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# Productivity and land use of different cropping systems under conventional and natural farming in mid hills of Himachal Pradesh

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## Abstract

**A field experiment was carried during *Rabi* and *Kharif* season of 2019-20 to evaluate the productivity and profitability of different cropping systems under conventional and natural farming in mid- hill conditions of Himachal Pradesh at AICRP-IFS Research Farm (Bhadiarkhar) of CSK Himachal Pradesh Krishi Vishvavidyalaya, Palampur. The soil of the test site was silty clay loam in texture, acidic in reaction, medium in organic carbon, low in available nitrogen, high in available phosphorus and medium in available potassium. Fourteen different cropping systems were eveluated for rice grain equivalent yield and land use efficiency to meet out the objectives of the study. Results revealed that under both conventional and natural farming, vegetable-based cropping systems proved superior to rest of cropping systems for productivity as well as profitability. Okra-radish-garlic cropping system resulted in highest rice grain equivalent yield. Similarly, higher rotational intensity was obtained under vegetable-based cropping systems owing to three crops in a rotation. Land use efficiency and cultivated land utilization index was also highest under okra-radish-garlic which was followed by okra-potato-frenchbean cropping system. Rice-wheat cropping system resulted in lowest land use efficiency and cultivated land utilization index.**

**Key words:** Rice grain equivalent yield, cropping system, diversification, land use efficiency

Agricultural productivity cannot be expected to increase unless adequate inputs such as improved seeds, power, fertilizers and irrigation water are available in a timely manner and used judiciously. Effective planning is required for energy use given the current rise in global population. A major dilemma for the developing world is how to provide more food for the world's expanding populations in the coming decades while also eradicating poverty and hunger presently. One of the promising ways to maximize land use and production is to diversify the system by growing legume or oilseed crops as intercrops in cereals. Crop diversification holds great promise for addressing these issues as well as meeting basic food needs for cereals, pulses, oilseeds, and vegetables, regulating farm income, enduring weather anomalies, controlling price fluctuation, ensuring a balanced food supply, conserving natural resources, lowering the use of chemical fertilisers and pesticides, ensuring environmental safety, and generating employment opportunities. Inclusion of vegetables in traditional cropping systems can improve system productivity and resource use efficiency. So, multiple cropping systems are viable option to increase the income of small and marginal farmers (Rana *et al*. 2011; Sharma *et al*. 2009). Intercropping is a sophisticated agronomic practice that allows two or more crops to be grown on the same plot of land. It is one of the most effective ways to improve resource utilisation and reduce weed competition, which improves yield stability and guarantees higher returns per unit area and time. It is mostly used to mitigate the risk of one of the component crops failing owing to unpredictable weather patterns or an occurrence of pests and diseases. When legume cereal intercropping is used instead of a single cereal crop, higher protein and grain yields are obtained (Lauk and Lauk 2005). Gram supplies nutrients to wheat through nitrogen fixation and uses less water, albeit from different soil layers as wheat. Intercropping of wheat and gram in the ratio of 3:1 and 1:1 resulted into maximum seed yield and monetary returns as compared to sole crops (Khan *et al*. 1999). Khan *et al*. (2005) found that chickpea and wheat intercropping in a 1:1 ratio resulted in maximum increase in wheat grain yield. Growing cereals with oilseeds of varying growth patterns and rooting depths promotes better extraction of soil moisture as well as nutrients from different soil profiles. Mixed intercropping of linseed with wheat led to increased spike length in spring wheat which resulted in a greater number of spikelets and grains (Klimek-Kopyra *et al*. 2016). Among field crops, legumes involve less energy than cereals and oilseeds. Maize production incurs much higher input of energy, mainly due to its high water and fertilizer requirements coupled with other practices like earthing up, weed control, harvesting and threshing. Existing cropping systems may not be efficient energy converters, therefore alternative cropping systems need to be designed so that apart from higher productivity and profitability, it must be efficient converter of energy (Kachroo *et al*. 2012). Thus, keeping in view above mentioned facts, present study was conducted with an objective to evaluate the productivity of different cropping systems in mid-hill conditions of Himachal Pradesh.

## Materials and Methods

The experiment was conducted during *Rabi* and *Kharif* season of 2019-20 at Bhadiarkhar Research farm of CSK Himachal Pradesh Krishi Vishvavidyalaya, Palampur. The experimental farm is located at 320 6′ N latitude, 760 3′ E longitude in the mid hills of North-West Himalayas at 1290 m altitude in the Palam valley of Kangra district of Himachal Pradesh. The region receives an average annual rainfall of 2600 mm (about 80% rainfall is received during June to September) along with occasional rainfall during winters (December to February). The soil of the test site was silty clay loam in texture, acidic in reaction, medium in organic carbon, low in available nitrogen, high in available phosphorus and medium in available potassium. Fourteen different cropping systems were compared for productivity and profitability. It was non replicated experiment, with different systems sown under total area of 7900 square meter. Area to each cropping system in both conventional and natural farming was allocated as mentioned in Table 1. Observations from each crop were taken from 1 square meter area from four random sites in each cropping system and considered as replicates. The data were subjected to statistical analysis in RBD design using the techniques of

**Table 1. Area allotted to different cropping systems**

| Treatment | Cropping system | Area ($m^2$) (Conventional farming) | Area ($m^2$) (Natural farming) |
|---|---|---|---|
| $T_1$ | Maize-wheat | 150 | 50 |
| $T_2$ | Maize + soybean-gobhi sarson | 225 | 75 |
| $T_3$ | Maize + cowpea-wheat + gram | 150 | 50 |
| $T_4$ | Soybean-gobhi sarson | 300 | 100 |
| $T_5$ | Soybean-wheat | 150 | 50 |
| $T_6$ | Rice-wheat | 2700 | 900 |
| $T_7$ | Rice-wheat + gram | 300 | 100 |
| $T_8$ | Rice-wheat + mustard | 300 | 100 |
| $T_9$ | Rice-wheat + lentil | 300 | 100 |
| $T_{10}$ | Rice-wheat + linseed | 300 | 100 |
| $T_{11}$ | Okra -radish-garlic | 150 | 50 |
| $T_{12}$ | Okra -potato-french bean | 300 | 100 |
| $T_{13}$ | Okra -potato -green manuring crop | 300 | 100 |
| $T_{14}$ | Okra + soybean-pea | 300 | 100 |

analysis of variance as described by Gomez and Gomez (1984). The treatment differences were compared at 5 per cent level of significance.

Yield of each crop obtained from net plot area was converted into kg/ha which was then converted into rice grain equivalent yield on price basis.

$$\text{RGEY (kg/ha)} = \frac{\text{Yield of crop (kg/ha) x Price of crop (Rs)}}{\text{Price of rice crop (Rs)}}$$

The RGEY of component crops in each cropping system were added to obtain the total RGEY of cropping system in different treatments.

Rotational intensity was calculated by dividing the number of crops grown in rotation by duration of rotation. Land use efficiency indicates the per cent land use in terms of duration. It was calculated by dividing the summation of number of days occupied by each crop to total number of days in year (365). Cultivated land utilization index was calculated by summing the products of land area to each crop, multiplied by the actual duration of that crop divided by product of total crop cultivated area and the total number of days in a year (365).

## Results and Discussion

### *Rice Grain Equivalent Yield*

The rice grain equivalent yield of *rabi* and *kharif* season is presented in Table 2. During *rabi* season, significantly higher rice grain equivalent yield was observed in radish-garlic crop sequence as compared to all other treatments in both conventional and natural farming. Significantly lower rice grain equivalent yield was noted in treatment where only pea was grown ($T_{14}$) in *rabi* season though it was found to be statistically at par with treatments under wheat + gram, wheat + lentil and wheat + linseed cropping systems in conventional farming. Under natural farming, lowest equivalent yield was observed under wheat + lentil system. In *kharif* season, maize + soybean cropping system resulted in significantly higher rice grain equivalent yield over all other systems under conventional farming; whereas under natural farming significantly higher equivalent yield was obtained in$T_5$(soybean). Lowest rice grain equivalent yield was observed where only okra was grown in *kharif* season in both conventional and natural farming systems.

**Table 2. Rice grain equivalent yield of different cropping systems in *rabi* and *kharif* season**

| *Rabi* season | | | | *Kharif* season | | | |
|---|---|---|---|---|---|---|---|
| | Treatment | RGEY (kg/ha) | | | Treatment | RGEY (kg/ha) | |
| | | Conventional | Natural | | | Conventional | Natural |
| $T_1$ | Wheat | 3761 | 2539 | $T_1$ | Maize | 3571 | 1200 |
| $T_2$ | Gobhi sarson | 4583 | 1904 | $T_2$ | Maize + soybean | 6705 | 3443 |
| $T_3$ | Wheat + gram | 3739 | 2084 | $T_3$ | Maize + cowpea | 4536 | 1746 |
| $T_4$ | Gobhi sarson | 4218 | 996 | $T_4$ | Soybean | 5314 | 4414 |
| $T_5$ | Wheat | 3865 | 1980 | $T_5$ | Soybean | 5614 | 4543 |
| $T_6$ | Wheat | 4190 | 1571 | $T_6$ | Rice | 3148 | 1222 |
| $T_7$ | Wheat + gram | 3610 | 1510 | $T_7$ | Rice | 2963 | 1300 |
| $T_8$ | Wheat + mustard | 3926 | 1173 | $T_8$ | Rice | 3110 | 1360 |
| $T_9$ | Wheat + lentil | 3160 | 907 | $T_9$ | Rice | 2923 | 1340 |
| $T_{10}$ | Wheat + linseed | 3473 | 1433 | $T_{10}$ | Rice | 3073 | 1270 |
| $T_{11}$ | Radish-garlic | 40000 | 24642 | $T_{11}$ | Okra | 1143 | 450 |
| $T_{12}$ | Potato-french bean | 11766 | 5500 | $T_{12}$ | Okra | 1000 | 643 |
| $T_{13}$ | Potato -green manuring crop | 13969 | 7650 | $T_{13}$ | Okra | 1029 | 643 |
| $T_{14}$ | Pea | 3333 | 3000 | $T_{14}$ | Okra + soybean | 2086 | 2636 |
| | SEm± | 135 | 87 | SEm± | 45 | 30 | |
| | LSD (P=0.05) | 388 | 248 | LSD (P=0.05) | 129 | 88 | |

Total rice grain equivalent yield of annual cropping systems is given in Table 3. It reveals that as compared to all other treatments; significantly higher total equivalent yield was obtained under $T_{11}$ (okra-radish-garlic) under both conventional and natural farming systems. This was followed by $T_{13}$ (okra-potato-green manuring crop). Treatment $T_{14}$ (okra + soybean -pea) resulted in significantly lower total rice grain equivalent yield under conventional farming. Whereas, under natural farming, $T_9$ (rice-wheat + lentil) resulted in significantly lower rice grain equivalent yield. The per cent increment in total rice grain equivalent yield in $T_{11}$ (okra-radish-garlic) over $T_1$ (maize-wheat) and $T_6$ (rice-wheat) was 461 and 460 per cent, respectively under conventional farming, whereas corresponding increments under natural farming were 571 and 798 per cent, respectively .The higher equivalent yield in these systems may be attributed to replacement of rice, maize and wheat with high volume and high-priced vegetable crops such as potato, radish and garlic (Sharma *et al*. 2015). The results are in agreement with Chaudhary *et al*. (2001) who reported higher productivity by replacing wheat with vegetables like radish and potato. Moreover, increased productivity by inclusion of vegetables in existing rice-wheat system is reported by many workers (Sharma *et al*. 2008; Tripathi and Singh, 2008).

***Rotational Intensity***

Data on rotational intensity of different cropping systems is presented in Table 4. Due to the similar planting and harvesting dates for various crops under each treatment in both production systems, the rotational intensity of each treatment under conventional and natural farming was the same. Highest rotational intensity (300) was observed in $T_{11}$ (okra-radish-garlic), $T_{12}$ (okra-potato-frenchbean) and $T_{13}$ (okra-potato-green manuring crop). Higher rotational intensity in these cropping systems is attributed to more number of short duration vegetable crops taken in a year

***Land Use Efficiency* (LUI)**

Land use efficiency differed under different cropping systems (Table 4). Due to the identical planting and harvesting dates for each treatment under conventional and natural farming, land use efficiency

**Table 3. Total RGEY of different cropping systems**

| Treatment | | Total RGEY (kg/ha) | |
|---|---|---|---|
| | | Conventional | Natural |
| $T_1$ | Maize-wheat | 7333 | 3739 |
| $T_2$ | Maize + soybean-gobhi sarson | 11288 | 5347 |
| $T_3$ | Maize + cowpea-wheat + gram | 8275 | 3831 |
| $T_4$ | Soybean-gobhi sarson | 9533 | 5411 |
| $T_5$ | Soybean-wheat | 9480 | 6523 |
| $T_6$ | Rice-wheat | 7339 | 2794 |
| $T_7$ | Rice-wheat + gram | 6574 | 2811 |
| $T_8$ | Rice-wheat + mustard | 7036 | 2534 |
| $T_9$ | Rice-wheat + lentil | 6083 | 2247 |
| $T_{10}$ | Rice-wheat + linseed | 6547 | 2703 |
| $T_{11}$ | Okra -radish-garlic | 41143 | 25093 |
| $T_{12}$ | Okra -potato-french bean | 12767 | 6143 |
| $T_{13}$ | Okra -potato -green manuring crop | 14998 | 8293 |
| $T_{14}$ | Okra + soybean-pea | 5419 | 5636 |
| | SEm± | 141 | 87 |
| | LSD (P=0.05) | 405 | 250 |

**Table 4.** **Rotational intensity, land use efficiency and cultivated land utilization index of different cropping systems**

| Treatment | | Rotational Intensity | LUE | CLUI |
|---|---|---|---|---|
| $T_1$ | Maize-wheat | 200 | 76.71 | 0.77 |
| $T_2$ | Maize + soybean-gobhi sarson | 200 | 71.78 | 0.72 |
| $T_3$ | Maize + cowpea-wheat + gram | 200 | 73.97 | 0.74 |
| $T_4$ | Soybean-gobhi sarson | 200 | 83.56 | 0.84 |
| $T_5$ | Soybean-wheat | 200 | 86.03 | 0.86 |
| $T_6$ | Rice-wheat | 200 | 69.32 | 0.69 |
| $T_7$ | Rice-wheat + gram | 200 | 72.05 | 0.72 |
| $T_8$ | Rice-wheat + mustard | 200 | 72.05 | 0.72 |
| $T_9$ | Rice-wheat + lentil | 200 | 69.86 | 0.70 |
| $T_{10}$ | Rice-wheat + linseed | 200 | 75.89 | 0.76 |
| $T_{11}$ | Okra -radish-garlic | 300 | 94.25 | 0.94 |
| $T_{12}$ | Okra -potato-french bean | 300 | 86.58 | 0.87 |
| $T_{13}$ | Okra -potato -green manuring crop | 300 | 72.60 | 0.73 |
| $T_{14}$ | Okra + soybean-pea | 200 | 73.42 | 0.73 |

*Due to the similar planting and harvesting dates for various crops under each treatment in both production systems, the rotational intensity, LUE and CLUI of each treatment under conventional and natural farming was the same

was the same for both production systems. $T_{11}$ (okra-radish-garlic) resulted in highest land use efficiency (94.25) which was followed by $T_{12}$ (okra-potato-frenchbean) with land use efficiency of 86.58. Lowest land use efficiency was observed in $T_6$ (rice-wheat) which was followed by $T_9$ (rice-wheat + lentil). More number of crops in vegetable-based cropping systems resulted in increased land use efficiency as compared to traditional rice- wheat system. Similar results were reported by Kumar (2015) who found that diversification through the inclusion of vegetables in the cropping system increases land use efficiency.

***Cultivated Land Utilization Index*** **(CLUI)**

Data on cultivated land utilization index is given in Table 4. Because different crops were planted and harvested at the same times for each treatment in both production systems, cultivated land utilization index was the same for each treatment under conventional and natural farming. Highest cultivated land utilization index (0.94) was obtained in $T_{11}$ (okra-radish-garlic). Whereas lowest cultivated land utilization index (0.69) was noted in $T_6$ (rice-wheat). Vegetable based cropping systems occupied land for maximum duration, thereby resulting in higher cultivated land utilization index. The results are in agreement with Sharma *et al*. (2004) who reported that crop diversification by the inclusion of vegetables and leguminous crops in existing cropping system increased land use efficiencies.

## Conclusion

It was observed in the study that higher rice grain equivalent yield was obtained with okra-radish-garlic cropping system. This system also performed better in terms of land use efficiency and cultivated land utilization index. However, traditional rice-wheat system resulted in lowest land use efficiency. Moreover, inclusion of vegetable crops increased rotational intensity as compared to field crops. Hence, it may be concluded that vegetable-based cropping systems should also be included in farming systems for increasing productivity and land use under mid-hill conditions of Himachal Pradesh.

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