Impact of Cropping Systems and Resource Conservation Techniques on Productivity and Profitability of Systems

Shaukat Ali¹, A.M. Patel², Sangeeta Sharma³

ABSTRACT

Background: A suitable cropping system seems to be the possible solution to meet the continuous increase in demand for food, stability of income and diverse requirement of food grains. Selection of suitable cropping system for conservation of resources has prime importance now a day. The cropping systems selected in study have higher potential of production along with incorporable residues during winter. The residues of cotton, castor and mustard crops (Crops in selected cropping systems) have more potential to feed nutrients to soil as compared to burning. So incorporation of such crop residues in to soil helps to recycle the nutrients to correct their deficiencies. Farmyard manure is being used as major source of organic manure in field crops. Thus to maintain the soil health, integrated nutrient management approaches involving FYM and mineral source need to be standardized. So there is need to find out agronomically efficient and economically viable cropping system which can perform better for increasing productivity and profitability with association of conservation of natural resources.

Methods: The experiment was laid out in split plot design with three replications. Sixteen treatment combinations comprising of four cropping system treatments viz, C₁: Cotton- Summer Pearl millet, C₂: Greengram + Kharif Castor (Relay), C₃: Greengram - Mustard - Summer Pearl millet and C₄: Greengram - Rabi Castor and two residue incorporation treatments viz, R₁: No residue incorporation and R₂: Residue incorporation as well as two fertilizer doses viz, F₁: 100% RDN through inorganic fertilizer and F₂: 75% RDN through inorganic fertilizer + 25% RDN through FYM were evaluated in the study.

Result: Cotton - summer pearl millet cropping system found significantly superior by recording higher pearl millet equivalent yield, system productivity and system profitability while, total weed count/m² and total weed dry weight were found the lowest under greengram-kharif castor (relay) cropping system. Residue incorporation secured top position by recording significantly the highest pearl millet equivalent yield, system productivity and system profitability as well as lowest total weed count/m² and total weed dry weight. Application of 75% RDN through inorganic fertilizer + 25% RDN through FYM recorded significantly highest pearl millet equivalent yield, system productivity and system profitability. In case of weed count and weed dry weight, 100% RDN through inorganic fertilizer found significantly superior by recording lowest total weed count/m² and total weed dry weight.

Key words: Cropping system, FYM, Pearl millet equivalent yield, Residue incorporation, System productivity, System profitability.

INTRODUCTION

In spite of substantial gain in agriculture production over the past few decades, the task of meeting the food grains, feed, fodder and fuel needs of increasing human and livestock population remains a formidable challenge before scientific community. Though India is a food surplus nation at present with about 284.8 million tonnes food grain production per annum, it will require about 4.5 million tonnes additional food grains every year if the trend in rising population persists (Anonymous, 2018). This additional production has to come from existing land and water resources. The present situation is comfortable, but to meet the future demand, we would need better planning and resource management as well as intensification of crop production.

A suitable cropping system seem to be the possible solution to meet the continuous increase in demand for food, stability of income and diverse requirement of food grains. Inclusion of different crops provides ways to recycle products and by products of one crop as input another crop and reduce the cost of production, increase production and thus increase total income of farm (Ravisankar et al., 2007). The feasibility and popularity of any cropping system depend upon the availability of all resources along with the economical gain to farmers. Selection of suitable cropping system for conservation of resources has prime importance now a day. The cropping systems selected in study have higher potential of production along with incorporable

Department of Agronomy, C.P. College of Agriculture, S.D. Agricultural University, Sardarkrushinagar-385 506, Gujarat, India.
¹SMS Agronomy, Krishi Vigyan Kendra, Chandgothi, Churu-331 305, Rajasthan, India.
²AICRP on IFS, S.D. Agricultural University, Sardarkrushinagar, Gujarat-385 506, India.
³Department of Clothing and Textile Chemistry, Mahatma Jyoti Rao Phool University, Jaipur-302 019, Rajasthan, India.

Corresponding Author: Shaukat Ali, SMS Agronomy, Krishi Vigyan Kendra, Chandgothi, Churu-331 305, Rajasthan, India. Email: shaukatagro@gmail.com

How to cite this article: Ali, S., Patel, A.M. and Sharma, S. (2021). Impact of Cropping Systems and Resource Conservation Techniques on Productivity and Profitability of Systems. Indian Journal of Agricultural Research. 55(2): 175-180. DOI: 10.18805/IJARe.A-5403.

Submitted: 18-09-2019 Accepted: 14-04-2020 Online: 10-09-2020
residues during winter. Proper or integrated nutrient management involving conjunctive use of organic, inorganic and crop residues may improve soil productivity (Patra et al., 2000 and Kumar et al., 2001) and also develop sustainable system productivity (Raju and Reddy, 2000). The residues of cotton, castor and mustard crops have more potential to feed nutrients to soil as compared to burning. So incorporation of such crop residues in to soil helps to recycle the nutrients to correct their deficiencies.

Farmyard manure (FYM) is being used as major source of organic manure in field crops. Thus to maintain the soil health, integrated nutrient management approaches involving FYM and mineral source need to be standardized. Studies indicated that use of organic sources can help to maintain a better N: P ratio and can produce higher yield (Bakhtiar, 2002 and Khanam et al., 2001). The combined use of organic and chemical fertilizers will help to maintain soil productivity even under intensive cropping systems. So there is need to find out agronomically efficient and economically viable cropping system which can perform better for increasing productivity and profitability with association of conservation of natural resources.

**MATERIALS AND METHODS**

The field experiment was conducted on loamy sand soils of Agronomy Instructional Farm, C. P. College of Agriculture, S. D. Agricultural University, Sardarkrushinagar (Gujarat) during the years 2012-13 and 2013-14 to study “Impact of cropping systems and resource conservation techniques on productivity and profitability of systems”. The soil of the experimental plot was low in organic carbon (0.20%) and available nitrogen (171 kg/ha), medium in available phosphorus (39 kg/ha), and potash (273 kg/ha) with particle density of 2.784 g/cc and bulk density of 1.639 g/cc. The experiment was laid out in split plot design with three replications. Sixteen treatment combinations comprising of four cropping system treatments viz. C1: Cotton- Summer Pearl Millet, C2: Greengram + Kharif Castor (Relay), C3: Greengram + Mustard – Summer Pearl Millet and C4: Greengram + Rabi Castor and two residue incorporation treatments viz. R1: No residue incorporation and R2: Residue incorporation as well as two fertilizer doses viz. F1: 100% RDN through inorganic fertilizer and F2: 75% RDN through inorganic fertilizer + 25% RDN through FYM were evaluated in the study. The ex-situ cotton, mustard and castor crop’s residues were incorporated during second fortnight of May month in respective treatments with the help of rotovator before initiation of experiment for making treatment equity. The quantity of residue (kg/ha) was calculated according to seed and straw ratio of different crops. During the 1st and 2nd year of experimentation in-situ cotton and mustard crop’s residue incorporation was done in second fortnight of February while castor in second fortnight of May month and field was prepared for sowing of next crop. According to nutrients content (0.5% N, 0.25% P2O5 and 0.5% K2O), the application of FYM for 25% Nitrogen was done in respective treatments before the sowing of each crop. There was no severe attack of insect and pest was observed during the entire growth periods of different crops. Pearl Millet crop was considered for equivalent yield because it is predominant crop of the region and it has less fluctuation of price as compared to other crop taken in experiment. The pearl millet equivalent yield was calculated on the basis of formula given below.

\[
\text{PMYE (kg/ha)} = \frac{\text{Yield of pearl millet crop} \times \text{Price of pearl millet grain}}{\text{Yield of sequence crop} \times \text{Price of sequence crop}}
\]

Total human labours used in each crop season of a cropping system was recorded and then summed for calculating the employment generation of each cropping system. Weed count at harvest of each crop was taken using 1 m x 1 m quadrant placed in two randomly selected spots in each net plot. The total number of weeds were counted and recorded after converting the same to per square meter basis. Dry weight of weeds from each plot at the time of harvest was recorded from one square meter area. Weeds were uprooted from the selected area after that sun dried and the dry weight of weeds was recorded when weeds attained constant weight and expressed g/m² for each plot.

Yield of different crops other than pearl millet was converted in to pearl millet equivalent yield according to prevailing market price. System productivity was calculated for different treatments by dividing equivalent yield (kg/ha) with days in a year.

System Productivity (kg/ha/day) = \frac{\text{Pearl Millet Equivalent yield (kg/ha)}}{365}

System profitability was calculated for different treatments by dividing net return (\$/ha) with days in a year.

System Profitability (\$/ha/day) = \frac{\text{Net return (\$/ha)}}{365}

Sequence duration was calculated by sum the total growing days of a cropping system. Each season (kharif, rabi and summer) growing days was recorded and totaled for each cropping sequence duration calculation. Land use efficiency was calculated by using the following formula.

\[
\text{LUE} (%) = \frac{\text{Total Duration of Cropping System (Days)}}{365} \times 100
\]

**RESULTS AND DISCUSSION**

**Effect of treatments on sequence duration and employment generation**

Table 1 indicates that cotton - summer pearl millet cropping system required 337 days to complete the cropping sequence with 92.33% land use efficiency which was the maximum as compared to other cropping systems which indicates that land was continue cultivated. Only for 28 days in year land was on rest because cotton crop was followed by pearl millet crop immediately after harvesting of cotton.
Impact of Cropping Systems and Resource Conservation Techniques on Productivity and Profitability of Systems

Table 1: Sequence duration, land use efficiency and employment generation as influenced by different treatments (Mean data of 2012-13 and 2013-14).

| Treatment symbols | Sequence duration (days) | Land use efficiency (%) | Employment generation (Man days/ha) |
|-------------------|--------------------------|--------------------------|-------------------------------------|
| CₐRᵢFᵢ | 337 | 92.33 | 206 |
| CₐRᵢFᵢ | 337 | 92.33 | 212 |
| CₐRᵢFᵢ | 337 | 92.33 | 196 |
| CₐRᵢFᵢ | 295.5 | 80.96 | 202 |
| CₐRᵢFᵢ | 295.5 | 80.96 | 200 |
| CₐRᵢFᵢ | 295.5 | 80.96 | 184 |
| CₐRᵢFᵢ | 295.5 | 80.96 | 190 |
| CₐRᵢFᵢ | 291.5 | 79.87 | 256 |
| CₐRᵢFᵢ | 291.5 | 79.87 | 265 |
| CₐRᵢFᵢ | 291.5 | 79.87 | 246 |
| CₐRᵢFᵢ | 291.5 | 79.87 | 255 |
| CₐRᵢFᵢ | 264.5 | 72.47 | 185 |
| CₐRᵢFᵢ | 264.5 | 72.47 | 191 |
| CₐRᵢFᵢ | 264.5 | 72.47 | 175 |
| CₐRᵢFᵢ | 264.5 | 72.47 | 181 |

Table 2: Pearlmillet equivalent yield, system productivity, system profitability, total weeds count/m² and total weed dry weight as influenced by different treatments (Pooled of 2012-13 and 2013-14).

| Treatments | Pearlmillet equivalent yield (kg/ha) | System productivity (kg/ha/day) | System profitability (`/ha/day) | Total weeds count/m² | Total weed dry weight (g/m²) |
|------------|--------------------------------------|---------------------------------|-------------------------------|----------------------|-----------------------------|
| Cropping systems | | | | | |
| C₁ : Cotton - Summer Pearlmillet | 15,241 | 41.76 | 380 | 64 | 117.22 |
| C₂ : Greengram - Kharif Castor (Relay) | 10,589 | 29.01 | 251 | 57 | 96.43 |
| C₃ : Greengram - Mustard - Summer Pearlmillet | 14,096 | 38.62 | 319 | 71 | 131.33 |
| C₄ : Greengram - Rabi Castor | 9,701 | 26.58 | 210 | 59 | 101.15 |
| S.Em. ± | 170 | 0.47 | 6.51 | 0.36 | 0.92 |
| C. D. at 5% | 523 | 1.43 | 20.07 | 1.12 | 2.83 |
| C. V. % | 8.84 | 8.84 | 14.25 | 3.95 | 5.53 |
| Residue incorporation | | | | | |
| R₀ : No residue incorporation | 11,507 | 31.53 | 258 | 65 | 112.36 |
| R₁ : Residue incorporation | 13,306 | 36.46 | 322 | 60 | 110.71 |
| S.Em. ± | 85 | 0.23 | 3.25 | 0.36 | 0.83 |
| C. D. at 5% | 238 | 0.65 | 9.13 | 1.01 | NS |
| Fertilizer doses | | | | | |
| F₀ : 100% RDN through inorganic fertilizer | 11,990 | 32.85 | 283 | 52 | 99.73 |
| F₁ : 75% RDN through inorganic fertilizer + 25% RDN through FYM | 12,824 | 35.13 | 297 | 73 | 123.34 |
| S.Em. ± | 69 | 0.19 | 2.65 | 0.29 | 0.68 |
| C. D. at 5% | 194 | 0.53 | 7.45 | 0.82 | 1.90 |
| C. V. % | 4.41 | 4.41 | 7.11 | 3.89 | 5.00 |
| Interaction | | | | | |
| C x R | NS | NS | NS | NS | NS |
| C x F | NS | NS | NS | Sig. | Sig. |
| R x F | NS | NS | NS | Sig. | NS |
| C x R x F | NS | NS | NS | Sig. | NS |

Selling price (₹/kg): Cotton: 45, Cotton stalk: 0.5, Greengram seed: 41, Greengram straw: 2.5, Castor seed: 35, Castor stalk: 0.5, Mustard seed: 35, Mustard stalk: 0.5, Pearlmillet grain: 14, Pearlmillet straw: 3
Indian Journal of Agricultural Research

Impact of Cropping Systems and Resource Conservation Techniques on Productivity and Profitability of Systems

Fig 1: Pearlmillet equivalent yield (kg/ha) in pooled data (2012-13 and 2013-14).

Pearl millet gave higher yields when it is grown after cotton in sequence. These finding are in conformity with those reported by SDAU (2010) and SDAU (2011). They reported that cotton - summer pearl millet was remunerative cropping system as compared to others.

System productivity in terms of pearl millet equivalent yield was the highest in cotton - summer pearl millet cropping system (41.76 kg/ha/day) as depicted in Table 2. The magnitude of increase in system productivity in cotton - summer pearl millet cropping system was to the extent of 8%, 44% and 57% compared to greengram - mustard - summer pearl millet, greengram - kharif castor (relay) and greengram - rabi castor. The system productivity was the highest in this treatment as a result of the higher quantity of yield produced. These findings are in close conformity with those reported by SDAU (2010), SDAU (2011) and SDAU (2013).

System profitability is a function of the quantity of yield produced, the cost of cultivation and the prevailing market price of the produce to obtain an overall net profit per day. System profitability among the treatments, in terms of net realization to the days in a year was significantly the highest in cotton - summer pearl millet cropping system (380/ha/day) as indicted in Table 2. Cotton - summer pearl millet cropping system secured 19%, 52% and 81% higher profitability as compared to greengram - mustard - summer pearl millet, greengram - kharif castor (relay) and greengram - rabi castor. Cotton and summer pearl millet in the system gave an economic advantage in terms of the quantity of yield produced which resulted higher amount of net realization. These results lend support of the findings reported by SDAU (2010), SDAU (2011) and SDAU (2013).

System productivity among the treatments, in terms of pearl millet equivalent yield per day was highest in residues incorporation (36.46 kg/ha/day) as depicted in Table 2. The magnitude of increase in system productivity in residue incorporation was to the extent of 16% as compared to no residue incorporation. Higher pearl millet equivalent yield secured in treatment might be due to residue incorporation increased organic matter in soil and availability of nutrients to crops which resulted higher biomass production. These finding are in conformity with those reported by Kaleeswari et al. (2007), Singh et al. (2010) and SDAU (2011). Kaleeswari et al. (2007) observed that incorporation of crop residue in soil recorded higher grain yield of maize and maize grain equivalent yield. Singh et al., 2010 reported that incorporation of crop residues has improved the mean rice equivalent yields of system by 7.86% as compared to their removal. SDAU (2011) observed that residue incorporation significantly increased pearl millet equivalent yield.

System productivity among the treatments, in terms of pearl millet equivalent yield per day was highest in residues incorporation (380/ha/day) as depicted in Table 2. The magnitude of increase in system productivity in residue incorporation was to the extent of 16% as compared to no residue incorporation. The system productivity was the highest in the residue incorporation as a result of the higher quantity of yield produced by application of residue in soil which increased organic carbon and helps to improve soil physico chemical properties.

From the evidence (Table 2) it seems that system profitability in terms of net realization per day was significantly the highest in residue incorporation (322/ha/
day. Residue incorporation secured 25% higher profitability as compared to no residue incorporation. Higher amount of net realization obtained in this treatment possibly the main reason for higher profitability.

Residue incorporation treatment rank first by recording significantly the lowest total number of weeds per m$^2$ of sequence. This might be due to the organic acid produced by residues might have become barrier for germination of weeds. Moreover while incorporation of residue the upper layer of weed seeds placed at depth which is also responsible for lower number of weeds. Total weeds dry weight of sequence was found to be non-significant.

**Effect of fertilizer dose**

Among the treatments, the highest pearlmillet equivalent yield (12.824 kg/ha) was observed under 75% RDN through inorganic fertilizer + 25% RDN through FYM which was 7% higher over 100% RDN through inorganic fertilizer (Table 2 and Fig 1). Higher pearlmillet equivalent yield secured in this treatment might be due to application of FYM which increased organic matter in soil and availability of nutrients to crops which resulted higher biomass production. These finding are in conformity with those reported by Kaleeswari et al. 2007, Patil et al. (2007) and Jat et al. (2011). Patil et al. (2007) recorded that application of recommended package of practice ($\frac{1}{2}$ N through urea + $\frac{1}{2}$ N through FYM) registered significantly higher maize equivalent yield as compared to farmers practice except fertilizer + RDF. Jat et al. (2011) found that application of FYM 5 t/ha + 50% RDF to groundnut recorded significantly higher groundnut equivalent yield.

System productivity among the treatments, in terms of pearlmillet equivalent yield per day was the highest in treatment 75% RDN through inorganic fertilizer + 25% RDN through FYM (35.13 kg/ha/day) as depicted in Table 2. The magnitude of increase in system productivity in this treatment was to the extent of 7% as compared to 100% RDN through inorganic fertilizer. The system productivity was the highest in this treatment as a result of the higher quantity of yield produced by application of FYM which increased organic matter in soil helps to improve soil physico chemical properties. These results lend support of the findings reported by Jat et al. (2011). They observed that use of organic and inorganic nutrients (FYM 5 t/ha + 50% RDF) to kharif groundnut recorded significantly higher total system productivity in term of groundnut equivalent yield over the use of inorganic nutrients.

From the evidence (Table 2) it seems that system profitability among the treatments in terms of net return per day was significantly the highest under 75% RDN through inorganic fertilizer + 25% RDN through FYM (12,824 kg/ha). This treatment secured 5% higher profitability as compared to 100% RDN through inorganic fertilizer. Higher amount of net realization obtained in this treatment possibly the main reason for higher profitability.

**Interaction effect**

**Weed counts**

Interaction effect of cropping systems and fertilizer dose (C x F) and residue incorporation and fertilizer dose (R x F) as well as cropping systems, residue incorporation and fertilizer dose (C x R x F) were found to be significant with respect to weed count.

From the interaction data (Table 2.1), it is revealed that treatment combination $C_1F_0$, (Greengram + kharif castor (relay) + 100% RDN through inorganic fertilizer) recorded significantly the lowest total weeds (45.3) but was at par with combination $C_0F_1$. This might be due to the organic acid produced by residues might make a barrier for germination of weeds. Moreover while incorporation of residue, the upper layer of weed seeds placed at depth which is also responsible for lower number of weeds. Beside this, chemical fertilizer does not contain weed seeds which could be responsible for higher total weeds.

Residue incorporation + 100% RDN through inorganic fertilizer ($R_F_1$) recorded significantly the lowest total number of weeds (51.0).

The treatment combination $C_0R_0F_1$, (Greengram + kharif castor (relay) + residue incorporation + 75% RDN through inorganic fertilizer + 25% RDN through FYM) recorded significantly lower total number of weeds which was at par with $C_1R_F_1$ and $C_0R_0F_1$. Lower number of weeds in this combination because greengram and kharif castor relay system suppress growth of weed by their dense crop canopy imparted smothering effect as well as residues incorporation reduced germination of weeds as seeds of weed placed deep during incorporation. Beside this, chemical fertilizer does not contain weed seeds which could be responsible for higher total weeds.

**Weed dry matter**

Combined effect of cropping systems and fertilizer dose (C x F) on total of weeds dry weight was found to be significant with respect to weed dry matter.

---

**Table 2.1: Interaction effect of C x F, R x F and C x R x F on numbers of weed per m².**

| Treatments | $C_1$ | $C_2$ | $C_3$ | $C_4$ | $R_0$ | $R_1$ |
|------------|-------|-------|-------|-------|-------|-------|
| $F_1$      | 58    | 45    | 59    | 47    | 54    | 51    |
| $F_2$      | 71    | 68    | 82    | 72    | 77    | 69    |
| S. Em. ±   | 0.51  | 0.51  |
| C. D. at 5%| 1.43  |
| C. V. %    | 3.89  |

| $C_1$ | $C_2$ | $C_3$ | $C_4$ |
|-------|-------|-------|-------|
| $R_0$ | $R_1$ | $R_0$ | $R_1$ |
| 60    | 57    | 46    | 45    |
| 73    | 69    | 74    | 63    |
| 85    | 79    | 77    | 66    |

179

Impact of Cropping Systems and Resource Conservation Techniques on Productivity and Profitability of Systems
Table 2.2: Interaction effect of C x F on total weed dry weight of sequence.

| Treatments | C₁ | C₂ | C₃ | C₄ |
|------------|----|----|----|----|
| F₁         | 108.0 | 86.5 | 116.3 | 88.1 |
| F₂         | 126.5 | 106.4 | 146.3 | 114.2 |
| S.Em. ±    | 1.17 |     |     |     |
| C. D. at 5%| 3.30 |     |     |     |
| C. V. %    | 5.00 |     |     |     |

It is revealed (Table 2.2) that lower weed dry weight (86.5 g/m²) was recorded with treatment combination C₂F₁ (Greengram + kharif castor (relay) + 100% RDN through inorganic fertilizer) but it was at par with C₄F₁. Lower total number of weeds in this combination was main reason for low weed dry weight. This is true because the total number of weeds were less in this treatment combination.

REFERENCES
Anonymous (2018). Agriculture Statistics at a Glance. Directorate of Economics and Statistics, Department of Agriculture and Cooperation, New Delhi. Pp72.
Bakhtiar, S.M., Alam, M.J., Mahmood, K. and Rahman, M.H. (2002). Integrated nutrient management under three agro-ecological zones of Bangladesh. Pakistan Journal Biological Science. 5: 390-393.
Jat, R.S., Dyal, D., Meena, H.N., Singh, V. and Gedia, M.V. (2011). Long term effect of nutrient management and rainfall on pod yield of groundnut (Arachis hypogaea) in groundnut based cropping system. Indian Journal of Agronomy. 56 (2): 145-149.
Kaleeswari, R.K., Kalpana, R. and Devasenapath, P. (2007). Impact of organic resources on soil carbon conservation in maize based cropping system. Journal of Farming Systems Research and Development. 13(1): 122-123.
Khanam, M., Rahman, M.M. and Islam, M.R. (2001). Effect of manures and fertilizers on the growth and yield of BRRI Dhan 30. Pakistan Journal of Biological Sciences. 4: 172-174.
Kumar, N., Verma, L.P., Singh, R. and Prasad, K. (2001). Soil properties, nutrient uptake and productivity of rice under integrated nutrient management system. Annals of Plant and Soil Research. 3 (1): 54-57.
Patil, Y.J., Hile, R.B., Bodake, P.S. and Chauhan, M.R. (2007). Agronomic management for maximizing productivity of maize - wheat cropping system. Journal of Farming Systems Research and Development. 13(1): 122-123.
Patra, A.K., Nayak, B.C. and Mishra, M.M. (2000). Integrated nutrient management in rice-wheat cropping system. Indian Journal of Agronomy. 45(3): 453-457.
Raju, R.A. and Reddy, M.N. (2000). Sustainability and productivity in rice - rice sequential cropping systems through integrated nutrient management in coastal eco system. Indian Journal of Agronomy. 45(3): 447-452.
Ravisankar, N., Pramanik, S.C., Jayakumar, S., Singh, D.R., Bibi, N., Nawaz, S. and Biswas, T.K. (2007). Study on integrated farming system (IFS) under different resource conditions of island ecosystems. Journal of Farming Systems Research and Development. 13(1): 1-9.
SDAU (2010). 7th AGRESCO report, AICRP on IFS, SDAU. pp. 6-13: 19-24.
SDAU (2010). Annual report, AICRP on IFS, SDAU. pp. 24-31: 64-70.
SDAU (2011). 8th AGRESCO Report, AICRP on IFS, SDAU. pp. 14-21: 27-32.
SDAU (2011). Annual report, AICRP on IFS, SDAU. pp. 24-32: 64-70.
SDAU (2013). 10th AGRESCO Report, AICRP on IFS, SDAU. pp. 28-33.
Singh, S.K., Kumar, D. and Lal, S.S. (2010). Integrated use of crop residues and fertilizers for sustainability of potato (Solanum tuberosum) based cropping systems in Bihar. Indian Journal of Agronomy. 55(3): 203-208.