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Soil Test Based Micro-Nutrient Application and Its Profitability in Pulse Production: A Micro-Evaluation Study of Bhoochetana Scheme

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Authors' contributions

This work was carried out in collaboration among all authors. Author Sagar designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Author MS is member of advisory committee, and he corrected the manuscript. Author MK is the major advisor for masters degree, and he corrected the manuscript, guided me regarding how to conduct the study and select the tools for analysis, etc. All authors read and approved the final manuscript.

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ABSTRACT

'Bhoochethana' (*Bhoo= soil; Chethana =rejuvenation*) scheme was launched by the Government of Karnataka in the year 2009 in technical collaboration with ICRISAT to enhance the yield level of major dry land crops by adopting integrated crop management (ICM) practices. The primary strategy of Bhoochetana is soil test based nutrient management with a major thrust on micronutrients and bio-fertilizers. In this study, the cost and returns, resource use efficiency and functional analysis of redgram production among the beneficiaries and non-beneficiaries of Bhoochetana scheme have been reported. The study has been conducted in the Kalaburagi District of Karnataka State which is an economically backward region with large part of the area is under dry land and redgram is the predominant crop. The study found that cost of cultivation of redgram among beneficiaries was marginally higher than non- beneficiaries. But, beneficiaries harvested additional redgram and their returns were also higher. The ratio of MVP to MFC (Resource use efficiency) was also higher among the beneficiaries compared to non-beneficiaries. A significant

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positive co-efficient of dummy variable indicate that the Bhoochetana beneficiaries realised higher redgram production by 0.38 quintals per farm. Hence, the schemes like Bhoochetana are highly beneficial for the dry-land farmers when they are implemented and monitored efficiently.

Keywords: Dummy variable regression; micronutrients; partial budgeting; resource use efficiency.

1. INTRODUCTION

Development of the agricultural sector is very important for a developing country like India. The livelihood of about two third of the rural population is dependent on the agricultural sector. Soil is a critical part of successful agriculture and is the original source of the plant nutrients. As a result of poor soil management practices at farm level (like imbalance use of fertilizers) and inefficient soil and water conservation policies, soils are degrading at an alarming rate. Globally, dry lands occupy 40 per cent of the earth's surface and are highly prone to land degradation. About 3.6 billion ha of the dry-land has already degraded and this is jeopardizing about 250 million people [1,2]. In India, over 108 million ha of area is dry land (75 % of cultivated area) [3]. Around 44 per cent of total food grain is produced in dry-land, which also supports 60 per cent of total livestock population. Agricultural productivity in rain-fed areas has remained low and unstable due to vulnerability of the area to vagaries of the weather, degraded soils and continuing poverty of farmers, who are mostly small and marginal. It is also estimated that by 2025 around 500 million people will live in rain-fed areas. Thus, ensuring sustainability of rain-fed agriculture is critical [4].

Karnataka state has the second largest area (5 million ha) in India under rain-fed agriculture but its soils are highly degraded and crop yields are low [5]. Soil health analysis of 220 taluks of Karnataka state showed widespread soil degradation and more than 50 per cent of the soils are deficient in micronutrients like boron, sulphur and zinc [6,7]. About 35 per cent increase in both crop yield and farm income was recorded from a large scale crop-cutting study on balanced fertilizer application in different crops (cereals, pulses, and oilseeds) in Karnataka [8] clearly indicates the extent of soil degradation and scope to improve the soil productivity through integrated crop management practices. Looking into these aspects, ‘Bhoochetana’ (*Bhoo= soil; Chetana =rejuvenation*) scheme was launched by the Government of Karnataka in the year 2009 in technical collaboration with ICRISAT to enhance the yield level of major dry land crops (about 20 per cent) by adopting integrated crop management (ICM) practices. The primary strategy of Bhoochetana is soil test based nutrient management with a major thrust on micronutrients and bio-fertilizers which were made available at subsidized prices (50 per cent) to farmers through Raitha Samparka Kendra’s (RSKs) and timely extension and sensitization by wide publicity through wall writings, posters, village meetings and mass media.

The crop specific micro-level impact study of the programme gives a clear picture and precise estimates for the informed policy making. In this background, present study was conducted in Kalaburagi District of Karnataka State where 88.90 per cent of area is under rain-fed agriculture [9]. It is called the ‘Red Gram Bowl’ of Karnataka as this crop is predominantly cultivated in rain-fed conditions. Around 42.96 per cent (3.9 lakh ha) of total cultivable area (9.05 lakh ha) is covered by redgram crop [10]. This paper looked into the impact of Bhoochetana scheme on yield, resource use efficiency and income from redgram cultivation with the following objectives.

1. To assess the cost and returns of redgram production by Bhoochetana beneficiary and non-beneficiary farmers
2. To analyse the resource use efficiency of Bhoochetana beneficiary and non-beneficiary farmers.

2. METHODOLOGY AND DATA ANALYSIS

2.1 Data Collection

The primary data pertaining to socio-economic characteristics, resources used, yield, economics of crop production *etc*. were collected from sample farmers for the agriculture year 2017-2018 by using pre-tested, structured interview schedule in Kalaburagi district of Karnataka. 60 Bhoochetana beneficiaries and 60 non-beneficiaries were selected at random.

2.2 Data Analysis

2.2.1 Estimation of costs and returns of redgram production

Cost of cultivation was arrived at by considering both variable and fixed costs as well as explicit and implicit costs. Under the variable costs; labour cost (both family and hired), cost of inputs and interest on working capital were calculated. Under the fixed cost, rental value of land, depreciation (straight line method was used), interest on fixed capital, land revenue and taxes are computed. Gross returns from redgram production, net returns over total cost, cost of production per quintal and returns per rupee of expenditure are calculated.

2.2.2 Partial budgeting

A simple yet powerful tool partial budgeting technique was used to estimate the direct economic benefit (or loss) at farm-level by adoption of Bhoochetana programme. It focuses only on the changes in income and expenses that would result from implementing an alternative technology. Thus, all components of farm profits which remain unchanged by the decision were not considered. In this study, the impact of Bhoochetana scheme on income level of farmers is evaluated by considering the additional costs incurred in application of inputs (micronutrients and bio-fertilizers) and decreasing in gross returns (if any) were used under debit. Decrease in cost if any by adoption of Bhoochetana scheme and incremental returns realized (if any) were taken under credit as shown in Table 1. Sum of credits were subtracted from the sum of debit to arrive net gain or loss.

2.2.3 Resource Use Efficiency (RUE)

Resource use efficiency in redgram production was estimated among beneficiaries and non-beneficiaries of Bhoochetana by using Cobb-Douglas type of production function and its empirical form is shown in equation (1).

$$Y = a\prod_{i=1}^{7} X_i^{\beta_i} + e^u, where\ i = 1\ to\ 7 \tag{1}$$

Where, Y_i is the gross returns (₹) from redgram, β_1 to β_7 parameters to be estimated, X_1= area (acres) under redgram crop, X_2 =Seed quantity (kg), X_3= FYM and fertilizer cost (₹), X_4= Cost of human labour (₹), X_5= Cost of bullock labour (₹), X_6= Cost of machine labour (₹), X_7= Cost of plant protection chemical (₹), 'a' is a Constant and 'u' is a random error.

2.2.4 Marginal Value Product (MVP)

The estimated coefficients were used to compute the MVP. We can assess the relative importance of factors of production by studying the marginal value product. Marginal Value Product of X_i, *i.e.* for the i^{th} input, it is estimated by the following formula (equation 2)

$$MVP = bi \times \frac{GM(Y)}{GM(Xi)} \times P_y \tag{2}$$

GM(Y) and GM (Xi) represent the geometric means of output and input respectively, b_i is the regression coefficient of i^{th} input and P_y is price of output. The model was estimated as in equation 3.

$$r = \frac{MVP}{MFC} \tag{3}$$

Where, 'r'is the efficiency ratio, MVP is the marginal value product of variable input and MFC is the marginal factor cost (price per unit input).

Based on economic theory, a firm maximizes profits with regards to resource use when the ratio of the marginal return to the opportunity cost is one. The values are interpreted thus, If r is less than 1 indicates that the resource is excessively used (there exist scope for the reduction). If r is greater than 1, indicates that the resource is under used or being underutilized (there is a scope to increase). If r is equal to 1, indicate optimum utilization of resource.

Table 1. Partial Budgeting Tool

Debit	**Credit**
Increase in cost due to application of Bhoochetana inputs = A	Decrease in cost due to application of Bhoochetana inputs = C
Decrease in gross returns due to application of Bhoochetana inputs = B	Increase in gross returns due to application of Bhoochetana inputs= D
Total = A+B	Total = C+D
Credit-Debit = Net gain / loss	

2.2.5 Bhoochetana Impact on redgram production

Cobb-Douglas regression function was used to analyze the impact of Bhoochetana scheme on redgram production and the functional form is presented in equation (4).

$$Y = aX_1^{b1}X_2^{b2}X_3^{b3}X_4^{b4}X_5^{b5}D^{b6}e^u \quad (4)$$

Where, Y is total redgram production (Quintals), X_1 is the area (acre), X_2 is seed (Kg), X_3 is nutrient cost (₹), X_4 is Human labour cost (₹), X_5 is bullock and machine cost (₹), D is a Dummy variable (D=1 for Beneficiary, 0 otherwise) and u is an error term.

3. RESULTS AND DISCUSSION

3.1 Costs and Returns

The total cost of cultivation of redgram among beneficiary farmers (₹57,672/ha) was marginally higher than non-beneficiary farms (₹54,726/ha) per ha of which more than 70 per cent was spent on variable inputs. At least 30 per cent of the total cost of cultivation was spent to engage the human labours. This clearly demonstrates that redgram cultivation is highly labour intensive crop. Also, it was recorded that the higher cost of cultivation among the beneficiary farmers was due to the use of additional inputs like micro-nutrients and bio-fertilizers (Table 2). As a result, beneficiary farmers could able to reap additional yield of redgram to the tune of 1.32 quintals, this results are in line with Dhanalakshmi et al. 2017 [11]. This has helped the beneficiary farmers to gain additional net returns of ₹ 5,186/ha consequently lower cost of production was recorded among beneficiaries (₹3,866/quintal) than non-beneficiaries (₹ 4,024/quintal), this results are also in line with Hamsa et al. 2018 [12].

3.2 Relative Benefits of Bhoochetana Scheme for Redgram Growers

Partial budgeting technique was used to elucidate the relative benefit of Bhoochetana scheme on income level of farmers in redgram cultivation (Table 4). Results indicated that a net gain of ₹ 5,367 per hectare was realized by Bhoochetana beneficiary farmers over non-beneficiary farmers. This clearly shows that the Bhoochetana scheme has benefitted farmers to increase the farm income.

Table 2. Cost of cultivation of redgram

(₹/ha)

Particulars	Beneficiary			Non-beneficiary		
	Quantity	**Total cost**	**%**	**Quantity**	**Total cost**	**%**
Variable cost						
Human labour	60 Man-days	18000	31.21	56 Man-days	16800	30.69
Bullock labour	5.25 BP-days	4725	8.19	5.1 BP-days	4590	8.38
Machine labour	6.74 hr	4044	7.01	6.65 hr	3990	7.29
Seed	15 kg	900	1.56	15.5 kg	930	1.69
FYM	2.50 tractor-load	5373	9.31	2.3 tractor-load	5060	9.25
Fertilizer cost		3375	5.85		3158	5.77
Micro nutrient and Bio fertilizer		807	1.39		0	0.00
Plant protection chemicals		2820	4.88		2749	5.02
Interest on working capital @ 7 per cent		2803	4.86		2609	4.76
Total variable cost		42847	74.29		39886	72.88
Fixed cost						
Depreciation		730	1.26		742	1.36
Land revenue		20	0.03		22	0.04
Interest on fixed capital @ 10 per cent		75	0.13		76	0.14
Rental value of land		14000	24.27		14000	25.58
Total fixed cost		14825	25.70		14840	27.12
Total cost of cultivation		57672	100.00		54726	100.00

Table 3. Per hectare returns from redgram production in the study area

Per hectare

Particulars	Beneficiary	Non-beneficiary
Main product (Quintals)	14.92	13.60
By product (Quintals)	2.70	2.50
Returns from main product(₹)	89520.00	81600.00
Returns from by-product (₹)	2222.00	2009.00
Gross returns (₹)	91742.00	83609.00
Net returns (₹)	34069.00	28883.00
Cost of production (₹ /Quintal)	3866.00	4024.00
Returns per rupee of expenditure	1.59	1.52

Table 4. Relative benefits for Bhoochetana beneficiary's v/s non-beneficiaries in redgram production

(₹/ha)

Debit	Amount	Credit	Amount
A. Increase in cost		**Decrease in cost**	
i) Human Labour	1200.00	i) Seed	30.00
ii) Bullock Labour	135.00		
iii) Fertilizer cost	217.00		
iv) Micro nutrients	807.00		
v) Machine labour	54.00		
vi) FYM	312.00		
vii) Plant protection chemicals	71.00		
B. Decrease in returns	**0**.00	**D. Increase in returns**	**8133.00**
Total debits (A+B)	**2796.00**	**Total credits (C+D)**	8163.00

Net gain per hectare (Total Credit-Total Debits) = ₹. 5367.00

Table 5. Resource use efficiency in redgram production

Particulars	Beneficiary		Non-beneficiary	
	Coefficient	**r**	**Coefficient**	**r**
Land (acre)	0.025 (1.34)	0.080	0.035** (3.76)	0.079
Seed (kg)	0.012 (0.98)	0.450	-0.025 (-1.48)	-0.862
FYM and Fertilizer cost (₹)	0.136* (2.52)	1.104	0.005 (1.65)	0.038
Cost of Human Labour (₹)	0.025* (2.06)	0.172	0.193* (2.26)	1.179
Cost of Bullock and machine labour (₹)	0.037 (1.85)	1.014	0.032 (0.38)	0.978
R^2	0.75		0.64	

*Note: 1. ** indicates Significant at 1 per cent and * indicates significant at one per cent*
1. NS- Non-significant values
2. r – Ratio of MVP to MFC

3.3 Resource Use Efficiency in Redgram Production

Among the Bhoochetana beneficiaries 'r' coefficient for land, seed and human labour is less than one indicates that there is a scope for the reduction in use of these inputs or in other way the same level of redgram can be realised by efficient management of these resources. Rather, bullocks, machines and fertilizers were being put into use bit efficient way. But, non-beneficiaries were using all the resources (except bullocks and machines) at an inefficient way as land, seeds and fertilizers (and manures) were over used (there is scope for the reduction in use of these resources) and human labours were underutilized.

Table 6. Impact of Bhoochetana scheme on yield of redgram in study area

(Dependent Variable: production in quintals)

Particulars	Coefficient	t value
Intercept	17.20**	3.64
Area (ac)	1.058**	11.01
Seed (Kg)	-0.003	-0.04
Nutrients cost (₹)	0.120*	2.17
Human labour cost (₹)	-0.023	-0.31
Bullock and Machine cost	0.036	1.01
D (1= Beneficiary, 0 otherwise)	0.378**	7.12
R^2		0.83

*Note: **, * indicates significance at one and five per cent, respectively*

3.4 Effect of Bhoochetana Scheme on Redgram Production

To assess the impact of the Bhoochetana scheme on production level of redgram, the Cobb-Douglas production function was used. A dummy for the beneficiaries was regressed on the production level along with area, seed, fertilizers, human labour and bullock labour (Table 6).The estimate indicates that a unit increase in area and plant nutrients from its mean level results in increase in redgram production by 1.06 units and 0.12 units. A significant positive co-efficient on dummy variable indicate that the Bhoochetana beneficiaries realised higher redgram production by 0.38 quintals per farm. Because of use of additional micronutrients and biofertilizers, the yield of red gram was higher.

4. CONCLUSION

The study has shown that there is a large difference between Bhoochetana beneficiaries and non-beneficiaries in yield levels and profitability of redgram production which is a major pulse both in-terms of production and meeting the dietary protein requirement of the masses. Kalaburagi comes under economically backward region of the State; this increase in income is a substantial gain for the farmers. Overall, this technology has potential and can play an important role in uplifting the socio-economic position of the farmers. Provided, the schemes like this should be efficiently implemented and monitored by ensuring timely supply of micro nutrients and certified biofertilizers, only soil test based micro-nutrient application (as micro-nutrients like Zn, Boron, sulphur and gypsum may cause adverse effect if applied beyond the required levels). However, redgram is predominantly produced in the rain-fed area and it is already found that the rain-fed areas are highly prone for the soil degradation and are already degraded beyond the level of tolerance. Looking in to the extent of human settlements and dependence on dry land to access the livelihood stresses the importance of soil rejuvenation (or soil and water conservation) schemes like Bhoochetana.

CONSENT

As per international standard or university standard, respondents' written consent has been collected and preserved by the author(s).

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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