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Ways for the Prosperity of Farmers in Western Hills and Terai, Nepal

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Abstract

The Institute of Agriculture and Animal Science (IAAS) under Tribhuvan University (TU) has launched the internship programme me for their final semester students studying under-graduate level since 2014/15 in its all constituent and affiliated campuses. About 106 UPA mini-theses accomplished by 221 B.Sc. Ag. graduates from the Prithu Technical College (PTC) libraries were systematically arranged and categorized in chronological order based on the disciplinary subjects and thematic areas, and the technologies have been recommended to scale-out for the prosperity of the farmers in the western Terai and mid-hill agro-ecology of Lumbini and adjoining provinces in Nepal. The review revealed that the researches at PTC were concentrated majorly on major food grain crops with five major themes viz. varietal evaluation, crop management, soil nutrient, weed and insect pest management. The review further revealed that the adequate number of researches were in the vegetable crops specially in production packages and value-chain analysis followed by the control of insect pests and diseases both in on-farm and storage structures, suggesting to follow the integrated pest management (IPM) approach. Varietal testing in major field and vegetable crops, and economic survey of chamomile, marigold, honeybees, broiler chicken, cardamom and ginger and oyster mushroom cultivation practices are the newly defined arena to be adopted for harnessing the prosperity of the farmers of the western hills and Terai region in Nepal and its adjoining congenial agro-climatic environment. Future collaboration with the various agriculture related national and international organizations as adopted by PTC on these recent years has to be continued and strengthened further to extrapolate the UPA research innovations obtained from the graduate student's mini-thesis works.

***Keywords*:** Innovative Agriculture Technologies, Prithu Technical College, Under-graduate Practicum Assessment

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Introduction

The United Nations (UN) listed the 17 Sustainable Development Goals (SDGs) in 2015 (UN, 2015) in which the higher education is announced more important by the name the SDG Goal No. 4, as defined "equal access to higher education as part of the promotion of life learning opportunities for all". As a UN member country, Nepal has also adopted and incorporated these goals in her national development agendas. For example, the country has developed a framework "Nepal National Framework of SDG 4: Education 2030" to achieve the targets of SDG-4 (MoES & T, 2019). Similarly, National Education Policy (2019) has also been implemented to improve the access of quality education and for increasing the relevance of higher education to national priorities and sustainable development of the country. The policy further encourages expanding higher education across the country focusing to technical education (MoES & T, 2019a).

Agriculture as a technical discipline, deals with food security and environmental problems and contribute to the solution as well. Poverty alleviation, food security and climate change are the national and global concerns and seen them as the problem of 'global commons' (World Bank, 1999) wherein, agriculture academia, research and extension are suggested as a solution measure amongst the various measures to achieve this target (ABPSD, 2022). Graduates from Nepalese universities must engage among each other and approach to wider society for promoting the economic development, social welfare and environmental stewardship of the country.

Prithu Technical College (PTC) is one of the agricultural colleges under IAAS, TU, established as a private college in Lamahi Municipality Ward-3, Bangaun, Deukhuri Dang, Nepal in the year 2013 AD (2070 BS) for providing the theory and practical courses of the Bachelor of Science in Agriculture (B.Sc. Ag). The education and training landscape at PTC as evolved from the beginning is emphasizing the vocational and technical skills to the marginal and talented students willing to study B.Sc. Ag. in specific and to boost the Nepalese economy in general. The graduates from this college have designed and launched innovative Under-graduate Practicum Assessment (UPA) researches by using their ingenuity and determination as a minimum requirement for the partial fulfillment of the B.Sc. Ag. degree. Since, PTC has already produced about 220 high-sounding B.Sc. Ag. graduates and able to enroll and pass out about 100 M.Sc. Ag. students from different institutions nationally and internationally its popularity is increasing amongst other private colleges as a pioneer organization in the field of strong research base with high-sounding academic quality.

This compilation study of all under- graduate thesis works of UPA research in one place as a review article would be a great job to get a bird's eyes view in disciplinary researches, which do not only reduce the costs of further research from

repeated experimentations, but also save time of researchers and institutions, help to maintain food and nutritional security after boosting the crop and animal productivity, to direct the command of future research needs of the under-graduate's programme, and to strengthen the academic and research bases of PTC.

Materials and Methods

As a minimum pre-requisite of the under-graduate courses, the IAAS has developed the academic course curricula with the inclusion of Under-graduate Practicum Assessment (UPA) thesis to the B.Sc. Ag. 8th semester students with 3 credit courses (IAAS Bulletin, 2009), which now has been named as Research, Practice and Seminar (RPS) with 1+3 credit hours (IAAS Bulletin, 2019). To be acquainted with the various disciplinary and system research works of the Prithu Technical College (PTC) and to recommend the innovative research technologies of PTC, the Under-graduate Practicum Assessment (UPA) thesis of PTC under IAAS, Tribhuvan University (TU) being conducted over last 5 years (2018-2022) were critically reviewed. Almost all those mini-theses kept at Prithu Technical Campus Library were collected and documented with their respective topics. We prepared the inventory of the theses and presented in tabular forms and dragged the research outputs according to disciplinary subjects and thematic areas in capsulated form. Yield and economic potentialities, and the modern production technologies for getting the researchable yields of the of different agronomic and horticultural crops, and animal commodities being grown mostly around the Lamahi, Dang and adjoining districts of Lumbini provinces were identified and key research gaps and future research priorities have been recommendation. Mean comparisons on review data were calculated through Microsoft Excel and qualitative traits were analyzed in percentage as per need.

Results and Discussion

As the basic pre-requisites of the B.Sc. Ag. course, the PTC has also been producing about 106 mini-thesis based on on-station and on-farm researches for last 5 years (2018-2022) on different agronomic and horticultural crops, apiary and livestock animals mainly in poultry birds and fishery. The two-way matrices of years of passed out students and major departments offering min-thesis has been documented in Table 1 highlighting the major research focus was in Agronomy, Horticulture, Plant Pathology, Agri-Economics and Plant Breeding. It was also overlooked that the number of students in choosing subject disciplines was mainly based on the available faculties enrolled in different departments over different time-frame in the college

Table 1

Two-way Matrices on Students Passed out in Different Batches/ Years with their Multi-disciplinary UPA Research Subjects from IAAS, PTC, Dangduring Last 5 Years (2018-2022)

SN	UPA mini-thesis Departments	Years and number of min-theses produced					Total
		2018	2019	2020	2021	2022	
1	Agronomy	6 (10)	3(6)	3(6)	4 (11)	7 (17)	23 (50)
2	Plant Breeding	1 (1)	2 (5)	3 (8)	3 (9)	3 (8)	12 (31)
3	Animal Science				1 (2)		1 (2)
5	Agri-Economics	5 (5)	5 (6)	6 (9)	2 (5)	4 (8)	22 (33)
6	Agri-Extension	1 (1)					1 (1)
8	Entomology	1 (2)	2 (4)	3 (6)	1 (2)	1 (2)	8 (16)
9	Horticulture	2 (4)	5 (13)	5 (11)	4 (11)	4 (9)	20 (48)
10	Plant Pathology	4 (4)	6 (13)	2 (4)	3 (7)	2 (6)	17 (34)
11	Soil Science and Agri-Eng.			1 (3)	1 (3)		2 (6)
Total		20 (27)	23 (47)	23 (47)	19 (50)	21 (50)	106 (221)

Note: Figures in parenthesis denotes the number of students writing UPA thesis and passed in the particular batches

As per the tracer study recorded in PTC, it has also been reported that about 46 PTC alumni have gone to abroad for higher study, about 62 have completed their M Sc Ag study in Nepalese universities, about 11 have gone to Israel for 'earn and learn programme' and about 50 are working in different agriculture related offices in Nepal (PTC profile, 2022).

Major Research Innovations in Various Thematic Areas of Agronomy and Plant Breeding

In total of 81 students doing 35 UPA research in Agronomy and Plant Breeding, 39 students have published 16 UPA thesis in maize, followed by 13 students with 6 UPA research in wheat, 10 students with 5 theses in rice and 19 students with 8 theses in other field crops (Table 2). Varietal, fertilizer and weed management and other cultural practices like tillage and priming were the major thematic areas of agronomic research, while study of heritability characters and varietal screening of maize and wheat were the major research themes adopted by PTC alumni. The details of the findings as per crop and thematic areas have been expressed in Table 3-4.

Table 2

Two-way Matrices on Number of UPA Thesis in Various Thematic Areas under Agronomy and Plant Breeding subjects at PTC, IAAS/TU, Lamahi, Dang during 2018-2022

SN	Major thematic areas of research					Total
	Crops	Varietal management	Fertilizer management	Weed management	Tillage and other practices	
1	Rice	1 (3)	2 (4)		2 (3)	5 (10)
2	Maize	8 (20)	3 (7)	2 (5)	3 (7)	16 (39)
3	Wheat	2 (5)	3 (6)		1(2)	6 (13)
4	Others	2 (4)	4 (10)	1 (2)	1 (3)	8 (19)
	Total	13 (32)	12 (27)	3 (7)	7 (15)	35 (81)

Note: The figures in the parenthesis denotes the number of students accomplished the thesis in respective themes

Table 3

Major Research Innovations of the UPA Theses in Varietal Management of Agronomic Crops at PTC during 2018-2022

Varietal development Innovations	References
Rice-Early transplanting date on June/July governed 30.75% higher yield while with hybrid cultivar Arize-6444 resulted about 80.92% over local cultivar (Sarju-52) in Lamahi, Dang. Early transplanting date required a greater number of days to maturity, thereby accumulating higher GDD than transplanted conditions converting the yield data to light and temperature relation. At Tulsipur, Dang, US-321 hybrid variety of rice was cultivated most and was found economical.	Bhandari, 2019; Oli, 2018
Wheat - Gautam variety recorded higher B:C ratio, yield attributes like length of spike, no of grains spike^{-1} and 1000 grain weight at Lamahi. Amongst the three different wheat varieties tested (Vijay, Borlaug 2020 and Bhrikuti) in Lamahi, Bijay showed better result on plant height. Borlaug 2020 performed the highest grain yield (4.21t/ha) and other yield attributes. To assess the heat tolerance in wheat genotypes next study stipulated that Zinc Wheat-1 &2, Borlaug 2020 and Bhrikuti were found high yielding genotypes under stress condition, while under normal condition, Aditya was found to be high yielding. Heat stress tolerant was found susceptible in WK-3165 cultivar. After studying the effect of peg- induced stress on germination of bread wheat genotypes, it was found that germination index and germination% were better in BL-4341 than Gautam.	Timilsena, 2018; Adhikari & DC, 2022; Bhatta et al., 2022; Poudel and Paudel, 2022; Maharjan et al., 2022

Maize-Productivity of RH-2 showed significantly higher yield (6.19 ton/ha), higher B:C ratio (1:7.2), cob diameter (13.60 cm) and number of kernel rows cob^{-1} (13.35). The next study exhibited that variety 10V10 showed significantly higher net return (NRs. 174066 thousand ha^{-1}) and B:C ratio (1.91) accompanied by superiority in yield attributes like cob length (16.25) and number of grains row^{-1} (32.35). In another study, the highest plant height (210.43 cm), longest cob length (16.25 cm), maximum diameter of cob (4.27 cm), highest number of kernels row^{1}, the highest1000-grain weight (314 g), and maximum harvest index (44%) were observed in RML95/ RML96 hybrid maize. High sense of heritability was found for 50% tasseling, ear height, tassel branch,50% silking, tassel length, grain yield and no. of kernels, whereas low sense of heritability was found for traits: stem diameter, length, breadth, 1000 seed weight, ASI and cob length. Study on heterosis of maize genotypes in Bangaun, Dang resulted that RH-10 hybrid recorded commercial heterosis on grain yield over Rajkumar followed by RH-6 and RML86/RML. At the river basin of Karnali maize hybrid KML-5(A)*KYM -33 was found promising one followed by KWM-92*KWH-93, KML-4(A)*KYM-33 and least of KML-9(A)*RML-4. The multi-national performance of maize hybrids resulted that*9,10v10 hybrid was found superior and yielded 11, 10.71 and 10.62 ton/ha, respectively than Rampur and Khumal hybrids which yielded 7.54 and 9.54 ton/ha in terms of grain yield. The next varietal performance trial at Lamahi Dang resulted that RML-98, RML-4, RL-107 was superior wherein the grain yield was 11.26, 9.92 and 10.22 ton/ha than the standard check RH-10(9.24 ton/ha) and RH-6(8.23ton/ha). The evaluation and variability of quality protein maize resulted that Rampur-S13FQ-02, Rampur-S03FQ-02, Rampur-S13FQ010 and Rampur S13FQ-08 yielded 4.32,3.97,3.89, 3.63 ton/ha and was found superior in yield than PoshiloMakai-2 yield (2.66 t/ha).	Paudel & Bhatta, 2018; Adhikari & Bhandari, 2020, Raut et al., 2020; Rai, 2018; Upreti and Acharya, 2019; Gyawali et al., 2020; Acharya and Parajuli, 2020; Shrestha et al., 2021; Khanal et al., 2021; Niraula et al., 2021

Table 4

Major Research Innovations of the UPA Theses in Different Thematic Areas of Agronomic Crops at PTC during 2018-2022

Crops, Major Thematic Research Areas and their Findings	References
1. Crop management	
Rice-Treatments with 29 days old seedlings with 4 seedlings/hill produced the highest grain yield (3.9t/ha), biomass yield(9.9t/ha), effective tillers m^{-2}(285) and number of tillers. The rice grown on June 20thwith 120 kg N/ha produced the maximum gross return, net return and B:C ratio.	Pokharel & Singh, 2018, Gautam & Kunwar, 2018

Wheat-Zero tillage showed significantly higher yield than conventional tillage.	Bartaula & Panthi, 2019
Maize-The longest plant, highest cob weight, maximum diameter of cob, highest number of kernels cob^{-1}, maximum number of kernel rows cob^{-1}, the highest 1000-grain weight, harvest index and stover yield was observed in the spacing of 75cm x 25 cm. In another study in maize, inter row spacing of 60 x 25 cm produced maximum yield (3.8 tha^{-1}), cob length (15.5 cm), cob circumference (12.6 cm), 1000 grain weight (290.3 g), stover yield (7.0 tha^{-1}) and highest net return (NRs 66.5 thousand ha^{-1}) and B:C ratio (2.0). Research on effect of Salicylic acid and irrigation on response of maize revealed that 450 mllit^{-1} recorded highest 1000-grain weight (306.91 g). Irrigation provided at knee high, tasseling and grain filling recorded the highest number of rows cob^{-1} (16.3), grain yield (6.18ton ha^{-1}) which remained statistically as par with four irrigations. Field results from six different intercropping treatments of maize and soybean namely; sole maize, 1M:1S, 1M:2S, 1M:3S, 1M:4S and sole soybean reveled that maximum grain yield of maize (2.63 ton ha^{-1}) with the highest stover yield (5.63 ton ha^{-1}), biological yield (8.27 ton ha^{-1}) and harvest index (31.83%) was recorded from treatment combination in 1M:2S, while the maximum number of grains cob^{-1} was obtained in treatment ratio 1M:3S. In contrast, the maximum pod yield of soybean (2.73 tonha^{-1}) and stalk yield (4.70 ton ha^{-1}). was recorded with 1M:4Swhile, the maximum biological yield (7.0 ton ha^{-1})and harvest index (38.57%)was recorded in sole soybean.	Raut et al., 2019; Koirala et al., 2019; Dhami et al., 2021; Adhikari & Karki, 2018
2. Soil nutrient management	
Rice-The grain yield of rice increased by 23.97% for NE- Rice in comparison with FFP and yield attributing characters like effective tillers m^{-2}(354.50), panicle length (26.31 cm), panicle weight (81.50 g), filled grains panicle^{-1} (389.50) and fertility %(87.56).	Mahara & Acharya, 2019
Wheat-Recommended dose of NPK fertilizers::120:50:50 kg NPK/ ha resulted higher grain yield, biological yield and grains spike^{-1}.The fertilizer dose 125:50:50 kg NPK/ha produced the highest gross return (NRs.113.9 thousand ha^{-1}) by the expense of (NRs.64.2 thousand ha^{-1}), producing B:C ratio of 1.8. Similarly, in another research, fertilizer dose of 120:60:60kg NPK/ha produced gross return (NRs.92.90 thousands ha^{-1}) by the expense of (NRs.75.4 thousands ha^{-1}) and B:C ratio 1.23.	Bhatta et al., 2022

Maize-Fertilizer dose of 180:60:40 kg NPK ha^{-1} showed the highest plant height and the longest cob length (18.31 cm). In another study, maximum grain yield (10.77 t ha^{-1}), cob length (16.33 cm), no of rows cob^{-1} (14.97), cob diameter (4.54), 1000-grain weight (276.77g), stover yield (12.91ton ha^{-1}), biological yield (23.00ton ha^{-1}), harvest index (43.80), gross return (NRs. 208.94 thousand ha^{-1}), net return (NRs. 104.488 thousand ha^{-1}) and B:C ratio (2.001) with 220 kg N/ha. Judicious use of organic and inorganic fertilizer on INM practice, 50% nitrogen with chemical fertilizer and 50% nitrogen with vermi-compost showed the highest grain yield (6.84ton ha^{-1}), cob circumference (16.67 cm), and number of rows cob^{-1} (16.9) which was par with the 100% nitrogen through chemical fertilizer.)	Paudel & Bhatta, 2018; Pandit & Khadka, 2021; Adhikari & Bhandari, 2020; Pandit & Khadka, 2021
3. Weed management	
Maize- The highest weed control efficiency at 60 DAS was recorded by pre- emergence application of Pendimethalin @ 2-3 kg a. i./ha. Kharif maize produced maximum plant height, highest cob circumference, longest cob length, number of rows per cob, number of grains per cob and grain yield with Laudis (Mesotrion) treated plot which was statistically at par with weed free plot. Laudis treated plot also recorded the highest net return (NRs 68.2 thousand ha^{-1}) and B:C ratio (1.73).	Karki et al., 2021; Thani & Khanal, 2022

Major Research Innovations in Various Thematic Areas of Horticulture

About 53 students have accomplished the mini-thesis research in various horticultural crops mainly in varietal and fertilizer management theme and other different growth hormones (Table 5). The maximum research was concentrated to solanaceous vegetables, but few students have studied on other vegetables like cole crops, lady's finger, root vegetables and coriander, and some fruits like citrus and banana and even in marigold flower too. The major UPA research innovations as per thematic areas of horticultural crops at PTC during 2018-2022 is given in Table 6.

Table 5

Two- way Matrices on Number of UPA Thesis in Various Thematic Areas under Horticulture Subject at PTC, IAAS/TU, Lamahi, Dang during 2018-2022

SN	Major thematic areas of research				Total
	Crops	Varietal management	Fertilizer management	Other specials	
Major Vegetables					
1	Cole crops		2 (3)		2 (3)
2	Root vegetables		1 (3)		1 (3)
4	Solanaceous		3 (8)	6(13)	9 (21)
5	Coriander	1 (3)			1 (3)
6	Malvaceous	1 (2)		1(3)	2 (5)
	Total	2 (5)	6 (14)	7(16)	15(35)
Major Fruits					
3	Citrus			1(2)	1 (2)
4	Banana			1(3)	1 (3)
	Total			1(5)	1 (5)
Major flower					
1	Marigold		1 (2)	2 (6)	3 (8)
Grand total		2 (5)	7 (16)	12 (32)	21 (53)

Table 6

Major UPA Research Innovations as Per Thematic Areas of Horticultural Crops at PTC during 2018-2022

Crops, Major Research Thematic Areas and their Findings	References
1. **Varietal management**	
Vegetables- The leaf area, branch length, number of male and female flowers could be important selection criteria in evaluation and estimation of genetic parameters of hybrid cucumber in Lamahi, Dang. Similarly, the Arka Anamika cultivar of Brinjal was the best in the vegetative growth mostly on plant height (81.7 cm), leaf number (32.04) and branches (23.17), while Bhindi-10 was the best in terms of yield and yield attributing characters like fruit length(11.43 cm), fruit diameter (1.49 cm), fruit weight (15.53 g) and yield plant^{-1} (522.26 g).In case of coriander cultivars, Kalami 5, Evergreen and Komal was found to have better performance under Lamahi Dang condition.	Khadka et al., 2022; Regmi & Regmi, 2018; Bhattarai et al., 2020

2. **Crop management**	
Vegetables- The spacing of 50 x 30 cm in brinjal showed significant effect on yield and yield attributing characters like fruit length (11.43 cm), fruit diameter (1.61 cm), fruit weight (15.53 g) and yield per plant (522.26 g). Similarly, the highest number of fruits, fresh and dry fruit yield (5.48 and 1.34 g), length of fruit (11.34 cm) and fruit diameter of chilli was recorded while grown under black double thickness plastic. Similar research on mulching of okra showed that plastic mulch of 20µ was the best in terms of vegetative growth and phenological observation like plant height, number of leaves at 60DAS, and other yield attributing characters like fruit length, fruit weight and yield per plot (5.4 tons/ ha). Among the priming methods tested in okra, the highest plant height was recorded in hydropriming, greater number of flower (7.67) and the lowest number of days to flowering (40.33) was obtained when there was priming with 50% sulphuric acid. Similarly, yield per plot was high with hot water priming (595.02 g). Among different dose of Auxin and Gibberellin applied on tomato (Gaurav 555) under greenhouse condition, the highest number of flowers and fruits cluster^{-1} and the highest fruit weight was recorded in spraying 10 ppm IAA+ 20 ppm GA3. On similar research performed in field condition in chilli at Lamahi, Dang, the application of GA3 100 ppm enhanced the growth where as low concentration of NAA in range of 30 to 60 ppm enhanced the yield attributing characters of chilli. In case of Broccoli (Greenmagic), the highest result in yield (7.18 ton/ ha) and curd weight (167g) was found with 75 ppm GA3 followed by 50 ppm.	Regmi & Regmi, 2018; Neupane, 2020; Panthi & Thapa, 2022; Khatri, 2021;Giri & Paudel, 2021; Khanal et al., 2021; Neupane & Pandey, 2022

3. **Soil nutrient management**	
Vegetables-On different phosphorous level applied on chilly cultivar NS-1701, 90 kg P_2O_5/ha was the best in plant height (60.25 cm), number of primary branches (9.60), days to 50% flowering (44 days), yield per plant (123.20 g)and yield (9.15 ton/ha). Phosphorous level of 120 kg/ha was superior in terms of fresh weight of fruit with lengthy fruits. In comparing three different organic manure (FYM, Poultry manure and Mustard cake), maximum plant height, number of leaves at 65 days, leaf length, root diameter, root weight, shoot weight, total weight, root yield, shoot yield, total yield, dry matter and B:C ratio of radish was recorded maximum with the mustard cake. Integrated nutrient management of early season cauliflower with FYM, Poultry manure and Vermicompost has found the improved soil physical and chemical properties, enhance nutrient availability of plants resulting in better growth and yield. While applying different level of potassium on 'Cardinal' variety of potato, potassium 60 kg/ha showed significantly higher yield (2.23 ton/ha) and better economics of production.	Adhikari et al., 2019; Belbase et al., 2019; Neupane, 2020; Ghimire et al., 2019
4. **Post-harvest management**	
Vegetables-To maintain post-harvest quality of tomato, different concentration of Ethephone was tested and resulted that the highest ripening percentage was registered in 750 ppm ethephon solution. Low concentration of ethephon has higher TA than high concentration of ethephon. Average marketable fruit percentage was higher in low concentration of ethephon. Among different post-harvest treatments on self-life and quality of tomato, application of GA3 (0.3%) has the potential to control decay and prolong the self-life at ambient condition.	Rawat & Oli, 2018; Karki et al., 2022

Fruits-The quality and self-life of mandarine orange was judged by applying Paraffin wax, Mustard oil, *Aloe vera* and Turmeric and result revealed that Paraffin wax 75% can be technically suggested for keeping orange fresh and edible for longer time.	D. C. & Singh, 2019

Major Research Innovations in Different Thematic Areas of Soil Science and Plant Protection

About 58 students have accomplished the mini-thesis research in soil science (2 mini-thesis with 6 students) and plant protection (18 min-thesis by 32 UPA students). About 20 students have developed mini-theses on mushroom cultivation (Table 7). The major UPA research innovations on various crop commodities of agronomical and horticultural crops at PTC during 2018-2022 is given in Table 8.

Table 7

Two-way Matrices on Number of UPA Thesis in Various Thematic Areas under Soil Science and Plant Protection subjects at PTC, IAAS/TU, Lamahi, Dang during 2018-2022

SN	Major thematic subjects of research					Total
	Crops	Soil Science	Insect management	Disease management	Other specials (mushroom)	
Major agronomic crops						
1	Cereals	2 (6)	4 (8)	8 (13)		14 (27)
2	Legumes		2 (3)	1 (2)		3 (5)
3	Oilseeds		1 (3)			1 (3)
Major horticultural crops						
1	Vegetables			2(3)		2 (3)
3	Mushroom				7 (18)	7 (18)
4	Honeybees				1 (2)	1 (2)
	Total	2 (6)	7 (14)	11(18)	8 (20)	28 (58)

Table 8

Major Findings of the UPA Research Innovations as Per Thematic Areas in Plant Protection Themes of Various Agronomic and Horticultural Crops and Mushroom Cultivation at PTC during 2018-2022

Crops, major innovative plant protection researches at PTC, Lamahi, Dang	References
Rice- From a survey study in Chitwan, it was noticed that rice weevils and rice moth were the major insect pest in cereals and bruchids in legumes. Hybrid rice genotypes screened for rice blast disease in Lamahi resulted the significantly low AUDPC value in Sabitri cultivar (36.46) followed by Hardinath-1 (39.93). The similar research resulted that fungicide Tricyclozole 75% WP was found to be most effective to least leaf blast severity (27.85 %), least incidence (35.5 %), least mean AUDPC (64.64 %) and high grain yield (3.93ton ha^{-1}). Similar research for screening rice genotypes against brown spot disease in Dang showed high mean AUDPC value in Basmati (260.65), followed by Radha-13 (172.80), and the lowest in Kathe Jhinuwa (88.51). The lowest severity was also recorded in Kathe Jhinuwa (11.33) which was at par with Radha 4 (11.11).	Shrestha et al., 2020; Bohora, 2018; Moktan, 2018, Dhungana & Puri, 2019
Maize-To control bacterial stalk rot of maize, the highest economic yield was obtained by the application of Agricin + Surya, and seemed to be the best to control bacterial stalk rot. Similarly, in the next study screened for 20 maize genotypes against banded leaf and sheath blight in Bangaun, Dang, RampurS03F08, HG-AB, Rampur 2, Rampur Composite and Rampur-43 were recorded for the lowest AUDPC value with moderately resistant reaction against this disease with significantly higher grain yield. To control the same disease, the application of *Trichoderma viridae* was recorded for the lowest AUDPC value as bio-control and Mancozeb as a chemical control. The next study to evaluate the efficacy of different *Trichoderma* isolates from different geographical region of Nepal reported that the mycelium growth inhibition percentage was higher in *Trichoderma* in Banke followed by *Trichoderma* in Dang and *Trichoderma* in Chitwan which showed that *Trichoderma* in Banke had more potential effect to check the banded leaf and sheath blight pathogen. Similar research was also performed for screening of maize genotype against Southern Leaf Blight during summer at Lamahi using 20 maize genotypes and results revealed that two maize genotypes RampurSO3FO8 (yield 1.8 ton/ha, mean AUDPC 65), Across- 0091 (yield 1.65 ton/ha, mean AUDPC 67.08) were found significantly superior in terms of disease resistant and grain yield both.	Karki, 2018; Rijal, 2018; Pangeni et al., 2019; Yadav & Chaudhary, 2020; Shah & Pande, 2019
Vegetables- A trial with different fungicides tested against late blight of potato in Dang, Sectin was found to be more effective in controlling disease with least disease severity (18.7 %), least disease incidence (5.33%), least mean AUDPC (85.56) and high tuber yield (9.49 kg/ plot) over Relaxyl, Antracol, Mancozeb, Metalayxl, Cerbendazim and control. While evaluating the five local cultivars of potato with two checks for their host resistant against late blight, Khumal Ujowal had recorded the significantly lowest disease incidence and severity.	Paudel, 2019; Pandit & Bhatta, 2019

Fruits-In Chitwan, *Fusarium* wilt was the serious disease and pseudo stem borer was key pest damaging the banana.	Shrestha et al., 2020; Neupane, 2020
Mushroom cultivation packages	
A study on different substrates used for growing oyster mushroom, lentil straw was found most suitable followed by rice straw mixed with maize cob at Lamahi. The rice straw + banana leaves could also be reasonably used in mixture with rice bran supplement for better mushroom cultivation. On different method of substrate sterilization, the Bavistin and formaldehyde recorded the highest yield (1.86 kg/ bed) of mushroom. Substrate sterilized neem extract+ steam also produced good yield with low contamination. In another research, steam sterilization was found to be most effective sterilization technique. Among different doses of gibberellic acid applied on oyster mushroom cultivation, the highest yield (2851.5 g ball^{-1}), number of fruiting body (47), the effective primordia (11) and better stipe length (5.123 cm)was found in 10 ppm of GA3 application. Similarly, it was noted that the largest stipe length (6.49 cm)and stipe diameter (1.57 cm) was found on rice bran and lime, respectively. The highest mushroom yield and biological efficiency were recorded when corn flour followed by chickpea powder were added as the catalyst.	Pokharel et al., 2019 Neupane et al., 2021; Aryal & Kandel, 2020; Gautam & Devkota, 2021 Parajuli & Pokharel, 2021; Pandey et al., 2022

Major Research Innovations in Different Thematic Areas of Social Sciences

About 37 students have accomplished the mini-thesis research in Agri-Eco (22 mini-thesis with 33 students) and Agri-Extension (3 min-thesis by 4 UPA students). A student produced mini-theses in food security status of Pyuthan district, while 3 mini-theses by 4 students have developed in Agri-Extension, suggesting that the dissemination of technology is lagging over there at PTC (Table 9). The major UPA research innovations on various socio-economic status at PTC during 2018-2022 is given in Table 10.

Table 9

Two- way Matrices on Number of UPA Thesis in Various Thematic Areas under Social Science Subjects at IAAS PTC, Lamahi, Dang during 2018-2022

SN	Major thematic subjects of research			**Total**
	Subjects	Production economics	Food security survey	
Agri-Economics				
1	Agronomic crops	4 (7)	1 (1)	5 (8)
2	Horticultural crops	9 (12)		9 (12)
3	Animals	6 (10)		6 (10)
4	Apiculture	1 (1)		1 (1)
5	Food security		1 (2)	1 (2)

	Total	20 (30)	2 (3)	22 (33)
Agri-Extension		Adoption measures	Socio-economic survey	
1	Agronomic crops	1 (1)	1 (1)	2 (2)
3	Animals		1 (2) Animal Nutrition	1 (2)
	Total	1 (1)	2 (3)	3 (4)

Table 10

Major Research Innovations on Economics of Agronomic and Horticultural Crops, Poultry and Fishes, Honey Bees and Food Security Status by the UPA Research Students of PTC during 2018-2022

Major socio-economic innovations in various crops and animal sciences	References
1. **Agronomical Crops**	
Rice-A field survey study in Lamjug resulted higher B: C ratio (1.78)and found to be economical. **Maize**- The benefit: cost ratio (1.38) of small sized farm in growing maize in Lamahi was most beneficial than the bigger sized farm. **Sugarcane**- The survey in sugarcane accomplished in Nawalparasi has found a profitable business, wherein the Gross and Net Returns wereNRs.270222.30 $ha^{-1}$and NRs 102628.20 ha^{-1}, respectively. **Cotton**-Economic analysis on cotton exhibited that the higher B:C ratio (1.98) was most profitable in Dang district in which, the gross and net profit was found to be NRs.126729 ha^{-1}andNRs.62889.45 ha^{-1}, respectively.	Adhikari, 2018; Acharya et al., 2022; Bharati, 2018; Joshi, 2020
2. **Horticultural Crops**	
Vegetables: Socio-economic analysis on tomato in Lamahi Dang recorded the higher B:C ratio (3.70) and gross margin (NRs.27621.20 ha^{-1}) and found very much profitable. On the same way another research on tomato resulted that the higher B:C ratio (2.66) and average return was found to be NRs.83578.05 $kattha^{-1}$. **Spices:** The survey on ginger production in West-Rukum district resulted the higher gross return (NRs.35839 $ropani^{-1}$) and net return (NRs.20666.02 $ropani^{-1}$). Another survey on large cardamom in Bhojpur district exhibited the higher B:C ratio (3.75) as the most profitable enterprises in the survey area. **Fruits:** The survey on oranges in Syangja resulted the higher B:C ratio indicating that the business was found to be profitable. Survey on banana in Chitwan expressed the higher B:C ratio (1.52) and the average production cost NRs. 5211.65 $kattha^{-1}$. **Chamomile-**The survey on chamomile in Dang district noticed the higher B: C ratio (1.72) and total return (NRs.143407.40 $katha^{-1}$).	Basyal, 2018; Gyawali and Shah, 2022; Magar & K.R., 2019; Rai, 2020; Marasini, 2018; Rijal, 2019; Chaudhary, 2020

3. **Animal Science**	
Broiler chicken- In Deukhuri valley, the B: C ratio (1.41) of poultry business was noticed to be profitable. The B:C ratio of different sized poultry in Dang is 1.11 for small sized farm,1.243 for medium sized farm and 1.283 for large sized farm suggesting to increase the poultry population to be economical. In Chitwan the B:C ratio of broiler production for small, medium and large sized farms were 1.09,1.20 and 1.27 and suggested to follow it in large scale.	Paudel, 2018; Neupane & Basnet, 2020; Dawadi, 2022
Fishes-The B: C ratio of fish farming was 2.47, 2.25 and 1.62 in Rupandehi, Kapilvastu and Dang districts, suggesting the most feasible and beneficial cultivation was in Rupandehi mainly due to the easy access of fish fingerlings and feed market over there.	Dhakal & Ghimire, 2022
Milk- At Lamahi, the marketing channel of dairy milk was analyzed and advocated that about 78% of 5047 tons produced milk was marked surplus, of which 89% to formal marketing, 3% to local channel and 97% to large processor. On the same way another survey was done on milk, wherein the highest gain was by processor (59.57%) followed by producer (40.6%) and by retailer (9.75%).	Kandel, 2019; Ojha et al., 2021
Honey bees-B: C ratio of *Apis mellifera and Apis cerena* was 1.88 and 3.71, respectively, recommend to increase the cultivation of *A. cerena* in Lumbini province.	Yogi, 2019
Food security status- Rural areas faced more food security problem than the urban areas of Pyuthan district suggesting to follow scientific crop production packages in the hilly districts of Nepal.	Paudel & Poudel, 2021

Conclusion

Though the UPA research conducted by the B Sc Ag students could not produce the technology recommendations, but it ways-out the major avenues to be prioritized for the future research. After rigorous review study, a range of innovative and relevant research programmes including the effective and efficient on-farm research and extension systems would be suggested as urgent need for substantially narrowing the yield gaps of various agronomic and horticultural crops and livestock animals and wider benefits to the farmers. In agronomic crops, biodiversity conservation, development of high yielding varieties and eco-region suited technology identification through agro-climatic modeling should be given emphasis. Variety identification, weed management and up-scaling the technologies is really needed for hilly uplands. Ecological zone classification and technology identification and hybrid seed production could be some priority areas for maize and wheat researches around Lamahi areas. Search for the cost- and energy-efficient production technology options is major challenge in vegetable production. Integrated nutrient management (INM) and integrated pest

management (IPM) approaches should be emphasized. Researches on precision agriculture like conservation agriculture and crop diversification for value addition as like in chamomile, honey bees, citrus and banana fruits, marigold and other new innovative areas were very rare at PTC, and hence, therefore would be very beneficial to start the UPA researches in this line. Further research funding would be granted to continue and flourish the advance and innovative UPA research works at PTC. The outputs of researches published in PTC journals should also be disseminated for the welfare of the mid-western terai and hill areas of Lumbini and adjacent Provinces.

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