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Economic Valuation of *Rhizobium* Bio-fertilizer for the Production of Chickpea in North Shewa Zone, Amhara Region, Ethiopia

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Abstract: Biodiversity has significant economic value that is both implicit and explicit. Even if biodiversity goods have a market, they are imperfect and experience market distortions. The existing price of bio-resources does not reveal its real value. Such an underestimation is considered as one of the factors for rapid depletion of biodiversity and loss of habitats and species. A questionnaire based survey was employed in North Shewa Zone of Amhara Region to determine the Willingness to Pay (WTP) for Rhizobium bio-fertilizer for the production of Chickpea. Proportionate random sampling was employed to draw informants from the population of bio-fertilizer users in three kebeles. Results indicated that farmers who used the microbial bio-fertilizer gained more yield and benefited most. Farmers who cover large area of their land with chick pea bio-fertilizer have higher WTP than others. The independent sample t-test proves that there is significant difference in WTP with difference in hectare of land covered by chick pea bio-fertilizer by Levene's Test at (F=28.78, sig.= 0.000). 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 chick pea.

Key words: Economic value, Chick pea, *Rhizobia* bacteria, Willingness to pay

1. Introduction

The valuation of biodiversity is an essential step in conservation, because there are increasing pressures on declining biodiversity that it is likely to introduce the incentives in economic value of biodiversity[1]. 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 [2].

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 [3-7]. The biological nitrogen fixation by *Rhizobium* species and other bacteria is safe and cheap source of nitrogen fertilizer. Fertilizer nitrogen will continue to serve for increasing grain production until a foreseeable future, but effort is also being oriented towards augmenting biological nitrogen fixation mediated by microorganisms. Microorganisms also provide the plants with phosphates and other nutrients [8], [9].

Chickpea is one of the members of the subfamily *Papilionoideae* cultivated as food and fodder in different part of the world. However, the most important chickpea producing countries in the world are India, Turkey, Pakistan, Iran, Mexico, Australia, Ethiopia, Myanmar, and Canada. Chickpea can obtain a significant portion of its N_2 requirement through symbiotic N_2 fixation and is integrated with traditional agricultural system for it fixes nitrogen when grown in association with effective and compatible *Rhizobium* bacteria such as *Mesorhizobium cicero* and *Mesorhizobium mediteraneum* and replenish soil fertility [10, 11]. In Ethiopia, chickpea grows in several regions with an altitude range of 1400-2300 meter above sea level (m.a.s.l.) mainly in Shoa, Gojam, Tigray, West Wollo, Gonder, East Bale and West Hararge [12]. Although chickpea is widely grown in Ethiopia, research on BNF has mainly focused on yield increase in field trials. Furthermore, most of the BNF works were limited to other highland pulse crops such as faba bean, field pea and other pasture legumes [13].

This study, therefore, aims to understand the following specific objectives. (a) To determine the Willingness to Pay (WTP) for *Rhizobium* bio-fertilizer for the production of Chickpea (b) To determine factors affecting the value of *Rhizobium* bio-fertilizerin the community.

2. Materials and Methods

2.1 Study Area

The study was conducted in one of 10 Zones in the Ethiopian Amhara Region on bio-fertilizer direct use value on chick pea. North Shewa zone is purposely selected among other zones because of higher number of users of bio fertilizer than in other zones in the region. North Shewazone is the highest distribution area of the specific bio-fertilizers for each crop by MENAGESHA BIO-TEC Company. The Zone is bordered on the south and the west by the Oromia Region, on the north by Debub Wollo, on the northeast by the Oromia Zone, and on the east by the Afar Region.

Minjar Shenkora woreda was also selected purposively because of large number of bio fertilizer users than other Woredas in the Zone. There are 24 kebeles in Minjar Shenkora Woreda. Of these 23 kebeles were users of Rhizobial bio-fertilizer since 2000 E.C. Based on the information obtained from Woreda Agricultural Office, three kebeles namely Bolo Georgis, Chererti and Arerti are known by their higher consumption of Bio-fertilizers for check pea production than the other kebeles.

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. The selected sample size is calculated by using 10% total bio-fertilizer users. Respondents 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	Kebeles	Bio-fertilizer users	No. of respondents
Semen Shoa	Minjar shenkora	Bolo Georgis	120	12
		Chireti	170	17
		Arerti	170	17
Total			460	46

2.3.WTP Bid Calculation and Model Specification

The individual willingness to pay (WTP) bids to use bio-fertilizer for production of chickpea 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 legume withbio-fertilizer, Y_i= yield of chick pea produced with bio-fertilizer, P_i= price of chick pea produced by using bio-fertilizer, a_i= area covered with chick pea without bio-fertilizer, y_i= yield of chick pea produced without using bio-fertilizer, P_i= price of chick pea produced without bio-fertilizer.

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 calculated 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:

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

WhereWTP= farmers willingness to pay for chick pea bio-fertilizer, $\beta_{0=}$ constant, β_1- $\beta_{n=}$ coefficients, X_{1-} X_n= variables influencing WTP, e_n= random error.

3. Results and Discussion

3.1. Socio Demographic Data

The average age of respondents is 45.5. Out of 46 respondents only 3 were female the rest 43 were males. The age category is given on Table 2.

Age category	Frequency	Percent
21-40	18	2.2
41-50	14	4.3
51-60	9	2.2
Above 60	5	2.2
Total	**46**	**100.0**

Table 2. Age of respondents

The average size of a family is 5.5 while national average is 4.6. The difference is significant at 95% confidence interval and (significance value = 0.001). The educational level of respondents. About 8% were illiterate and the majority (85%) had primary school education. There is no statistical difference in benefits between education group.

Family Size	Frequency	Percent
1-4	17	37.0
4.1-7	23	50.0
>7.1	6	13.0
Total	**46**	**100.0**

Table 3. Family size of respondents from Minjar woreda.

3.2. Land Holding of Respondents

The average land holding of a farmer in Minjar-shenkora woreda is 1.7 hectare which is greater than the national average 1.18 hectare. The difference is significant at 95% significant level (value =0.000). On average a respondent use 0.33 hectare of land to cover with chick pea using bio-fertilizer, 71% of them cover 0.25 ha, 21.7% (Table 4).

Land size inhectare	Frequency	Percent
0. 25-1 ha	14	30.4
1.01-2 ha	18	39.1
2.01-3 ha	10	21.7
>3 ha	4	8.7
Total	**46**	**100.0**

Table 4. Land holding of respondents in Minjar woreda.

3.3. Land Covered with Bio-fertilizer

On average 71% of respondents cover 0.25 ha of their land by chickpea with bio-fertilizer, similarly 21.7% of the respondents used 0.5 ha of their land to produce chickpea with the bio-fertilizer. The others 4.3% and 2.2% of respondents covered 1.5ha and 1ha of their land respectively, for chickpea production. Most of the respondents used 0.25 hectare of land because 125gm of bio-fertilizer is recommended for 0.25 hectare of land by extension package.

Land inhectare	Frequency	Percent	Valid Percent
.25 ha	33	71.7	71.7
.50 ha	10	21.7	21.7
1 ha	1	2.2	2.2
1.50 ha	2	4.3	4.3
Total	**46**	**100.0**	**100.0**

Table 5. Hectare of land covered with bio-fertilizer for chick pea production.

3.4. Yield of Chickpea

The independent sample t-test table Levene Test uses two tests for equality of variance and unequal variance. If the vale for Levene test is >0.05 we use the result that assume equal variance is assumed otherwise equal variance not assumed. In this case we have (F=18.81, sig.= 0.000) so, we use equal variance not assumed. The mean WTP difference in the result is 2265.49 birr. This difference is large enough to confirm, statistically significant difference (t=3.5and sig.=0.002) between the group. From the table we can conclude that yield affect willingness to pay. Farmers who produce higher yield have more willingness to pay for chickpea bio-fertilizer than others.

Yield of chick pea inquintal	Frequency	Percent
<11 quintals	27	58.7
>11.1 quintals	19	41.3
Total	46	100.0

Table 6. Yield of chickpea of respondents

3.5. The Type of Variety Used with Bio-Fertilizer

From the total chickpea growers 42.5% use 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 300 birr/quintals. On the other hand, 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 300 birr/quintals.

3.6. The Use of Herbicide Chemicals

From the total respondents 72.5% have used herbicide chemicals for weed while 27.5% have not used herbicides. From the herbicide users 82.8% have low WTP and 6.9% have high WTP, while from non-herbicide user respondents have low WTP for chickpea with bio-fertilizer.

3.7. Willingness to Pay (WTP) for Bio-Fertilizer

The independent sample t-test proves that there is significant difference in WTP with difference in hectare of land covered by chick pea bio-fertilizer by Levene's Test at (F=28.78, sig.= 0.000). The mean variation is also significant using Equal variance. There is equal variance at (t= 6.18, sig.=0.000). Thus, the use of rhizobial bio-fertilizer significantly affects WTP. Farmers who cover large area of their land with chick pea bio-fertilizer have higher WTP than others. The paired sample T-test proved that there is no statistical significant difference between hectare covered by chick pea bio-fertilizer and chemical fertilizers.

WTP with bio-fertilizer (A_i Y_i P_i) in			WTP without bio-fertilizer ($a_i y_i$ p_i)			WTP with bio-fertilizer	WTP without bio-fertilizer $	Total WTP WTP= $\sum$ (A_i Y_i P_i) – $\sum$ ($a_i y_i$ p_i)
Area	**Yield**	**Price ($)**	**Area**	**Yield**	**Price ($)**	**($)**	**($)**	**($)**
.25	10	66.66	.13	3	42.86	166.66	13.39	153.27
.25	12	76.19	.38	16	42.86	171.43	257.14	-85.71
.25	12	76.19	.25	9	38.10	171.43	85.71	85.71
.25	12	42.86	.25	7	52.38	171.43	91.66	79.76
.25	7	42.86	.25	6	38.10	108.33	72	36.31
.25	7	76.19	.50	2	19.04	116.66	19.05	97.62
.25	7	33.33	.13	5	19.04	100	11.90	88.10
.25	9	42.86	.25	6	42.86	150	64.29	85.71
.25	9	76.19	.25	6	71.43	139.29	107.14	32.14
.25	7	57.14	.25	6	38.10	125	57.14	67.86
.25	11	76.19	.50	16	45.24	196.43	361.90	-165.48
.25	9	57.14	.25	8	57.14	171.43	114.29	57.14
.50	14	47.62	.25	4	38.10	400	38.10	361.90
.25	15	28.57	.25	11	47.62	403.57	130.95	101.19
.50	17	28.57	.75	12	42.86	607.14	385.71	221.43
.25	7	76.19	.50	6	42.86	133.33	128.57	4.76
.25	9	75.24	.25	7	47.62	117.86	77.38	40.48
.25	11	66.66	.25	9	33.33	117.86	75	42.86
.25	6	71.43	.25	4	28.57	64.29	28.57	35.71
.25	10	80.95	.25	7	23.81	101.19	41.66	59.52
.25	7	61.90	.50	4	38.10	133.33	76.19	57.14
.25	12	59.52	.25	6	30.95	121.43	46.23	75
.25	6	66.66	.25	8	33.33	114.29	28.57	85.71
.50	16	76.19	.25	5	57.14	609.52	71.43	538.10
.50	20	76.19	.25	4	38.10	66.66	38.10	628.58
.25	14	42.86	.25	4	47.62	266.66	47.62	219.05
.25	9	42.86	.25	6	33.33	171.43	50	121.43
.25	15	76.19	.50	4	33.33	160.71	66.66	94.05
.50	15	33.33	.50	6	33.33	321.43	100	221.43
.25	3	42.86	.25	10	57.14	57.14	142.86	-85.71
.50	12	76.19	.25	3	28.57	200	21.43	178.57
.25	6	57.14	.25	5	28.57	64.29	35.71	28.57
.50	5	76.19	.50	4	71.43	190.48	142.86	47.62
.25	7	57.14	1.00	16	42.86	100	685.21	585.71
.25	3	47.62	.25	8	33.33	57.14	66.66	-9.52
.50	21	28.57	.75	12	42.86	600	385.71	214.29
.25	7	28.57	.25	4	76.19	83.33	76.19	7.14
.25	9	76.19	.25	4	19.04	64.29	19.05	45.24
.25	9	75.24	.50	6	33.33	64.29	100	35.71
.25	9	66.66	.50	7	42.86	171.43	150	21.43
.50	20	71.43	.25	7	38.10	752.38	66.66	685.71
1.00	24	71.43	1.00	5	42.86	1600	214.29	1381.71
.50	24	61.90	.25	8	52.38	857.14	104.76	752.38
.25	6	59.52	.50	8	42.86	121.43	171.43	-50
1.50	23	66.66	.75	10	42.86	2135.71	321.43	1814.29
1.50	14	76.19	.13	5	28.57	1250	18.57	1231.43

Table 7. WTP for chick pea of respondents.

3.8. Regression Model

The ANOVA table indicates the overall significance of the explanatory variables for the dependent variable WTP. Size of family, size of land in hectare, hectares of land covered by chick pea and amount of yield produced have significantly related to WTP at F= 81.67, sig.= 0.000.

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	2952095913.015	4	738023978.254	81.672	.000[b]
	Residual	370494792.318	41	9036458.349		
	Total	3322590705.333	45			

Table 8. ANOVA table

The coefficients table also showed that the individual contribution of each explanatory variable in the model. From the variables hectare of land covered with bio-fertilizer, Amount of yield produced affect WTP significantly and positively while, size of land in hectare affect significantly negatively.

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-6603.287	1683.964		-3.921	.000
	Size of family	-210.954	249.773	-.046	-.845	.403
	landholding in hectare	-1022.582	440.866	-.124	-2.319	.025
	Hectares of land covered	22446.119	2022.649	.738	11.097	.000
	Amount of yield with biofertilizer in quintals	465.958	103.732	.292	4.492	.000

Table 9. Table of coefficients

3.9. Model Summary

There is strong correlation between the explanatory variables and WTP with correlation coefficient of R= 0.94. R^2 =0.89 shows about 88% of the independent variables are explained in the model. This indicates that the model is fit.

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	.943[a]	.888	.878	3006.07025	.888	81.672	4	41	.000

Table 10. Model Summary

4. Conclusion and Recommendations

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). 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.

The study does not attempt to determine the economic value of rhizobium species directly but the benefit obtained by the farmers using rhizobial bio- fertilizers for producing the chick pea. Farmers who used the microbial bio-fertilizer gained more yield and benefited than their previous experience without bio-fertilizer. 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 chickpea. This study laid foundation for similar valuation studies concerning microorganisms.

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