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Economic Valuation of *Rhizobium* Bio-fertilizer for Production of Haricot Bean in Wolayta Zone, SNNP Region, Ethiopia

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Abstract: Microorganisms as components of biodiversity play important roles in different economic sectors including agriculture, pharmaceutical and in other industrial products. In Agriculture they are used as bio fertilizers and biological control agents. The biological nitrogen fixation by *Rhizobium* species and other bacteria is safe and cheap source of nitrogen fertilizer. A questionnaire based survey was employed in Wolayta zone of SNNP to determine the Willingness to Pay (WTP) for *Rhizobium* bio-fertilizer for production of haricot bean. A total of 50 respondents from two kebeles were involved in the study and proportionate random sampling was used to draw informants from the population of bio-fertilizer users. Results showed that average yield of haricot bean are 10.17 quintals using bio-fertilizer, and 3.65 quintals without bio-fertilizer and there is a difference of 6.52 quintals. Yield and WTP are positively correlated with each other. As the mean yield of haricot bean with bio-fertilizer exceeds by 6.52 quintal, the difference is significant (t=8.5, sig.= 0.000) at 95% level). Thus it may be possible to conclude that the gain from the use of the bio-fertilizer estimated the economic value of the *rhizobial bacteria* used as input for the production of haricot bean.

Keywords: Economic Value, Haricot Bean, *Rhizobial bacteria,* Willingness to Pay

1. Introduction

Microorganisms as components of biodiversity play important roles in different economic sectors including agriculture, pharmaceutical and in other industrial products. In Agriculture they are used as bio fertilizers and biological control agents [12], [2]. The soil contains many types of microorganism such as bacteria, actinomycetes, fungi, and algae. Amongst the soil bacteria there is a unique group called Rhizobia that have a beneficial effect on the growth of legumes. 'Rhizobia' is the general term used to describe soil-inhabiting gram-negative bacteria that are capable of producing N_2-fixing nodules on the roots of leguminous plants [2], [17], [8].

The biological nitrogen fixation by *Rhizobium* species and other bacteria is safe and cheap source of nitrogen fertilizer. Nitrogen Fertilizer will continue to serve for increasing grain production until a foreseeable future, but efforts are also being oriented towards augmenting biological nitrogen fixation mediated by microorganisms [12], [2]. Nitrogen fixing bacteria are very selective in choosing roots of particular legumes species to infect, invade and form root nodules. *Rhizobium* has the exceptional ability to form nodules on roots or stems of leguminous plants [12], [2], [17].

Bio fertilizers are the formulations of living microorganisms, which are able to fix atmospheric nitrogen in the available form to plants, either by living freely in the soil or being associated symbiotically with plants [12], [2], [17]. Biological nitrogen fixation (BNF) is carried out by both symbiotic and free living microorganisms. There is a considerable economic incentive to explore ways to increase the efficiency of BNF as a bio-fertilizer resource [13].

Haricot bean (*Phaseolus Vulagris* L), locally known as 'Boleqe' also known as dry bean, common bean, kidney bean and field bean is a very important legume crop grown worldwide. It is an annual crop which belongs to the family

Fabaceae. It grows best in warm climate at temperature of 18 to 24°C (14). It is considered as the main cash crop and protein source of farmers in many low lands and mid altitude zones of Ethiopia. The wide range of growth habits of haricot bean among varieties has enabled the crop to fit many growing situations [11]. Early maturity and moderate degree of drought tolerance led the crop's vital role in farmers' strategies for risk aversion in drought prone lowland areas of the country [6].

In Ethiopia, haricot bean is grown predominantly under smallholder producers as an important food crop and source of cash. It is one of the fast expanding legume crops that provide an essential part of the daily diet and foreign earnings for most Ethiopians [7]. Moreover, it has been an export crop for more than 40 years [15]. Although beans are largely grown in Ethiopia, the national average yield amounts to 0.8-0.9 t/ha under peasants farming condition [4]. This low yield is attributed to various constraints related to drought, lack of improved varieties, poor cultural practices, disease, and environmental degradation [3].

Although microorganisms are valuable resources for present developments and future innovations there is no established method for evaluating the economic value of microbial resources collected from natural habitats. The economic value of microbial resources used as bio-fertilizer, screening material for developing new pharmaceuticals may be used to estimate the initial charge and expected royalties obtained from companies using the microbial genetic resources [17], [5], [1], [10]. The study was designed to meet the following specific objectives. (a) To determine the Willingness to Pay (WTP) for *Rhizobium* Bio-fertilizer for the production of haricot bean (b) To determine factors affecting the value of *Rhizobium* bio-fertilizer use in the community and (c) To explore the need for large scale production of the *Rhizobium* bio- fertilizer and promote farmer's economy by increasing yield.

2. Materials and Methods

2.1. Study Area

The study was conducted in Wolayta Zone of Southern Nations Nationalities and People's Region (SNNPR). Wolayta Zone is one of the Zones in (SNNPR) and is located 400 kilometers south west of Addis Ababa. Wolayta zone is purposively selected from other zones of the region because of higher number of rhizobia bio-fertilizer consumers for production of haricot beans. These areas are the highest distribution areas of the specific bio-fertilizers for each crop by MENAGESHA BIO-TEC Company. The Zone has 12 woredas and Bolososore woreda was among the top users of rhizobia bio-fertilizer than others. Bolososore woreda has 29 kebeles and of which two kebeles were primarily selected for this study due to the fact that they are major producers of haricot bean using rhizobial bio fertilizer. Similarly, among the kebeles, Yukera and Achura were selected based on their highest usage of the bio-fertilizer for haricot bean production.

2.2. Sampling Methodology

A total of 50 respondents from 2 kebeles (Yukera and Achura) were involved in the study and the demographic data of the study group was recorded by interviewing. The respondents involved in the study were interviewed by means of semi structured questionnaire. The age, sex, level of education and size of land owned by the respondents were recorded by interviewing each respondent in the respective area of the study.

Table 1. *Population and the sample size of the study.*

Zone	District	Name of Kebele	Bio-fertilizer users in Kebele	Selected sample size of respondents
Wolayta	Bolososore Woreda	Achura	380	38
		Yukera	120	12
	Total		500	50

2.3. WTP Bid Calculation and Model Specification

The individual willingness to pay (WTP) bids to use bio-fertilizer for production of different legumes was calculated using the equation:

$$WTP = \sum (A_i\, Y_i\, P_i) - \sum (a_i\, y_i\, p_i) \quad (1)$$

Where WTP= total willingness to pay for bio-fertilizer, A_i= Area used for producing haricot bean with bio-fertilizer, Y_i= yield of haricot bean produced with bio-fertilizer, P_i= price of haricot bean produced by using bio-fertilizer, a_i= area covered with haricot bean without bio-fertilizer, y_i= yield of haricot bean produced without using bio-fertilizer, P_i= price of legume produced without bio-fertilizer. Using this formula calculation was done for haricot bean cultivated in the specific study area. The WTP bids were transferred to SPSS statistical software (SPSS, version 21) for analysis. Mean willingness to pay, standard deviation, confidence interval and the relationship of WTP to categorical variables were analyzed using descriptive statistics, two sample t-tests and ANOVA. The WTP bids were also regressed with various explanatory variables. The bid functions were arrived at using linear regression analysis, starting from all the potential explanatory variables, removing the least significant one, re-estimating the model and so on until all remaining variables were significant at 95% level. The valuation function was:

$$WTP = \beta_0 + \beta_1X_1 + \beta_2X_2 + \beta_3X_3 + \beta_4X_4 + \beta_5X_5 \text{-----------} \beta_nX_n + \beta_nX_n + e_n \quad (2)$$

Where WTP= farmers willingness to pay for a specific legume for instance haricot bean's bio-fertilizer, β_0= constant, β_1- β_n= coefficients, X_1-X_n= variables influencing WTP, e_n= random error.

3. Result and Discussion

3.1. Socio Economics and Demographic Information

Bolososore woreda was among the top users of Rhizobia bio fertilizer for haricot bean production. From among 29 kebeles of Bolososore woreda two kebeles, Yukera and Achura were primarily selected for this study due to frequently using Rhizobia bio fertilizer. A total of 50 respondents from these 2 kebeles were involved in the study and the demographic data of the study group was recorded by interviewing. The mean age of the respondents was 37 years.

Forty percent of the entire respondents in Yukera and Achura Kebeles had primary school education and 26% were illiterate. Similarly, 26% of the respondents had secondary level and only 8% of them had higher education. The respondents have an average size of family 8.06 which is greater than the national average 4.6 [4].

3.2. Land Holding

The average land holding of respondents were 1.17 ha which is above the national average. Table 2 shows the land of informants in the study kebeles covered with bio fertilizer and used for haricot bean without fertilizers respectively.

Table 2. *Respondents Land holding.*

Farmers land holding	Land	Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0.25-.5 ha	14	28.0	28.0	28.0
	1.51-1.75 ha	1	2.0	2.0	30.0
	1.76-3 ha	35	70.0	70.0	100.0
	Total	50	100.0	100.0	

Survey data

3.3. Hectare Covered with Bio-fertilizer Haricot Bean

All 50 respondents use bio-fertilizer from .25 ha-3 ha coverage and average coverage of bio-fertilizer 0.73 ha (SD .0.62). 70% of the total respondents cover .25 ha of their land with bio-fertilizer, 22% on 1-2 ha of land and 8% 2-3 ha of land. The majority of respondents use 0.25 ha of land for bio-fertilizer. Most of the respondents (36%) purchase 250 grams which is sufficient for 0.25 hectare of land, followed by 125 grams which is the minimum pack available and sufficient for 0.25 hectares. The ANOVA result also showed that there is a significant difference in WTP between the hectare of land covered by haricot bean and without bio-fertilizer at (F =19, sig. = 0.000) at 95% confidence level. The multiple comparisons between groups of hectare covered shows that the group 1.50-3 ha is statistically significant with the other group. The higher the hectare coverage the higher the WTP.

Table 3. *Land covered with bio-fertilizer for haricot bean.*

Hectare of land	Frequency	Percent
.25	17	34.0
.40	2	4.0
.50	13	26.0
.75	1	2.0
.80	1	2.0
1.00	9	18.0
1.50	1	2.0
2.00	5	10.0
3.00	1	2.0
Total	50	100.0

Survey data

The Paired Samples Test also showed that the comparison between the mean hectare coverage of haricot bean with bio-fertilizer and without bio-fertilizer. The difference is significant at (t= 3.15, sig. =0.003) at 95% confidence interval. The hectare coverage of haricot bean with bio-fertilizer is significantly higher than without using it. The respondents show their willingness for haricot bean bio-fertilizer by devoting large area of land.

Table 4. *Land used for haricot bean without bio-fertilizer.*

Hectare of land	Frequency	Percent	Valid Percent	Cumulative Percent
.13	1	2.0	2.0	2.0
.25	29	58.0	58.0	60.0
.27	1	2.0	2.0	62.0
.50	11	22.0	22.0	84.0
.75	2	4.0	4.0	88.0
1.00	4	8.0	8.0	96.0
2.00	2	4.0	4.0	100.0
Total	50	100.0	100.0	

Survey data

3.4. Yield of Haricot Bean

The average yield of haricot bean before and after using bio-fertilizer was compared using paired sample t-test. The paired sample statistics indicates the average yield of haricot bean is 10.17 quintals when using bio-fertilizer and 3.65 quintals without using it. There is a difference of 6.52 quintals which is almost twice of the amount produced by using fertilizer, the difference is significant (t=8.5, sig.= 0.000) at 95% level. The group statistics and independent t-test result shows that the yield above and below the average yield 10 quintals/year, the mean, standard deviation and standard error of the groups (table 4). The average willingness to pay for more than 10 quintals /year is (3.24$ birr) and (0.97$) for those who produce below 10 quintals. There is a big deviation in WTP between in the groups. The paired sample test the mean yield of haricot bean with bio-fertilizer exceeds by 6.52 quintal, the difference is significant (t=8.5, sig.= 0.000) at 95% level. This is interpreted as the difference in mean yield comes from the use of bio-fertilizer.

Table 5. *Yield of haricot bean in quintals.*

	Amount of yield with bio-fertilizer in quintals	N	Mean	Std. Deviation	Std. Error Mean
WTP1	>= 10	23	68.09	74.95	15.63
WTP2	< 10	27	20.46	19.09	36.74

Group Statistics table, N- number

3.5. Income Gained

The use of bio-fertilizer benefits the respondents with additional income (table 5). 18% of the respondents got more than 10,000-20,000 birr from the sale of haricot bean produced by using bio-fertilizer. Similarly, 40% of the respondents got additional income from 5001-10,000.

Table 6. *Income gained by the respondents.*

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	<5000 birr (238$)	21	42.0	42.0	42.0
	5001-10000 birr (239-476$)	20	40.0	40.0	82.0
	10001-21000 birr (478-10,000$)	9	18.0	18.0	100.0
	Total	50	100.0	100.0	

Survey data

3.6. Frequency of Using Bio-fertilizer

Majority of the respondents used the rhizobia bio-fertilizer for two years 58% (table 6) The rest of the respondents used only for one year 22% and for 3 years 10%. The frequent use of the bio-fertilizer statistically affects the WTP. Farmers who used frequently had more WTP than others.

Table 7. *Frequency of using bio-fertilizer.*

	Year	Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	11	22.0	22.0	22.0
	2	29	58.0	58.0	80.0
	3	10	20.0	20.0	100.0
	Total	50	100.0	100.0	

Survey data

3.7. Willingness to Pay for Bio Fertilizer in Haricot Bean Production

The total willingness to pay for haricot bean's bio-fertilizer of 50 respondents is calculated using the formula below. The average willingness to pay is 4,236.97 birr/household/ year. The total willingness to pay is affected by some factors such as hectare covered, yield per hectare and price.

$$WTP=\sum (A_i\,Y_i\,P_i)-\sum \sum (a_i\,y_i\,p_i) \quad (3)$$

$$=\sum 252{,}115-\sum 40{,}266.25$$

WTP = 211,848.75 Birr/Quintal/year

The mean WTP difference in the result is 47.63 birr. This difference is large enough to confirm, statistically significant difference (t=2.97 and sig.=0.000) between the group. From this we can conclude that farmers who produce above the mean yield 10 quintals/year have more willingness to pay for bio-fertilizer than below the mean.

Table 8. *Willingness to pay for bio-fertilizer in haricot bean production.*

TP with bio-fertilizer ($A_i\,Y_i\,P_i$)			WTP without bio-fertilizer ($a_i\,y_i\,p_i$)			WTP with bio-fertilizer USD	WTP without bio-fertilizer USD	Total WTP $WTP=\sum (A_i\,Y_i\,P_i)-\sum (a_i\,y_i\,p_i)$
Area	Yield	Price (USD)	Area	Yield	Price (USD)			
.80	21	22.7	.75	10	18.2	381.8	136.4	257
.50	9	31.8	.50	2	13	143.2	13	135.7
.25	13	31.8	.27	5	22.7	103.4	30.7	76..2
.50	10	27.3	.25	1	9.1	136.4	2.7	140
.25	12	27.3	.25	4	22.7	81.8	22.7	61.9
.25	7	27.3	.25	3	25	47.7	18.8	30.4
.50	7	31.8	.25	3	13	111.4	10.2	106
.25	7	31.8	.25	3	18	55.9	13.6	44
.25	7	36.4	.25	3	27.3	63.6	20.5	45.2
.25	10	36.4	.25	3	27.3	90.9	20.5	73.8
.25	7	31.8	.25	3	18	55.9	13.6	44
.25	7	27.3	.25	2	9.1	47.7	4.5	45.2
.25	12	34.1	.25	4	22	102.3	22.7	83.3

TP with bio-fertilizer (A_i Y_i P_i)			WTP without bio-fertilizer (a_i y_i p_i)			WTP with bio-fertilizer USD	WTP without bio-fertilizer USD	Total WTP WTP= ∑ (A_i Y_i P_i) – ∑ (a_i y_i p_i)
Area	Yield	Price (USD)	Area	Yield	Price (USD)			
.50	10	27.3	2.00	3	27.3	136.4	163.6	28.6
.50	8	22	.50	2	13	90.9	13.6	80.9
1.00	4	29.5	.25	1	18	118.2	2.7	121.4.
.25	7	30.9	.25	4	22	54.1	22.7	32.9
.75	12	31.8	.50	1	9.1	286.4	4.5	295.2.
.50	8	31.8	.50	5	22	127.3	56.8	73.8
1.00	4	31.8	.50	3	29.5	127.3	36.9	94.6.
.25	5	18	.25	3	13	22.7	10.2	13.1.
.25	10	27.3	.25	4	18	68.2	18.2	52.4
.40	12	27.3	.25	4	22	139.9	22.7	113.3
.50	5	29.5	.50	3	22	73.9	34	41.7
.25	4	28.2	.25	2	25	24.7	12.5	12.7
.50	12	29.1	.25	6	24.1	174.5	36.1	145
1.00	25	31.8	.50	10	9.1	795.5	45	785.7
.25	9	40.9	.25	3	20.5	86.9	15.3	75
1.00	18	45.5	1.00	5	31.8	81.8	159.1	690.5
.40	16	31.8	.25	5	22	203.6	28.4	183.6.
2.00	7	27.3	.50	4	22	381.8	45	352.4
1.00	17	27.3	1.00	7	18	463.6	127	352.4
.50	7	40.9	.25	3	18	143.2	13.6	135.7
.50	10	27.3	1.00	6	18	136.4	109.1	28.6
.25	7	40.9	.50	2	13	71.6	13.6	60.7
2.00	6	25	.25	2	18	300	9.1	304.8
1.00	3	13	.25	4	11.4	40.9	11.4	31
1.50	8	21.8	.25	1	22	245.5	5.7	251.2
2.00	6	20.9	.25	1	13.6	251.1	3.4	259.3
.50	9	22	.25	1	9.1	102.3	2.7	104.8
.50	4	22	.13	3	18	45	5.7	41.7
2.00	20	27.3	2.00	4	18	1090.9	152.4	990.5
1.00	10	27.3	1.00	7	18	272.7	127	152.4
.50	18	27.3	.50	9	13	238.6	59.1	185.7
.25	6	22	.25	2	13	34.1	6.8	28.6
1.00	4	20.5	.25	2	21.8	71.6	10.9	63.6
2.00	10	27.3	.50	4	13	545.5	22.3	542
3.00	14	27.3	.75	4	6.8	1145.5	17.9	1181.3
.25	12	54.5	.25	8	36.4	163.6	72.7	95.2
1.00	35	27.3	.25	1	9.1	954.5	1.1	998.8.

WTP in USD

3.8. Factors Affecting WTP

The One-way ANOVA table shows that there is significant relationship between the explanatory variables and dependent variable at (F= 58.65, sig. = 0.000) at 95% significant level. Among the listed variables income gained from bio-fertilizer, hectare of land covered by haricot bean with bio-fertilizer and yield with bio-fertilizer in year are statistically significant. Farmers getting higher income are more willing to use haricot bean bio-fertilizer than others. Respondents, who have higher willingness to use bio-fertilizer, cover large area of their land with haricot bean bio-fertilizer than without it.

Table 9. *Factors affecting WTP.*

Model	Unstandardized Coff.		St. Coff.	t	Sig.
	B	Std. Error	Beta		
(Constant)	-252.125	158.432	-		.121
Income with bio-fertilizer	.465	.061	.654		.000
yield	21.527	8.517	.165		.016
Type of fertilizer used	53.955	38.294	.091		.168
Hectares of land covered	157.197	36.665	.386		.000

B- beta

3.9. Model Summary

The Model Summary table indicates the reliability of the model by explaining how much of the explanatory variables explained the dependent variable. The R^2 value 0.87 shows about 87% of the dependent variable is explained by the independent variables showing R^2 more than 0.15 for few key variables is acceptable [18].

Table 10. *Model Summary.*

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.933[a]	.870	.855	35.497	.870	58.652	4	35	.000

4. Conclusion and Recommendations

The valuation of biodiversity is an essential step in conservation, because there is an increasing pressure on declining biodiversity that helps to introduce the incentives in economic value of biodiversity. Although microorganisms are valuable resources for present developments and future innovations there is no established method for evaluating the economic value of microbial resources collected from natural habitats. Therefore, it is difficult to implement the Access and Benefit-sharing (ABS) principle of Convention on Biological Diversity (CBD).

From the total haricot bean grown by bio-fertilizer 88% were used improved variety while 12% were landrace users. From the total farmers who have WTP greater than the mean 200 birr/quintal/year 83.3% are from farmers using improved variety and 16.7% are from landrace growers. Bio-fertilizers are recommended by extension agents as package with improved variety. This interpretation could lead us to the fact that land race varieties could also give high yield if packaged similar to improved varieties.

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