Biological Forum – An International Journal **15(7): 21-26(2023)**

ISSN No. (Print): 0975-1130
ISSN No. (Online): 2249-3239

Evaluation of Various Cropping Systems on Soil Health in Southern Telangana Zone

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(Received: 04 April 2023; Revised: 22 April 2023; Accepted: 18 May 2023; Published: 05 July 2023)
(Published by Research Trend)

ABSTRACT: Monocropping of cereals has been exploitative and not economical to the farmers. There is a need to design an agricultural production system that ensures food and nutritional security and enhances the soil health at the same time. There is need to maintain sustainability which can be possible with the help of practicing soil friendly cropping systems. This study was conducted to identify the efficient cropping systems in terms of soil health. To find out the impact of various cropping systems on soil health, an experiment was conducted at IFS Unit, College farm, College of Agriculture, PJTSAU, Rajendranagar during 2021-22 and 2022-23. Cultivation of Pigeonpea + Sweetcorn - Bajra and Pigeonpea + Maize - Sunhemp cropping systems is beneficial as they have positive impact on soil properties and it is observed that inclusion of legumes plays a vital role on soil health.

Keywords: Legumes, Monocropping, Soil properties, Soil health, Telangana.

INTRODUCTION

In the pre independence era, our country was in food crisis. We were unable to feed our country population. From 1891 to 1946, the annual growth rate of all crop output was very less and food grain output was practically stagnant and because of food crisis, many people especially children were suffered with malnutrition. Indian agriculture, which grew at the rate of about 1 percent per annum during the fifty years before Independence, has grown at the rate of about 2.6 percent per annum in the post-Independence era (Tripathi and Prasad 2009). Rice, maize and Bt cotton are the predominant crops which are either grown solely or in rotation with other crops in the Telangana state (Goverdhan *et al.*, 2018). As all are exhaustive, non leguminous in nature, cropping systems are to be identified to compliment the crops in cropping system module.

Thanks to green revolution in India for making the country self sufficient in food grain production (Behera and France 2016). Through green revolution, our country has increased its food grain production by 5 times, horticulture production by 9 times, milk production by 9.5 times and fish production by 12 times but all of this happened at the cost of resource degradation. Our country has recorded the tremendous crop yields by extensive cultivation of few crops. It has reaped good yields in the short run, but in long run it is becoming unprofitable as well as unsustainable. Continuous crop cultivation with inorganic fertilizers without addition of manures to the soil created the most concerned issues like drop in organic carbon, plant macro & micro nutrients and loss of soil plankton. Monoculturing has depleted the soil fertility, ground water and it is one of the reasons behind soil erosion. We need fibre, fuel, and fodder along with food to balance the environment which can be possible through crop diversification.

Reliance on biological nitrogen fixation through inclusion of legumes in a cropping system and maintenance of higher soil organic matter will help to built up soil fertility and better soil physical and microbial environment with good buffering capacity. Efficient cropping system should consist of crops like cereals, pulses and oilseeds which help in meeting the household nutritional security. Fodder crops should be included in a cropping system or feeding the livestock round the year. In crop diversification, high value crops like sweet corn and Bt cotton plays a important role in income enhancement. Growing of sweet corn both for food and forage can be encouraged in semi urban areas for their demand throughout the year.

Cropping system signifies the sequence of crops grown over a specific piece of cultivated land and to increase the benefits from the available resources. The main aim of efficient cropping system is to increase production and economic returns. It should be economically viable and maintains the environmental sustainability. The main concept of intercropping is to get increased total productivity per unit area and time, besides equitable and judicious utilization of land resources and farming inputs including labour (Marer *et al*., 2007). Crops should be selected in intercropping in such a way that there should be no or very less competition between crops for below and above soil resources.

Soil health is a crucial element which is ignored as focus is more in income enhancement. Soil organic carbon can be improved by inclusion of legumes in cereal based cropping systems and this might be due higher addition of easily decomposable crop residue due to overall higher biomass production over other crop rotations (Yadav *et al*., 2017). Among the various intercropping systems, cotton + greengram has recorded significantly higher available nitrogen in the soil over the sole cotton crop and they also reported that inclusion of legumes as intercrop in cotton play a multi beneficiary role by providing grains and improves nitrogen status of soil through fixation of atmospheric nitrogen (Kumar *et al*., 2016). Pigeonpea + mungbean intercropping system recorded significantly higher organic carbon in soil over sole pigeonpea and mungbean (Malik *et al*., 2013) which might be because of more addition of organic matter by combined cultivation of both the crops than their sole cultivation. In the long run, productivity will be decreased which impacts the profitability if soil health is not taken care of. There is a need to balance the soil sustainability along with profitability for which proper planning is needed. Cropping systems shall be planned in such a way that soil fertility is not impacted for the sake of income enhancement.

MATERIALS AND METHODS

An experiment was conducted at IFS Unit, College farm, College of Agriculture, PJTSAU, Rajendranagar during 2021-22 and 2022-23 with a view to compare and evaluate the impact of various cropping systems on soil health. The details ofthe materials used and the methods adopted during the course of investigation are described in this chapter.

Location of the Experimental Site

The experimental site was situated at an altitude of 527 m above mean sea level (MSL) at 17º 19′11.20″N latitude and 78º 24′32.65″E longitude in Southern Telangana Zone (STZ), India. The experiment was laid out in field No. B-20 of Agricultural College Farm, Rajendranagar.

Weather. The meteorological data recorded during the crop growth period of experimentation was taken from the meteorological observatory of Agro Climatic Research Centre (ACRC) located at Agricultural Research Institute, Rajendranagar, Hyderabad.

During 2021-2022 the maximum and minimum weekly temperature during the study period ranged from 27.4°C to 39.2°C with the average of 32.0°C and from 9.6°C to 26.1°C with the average of 20.5°C, respectively. Mean weekly morning relative humidity ranged from 67 to 98.9 per cent with the average of 88.1per cent and evening relative humidity ranged from 24.7 to 88.9 per cent with the average of 56.3 per cent, respectively. Mean weekly sunshine hours ranged between 1.4 and 10 with the average of 6.3. The average annual rainfall was 859.6 mm with 15 rainy days whereas total evaporation was 246.3 mm.

During 2022-2023 the maximum and minimum weekly temperature during the study period ranged from 27.8°C to 39.5°C with the average of 32.2°C and from 9.8°C to 26.7°C with the average of 20.9°C, respectively. Mean weekly morning relative humidity ranged from 69 to 98.7 per cent with the average of 88.3 per cent and evening relative humidity ranged from 24.9 to 88.8 per cent with the average of 56.5 per cent, respectively. Mean weekly sunshine hours ranged between 1.6 and 9.8 with the average of 6.5. The average annual rainfall was 1069.6 mm with 18 rainy days whereas total evaporation was 276.7 mm.

Soil. Composite soil samples from the experimental site were collected from 0-30 cm depth before conducting the experiment. The soil samples so collected were thoroughly mixed and kept for air drying. A representative soil sample of about one kg was drawn by quartering method. The soil sample was analyzed for different physical and physico-chemical properties

Table 1: Physio-chemical properties of experimental site.

Sr. No.	Property	Method	Reference
1.	Soil pH (1:2.5)	Potentiometry	Jackson (1973)
2.	EC (dSm^{-1})	Conductometry	Piper (1966)
3.	Organic carbon (%)	Wetoxidation Method	Jackson (1973)
4.	Soil available N($kg\ ha^{-1}$)	Alkaline Permanganate	Subbaiah (1956)
5.	Soil available P ($kg\ ha^{-1}$)	0.5M $NaHCO_3$(pH8.5)	Watanabe, F.S. and Olsen (1965)
6.	Soil available K ($kg\ ha^{-1}$)	N*N*NH_4OAc	Jackson (1973)

Experimental design and treatment details. The seven treatments were laid out in Randomized Block Design, replicated thrice and the site of the experimental field was same throughout the experimentation and all crops were grown under irrigated conditions. Seven treatments are **T_1:** Rice – Groundnut; **T_2:** Pigeonpea + Sweetcorn (1:3) – Bajra; **T_3**: Bt cotton + Greengram (1:2) – Maize; **T_4:** Pigeonpea + Maize (1:3) – Sunhemp, **T_5:** guava orchard; **T_6:** Hedge lucerne; **T_7:** Napier grass.

Table 2: Recommended package of practices of all crops in integrated farming system.

Sr. No.	Name of the crop	Season	Seed rate ha^{-1}	Spacing	Fertilizer dose ha^{-1}	Variety
1.	Rice	*Kharif*	25	20 × 15 cm	120:60:40	RNR 21278
2.	Groundnut	*Rabi*	75	22.5 × 10	20:50:30	K-6
3.	Pigeonpea	*Kharif*	2.5	240 × 20	20:50:30	WRG-97
4.	Sweetcorn	*Kharif*	10	60 × 20	200:60:40	Sugar 75
5.	Bajra	*Summer*	5	45 × 15	80:40:30	Local
6.	Bt Cotton	*Kharif*	2.5	90 × 30	150:60:60	Magna (RCH 530 BG II)
7.	Greengram	*Kharif*	8	30 × 10	20:50:30	WGG 42
8.	Maize	*Rabi*	25	60 × 20	240:80:60	Pioneer 3396
9.	Pigeonpea	*Kharif*	2.5	240 × 20	20:50:30	WRG-97
10.	Maize	*Kharif*	25	60 × 20	240:80:60	Pioneer 3396
11.	Sunhemp	*Summer*	40	30 × 10	10:20:0	
	Fodder crops					
11.	Hedge Lucerne	*Perennial*	10kg	30 cm	40:60:20	RL-88
12.	Hybrid napier	*Perennial*	9260cuttings	90cm× 60cm	180:60:60	
	Horticultural crops					
13.	Guava	*Perennial*		4 × 4 m	100:40:100 2.5kg Vermicompost plant^{-1} at the time of planting	Allahabad safeda

Manures and fertilizers application. The recommended doses of nutrients (N, P & K) were supplied through urea, SSP and MOP. Entire dose of phosphorous was applied as basal. Nitrogen and Potash were applied as per the schedule of respective crops.

After care. Gap filling and thinning of crops were done on 7th and 15th DAS, respectively based on moisture availability. Hoeing and weeding was done manually and were taken up twice to keep weed free condition. Adequate prophylactic plant protection measures were also carried out to keep crops free from pest and diseases.

Irrigation. Irrigation was applied with drip system to every system except for rice-groundnut system and LDPE pipes of 16 mm diameter were used as laterals keeping lateral spacing 60 cm and inline dripper spacing 60 mm with every emitter flow rate of 4 l/h. Flooding method of irrigation was used for rice-groundnut system.

Harvesting. Rice crop was harvested by cutting the tillers at the base of the crop. Groundnut plants were uprooted and pods were stripped off from pant. Entire plants of Pigeonpea and Bajra were removed and threshing with sticks after sun drying. Maize and sweet corn were harvested by removing the green cobs from the plants. The cotton crop was harvested completely in three pickings and green gram was harvested by picking the pods from plant. Phytomass yield of sunhemp was recorded at the time of incorporation. For every crop, grain and straw yields were recorded from three replications and mean yields were calculated.

Statistical analysis. The data generated from field experiment were analyzed in randomized block design (Gomez and Gomez 1984) in three replications with ten treatments by analysis of variance (ANOVA). The significance of different sources of variation was tested by the error mean square of Fisher Snedecor's 'F' test at probability level 0.05. Standard error of mean (SEm) and least significant difference (LSD) at 0.05 level of significance were used to compare treatments.

RESULTS AND DISCUSSION

pH. There is not much change in the soil pH in the two years. Initial value of pH in Rice-Groundnut cropping system is 7.40 and there was no change in pH at the end of 2021-22 whereas it was changed to 7.41 at the end of 2022-23. Initial value of pH in Pigeonpea + Sweetcorn - Bajra cropping system is 7.32 and it was changed to 7.31 at the end of 2021-22 and no change in pH in 2022-23. Initial value of pH in Bt Cotton + Greengram - Maize cropping system is 7.25 and it was changed to 7.26 at the end of 2021-22 and no change in pH in 2022-23. Initial value of pH in Pigeonpea + Maize - Sunhemp cropping system is 7.49 and it remained same till the end of 2022-23. Initial value of pH in Guava orchard is 7.59 and there was no change in pH at the end of 2021-22 whereas it was changed to 7.58 at the end of 2022-23. Initial value of pH in Hedge lucerne is 7.59 and there was no change in pH at the end of 2021-22 whereas it was changed to 7.58 at the end of 2022-23. Initial value of pH in hybrid napier is 7.21 and it was changed to 7.20 at the end of 2021-22 and no change in pH in 2022-23. There is not much change in the pH in all cropping systems as it might take more years to change as reported by Kumar *et al*. (2020).

E.C. There is no significant change in the EC over the two years. Initial value of E.C (dS/m) in Rice-Groundnut cropping system is 0.30 dS/m and whereas it was changed to 0.31 dS/m at the end of 2021-22 and

0.32 dS/m at the end of 2022-23. In Pigeonpea + Sweetcorn – Bajra cropping system, initial value of E.C is 0.22 dS/m which increased to 0.23 dS/m at the end of 1st year and 0.25 dS/m at the end of 2nd year. In Bt Cotton + Greengram- Maize cropping system, initial value of E.C is 0.35 dS/m which increased to 0.36 dS/m at the end of 1st year and 0.37 dS/m at the end of 2nd year. In Pigeonpea + Maize - Sunhemp cropping system, initial value of E.C is 0.26 dS/m which remained same at the end of 1st year and increased to 0.27 dS/m at the end of 2nd year. In guava orchard, initial value of E.C is 0.39 dS/m which increased to 0.40 dS/m at the end of 1st year and 0.41 dS/m at the end of 2nd year. In hedge lucerne, initial value of E.C is 0.40 dS/m which remained same at the end of 1st year and increased to 0.41 dS/m at the end of 2nd year. In hybrid napier, initial value of E.C is 0.42 dS/m which remained same at the end of 1st year and increased to 0.43 dS/m at the end of 2nd year. Kumar *et al*. (2016) found that E.C might be increased by over dose of fertilizers and higher E.C could be mitigated with addition of manures or legume crops.

O.C. Initial value of organic carbon in Rice-Groundnut cropping system is 0.49% which increased to 0.50% at the end of 2021-22 and 0.51% at the end of 2022-23. Initial value of organic carbon in Pigeonpea + Sweetcorn- Bajra cropping system is 0.48% which increased to 0.49% at the end of 2021-22 and 0.50% at the end of 2022-23. Initial value of organic carbon in Bt Cotton + Greengram- Maize cropping system is 0.47% which increased to 0.48% at the end of 2021-22 and 0.50% at the end of 2022-23. Initial value of organic carbon in Pigeonpea + Maize - Sunhemp cropping system is 0.50% which increased to 0.52% at the end of 2021-22 and 0.54% at the end of 2022-23. In guava orchard, initial value of organic carbon is 0.53% which increased to 0.55% at the end of 2021-22 and 0.57% at the end of 2022-23. In hedge lucerne, initial value of organic carbon is 0.53% which increased to 0.55% at the end of 2021-22 and 0.57% at the end of 2022-23. In hybrid napier, initial value of organic carbon is 0.62% which remained same at the end of 2021-22 and increased to 0.63% at the end of 2022-23. Valani *et al*. (2021) reported that cropping systems with legumes and more biomass compared to monoculture reported higher total organic carbon, microbial biomass carbon, dissolved organic carbon and particulate organic carbon content mainly because of efficient utilization of residues.

Available nitrogen. Initial value of available nitrogen was 146.5 kg/ha in Rice-Groundnut cropping system which is increased to 150.0 kg/ha at the end of 2021-22 and to 155.4 kg/ha at the end of 2022-23. Initial value of available nitrogen in Pigeonpea + Sweet corn- Bajra cropping system was 140.3 kg/ha which is increased to 146.0 kg/ha at the end of 2021-22 and to 152.6 kg/ha at the end of 2022-23. Initial value of available nitrogen in Bt Cotton + Greengram- Maize cropping system was 137.8 kg/ha which is increased to 142.0 kg/ha at the end of 2021-22 and to 147.8 kg/ha at the end of 2022-23. Initial value of available nitrogen in Pigeonpea + Maize - Sunhemp cropping system was 156.2 kg/ha which is increased to 163.0 kg/ha at the end of 2021-22 and to 170.1 kg/ha at the end of 2022-23. Initial value of available nitrogen in guava orchard was 171.3 kg/ha which is increased to 175.0 kg/ha at the end of 2021-22 and to 180.2 kg/ha at the end of 2022-23. Initial value of available nitrogen in hedge lucerne was 171.9 kg/ha which is increased to 175.0 kg/ha at the end of 2021-22 and to 181.0 kg/ha at the end of 2022-23. Initial value of available nitrogen in hybrid napier was 188.6 kg/ha which is increased to 192.0 kg/ha at the end of 2021-22 and to 196.3 kg/ha at the end of 2022-23. Enhancement in available nitrogen has occurred in cropping systems with legume crop because of nitrogen fixation capacity of legume crop. These results are supported by Kumari *et al*. (2022) who found that addition of legumes in the cropping system enhances the nitrogen content in the soil and benefits the crop.

Available phosphorous. Initial value of available phosphorous in Rice-Groundnut cropping system was 31.3 kg/ha which is slightly increased to 31.53 kg/ha at the end of 2021-22 and to 31.90 kg/ha at the end of 2022-23. Initial value of available phosphorous in Pigeonpea + Sweetcorn - Bajra cropping system was 29.4 kg/ha which is increased to 29.70 kg/ha at the end of 2021-22 and to 30.20 kg/ha at the end of 2022-23. Initial value of available phosphorous in Bt Cotton + Greengram - Maize cropping system was 30.0 kg/ha which is increased to 30.40 kg/ha at the end of 2021-22 and to 30.90 kg/ha at the end of 2022-23. Initial value of available phosphorous in Pigeonpea + Maize - Sunhemp cropping system was 28.7 kg/ha which is slightly increased to 29.00 kg/ha at the end of 2021-22 and to 30.10 kg/ha at the end of 2022-23. Initial value of available phosphorous in guava orchard was 31.1 kg/ha which is slightly increased to 31.20 kg/ha at the end of 2021-22 and to 32.0 kg/ha at the end of 2022-23. Initial value of available phosphorous in hedge lucerne was 31.2 kg/ha which is slightly increased to 31.30 kg/ha at the end of 2021-22 and to 32.1 kg/ha at the end of 2022-23. Initial value of available phosphorous in hybrid napier was 35.6 kg/ha which is increased to 36.17 kg/ha at the end of 2021-22 and to 37.3 kg/ha at the end of 2022-23. Change in the available phosphorous was low in all of the cropping systems. This might be due to change in phosphorous content might take more years and addition of large amounts of fertilizers might result in the immediate change. These results are in agreement with Malik *et al*. (2013) who found that available P takes many years to change.

Available potassium. Initial value of available potassium in Rice-Groundnut cropping system was 210.2 kg/ha which is increased to 213.0 kg/ha at the end of 2021-22 and to 215.90 kg/ha at the end of 2022-23. Initial value of available potassium in Pigeonpea + Sweetcorn - Bajra cropping system was 266.3 kg/ha which is increased to 269.0 kg/ha at the end of 2021-22 and to 272.3 kg/ha at the end of 2022-23. Initial value of available potassium in Bt Cotton + Greengram - Maize cropping system was 242.2 kg/ha which is increased to 244.0 kg/ha at the end of 2021-22 and to 245.6 kg/ha at the end of 2022-23. Initial value of available potassium in Pigeonpea + Maize - Sunhemp cropping system was 269.3 kg/ha which is increased to 271.0 kg/ha at the end of 2021-22 and to 273.8 kg/ha at the end of 2022-23. Initial value of available potassium in guava orchard was 269.6 kg/ha which is increased to 274.0 kg/ha at the end of 2021-22 and to 279.6 kg/ha at the end of 2022-23. Initial value of available potassium in hedge lucerne was 269.6 kg/ha which is increased to 274.5 kg/ha at the end of 2021-22 and to 280.6 kg/ha at the end of 2022-23. Initial value of available potassium in hybrid napier was 271.1 kg/ha which is increased to 280.0 kg/ha at the end of 2021-22 and to 288.9 kg/ha at the end of 2022-23. Increase in available potassium is more in forage crops compared to other cropping systems which might be due to more potassium application in these cropping systems. These results are in agreement with Kumari *et al*. (2022) who found that forage crops needs higher amount of potassium fertilizer and application of same also leads to increase in soil potassium content.

Table 3: Impact of various cropping systems on soil physio-chemical properties.

Crop components	pH			EC (dS/m)			OC		
	Initial	2021-2022	2022-2023	Initial	2021-2022	2022-2023	Initial	2021-2022	2022-2023
T1: Rice-Groundnut	7.40	7.40	7.41	0.30	0.31	0.32	0.49	0.50	0.51
T2: Pigeonpea + Sweetcorn (1:3)-Bajra	7.32	7.31	7.31	0.22	0.23	0.25	0.48	0.49	0.50
T3:Bt Cotton + Greengram (1:2)-Maize	7.25	7.26	7.26	0.35	0.36	0.37	0.47	0.48	0.50
T4: Pigeonpea + Maize (1:3)- Sunhemp	7.49	7.49	7.49	0.26	0.26	0.27	0.50	0.52	0.54
T5: Guava Orchard	7.59	7.59	7.58	0.39	0.40	0.41	0.53	0.55	0.57
T6: Hedge Lucerne	7.59	7.59	7.58	0.40	0.40	0.41	0.53	0.55	0.57
T7: Hybrid Napier	7.21	7.20	7.20	0.42	0.42	0.43	0.62	0.62	0.63
SEm(±)		0.12	0.12		0.005	0.0051		0.008	0.009
LSD (p=0.05)		0.37	0.36		0.016	0.017		0.026	0.027

Table 4: Impact of various cropping systems on Nutrient availability.

Crop components	Avl. N (kg/ha)			Avl. P (kg/ha)			Avl. K (kg/ha)		
	Initial	2021-2022	2022-2023	Initial	2021-2022	2022-2023	Initial	2021-2022	2022-2023
T1: Rice-Groundnut	146.5	150.0	155.4	31.3	31.53	31.9	210.2	213.0	215.9
T2: Pigeonpea + Sweetcorn (1:3)- Bajra	140.3	146.0	152.6	29.4	29.70	30.2	266.3	269.0	272.3
T3:Bt Cotton + Greengram (1:2)-Maize	137.8	142.0	147.8	30.0	30.40	30.9	242.2	244.0	245.6
T4: Pigeonpea + Maize (1:3)- Sunhemp	156.2	163.0	170.1	28.7	29.00	30.1	269.3	271.0	273.8
T5: Guava Orchard	171.3	175.0	180.2	31.1	31.2	32.0	269.6	274.0	279.6
T6: Hedge Lucerne	171.9	175.0	181.0	31.2	31.3	32.1	269.9	274.5	280.6
T7: Hybrid Napier	188.6	192.0	196.3	35.6	36.17	37.3	271.1	280.0	288.9
SEm(±)		7.48	7.59		1.35	1.36		9.84	10.32
LSD (p=0.05)		23.05	23.38		4.17	4.20		30.32	31.81

CONCLUSIONS

Conducting research on suitable cropping systems helps to find out their impact on soil properties and contribution to soil sustainability over the years. It is very important to grow profitable crops but not at the cost of soil health. Inclusion of soil friendly crops in cropping systems is the need of the hour. There is no significant change in pH and EC as it might take more years and having crops which produce more biomass have a positive impact on organic carbon. Change in available nitrogen was high in Pigeonpea + Sweetcorn - Bajra and Pigeonpea + Maize - Sunhemp cropping systems over the two years because of having legume whereas there was not much change in available phosphorous. However, increase in available potassium is more in forage crops compared to other cropping systems which might be due to more potassium application in these cropping systems.

FUTURE SCOPE

- To study the impact of more cropping systems on soil health
- To study about inter cropping systems
- To include the green manuring crops in cropping systems.

Acknowledgement. We are grateful to the Professor Jayashankar Telangana State Agricultural University and IIFSR, Modipuram for providing the financial funding for conducting research work.
Conflict of Interest. None.

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How to cite this article: Rayapati Karthik, M. Venkata Ramana, Ch. Pragathi Kumari, T. Ram Prakash, D. Saida Naik and M. Yakadri (2023). Evaluation of various Cropping Systems on Soil Health in Southern Telangana Zone. *Biological Forum – An International Journal, 15*(7): 21-26.