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# Profitability of Rice based Cropping System by Sequencing Vegetable Cowpea under Various Establishment Techniques in Periyar-Vaigai Command

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**Field experiment was conducted during *Rabi* season, 2013-14 to the study the effect of crop establishment techniques and crop geometries on yield and economics of rice-vegetable cowpea cropping system. Experiment was laid out in strip plot design and treatments were replicated thrice. The sixteen treatment combination consisted of four establishment techniques *viz.,* puddled transplanting ($E_1$), puddled direct seeding ($E_2$), unpuddled transplanting ($E_3$), unpuddled direct seeding ($E_4$) and four crop geometries such as 30 x 20 cm ($S_1$), 20 x 10 cm ($S_1$), 25 x 25 cm ($S_3$) and 30 x 30 cm ($S_4$). Among the different treatment combinations, square planting of 25 x 25 cm adopted in puddled condition gave higher grain yield of 6963 kg ha$^{-1}$ and straw yield of 9299 kg ha$^{-1}$. In case of succeeding vegetable cowpea, higher yield of 8780 kg ha$^{-1}$ and halum yield (13926 kg ha$^{-1}$) was obtained in the combination of 30 x 30 cm under unpuddled direct seeded method. Similarly, higher gross return, net return, B:C ratio and lower production cost recorded under same combination. Puddling practice was conducive for rice, unpuddled soil was found to be optimum for succeeding deep rooted crops like vegetable cowpea.**

**Key words:** Crop geometries, Establishment techniques, Economics, Rice–Vegetable cowpea, Cropping system.

Rice is a predominant crop of Asian agriculture and it has tremendous importance as it constitutes the major diet and serves as the main source of energy. It accounts for about 50% of annual per capita calorie intake. Predominant rice producing regions in India are canal irrigated. Rice-fallow-rice system is a major system in a canal command area. *Periyar-Vaigai* command in Tamil Nadu is a source of water for a cultivated area of 80,000 ha, with monsoon depended predominant rice based cropping system along with the rainfall quantity of 856 mm / year distributed with high intensity (GOI, 2013). Drought and crop failures are common phenomenan during post rainy season due to high intensity of rainfall during *Rabi* (October-November). Soils become wet and their workability decreases. In the canal irrigated areas, water delivery schedule is not always matching the demand. Thus variations in availability of irrigation water coupled with the random nature of irrigation water supply have created an imbalance in the rice-based systems. Mono cropping of rice leads to declining yield as well as low land utilization efficiency, low system productivity often declining soil fertility due to multiple nutrient deficiencies, deterioration of soil health and factor productivity. Therefore, diversification is needed to identify suitable crop(s) for dry period during summer. Hence, the only option left is to growing of pulse cum vegetables in the dry period for realizing higher productivity and profitability, but the comparative assessment and scientific evidence of stable systems on inclusion of non-rice crop(s) is meagre. It has several benefits. It fulfills the basic needs for cereals and vegetables; enhances farm income; withstands weather variations; conserves natural resources; creates employment opportunity, and reduces risk. Hence, intensification of rice-based systems is very essential to increase productivity and maintain sustainability. These options have not been systematically studied under *Periyar-Vagai* command. Under these circumstances, green manure-rice-legume cum commercial cropping system offers greater potential to overcome risk and effective utilization of resources.

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## Material and Methods

A field experiment was carried out to evaluate the crop establishment techniques and various crop geometries on profitability of rice-vegetable cowpea cropping system during *Rabi* (October-January) season of 2013-14 and summer (February-May) season of 2014 in the Department of Farm Management, Agricultural College and Research Institute, Madurai. Experimental site is located at southern agro climatic zone of Tamil Nadu at 9° 54' N latitude and 78° 54' E longitude with an elevation of 147 m above MSL. The quantity of precipitation received through rainfall during period of sequential cropping *i.e.* October 2013-May 2014 was 240.6 mm and distributed in 18 rainy days. Field experiment were laid out by strip plot design and the treatments were replicated thrice. The soil of the experimental field was clay loam in texture belonging to *Typic Ustropept*. The nutrient status was low in available nitrogen, medium in available phosphrous and high in available potassium. The treatment combinations include four crop establishment techniques *viz.,* Puddled transplanting ($E_1$), Unpuddled transplanting ($E_2$), Puddled direct seeding ($E_3$) and Unpuddled direct seeding ($E_4$) and four crop geometries such as 30 cm x 20 cm ($S_1$), 20 cm x 10 cm ($S_2$), 25 cm x 25 cm ($S_3$) and 30 cm x 30 cm ($S_4$). Rice variety ADT 39 was chosen for the study. Rice seedlings with an age of 18 days were transplanted in puddled and unpuddled soil conditions with various crop geometries as per the treatment schedule ($E_1$ and $E_2$). For puddled and unpuddled direct seeded condition, seeds were treated with Azospirillum at 600 g kg$^{-1}$ as pre sowing seed treatment and then 2-3 seeds were placed manually as per the spacing treatment ($E_3$ and $E_4$). For puddled transplanting, experimental plots were irrigated to 2 cm depth uniformly in all the treatments after the appearance of hair line cracks, upto panicle initiation stage. After panicle initiation, the plots were irrigated with 5 cm depth on disappearance of ponded water. Irrigation was stopped 15 days prior to harvest. In puddled direct seeding, before sowing, the field was drained to keep it under saturated condition to facilitate easy sowing and uniform establishment of seedlings. A thin film of water was maintained at the time of sowing. For the next 8-15 days, irrigation and drainage of water were alternated to facilitate aeration and adequate moisture for germination of seeds and establishments of seedlings. Thereafter, the plots were irrigated upto soil saturation, uniformly in all the treatments after the appearance of hair line cracks, upto panicle initiation stage. After panicle initiation, the plots were irrigated with 5 cm depth on disappearance of ponded water. Irrigation was stopped 15 days prior to harvest. For unpuddled transplanting, prior to transplanting, the soil was saturated and a thin film of water was stagnated during transplanting. For the next 8-15 days, irrigation and drainage of water were alternated to facilitate aeration and adequate moisture for establishments of seedlings. Subsequently irrigation scheduled to saturate the soil at critical stages of crop growth. In case of unpuddled transplanting, after sowing, life saving irrigation was done on 3 DAT to promote seedling establishment. Further, irrigation was given at critical stages of crop water requirement. Succeeding vegetable cowpea was raised without disturbing the layout of rice crop. Vegetable cowpea seeds were dibbled in between rice stubbles as per the spacing treatment, scheduled for rice. After life saving irrigation, plots were irrigated with ten days interval. Five plants in each plot were selected at random and labeled for recording observations in all the three replications.

## Rice

### *Grain yield*

Grains from each net plot were harvested, cleaned; sun dried, weighed and adjusted to 14 per cent moisture content and the grain yield was recorded in kg ha$^{-1}$.

### *Straw yield*

The straw obtained from each net plot area was sun dried and weighed. The straw yield was expressed in kg ha$^{-1}$.

### *Vegetable cowpea*

### *Vegetable yield*

For determining vegetable yield, pods picked from each treatment plot were quantified and total vegetable yield was assessed from sum of three harvests

### *Haulm yield*

The haulm yield after three harvests, the plant weight from net plot was recorded and expressed in kg ha$^{-1}$.

### *System productivity for cropping system*

The total quantity of produce obtained from each crop converted as rice grain equivalent yield by working out the ratio between total economic outcome from each crop and cost of rice/kg.

$$\text{Rice grain equivalents (kg)} = \frac{\text{Productivity of Component (rs)} \times \text{Unit cost of Component (rs)}}{\text{Cost of rice (Rs/kg)}}$$

### *Economic analysis*

Cost of cultivation and gross return for all the treatments were worked out on the basis of prevailing input cost and market price of the grain at the time of experimentation as suggested by Bhandari (1993). The net income was calculated by deducting the cost of cultivation from the gross return. The benefit cost ratio (BCR) was also worked out.

## Results and Discussion

### *Effect on grain and straw yield of rice*

Square planting of 25 x 25 cm produced 5148 kg ha$^{-1}$; however it was comparable with 30 x 30 cm (5010 kg ha$^{-1}$) and 30 x 20 cm (5288 kg ha$^{-1}$). Lower grain yield of 4997 kg ha$^{-1}$ was obtained in the spacing of 20 x 10 cm. Similar trend was noticed in straw yield also. Results indicated that wider spacing had linearly increased the performance of individual plants. The plants grown with wider spacing have more area of land around them to draw the nutrition and had more solar radiation to absorb for better photosynthetic process and hence performed better as individual plants. The reason for deviation of this linearity in case of grain yield per plot is that the yield not only depend upon the performance of individual plant but also on the total number of plants per plot and yield contributing parameters within plant. Higher grain yield of 6963 kg ha$^{-1}$ and straw yield of 9299 kg ha$^{-1}$ were obtained under the combination of puddled transplanting with 25 x 25 cm spacing (Oteng *et al.,* 2013).

**Table 1. Crop establishment techniques and crop geometries on grain yield and straw yield of rice**

| CET / Crop geometries | Grain yield (kg/ha) | | | | | Straw yield (kg/ha) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | $E_1$-PT | $E_2$-PDS | $E_3$-UPT | $E_4$-UPDS | Mean | $E_1$-PT | $E_2$-PDS | $E_3$-UPT | $E_4$-UPDS | Mean |
| $S_1$ -30 x 20 cm | 6192 | 5043 | 3721 | 5627 | 5146 | 8012 | 8008 | 6714 | 7194 | 7482 |
| $S_2$ -20 x 10 cm | 5197 | 4478 | 3974 | 4492 | 4676 | 8698 | 8478 | 6734 | 7725 | 7909 |
| $S_3$ - 25 x 25 cm | 6991 | 5509 | 3609 | 5829 | 5241 | 8299 | 7838 | 6864 | 7596 | 7649 |
| $S_4$ -30 x 30 cm | 5746 | 5902 | 3069 | 5420 | 5136 | 7375 | 6403 | 6012 | 6562 | 6588 |
| Mean | 6032 | 5233 | 3593 | 5342 | | 8096 | 7682 | 6581 | 7269 | |
| | CET | CG | CET x CG | CG x CET | | CET | CG | CET x CG | CG x CET | |
| SEd | 171 | 128 | 332 | 351 | | 181 | 163 | 353 | 361 | |
| CD (P = 0.05) | 419 | 313 | 725 | 756 | | 442 | 400 | 772 | 786 | |

Among various crop establishment techniques, puddled transplanted crop produced higher yield of 6303 kg ha$^{-1}$, unpuddled transplanting attained lower productivity of 3588 kg ha$^{-1}$. In case of direct seeding in unpuddled condition resulted in a grain yield of 5347 kg ha$^{-1}$ which was comparable with puddled direct seeding (5205 kg ha$^{-1}$). The straw yield was in same trend.

**Table 2. Crop establishment techniques and crop geometries of rice on vegetable and halum yield of succeeding vegetable cowpea**

| CET / Crop geometries | Vegetable yield (kg/ha) | | | | | Haulm yield (kg/ha) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | $E_1$-PT | $E_2$-PDS | $E_3$-UPT | $E_4$-UPDS | Mean | $E_1$-PT | $E_2$-PDS | $E_3$-UPT | $E_4$-UPDS | Mean |
| $S_1$ -30 x 20 cm | 4964 | 5040 | 6120 | 7200 | 5831 | 9509 | 10334 | 10737 | 13585 | 11041 |
| $S_2$ -20 x 10 cm | 4137 | 4200 | 5100 | 6000 | 4859 | 8571 | 8619 | 10000 | 12578 | 9942 |
| $S_3$ - 25 x 25 cm | 5185 | 5264 | 6392 | 7520 | 6090 | 9571 | 9783 | 11113 | 13303 | 11923 |
| $S_4$ -30 x 30 cm | 6054 | 6146 | 7463 | 8780 | 7111 | 10782 | 11007 | 12589 | 13926 | 12076 |
| Mean | 5085 | 5163 | 6269 | 7375 | | 9609 | 9936 | 11110 | 13348 | |
| | CET | CG | CET x CG | CG x CET | | CET | CG | CET x CG | CG x CET | |
| SEd | 121 | 106 | 223 | 231 | | 254 | 243 | 548 | 553 | |
| CD (P = 0.05) | 296 | 258 | 490 | 503 | | 623 | 595 | 1191 | 1199 | |

$E_1$ - PT - Puddled transplanting; $E_3$ - UPT - Unpuddled transplanting; CET - Crop Establishment techniques
$E_2$ - PDS - Puddled direct seeding; $E_4$ - UPDS - Unpuddled direct seeding; CG - Crop geometries

This might be due to conducive soil rhizoshere created in puddled condition provided faster recovery from transplanting shock and enabled extraction of nutrients and water from root zone. In case of unpuddled transplanted condition, prolonged transplanting shock and seedling mortality led to poor establishment. Energy diverted to overcome initial stress putforth lesser biomass prodution and grain yield. Under unpuddled direct seeded condition, with an alternate drying and wetting, initially biomass production diverted to roots rather than shoots also energy spent to convert N-$NO_3$ to N-$NH_4$. This is in accordance with the finding of Bouman et al. (2005). Who had reported energy required to convert N-$NO_3$ to N-$NH_4$ was higher than direct uptake of N-$NH_4$ and subsequently it would reduce shoot biomass accumulation.

***Effect on Vegetable yield and Haulm yield***

Establishment techniques adopted for rice and crop geometries had significant influence on green pod and haulm yield of vegetable cowpea. Higher yield of 8780 kg ha$^{-1}$ was harvested under unpuddled transplanting with 30 x 30 cm favorable micro-climatic conditions, availability of uniform and adequate moisture for plant growth and keeping the soil structure loose and friable which was conducive to good aeration resulted in better growth and partitioning of DMP. In case of higher haulm yield of 13926 kg ha$^{-1}$ recorded under square planting of 25 x 25 cm in unpuddled direct seeded condition, due to high plant density than 30 x 30 cm spacing (13303 kg ha$^{-1}$). In case of puddling practices adopted for rice lead to create hard pan for surface soil column (Impervious layer) put forth low penetration and proliferation of roots of succeeding vegetable cowpea, thus reduced plant growth and green pod production.

***System productivity and profitability of dhaincha-Rice-Vegetable cowpea cropping system***

***System productivity***

Stand establishment techniques and crop geometries of rice had markeable influence on rice-vegetable cowpea cropping system. Higher system productivity (11242 kg $ha^{-1}$) was registered under unpuddled direct seeding method ($E_4$). This was followed by puddled transplanted ($E_1$) soil resulted in 10162 kg $ha^{-1}$. Lower productivity of 8608 kg $ha^{-1}$ obtained under unpuddled transplanted condition ($E_3$). With respect to crop geometries, wider spacing of 30 x 30 cm ($S_4$) had produced higher productivity (10825 kg $ha^{-1}$) than other crop geometries tested. The treatment combination of unpuddled direct seeding method along with crop geometry of 30 x 30 cm ($E_4S_4$) recorded higher (12853 kg $ha^{-1}$) system productivity. Being a deep rooted upland crop, high yield of vegetable cowpea in unpuddled direct seeded condition had increased total system productivity.

**Table 3. Crop establishment techniques and crop geometries on system productivity and profitability of Dhaincha - Rice -Vegetable cowpea cropping system**

| CET / Crop geometries | System productivity (RGEY) (kg/ha) | | | | | Cost of cultivation (Rs) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | $E_1$-PT | $E_2$-PDS | $E_3$-UPT | $E_4$-UPDS | Mean | $E_1$-PT | $E_2$-PDS | $E_3$-UPT | $E_4$-UPDS | Mean |
| $S_1$ -30 x 20 cm | 10224 | 9014 | 8617 | 11387 | 9811 | 64180 | 54553 | 62736 | 51344 | 58203 |
| $S_2$ - 20 x 10 cm | 8557 | 7788 | 7689 | 10220 | 8563 | 64300 | 54655 | 62853 | 51440 | 58312 |
| $S_3$ - 25 x 25 cm | 11202 | 9657 | 9088 | 10508 | 10113 | 63500 | 53975 | 62071 | 50800 | 57587 |
| $S_4$ -30 x 30 cm | 10663 | 10745 | 9039 | 12853 | 10825 | 63250 | 53763 | 61827 | 50600 | 57360 |
| Mean | 10162 | 9301 | 8608 | 11242 | | 63808 | 54236 | 62372 | 51046 | |
| | Gross return (Rs) | | | | | Net return (Rs) | | | | |
| $S_1$ -30 x 20 cm | 102240 | 90140 | 86170 | 113870 | 98110 | 38060 | 35587 | 23434 | 62526 | 39907 |
| $S_2$ - 20 x 10 cm | 85570 | 77880 | 76890 | 102200 | 85630 | 21270 | 23225 | 14037 | 50760 | 27318 |
| $S_3$ - 25 x 25 cm | 112020 | 96570 | 90880 | 105080 | 101130 | 48520 | 42595 | 28809 | 54280 | 43543 |
| $S_4$ -30 x 30 cm | 106630 | 107450 | 90390 | 128530 | 108250 | 43380 | 53687 | 28563 | 77930 | 50890 |
| Mean | 101620 | 93010 | 86080 | 112420 | | 37812 | 38774 | 23708 | 61374 | |
| | Per day return (Rs) | | | | | B:C ratio | | | | |
| $S_1$ -30 x 20 cm | 511 | 451 | 431 | 569 | 491 | 1.59 | 1.65 | 1.37 | 2.22 | 1.69 |
| $S_2$ - 20 x 10 cm | 428 | 389 | 384 | 511 | 428 | 1.33 | 1.42 | 1.22 | 1.99 | 1.47 |
| $S_3$ - 25 x 25 cm | 560 | 483 | 454 | 525 | 506 | 1.76 | 1.79 | 1.46 | 2.07 | 1.76 |
| $S_4$ -30 x 30 cm | 533 | 537 | 452 | 643 | 541 | 1.69 | 2.00 | 1.46 | 2.54 | 1.89 |
| Mean | 508 | 465 | 430 | 562 | | 1.59 | 1.71 | 1.38 | 2.20 | |

$E_1$ - PT - Puddled transplanting; $E_3$ - UPT - Unpuddled transplanting; CET - Crop Establishment techniques
$E_2$ - PDS - Puddled direct seeding; $E_4$ - UPDS - Unpuddled direct seeding; CG - Crop geometries

***System profitability***

Dhaincha-rice-vegetable cowpea system profitability determined through cost of cultivation, gross and net returns, B: C ratio and per day return. Methods of cultivation for rice and crop geometries had notable influence on system productivity.

***Cost of cultivation***

Establishment techniques and crop geometries were greatly influenced cost of production of the cropping system. Puddling and transplanting techniques incurred high cost than dry ploughing and direct seeding. In case of various crop geometries with different plant densities, seed cost accounted difference in total cost of production. Among the various establishment and crop geometries combinations, puddled transplanting with 25 cm x 25 cm utilized higher (₹ 63500) cost production and lower (₹ 503444) cost spent for 30 cm x 20 cm along with unpuddled direct seeding.

***Gross and net return, per day return and B: C ratio***

System productivity a factor directly determined the gross and net income from the system at the end of the cycle. Total and net income was higher (Rs 128530 and Rs 77930) in unpuddled direct seeding with 30 x 30 cm due to high system productivity and vice versa (Rs 76890 and Rs 14037) in 20 x 10 cm along with transplanting in unpuddled soil. The same combinations were recorded similar trend of per day income (Rs 643 and Rs 384) and benefit out of rupee invested (2.54 and 1.22).

Among the various treatment combinations, wider spacing of 30 x 30 cm and unpuddled direct seeding ($E_4S_4$) had higher profit margin with lower production cost. In general, comparatively production cost was higher in transplanting methods than direct seeding technique due to labour cost for land preparation and crop management, also puddling incurred high cost than dry ploughing practices. Opposite trend was observed for system profitability. While in case of crop geometries, wider spacing obtained higher profit than closer spacing. The lower system yield and profit were recorded in unpuddled transplanting with closer spacing 20 x 10 cm ($E_3S_2$).

From the experiment results, it can be concluded that, inclusion of legume cum vegetable crop like vegetable cowpea in rice system especially in *Periyar-Vaigai* canal command area, (double crop wetland) will be a remunerative with unpuddled direct seeding of rice fallow vegetable cowpea.

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