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Valuation of *Rhizobium* Bio-fertilizer forthe Production of Faba Bean in ArsiZone, Oromia Region, Ethiopia

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Abstract: Microorganisms as components of biodiversity play important roles in agriculture and different economic sectors. The biological nitrogen fixation by *Rhizobium* species and other bacteria is safe and cheap source of nitrogen fertilizer. The existing price of bio-resources does not reveal its real value. A questionnaire based survey was employed in Arsi Zone of Oromia Region to determine the Willingness to Pay (WTP) for Rhizobium bio-fertilizer for the production of Faba bean. Proportionate random sampling was employed to draw informants from the population of bio-fertilizer users in two kebeles. The average land holding of a farmer in two kebeles is 2.24 hectare which is greater than the national average 1.18 hectare. The paired sample t-test indicates the average value of yield with bio-fertilizer and without bio-fertilizer. The average yield when using bio fertilizer was 10.68 quintals while without using bio-fertilizer was 6.7 quintals. The difference is statistically significant (t=4.80, sig.= 0.000) at 95 % confidence interval level. From this observation we can conclude that the use of bio-fertilizer significantly affects WTP. 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 the studied Faba bean.

Keywords: Faba bean, Economic value, *Rhizobia bacteria*, Willingness to pay

1. Introduction

Biodiversity is base for many manufacturing sectors such as pharmaceuticals, agriculture, horticulture, cosmetics and biotechnology. Ethiopia is known to be among the countries rich in biodiversity and bio-resources of the world. The diverse ecosystems have endowed the country with a diverse biological wealth of plants, animals and microbial species [8]. 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 [11], [4].

Faba bean is one of the major pulse crops commonly grown in Ethiopia, and it ranks first in area and production. It occupies areas of 459, 183.5 ha land with annual production of 697, 798.3 tons [9]. The potential of this food legume as a supplier of biologically fixed nitrogen for non-leguminous crops might be more important than their potential as food or cash [5]. They are also used in the preparation of local dishes such as '*shiro wot* 'and '*kik wot'*. Moreover, they provide large cash for farmers and foreign exchange for the country [7]. Faba bean is also predominantly cultivated in marginal agricultural areas where the other cereal crops fail to grow. The productivity of faba bean has remained very low compared to the potential. Soil related stresses such as acidity and associated low phosphate availability are among the major yield limiting constraints [1]. In low-input agriculture systems of Ethiopia, chemical fertilizers are rarely used in the production of faba bean and other pulse crops; instead, these crops are used as a restorer of soil fertility for the following cereal crops [3], [2].

The economic value of microbial resources used as bio-fertilizer may be used to estimate the initial charge and expected royalties obtained from companies using the microbial genetic resources [15], [6], [2], [10]. The contingent-valuation method can be used to measure the economic value of a given resource. The procedure is based on a hypothetical market in which people are asked through questionnaires to express their maximum willingness to pay (WTP) for the protection of biodiversity [14]. The Convention on Biological Diversity (CBD) declared that Access and Benefit Sharing (ABS) is one of the three main objectives and act as an incentive mechanism to local communities in conserving and preserving the biodiversity and it resources potential. However, understanding the non-marketed benefits of biodiversity and the true value of bio-resources are critical for initiating effective policies towards the conservation and sustainable use of biodiversity besides securing ABS meaningfully [13].This study, therefore, designed to meet the following specific objectives, (a) determining the willingness to Pay (WTP) for *Rhizobium* bio-fertilizer for the production of Faba bean, (b) determining factors affecting the value of *Rhizobium* bio- fertilizerin the community.

2. Materials and Methods

2.1 Study Area

The study was conducted in Arsi Zone of Oromia Regional State on bio-fertilizer direct use value on faba bean. Arsi zone is one of the highest distribution area of the specific bio-fertilizers for each crop by MENAGESHA BIO-TEC Company in the Region. The Zone bordered on the south by Bale, on the northwest by East Shewa, on the north by the Afar Region and on the east by West Hararghe. Arsi Zone has 22 districts (Woredas) and among these woredas Limuna bilbilo Woreda was selected because of its highest number of bio-fertilizer utilization for Faba bean production. Limuna bilbilo woreda is 55km far from zonal administrative city, Asella. The woreda has 25 kebeles and of which 18 kebeles were beneficiary of the bio fertilizer. Out of the 18 kebeles, two kebeles, Bokoji Negesso and Chiba Mikael were deliberately selected for the economic valuation of the bio-fertilizer because of their highest consumption of bio-fertilizer in the district.

2.2. Sampling Techniques and Sample Size

Proportionate random sampling was used to draw informants from the population of bio-fertilizer users in each Kebele.

Table 1. Study population and sample size of the study

Zone	District		Kebeles	Bio-fertilizer users	No. of respondents
			Bekoji Negeso	250	25
Arsi	Limuna Woreda	Bilbilo	Chiba Mikael	150	15
Total				400	40

2.3. WTP Bid Calculation and Model Specification

The individual willingness to pay bids to use bio-fertilizer for production of faba bean was calculated using the equation:

$$WTP = \sum (A_i Y_i P_i) - \sum (a_i y_i p_i) \text{----------------------(1)}$$

Where WTP= total willingness to pay for bio-fertilizer, A_i= Area used for producing faba bean withbio-fertilizer, Y_i= yield of faba bean produced with bio-fertilizer, P_i= price of faba bean produced by using bio-fertilizer, a_i= area covered with faba bean without bio-fertilizer, y_i= yield of faba bean produced without using bio-fertilizer, P_i= price of faba bean produced without bio-fertilizer. Using this formula calculation was done for each of the three types of legumes 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:

$$WTP = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 \text{-----------} \beta_n X_n + \beta_n X_n + e_n \text{----------------------(2)}$$

WhereWTP= farmers willingness to pay for a specific legume for instance haricot bean's bio-fertilizer, $\beta_{0=}$ constant, β_1- $\beta_{n=}$ coefficients, X_{1-} X_n= variables influencing WTP, e_n= random error.

3. Result and Discussion

3.1 Demographic Information

The study design was to involve a total of 40, respondents from the two kebeles Bokoji negesso and Chiba-mickael 25 and 15, respectively based on proportionate sampling method. The average age of respondents was 40 years (Table 2).

The average size of a family was 6.56 (Table 3) while the national average is 4.6 [5]. The difference is significant at 95% confidence interval (F=4.85, sig. =0.000). Respondent's family size is statistically significantly higher than the national average. From education point of view, 5% of the respondents were illiterate while, the remaining 95% have educational level ranging from primary to higher education.

3.2. Land Holding of Respondents

The average land holding of a farmer in the district is 2.24 hectare which is greater than the national average 1.18 hectare (Table 4). The difference is significant at 95% confidence interval (F=3.86, Sig.=0.000).

Table 2. Age of respondents in the studied kebeles from Limuna bilbilo district.

Age of respondent	Frequency	Percent
27-31	4	2.5
32-40	21	17.5
41-50	9	2.5
Above 50	6	5.0
Total	40	100.0

Table 3. Family size of respondents.

Family size	Frequency	Percent
<5	13	32.5
5.1-10	25	62.5
10.1-15	2	5.0
Total	40	100.0

Table.4 Land holding of respondents.

Hectare	Frequency	Percent
<1 ha	17	42.5
1.01-2 ha	7	17.5
2.01-4 ha	12	30.0
4.01-7 Ha	4	10.0
Total	40	100.0

3.3. Hectare Covered with and without Bio-fertilizer

The mean hectare of land used by faba bean with bio-fertilizer and before using bio-fertilizer there is a difference of 0.053 hectare (Table 5). The paired sample statics also showed that the hectare used for faba bean with bio-fertilizer is significantly greater than before without using it.

3.4. Yield of Faba Bean

The average yield when using bio fertilizer was 10.68 quintals while without using bio-fertilizer was 6.7 quintals. The difference is statistically significant (t=4.80, sig.= 0.000) at 95% confidence interval level. Therefor this indicate that the yield with bio-fertilizer is higher than without bio-fertilizer. The paired sample t-test indicates the average value of yield before and after using bio-fertilizer.

Table 5. Paired Samples Statistics

		Mean	**N**	**Std. Deviation**	**Std. Error Mean**
Pair 1	Hectares of land covered with bio-fertilizer	.3941	40	.22915	.03623
	Hectare covered without bio-fertilizer	.3408	40	.18759	.02966

Table 6. Paired samples test

		Paired Differences					**t**	**df**	**Sig. (2-tailed)**
		Mean	**Std. Deviation**	**Std. Error Mean**	**95% Confidence Interval of the Difference**				
					Lower	Upper			
Pair 1	Yield with bio-fertilizer vs Yield without bio-fertilizer in quintals	3.975	5.235	.828	2.301	5.649	4.802	39	.000

3.5. The Type of Variety Used with Bio-Fertilizer

From the total chickpea growers 42.5% used improved variety and 57.5% use landrace. About 82% of improved variety users have low WTP less than 100birr/quintals, while 6% have high WTP greater than 14.2$/quintals. From the total landrace growers 91% of the respondents were having WTP less than 100birr/quintals and 4.3% of them have higher WTP greater than 14.2$/quintals. Thus, improved variety users have higher WTP for bio-fertilizer than landrace users.

3.6 Willingness to Pay (WTP) for Bio-Fertilizer

When bio-fertilizer was used for faba bean production, increase by 1hectare of land, increases the willingness to pay for bio-fertilizer by 699.23$/quintal/year. More over higher income is significantly related to higher WTP at (F=72.17, sig.= 0.000). There is strong correlation between the explanatory variables and WTP (R= 0.79. R^2 =0.62).

3.7 Factors Affecting WTP

The Coefficients table showed that income gained from bio-fertilizer, hectare of land covered by haricot bean bio-fertilizer and frequency of using bio-fertilizer in year are statistically significant. Farmers getting higher income are more willing to use haricot bean with bio-fertilizer than others and cover large area of their land. Respondents who used bio-fertilizer for the first time have higher willingness than those who used frequently. When the hectare covered by faba bean bio-fertilizer increases by 1hectare, the willingness to pay for bio-fertilizer increases by 699.23$/quintal/year. They use higher hectare of land when they saw with bio-fertilizer than any other fertilizer. When the experience of using bio-fertilizer increase by one year, the WTP for faba bean bio-fertilizer decreases by 115$/quintal/year.

3.8 Regression Model

The ANOVA table indicates that WTP frequency of using bio-fertilizer, hectares of land covered by faba bean and amount of yield produced have significantly related to WTP at F= 19.95, sig.= 0.000 at 95% confidence level.

3.9 Model Summary

There is strong correlation between the explanatory variables and WTP with correlation coefficient of R= 0.79.

R^2 =0.62 shows about 62% of the independent variables are explained in the model. This indicates that the model is fit (Table 10).

Table 7. Willingness to pay of respondents in USD.

WTP with bio-fertilizer (A_i Y_i P_i)			**WTP without bio-fertilizer ($a_i y_i$ p_i)**			**WTP with bio-fertilizer in $**	**WTP without bio-fertilizer in $**	**Total willingness to pay** WTP= Σ (A_i Y_i P_i) – Σ ($a_i y_i$ p_i) in $
Area	Yield	Price $	Area	Yield	Price $			
.25	5	33.3	.25	3	19.05	41.66	14.29	27.38
.25	6	33.3	.25	3	19.05	50	14.29	35.71
.25	5	71.43	.50	8	52.38	89.29	209.52	-120.24
.75	25	80.95	.25	6	38.09	1517.86	57.14	1460.71
.75	18	57.14	.50	8	42.86	60	171.43	60
.25	6	80.95	.25	5	41.90	121.43	52.38	69.04
.38	12	80.95	.25	7	57.14	364.29	100	264.29
.25	8	38.09	.25	5	33.33	76.19	41.66	34.52
.25	5	61.90	.25	3	42.86	77.38	32.14	45.24
.25	7	61.90	.25	4	33.33	108.33	33.33	75
.38	10	47.62	.25	9	42.86	180.95	96.43	84.52
.25	3	57.14	.13	3	52.38	42.95	20.43	22.49
.25	5	61.90	.25	4	42.86	77.38	42.86	34.52
.50	12	38.09	.50	6	33.33	228.57	100	128.57
.38	9	57.14	.25	5	33.33	195.43	41.66	153.76
.50	13	61.90	.25	5	33.33	402.38	41.66	360.71
.25	9	57.14	.25	7	33.33	128.57	58.33	70.24
.25	8	57.14	.25	4	42.86	114.29	42.86	71.43
.25	8	40.48	.25	4	35.71	80.95	35 .71	42.86
.25	7	71.43	.25	3	38.09	125	28.57	96.43
1.00	32	71.43	.50	11	33.33	2285.71	183.33	2102.38
.25	7	38.09	.25	5	23.81	66.66	29.76	36.90
.25	7	33.3	.25	5	23.81	58.33	29.76	28.57
.75	17	61.90	1.00	10	47.62	789.29	476.19	313.10
.25	7	38.09	.25	1	23.81	66.66	5.95	60.71
.25	5	52.38	.25	2	33.33	65.48	16.66	48.81
.25	6	57.14	.25	4	33.33	85.71	33.3	52.38
.25	6	57.14	.25	5	38.09	85.71	47.62	38.09
.25	6	38.09	.25	4	28.57	57.14	28.57	28.57
.25	7	42.86	.25	7	33.33	75	58.33	16.66
.50	24	47.62	.50	16	38.09	57.14	304.76	266.66
.50	15	78.58	.50	16	38.09	589.29	304.76	284.52
.50	37	71.43	.50	25	38.09	1321.43	476.19	845.24
.25	8	71.43	.25	3	38.09	142.86	28.57	114.29
.25	4	33.3	.25	4	28.57	33.3	28.57	4.56
.38	14	66.66	.25	6	38.09	354.66	57.14	297.52
1.00	29	76.19	1.00	20	47.62	2209.52	952.38	1257.14
.50	4	42.86	.50	12	38.09	85.71	228.57	14.29
1.00	5	76.19	.50	6	38.09	380.95	114.29	266.66
.25	6	52.38	.25	4	42.86	78.71	42.86	35.71

Table 8. Fitness of the model

Model	Un standardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
	B	Std. Error	Beta			Tolerance	VIF
(Constant)	-4416.952	1092.142		-4.044	.000		
For how long did you use bio-fertilizer	1816.493	558.250	.347	3.254	.002	.915	1.093
Hectares of land covered	3776.052	2348.613	.231	1.608	.117	.505	1.981
Yield with bio-fertilizer in quintals	204.719	64.606	.445	3.169	.003	.528	1.894

Table 9. Summary of the model

Model	Sum of Squares	df	Mean Square	F	Sig.
Regression	341349173.557	3	113783057.852	19.956	.000[b]
Residual	205258811.418	37	5701633.650		
Total	546607984.975	40			

Table 10. Model fitness.

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	.790[a]	.624	.593	2387.80938	.624	19.956	3	36	.000

4. Conclusion and Recommendations

The study attempts to determine the indirect economic value of rhizobium species from the benefit obtained by the farmers using rhizobial bio- fertilizers for producing the faba bean. Results indicated that farmers who used the microbial bio-fertilizer gained more yield and benefited most, thus showed higher WTP than those who have not used the same fertilizer. Therefore, it is possible to conclude that the gain from the use of the bio-fertilizer estimated the economic value of the rhizobial bacteria indirectly. Understanding the non-marketed benefits of biodiversity and the true value of bio-resources are critical for initiating effective policies towards the conservation and sustainable use of biodiversity besides securing ABS meaningfully.

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