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RESOURCE USE EFFICIENCY AND INPUT ALLOCATION IN ORGANIC AND INORGANIC WHEAT FARMING IN SOUTHERN RAJASTHAN, INDIA

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ABSTRACT

The study was conducted during Rabi season in year 2022 in Udaipur district of Rajasthan. The present study was undertaken for comparative economics of organic and inorganic wheat farming in Rajasthan. Udaipur district of Rajasthan was selected based on researcher conveniences acquaintance with the study area. The resource use efficiency under the organic farming the regression coefficient for FYM (0.595) were significant at p=0.05 levels of significance and VMP (Value of the marginal product) for FYM (0.623) was less than unity, which indicated over-use of these resources. The resource use efficiency under inorganic farming the regression coefficient for machine (2.084), seed (0.475) and irrigation (0.411) were significant at 0.01 and 0.1 levels of significance, respectively. The VMP for machine (2.652) was more than unity, which indicated under-use of this resource. This implied that additional investment in this input was economical as the corresponding additional revenue obtained by farmers. VMP for seed (0.479) and irrigation (0.454) was less than unity indicating over-use of these resources. Additional one rupee invested in these inputs would thus not be economical. However, the VMP of fertilizers (-0.554) was negative indicating that the farmers were using higher doses of fertilizers causing third zone of classical production function, where each additional unit of fertilizer would incur additional cost and loss in yield due to adverse effect of fertilizer dose.

***Key-words*:** Efficiency, Environmental, Organic, Regression, MVP and VMP

Introduction

It is common knowledge that India's economy is based primarily on agriculture. In 2024, agriculture and related industries contributed 17.07% of India's overall GDP (Anonymous, 2024c). It remains India's largest economic sector and has a big impact on the country's overall socio-economic progress. India's currently rank first in the world for producing milk, pulses, jute, cotton, second for producing rice, wheat, sugar, fruits, and vegetables, and third for producing tobacco (Anonymous, 2024a). The agricultural sector's direct impact on the national economy can be seen in its percentage of the GDP, its foreign exchange profits, and its ability to supply labour and savings to other industries. It is all possible due to Green Revolution but the dark side of Green Revolution is that the Green Revolution forced Indian farmers to rely heavily on chemical pesticides and fertilisers, which reduced soil fertility and damage the environment. Crop productivity is reduced and the quality of natural resources is degraded as a result of increased usage of chemical fertilisers and pesticides (Tudi, M., *et al.*, 2021). In recent decades, however, conventional farming systems have raised concerns regarding environmental degradation, soil health deterioration, and declining economic sustainability. Excessive reliance on chemical fertilizers and pesticides has not only increased input costs but also reduced long-term productivity and resilience of agro-ecosystems. In this context, organic farming has emerged as a sustainable alternative that promises to balance environmental stewardship with economic viability. Organic products are grown under a system of agriculture without the use of chemical fertilizers and pesticides with an environmentally and socially responsible approach (Tal, 2018) (Thakur *et al.*, 2022). This is a method of farming that works at grass root level preserving the reproductive and regenerative capacity of the soil, good plant nutrition (Ravisankar, 2017), and sound soil management, produces nutritious food rich in vitality which has resistance to diseases (Montgomery and Biklé, (2021). The negative consequences of higher use of chemical fertilizers and pesticides are reduction in crop productivity and deterioration in the quality of natural resources (Baweja *et al.*, 2020). Demand for organic products is on the rise globally, driven by growing awareness of the benefits of a healthy lifestyle, increasing urbanisation, knowledge of the hazards associated with the use of chemical fertilisers and pesticides in food production, and rising disposable income. India ranked second in global organic land area and first in organic producers (farmers) in 2022. In India, Madhya Pradesh (26%), Maharashtra (22%), Gujarat (15%) and Rajasthan (13%) together accounted for about (76%) of the organically cultivated area. However, when considering the share of organic area relative to the net sown area (NSA) of each state, Sikkim led with (98%) of its NSA under organic cultivation, followed by Uttarakhand with (39%) Karnataka. During 2016, Sikkim has achieved a remarkable distinction of converting its entire cultivable land (more than 75000 ha) under organic certification. India produced around 3496800.34 mt (2020–21) of certified organic products. In fiscal 2024, India exported 2.6 lakh mt of organic products, with a total value of $0.49 billion (Anonymous, 2024b). The present study was undertaken for comparative economics of organic and inorganic wheat farming in Rajasthan.

Materials and Methods

The study was conducted during 2022 (Sept. 2021 to Sept. 2022) at Udaipur. Udaipur District of Rajasthan was selected based on highest organic cropped area under organic grower groups and researcher conveniences acquaintance with the study area. One major crop Wheat was selected based on the highest proportion of area and production of organic farming under organic grower groups in Udaipur. The 100 wheat cultivating farmers comprising of 50 organic and 50 inorganic farmers were randomly selected from the Udaipur District.

Analytical Techniques

For the analysis of primary data, all sampled farmers were into divided into organic and inorganic wheat farming.

Resource use Efficiency

For estimating resource use efficiency, production function approach was used and out of several functions, log-linear production function (Cobb-Douglas version) was used as it gave best fit to the observed data.

$Y = f(X_1, X_2, X_3, X_4, X_5, X_6)$ ...1

The specific Cobb-Douglas type of production function used for the study was:

$Y = aX_1^{b1} X_2^{b2} X_3^{b3} X_4^{b4} X_5^{b5} X_6^{b6} U$ ...2

Where,

Y=Yield of Wheat (Rs /ha^{-1})

a=Intercept

X_1=seed (Rs ha^{-1})

X_2=Total human labour (Rs ha^{-1})

X_3=Machine labour (Rs ha^{-1})

X_4=Farmyard Manure (Rs ha^{-1})

X_5=Costs of Organic Inputs for organic farming (Rs ha^{-1}) / costs of fertilizers for inorganic farming (Rs ha^{-1})

X_6 = Costs of plant protection chemicals (only for inorganic farming) (Rs ha^{-1})

U_t =Error term

b_1=Output elasticity of respective inputs.

The equation (2), upon logarithimic transformation, takes the linear form. The parameters were estimated using the Ordinary Least Square (OLS) method.

The form of regression model organic and inorganic cultivation specified is as follows:

$\text{In } Y = \text{In } a + b_1 \text{ In } X_1 + b_2 \text{ In } X_2 + b_3 \text{ In } X_3 + b_4 \text{ In } X_4 + b_5 \text{ In } X_5 + b_6 \text{ In } X_6 + U$ ...3

The Cobb-Douglas type production function was used to compute the resource use efficiency. The first differential itself was the VMP of the factor, as the dependent variable was the gross returns from crop cultivation. Since all independent variables in regression are the cost of inputs, the MFC of all factors were unity. Thus, the resource use efficiency measure of all factors was given by the equation:

Resource use efficiency=VMP_{xi} / MFC_{xi}

$$VMP_{Xi} = \frac{b_i \bar{Y_i}}{\bar{X_i}}$$

Where,

VMP_{xi}=Value marginal product of ith input

b_i=Input co-efficient of ithinput

$\bar{Y_i}$=Geometric mean of gross returns of ith input

$\bar{X}_i$=Geometric mean of input of i^{th} input.

The marginal value of product of the inputs were worked out by multiplying the respective input co-efficient with the geometric mean level of gross return and divided by the geometric mean level of respective input cost.

Results and Discussion

Resource use Pattern of Organic and Inorganic Wheat Farming in Udaipur District of Rajasthan

The input use pattern and cultural practices done in organic and inorganic wheat farming was present Table 2. The field preparation for growing of wheat crop in the study area started in the month of October–November. On an average, 11.20 and 10.08 hrs machine power were used on organic and inorganic farm, respectively. The machine labour higher in the organic farms as compared to inorganic farms. The overall human (both family and hired labour) labour were in organic wheat farming for field preparation to harvesting were 109.65 and 85.23 respectively and the overall human (both family and hired labour) labour were in inorganic wheat farming for field preparation to harvesting were 91.24 and 74.23 respectively. The table that showed the higher use of human labour were in the farm operation of wheat crop under organic wheat in comparison to the wheat crop grown on inorganic farms. Sowing of seed was done in the month of November to December. The seed rate of wheat was 101.4 and 109.3 kg ha^{-1} for organic and inorganic farms respectively. The seed rate used ha^{-1} on inorganic farm was higher than on organic farm. The FYM applied to the field was 6.12 t and 3.9 t ha^{-1} for organic and inorganic farm respectively. The FYM applied ha^{-1} on organic farm was higher than the inorganic farm. The organic inputs included bio fertilizers (Azotobacter) 1.11 kg ha^{-1} and vermi-compost 494.34 kg ha^{-1} were applied only under organic farm. The chemical fertilizers were included Urea 251 kg ha^{-1} and DAP 74.72 kg ha^{-1} were applied only under inorganic farm. The bio-pesticide were applied under organic farming and plant protection chemicals under inorganic farming. On an average, 4 irrigations were given to the wheat crop, grown under organic farms while in case of inorganic farms it was 6 irrigations. Thus, the overall number of irrigation on inorganic farms was higher than organic farms.

Table 1: Area and Production of Organic Farming of Major Crops in Udaipur District under Organic Grower Groups.

S no.	Crop Name	Area (in ha)	Production (in mt)
1	Wheat	1186	3374
2	Maize	611	1220
3	Soybean	565	800
4	Mustard	522	636
5	Gram	473	630
6	Barley	122	284
7	Turmeric	50	790
8	Ginger	32	633

Source- Rajasthan State Organic Certification Agency (2021)

Table 2: Resource use pattern of organic and inorganic wheat farming in Udaipur district of Rajasthan (ha^{-1}).

Particulars	Organic Farming	Inorganic Farming
Machine labour (hrs)	11.20	10.08
Family labour (hrs)	109.65	91.24
Hired labour (hrs)	85.23	74.23
Seeds (Kg ha)	101.4	109.3
FYM (t ha^{-1})	6.12	3.9
Organic inputs		
(1) Bio-fertilizers (Kg ha^{-1}) (Azotobacter)	1.11	NA
(2) Vermi-compost (Kg ha^{-1})	494.34	NA
Chemical Fertilizers		
(1) Urea (Kg ha^{-1})	NA	251.06
(2) DAP (Kg ha^{-1})	NA	74.72
Bio-pesticide (No. of sprays)		
NSKE(Neem seed kernel extract)	0.88	NA
Vermi- wash	1.56	NA
Non edible cakes	0.52	NA
PPC (No. of sprays)	NA	1.98
Irrigation (No.)	4	6

Source: Primary survey

Resource Productivity in Organic Wheat Farming System

The regression estimate of Cobb-Douglas was presented in Table 3. The R Square coefficient of multiple determinations was 0.609 indicating that 60% variability in gross returns were explained by the variables considered. The regression co-efficient, which shows change in dependent variable due to unit change in input was worked out.

The result showed that the regression coefficient for FYM (0.595) were significant at p=0.05 levels of significance. This meant that this one factors positively affected the yield. The regression coefficient for machine (0.368), human labour (0.049), seed (0.192), organic inputs (0.183) and irrigation (0.059) were positive, but not significant. Bio-pesticide (-0.053) was negatively, but non-significant because the farmers have not fixed the optimum range of bio-pesticides and they did not use commercial bio-pesticides. Similar results were observed by (Thippeswamy, 2014) (Saran, 2022).

Table 3: Regression coefficient under organic wheat farming in Udaipur District of Rajasthan.

S. no.	Particulars	β co-efficient	Standard Error	t – value
1	Machine	0.368	0.219	1.680
2	Human labour	0.049	1.171	0.042
3	FYM	0.595**	0.245	2.419
4	Seed	0.192	0.162	1.182
5	Organic Input	0.183	0.130	1.406
6	Irrigation	0.059	0.145	0.404
7	Bio-pesticide	-0.053	0.118	-0.444
Source: Primary Survey; # R Square 0.609				
Note: ** Significane at p=0.05 level of Significance				

Resource Productivity in Inorganic Wheat Farming System

The regression estimates were presented in Table 4. The R Square coefficient of multiple determination was 0.78, indicating that 78% variability in gross returns were explained by the variables considered in the model. The regression co-efficient which showed change in dependent variable due to unit change in input was worked out. The result showed that the regression coefficient for machine labour (2.084), seed (0.475) and irrigation (0.411) were significant at $^{*}p$=0.01 and $^{**}p$=0.1 levels of significance, respectively. This meant that these three factors positively affected the yield. The regression coefficient for human labour (0.531) and FYM (0.889) were positive, but non-significant. The coefficient pertaining to fertilizers (-0.552) was negatively, and significant at $^{*}p$=0.1 level of significance. This suggested that if the fertilizer dose was increased, it would negatively affect the yield. Plant protection chemical (PPC -1.559) however, was negative but non-significant. Similar results were observed by (Saran, 2022).

Resource use Efficiency of Organic and Inorganic Wheat Farming

A production actively was resource efficient when the value of the marginal product (VMP) of a factor was equal to the marginal factor cost (MFC). It meant allocation of resources in such a way that a farmer got maximum yield by using a given technology. The allocation of resources under organic and inorganic wheat farming presented in Table 5. The resource use efficiency VMP for FYM (0.623) was less than unity, which indicated over-use of this resource in organic farming. This implied that additional investment in FYM was not economical as the corresponding additional revenue obtained would not be adequate to cover the additional cost incurred. However, the resource use efficiency measure of bio-pesticide (-0.068) was negative indicating that the farmers were not understanding of optimum range used of bio-pesticide. Other inputs like machine labour, human labour, seed, organic input and irrigation were positively but, non-significant.

Table 4: Regression coefficient under inorganic wheat farming in Udaipur District of Rajasthan.

S. no.	Particulars	β co-efficient	Standard Error	t – value
1	Machine	2.084*	0.261	7.975
2	Human labour	0.531	0.871	0.610
3	FYM	0.889	0.654	1.360
4	Seed	0.475***	0.275	1.729
5	Organic Input	-0.552***	0.279	-1.979
6	Irrigation	0.411***	0.222	-1.853
7	Bio-pesticide	-1.559	1.073	1.453
Source: Primary Survey; # R Square 0.786				
Note: * Significant at $^{*}p$=0.01% level of significance, ***Significant at p=0.1 level of significance				

In case of inorganic wheat farming was the resource use efficiency VMP for machine labour (2.652) was more than unity, which indicated under-use of this resource. This implied that additional investment in this input was economical as the corresponding additional revenue obtained by farmers. VMP for seed (0.479) and irrigation (0.454) were less than unity indicating that over-uses of these resources. Additional one rupee invested in these inputs would thus not be economical. However, the VMP of fertilizers (-0.554) was negative indicating that the farmers were using higher doses of fertilizers causing reached in third zone of classical production function, where each additional unit of fertilizer would incur additional cost and loss in yield due to adverse effect of fertilizer dose. Other inputs like human labour, seed and plant protection chemicals (PPC) showed non-significant. Similar results were observed by (Yadav *et al.,* 2016).

Environmental Benefits of Organic Farming

Organic farming as an environmentally friendly version of agriculture was been selected especially by

Table 5: Resource use efficiency of organic and inorganic wheat farming in Udaipur District of Rajasthan.

S no.	Organic farming		Inorganic farming	
	Particulars	VMP	Particulars	VMP
1	Machine labour	0.468	Machine labour	2.652
2	Human labour	0.048	human labour	0.537
3	FYM	0.623	FYM	0.972
4	Seed	0.207	Seed	0.479
5	Organic Input	0.194	Chemical Fertilizers	-0.554
6	Irrigation	0.053	Irrigation	0.454
7	Biopesticide	-0.068	PPC	-1.279
Source: Primary survey; VMP- Value of marginal product				

people of developed countries (Patle *et al.*, 2020). It provided organic food which was healthier because it did not contain synthetic pesticide traces (Mie *et al*., 2017) (Ramakrishnan *et al.*, 2021). The soil structure on organic farms was much better leading to less pollution from nitrate and was healthier for the crop plant (Tahat *et al.*, 2020), and environmentally organic was better than the other forms and was chemical free (Œrednicka-Tober *et al.,* 2016). In contrast agriculture with use of pesticides and other chemical materials have been reported to produce foods leading to cancer (Ali *et al.,* 2021).

Conclusion

The study indicated of VMP for FYM (0.623) was less than unity, which indicated over-use of FYM in organic farming. However, the resource use efficiency of bio-pesticide (-0.068) was negative and other inputs were positively but, non-significant. In case of inorganic wheat farming, VMP for machine labour (2.652) was more than unity, which indicated underutilisation of machine labour. VMP for seed (0.479) and irrigation (0.454) were less than unity that indicated, the over-uses of these resources.

Declaration of Competing Interest: The authors declare that no competing interests exist.

Authors' Contributions

Shirish Sharma designed the study, performed the statistical analysis and wrote the protocol, and Deepak Kumar Jain wrote the first draft of the manuscript. Deepak Meena, Bhupender and Sonu Mehta managed the analyses of the study, literature searches. All authors read and approved the final manuscript.

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