International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
www.chemijournal.com
IJCS 2020; 8(4): 1849-1851

Received: 19-05-2020
Accepted: 20-06-2020

S Somasundaram
Associate Professor, Department of Agronomy, Anbil Dharmalingam Agricultural College and Research Institute, Tiruchirappalli, Tamil Nadu, India

PM Shanmugam
Associate Professor, Institute of Agriculture, Kumulur, Tiruchirappalli District, Tamil Nadu, India

S Avudaithai
Professor, Department of Agronomy, Anbil Dharmalingam Agricultural College and Research Institute, Tiruchirappalli, Tamil Nadu, India

Corresponding Author:
S Somasundaram
Associate Professor, Department of Agronomy, Anbil Dharmalingam Agricultural College and Research Institute, Tiruchirappalli, Tamil Nadu, India

Effect of complementary intercropping and organic amendments on productivity and profitability in sodic soil

S Somasundaram, PM Shanmugam and S Avudaithai

DOI: https://doi.org/10.22271/chemi.2020.v8.i4s.9897

Abstract
Field experiment was conducted to identify productive and profitable complementary intercropping combined with graded dose of fertilizers with organic amendments in sodic soil. The treatments consist of three complementary intercropping and five graded dose of fertilizers with organic amendments. Complementary intercropping, maize + cowpea + daincha recorded higher maize equivalent yield, water productivity, net return and B: C ratio. The daincha was incorporated at 45 DAS. Regarding fertilizer dose and organic amendments, 75% recommended NPK through fertilizers + 25% N through decomposed poultry manure excelled in all the above parameters. In case of the combined effect, higher maize equivalent yield, net return, B: C ratio was recorded by maize + cowpea + daincha with 75% recommended NPK through fertilizers + 25% N through decomposed poultry manure. This was followed by maize + cowpea + daincha with 75% recommended NPK through fertilizers + 25% N through FYM and maize + cowpea + daincha with 50% recommended NPK through fertilizers + 50% N through decomposed poultry manure. Thus in sodic soil, complementary intercropping of maize + cowpea + daincha combined with application of 75% recommended NPK through fertilizers + 25% N through decomposed poultry manure may be recommended for enhanced productivity and profitability.

Keywords: Complementary intercropping, poultry manure, FYM, sodic soil, maize

Introduction
Salt-affected soils in India (6.73 M ha) may increase to 16.20 M ha by 2050 and sodic soils account for about 56 per cent. In the study area, Manikandam block of Tiruchirappalli district, sodic soils accounts for about 18,115 ha. Sodic soils are non-saline soils containing sufficient exchangeable Na ions to adversely affect crop production and soil structure under most condition of soil and plant type. Productivity enhancement of salt-affected soils through crop-based management including organic amendments has the potential to transform them from environmental burdens into economic opportunities. Research efforts have led to the identification of a number of crops and cropping systems which are profitable and suit a variety of salt-affected environments. Therefore, complementary intercropping with crop diversification (Gill and Ahlawat, 2006) [4] based on salt-tolerant plant species is likely to be the key to future agricultural and economic growth in regions where salt-affected soils exist. Another important tool for improving productivity in sodic soil is organic amendments. Studies underline that input of organic matter (manure, plant residues, etc.) can be a feasible way to reclaim salt affected soils while favouring plant growth and productivity, without any risks for the environment (Tejada *et al.*, 2006) [9]. Still more researchers have tired the combination of inorganic fertilizers with organic manures (Kramer *et al*., 2002) [7] or including green manures (Harris and Rengasamy, 2004) [6] to improve yield and to sustain soil health in salt affected soils. Thus the combination of complementary intercropping and organic amendments may be vital tool for enhancing productivity in sodic soils. However, such systems will need to consider three issues: improving the productivity per unit of salt-affected land and saline water resources, protecting the soil health and mitigating any economic risks. In the era of shrinking resource base of land, water and energy, resource use efficiency is an important aspect for considering the suitability of a cropping system (Yadav, 2002) [11]. Hence, selection of component crops needs to be suitably planned to harvest the synergism among them towards efficient utilization of resource base and to increase overall productivity

(Anderson, 2005) [1]. Therefore the present experiment was carried out to evaluate the most suitable complementary intercropping combined with graded dose of fertilizers with organic manure with respect to high productivity levels and profitability in sodic soil.

Material and Methods

Field experiment was conducted at Anbil Dharmalingam Agricultural College and Research Institute, Trichy farm during 2018. The sodic soil of the experiential field was sandy clay loam with pH 8.80, EC 0.9 dSm^{-1}, ESP 17.1, organic carbon 0.53 per cent, available nitrogen (137.4 kg ha^{-1}), available phosphorus (11.2 kg ha^{-1}), available potassium (265.6 kg ha^{-1}). The treatment structure was three complementary intercropping viz., M_1 – Maize+Cowpea+Daincha, M_2 - Sunflower+Greengram+Daincha and M_3 - Bhendi +Onion+Daincha in main plot and five graded dose of fertilizers with organic amendments viz., S_1 – 100% recommended NPK through fertilizers, S_2 - 50% recommended NPK through fertilizers + 50% N through FYM, S_3 - 75% recommended NPK through fertilizers + 25% N through FYM, S_4 - 50% recommended NPK through fertilizers + 50% N through decomposed poultry manure and S_5- 75% recommended NPK through fertilizers + 25% N through decomposed poultry manure in the sub-plot. The varieties used in the study was, TNAU Maize hybrid CO 6, TNAU Sunflower hybrid CO 2, Arka Anamika, CO (CP) 7, VBN (Gg) 3, CO (On) 5. The 100 per cent recommended fertilizer dose was 150:75:75 Kg NPK ha^{-1} for maize, 60:90:60 Kg NPK ha^{-1} for sunflower and 40:50:30 Kg NPK ha^{-1} for bhendi respectively. The land configuration for the study was FIRB (Furrow irrigated raised bed). The plot size was 5m x 4m. In the main plot daincha was sown in the furrows and incorporated 40 days after sowing. Sowing was taken on 31.1.2018. Irrigation was given using IW/CPE ratio of 0.8. The nutrient content of FYM was 0.60 % (N), 0.32 % (P) and 0.50 % (K) and decomposed poultry manure was 2.89 % (N), 1.94 % (P) and 1.40 % (K). For comparison between complementary intercropping, the yields of all the crops were converted into maize equivalent yield on price basis. The mean of prevailing market rates during 2018 was used for computing economic viability. The water productivity of different intercropping was calculated by dividing the maize equivalent yield of the system by the total of average water use by different crops in the cropping. The data on maize equivalent yield, water productivity and economics was statistically analysed and presented as per Gomez and Gomez (1984) [5].

Results and Discussion

Maize Equivalent yield

Complementary intercropping and graded dose of fertilizers with organic amendments significantly influenced maize equivalent yield and given in Table 1. Higher maize equivalent yield was recorded by maize + cowpea +daincha (M_1- 6666 kg/ha) cropping followed by bhendi + onion + daincha (M_3 - 5033 kg/ha) cropping. Regarding fertilizer dose and organic amendments, application of 75% recommended NPK through fertilizers + 25% N through decomposed poultry manure recorded higher maize equivalent yield (S_5 - 6031 kg/ha) and was comparable to application of 75% re commended NPK through fertilizers + 25% N through FYM (S_3). Interaction was significant. Higher maize equivalent yield was recorded by maize + cowpea +daincha with 75% recommended NPK through fertilizers + 25% N through decomposed poultry manure (M_1S_5 - 7407 kg/ha) and was comparable with maize + cowpea +daincha with 75% recommended NPK through fertilizers + 25% N through FYM (M_1S_3 - 6961 kg/ha). Lowest maize equivalent yield was recorded by bhendi + onion + daincha with application of 100% recommended NPK through fertilizers (M_3S_1). Sharma *et al.* (2004) [8] also reported that intensification through inclusion of vegetables and leguminous crops increase the productivity of the system. Choudhary *et al.* (2001) [2] have also reported greater productivity by replacing wheat with vegetables crops like radish and potato.

Table 1: Effect of treatments on maize equivalent yield (kg/ha)

Treatment	S_1	S_2	S_3	S_4	S_5	Mean
M_1	5942	6405	6961	6617	7407	6666
M_2	3652	3777	4308	4285	4869	4178
M_3	3387	4879	5689	5394	5817	5033
Mean	4327	5020	5652	5432	6031	
	M	S	MxS	SxM		
SEd	133	185	316	320		
CD (p=0.05)	370	382	693	662		

Water productivity

Water productivity was significantly influenced by complementary cropping and graded dose of fertilizers with organic amendments and given in Table 2. Significantly higher water productivity was recorded by maize + cowpea + daincha (M_1 - 12.1 kg/ha mm) cropping and lower water productivity was recorded by sunflower + greengram + daincha (M_2 - 7.6 kg/ha mm) cropping. Regarding fertilizer dose and organic amendments, application of 75% recommended NPK through fertilizers + 25% N through decomposed poultry manure recorded higher water productivity (S_5 - 11.0 kg/ha mm) and was comparable to application of 75% recommended NPK through fertilizers + 25% N through FYM(S_3). Interaction was not significant. In this study higher water productivity was due to higher yield with less water. In salt affected soils there is a need to record more yield with less water as, excessive exploitation has pushed the groundwater table and increased the salinity level in irrigation water (Dhawan and Singh, 2015) [3].

Table 2: Effect of treatments on water productivity (kg/ha mm)

Treatment	S_1	S_2	S_3	S_4	S_5	Mean
M_1	10.8	11.6	12.7	12.0	13.5	12.1
M_2	6.6	6.9	7.8	7.8	8.9	7.6
M_3	6.2	8.9	10.3	9.8	10.6	9.2
Mean	7.9	9.1	10.3	9.9	11.0	
	M	S	MxS	SxM		
SEd	0.27	0.50	0.83	0.87		
CD (p=0.05)	0.77	1.04	NS	NS		

Economics

The economic analysis (Table 3 and Table 4) averaged over treatments indicated that regarding complementary intercropping higher gross income, net income and B: C ratio was recorded by maize + cowpea + daincha (M_1) and regarding graded dose of fertilizer with organic amendments higher gross income, net income and B: C ratio was recorded by 75% recommended NPK through fertilizers + 25% N through decomposed poultry manure (S_5). The combined effect indicated that higher gross income, net income and B: C ratio was realized with maize + cowpea +daincha with 75% recommended NPK through fertilizers + 25% N through

decomposed poultry manure (M_1S_5). This was followed by same intercropping system with 75% recommended NPK through fertilizers + 25% N through FYM (M_1S_3) for gross income and net income and with 50% recommended NPK through fertilizers + 50% N through decomposed poultry manure for B:C ratio (M_1S_4). Lowest gross income, net income and B: C ratio was recorded by bhendi + onion + daincha with application of 100% recommended NPK through fertilizers (M_3S_1). The highest cost of cultivation was realized in maize + cowpea + daincha with 50% recommended NPK through fertilizers + 50% N through FYM plots (M_1S_3). Similar results were obtained in experiments conducted by Sharma *et al.* (2004) [8] and Walia *et al.* (2010) [10]

Table 3: Effect of treatments on economics

Treatments	Cost of cultivation (Rs ha^{-1})	Gross income (Rs ha^{-1})	Net income (Rs ha^{-1})	Benefit Cost ratio
M_1S_1	49311	118840	69529	2.41
M_1S_2	63143	128100	64957	2.03
M_1S_3	56177	139220	83043	2.48
M_1S_4	49771	132360	82589	2.66
M_1S_5	49491	148160	98669	2.99
M_2S_1	48333	73050	24717	1.51
M_2S_2	52591	75450	22859	1.43
M_2S_3	50462	86160	35698	1.71
M_2S_4	46648	85710	39062	1.84
M_2S_5	47991	97380	49389	2.03
M_3S_1	54522	67740	13218	1.24
M_3S_2	57711	97600	39889	1.69
M_3S_3	56116	113785	57669	2.03
M_3S_4	53749	107880	54131	2.01
M_3S_5	54135	116350	62215	2.15

Table 4: Effect of treatments on economics (average over treatments)

Treatments	Cost of cultivation (Rs ha^{-1})	Gross income (Rs ha^{-1})	Net income (Rs ha^{-1})	Benefit Cost ratio
Complementary cropping				
M_1	52867	130920	78053	2.50
M_2	49205	83550	34345	1.70
M_3	55247	100671	45424	1.82
Graded dose of fertilizers with organic amendments				
S_1	50722	86543	35821	1.72
S_2	57815	100383	42568	1.72
S_3	54252	113055	58803	2.07
S_4	50056	108650	58594	2.17
S_5	50539	120630	70091	2.39

Conclusion

In sodic soils, complementary intercropping of maize + cowpea + daincha combined with application of 75% recommended NPK through fertilizers + 25% N through decomposed poultry manure may be recommended for higher productivity and profitability.

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