks and alerting farmers through the media.

ICAR-Indian Institute of farming systems research have developed 38 Integrated Farming systems models across th agroclimatic region of India under AICRP project. All the IFS models are evaluated in respect of carbon neutrality. In We Coast Plains & Hillsregion, four IFS model were developed in the Kerala state. Among the four models *viz.*homestead b coconut based, banana based IFS model were carbon neutral whereas the rice base IFS model were not carbon neutral IFS model (crop + livestock + fishery + apiary component)developed in Eastern Himalayan Region,was estimated 865.00 Kg CO_2 equivalent net GHG emission. IFS model developed under different agro-climatic region are nearly ca neutral due to the integration of higher carbon sink component through introduction of agroforestry, nutrient cy vermicomposting and integration of horticulture component.

In countries like India where majority of farmers holding less than two hectares of land practice subsistence farming, are heightened through monocropping. Integrated farming has immense potential to make farmers' climate smart thr the cultivation of different crops on the same land and using farm resources sustainably:

- It involves integrated resource management for maximum productivity
- It involves best utilization of the growing space through the integrated farming approach
- Nutritional and economic security is ensured for better health of the farm family as they get different fruits, ce vegetables, livestock products and cash crops from their own land. It boosts food security through local productio consumption and checks migration
- This improves soil's physical and chemical properties, its nutrient status and biological components. Such inter systems affect the microclimate and provide a strong base to good agricultural practices for increased productivit

As integrated farming systemfollows an integrated approach, inter-sectoral management of natural resources needs strengthened for progressive sustained productivity rather than simple sustainable productivity. For the same, time to evaluation of resources needs to done, along with benefits accrued from their management and use. Both the publ private sectors need to come forward for livelihood improvement through integrated farming for climate-resilient agric promotion. This can be achieved through micro-finance approach and creating awareness among producers. Transpor cost of different farm products needs to be minimized. This will check emissions on one side and promote consumpt the produce locally on the other. Let us take up the initiative to promote integrated farming system before climate thr our food security.

References

Batjes, N. H., 1996,The total C and N in soils of the world. *European Journal Soil Science* 47, 151–163.

Jenny, H., Raychaudhuri, S. P., 1960, Effect of Climate and Cultivation on Nitrogen and Organic Matter Reserves in Soils.ICAR, NewDelhi, India.

Lal, R., 2002, Soil carbon dynamics in cropland and rangeland. *Environmental Pollution* 116: 353–362.

Lehner Peter and Rosenberg Nathan, A. 2017, Legal Pathways to Carbon-Neutral Agriculture. *News & Analysis***47** (1 10845.

Rosell, R.A. andGalantini, J. A., 1998, Soil organic carbon dynamics in native and cultivated ecosystems of South Amer Lal.

R.,Kimble, J., Follett, R., Stewart, B. A., Management of Carbon Sequestration in Soil. *CRC, Boca Raton, FL*, pp. 11–3

Schulte R.P.O. et al.,2013,A report by the Teagasc Working Group on Greenhouse Gas Emissions. Agriculture an Development authority.

Tate, K. R., 1992, Assessment based on a climosequence of soils in tussock grasslands of soil carbon storage and rel response toglobal warming. J. Soil Sci. 43: 697–707.

Integrated Farming System GHG emission estimator – A tool for identifying/quantifying climate resilient modules of IFS to mitigate the ill effects of climate change

Subash.[1]N., Debashis Dutta[1], Sridevi[2]S., Ravisankar[1]N., Shamim[1], M.,Panwar[1]A.S. and Bhaskar[3], S.

[1]ICAR-Indian Institute of Farming Systems Research

Modipuram-250 110, Meerut, Uttar Pradesh

[2]AICRP-IFS, PJTSAU, Rajendranagar, Hyderabad, Telangana

[3]Natural Resource Management Division, Indian Council of Agricultural Research, KAB-II, Pusa, New Delhi

*Email: nsubashpdfsr@gmail.com, n_suby@rediffmail.com

Abstract

Food and Agricultural Organization in its latest report on "The future of food and Agriculture: Trends and Challenges" described that high-input, resource-intensive farming systems, which have caused massive deforestation, water scarcities, soil depletion and high levels of greenhouse gas emissions, cannot deliver sustainable food and agricultural production. The frequent occurrence of extreme climatic events at one or other places over India due to Global Climate Change, directly or indirectly put pressure or risk on small and marginal farm households, which is the major chunk of the farming population. Several tools developed by different National/International Organizations to estimate the GHG emission from agriculture sector are available in public domain. However, there is a need to develop an GHGs emission estimation tool, which represents Indian farming scenario/situation with possibility of all the components/ enterprises of integrated farming system, so that any stakeholder can use without any hindrance to identify/quantify the GHG emission potential of their farming system. Hence, an attempt has been made under AICRP-IFS at ICAR-IIFSR, Modipuram to develop a user friendly IFS-GHG estimator in excel platform.

Introduction

GHG emissions in farming system systems is dominantly majorlythrough improper crop management practices, livestock population and improper diet usage, deforestation, non-forest land usechanges and over use of inorganic fertilizers which can result in loss of soilorganic matter (Srinivasarao et al.,2014).There is an opportunity to achieve climate-friendly agriculture by bothsequestering carbon and reducing emissions through different interventions viz.enriching soil carbon by agronomic practices, livestock production technologies,balanced use of fertilizers, planting boundary plantations and agroforestry etc. Better agricultural practices improve C sink and help compensate/reduce GHG emission. According to a study conducted by Pathak et al (2014), agricultural soils emitted23% of the total CO2eq. emission fromagriculture, whereasrice cultivation contributed 17%. Livestock manuremanagementcontributed 6% ofthe emissions and2% was attributed tothe burning of cropresidues in field.The direct and indirectN2O emissionsfrom Indian agriculturalsoils were 259Gg and 45 Gg (94Tg CO2 eq.), respectivelyin 2010. Fertilizerwas the largestsource contributing77% to the total directnitrous oxideemissions. However, most of the studies done at the National level with different components of the farming system separately. Several tools developed by different National/International Organizations to estimate the GHG emission from agriculture sector are available in public domain. However, there is a need to develop an GHGs emission estimation tool, which represents Indian farming scenario/situation with possibility of all the components/ enterprises of integrated farming system, so that any stakeholder can use without any hindrance to identify/quantify the GHG emission potential of their farming system. Hence, an attempt has been made under AICRP-IFS at ICAR-IIFSR, Modipuram to develop a user friendly IFS-GHG estimator in excel platform.

IFS-GHG emission Estimation Tool

The IFS-GHG Estimation Tool is a Farming System GreenHouse Gas (GHG) Estimator for calculating net GHG emission from on-station IFS models and also from on-farm participatory farming system research. This tool can be used for estimation of GHG from different farming system components and also from individual farm households/farms. This is simple and user friendly tool for any Indian farming situations to identify climate resilient farming system components to mitigate the ill effects of climate change impacts on agriculture. The various stakeholders ie, researchers, technical officials, developmental officials, policy planners can easilyuse this tool by selecting default emission factors or their own factorsbased on their research data set.

This estimator has thirteen input sections dealt with each enterprises of the farming system, each on a separate excel worksheet, relating to

- Basic information (Name of the Centre, State, Year of Experiment, Agro-Eco system, Agro-climatic zone (As per Planning Commission), NARP zone, Location (District), Farming System components and Area(in ha)).
- Crop-cropping system (crop area, synthetic fertilizer used, crop residue and manure incorporated, energy used for farm operations)
- Fodder(area, synthetic fertilizer used, crop residue and manure incorporated, energy used for farm operations)
- Horticulture-Vegetable module(crop name, synthetic fertilizer used, crop residue and manure incorporated, energy used for farm operations)
- Paddy-special input (rice ecosystem and area)
- Livestock-input (type of animal and its age)
- Sheep-goatry-piggery-poultry (number)
- Kitchen garden (crop area, synthetic fertilizer used, crop residue and manure incorporated, energy used for farm operations)
- Fertilizer-Forestry-border plantation (area, synthetic fertilizer used, crop residue and manure incorporated, energy used for farm operations)
- Pond (area and production)
- Agroforestry-sink with dbh (dbh, mean height and age of the tree)
- Agroforestry-sink without dbh (number)
- Energy used for household (source and quantity)
- Output enterprises (CO_2-e GHG emission by different components/enterprises and net GHG)

The user can verify the results by unhide the calculations sheets and can see the emission factors used in this study. The typical output sheet looks like;

Net GHG emission in IFS Model (CO_2.e in Kg)		
Carbon Sources	Enterprises	CO_2-e(kg)
1	Cropping System	
CS1	Rice-wheat-sesbania	323.83
CS2	Maize-wheat	352.78
CS3	Rice-Wheat-fallow	301.26
CS4	Rice-wheat-vegetables	301.26
CS5	Sugarcane-wheat	355.26
	Fodder crops	1.76
	Horticultural-Vegetable crops	5.12
	Livestock (Cattle and buffalo)	0.00
	Sheep	3480.96
	Goatry	3480.96
	Poultry	0.00
	Piggery	0.00
	Kichen garden	5.12
	Pond	0.00
	Border plantation and agroforestry	0.96
	Energy used for household	0.00
Carbon Sink	Agro-Forestry- SINK	67.80
	Total Biomass/compost added - SINK	4082.92
	Total SOURCE	8609.28
	Total SINK	4150.72
	GHG-IFS	4458.56

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Using this excel tool, we can make identification/quantification of GHG emission from different components of th suggest mitigation/adaptation strategies, which are climate resilient under any farming system/household.

References

SrinivasaRao, Ch., B. Venkateshwarlu, Y. Sudha Rani, A.K. Singh and S. Dixit. 2014. Soil carbon sequestration with i soil management in three Tribal villages in India. Ed. A.E. Hartemink and K. McSweeney.Soil Carbon Publications, USA. PP:239-248.

Pathak, H., A. Bhatia and N. Jain. 2014. Green house gas emission from Indian Agriculture: Trends, mitigation a needs. Published by IARI, New Delhi. PP:1-59.

Enhancement in productivity, nutrients use efficiency and economics of rice wheat cropping systems under different agro-ecosystems through farmer participatory approach

M. Shamim[1], N. Ravisankar[1], Subhash Babu[2], A.S.Panwar[1] and A. K. Prusty[1]

[1]ICAR-Indian Institute of Framing Systems Research, Modipuram - 250 110 (U.P)

[2]ICAR- Research Complex for NEH Region, Umiam (Meghalaya)

Abstract

On-farm experiments conducted at eight locations (Amritsar, Katni, Nainital, Samba, Pakur, Kanpur, Ambedkarnagar and Dindori) covering five agro climatic zones of six Indian state to (i) measured the response of NPK on grain yield of rice and wheat in rice wheat cropping system (RWCS) through Partial factor productivity (PFP) and Agronomic use efficiency (AE) and (ii) worked out the economic feasibility of different combination of NPK in rice and wheat. Seven fertilizer treatments: Control (0-0-0), N alone (N-0-0), N and P (N-P-0), N and K (N-0-K), NPK (N-P-K), NPK+Zn (N-P-K-Zn) and FFMP (Farmers Fertilizer Management Practice) were imposed at all locations. The levels of applied NPK and Zn used were as per the standard recommendation of the location. Application of N and P exerted the significant effect on grain yield of both the crops at all the location as grain yield of rice and wheat enhanced 104.6% and 97.04% over the control, respectively. System productivity of RWCS was also assessed in terms of rice grain equivalent yield (RGEY), Mg ha^{-1} Among the locations, Samba recorded the lowest productivity of RWCS with fertilizer treatments. In contrary, the highest productivity of RWCS with fertilizer treatments was recorded at Amritsar, except with NPK and NPK+Zn fertilization, where Katni superseded the Amritsar. About three times productivity gain in RWCS was recorded with combined application of NP over control across the locations. Balanced application of NPK proves its superiority over the single application of these macronutrients and recorded 244.59% enhancement in system productivity over control. PFP_n of nitrogen of N alone in rice varied across the location and ranged from19 kg grain kg^{-1} N at Pakur to 41kg grain kg^{-1} N at Amritsar. PFPn of N alone in wheat also ranged from 15.5 kg grain kg^{-1} of N at Ambedkarnagar to 28 kg grain kg^{-1} N at Amritsar. However, across the locations the mean value of PFPn of N alone was 29 kg grain kg^{-1}N in rice and 21 kg grain kg^{-1} N in wheat. PFPn increases when combined application of N and P sorted in both rice and wheat across the locations. Reasonable difference was noted in PFPp when P application combined with N and K in both the crops at all the locations. The combined application of NPK increases the PFP_k for applied K at all the location. Response of combined application of K along with NP when averaged over the location was 114% in rice and 93% in wheat over NK application. In our study, irrespective of fertilizer treatments the AE_n of applied N and AE_p of applied P along with N were greater in rice than in wheat across the location. The gross return and net return from applied K, P and Zn was positive for RWCS at all locations and mean net return for system was minimum (Rs. 29.5 x 10^3 ha^{-1}) for application of N alone and maximum (Rs. 8.65 x 10^3 ha^{-1}) for application of NPK + Zn compared to control. The mean marginal returns across the locations was in order of N alone>NK>FFM>NPK>NP>NPK+Zn.

Keywords: Rice-wheat cropping system, fertilizer N P K and Zn, Partial Factor Productivity, Agronomic Efficiency, Net Return

Introduction

Rice and wheat are the two central pillars of food security in India, accounted about 58% and 77% of the area and food grain production in the country, respectively (Singh, 2011). Majority of the population of India lives in the villages and the combined share of these two commodities accounted more than 90% of total cereal consumption in rural India. However, the sustainability of rice and wheat production is under stress due to continuous cultivation of rice-wheat cropping systems (RWCS) in the same field which leads to the soil nutrients mining (Dwivedi et al., 2003, Yadav 2003). Hence, productivity enhancement of RWCS should be a prime concern to feed the galloping population of India, which is predicted to increase up to 1.35 billion by 2025 (UNEP, 2008).The conventional farmer's practices to grow rice and wheat are highly unbalanced, capital and energy-intensive brings this life supporting production system on ventilator. RWCS is practices on diverse soil types and ecologies across the agro climatic zones of India. They includes shallow to deep loamy forest and podzolic brown soils with medium to high organic matter content under arid to sub-humid climates of the Western Himalayan region (WH), coarse to fine textured loamy soils under semiarid to sub humid climate of the Upper Gangetic Plains (UGP), sandy loam to clay soils under moist sub humid to dry sub humid climate of the Middle Gangetic Plains (MGP) and the Lower Gangetic Plain (LGP), sandy red to yellow soils under moist sub-humid to sub-humid climate of Eastern Plateau and Hills (EPH), and mixed red to black soils under dry sub-humid climate of Central Plateau and Hills (CPH). RWCS are grown under assured irrigation conditions with a number of irrigations ranging from 15 to 30 for rice and 3 to 6 for wheat in the TGP and UGP (Singh et al., 2013). However, the RWCS in MGP and LGP is moderately irrigated (Sharma, 2003) and under EPH and CPH rice is grown under rainfed situation and wheat is under restricted irrigation supply situation (1-3 irrigation). Fertilizer use in

RWCS is also highly variable across the agro climatic regions of India (Sharma, 2003). Both rice and wheat are heavy feeder and nutrients exhaustive crops (Hegde and Dwivedi, 1992).

Most of the nutrients management studies in RWCS were conducted in on station experiments in IGP. Information on the benefit of balance fertilization application on productivity of the RWCS based on multi locational trials on farmer's fields across the rice-wheat growing agro ecosystems in India is very scarce. We, therefore, conducted scientifically designed farmer-managed on farm experiments with rice and wheat in system mode, representing a range of contrasting locations in India, with following objectives to (i) determine the grain yield of rice and wheat with per kg application of NPK and micronutrients ; (ii) made a comparative assessment of yield of rice and wheat with combined and balance application of NPK and need based micronutrients application over farmers practices and N alone; (iii) profitability assessment and/or financial budgeting for NPK and micronutrients use.

Materials and Method

Data employed in this study were taken from on-farm experiments conducted with rice and wheat during 2016–2017 in the Indian districts of Samba in the Jammu & Kashmir state; Amritsar in Punjab state; Nainital in Uttarakhand state, Kanpur and Ambedkar Nagar in Uttar Pradesh state; Pakur in Jharkhand state; Katni and Dindori in Madhaya Pradesh state (Fig. 1) under the aegis of All India Coordinated Research Project (AICRP) on Integrated Farming Systems (IFS) on farm research (OFR) by ICAR-Indian Institute of Farming Systems Research, Modipuram, UP, India. Among the tested locations, Amritsar, Kanpur and Ambedkarnagar are located in the Indo Gangetic Plain (IGP) where the RWCS is a principal food production system. However, Samba, Nainital, Pakur, Katni and Dindori are located outside IGP where the RWCS is an emerging production system.

Results

Effect of NPK and Zn on system productivity of RWCS

System productivity of RWCS was assessed in term of rice grain equivalent yield (RGEY), Mg ha^{-1}. Among the locations, Samba recorded the lowest productivity of RWCS with fertilizer treatments. In contrary, the highest productivity of RWCS with fertilizer treatments was recorded at Amritsar, except with NPK and NPK+Zn fertilization, where Katni superseded the Amritsar. Application of N exerted the significant effect on RGEY and on average 106% productivity enhancement was recorded over the control across the location. However the yield improvement varied from 31.19% at Samba and 121.68% at Pakur over control. About three times productivity gain in RWCS was recorded with combined application of NP over control across the locations. Although, increase in system productivity ranged from 83.44% to 264.56% over the control. Average productivity enhancement due to NK fertilizers across the locations was 153.37%, however between the locations wide variations in productivity due to NK fertilizer was observed. Minimum improvement in system productivity due to N and K was observed at Kanpur (56.77%) and maximum at Pakur (159.55%) over control. Balance application of NPK proves its superiority over the single application of these macronutrients and recorded 244.59% enhancement in system productivity over control. However, the maximum (326%) and minimum (89%) improvement in RGEY due to NPK application was recorded at Pakur and Amritsar over control, respectively. Inclusion of Zn in fertilizers schedule again geared the productivity of RWCS at all the locations over control. Application of NPK and Zn recorded an average of 255% productivity enhancement of RWCS over control. However, response varied among the locations, the maximum response (328%) was recorded at Pakur and minimum (105%) at Amritsar over control (Fig. 1).

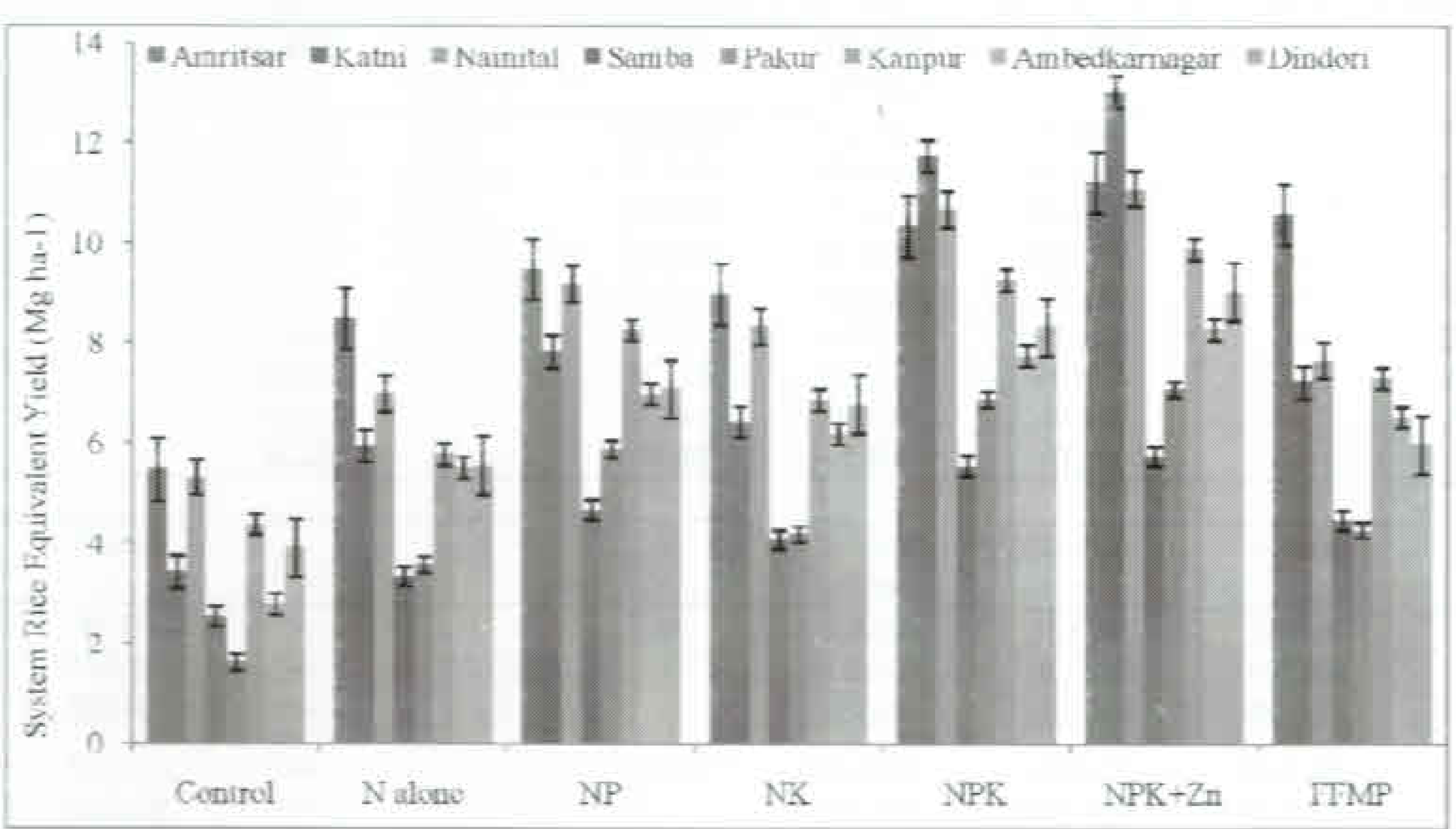


Fig.1: Effect of NPK and Zn on system rice equivalent yield (SREY) Mg ha^{-1} at farmer's field across the locations (Error bar showing LSD 5%)

Effect of NPK and Zn on AE of RWCS

In our study, irrespective of fertilizer treatments the AE_n of applied N is greater in rice than in wheat at all the location. AE_n of applied N alone when averaged over the locations was 9.8 kg grain increase kg^{-1} N in rice and 7.8 kg grain increase kg^{-1} N in wheat. However, AE_n of applied N alone in rice ranged from 5 kg grain increase kg N in Nainital to 16 kg grain increase kg of N in Amritsar. Similarly in wheat, AE_n of applied N alone ranged from 3 kg increase in grain kg^{-1} N in Kanpur to 12 kg grain increase kg^{-1} N in Samba. AE of applied N increases at all the locations in both the crops, when N was supplied along with P. The efficiency of N increases in the tune of 98.7% in rice and 108% in wheat over N alone. The AEn of applied N was also higher than the N alone. When AEn of applied N with K averaged across the locations was 14.4 kg grain increase kg^{-1} N in rice and 12.1 kg grain increase kg^{-1} N. AEn was further increases when N was applied in combination with P and K over N alone in both the crops. However, when response of N and P averaged over the location the increment was 167.9% in rice and 206.1% in wheat over N alone. Application of Zn along with balance application of NPK augments the AEn in both the crops in all the locations. When AEn averaged over the locations, Zn contributed 6.2% and 16.6% enhancement in AEn of rice and wheat over NPK, respectively.

AE_p of applied P along with N was higher in rice than in wheat at all the locations. In rice, AEp ranged from 26 kg increase in grain kg P in Dindori to 83 kg increase in grain kg P in Amritsar. However, in wheat AEp ranged from 24 kg increase in grain kg^{-1} P in Amritsar to54 kg grain^{-1} kg P in Samba. The AEp increases in both the crops when P fertilizer assigned with N and K in both the crops over NP application. In rice the AEp ranged from 8 kg increase in grain kg P with NK in Dindori to 98 kg grain kg P with NK in Amritsar. Similarly, in wheat AEp ranged from 7 kg grain kg P with NK in Amritsar to 64 kg grain kg P with NK in Katni. On an average across the locations, the applications of NPK along with Zn further augment the AEp of rice by 33.7% and by 46.6% of wheat over the NPK.

In general, AE of applied K (AE_k) was greater in rice than in wheat in all the fertilizers treatment across the locations. When AEk with N averaged over the locations, in rice it ranged between 6 kg grain kg K with N in Ambedkarnagar to 52 kg grain kg K with N in Pakur, whereas in wheat the AEk with N ranged from 8 kg grain kg K with N in Ambedkarnagar to 50 kg grain kg K with N in Pakur. Average of all the location indicates that the application of K with NP increases the AEk in the tune of 58.5% in rice and 55.5% in wheat over N and K application. Application of Zn along with NPK attributed positive effect on AEk in both the crops at all the locations. Across the locations 18.2% and 15.7% increment in AEk was noticed in rice and wheat, respectively over NPK application (Table 1)

Table 1 : Agronomic efficiency (AE) of N, P and K (kg increased grain kg^{-1} nutrient applied) of rice and wheat in RWCS across the locations in India

Location	Rice						Wheat					
AEn												
	N alone	With P	With K	With PK	With PK and Mn	FFM	N alone	With P	With K	With PK	With PK and Mn.	FFM
Amritsar	16±1.24	21±1.3	18±1.19	25±1.68	29±1.57	20±1.34	8±1.05	12±1.04	10±0.89	16±1.02	18±1.12	13±0.91
Katni	11±0.44	19±0.55	13±0.68	36±0.60	41±0.70	24±0.66	9±0.51	17±0.53	11±0.55	32±0.56	37±0.34	23±0.95
Nainital	5±0.49	14±0.60	11±0.59	19±0.52	10±0.55	11±1.08	6±0.35	11±0.54	9±0.51	16±0.67	18±0.66	12±1.06
Samba	14±0.70	34±0.60	25±0.87	47±1.30	50±1.17	47±2.48	12±2.48	36±1.70	26±1.43	52±1.88	55±1.84	47±2.51
Pakur	10±0.23	21±0.33	13±0.30	26±0.37	27±0.50	22±1.03	9±0.20	21±0.28	12±0.20	26±0.25	27±0.27	22±0.70
Kanpur	6±0.20	17±0.30	11±0.45	21±0.21	24±0.26	8±0.42	3±0.04	8±0.06	6±0.28	11±0.07	26±0.06	6±0.04
Ambedkarnagar	10±0.26	16±0.31	13±0.29	18±0.44	20±0.50	17±0.33	7±0.30	12±0.39	10±0.43	14±0.41	16±0.40	14±0.50
Dindori	6±0.72	13±0.94	11±0.91	17±0.69	21±1.20	6±0.69	8 ±0.46	13±0.81	13±0.96	20±0.86	21±0.72	8±0.84
Mean	**9.97**	**19.37**	**14.37**	**26.12**	**27.75**	**19.37**	**7.75**	**16.25**	**12.12**	**23.37**	**27.25**	**18.12**
AEp												
		With N		With NK	With NK and Zn	FFM		With N		With K	With NK and Zn	FFM
Amritsar	--	83±5.41	--	98±6.76	115±6.29	102±6.74	--	24±2.09	–	7±1.87	16±1.80	65±4.56
Katni	--	37±1.10	--	72±1.20	83±1.40	63±1.75	--	35±1.05	–	64±1.13	74±0.68	61±2.54
Nainital	--	33±1.51	--	47±1.30	49±1.37	19±1.80	--	26±1.35	–	41±1.69	45±1.66	29±2.66
Samba	--	50±0.89	--	20±1.51	75±1.75	93±4.96	--	54±2.56	–	24±1.72	82±2.75	95±5.02
Pakur	--	41±0.66	--	52±0.74	54±0.92	44±2.05	--	43±0.56	–	52±0.50	54±0.54	44±1.41
Kanpur	--	43±0.7	--	52±0.54	59±0.64	27±1.13	--	20±0.15	–	26±0.17	32±0.16	32±0.20
Ambedkarnagar	--	39±0.78	--	46±1.11	51±1.27	67±1.36	--	30±0.98	–	36±1.03	39±1.01	56±2.03
Dindori	--	26±1.88	--	8±1.45	42±2.41	36±4.54	--	26±1.63	–	12±1.44	42±1.45	50 ±5.50
Mean	--	**44.0**	--	**49.37**	**66.0**	**56.37**		**32.25**		**32.75**	**48**	**54**
AEk												
			With N	With NP	With NP and Zn				With N	With NP	With NP and Zn	
Amritsar	--	--	8±3.59	15±4.54	42±6.1	--	--	–	8±3.58	14±3.74	32±3.60	–
Katni	--	--	40±2.04	108±1.81	124±2.11	--	--	–	34±1.65	97±1.70	112±1.03	–
Nainital	--	--	27±1.48	47±1.30	49±1.37	--	--	–	34±1.90	62±2.53	68±2.50	–
Samba	--	--	30±1.04	57±1.56	60±1.40	--	--	–	31±1.72	62±2.25	65±2.20	–
Pakur	--	--	52±1.15	103±1.48	107±1.85	--	--	–	50±0.80	104±1.01	107±1.09	–
Kanpur	--	--	40±1.71	78±0.61	88±0.96	--	--	–	21±1.06	42±0.26	47±0.25	–
Ambedkarnagar	--	--	6±0.47	7±0.61	19±0.82	--	--	–	8±0.97	9±0.45	23±0.58	–
Dindori	--	--	32±2.74	51±2.10	62±3.62	--	--	–	38±2.90	57±2.60	63±2.18	–
Mean	--	--	29.37	58.25	68.87				28	55.87	64.62	

Economics of rice wheat cropping systems

Average cost of added fertilizer across the locations for RWCS was Rs 4.8 x10^3 ha-1 for N, Rs 5.3 x10^3 ha^{-1} for P, Rs 2.0 x10^3 ha^{-1} for K and Rs 3.0 x10^3 ha^{-1} for Zn. Added fertilizer input cost for systems was small compared to the value of the increased gross return i.e. Rs 34.9 x10^3 ha^{-1} for N, Rs 31.5 x10^3 ha^{-1} for P, Rs 15.0 x10^3 ha^{-1} for K and Rs10.3 x10^3 ha^{-1} for Zn from the same combinations of fertilizer application. This added cost, and the gross return from applied K, P and Zn was positive for system at all locations (Table 5). Added mean net return for RWCS was lowest (Rs 29.5 x 10^3 ha^{-1}) for application of N alone and highest (Rs 8.65 x 10^3 ha^{-1} for application of NPK + Zn compared to control. Among the locations, Katni registered highest net return (Rs 176.6x10^3 ha^{-1}) while Pakur registered the lowest net return (Rs 63.8x10^3 ha^{-1}). The increase in mean net returns from NPK + Zn over farmer practice was found to be 61%, across the locations while increase in the cost of cultivation due to balanced application was found to be only 11% (Table 3).

Table 2 : Effect of NPK and Zn on net returns and B: C ratio of rice-wheat cropping systems at farmer's field across the locations in India

Location	Net returns (INR x10^3)								B:C ratio							
	Control	N	NP	NK	NPK	NPK Zn	FFM	LSD (5%)	Control	N	NP	NK	NPK	NPK Zn	FFM	LSD (5%)
Amritsar	10.8	53.7	65.4	59.4	77.5	86.6	80.4	9.31	1.14	1.71	1.83	1.77	1.96	2.03	2.01	0.12
Katni	27.5	65.5	91.1	72.1	157.9	176.6	84.9	7.28	1.81	2.60	2.90	2.60	4.28	4.30	2.94	0.44
Nainital	25.8	49.2	84.5	71.4	108.8	111.4	56.8	7.48	1.33	1.56	1.91	1.79	2.12	2.09	1.61	0.09
Samba	26.4	49.6	77.2	64.7	99.6	102.5	73.9	6.30	1.61	2.09	2.55	2.38	2.93	2.93	2.54	0.13
Pakur	-17.1	12.5	47.1	21.7	62.7	63.8	25.8	2.40	0.61	1.25	1.87	1.43	2.13	2.11	1.53	0.04
Kanpur	23.7	43.5	79.0	59.6	95.3	104.8	80.8	2.49	1.44	1.76	2.25	2.02	2.49	2.60	2.28	0.05
Ambedkarnagar	11.6	50.7	70.0	60.0	81.3	87.1	64.4	3.52	1.32	2.26	2.55	2.44	2.74	2.76	2.48	0.08
Dindori	23.2	43.3	64.0	63.1	82.9	91.2	47.7	9.43	1.56	1.90	2.20	2.28	2.50	2.57	1.92	0.18
Mean	**16.5**	**46.0**	**72.3**	**59.0**	**95.8**	**103.0**	**64.3**		**1.35**	**1.89**	**2.26**	**2.09**	**2.64**	**2.67**	**2.16**	

References

Dwivedi, B.S., Shukla, A.K., Singh, V.K., Yadav, R.L., 2003. Improving nitrogen and phosphorus use efficiencies through inclusion of forage cowpea in rice-wheat systems in the Indo-Gangetic plains of India. Field Crops Research. 84, 399-418.

Hegde, D.M., Dwivedi, B.S., 1992. Nutrient management in rice–wheat cropping system in India. Fert. News. 37 (2), 27–41.

Sharma, S.K., 2003. Characterization and mapping of rice–wheat system: Its changes and constraints to system sustainability. Final Report for National Agricultural Technology Project, Irrigated Agro-Ecosystem Production Systems Research (PSR 4.1). Project Directorate for Cropping Systems Res., Modipuram, Meerut, India.

Singh V K., Dwivedi BS., Buresh RJ, Jat M. L., Majumdar K, Gangwar B, Govil V and Singh SK. 2013Potassium Fertilization in Rice–Wheat System across Northern India: Crop Performance and Soil Nutrients.Agronomy Journal 105 (2) 471-481

Singh, M., 2011. Yield gap and production constraints in rice-wheat system: scenario from eastern Uttar Pradesh. *Bangladesh J. Agril. Res.* 36(4), 623-632

UNEP (2008). Fresh Water under Threat, South Asia, Vulnerability Assessment of Freshwater Resources to Environmental Change.United Nations Environment Program.

Yadav, R.L., 2003. Assessing on-farm efficiency and economics of fertilizers N, P and K in rice-wheat system of India. Field Crops Res. 20 81(1), 39-51.

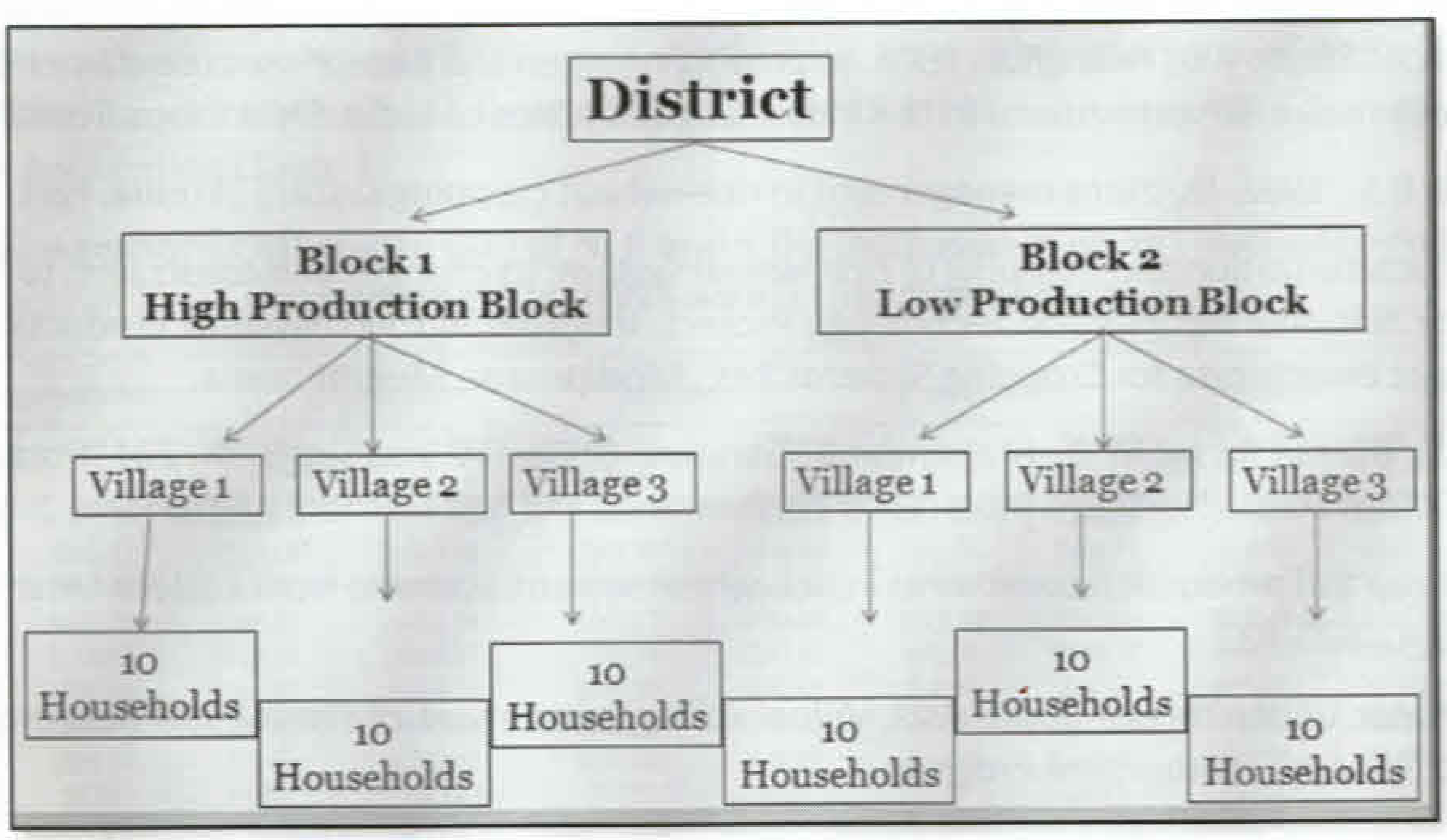
Statistical analysis methodology for farmer participatory farming systems research

Cini Varghese, Sukhanta Dash, Arpan Bhowmik, V.V.,Sonani, Manabendra Ray, Ravisankar,N. and. Panwar, A.S.

On-farm research experiments of AICRP on Integrated Farming Systems have been conducted in farmers participatory mode by On-Farm Research (OFR) centres located in various State Agricultural Universities. Under 'ON FARM RESEARCH' three different experiments have been planned, viz., OFR 1 (Response of nutrients (N,P and K) on farmer's field), OFR 2 (Diversification of existing farming systems under marginal household conditions) and OFR 3 (On-Farm evaluation of farming system modules for improving profitability and livelihood of small and marginal farmers).

On-farm research experiments of AICRP on Integrated Farming Systems were conducted in farmers participatory mode by On-Farm Research (OFR) centres located in various State Agricultural Universities. Common methodology used for selection of farmers, systematic characterization, farm interventions and studying the changes is briefly given below.

Selection of district and farmers: Representative district in a NARP zone was selected for on-farm study. In each district, available blocks were categorized in to "high productive" and "low productive" based on the productivity of major crops and livestock. The blocks which were having less productivity than district or state productivity were categorized as low productive and the blocks which were having high productivity than district or state productivity were categorized as high productive. One block from each category was selected using random sampling for on-farm experimentation. In each block, three villages were identified randomly and in each village 10 farm households were identified for various on-farm research experiments of AICRP on Integrated Farming Systems. Thus, in each district 60 farm households (2 blocks X 3 villages X 10 farm households) were selected as per statistical requirement.



Yearly data analysis

Online data entry and analysis is carried out (yearly basis) for OFR 1. Data submitted online by various centres are monitored on a regular basis. Errors in data entry are detected and reported through mail, whenever required.Data analysis is carried out online by respective centres. After completion of data entry and analysis by the centres, consolidated tables of results of OFR 1 are prepared. Another table containing distribution of CVs is also prepared.

OFR 2 experiment was designed with innovative approach in which changes are compulsorily made in all components of farming systems by way of introducing new crops, livestock species and product or processing techniques in marginal households aiming to increase the income of the family from a less land resource.Under OFR 2 experiments alone, from each centre, every year, data is received in 16 excel worksheets, broadly grouped into 9 classes *viz*., PART A (Identification, Farming history, Water), PART B (Benchmark), PART C (Systems, Interventions, Results), PART D (Species, Interventions, Results), PART E (Product Results), PART F (Trainings, Results), PART G (Natural resources improvement), PART H (Abnormal weather), PART I (ITK). Also, data is received with respect to existing and diversified farming conditions from the same 24 households for each of the centres. This data is processed for bringing out reduced variables of interest, *viz*., production, marketable surplus, cost, return and profit, at ICAR-IASRI.

Then the processed data is analyzed as given below :

- **One way ANOVA** is carried out to compare the performance of various farming systems within each centre.
- **Wilcoxon signed-rank test** is used to compare between existing vs. diversified systems, within each farming system, as number of households belonging to each farming system are less.
- No test is carried out for those farming systems having less than 3 households.
- Within each centre, for overall existing vs. diversified farming system comparison, **paired t-test** is used.

An illustration of the analysis procedure is given below :

Name of the centre: Panchmahal

No. of Farming Systems (FS) : 6

- FC+D: Field crop+Dairy
- FC+D+G: Field crop+Dairy+Goat
- FC+D+G+P: Field crop+Dairy+Goat+Pigs
- FC+D+P: Field crop+Dairy+Pigs
- FC+G: Field crop+Goat
- FC+G+P: Field crop+Goat+Pigs

Farming System-wise No. of Households:

- FC+D: 7 farmers
- FC+D+G: 7 Farmers
- FC+D+G+P:7 Farmers
- FC+D+P: 1 Farmer
- FC+G: 1 Farmer
- FC+G+P: 1 Farmer

To analyze the data for this centre, FS: 3,4 and 5 have not been considered as there is only one farmer for each of these three FS. The remaining 21 farmers have been considered for analysis. Two types of statistical analysis (ANOVA and Paired t-test) have been performed on the data. The details of which are as follows:

ANOVA

One way analyses of variance have been performed separately for existing and diversified data to identify statistically significant FS. The analysis has been performed using Statistical Analysis System (SAS 9.3). The code along with the ANOVA table for both existing and diversified data has been given as follows:

SAS code for analyzing existing data

```
DATA panchmahal_exixting_fs;
INPUT fs Production Surplus Cost Return Profit;
CARDS;
1    14957    12873    112000    67480    42480
1    6417     4790     46100     30900    11380
1    6070     4425     51600     21240    1500
1    11333    9074     97900     38100    10990
1    9055     6643     79000     29660    720
1    6379     3923     52300     24250    -5225
1    5621     4203     49450     18000    990
```

2	7532	4898	56600	33780	2180
2	9738	7443	71900	44960	17420
2	8797	6731	81200	24360	-430
2	9743	7322	70800	46113	17063
2	10000	7237	76400	43600	10440
2	11092	8617	89350	43750	14050
2	9519	6990	66000	48225	17875
3	11300	8732	72500	63100	32280
3	11725	9428	89600	51100	23530
3	7102	4804	55950	29270	1700
3	10483	7340	75500	50300	12580
3	19680	17226	115350	120810	91360
3	6813	4742	56800	24950	100
3	10146	8440	67700	54050	33575

```
;
procglm;
class fs;
model Production Surplus Cost Return Profit =fs /ss3;
lsmeans fs /pdiffstderrlines;
run;
```

Similar analysis was carried out for diversified data.

Paired t-Test

To make comparison among existing and diversified data within a FS, paired t-test has been performed. The output of paired t-test helped in identifying whether diversification has brought statistically significant changes within a FS when compared with existing data of the same FS. The analyses have been performed using Statistical Package for Social Sciences (SPSS). The steps involved are:

Enter the data in **DATA View**———Enter the name and type of variable in **Variable view**————click **Analyze**—————-**Compare means**——————**Paired-Samples T Test**—————enter pair of variables to be compared in **Paired Variables**———-**OK**.

To identify whether diversification have significant impact for Panchmahal centre as a whole, paired t-test has been performed by considering all the six farming systems consisting of 24 farmers.

Table-1 highlights the summary table for Panchmahal centre. Likewise data analysis has been carried out for all other centres.

Table-1: Summary table based on OFR-2 for Panchmahal centre.

Farming System	Area (ha)	No. of Households	Existing System					Improved (Diversified System)					P value Significance - Existing vs improved				
			Production (kg)	Marketable Surplus (kg)	Cost (Rs)	Return (Rs)	Profit (Rs)	Production (kg)	Marketable Surplus (kg)	Cost (Rs)	Return (Rs)	Profit (Rs)	Production (kg)	Marketable Surplus (kg)	Cost (Rs)	Return	Profit (Rs)
FC+D	6.34	7	8547.43 (1227.93)	6561.57 (1194.63)	69764.29 (7727.21)	32804.30 (8015.85)	8976.43 (7795.21)	12906.71 (1894.95)	11115.00 (1830.41)	82572.86 (7575.56)	98118.00 (21500.42)	73036.57 (20690.95)	<0.001**	<0.001**	0.002**	<0.001**	<0.001**
FC+D +G	4.86	7	9488.71 (1227.93)	7034.00 (1194.63)	73178.57 (7727.21)	40684.00 (8015.85)	11228.30 (7795.21)	16421.86 (1894.95)	14390.43 (1830.41)	89764.29 (7575.56)	140143.29 (21500.42)	111701.14 (20690.95)	0.032*	0.021*	0.005**	0.021**	0.016*
FC+D +G +P	7.46	7	11035.48 (1227.93)	8673.04 (1194.63)	76200.00 (7727.21)	56225.71 (8015.85)	27875.00 (7795.21)	15264.71 (1894.95)	12748.43 (1830.41)	90500.00 (7575.56)	123208.14 (21500.42)	87978.43 (20690.95)	0.001**	0.004**	0.007**	<0.001***	<0.001**
FC+D +P	0.84	1	4633	3183	35400	20200	2800	11766	10423	60450	104280	85465	-	-	-	-	-
FC+G	0.54	1	3233	2675	16900	21900	15200	5962	5023	33200	50270	37120	-	-	-	-	-
FC+G +P	0.84	1	8149	6682	40200	57592	39988	13535	11090	60060	129425	95201	-	-	-	-	-
Overall FS													<0.001**	<0.001**	<0.001**	<0.001**	<0.001**
CD [P = 0.05]			3648.4	3549.4	22959	23816	23161	5630.2	5438.4	22508	63881	61476					

Note: ** significant at 1% level of significance

* significant at 5% level of significance

Statistical method used for OFR 2 was also used in OFR 3. An illustration of analysis procedure is given below:

Name of the centre: Kakdwip

No. of Farming Systems (FS): 3

[FC: Field crop,

FC+D: Field crop+Dairy,

FC+D+P: Field crop+Dairy +Pigs,]

Farming System-wise No. of Households

1. FC: 3 farmers
2. FC+D: 8 Farmers
3. FC+D+P:1 Farmers

To analyze the data for this centre, for different FS, two types of statistical analyses (ANOVA and Paired t-test) were performed on the data. The details of which are as follows:

ANOVA

One way analyses of variance were performed separately for existing and diversified data to identify statistically significant FS. The analyses have been performed using SAS 9.4. One may use SAS 9.3 for OFR-2 &3 both. The code along with the ANOVA table for both existing and diversified data is given as follows:

SAS Code for analyzing Existing Farming system:

```
title"OFR3 of Kakdwip";
Data existing;
input   FS    Production   MS    cost    Profit;
cards;
1    13437    11067    54802    65923
1    2106     591      15586    5059
1    4091     2544     29222    7209
2    5718     4449     40256    11208
2    9261     3395     56708    26639
2    7932     5961     41586    29801
2    31854    27856    48976    239790
2    3375     801      24328    5637
2    5591     2532     46217    3833
2    4935     4021     31430    20110
2    5125     2668     25764    20213
3    5753     4197     49280    13010
;
odsrtffile="Kakdwip Existing.rtf";
procglmdata=existing;
class FS;
Model Production    MS    cost    Profit=FS;
lsmeans FS/pdiffstderrlines;
run;
odsrtfclose;
```

In a similar manner one can analyze the processed data pertaining to diversified farming system.

Paired t-Test

To make comparison among existing and diversified data within a FS, paired t-test was performed. The output of paired t-test helped in identifying whether diversification brought statistically significant changes within a FS when compared with existing data of the same FS. The analyses have been performed using SAS 9.4. SAS 9.3 may be used for all situations. The results based on paired t-tests for different FS (farming systems with only one observation, have not been considered) have been summarized as follows:

T-test SAS code

```
Title"Pairt test for Kakdwipcenter";
odsrtffile="paired.rtf";
data Pairt1;
input PDE     PDD   ME    MD    CE    CD    PFE    PFD;
cards;
13437   19533   11067   16820   54802   128331   65923   105201
2106    6044    591     3695    15586   42618    5059    31631
4091    10389   2544    7812    29222   76962    7209    52121
;
procttest;
paired PDE*PDD    ME*MD    CE*CD PFE*PFD;
run;
data Pairt2;
input PDE     PDD   ME    MD    CE    CD    PFE    PFD;
cards;
5718    5947    4449    3852    40256   50062    11208    21298
5261    12321   3395    7625    56708   101366   26639    46480
7932    11003   5961    9070    41586   74776    29801    56614
31854   15603   27856   11932   48976   84334    239790   102905
3375    4137    801     1400    24328   37959    5637     16589
5591    7571    2532    5323    46217   70569    3833     26773
4935    8450    4021    5869    31430   71798    20110    33209
5125    10751   2668    7580    25764   54761    20213    76408
;
procttest;
paired PDE*PDD    ME*MD    CE*CD PFE*PFD;
run;
dataPairtall;
input PDE     PDD   ME    MD    CE    CD    PFE    PFD;
cards;
13437   19533   11067   16820   54802   128331   65923   105201
2106    6044    591     3695    15586   42618    5059    31631
4091    10389   2544    7812    29222   76962    7209    52121
```

```
5718   5947    4449   3852    40256   50062    11208   21298
9261   12321   3395   7625    56708   101366   26639   46480
7932   11003   5961   9070    41586   74776    29801   56614
31854  15603   27856  11932   48976   84334    239790  102905
3375   4137    801    1400    24328   37959    5637    16589
5591   7571    2532   5323    46217   70569    3833    26773
4935   8450    4021   5869    31430   71798    20110   33209
5125   10751   2668   7580    25764   54761    20213   76408
5753   8735    4197   6757    49280   63981    13010   40836
;
procttest;
paired PDE*PDD     ME*MD      CE*CD PFE*PFD;
run;
odsrtfclose;
```

The results of t-test are given in Table 2. Similar data analysis has been carried out for all the centres.

Table 2: Summary table based on OFR-3 for Kakdwip centre

Centre : Kakdwip NARP Zone :														
Farming System	Area (ha)	No. of House holds	Existing System				Improved (Diversified System)				P value Significance - Existing vs Improved			
			Production (kg)	Marketable Surplus (kg)	Cost (Rs)	Profit (Rs)	Production (kg)	Marketable Surplus (kg)	Cost (Rs)	Profit (Rs)	Production (kg)	Marketable Surplus (kg)	Cost (Rs)	Profit (Rs)
Crop (3)		3	6545 (5026)	4734 (4719)	33203 (7964)	26063 (41506)	11988 (2653)	9442 (2460)	82637 (15596)	62984 (18407)	**0.019***	**0.029***	0.067	**0.021***
Crop+Dairy (8)		8	9223 (3077)	6460 (2889)	39408 (11661)	44653 (25417)	9472 (1624)	6581 (1506)	68203 (9550)	47534 (11272)	0.921	0.961	**0.0003***	0.893
Crop+Dairy + Poultry (1)		1	5753 (8704)	4197 (8173)	49280 (13794)	13010 (71891)	8735 (4595)	6757 (4261)	63981 (27014)	40836 (31882)	-	-	-	-
Overall FS											0.245	0.526	0.126	0.159
CD [P = 0.05]	FS1 Vs FS2		8334	7826	13207	68831	4400	4080	25864	30526				
CD [P = 0.05]	FS1 Vs FS3		14214	13348	22526	117399	7504	6958	44114	52064				
CD [P = 0.05]	FS2 Vs FS3		13057	12261	20692	107838	6893	6392	40521	47824				

* significant at 5% level of significance

Nonparametric Tests

Non-parametric tests *viz.*, sign test and Wilcoxon signed rank test have been used to compare the farming systems under existing and diversified conditions, wherever the number of households are not sufficient to carry out a parametric paired t-test. Analysis was carried out in SPSS. Steps involved are as follows:

Analyze———————**Nonparametric Tests**———————**Legacy Dialogs**——————**2 Related Samples**———————enter pair of variables to be compared in **Test Pairs**————————Select **Wilcoxon and Sign** available in **Test type**————————**OK.**

Application of quantitative analysis tools in farming systems

Prusty, A. K[1]., Ravisankar, N[1]., Panwar, A. S[1]., Ghasal,P. C[1]., TetarwalJ. P[2].,JatM. L[3]., RidauraS. L[4]., Jeroen C.J. Groot[5],Roos de Adelhart Toorop[5] and Jelle van den Akker[5]

[1]ICAR-Indian Institute of Farming Systems Research, Modipuram

[2]AgriculturalUniversity, Kota, Rajasthan

[3] CIMMYT, India

[4] CIMMYT, Mexico

[5] Farming Systems Ecology, Wageningen University & Research, The Netherlands

Introduction

In India, agriculture and allied sector provides livelihood support to about two thirds of the population. The western plain zone of Uttar Pradesh is considered to be the major contributor to the food bowl of the country next to Punjab. Mixed Crop-Livestock or mixed Crop-Livestock-Horticulture is the dominant farming systems of the region. Rapid fragmentation of land holdings, deteriorating ground water table, low resource recycling and lack of crop diversification are, among others, of major concern in the way of sustainable agricultural development. At this critical juncture, well managed integrated farming system through judicious mix of agricultural enterprises like dairy, poultry, piggery, fishery, sericulture etc. suited to the given agro-climatic conditions and socio-economic status of the farmers would bring prosperity in the farming. In well-managed mixed farming systems with limited external inputs, balanced rotations and appropriate stocking rate, nutrient recycling and use of organic matter to the soil can be improved to avoid soil mining and pollution and enrich the organic matter content in the soil structure. (Watson et al., 2005; Petersen et al., 2007; Russelle et al., 2007; Hendrickson et al., 2008). This holds large promises for the development of sustainable agro-ecosystems (Wilkins, 2008; Hilimire, 2011). In this situation, optimization techniques are useful for resource allocation and designing IFS on scientific basis. Major developments are taking place especially in the implementation of decision-making in the models.Different modelling techniques can deal with different aspects related to the consequences of global change for farm households: combining different techniques into a single modelling framework seems therefore a logical choice and is actually taking place in many new farm-level modelling studies. A variety of quantitative and qualitative design approaches have been developed to support the analysis of current farming systems and the design and evaluation of alternatives.Groot et al. (2012) described about Farm DESIGN tool, which supports evaluation and re-design of mixed farming systems in tactical planning processes and supported the analysis of problems in the original farm configuration and indicated avenues for adjustments of the configuration to improve farm performance in terms of various objectives. Relatively small modifications in the farm configuration through optimization may result in considerable improvement of farm performance. For precise and effective technological interventions, in-depth characterization of the heterogeneity of the farming systems is of practical interest. Farm typology study recognizes that farmers are not a monolithic group and face differential constraints in their farming decisions depending on the resources available to them and their lifestyle (Alvarez et al., 2018).Developing a typology constitutes an essential step in any realistic evaluation of constraints and opportunities that farmers face and helps forwarding appropriate technological solutions. Moreover, typology studies are of paramount importance for understanding the factors that explain the adoption and/or rejection of new technologies. In this context a whole farm model approach combining quantitative analysis tools viz. typology construction for farm types and optimizing the farm performance based on multiple objectives and constraints using farm design for IFS prototypes was applied for sustainable intensification of science-based farming systems.

Materials and methods

Having a good understanding of farming system diversity within the regions surrounding the IFS prototypes has been essential for assessing the impact of prototype cropping patterns. The methodology employed was a combination of quantitative analysis and participatory research.Two multivariate statistical techniques were employed sequentially for generating a typology of the surveyed farm households: Principal Component Analysis (PCA) to reduce the dataset into non-correlated components followed by Hierarchical Cluster Analysis (CA) for partitioning the PCA output into clusters. The approach has been used in many studies to categorize farming systems.R software with package ade4 was used to perform a PCA to identify primary patterns and variability. PCA variables for further analysis were selected and relevant principle components were chosen using a screen test and bar plot of the eigenvalues per principal component. The selection of the number of PCs was based on explained variability (eigenvalue greater than 1). Hierarchical clustering was applied on the PCA results using the Ward method and the dendrogram constructed served both as a visualization and a partitioning tool. The optimal number of clusters for k-mean clustering was defined using the Elbow method. To identify significant differences in PCA variables and other variables a Kruskal-Wallis test was performed. Variables used for construction of typology is presented in Table 1.

Table 1 : Variables used for the construction of household typology

Code	Variable	Unit	PCA variable
Totlandmanaged	sum of rented and owned land	ha	X
Rentland	rented land	ha	
Cultkharif	land cultivated in kharif	%	
Cultrabi	land cultivated in rabi	%	
land sugarcane	land under sugarcane	%	X
land jawar	land under sorghum	%	X
land paddy	land under rice	%	
land wheat	land under wheat	%	X
Jawarsold	sorghum sold	%	
Wheatsold	wheat sold	%	
Harvestedcropssold	harvested crops sold	%	
Cropdiversity	sum of crops	Crop number/farm/year	
TLUdensity	tropical livestock unit density	TLU/ha	
TLUnumber	sum of tropical livestock units	number of TLUs	X
Animalproductsold	animal products sold	%	
Totaladultsworkingfields	total workforce involved in farming	number of people	
Totaladults	adults living on farm	number of people	
children	children living on farm	number of people	
Totalhhmembers	sum of adults and children living on farm	number of people	X
HH membersperha	HH members per hectare	HH members/ha	

The whole farm quantitative analysis tool farm design model (Groot et al., 2012) was used to analyse the performance of the IFS prototypes developed at ICAR-Indian Institute of Farming Systems Research, Modipuram, Meerut (0.68 ha) having mixed crop livestock, horti-pasture and agri-horti system and local farms based on defined objectives and constraints.

Results and discussions

A typology was constructed to understand the diversity of farming systems in the vicinity of Modipuram. From the initial 20 variables six final PCA variables were selected (Table 1). These variables were related to land use (area, cropping practice and herd size) and household (total household members). Analysis was done with two PC's explaining ~55% of the variability. Hierarchical clustering analysis indicated three types with 47, 60 and 40 farms respectively.Farms were clustered into three groups with similar farm characteristics in Modipuramviz. Type 1: Marginal, poorly-endowed farmers. (MPF), Type 2: Marginal, mechanised farmers. (MME), Type 3: Medium, well-endowed farmers. (MWF) based in terms of land use, household size, livestock numbers etc. Mean outcomes per PC variable for each type of farmers is presented in Table 2.

Table 2 : Mean outcomes per PC-variable for each of the types

Type	No. of Farm hosueholds nos. (%)	Totlandmanaged (ha)	Landsugarcane (%)	Landjawar (%)	Landwheat (%)	TLUnumber (TLU nos.)	Totalhhmembers (nos.)
1	47 (31.98)	0.6	96.1	3.6	48.9	1.5	5.4
2	60 (40.81)	0.8	72.3	22.7	44.5	2.8	7.9
3	40 (27.21)	2.7	86.6	9.4	23.5	3.8	9.7

The prototype farm (0.68 ha) was modelled using a whole-farm modelling approach, farm design that consists of describing the current farm and explaining the current farm situation followed by exploring alternative options. Parameterization of data involved both primary (e.g. yield, price, costs, destination of products) and secondary published sources. performance of the prototype farm was compared with the representative farm types obtained from typology construction using farm design. Although the prototype is smaller the profit of the farm is higher as compared to that of type 1 and 3 of the study farms. When looking at the profit per ha, it can be observed it ranks second behind the type 2-study farm. Interestingly the study farm used to represent type 2 allocates 13% of the land to banana accounting for a large part of the profit bringing the land used for cash crops to 77.4%. This type stands out regarding profit per ha. However, the net system yield is low compared to the prototype farm. For both the local farming systems and the prototype farming system the gross margin of cropping activities was higher than that of animal activities (Milk sales). For type 1 farm the gross margin from animal production contributes 55% to the total operating profit. This is the only case where animal production contributes a more significant share to the total than crop production. For type 2 crop production is 63% of the total income and this is 58% for type 3. Best cropping systems were identified from the IFS prototype based on feedback from representative farmers and was explored for its performance by integrating these cropping systems of the farm types using farm design for its upscaling and adoption in the farmers field. Applicationof farm design provided improved understanding of the performance of the prototype IFS and showed a clear trade-off between organic matter balance and operating profit exists. Exploration of alternative farm configuration moved towards higher economic profit and reduced fertilizer use suggesting scope for further improvement.

Conclusion

Application of farm design provided improved understanding of the performance of the prototype IFS and showed that it satisfied the nutritional demand of a 5-member family in terms of dietary energy, protein, carbohydrate and fibre, a clear trade-off between organic matter balance and operating profit exists. Exploration of alternative farm configuration moved towards higher economic profit and reduced fertilizer use suggesting scope for further improvement.

The modelling involving multiple objectives is useful in farming systems research and extension and will more accurately evaluate the extent of adoption of a new technology within a farm system by more closely matching the farmer's decision-making priorities. Farm design exploration provides a holistic approach supporting decision making in moving from prototype design to the farmer's field. This supports closing the think-do-gap and could be used to decide what patterns are most interesting for future on-farm research or adoption. A combinational approach of quantitative analysis tools such as typology construction and Farm DESIGN exploration and participatory researchtogether with local experts, could prove beneficial in redesigning of farming systems.

References

Alvarez, S. *et. al.*, 2018, Capturing farm diversity with hypothesis-based typologies: An innovative methodological framework for farming system typology development. *PLoS ONE*, **13**(5):1–24.

Groot, J.C. J and Rossing, W.A. H., 2011, Model-aided learning for adaptive management of natural resources: an evolutionary design perspective.*Methods in Ecology and Evolution*,2:643–650.

Hendrickson, J.R., Liebig, M. A. and Sassenrath, G.F., 2008, Environment and integrated agricultural systems. *Renew. Agr. Food Syst*. 23:304–313.

Hilimire, K., 2011. Integrated crop/livestock agriculture in the United States: a review*J. Sustain. Agric*. 35:376–393.

Russelle, M.P., Entz, M.H. and Franzluebbers, A. J., 2007, Reconsidering integrated crop livestock systems in North America. *Agron J*. 99:325–334.

Watson, C.A., Öborn, I., Eriksen, J. and Edwards, A. C., 2005, Perspectives on nutrient management in mixed farming systems. *Soil Use Manage*. 21:132–140.

Wilkins, R.J., 2008, Eco-efficient approaches to land management: a case for increased integration of crop and animal production systems. *Philos. Trans. Roy. Soc. B – Biol. Sci.* 363:517–525.

On-farm farming systems research: over view including statistical analysis methodology

N. Ravisankar

Principal Scientist, ICAR-Indian Institute of Farming Systems Research
Modipuram, Meerut-250 110, Uttar Pradesh

Production performance of small holder farms in India is always better due to the strong advantage in higher land productivity compared to larger holdings. However, their per capita income is very low. As per the 59th round of situation assessment survey (Report No. 497) by National Sample Survey Organization, the output value of small holders (up to 2 ha) on per ha basis is Rs 20,291 which is 67 % higher than the output value of large holders (>4ha). However, on per capita basis, small holders have only Rs 2376 which is 79 % lesser than large holders. It is mainly due to the wider land-manpower ratio. Profitable employment opportunities within the farms need to be created to improve the per capita income of small holders. Integrated farming systems with intentional integration of components for profitability and employment can improve the livelihood of people involved in small holder agriculture.

Systematic characterization: Characterization of existing farming system in the farm household is essential for understanding the constraints and temporal dynamics of the system. Hence, theidentified farm households were geo-referenced by collecting the latitude, longitude and altitude of each household and their fields. If fields are spread in more than one location, co-ordinates of each location were also collected. Benchmark data of general information which includes holding size, distance to market etc, family details including education level, vegetarian/non-vegetarian, primary occupation, details of farm land, household assets, farm machinery and equipment's, crop wise input used, production, family consumption, market sale and income were collected from each household using pre-designed proforma. The data on livestock components, production, income etc were also collected besides household expenditure pattern on various activities. Extent of participation of women in decision making of farming systems and perceived constraints in each component are also collected.

Analysis of benchmark data of 732 marginal households across the 30 NARP zones indicates existence of 38 types of farming systems. Out of this, 47 % of households have the integration of crop + dairy, 11 % have crop + dairy + goat, 9 % households have crop + dairy + poultry systems and 6 % households have only crop component. In terms of number of components integrated by marginal households, 52 % households are practicing only two components while 7 % have only one component. Remaining 41 % households have components ranging from 3 to 5. Scope exists in the 59 % of marginal households for intentional integration of allied enterprises for improving the per capita income. Though, the mean holding and family size of marginal households having up to 2 components and more than 2 components remains almost same (0.82 ha with 5 no's in ≤2 component category and 0.84 ha with 5 no's in > 2 component category), the mean income level is much higher (Rs 1.61 lakhs) in the farms having more than 2 components (e.g. crop+dairy+goat; crop+dairy+goat+poultry; crop+dairy+goat+poultry+fish etc.) than with farms having 2 or less components (Rs 0.57 lakhs only in crop alone, dairy alone, crop + dairy, crop + goat etc.). Diversification of one and two component systems (crop alone, dairy alone, crop+dairy, crop+pig, crop+poultry, crop+fisheries, crop+horticulture, crop+goat, dairy+goat) in the 59 % marginal household is essential to augment the per capita income.

Farming System interventions: Farming system interventions were planned with identification of problem, constraints and available low cost options to address the constraints. Perception of farm family on interventions and farming system components were also taken while finalizing the critical need based interventions. Critical inputs such as seeds of improved varieties, nutrients (If K is not applied by farmer, then only Muriate of Potash is given as input), diversification of crops and cropping systems, improved management practices etc were done under crop or cropping systems diversification module. Low cost interventions such as timely Artificial insemination, mineral mixture in feed, round the year fodder supply, deworming etc were done for livestock components besides farmer perception based livestock diversification with poultry, pig, goat, and sheep in marginal households for enhancing the income. The product diversification or processing was done in two ways viz., changing the physical state of product or through the change in process of cultivation. The product diversification module consisted of making of flour from grains, oil from oilseeds, value addition through selected ingredients, organic kitchen garden etc. Capacity building of farm family was kept as separate module to train the farm family where in new crops, livestock species and other activities are introduced as a part of diversification approach in marginal households. Inputs of interventions were given only once to farmers and the total amount invested for each farm household was restricted up to Rs 10,000/ year only (varies with location to location and type of farming systems). The interventions were carried out as on-farm experimentsas mentioned below.

Diversification of existing farming systems under marginal household conditions: The experiment was designed with innovative approach in which changes are compulsorily made in all components of farming systems by way of introducing new crops, livestock species and product or processing techniques in marginal households aiming to increase the income of the family from a less land resource. The major strength of marginal household is having sufficient manpower (due to family size) for farm operations. Four modules comprising of **Cropping system diversification** (most efficient cropping systems was synthesized keeping in view of the farmers resources, perception, willingness, market and requirement other components in the system), **Livestock diversification** [(Mineral mixture + deworming+ round the year fodder supply for existing components) + introduction of location specific low cost livestock components viz., BYP, duckery, piggery, goat etc)], **Product diversification** (Preparation of mineral mixture/value addition of market surplus products/Kitchen /roof gardening) and **Capacity building** (Training of farm households on farming systems including post harvest and value addition and assessing its impact) were implemented in 4 farm households in each village.

On-Farm evaluation of farming system modules for improving profitability and livelihood of small and marginal farmers: The experiment was designed with holistic approach where in improvement of productivity of existing components of the farming system was concentrated by appropriate interventions besides farmer opinion based introduction of new components. Four modules comprising of **crop** (Low cost interventions in existing cropping systems based constraint analysis), **Livestock** (Low cost interventions in existing livestock components based on constraint analysis), **On farm processing & value addition** (On farm agro processing and value addition for marketable surplus) and **Optional** (Introduction of additional components based on households perception) were implemented in 2 farm households in each village comprising of 1 marginal and small household.

Studying the changes: Changesin productivity, production, marketable surplus, income, expenditure pattern of farm family, soil health etc were observed by collecting thedata on all aspects of household and farming systems over the years in pre-designed proforma and the same was compared with the benchmark data collected in the first year. At some locations, the numbers of other farmers who have adopted the interventions were also collected. Some of the successful interventions of OFR experiments are documented.

Data analysis methodology: Based on the benchmark data, farming systems practiced by the households were identified and grouped in to different farming system categories such as field crops+ dairy, field crops + dairy+ goat *etc*. Five parameters namely production (on equivalent basis of base pre-dominant crop), marketable surplus (calculated by deducting the family consumption for food, feed, seed *etc* from the total production), cost (total cost of the system including all components and diversification), returns (calculated by deducting the total cost from gross returns of the system) and profit (calculated by deducting the cost of the system from the gross income obtained from marketable surplus) were used for comparison of existing with improved (diversified) system and also different farming systems. Farming system with more than one household was subjected to ANOVA and paired t-test analysis. Paired t-test has been carried out for comparing existing and diversified systems with respect to production, marketable surplus, cost, return and profit. Similarly, one-way ANOVA has been carried out to identify the best farming system with respect to production, marketable surplus, cost, return and profit for the district.

The results of on-farm participatory intentional integration of components in the existing farming system indicates improvement in income (3-4 times) and nutritional intake (in terms of calories). The approaches of alternative efficient diversified cropping/livestock systems and small scale secondary agriculture can play a vital role in improving the per capita income of the marginal households. Market driven and family perceptive diversification is essential to ensure the round the year income and employment which will enhance the livelihood status of small holders.

Farming systems typology for Indo-Gangetic Plains of India- an overview

Jashanjot Kaur[1], Prusty, A. K[2]., Ravisankar, N[2]., Panwar, A. S[2]., Chaterjee, S[3]., Pasha, M. L[4]., Roos de Adelhart Toorop[5] ,Santiago López-Ridaura[6]and Jat, M. L[7].

[1] AICRP-IFS ECF Center, Punjab Agricultural University, Patiala, India
[2]ICAR-Indian Institute of Farming Systems Research (ICAR-IIFSR), Modipuram, India
[3]Department of Agricultural Economics, Bidhan Chandra Krishi Viswavidyalaya, Kalyani, Nadia-741 235, WB, India; soumitra.soum123123@gmail.com
[4]College of Agriculture, PJTSAU, Rajendranagar, Hyderabad-500 030, Telangana, India; lateef_pasha@rediffmail.com
5Farming Systems Ecology, Wageningen University & Research, The Netherlands
[6]International Maize and Wheat Improvement Center (CIMMYT), México
[7]International Maize and Wheat Improvement Center (CIMMYT), NASC Complex, New Delhi, India
email: jashanjotk89@gmail.com

Abstract

In the study,we developed a typology for small and marginal farmers of IGP using survey data of 234 households and 6 variables. Principal component analysis and cluster analysis were used to group farms into 5distinct types differentiated by their production objectives, land and livestock resources and income generated characteristics. Type 1 isSmall farm Household with cereal based intensive farming system, Type 2 are small farm HH- having livestock-based farming system, Type 3 includes Marginal farm HH with cash crop-based farming system, Type 4 are the marginal farm HH with cereal and small ruminant based farming system and Type 5 are the small farm HH with cash crop-based farming system.The result of the study may help the policy makers and the scientists to introduce policiesand intervention stratergies for the specific group of farmers present in that area.

Introduction

A farming system is defined as the complex of resources that are arranged and managed accordingly to the totality of the production and consumption decisions taken by a farm household, including the choice of crops, livestock, on-farm and off-farm enterprises. Small holder farming systems are perceived to share certain characteristics which could differentiate them from large-scale profit-driven enterprises. These includes: limited access to land, capital investment and input use, high level of risk and uncertainty and low market accessibility. Therefore, the most practical way to deal with farming system complexity and diversity and typology attempts to perform such groupings, and the choice of differentiating criteria depends on the objective of typology and the kind of data available. Farm typology study recognizes that farmers are not a monolithic group and face differential constraints in their farming decisions depending on the resources available to them and their lifestyle (Soule 2001).

Adopting an inductive approach, this article attempts to explore the farming system variability in seven major on-farm research centres of Indo-gangetic plains of India under ICAR-Indian Institute of Farming System Research (IIFSR) namely Amritsar, Patiala, Sirsa, Meerut, Kanpur, Purnea and Kalyani. With economic characterization of farms as the objective at hand, the present study assumes that classification of farms based on economic returns from farm enterprises, along with land allocation to different crops, possession of livestock will give more effective insights into the farm type identification.

Materials and Methods

The study was performed on 234 farm households considering 6 variables for studying the types of farms using principal Component Analysis (PCA) to reduce the dataset into non-correlated components followed by Hierarchical Cluster Analysis (CA) for partitioning the PCA output into clusters. All analyses were executed in R (version 3.1.0) with the ade4 package (version 1.6-2, available online at: http://pbil.univ-lyon1.fr/ADE-4/) and the cluster package (version 1.15.2).The principal components (PC's) to keep were retained using standard criteria of eigen value of 1.00 and minimum cumulative percentage of variance chosen, here 70%. The PCA output in the form of a reduced dataset based on the retained PC's was subjected to Cluster Analysis.

Result: Characteristics of Farm Typology

PCA resulted in extraction of three principal components and the scree plot of eigen value (Fig 1) indicated that diversity in farm HH characteristics was associated with these three principal components altogether explain 71.1 % of variance. The variables were related to cropping activities (diversity and intensity), relative importance of farming enterprises comprising of crop and livestock in income generation, livestock number. Component 1 explains 29.5% variance and is correlated with percent of land area under cereals and cash crops, thus represents cereal intensity and cash crops intensity. Component 2 shows correlation with fodder intensity and livestock number, and it explains 21.2% variance. These two components together explain 50.7% of variance. However, component 3 explains variance of 20.4% and shows correlation with total cultivable area (own as well as leased) available with farmer, number of small ruminants and proportion of total income generated from crops. These components were then used in Hierarchical clustering as input variables and then the choice of number of clusters was then made Ward's method

Characteristics of the farm types

The results from the hierarchical clustering indicated 5- cluster cut off points grouped by their production objectives, land and livestock resources and income generated characteristics.

Type 1. Small farm Household - cereal based intensive farming system

This cluster is a group of 40% of farmers selected for the study, biggest of all clusters, can be described as Small-scale farmer households having1-2hectare land holding with more dependence on crops for their income (82-83 per cent share of crop based income). This group has more inclination to cereal crops (163-64 % cereal intensity) in comparison to fodder and cash crops. Livestock units (Cow & buffalo) is medium (2-3) and number of small ruminants (sheep and goat) is negligible.

Type 2. Small farm HH- livestock based farming system

This cluster is a group of farmers described as small farm and livestock-based farmers representing 9 % of the sample. This group has moderate dependency on crops, as the share from crop is 60-61 per cent in the total income. The household have highest livestock (5-6 units) and to sustain them the cropping system has 44-45 per cent fodder intensity

Type 3. Marginal farm HH- cash crop-based farming system

The farm households in type 3 farmers are characterized by diversification in cropping system: highest cash crop intensity (91-92 %) and moderate cereal crop intensity (75-76%) and low fodder crop intensity (12-13 %). Although all other things are similar to the other farms except the cash crop intensity.

Type 4. Marginal farm HH- cereal and small ruminant based farming system

The cluster comprised of marginal farms with total area less than 1 ha and moderate dependence on crops for their income (53-54 % share of crops to income). The distinguishing feature from other clusters is the possession of small ruminants (3-4) by the farm household.

Type 5. Small farm HH- cash crop-based farming system

This cluster is a group of small farmers having 1-2 ha land area. The farm household is mainly dependent on crops for their income (78-79 %). They also have more inclination to cash crops as depicted through cash crop intensity (83-84 %). The only difference of this cluster from cluster 3 is the size of land holding, type 3 is the marginal farmer and this cluster is small farmer.

PROPORTIONS OF DIFFERENT TYPES OF FARM HOUSEHOLDS IN DIFFERENT DISTRICTS

All districts have different types of farmers, but Kanpur, Sirsa, and Kalayani have more diversification among farmers in comparison to Amritsar, Patiala and Purnia (Table 3). Amritsar has almost equal proportion of type 1 and type 2 farmers. i.e. small farmers either cereal based or livestock-based farming system households (51 and 49% respectively). Patiala has larger proportion of small farmers with cereal based farming system (94% of type 1) and 6 percent type 2 farmers (small farmers with livestock-based farming system). Purnia has higher number of type 4 farmers (70%) which are marginal farmers with higher number of small ruminats, and lesser proportion of type1 farmers which are small farmers with land holding 1-2ha and higher cereal crop intensity. Kalyani, Kanpur and Sirsa have diversification in types of farmers. In Kalyani and Kanpur there are type1, 3,4 and 5 farmers whereas in Sirsa there are type few type 1 and 2 farmers (6&3% respectively), 22% type 5 farmers and larger proportion of type 3 farmers (69%).

Conclusion

In the study, farmers of IGP were characterized and classified into 5 distinct types. The farm households were analyzed with focus on allocation of land area to cereals, cash and fodder crops, possession of livestock and small ruminants. Based on these the farms were divided into 5 farm types, the distinguishing feature were their production objectives, land and livestock resources and income generated characteristics. Amritsar and Patiala were dominated by small farm household having cereal intensive farming system. Purnia was dominated by marginal farm household having high cereal intensity and small ruminant based farming system. Kalyani and Kanpur were having diversified farm household but dominated by small farm household having cereal intensive farming system. Meerut was dominated by small farm household with cash crop-based farming system. Sirsa also had diversified farmers but marginal farm households with cash crop-based farming system were dominant. Further research is needed in typology including environmental, socio-economic and qualitative variables also.

Table 3: Proportions of different types of farm households in different districts

Districts	Type 1	Type 2	Type 3	Type 4	Type 5
Amritsar	51%	49%	0%	0%	0%
Patiala	94%	6%	0%	0%	0%
Purnia	30%	0%	0%	70%	0%
Kalayani	45%	0%	21%	3%	31%
Meerut	3%	0%	42%	0%	56%
Sirsa	6%	3%	69%	0%	22%
Kanpur	50%	0%	6%	42%	3%

References

Ellis, F., 1993, Peasant Economics: Farm Households and Agrarian Development. *Cambridge University Press*, Cambridge.

Soule, M.J., 2001, Soil management and the farm typology: do small family farms manage soil and nutrient resources differently than large family farms? *Agric Resource Econ Rev* 30: 179–188.

Farm design applications in prototype IFS models in Western India

Tetarwal, J.P.[1*], Baldev Ram[1], Prusty, A.K.[2], Ravisankar, N.[2], Panwar, A.S.,[2] Santiago L Ridaura[3], Jeroen Groot[4], Roos de Adelhart Toorop[4], Jelle van den Akker[4], and Jat, M.L.[5]

[1]AICRPon Integrated Farming Systems, Agriculture University Kota, India

[2]ICAR-Indian Institute of Farming Systems Research (ICAR-IIFSR), Modipuram, India

[3]International Maize and Wheat Improvement Centre (CIMMYT), Mexico

[4]Farming Systems Ecology, Wageningen University &Research (WUR), The Netherlands

[5]International Maize and Wheat Improvement Centre (CIMMYT), NASC Complex, New Delh , India

Email:-jptetarwal@gmail.commob: +91-9530091236

Abstract

Indian economy is predominantly rural agrarian, and the declining trend in size of land holding poses a serious challenge to the sustainability and profitability of small households, especially for small and marginal farmers who constituted more than 85 % of the Indian farming community. Farming Systems Research is considered as a powerful tool for resource management while maximizing profits in smallholder agriculture. FSR is a multidisciplinary whole-farm approach and very effective in solving the problems of small and marginal farmers with multiple objectives of round the year income and employment generation, food and nutritional security, competitiveness and sustainability, resource recycling and input use efficiency, soil health and environmental issues. Rajasthan is the largest state, occupies nearly 10.4 per cent geographical area and representing diverse farming system typologies of Western India. Agriculture and allied activities, despite all odds considered to be the main stay of rural masses in the state. The agriculture in most part of the state is rainfed and is prone to high production risk. Continues fragmentation of land holdings and increasing population of small households coupled with monocropping, nutrient mining, poor resource recycling, terminal heat, shrinking water resources and imbalance nutrition etc. are of major concern in the way of sustainable livelihood. To support smallholder farmers, ICAR through the AICRP-IFS have developed farming system prototypes in all the agro-ecologies of India. Accordingly, an on-station integrated farming system (IFS)prototype for 1.0 ha land was developed at Agriculture University,Kota, Rajasthan where 69% of farmsare small (1-2 ha) and marginal (<1 ha)having predominantly mixed crop-livestock farming systems.The primary objective of the IFS prototypes is to generate evidence towards the desired goals of food, nutrition and livelihood security and scaling through on-farm farming system approach. A variety of farm design approaches have been developed to support the analysis of current farming systems and the design and evaluation of alternatives.

Groot et al. (2012) described about Farm DESIGN tool, which supports evaluation and re-design of mixed farming systems and supported the analysis of problems in the original farm configuration and indicated avenues for adjustments of the configuration to improve farm performance as per objectives.Alternative integrated farming systems prototypes have been developed for different agro-ecological zones, and are realised in research stations. However, components of these prototype farming systems affect the profitability and sustainability of different types of farmers is unknown. This restricts moving from on-station prototype research towards adoption in farmers' fields. Thus,its further upscaling at farmers field, required typology studies. Typology development constitutes an essential step in any realistic evaluation of constraints and opportunities for appropriate technological solutions. Farm typology study recognizes that farmers are not a monolithic group and face differential constraints in their farming decisions depending on the resources available to them and their lifestyle (Alvarez *et al.*, 2018). These challenges cause a need to re-design the current farming systems though FarmDESIGN toolto capture farming systems diversity.

Objectives

The study aims to assess the performance of on-station IFS prototype model to addresses the following objectives:

- Explore opportunities and possibilities to improve on-going IFS prototype model.
- Allocation of available farm resources as per the objectives & constraints.
- Optimization of enterprises with available resources & opportunities.
- Addressing background science-based evidences under farming systems.
- Addressing soil health, nutritional aspects & environmental concerns.
- Up scaling of the Farm Design results and the practices atfarm level based on typology.

Methodology

The prototype farms are being modelled using a whole-farm modelling approach, using the farming system modelling tool FarmDESIGN (Groot *et al.*, 2012). The FarmDESIGN model is used to design mixed farming systems reaching various productive and environmental objectives (Groot et al., 2012). The FarmDESIGN Model will be used to assess if prototype innovations can be matched to farmers reality. The model follows the DEED research cycle consists of four steps Describe – Explain – Explore – Design (DEED), this entails describing the current production systems and the components in place. Exploring alternative options for the farming system and designing a new configuration to implement. During this research, the focus will be on the explore and design steps of the DEED-cycle. Farming systems. The typology of the region have been developed by surveying 100 farmers with all possible variables each farm households (FHH). These variables provide information on different FHH subsystems, the household family structure, the allocation of labour available, landholding and land allocation to crops, the livestock component, and the FHH's products destination. Principal Component Analysis (PCA) is applied to reduce the dataset into non-correlated components followed by Hierarchical Cluster Analysis (CA) for partitioning the PCA output into four clusters. Quantitative and qualitative interviews of two farmers in each cluster were taken to generate primary data base for FarmDesign. Windows of opportunity to improve performance will be explored by combining current and prototype practices together with objectives and constraints of the farmers in the model.

Results

The prototype IFSin Kota was analyzed, using the farming system modelling tool FarmDESIGN (Groot et al., 2012), to describe and assess itscurrent performancethrough various indicators followed by exploring alternative options for achieving desired objectives.The objective of this study wasto explore the windows of opportunity for optimizing resources using the FarmDESIGN, which was parameterized using the data (yield, price, costs, labour,*etc*) from prototype IFS and information regarding dietarycomposition of products and by-products, GHG emissions,*etc*from secondary published sources.Results revealed that by applying FarmDESIGN, an improved understanding of the performance of the prototype IFS was achieved. Model results show a clear trade-off between OM balance and operating profit. The optimal solutions were foundin a broader range with a maximum operating profit, OM balance and minimum losses of N, pesticide load and GHG emission compared to existing farm configuration. The tool provided options to modify area allocation under existing towards desired objectives of food, nutrition, income and livelihood security of a 6-member family in southern ecologies of Rajasthan, India.The tool also gave options to modify area allocation under existing systems and like options to increase the area for urdbean-mustard-cowpea, sweet corn+urdbean-coriander-mungbean and decrease area for soybean-wheat cropping systems to contribute towards desired objectives. The cropping pattern with most positive impact on all objectives is a combination of Urd bean, Mustard and Cowpea. Thus, that particular alternative farm configuration is outperform in the current systems and move in the desired direction. The findings of this research also suggest that the impact of prototype cropping patterns is positive in terms of economic performance, food self-sufficiency, soil fertility and pesticide use at prototype level.

Conclusions

Model results show a clear trade-off between soil organic matter balance and operating profit. FarmDESIGN outcomes are useful to support decision making in moving from prototype design to the farmer's field. Thissupports closing the think-do-gap and could be used to decide what systems are most interesting for future objectives and on-farm research or adoption. For Farmers in Kota region the cropping pattern with most positive impact on all objectives is a combination of Urd bean, Mustard and Cowpea. Having a good understanding of farming system diversity within the regions surrounding the IFS prototypes has been essential for assessing the impact of prototype cropping patterns upscaling at farm level.

References

Alvarez, S., 2018, Capturing farm diversity with hypothesis-based typologies: An innovative methodological framework for farming system typology development, *PLoS ONE*, **13**(5), pp. 1–24. doi: 10.1371/journal.pone.0194757.

Groot, J. C. J., Oomen, G. J. M. and Rossing, W. A. H., 2012, Multi-objective optimization and design of farming systems,*Agricultural Systems*. Elsevier Ltd, 110, pp. 63–77. doi: 10.1016/j.agsy.2012.03.012.

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Cropping system diversification and/or intensification under Saurashtra region of Gujarat

Solanki R.M.* Gohil P.J., Sagarka B.K. and Pathak A.R.

Farming System Research Centre and AICRP on IFS, Department of Agronomy, Junagadh Agricultural University, Junagadh-362 001 (Gujarat); Email : rmsolanki@jau.in

Indian agriculture is now facing second generation problems like raising or lowering of water table, nutrient imbalance, soil degradation, salinity, resurgence of pests and diseases, environmental pollution and decline in farm profit. Crop diversification shows lot of promise in alleviating these problems through fulfilling the basic needs and regulating farm income, withstanding weather aberrations, controlling price fluctuation, ensuring balanced food supply, conserving natural resources, reducing the chemical fertilizer and pesticide loads, environmental safety and creating employment opportunity. Crop diversification has been recognized as an effective strategy for achieving the objectives of food security, nutrition security, income growth, poverty alleviation, employment generation, judicious use of land and water resources, sustainable agricultural development and environmental improvement. Therefore present investigation was undertaken to develop specific expertise in pre-dominant groundnut based cropping system and relevant technologies to solve agronomic issues under Saurashtra region of Gujarat.

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Integrated Farming System GHG emission estimator – A tool for identifying/quantifying climate resilient modules of IFS to mitigate the ill effects of climate change

Subash N.[1*], Debashis Dutta[1], Sridevi S.[2], Ravisankar N.[1], Shamim M.[1], Panwar A.S.[1] and Baskar S.[3]

[1]ICAR-Indian Institute of Farming Systems Research; Modipuram-250 110, Meerut, Uttar Pradesh; AICRP-IFS, PJTSAU, Rajendranagar, Hyderabad, Telangana; [3]Natural Resource Management Division, Indian Council of Agricultural Research, KAB-II, Pusa, New Delhi

Email : nsubashpdfsr@gmail.com, n_suby@rediffmail.com

Food and Agricultural Organization in its latest report on "The future of food and Agriculture: Trends and Challenges" described that high-input, resource-intensive farming systems, which have caused massive deforestation, water scarcities, soil depletion and high levels of greenhouse gas emissions, cannot deliver sustainable food and agricultural production. The frequent occurrence of extreme climatic events at one or other places over India due to Global Climate Change, directly or indirectly put pressure or risk on small and marginal farm households, which is the major chunk of the farming population. Several tools developed by different National/International Organizations to estimate the GHG emission from agriculture sector are available in public domain. However, there is a need to develop an GHGs emission estimation tool, which represents Indian farming scenario/situation with possibility of all the components/ enterprises of integrated farming system, so that any stakeholder can use without any hindrance to identify/quantify the GHG emission potential of their farming system. Hence, an attempt has been made under AICRP-IFS at ICAR-IIFSR, Modipuram to develop a user friendly IFS-GHG estimator in excel platform. The IFS-GHG Estimation Tool is a Farming System GreenHouse Gas (GHG) Estimator for calculating net GHG emission from on-station IFS models and also from on-farm participatory farming system research. This tool can be used for estimation of GHG from different farming system components and also from individual farm households/farms. This is simple and user friendly tool for any Indian farming situations to identify climate resilient farming system components to mitigate the ill effects of climate change impacts on agriculture. The various stakeholders ie, researchers, technical officials, developmental officials, policy planners can easily use this tool by selecting default emission factors or their own factors based on their research data set. In this study, the methodological framework for identification/quantification of GHG emission from different components of the IFS and how the mitigation strategies can be developed/evolved based on the output of the estimation tool.

number of ecosystem service.multispAace cover crop mixture is often promoted as a way of diversification and redundancy into the system to be more resistance to abiotic stress by adopting IFS one or other way farmers will generate higher income through diversification of products and which then reduces the risk in agriculture .but decision regarding judicious contribution of an enterprise is essential in reducing risk in farming .it requires a lot of management skills which is needed by the farmers .institutions and extension agent should assist the farmers in this regard.

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Enhancement of Income through Value Addition of Farm Produces in Farming Systems Perspective

Nath A., Ravisankar N., Ghasal P.C., Dutta D. and Prusty A.K.
ICAR-IIFSR, Modipuram, Meerut, UP - 2501110

Kinnow mandarin fruits were grown under the AICRP on Integrated Farming Systems, On-station centre at Modipuram, Meerut. An experiment was conducted on marketable surplus of kinnow mandarin fruits for development of value added product and also to know the economic feasibility. For this purpose, matured mandarin fruits were harvested during the month of October, 2017 and harvested fruits were washed with clean water and sorted for removing the damaged fruits. Kinnow mandarin fruits juices were extracted with the help of hand juice extractor. Different kinnow mandarin squashes were prepared by using different concentration of kinnow juices (30-50%) and final products were packed in PET bottles (500ml and 1 litre capacity) and sealed with automatic self sealing caps. The final products qualities with respect to total soluble solid (TSS), tritable acidity and organoleptic scores were evaluated. Among different treatments, kinnow mandarin squash with 45% juice and 55 % syrup with 65°Brix was recorded 41% TSS with high overall acceptability score (8.2) having attractive colour, flavour and taste. Economic analysis of value addition to kinnow indicates that additional income of Rs 0.28 lakhs can be obtained from 0.18 ha by making kinnow mandarin squash. The increase in net income due to value addition was found to be 3 times over net income obtained by selling fresh kinnow.

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Effect of dates of sowing and levels of nitrogen on seed yield of fodder Oats (*Avena sativa* L.) in Southern dry zone of Karnataka

Naveena B.M., Viswanath A.P. and Shekar B.G.
Department of Agronomy, UAS, GKVK, Bengaluru-560065

A field experiment was conducted at ZARS, V. C. Farm, Mandya during *rabi* 2015 to know the effect of dates of sowing and levels of nitrogen on growth and yield of fodder oats. The experiment was conducted in red sandy loam soil with low available nitrogen (258.34 kg ha^{-1}), medium available phosphorous (27.13 kg ha^{-1}) and potassium (158.47 kg ha^{-1}). The experiment was laid out in factorial RCBD with 12 treatment combinations which consist of four different dates of sowing and three nitrogen levels are replicated thrice. The results revealed that sowing during second fortnight of October recorded significantly higher plant height (133.39 cm), dry matter accumulation (172.43 g $0.5m^{-1}$ row length), test weight (34.63 g) and total number of seeds $panicle^{-1}$ (58.51 $0.5m^{-1}$ row length), higher seed yield (20.19 q ha^{-1}), straw yield (61.55 q ha^{-1}). The higher seed and straw yield from early sowing may be attributed to sufficient time available for the successful completion of both vegetative as well as reproductive phases of crop under the conducive environment conditions, which resulted in better resource utilization. The significantly lower yield with the sowing during second fortnight of November could be attributed due to higher temperature at later stage of growth, which hastened the flowering leading to early maturation, increased respiration and shortened the crop duration. Application of 125 kg ha^{-1} recorded significantly higher plant height (133.23 cm), dry matter accumulation (163.92 g $0.5m^{-1}$ row length), test weight (34.43 g) and total number of seeds per $panicle^{-1}$ (55.49 $0.5m^{-1}$ row length), higher seed yield (18.98 q ha^{-1}), straw yield (58.21 q ha^{-1}) as compared to 75 kg ha^{-1}, but it was found on-par with 100 kg ha^{-1}. The improvement in yield under 125 kg N ha^{-1} might be due to higher growth and yield components. Increasing level of fertilizers in growth medium increased the quantity of carbohydrates that is assimilated by the panicle alone or translocated from other parts to the developing kernel in the panicle, which produced greater number of grains and other yield attributes.


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