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REGRESSION ANALYSIS OF ROTATIONAL INTENSITY, CROP DIVERSITY INDEX, LAND UTILIZATION INDEX AND YIELD EFFICIENCY IN BIO-INTENSIVE AND CONVENTIONAL FARMING SYSTEMS IN NEPAL

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ABSTRACT

This study was conducted in Udayapur district, Nepal. A questionnaire-based survey with 100 household heads along with field visit and personal interaction with the concerned farmers were conducted to gather required information. Data were analyzed to compute rotational intensity (RI), crop diversity index (CDI), land utilization index (LUI), and yield efficiency (YE). Regression analyses were done to reveal relationships among these traits. Bio-intensive farming system (BIFS) farmers were found to practice scientific crop rotation substantially more than conventional farming system (CFS) farmers both in rice-based and maize-based cropping systems. In this study, higher RI, CDI, LUI and YE were found in sustainable bio-intensive farming system (BIFS) as compared to conventional farming system (CFS). The study has revealed strong positive relationship of RI with CDI and LUI in BIFS, CFS and in general. Cropping system both in BIFS and CFS with scientific crop rotation that ensures higher CDI and LUI is recommended for increasing yield efficiency. Direct positive relationship among RI, CDI and LUI has been revealed by this study as a rule; and has suggested to be used in validating yield efficiency of optional farming system as compared to the mainstream conventional farming system.

Key words: r*otational intensity, crop diversity index, land utilization index, yield efficiency, bio-intensive farming system.*

INTRODUCTION

Proponents of High Chemical Inputs Agriculture System (HCIAS) generally argue that developing countries should opt for an agro-industrial model that relies on standardized technologies and ever-increasing use of the chemical fertilizers and pesticides to provide additional food supplies for growing population. In contrast, a growing number of farmers, agro-ecologists, I/NGOs and analysts propose that instead of the capital and petro-chemical input-intensive as well as environment-degrading approach, developing countries should favour an agro-ecological and socio-economic model (Altieri, Rosset, & Thrupp, 1998; Rajbhandari, 2000). Many of the techniques that comprise the bio-intensive method were present in the agriculture of the ancient Chinese, Greeks, Mayans, and of the Early Modern period in Europe (early 90s). Bio-intensive farming is a system that emphasizes biodiversity conservation, recycling of nutrients, synergy among crops, animals, soils, and other biological components, and regeneration and conservation of resources. In other words, the concept and approaches of BIF system is based on holistic system of sustainable management of natural resources in a given agro-ecosystem with specific cultural and knowledge base (Rajbhandari & Gautam, 1998). The bio-intensive method was further developed by Ecology Action (2001) into a sustainable 8-step food-raising method known as "GROW BIOINTENSIVE".

The principles of BIF system include scientific crop rotation; mixed farming systems; optimization of organic recycling; participatory and sustainable management of natural resources including biodiversity; participatory research and extension; and attainment of high degree of self-reliance of farm households against external techno-economic shocks (Rajbhandari, 2000). The bio-intensive approach is initially more labor-intensive than conventional approaches, and therefore best suites to small scale family centered food production in urban or rural settings. The bio-intensive farming system is a biologically intensive mixed farming system, which relies on intensive engagement of farmers, and organic recycling optimization through intensive scientific crop rotations. It relies on appropriate spatial management of field crops, vegetable crops, fruits and fodder trees as well as livestock and poultry for rational and ecologically non-destructive utilization of lands. Furthermore, it increases the soil fertility, revitalizes the degraded soil, decreases environmental pollution and prevents health hazards to humans and livestock as well as reduces further degradation of the environment, which otherwise might lead to desertification of the land. It is, therefore, not only eco-friendly but also friendly to human and animal health (Rajbhandari, 2010 b).

The technique behind adopting bio-intensive farming is that cropping systems and techniques specially tailored to the needs of specific agro-ecosystems are based on local inputs and techniques with each combination fitting to particular ecological resources by combining different components of the farming system (plants, animal, soil, water, climate and people) in order to optimize the synergistic interaction among the components (Rajbhandari, 2010 b). In this approach, performance criteria include not only increased production but also properties of sustainable food security, biological stability, resource conservation and equity (UNDP, 1995). However, there is not a single and simple method of validating efficiency of the alternate farming system like BIFS as compared to the mainstream conventional (petro-chemical based) farming system.

This study was conducted to estimate and analyze the relationships among rotational intensity, land utilization index, crop diversity index and yield efficiency, and find out the means of validating efficiency of bio-intensive farming as compared to the mainstream conventional farming system.

MATERIALS AND METHODS

Bio-intensive farming system initiative has been implemented in Udayapur, Nepal for the last 15 years; and therefore this district was selected as the study site. This study was conducted covering four Village Development Committee (area) s i.e. Rauta, Triveni, Hadiya and Jogidaha and one Triyuga municipality. Sample households were taken based on the farmer's engagement in bio-intensive farming system (BIFS) and conventional farming system (CFS). The total sample size was 100 households, i.e. 50 households from each system (10 households per VDC/municipality). Purposive random sampling technique was used to select the required number of households from both systems.

The study was based on the primary data collected from the household heads or senior members with the help of semi-structured questionnaire and published secondary information. No obstacles were faced while conducting the survey. The local farmers were quite supportive. The questionnaire was developed to gather relevant information required to meet the specific objectives. The questionnaire was first pre-tested with randomly selected ten farmers from the same communities for its accuracy and clarity. Some of these farmers were also included in the final round of interview. The questionnaire was finalized by incorporating farmers' suggestions. The collected data were grouped, coded and entered into the computer for processing. Computer software MS excel was used to analyze the data. Mean value, standard deviation (SD) and R^2 were obtained to interpret the results. Similarly information was also used to compute Rotational Intensity (RI), Land Utilization Index (LUI), Crop Diversity Index (CDI), and Yield Efficiency (YE). These were computed using the formulae given below. The number of crops grown in 5-year rotation, and respective areas and crop yields were taken into consideration. Regression plains were drawn and R^2 determined to estimate relationship between various parameters.

$$RI = \frac{\text{No. of crops grown in a rotation}}{\text{Duration of rotation}} \times 100$$

$$LUI = \sum_{i=1}^{n} a_i d_i / A \times 365$$

Where, a_i=Area occupied by i^{th} crop

d_i =days occupied by i^{th} crop

A=Total cultivated area available for 365 days (1 year)

n=Total number of crops gown per year

$$CDI = 1 - \sum x^2 / (\sum x)^2$$

Where, x=Area under the individual crop

$$YE = Y_a / Y_l \times 100$$

Where, Ya= Yield per unit area of the farm

Y_l=Yield per unit area of locality

RESULTS AND DISCUSSION

Scientific crop rotation

Scientific crop rotation is one of the important agro-techniques employed in order to reduce the pest incidence in the field as well as sustain crop yield. It was found that 68 percent of the BIFS adopting households followed the scientific crop rotation but in the case of CFS adopting households the case was just opposite. Sixty four percent of the households employing CFS had not followed scientific crop rotation (Figure 1). Those who did not followed the crop rotation usually used to grow the same vegetable (in the rice-based and maize-based cropping systems) in the same season, which actually provided ground for pest incidence.

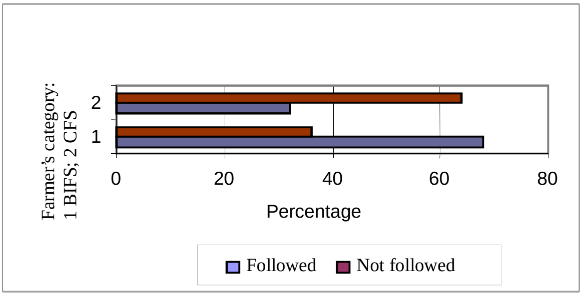

Figure 1: Practice of scientific crop rotation by the respondents (%)

Rotational intensity (RI), CDI, LUI and YE

Computed mean values and standard deviations of rotational intensity (RI), crop diversity index (CDI), land utilization index (LUI) and yield efficiency (YE) in bio-intensive farming system and conventional farming system are presented in Table 1.

Table 1. Mean values and SD of RI, CDI, LUI and YE in BIFS and CFS

Farming systems		RI, %	CDI	LUI	YE, %
BIFS	Mean	440	0.70	0.91	123.00
	SD	54.77	0.054	0.035	12.29
CFS	Mean	260	0.44	0.65	84.00
	SD	54.77	0.051	0.055	11.00

It is evident from the table 1 that RI was only 260 percent in CFS, where farmers used to grow only 2-3 crops in the annual pattern, while in case of BIFS it was 440 percent (increase by 180%). The BIFS adopting farmers used to grow 4 or more crops in the annual cropping pattern. Owing to higher RI the BIFS had higher CDI (0.70) than in CFS (0.44). Likewise, the BIFS had higher LUI (0.91) and YE (123%) as compared to the CFS (LUI = 0.65, YE = 84%). Rajbhandari (2010 a) and Duwal (2008) have shown that CDI and LUI have direct positive relationship with yield efficiency.

BIFS farmers had higher return due to the higher RI, CDI and LUI. This clearly showed the supremacy of bio-intensive farming system based on sustainable agro-ecological approach over petro-chemical based conventional farming system.

Regression analysis of RI, CDI and LUI

Regression plains computed among various pairs of quantitative traits have revealed strong positive relationship of RI with CDI and LUI and that of CDI with LUI in general (in both systems together) and in both systems- BIFS and CFS-separately (Fig. 2 to 10). The computed value of R^2 in all pairs of traits in both systems combined (general) and separately was statistically significant (P= 0.900).

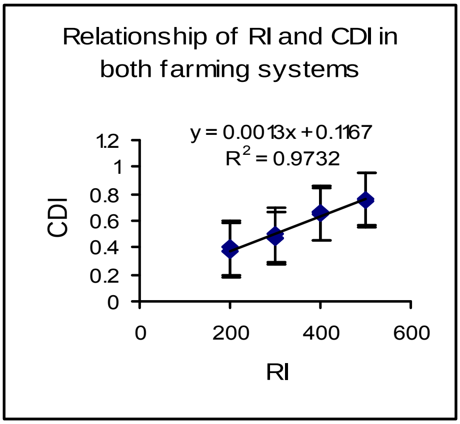

Figure 2: Relationship between RI & CDI in both farming system combined

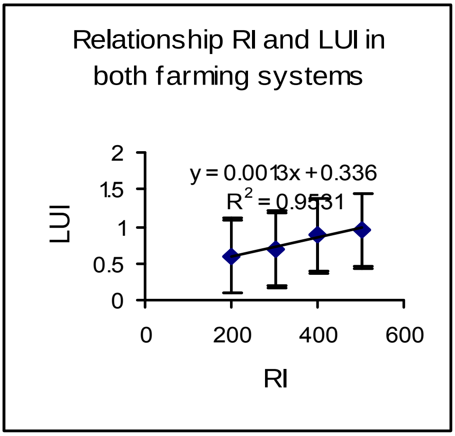

Figure 3: Relationship between RI & LUI both farming system combined

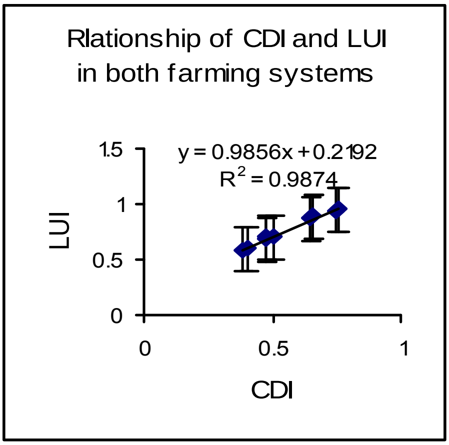

Figure 4. Relationship between LUI & CDI in both farming systems combined

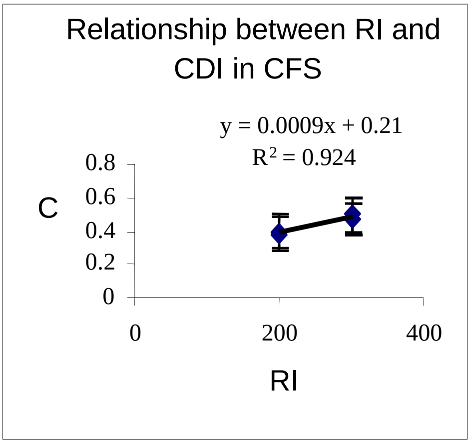

Figure 5. Relationship between RI and CDI in CFS in both farming systems combined

Similar trends in the relationship among CDI, LUI and YE were reported by Rajbhandari (2010a). Positive relationship between cropping intensity and CDI was reported by Shahidullah *et al* (2006). The findings of this study were at par to those described by Rajbhandari (2010 a), Duwal (2008) and Shahidullah et al (2006).
Regression analysis has also revealed strong negative relationship of crop rotation and LUI with severity (incidence) of pest damage as reported by Duwal (2008) and Rajbhandari (2010 a). Obviously, in the CFS where RI and LUI are lower, the pest damage to yield is substantial. This is an important reason that yield has been declining in the mono-cropping-based farms, where the use of only chemical fertilizers along with chemical pesticides are continued without following scientific crop rotation. The farmers adopting BIFS had reported lesser incidence of crop damage by pests, and they have higher cropping intensity, CDI and YE (Duwal, 2008).

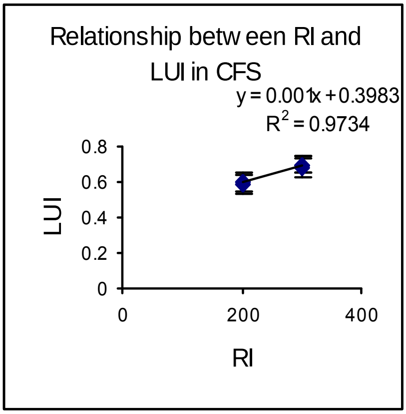

Figure 6. Relationship between RI & LUI in CFS

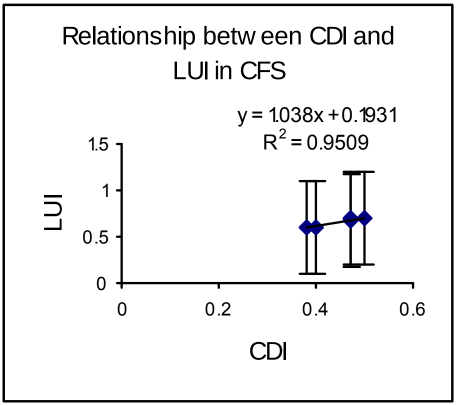

Figure 7. Relationship between CDI and LUI in CFS

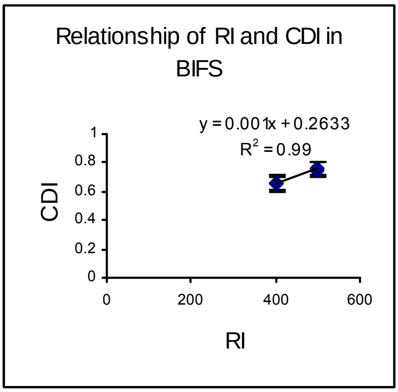

Figure 8. Relationship between RI & CDI in BIFS

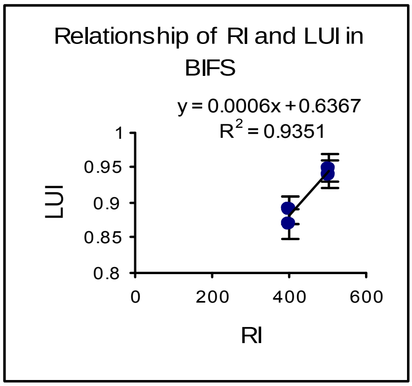

Figure 9. Relationship between RI and LUI in BIFS

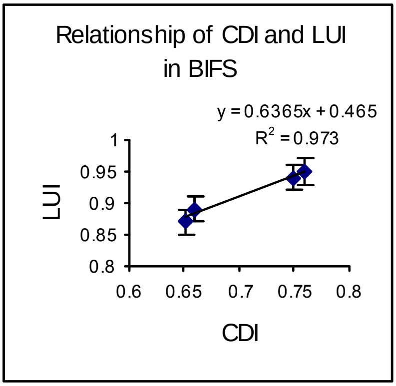

Figure 10. Relationship between CDI and LUI in BIFS

The RI, CDI and LUI had direct positive relationship in general (Figure 11) as well as in both farming systems separately (Figure 12 & 13). Thus direct positive relationship among RI, CDI and LUI has been revealed by this study as a rule that might be used in validating yield efficiency of optional agricultural system, e.g. BIFS as compared to the mainstream conventional agricultural system.

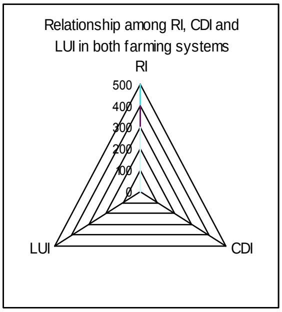

Figure 11. Relationships among RI, CDI & LUI in general (both farming systems combined)

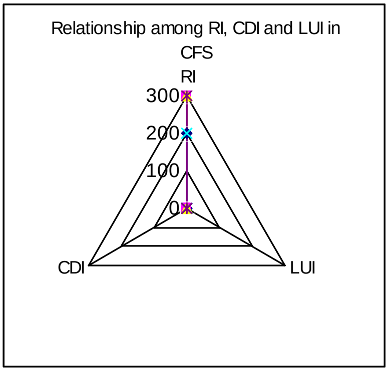

Figure 12. Relationship among RI, CDI & LUI in CFS

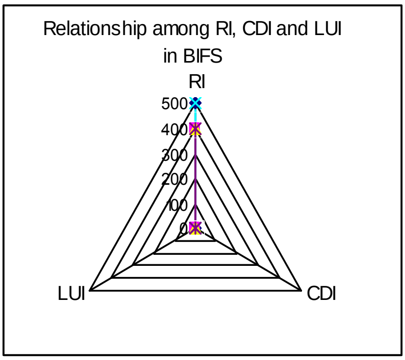

Figure 13. Relationship among RI, CDI & LUI in BIFS

CONCLUSION

It is obvious from the findings that scientific crop rotation increases crop diversity and land utilization, and consequently the total crop yield in a given locality both under bio-intensive and conventional farming systems. Bio-intensive farming may be one of the best options to govern this relationship positively in favour of ecology and environment protection as well as food production and human health.

Direct positive relationship among RI, CDI and LUI has been revealed by this study as a rule that might be used in validating yield efficiency of optional agricultural system as compared to the mainstream conventional agricultural system.

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