Crop and cropping systems research in the central Terai, Nepal

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Abstract

The Institute of Agriculture and Animal Sciences (IAAS) has been conducting research on a range of field crops in the central Terai region of Nepal for over 25 years. A review of published and unpublished results of crop research at IAAS was undertaken to identify the nature of the research effort over the past 25 years, and to determine yield gaps and identify future research priorities. On-station research has included 14 crop types, however the main research effort has been on wheat followed by rice, but with some focus also on maize, potatoes, oilseeds, and legumes, and with a small amount of cropping and farming systems research. The main research themes were varietal performance and breeding (especially wheat), crop, soil and water management, weed management (especially in rice) and insect pest and disease management. Potential yields of rice, maize and wheat were 5.5, 4.4, and 5.0 t/ha, respectively, higher than research station yields (3.4, 3.3 and 3.5 t/ha, respectively) and farmers' yields (2.7, 1.8, and 1.9 t/ha, respectively) in Chitwan. The results suggest that there is great scope to raise yields of all cereals in farmers' fields, more so for wheat and maize than for rice. Improved agronomical research on rice varieties and crop and soil management are required to reduce the yield gap for rice, while adoption of recommended technologies by farmers would help reduce the wheat yield gap. For soybean, lentil, and potato, the gap between potential and farmer yields is much larger than the other yield gaps, suggesting large scope for increase in yields in farmers' fields through both improved management and improved varieties. Innovative and new research on eco-region suited variety identification, improved crop and soil management, improved water and N management, agro-meteorology and crop modelling are suggested as priorities for future research to increase productivity and reduce yield gaps of major field crops in the Chitwan district of Nepal.

Media summary

The agronomic research work of IAAS can help to increase crop productivity, reduce the gaps between potential and farmer yields, and can mitigate the poverty alleviation of the nation.

Key Words

Field crops, on-station research, potential yields, yield gap analysis, crop modelling

Introduction

The Institute of Agriculture and Animal Sciences (IAAS), Tribhuvan University, situated in the central Terai region of Nepal (27^0 37' N; $84^0$25' E and 256 m asl.), has a long history of integrating research activities with teaching and extension. This integration is imperative and relevant for the needs of the country. The IAAS does not receive any core funds from the national government to undertake its research programmes, but its faculties have been receiving substantial competitive research grants from several national and international donor and research organizations. The IAAS, however, provides its faculties with small grants from its own internally generated resources, which have given continuity to the research program in the fields of agriculture and animal sciences to tackle the problems and issues related to the food production of the country. The IAAS has, for this reason, established a Directorate of Research and Publication (DOR) to institutionalize and strengthen its research programs. The DOR publishes scientific information through the IAAS Journal and IAAS Research Reports. As the institute is located in the Terai

region, it has focused its research activities to suit to the Terai and Inner Terai regions, especially Chitwan and adjoining districts. By launching the Master Programmes in 13 Departments and Doctoral Programmes in 3 Departments, the institute has generated several theses and resulting publications (IAAS Bulletin 2003). The availability of about 50 hectares of cultivable land in the IAAS Rampur Campus provides enough space to conduct on-station agronomical research, but many research and extension activities are also conducted off-campus in farmers' fields (Timsina 2001).

Rice, maize, wheat and potato are the priority crops in the Agricultural Perspective Plan of Nepal (APP 1995). However, other crops such as finger millet, groundnut, soybean, mungbean and cowpea are also grown during the monsoon/spring season, and rapeseed, mustard, buckwheat, lentil and chickpea are grown widely across Nepal, including Chitwan district (Timsina 2001). To overcome the problem of food insecurity and poverty alleviation, the agriculture research institutions in Nepal have been generating several need-based output-oriented research results but not all have been adopted by farmers (Joshy and Rajbhandadri 2001). On-station and on-farm agronomic investigations conducted at IAAS concentrate on variety identification, selection and breeding, cultural and management practices, soil fertility, weed control and pest control. There has been a large amount of research activity with publication of results in national and international workshop and conference proceedings and journals, annual reports and as special booklets. However systematic documentation and synthesis in one consolidated report is lacking. Therefore an effort was made to review the agronomic research work for the major field crops and cropping systems at IAAS to determine yield gaps and to identify future research priorities (Amgain and Timsina 2004). This paper summarises the major findings of major crops for various themes, identifies gaps between climatically-achievable potential yields and research station and farmers' field yields, and suggests areas for future research at IAAS.

Methods

The research results published in the IAAS Journal (1977-2002), the IAAS Research Reports (1985-2001), international journals and proceedings, were reviewed and summarized for major field crops, with various themes/issues for each crop. The gaps between potential and the experimental station yields, between experimental station and farmers' yields, and between potential and farmers' yields were determined, and causes of yield gaps identified for major crops in the Chitwan District.

Results and discussion

On-station research on crops and cropping systems

Over the past 25 years on-station research at IAAS was conducted on 14 crops, on maize- and wheat-based cropping systems, under 5 major themes (Table 1). The main effort was on wheat followed by rice, which together accounted for half the reports. This was followed by maize, soybean, rapeseed/mustard and potato, with almost the same number of reports on each. The major research themes were: varietal performance and breeding (particularly for wheat and soybeans), crop management and soil management, followed by weed management (mostly in rice) and pest management. Crop management research included issues related to plant spacing and population, seed rate, sowing date, system for rice intensification (SRI), seed priming, and seed inoculations, while the soil management research included land preparation, tillage, compost, residue and green manure management, and inorganic fertilizer management. Pest management issues included management of both insect pests and diseases. Research was carried out on all themes for wheat and rice, but with more focus on varieties in wheat and weed management in rice In maize, rapeseed/mustard, and potato, research was carried out on all themes, except varietal performance/breeding.

On-farm research on crops and cropping systems

Many off-research station or on-farm research activities were also conducted by IAAS in Chitwan district through farmer-participatory cropping and farming systems research and extension projects. Timsina (2001) summarised the on-farm cropping and farming systems research and extension activities in which farmers and extension workers were largely involved in various stages of the research from planning and

designing on-farm trials to implementation, monitoring and evaluation of trials. That literature lists major publications resulting from cropping and farming systems research at IAAS.

Table 1. Summary of on-station research on major agronomic crops at IAAS (the figures denote the numbers of research papers published in IAAS Journal and IAAS Research Reports).

Crop	Major issues/ themes					
	Varietal performance and breeding	Crop management	Soil management	Weed management	Pest management	**Total**
			Cereals			
Rice	2	1	3	6	2	**14**
Maize	-	-	4	1	1	**6**
Wheat	11	2	6	2	2	**23**
Finger millet	-	1	-	-	-	**1**
Buckwheat	2	-	-	-	-	**2**
			Legumes			
Soybean	5	2	-	-	-	**7**
Mungbean	-	1	2	-	-	**3**
Cowpea	-	2	-	-	-	**2**
Lentil and Chickpea	-	1	-	-	-	**1**
			Oilseed and tuber crops			
Rapeseed and mustard		3	2	1	1	**7**

Ground nut	2	-	-	-	-	**2**
Sunflower		1	-	-	-	**1**
Potato		1	3	1	1	**6**
			Total			
Total	**22**	**15**	**20**	**11**	**7**	**75**

	Cropping system	
Maize-based	Maize-soybean	1
	Maize-lablab	1
Wheat-based	Wheat- lentil	1
	Winter crop-weed	1

Yield gap analysis

Table 2 compares mean potential (climatically achievable), research station and farmer yields. Potential yields are based on the average potential yields of major varieties grown in the Terai region as reported by (MOAC 2003). The IAAS station yields are means of experimental results reported in IAAS Journal articles for recommended practice, and average farmers' yields are average Chitwan district yields as reported by MOAC (2003). The gaps between the potential and farmers' field yields (yield gap 3) of rice, maize and wheat are quite large at 2.76, 2.58, and 3.15 t/ha, respectively. The gaps between potential and research station yields (yield gap 1) are lower, but are still considerable at 2.1, 1.1, and 1.53 t/ha, respectively. The gaps between research station and farmers' field yields (yield gap 2) are much smaller in rice (0.66 t/ha) than in maize (1.48 t/ha) and wheat (1.62 t/ha). For rice, the yield gap between potential and research station yields (yield gap 1) is larger than that for maize and wheat, suggesting that improved agronomical research on rice varieties and crop and soil management would be required to reduce this gap. The gap between research station and farmers' field yields is larger for wheat than for the other two crops, suggesting that farmers' management for wheat is poor and that extension of recommended technologies to, and their adoption by, farmers would help increase farmers' yields and reduce the gap. The results suggest that there is great scope to raise yields of all cereals in farmers' fields, more so for wheat and maize than for rice. For rape and mustard, all three forms of yield gaps are smaller, suggesting less scope for improvement through agronomic research. For soybean, lentil, and potato, however, the gap between potential and farmer yields is much larger than the other yield gaps, suggesting large scope for increase in yields in farmers' fields through both improved management and improved varieties.

Since the potential yield is governed by both biotic and abiotic factors, it is often difficult to achieve potential either in farmers' fields or in research station trials. Nevertheless, the data reveal that potential yields of all crops, except wheat, as reported by the MOAC (2003) are much smaller than what is normally expected for sub-tropical regions of Asia (IRRI 1983). Using CERES models for various sites in Nepal, including Chitwan, Timsina et al. (1997) also concluded that the long-term mean potential yields of rice (about 8 t/ha) and maize (about 5 t/ha) were much larger, while that of wheat was lower (about 4.2 t/ha)

than the potential yields suggested by MOAC (2003). They also found larger gaps between potential and farmers' yields than reported by MOAC (2003) for Chitwan. The model-predicted data suggest large uncertainties in the potential yield data reported by MOAC (2003). In farmers' fields in Chitwan, yields could be reduced by reduced supply of organic manures, sub-optimal use of water, imbalanced use of chemical fertilizers (e.g., urea only), decreasing soil fertility, damage by insects and diseases, recurrent flooding during the monsoon (e.g., in river basin areas of eastern Chitwan) and the resulting deep water or waterlogging effects on rice, maize and other monsoon crops, poor access to resources and technologies, and due to intensive cropping and, consequently, large amounts of nutrient export, etc.

Table 2. Yields and yield gaps (t/ha) of major crops in Chitwan, Nepal (source: MOAC 2003, HMG, Nepal and various research papers of IAAS).

Crops	Potential yield (A)	IAAS station yield (B)	Farmers' yield (C)	Yield gap 1 (A-B)	Yield gap 2 (B-C)	Yield gap 3 (A-C)
Rice	5.50	3.40	2.74	2.10	0.66	2.76
Maize	4.40	3.30	1.82	1.10	1.48	2.58
Wheat	5.03	3.50	1.88	1.53	1.62	3.15
Rapeseed and mustard	1.10	1.00	0.71	0.10	0.29	0.39
Soybean	2.00	1.50	0.85	0.50	0.65	1.15
Lentil	2.50	1.75	0.82	0.75	0.93	1.68
Potato	20.0	16.5	10.9	3.5	5.6	9.1

Conclusions and future research priorities

Since the commencement of APP in 1993, the national research issues in Nepal have been focused on the agricultural problems prevalent in the farmers' fields (Joshy and Rajbhandari 2001). Bridging the gaps between potential and experimental station yields, between experimental station and farmers' field yields, and between potential and farmers' field yields will only be possible through rigorous scientific agricultural research. While the research conducted so far at IAAS has contributed to some degree to narrowing the various gaps, it has not substantially benefited the farmers because the research and extension systems could not effectively reach the farmers. A range of innovative and relevant research programs, including effective and efficient on-farm research and extension systems, are needed to substantially narrow the yield gaps and benefit the farmers. For example, in rice, research on biodiversity maintenance, high quality or aromatic rice production, and development of high yielding varieties, are required. Research programs on variety evaluation and improved management practices for upland conditions and hybrid seed production are needed for maize research. Development of cost- and energy-efficient land preparation options is a major challenge for wheat in the rice-wheat system. True potato seed production and post harvest study management studies, etc., are needed to increase potato yields. Development of resistant varieties and fertiliser management strategies are needed to control aphids and alternaria leaf blight in oilseed crops. Integrated nutrient management (e.g. use of leaf color chart and chlorophyll meter, improved methods of fertilizer placement such as the use of slow- and controlled-release, and deep

placement of, fertilizers, etc.) and improved water management (e.g., new and efficient techniques of irrigation such as furrow and sprinkler irrigation, surface and sub-surface drip irrigation, etc.), and planting of crops on raised beds are required to increase nutrient- and water-use efficiencies for various crops and cropping systems. Most importantly, research on eco-region suited technology identification through crop modeling and agro-meteorology are required for all crops and cropping systems. Both national- and international-level collaboration and internal and external funding are required to continue and flourish the agronomic research work at IAAS.

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