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# Vegetable Based Multitier Cropping System: A Model for Higher Income for the Farmers in Old Alluvial Soils of West Bengal

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***Authors' contributions***

*This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.*

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## ABSTRACT

The weather condition prevailing during the crop season always plays very crucial role in crop production. Off and on crops face aberrant weather like flood that causes total crop failure in low line or flood prone areas. Vagaries of weather spoil the source of income which aggravates the farmer's poverty. To overcome the problem of crop failure and financial loss in flood prone areas of Gangetic plain in Malda district, vegetable based multi-tier cropping system was propagated in farmers fields on upland situation. The study was conducted with five combinations of horticulture crops at upland situation of 15 farmers fields in Narayanpur village of Malda district of West Bengal for six years from 2014-15 to 2019-20.The farmers are usually growing single climber crop in upland on bower system and most of the land down under remains unutilized. In this situation, multi- tier cropping system is a resilient practice which opens a new door to the farmers for providing more production and income from succeeding crop. The study showed that practice enhanced production, farm income and subsequently increased the benefit cost ratio up to 3.13. Bitter gourd + elephant foot yam cropping system is economically viable and profitable because it provides highest land equivalent ratio and higher Monetary Advantage Index (MAI) value.

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*Keywords: Crop equivalent yield; land equivalent ratio; Malda; multi-tier horticulture; upland.*

## 1. INTRODUCTION

Unavailability of cultivable land is a major hindrance due to rapid urbanization, construction of dams, rivers, highway roads and degradation of fertile land due to soil erosion, soil salinity and water logging. As per estimates, in India, more than 95 % holdings will be under the category of small and marginal holders by 2050 [1]. Now estimated land is about 150 million ha, soil salinity and water logging about 12 million ha [2]. Further, low land areas are highly at risk due to flood prone. In this context, it is need to improve the crop productivity from a unit area through using both vertical and horizontal available land along with sunlight and other natural resources [3]. Multi-tier cropping system involving multispecies crop combinations, both annuals and perennials and it is a modern alternative approach for sustainable productivity in horticultural crops for small and marginal land which can provide greater economic return per unit area [4]. Multitier cropping systems are dynamic interactive practices that better the use of the production components such as soil, water, air space, solar radiation and all other inputs on sustainable basis to take full advantage of limited land resources [5]. This is most popular and applicable among the small and marginal farmers. Multi- tier cropping system is also beneficial for providing insurance against market glut of single commodity, growing crop according to market demand; maintaining an ecological balance and generating higher income from per unit area, supply food and nutritional security to the farming family [6] and regular employment [7]. In Malda district, a large portion of area is flood prone and the cultivating low land remains under flooding water which causes huge loss of crop, sometimes total crop failure occurs in low-lying areas. Farmers are generally becoming season bound and cultivate seasonal crops. Hence, during the aberrant weather condition, there is limited scope to earn. Vagaries of weather many a times destroy the standing crop, which aggravates their poverty [8]. In this situation the farmers tried to cultivate some short duration and leafy vegetable crops through utilization of available vertical and horizontal space for getting more production and extra income. Therefore, a study was undertaken to assess income and benefit cost ratio under different combinations of treatment in vegetable based multitier cropping system in upland areas of NICRA villages.

## 2. MATERIALS AND METHODS

The study was conducted with 15 farmers fields at upland situation at NICRA (National Innovations on Climate Resilient Agriculture) Project adopted village namely Narayanpur at Malda district of West Bengal from 2014-15 to 2019-20. Geographically, experimental site situated at 23.5°North latitude, 89°East longitude having an average altitude of 9.75 m above mean sea level. The experimental site was located in sub-tropical humid climate with Gangetic old alluvial soil, sandy clay loam texture, and good water holding capacity and with acidic to neutral reaction and moderate fertility status. The land size of each farmer was 666 $m^2$ areas. The experiment Design was randomized block design (RBD). Benefit cost ratio calculated on the basis of cost of cultivation and net return for each treatment. Economical viability and profitability calculated on the basis of CEY, LER and MAI. The data on various characters were analyzed statistically by following the methods of using Software SPSS 20 and MS exel [9].

### 2.1 Crop Equivalent Yield (CEY)

The yields of different intercrops were converted into equivalent yield of main crop based on price of the produce of the crop. The crop equivalent yield (CEY) is calculated as follows,

$$CEY = \sum_{I=1}^{n} (Y_i * E_i)$$

[Where $Y_i$ is yield of main crop and $E_i$ is equivalent factor of main crop or price of main crop.]

Equivalent Yield of main crop= (Yield of main crop x price of main crop)/ price of main crop.

Component crop Equivalent Yield of main crop= (yield of component crop x price of component crop)/ price of main crop.

Crop Equivalent Yield of cropping system = Equivalent Yield of main crop + Equivalent Yield of component crop.

Component crop equivalent yield of main crop, that the value of main crop which is equivalent to component crop.

## 2.2 Land Equivalent Ratio (LER)

Land equivalent ratio (LER) is the relative land area under sole crops that is required to produce the yields achieved through multi tier cropping system. LER can be mathematically represented as follows:

$$LER = \sum_{i=1}^{m} \frac{Y_i}{Y_{ij}}$$

Where, $Y_i$ is the yield of main from a unit area grown as intercrop and $Y_{ij}$ is the yield of another component crop grown in the same area. In brief, LER is the summation of ratios of yields of intercrop to the yield of sole crop.

$$\text{LER of crop} = \frac{\text{Yield as inter crop}}{\text{Yield as sole crop}}$$

LER of cropping system = LER main crop + LER of component crop

**Monetary advantage index (MAI) =**Value of combined crops x (LER-1) / LER

**Table 1. Treatments with crop combinationsof multi-tier horticulture cropping system**

| Sl. no. | Treatment | Crop combinations |
|---|---|---|
| 1 | T1 | Cucumber + brinjal |
| 2 | T2 | Ash gourd+ brinjal |
| 3 | T3 | Ash gourd+ leafy vegetables (spinach, coriander) |
| 4 | T4 | Bitter gourd + leafy vegetables (amaranthus) |
| 5 | T5 | Bitter gourd+ elephant foot yam |

## 2.3 Description of Technology

A bamboo structure about 6 ft height was prepared on which climber crops like cucumber, ash gourd, bitter gourd, were grown. In this system the tallest components have foliage of strong light and high evaporative demand and shorter components with foliage requiring shade and or relatively high humidity. Different vegetable crops according to their height can be grown under the structure. The land under the structure were properly ploughed and prepared plots and irrigation channels. The soil was enriched with fertilizer and manures according to crop requirement. Seasonal vegetables which were selected for multitier cropping system depending on market preferences were leafy vegetables viz. coriander, spinach and amaranthus, brinjal and elephant foot yam. All growing space was used as crops fit together vertically or horizontally (tall, medium and short) and underground (deep-rooted and shallow-rooted plants). Crop varieties used in this system were hybrids only.

## 3. RESULTS AND DISCUSSION

It was revealed from the results of the pooled data of six years *i.e.* 2014-15 to 2019-20 that among the different treatment combinations of vegetable based multi-tier cropping system, bitter gourd and elephant foot yam (T5) proved to be the highest income giving combination though ash gourd (249.6 ±1.53 q /ha) combination with brinjal (150.07±1.72 q /ha) (T2) gave better gross total yield. In the treatment combination (T5), elephant foot yam was harvested about (270 ± 0.73) q /ha along with bitter gourd about (125.20±0.86) t/ha at farmers' field (Table 2).

Pooled data of six years i.e. 2014 -15 to 2019-20 presented in Table 3 revealed that total cost of cultivation of elephant foot yam (high volume) and bitter gourd was higher which was due to higher price of planting materials. However, bitter gourd and elephant foot yam (T5) was found to be the best combination having highest BC ratio (3.13) followed by ash gourd combination with leafy vegetables (T3) and ash gourd combination with brinjal (T2) with BC ratio of 3.07 and 2.87, respectively. The result was in accordance with the findings that elephant foot yam grows as companion crop [7]. This also supported the technology (multi-tier system) and explained that vegetable cultivation year round at homestead provides food and nutritional security to the poor and earned maximum prices from the local market [10].

## 3.1 Profitability of Intercropping Systems

Land equivalent ratio (LER) and Value of combined crops, etc. in a cropping system are the indices which give the suitability, economical viability and profitability of particular cropping systems to an area. T5 had the higher MAI value which was more profitable among the crop combinations.

**Table 2. Yield and economics of different treatments (Mean±SD) of multi-tier horticulture cropping system**

| Treatment | Main crop Yield (t/ha) | Companion crop Yield (t/ha) | Main crop income (`in '000) | Companion crop income (`in '000) | Gross income (`in '000) |
|---|---|---|---|---|---|
| T1 | 113.28±2.96 | 151.12±2.16 | 219.48±2.37 | 294.68±3.10 | 513.93±3.89 |
| T2 | 249.6 ±1.53 | 150.07±1.72 | 271.44±1.84 | 289.90±1.08 | 561.34±1.24 |
| T3 | 250.27±1.45 | 80.07±2.16 | 272.17±3.10 | 90.08±1.77 | 362.24±2.12 |
| T4 | 125.47±1.29 | 71.03±1.27 | 153.70±2.19 | 84.34±0.82 | 238.03±0.95 |
| T5 | 125.20±0.86 | 270.5±0.73 | 153.37±1.97 | 527.48±3.02 | 680.85±3.38 |

**Table 3. Income of different treatments (Mean ± SD) of multi-tier horticulture cropping system**

| Treatment | Cost of cultivation (`in '000) | Gross income (`in '000) | Net Income (`in '000) | B C Ratio |
|---|---|---|---|---|
| T1 | 155.00 | 513.93±3.89 | 358.93±1.53 | 2.31 |
| T2 | 145.00 | 561.34±1.24 | 416.34±2.19 | 2.87 |
| T3 | 89.00 | 362.24±2.12 | 273.24±3.02 | 3.07 |
| T4 | 90.00 | 238.03±0.95 | 148.03±2.28 | 1.64 |
| T5 | 164.75 | 680.85±3.38 | 516.09±2.42 | 3.13 |

**Table 4. Land equivalent ratio of different treatments of multi-tier horticulture cropping system**

| Treatment | Main crop yield (t/ha) | | Companion crop yield (t/ha) | | Main crop Equivalent Yields (t/ha) | LER |
|---|---|---|---|---|---|---|
| | Sole crop | As intercrop | Sole crop | As intercrop | | |
| T1 | 158.3 | 113.00 | 207.1 | 151.00 | 264.97 | 1.44 |
| T2 | 289.3 | 250.00 | 207.1 | 150.06 | 519.09 | 1.59 |
| T3 | 289.3 | 250.27 | 111.8 | 80.00 | 333.03 | 1.58 |
| T4 | 135.1 | 125.47 | 111.1 | 71.03 | 190.70 | 1.57 |
| T5 | 135.1 | 125.20 | 368.4 | 270.50 | 555.79 | 1.66 |

**Table 5. Monetary advantage index of different treatments of multi-tier horticulture cropping system**

| Treatment | Value of combined crops (`in '000) | LER | Monetary advantage index |
|---|---|---|---|
| T1 | 513.39 | 1.44 | 382758.9 |
| T2 | 561.78 | 1.59 | 539904.6 |
| T3 | 362.17 | 1.58 | 343002.3 |
| T4 | 238.03 | 1.57 | 222099.6 |
| T5 | 680.85 | 1.66 | 720055.1 |

LER of 1.66 indicates that 66 per cent yield advantage is obtained when grown as intercrops compared to growing as sole crop. It means sole crops have to be grown in 1.66 ha to get the same yield level that is obtained from 1.0 ha of intercropping. If the LER is less than 1, it means the cropping system is not profitable compared to pure crop (Table 4).

Cultivation of vegetables on raised beds in flood prone area had been reported to enhance system productivity and income substantially over sole cropping. Bitter gourd+ elephant foot yam, Ash gourd + brinjal and Ash gourd + leafy vegetables (spinach, coriander) cropping system had recorded the highest system productivity in low line areas. These intercropping combinations gave bitter gourd and ash gourd equivalent yields of 555.79, 519.09 and 333.03 t/ha, respectively (Table 4). Treatment T5 had the highest value (Table 5) so bitter gourd + elephant foot yam cropping system was suitable and profitable than others. It was reported that higher LER is closely related to higher MAI values which emphasize the economic benefits of multitier cropping system [11,12].

## 4. CONCLUSION

Among the vegetable based multi-tier cropping system, bitter gourd + elephant foot yam (T5) crop combination was proved that the most competent and promising than other

combinations in flood prone low line areas. Both the crops had proper utilized the land and other resources. It is also concluded that the intercropping of EFY is more remunerative than other crop because elephant foot yam does not compete for light because it tolerated shade. It was also observed that the inclusion of any of the companion crops reduced the yield of main crop. The outcomes of various crop combinations from the study confirmed that vegetable based multitier cropping system is economically most suitable and viable. Farmers having same constraints of lowland which is prone to flood can easily adopt this practice for higher income. After the successful conduction of the experiment several demonstrations have been conducted in the farmers fields and huge numbers of farmers of Malda district of West Bengal are using the technology and are fetching more returns.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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