



Identification of Biological Efficient and Profitable Cropping Systems in Central Plain Zone of Uttar Pradesh

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

A field experiment was executed with ten crop sequences during 2016-17 at C.S.Azad University of Agriculture and Technology, Kanpur, Uttar Pradesh. All these sequences were evaluated for their system productivity, production efficiency, land use efficiency and economic analysis. Highest system productivity 320.43 q REY /ha was obtained through maize + black gram – potato – onion crop sequence followed by maize – garlic – green gram (291.1 q REY /ha). Highest land use efficiency (90.1%) measured through Scented rice – wheat –okra crop sequence while maximum production efficiency 121.83 kg/ha/ day was achieved by maize + black gram – potato – onion crop sequence. The highest net return of Rs.282799.0 /ha, crop profitability of Rs. 1075.28 /ha / day and system profitability of Rs. 774.79 /ha/day was obtained through maize + black gram – potato – onion followed by maize – garlic – green gram (G+R) crop sequence, while highest return per rupee investment (1:3.24) was computed on hybrid rice- wheat cropping system followed by maize – mustard- onion crop sequence (1: 3.21). Electrochemical properties were also evaluated in each cropping sequence. On the basis of different biological indices and economical analysis maize + black gram – potato – onion crop sequence observed as biological efficient followed by maize – garlic – green gram (G+R) crop sequence over all other cropping systems.

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1. INTRODUCTION

Planning and adoption of suitable cropping is essential for ensuring the most rational use of land and increasing the productivity/unit area/unit time so that farmers can get maximum net return from the cropping system. A flexible cropping system helps in capturing economic opportunities and environmental realities [1] and in ensuring balanced farm growth at regional level [2] farmers is the most important cropping system in India. Rice –wheat cropping system (RWCS) is the world's largest agricultural production system occupying around 12.3 m ha in India and around 85 percent of this area falls in Indo-Gangetic plains (IGP) [3,4]. This system requires high input resources for higher productivity resulting in higher cost per unit area and time. Adopting continuous same system has adverse effects on soil health, ultimately declining factor productivity of the system. Agricultural intensification increases crop productivity but simplifies production with lower diversity of cropping systems, higher genetic uniformity, and a higher uniformity of agricultural landscapes. Associated detrimental effects on the environment and biodiversity as well as the resilience and adaptability of cropping systems to climate change are of growing concern.

Crop diversification may stabilize productivity of cropping systems and reduce negative environmental impacts and loss of biodiversity, but a shared understanding of crop diversification including approaches towards a more systematic research is lacking [5]. Crop diversification shows lot of promises in alleviating these problems besides, fulfilling basic needs for cereals, pulses, oilseeds and vegetables and, regulating farm income, withstanding weather aberrations, controlling price fluctuation, ensuring balanced food supply, conserving natural resources, reducing the chemical fertilizer and pesticide loads, ensuring environmental safety and creating employment opportunity ([6]. Resource use efficiency is an important aspect for considering the suitability of a cropping system [7]. So, diversification has been envisaged as a new strategy for enhancing and stabilizing productivity, making Indian agriculture competitive and increasing net farm income and economic security toward achieving the sustainable agricultural development. This system has sustained over years and brings together conflicting and complementary

practices. Because of high productivity, stability and less risk, the wide adoption of this system will also play a major role in future planning to sustain self sufficiency of food grains in the years to come. But now the productivity of the crops has stagnated and factor productivity is declining year after year. In Uttar Pradesh, this system covers more than 5.3 million hectares. The farmers realize much of their food security from this cropping system but the low production level needs urgent attention. Besides food security, the low production levels jeopardize farmers' economic security to a considerable extent. To strengthen the economic security, it is imperative to intensify and diversify the existing rice-wheat system with some other crops of greater economic worth.

Cropping systems in central plain zone region aims to make agriculture achieving nutritional security, more employment and income generating, ecofriendly, poverty alleviation and comparative advantage in new trade regime. Keeping above facts in view, the present investigation "Identification of biological efficient and profitable cropping systems in central plain zone of Uttar Pradesh" was conducted.

2. MATERIALS AND METHODS

The field experiment was conducted during 2016-17 at student's instructional farm, Chandra Shekhar Azad University of Agriculture and Technology, Kanpur, India to identify the biological efficient and economically profitable systems. The soil was neutral to slightly alkaline of alluvial type having pH 8.1, 0.45 per cent organic carbon, available nitrogen (175 kg/ha) low in available phosphorus (11.5 kg/ha) and medium in available potash (205 kg/ha). A total of ten cereal based crop (Four rice based and six maize based) T₁-Rice-Wheat, T₂ –Hybrid rice – Wheat, T₃ –Hybrid rice –Wheat –Green gram (G+R), T₄ – Maize – Wheat , T₅ –Maize – Mustard – Onion, T₆ – Maize – Mustard-Green gram, T₇– Maize + Green gram-Potato – Wheat, T₈ – Maize + Black gram-Potato – Onion , T₉ – Maize –Garlic –Green gram(G+R) and T₁₀ – Scented rice – Wheat- okra sequences were tested in randomized block design with four replications. The yields of each rotation were converted into rice equivalent yield (REY) on price basis to compare the different crop sequences. The system productivity and economic analysis of each consecutive years

have been computed to evaluate the efficiency of different crop sequences. Production efficiency values kg/ha/day were worked out by total production in crop sequence divided by total duration of crop in that sequence. Land use efficiency was worked out by taking total duration of crop in individual crop rotation divided by 365 days [8]. Crop profitability in term of Rs/ha/day was calculated by net monetary returns of the rotation divided by total duration of the crop in that rotation. System profitability in term of Rs/ha/day was calculated by dividing net returns (Rs/ha) in a sequence by 365 days. The computation of calories was worked out on the basis of calories found in a particular crop on per 100 g.

3. RESULTS AND DISCUSSION

The results obtained from the present investigation as well as relevant discussion have been summarized under following heads:

3.1 Biological Yield and System Productivity

The mean analysis of two years revealed that the highest biological yield of rice was obtained in hybrid rice-wheat-green gram (G+R) crop sequence where green gram was incorporated in soil after picking the pods in summer (Table 1). It was due to beneficial effect of incorporation as well as inclusion of legumes in the system. Among maize based crop sequences, the highest biological yield of maize was achieved in maize – garlic - green gram crop sequence due to inclusion of the summer pulse crop and followed by maize – mustard – green gram crop sequence. The highest system productivity 320.43 q /ha in terms of rice equivalent yield was obtained through maize + black gram-potato – onion crop sequence due to higher biological yield and net monetary returns and followed by maize – garlic – green gram (G+R) cropping system 291.14 q REY/ha over all crop sequences evaluated, similar results were obtained by Rai and Tiwari, [9].

3.2 Production Efficiency and Land use Efficiency

The highest production efficiency 121.83 kg/ha /day was recorded through maize + black gram-potato – onion crop sequence due to higher net monetary returns while maize –garlic –green gram(G+R) crop sequence yielded 93.61 kg/ha/day of efficient production and maize – mustard –onion crop sequence showed 88.20

kg/ha/day of production efficiency over all other sequences. Jain et al. [10] recorded the similar results. The highest land use efficiency (92.32%) was measured through scented rice – wheat – okra due to the duration of the whole cropping sequence on land was more, while 90.13 per cent land use efficiency was obtained with hybrid rice – wheat- green gram (G+R) crop sequence. The third best sequence Maize-Garlic-Green gram (G+R) crop sequence utilized 85.20 per cent of the land over 365 days (Table 1) similar results were obtained by Rai and Tiwari, [9] and Sharma et al., [11].

3.3 Economics and Profitability

The economic analysis revealed that highest gross return of Rs. 448599.00 /ha was recorded through maize+black gram- potato- onion crop sequence as due to the higher cost of potato and onion followed by Rs. 407294.75 /ha by maize – garlic –green gram (G+R) crop sequence. Maize +black gram- potato- onion cropping system fetched highest net monetary return of Rs.282799.00 /ha while maize – garlic – green gram (G+R) ranked as next best remunerative crop sequence (Rs. 276794.75 /ha). Hybrid rice –wheat cropping system was observed as best economical sequence by fetching Rs. 3.24 on per rupee investment while maize - mustard - onion cropping system was the next best economical sequence by fetching Rs. 3.21 on investment of Re 1. On the crop profitability front, maize+black gram-potato-onion crop sequence produced maximum of Rs. 1075.28 /ha/day while maize –garlic –green gram (G+R) sequence produced at the tune of Rs. 890.01 /ha/day of profitability followed by maize – mustard - onion (Rs. 849.95 /ha/day) over all crop sequences evaluated, while system profitability recorded by the same crop profitability pattern maize+black gram-potato-onion of Rs. 774.79 /ha/day, maize –garlic – green gram (G+R) of Rs. 758.34 /ha/day and finally maize – mustard - onion of Rs. 661.33 /ha/day) (Table 2) similar results were obtained by Rai and Tiwari, [9] and Sharma et al., [11].

3.4 Effect on Soil Electrochemical Properties (at Harvest)

The data presented in the Table 3, indicates that soil electrochemical properties (pH, EC and OC) after harvest of ten cereal based cropping sequences in Central Plain Zone of Uttar Pradesh. There was a little change in soil pH i.e. 0.1 unit either less or more in all crop sequences.

Table 1. Biological yield, rice equivalent yield (REY), Land use efficiency and Production efficiency of different crop sequences during 2016-17

Cropping sequences	Biological Yield (Kg/ha)						Rice Equivalent Yield (q/ha)	Land Use Efficiency	Production Efficiency (Kg/ha/day)
	Kharif		Rabi		Summer				
	Grain	Straw	Grain	Straw	Grain	Straw			
T ₁ :Rice-Wheat	4952.38	5942.85	4380.95	5388.57	-	-	140.76	73.15	52.71
T ₂ : Hyb. Rice-Wheat	8120.00	9338.00	4690.00	5768.70	-	-	187.38	73.15	70.17
T ₃ : Hyb. Rice-Wheat-Green gram	8381.00	9721.96	4810.00	835.00	835.00	-	219.04	90.13	66.57
T ₄ :Maize-Wheat	2905.00	9121.70	4857.14	6071.42	-	-	136.82	61.64	60.80
T ₅ : Maize-Mustard-Onion	2950.00	9233.50	1785.71	6357.14	12928.75	-	250.49	77.80	88.20
T ₆ : Maize-Mustard-Green gram	3070.86	10041.71	1922.22	5920.45	920.67	-	138.81	72.60	52.38
T ₇ :Maize+Green gram-Potato-Wheat	3000.00 381.00	8879.75 1413.75	20880.75		3435.50	3626.75	195.35	67.39	79.41
T ₈ :Maize+Black gram-Potato-Onion	3047.75 452.00	9753.75 1446.50	24238.00	-	13950.00	-	320.43	72.05	121.83
T ₉ : Maize-Garlic-Green gram	3118.75	10011.75	6714.25	-	976.00	-	291.14	85.20	93.61
T ₁₀ : Rice-Wheat-Okra	4786.00	8518.75	4357.25	4923.50	3262.00	-	190.78	92.32	56.61
CD (P=0.05)	-	-	-	-	-	-	6.47	-	-

Table 2. Economics and profitability of different crop sequences during 2016-17

Cropping sequences	Cost of Cultivation (Rs./ha)	Gross returns (Rs./ha)	Net returns (Rs./ha)	B:C ratio	Crop sequence duration	System Profitability (Rs./ha/day)	Crop Profitability (Rs./ha/day)
T ₁ :Rice-Wheat	76750.00	197064.67	120314.67	2.57	267	329.62	450.61
T ₂ : Hyb. Rice-Wheat	80900.00	262325.64	181425.64	3.24	267	497.05	679.49
T ₃ : Hyb. Rice-Wheat-Green gram	108200.00	306654.70	198454.70	2.83	329	543.71	603.20
T ₄ :Maize-Wheat	67300.00	191547.16	124247.16	2.85	225	340.40	552.20
T ₅ : Maize-Mustard-Onion	109300.00	350687.26	241387.16	3.21	284	661.33	849.95
T ₆ : Maize-Mustard-Green gram	79900.00	191827.37	111927.37	2.40	265	306.65	422.36
T ₇ :Maize+Greengram-Potato-Wheat	147250.00	273611.25	126361.25	1.86	246	346.19	513.68
T ₈ :Maize+Black gram-Potato-Onion	165800.00	448599.00	282799.00	2.71	263	774.79	1075.28
T ₉ : Maize-Garlic-Green gram	130800.00	407294.75	276794.75	3.12	311	758.34	890.01
T ₁₀ : Rice-Wheat-Okra	105650.00	267093.00	161443.00	2.53	337	442.30	479.05
CD (P=0.05)	-	9145.41	13405.00	0.15	-	25.06	34.25

Table 3. Electrochemical properties of Soil

Cropping sequence	Before sowing			After harvest		
	pH	EC (ds m ⁻¹)	OC (%)	pH	EC (ds m ⁻¹)	OC (%)
T ₁ :Rice-Wheat	7.9	0.16	0.51	7.8	0.15	0.52
T ₂ : Hyb. Rice-Wheat	7.8	0.15	0.53	7.8	0.15	0.54
T ₃ : Hyb. Rice-Wheat-Green gram (G+R)	7.6	0.22	0.60	7.6	0.23	0.62
T ₄ :Maize-Wheat	7.8	0.16	0.52	7.7	0.16	0.53
T ₅ : Maize-Mustard-Onion	7.9	0.17	0.51	7.8	0.17	0.52
T ₆ : Maize-Mustard-Green gram (G+R)	7.7	0.23	0.58	7.6	0.24	0.60
T ₇ :Maize+Greengram-Potato-Wheat	7.8	0.20	0.55	7.8	0.21	0.56
T ₈ :Maize+Black gram-Potato-Onion	7.8	0.21	0.56	7.7	0.22	0.57
T ₉ : Maize-Garlic-Green gram (G+R)	7.6	0.23	0.59	7.6	0.24	0.61
T ₁₀ : Rice-Wheat-Okra	7.8	0.16	0.51	7.7	0.15	0.53

Table 4. Soil available nutrient status

Cropping sequence	At sowing			At harvest		
	Avail. N (kg/ha)	Avail. P (kg/ha)	Avail. K (kg/ha)	Avail. N (kg/ha)	Avail. P (kg/ha)	Avail. K (kg/ha)
T ₁ :Rice-Wheat	216.7	13.8	213	221.0	13.8	214
T ₂ : Hyb. Rice-Wheat	225.2	14.5	215	229.5	13.5	217
T ₃ : Hyb. Rice-Wheat-Green gram (G+R)	255.0	14.8	221	263.5	14.9	223
T ₄ :Maize-Wheat	221.0	13.6	211	225.2	13.7	212
T ₅ : Maize-Mustard-Onion	216.7	13.5	214	221.0	13.4	215
T ₆ : Maize-Mustard-Green gram (G+R)	246.5	14.2	219	255.0	13.3	221
T ₇ :Maize+Greengram-Potato-Wheat	233.7	13.8	215	238.0	13.6	216
T ₈ :Maize+Black gram-Potato-Onion	238.0	14.0	217	242.2	14.1	218
T ₉ : Maize-Garlic-Green gram (G+R)	250.7	14.4	220	259.2	14.5	222
T ₁₀ : Rice-Wheat-Okra	216.7	13.6	213	225.2	13.7	215
SEM ±	12.02	0.44	7.67	12.82	0.47	7.85
CD (P=0.05)	34.97	1.28	22.24	37.20	1.37	22.79

EC was also changed slightly i.e. 0.01 units either less or more in all crop sequences. OC % was improved well in crop sequences having green gram/black gram crop as a component crop of the crop sequence. Almost all crop sequences recorded improvement in soil organic carbon [12].

3.5 Effect on Available Nutrient Status in Soil (at Harvest)

Improvement in available nitrogen, phosphorus and potassium status was also observed in all crop rotations in comparison to initial values.

From Table 4, it is observe that maximum available nitrogen status (263 kg/ha) was recorded in Hyb. Rice-wheat-green gram (G+R) (T₃) followed by Maize-garlic- green gram (G+R) (259 kg/ha) (T₉). Maximum available phosphorus status (14.90 kg/ha) was recorded in Hyb. Rice-wheat-green gram (G+R) (T₃) followed by Maize-garlic- green gram (G+R) (14.55 kg/ha) (T₉). Maximum available phosphorus status (223 kg/ha) was recorded in Hyb. Rice-wheat-green gram (G+R) (T₃) followed by Maize-garlic- green gram (G+R) (222 kg/ha) (T₉). Porpavai et al. [11] also reported that inclusion of legumes in cropping system improved soil available NPK.

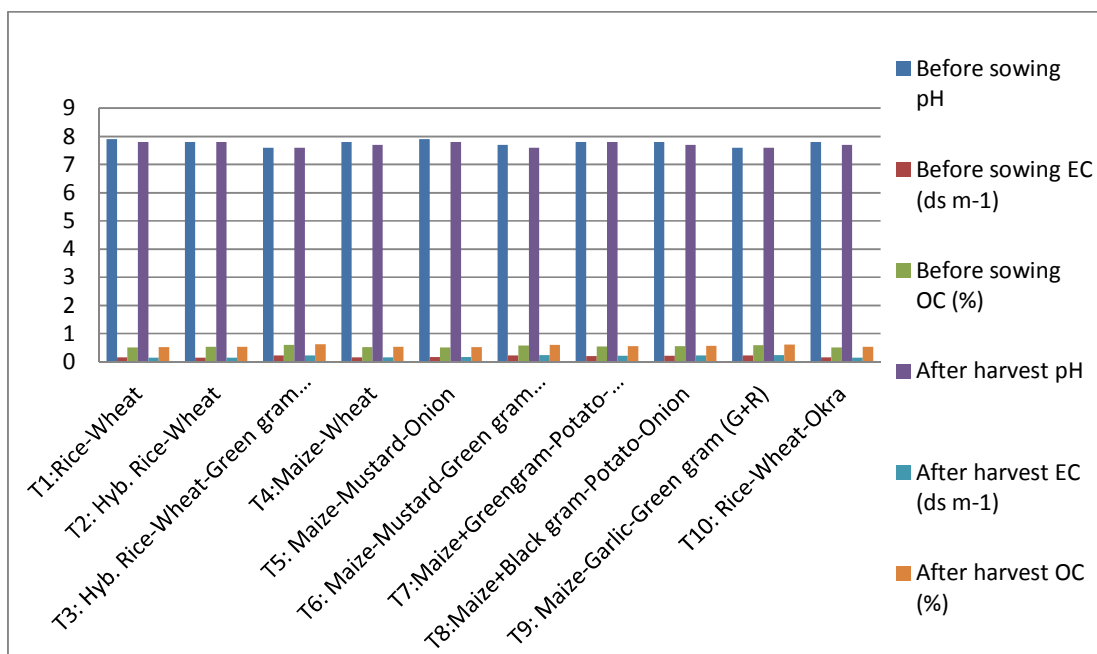


Fig. 1. Electrochemical properties of Soil

4. CONCLUSION

It may be concluded that traditional rice-wheat system couldn't be able to improve the profitability and biological yield unit area and time. Replacing traditional rice-wheat cropping system with hybrid rice and maize based intensive and biological profitable cropping sequences could enhance the total biological productivity, economic return and favorable impact on soil health. On the basis of overall productivity biological efficiency and economic return, maize+ blackgram-potato- onion and maize-garlic-green gram (G+R) crop sequences were treated as best biologically efficient systems while next best biological efficient crop sequences were maize+green gram-potato-wheat and hybrid rice-wheat-green gram (G+R) and if adopted by the farmers can go a long way in enhancing the productivity return and improving sustainability in Central Plain Zone of Uttar Pradesh.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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