ECONOMIC EFFICIENCY OF DIFFERENT CROPPING SYSTEMS UNDER FAISALABAD CONDITIONS

Tanweer Ahmad, Ehsan Ullah and Khawar Jabran*

ABSTRACT

Under agro-climatic conditions of Faisalabad mixed-wheat cropping system is being followed where sesbania, rice, cotton, maize, potato, mixed fodder, radish and spinach are grown in kharif while wheat as main crop in rabi season. The present study was conducted in the Department of Agronomy, University of Agriculture, Faisalabad, Pakistan during the year 2010-11 to determine the efficient cropping systems and their effect on soil nutrition status under Faisalabad conditions. Each crop was sown on its optimum sowing time with recommended production technology. Data on yield, cost of production and effect on soil health were recorded. Economic analysis was made to test the economic efficiency of different cropping systems. The results showed that bajra-potato-maize (grain) was the most economical cropping system with maximum net return of Rs.379693/- followed by sesbania-potato-maize (grain) (Rs.378490). Maximum benefit cost ratio of 2.19 was also recorded in sesbania-potato-maize (grain). Data on marginal rate of return (MRR) showed that radish-wheat proved as the best cropping system with MRR value of 395.56 percent. Very minute variation in N and P of soil was observed but main increase was found in cropping systems where sesbania was green manured.

KEYWORDS: Rice; cotton; wheat; maize; potato; sesbania; cropping patterns; green manuring; economic efficiency; cost benefit analysis; Pakistan.

INTRODUCTION

Cropping systems may include mono crop, two crops, three crops and multiple crops (9) according to ecological conditions of the area. These cropping systems not only provide the staple food to millions of people but also affect the livelihood and health of both rural and urban population (17). People of irrigated areas of Punjab mostly follow the old traditional and intensive cropping systems like rice-wheat, cotton-wheat and mixed-wheat cropping systems. The mixed cropping system seems deficient in giving its economical potential during kharif season.

Faisalabad region is characterized by arid climate due to high evapotranspiration rates. The climate can be extremely hot in summer with a
maximum temperature of 50°C (122°F) and can be as low as −1°C (30.2°F) in winter months (15). The area is known as grain belt of the Punjab province. Kharif crops include maize, rice, sugarcane and bajra, while rabi crops are wheat, barley, chickpea and berseem. In addition to these, there are also Zaid kharif and Zaid rabi crops. Zaid kharif crops are toria, raya and sarsoon while Zaid rabi crop is tobacco.

Many attempts have been made to help producers in making most critical administrative decisions to remain sustainable in an ever-changing environment of agriculture but a dynamic cropping system approach has been found more useful (14). This system is defined as a long-term strategy of annual crop sequencing that optimizes crop and soil use options and attainment of production, economic and resource conservation goals by using sound ecological management principles (18).

Some of cropping sequences adopted by the farmers were very exhaustive and unproductive which not only resulted in less returns but also caused persistent decline in soil productivity. Improved crops sequences include green manuring which improves soil productivity and fertility and higher economic returns. Biswas et al. (7) found that jute-potato-rice, rice-potato-rice and rice-potato-sesame could be recommended (based on economic considerations alone) for resource-rich growers in the eastern part of Indo-Gangetic Plain (IGP). Cropping systems such as jute-wheat, rice-wheat and jute-rape seed-rice appear to be most suitable for small and marginal farmers that cannot afford the large production costs associated with crops such as potato.

Sharma et al. (16) found that rice-potato-mungbean cropping system gave higher productivity, higher protein yield, energy output and resulted in higher available P, more fungi population, actinomycetes population, microbial biomass and CO₂ evolution in soil than rice-wheat cropping system. However, rice-potato-mungbean cropping system was significantly superior to the rice-rape seed-mungbean cropping system in productivity, protein yield and energy output and thus recommended as an alternative to rice-wheat cropping system. The involvement of sesbania crop in different cropping systems not only increases yield but also nitrogen status of the soil (9).

Cropping frequency could be effectively increased in dry land cropping systems through crop selection rules based on water use/yield production functions, measured available soil water, and expected precipitation (12). Vegetable based cropping sequences also showed more production.
efficiency, gross and net returns than a traditional sequence. Especially potato and radish increased the net returns and benefit cost ratio upto a greater extent (14). Green manuring vetch and fallow treatments gave comparable plant height, grain yield and straw yield (6). There is a need of modified package of cropping system based on modern and scientific agricultural practices which must be economical, viable, sustainable, less exhaustive and acceptable to farming community of the area, as on-going cropping system is outdated and nominal returns are obtained by the local farmers. At the same time such cropping system is expected to maximize farm output in terms of increased farm productivity, better water distribution and to achieve maximum water use efficiency and better utilization of farm labor, machinery and other resources.

The present research project was designed to find-out economically efficient cropping systems under agro-climatic conditions of Faisalabad and also to see their effect on soil fertility status.

**MATERIALS AND METHODS**

This study was conducted in the Department of Agronomy, University of Agriculture, Faisalabad, Pakistan, during 2010-11. The climate of Faisalabad region is semi-arid and sub-tropical while soil of experimental area is sandy clay loam. The meteorological data recorded during the year 2010-11 is given in Fig.

![Meteorological data recorded at Faisalabad during the year 2010-11](image)

Eight pre-assigned cropping systems, as detailed here, involve cereals, vegetables and green manurie crops in kharif (summer) season followed by wheat during rabi (winter) season.
**Cropping systems**

$S_1$ = Rice-wheat  
$S_2$ = Cotton-wheat  
$S_3$ = Radish-wheat  
$S_4$ = Spinach-wheat  
$S_5$ = Sesbania-potato-maize (grain)  
$S_6$ = Bajra (fodder)-potato-maize (grain)  
$S_7$ = Sesbania-maize (grain)-wheat  
$S_8$ = Sesbania-maize (fodder)-wheat

All cropping systems were arranged in a RCBD with three replications. There were 24 plots in experiment, each measuring 6m x 6m. The data on crops yield, total cost, net return and benefit cost ratio were collected. In addition, soil fertility (N and P) status was also monitored during cropping cycles. All this data were analyzed for partial budget and marginal analysis. The gross and net benefits for each cropping pattern were calculated as follows:

\[
\text{Gross benefit} = \text{Field price of produce} \times \text{Yield.}
\]

\[
\text{Net benefits} = \text{Gross income} - \text{Total cost}
\]

Benefit cost ratio for each cropping system was calculated using the following formula:

\[
\text{BCR} = \left( \frac{\text{Gross income}}{\text{Total cost}} \right) \times 100
\]

Marginal rate of return (MRR) was calculated by following formula (4):

\[
\text{MRR} = \left( \frac{\partial \text{NB}}{\partial \text{TCV}} \right) \times 100
\]

Here $\partial \text{NB}$ = Change in net benefit and $\partial \text{TCV}$ = change in total cost that varies.

Composite soil samples were collected from all three replications before and after harvesting of crops at 0-30 cm depth. The samples were analyzed for N and P following micro Kjeldahl and Olsen bicarbonate extraction methods, respectively (13). Extractable K was determined using Kjeldahl's apparatus, the material containing 10g soil, 40 ml of concentrated $\text{H}_2\text{SO}_4$ and 10g of digestion mixture ($\text{K}_2\text{SO}_4$:$\text{FeSO}_4$:$\text{CuSO}_4$ $\times_5$ 10:1:0.5) was digested. Then distillation was carried out by taking 10 mL of aliquot from the digestion mixture with micro Kjeldahl's apparatus. The $\text{NH}_3$ gas evolved was absorbed in a receiver containing 4 percent boric acid solution and mixed indicator (bromocresol green and methyl red). After distillation, contents of receiver were titrated against 0.1 N $\text{H}_2\text{SO}_4$ (10) and N was calculated by the formula given below:-

\[
N (\%) = 0.0014 \times (\text{Acid used for titration-blank}) \times \text{dilution factor} \times 100/\text{mL of aliquot}
\]
Soil (5 g) was extracted with NaHCO$_3$ (0.5 M) solution and adjusted to pH 8.5. Clear filtrate (5 ml) was taken in 100 ml volumetric flask and then 5 ml ascorbic acid (colour developing reagent) was added. Volume was made up to the mark. Reading was recorded on spectrophotometer (Milton Roy Company) using 880 nm wavelength with the help of standard curve (19). The same solution was used for extraction and extractable K was determined by corning flame photometer after calibrating with K standard solution (Handbook 60, Method 58, p.132).

**RESULTS AND DISCUSSION**

**Yield of crops**

The results revealed that yield and yield components of major field crops like rice, wheat, and cotton responded differently when involved in different cropping systems. In both seasons (kharif and rabi), yield of crops was significantly higher than average of those treatments in which sesbania was grown as green manure before these crops. Overall the vegetable-based and maize-wheat systems proved to be the best. Rice paddy yield under rice-wheat cropping system ($S_1$) was 3.83 tons per hectare (Table 2). Higher grain yield of maize (9.5 t/ha) was recorded in cropping system where green manure was used ($S_6$). Jabbar *et al.* (9) also noted that under rice based cropping system rice grain yield decreased to a significant level by forage intercrops compared to monocropped rice. Ajeigbe *et al.* (2) also reported similar results about maize based cropping systems. They concluded that total grain and

<table>
<thead>
<tr>
<th>S. No</th>
<th>Cropping systems</th>
<th>Kharif crops grain yield (t/ha)</th>
<th>Rabi crops grain yield (t/ha)</th>
<th>Income from kharif crops (Rs.)</th>
<th>Income from rabi crops (Rs.)</th>
<th>Gross return (Rs./ha)</th>
<th>Total cost (Rs./ha)</th>
<th>Net return (Rs./ha)</th>
<th>Benefit cost ratio (BCR)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$S_1$</td>
<td>Rice-wheat</td>
<td>3.83</td>
<td>5.12</td>
<td>153875</td>
<td>168800</td>
<td>322475</td>
<td>212179</td>
<td>110296</td>
<td>1.52</td>
</tr>
<tr>
<td>$S_2$</td>
<td>Cotton-wheat</td>
<td>2.94</td>
<td>4.9</td>
<td>275358</td>
<td>164620</td>
<td>439978</td>
<td>215469</td>
<td>224509</td>
<td>2.04</td>
</tr>
<tr>
<td>$S_3$</td>
<td>Radish-wheat</td>
<td>11.32</td>
<td>5.03</td>
<td>254700</td>
<td>165230</td>
<td>419930</td>
<td>202181</td>
<td>217749</td>
<td>2.08</td>
</tr>
<tr>
<td>$S_4$</td>
<td>Spinach-wheat</td>
<td>28.65</td>
<td>5.02</td>
<td>177900</td>
<td>166420</td>
<td>344320</td>
<td>195493</td>
<td>148827</td>
<td>1.76</td>
</tr>
<tr>
<td>$S_5$</td>
<td>Sesbania-potato-maize (grain)</td>
<td>28.15</td>
<td>9.5</td>
<td>506700</td>
<td>189095</td>
<td>695795</td>
<td>317305</td>
<td>378490</td>
<td>2.19</td>
</tr>
<tr>
<td>$S_6$</td>
<td>Bajra (fodder)-potato-maize (grain)</td>
<td>26.71</td>
<td>9.2</td>
<td>562000</td>
<td>183390</td>
<td>745390</td>
<td>365697</td>
<td>379693</td>
<td>2.04</td>
</tr>
<tr>
<td>$S_7$</td>
<td>Sesbania-maize (grain)-wheat</td>
<td>9.5</td>
<td>5.16</td>
<td>189325</td>
<td>171720</td>
<td>361045</td>
<td>236177</td>
<td>124868</td>
<td>1.53</td>
</tr>
<tr>
<td>$S_8$</td>
<td>Sesbania-maize (fodder)-wheat</td>
<td>---</td>
<td>5.23</td>
<td>80000</td>
<td>174670</td>
<td>254670</td>
<td>168833</td>
<td>85837</td>
<td>1.51</td>
</tr>
</tbody>
</table>
fodder (cowpea and maize) yield produced by relay cropping system was higher than sole crops.

There were no statically significant differences in grain yield of wheat in different cropping systems probably due to same variety and same planting time of wheat in all cropping systems. Maximum wheat grain yield (5.23 t/ha) was noted in sesbania-maize (fodder)-wheat cropping system (S₆) and minimum (4.9 t/ha) in cotton-wheat sequence (S₂). Green manure crops in cropping system not only restore the soil fertility status but also increase yield of all crops sown (6).

Potato yield was higher in sesbania-potato-maize (S₅) (28.15 t/ha) than S₆ (26.71 t/ha) due to the fact that in S₅ sesbania was manured which increased final yield of potato. Fresh weight of radish and spinach was 11.32 and 28.65 tons per hectare obtained in S₃ and S₄, respectively. In cotton-wheat cropping system (S₂), seed cotton yield of 2.9 tons per hectare was recorded. Khan and Khaliq (11) also reported that among cotton based cereal production cropping patterns, cotton-wheat proved as better relay cropping system. Sharma et al. (16) concluded that potato yield can be significantly increased by the practice of green manuring.

**Economic analysis**

**Gross returns:** The results (Table 2) indicated that S₆ [bajra (fodder)-potato-maize (grain)] gave higher gross returns (Rs.745390) followed by S₅ [sesbania-potato-maize (grain)] (Rs.695795). Total costs that varied were higher in S₅ followed by S₆. This was due to involvement of potato crop in both cropping systems which was a high value crop. Cotton-wheat (S₂) with gross income of Rs.439978 ranked 3rd. Radish-wheat (S₃) attained 4th position (Rs.419930). Similarly S₇ [sesbania-maize (grain)-wheat] ranked 5th in gross return (Rs. 361045) because maize yield and its price both were higher in this cropping system. S₄, S₁ and S₈ stood 6th, 7th and 8th with gross income of Rs.344320, Rs.322475 and Rs.254670, respectively. Dogan et al. (8) concluded that rotation systems including common vetch and fodder peas as forage plants under rain-fed conditions gave economically the highest net profit.

**Net returns:** S₆ [bajra (fodder)-potato-maize (grain)] gave maximum net returns (Rs.379693) followed by S₅ [sesbania-potato-maize (grain)] (Rs.378490) with a negligible difference (Table 2). Higher net benefits in S₆ than S₅ were due to bajra crop which was replaced with sesbania in S₅. S₂
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(cotton-wheat) and S3 (radish- wheat) stood 3rd and 4th with net returns of Rs.224509 and Rs.217749, respectively. In these systems price/unit value of both cotton and radish crops was high but cost involved in raising both these cropping systems was less. So these systems proved to be the most suitable for the farmers having less resources. Spinach-wheat ranked 5th (Rs.148827) due to its less price/unit while cost in raising spinach was high. These results are in accordance with those of Prasad et al. (14) who reported higher production efficiency, gross and net returns in vegetable cropping system than traditional sequence.

Rice-wheat cropping system (S1) attained 6th position with net return of Rs.110296 which was also cost intensive because gross monetary returns were low and cost involved in this cropping system was very high. So S5 and S6 may replace other kharif crops in high rainfall conditions of Faisalabad to make it more efficient in terms of net benefits for the farmers who have no resource scarcity. Jabbar et al. (9) do not agree to these findings who recorded maximum net benefits for rice and maize based cropping system.

S7 (sesbania-maize-wheat) gave net returns of Rs.124868 where maize was used for grain purpose instead of fodder which increased its net return. Minimum net benefits were calculated in sesbania-maize (fodder)-wheat (Rs.85837). The reason of low net returns in this cropping system was the involvement of maize fodder crop in kharif season which gave only Rs. 80000 and sesbania were used as green manure crop before fodder crop.

Benefit cost ratio: Sesbania-potato-maize (grain) cropping system (S5) attained first position with 2.19 BCR followed by S3 (radish-wheat) (BCR 2.08) (Table 2). The highest benefit cost ratio of S5 was mainly due to potato yield and involvement of sesbania crop as green manure in this cropping system. Sesbania not only increased the potato yield but also had an increasing effect on maize yield. BCR was also better for S6 and S2 (2.04 each) which stood 3rd and 4th, respectively. In S2 price of cotton crop was higher in 2010 due to heavy rain and flood during crop growth period in whole country, while in S6 sesbania was replaced with bajra which contributed to income in kharif season.

The data indicated that conventional cropping systems of rice-wheat and maize- wheat proved to be less efficient in terms of BCR, as S1 (rice-wheat), S7 [sesbania-maize (grain)-wheat] and S6 [sesbania-maize (fodder)-wheat] gave a BCR of only 1.52, 1.53 and 1.51, respectively. The vegetable based cropping systems were superior where BCR ranged from 1.76- 2.19 due to lower cost of production and higher yields under medium rainfall conditions of
Faisalabad. The rice-wheat (S\textsubscript{1}) and sesbania-maize (fodder)-wheat (S\textsubscript{8}) appeared less efficient due to low remunerative returns and high cost of production.

BCR of S\textsubscript{5} was higher (2.19) than S\textsubscript{6} (2.04) but its net return was slightly lower than S\textsubscript{6}. More net benefits of S\textsubscript{5} were higher but cost incurred was also very high which reduced its BCR to 2.04. This behaviour indicated that if farmers have fewer financial resources, then they should opt S\textsubscript{5} cropping system due to higher BCR. However, if farmers have no resource scarcity they should move towards S\textsubscript{6}.

**Dominance analysis of different cropping systems**

The dominance analysis of different cropping systems (Table 3) revealed that rice-wheat (S\textsubscript{1}) and sesbania-maize (grain)-wheat (S\textsubscript{7}) cropping systems were dominated over rest of cropping systems studied. The dominated cropping systems were actually less profitable than other cropping systems.

**Table 3. Dominance analysis of different cropping systems during 2010-2011.**

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Cropping systems</th>
<th>Total cost that varies (TCV) (Rs./ha)</th>
<th>Net benefits (NB) (Rs./ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>S\textsubscript{8}</td>
<td>Sesbania-maize (fodder)-wheat</td>
<td>168833</td>
<td>85837</td>
</tr>
<tr>
<td>S\textsubscript{4}</td>
<td>Spinach-wheat</td>
<td>195493</td>
<td>148827</td>
</tr>
<tr>
<td>S\textsubscript{3}</td>
<td>Radish-wheat</td>
<td>202181</td>
<td>217749</td>
</tr>
<tr>
<td>S\textsubscript{1}</td>
<td>Rice-wheat</td>
<td>212179</td>
<td>110296</td>
</tr>
<tr>
<td>S\textsubscript{2}</td>
<td>Cotton-wheat</td>
<td>215469</td>
<td>224510</td>
</tr>
<tr>
<td>S\textsubscript{7}</td>
<td>Sesbania-maize (grain)-wheat</td>
<td>236177</td>
<td>124868</td>
</tr>
<tr>
<td>S\textsubscript{5}</td>
<td>Sesbania-potato- maize (grain)</td>
<td>317305</td>
<td>378490</td>
</tr>
<tr>
<td>S\textsubscript{6}</td>
<td>Bajra (fodder)-potato-maize (grain)</td>
<td>365697</td>
<td>379693</td>
</tr>
</tbody>
</table>

**Marginal rate of return**

The data (Table 4) revealed that maximum MRR (395.56%) was noted in S\textsubscript{3} (radish-wheat) indicating that if S\textsubscript{3} is involved into cropping system instead of S\textsubscript{8} (sesbania-maize (fodder) - wheat), then MRR will be 395 percent, followed by S\textsubscript{2} (cotton-wheat) with MRR of 297 percent. This means that for every 100

**Table 4. Analysis of marginal rate of return.**

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Cropping systems</th>
<th>TCV (Rs./ha)</th>
<th>MC (Rs./ha)</th>
<th>NB (Rs./ha)</th>
<th>MNR (Rs./ha)</th>
<th>MRR (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>S\textsubscript{8}</td>
<td>Sesbania-maize (fodder)-wheat</td>
<td>168833</td>
<td>--</td>
<td>85837</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>S\textsubscript{4}</td>
<td>Spinach-wheat</td>
<td>195493</td>
<td>26660</td>
<td>148827</td>
<td>62990</td>
<td>236.27</td>
</tr>
<tr>
<td>S\textsubscript{3}</td>
<td>Radish-wheat</td>
<td>202181</td>
<td>33348</td>
<td>217749</td>
<td>131912</td>
<td>395.56</td>
</tr>
<tr>
<td>S\textsubscript{2}</td>
<td>Cotton-wheat</td>
<td>215469</td>
<td>46636</td>
<td>224509</td>
<td>138673</td>
<td>297.35</td>
</tr>
<tr>
<td>S\textsubscript{5}</td>
<td>Sesbania-potato- maize (grain)</td>
<td>317305</td>
<td>148472</td>
<td>378490</td>
<td>292653</td>
<td>197.11</td>
</tr>
<tr>
<td>S\textsubscript{6}</td>
<td>Bajra (fodder)-potato-maize (grain)</td>
<td>365697</td>
<td>196864</td>
<td>379693</td>
<td>293856</td>
<td>149.27</td>
</tr>
</tbody>
</table>
rupees invested in maize (fodder) production, one can expect to recover Rs. 100 and obtain an additional amount of Rs. 395.00 in radish-wheat cropping systems. This was due to the differences in costs that varied among these cropping systems. However, the differences in net benefits were substantial. MRR of S_4 (spinach-wheat) is 236 percent. However, comparison of S_8 with S_6 indicated MRR of 149 percent in S_6. When S_3 was compared with S_4, S_2, S_5 and S_6 for MRR, an increase of 40, 25, 50 and 62 percent, respectively was found in former case. MRR of S_5 was higher by 24 percent compared to S_6. It is evident from economic analysis of the data that S_3 (radish-wheat) is the best suited cropping system to earn more net profit by the farmers having limited financial resources, while with better financial resources the farmers can move towards S_2, S_4, S_5, and S_6.

**Effect of different cropping systems on soil fertility**

The data (Table 5) recorded before planting and after harvesting of each crop system revealed that S_5 (Sesbania-potato-maize (grain) left greater quantity of nitrogen (0.0525%) followed by S_7 (0.0522%) and S_8 (0.0520%) with maximum increase in N content i.e 9.375, 8.75 and 8.33 percent, respectively. However, differences among these were negligible. Minimum quantity of nitrogen after last harvest was in S_2 (cotton-wheat) (0.0467%) followed by rice-wheat (0.0469%) cropping system. The reduction in N contents in soil might be attributed to nitrogen exhaustive nature of rice and cotton. Hence nitrogen left in soil after their harvest was relatively in smaller quantities.

The favourable effect of nitrogen observed in S_5, S_7 and S_8 could be attributed to the addition of nitrogen through free atmospheric nitrogen fixation by sesbania (green manuring). Legumes and green manure crops must be included in traditional cereal-cereal cropping pattern to further improve the N input and organic fertility of these soils (1). Akbar *et al.* (3) also concluded that integration of a fodder legume into a rice-based cropping system was a practical solution to fodder shortage and also it restores soil fertility.

The data (Table 5) further indicated that maximum phosphorus (8.70 ppm) was recorded in sesbania-potato-maize (S_5) as compared to P value of 8.00 ppm before crops harvest. The increase of 8.75 percent in P content is due to sesbania involved as green manure in this cropping system. Sesbania-maize (fodder)-wheat (S_6) and sesbania-maize (grain)-wheat (S_7) stood 2^{nd} and 3^{rd} with P content of 8.46 and 8.43 ppm showing 5.75 and 5.37 percent increase, respectively. However, maximum P value was recorded after green manure (S_5) and minimum was recorded after wheat in S_2. Minimum
phosphorus content of 7.83 ppm was recorded in cotton-wheat because cotton was an exhaustive crop. It was followed by rice-wheat with P content of 7.85 ppm. The data showed negligible differences in phosphorus contents in different cropping systems.

Table 5. Soil nutrient status as affected by different cropping systems.

<table>
<thead>
<tr>
<th>S. No</th>
<th>Cropping systems</th>
<th>Soil nitrogen (%)</th>
<th>Soil phosphorus (ppm)</th>
<th>Soil potassium (ppm)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Initial level</td>
<td>Final level</td>
<td>Initial level</td>
</tr>
<tr>
<td>S₁</td>
<td>Rice-wheat</td>
<td>0.048</td>
<td>0.0469</td>
<td>8</td>
</tr>
<tr>
<td>S₂</td>
<td>Cotton-wheat</td>
<td>0.048</td>
<td>0.0467</td>
<td>8</td>
</tr>
<tr>
<td>S₃</td>
<td>Radish-wheat</td>
<td>0.048</td>
<td>0.0492</td>
<td>8</td>
</tr>
<tr>
<td>S₄</td>
<td>Spinach-wheat</td>
<td>0.048</td>
<td>0.0491</td>
<td>8</td>
</tr>
<tr>
<td>S₅</td>
<td>Sesbania-potato-maize (grain)</td>
<td>0.048</td>
<td>0.0525</td>
<td>8</td>
</tr>
<tr>
<td>S₆</td>
<td>Bajra (fodder)-potato-maize (grain)</td>
<td>0.048</td>
<td>0.0485</td>
<td>8</td>
</tr>
<tr>
<td>S₇</td>
<td>Sesbania-maize (grain)-wheat</td>
<td>0.048</td>
<td>0.0522</td>
<td>8</td>
</tr>
<tr>
<td>S₈</td>
<td>Sesbania-maize (fodder)-wheat</td>
<td>0.048</td>
<td>0.0520</td>
<td>8</td>
</tr>
</tbody>
</table>

The data (Table 5) further revealed that maximum potassium content (174 ppm) was also recorded in sesbania-potato-maize (S₅) as compared to value of 145 ppm before crops harvest. It was due to addition of sesbania as green manure in this cropping system. Increase in K content in this cropping system was 20 percent. Sesbania-maize (fodder)-wheat (S₈) and sesbania-maize (grain)-wheat (S₇) were 2nd and 3rd with K content of 171 ppm and 170 ppm, having 17.93 and 17.24 percent increase, respectively. However, difference in these two treatments was negligible. Minimum potassium content of 153 ppm was recorded in cotton-wheat cropping system. The data indicated negligible differences in potassium contents in different cropping systems.

CONCLUSION

The study concluded that bajra-potato-maize, sesbania-potato-maize and radish-wheat cropping systems proved better in economic efficiency, and fertility restoring than existing cropping patterns. Thus these proposed cropping patterns should be practiced by the farmers in mixed cropping zone. However, sesbania based cropping system improved more fertility status of the soil. So it is recommended that sesbania as green manure crop must be involved in existing cropping systems.

REFERENCES


