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Farmers' Knowledge, Attitude and Perception of Bee Pollination of Watermelon and Soybean in North-Central, Nigeria

A. M. Ajao[1*] and Y. U. Oladimeji[2]

[1]*Department of Bioscience and Biotechnology, Kwara State University, Malete, P.M.B. 1530, Ilorin, Nigeria.*
[2]*Department of Agricultural Economics and Rural Sociology, Ahmadu Bello University, P.M.B. 1044, Zaria, Nigeria.*

Authors' contributions

This work was carried out in collaboration between both authors. Author AMA designed the study, wrote the protocol and first draft of the manuscript while author YUO performed the statistical analysis, managed the literature searches, analyses of the study and further literature searches and review the manuscript. Both authors read and approved the final manuscript.

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ABSTRACT

Given the sheer size of the Nigerian population, increasing at geometric rate while food production increases at arithmetic rate, crop pollinations have important implications for nation food self-sufficiency and the sustainable increases in food production. This work was undertaken to assess farmers' knowledge, attitude and perception of bee pollination activity vis-à-vis watermelon and soybean production in North-Central, Nigeria. A field survey comprising questionnaire administration and group discussion of the watermelon and soybean farmers was conducted in 10 Local Government Areas (LGAs) of Kwara State, North-Central Nigeria. A total of 160 farmers consisting of 80 watermelon and 80 soybean farmers were randomly sampled. The main tools of analysis were descriptive statistics and propensity score matching. The results revealed that the average age of watermelon and soybean farmers were 43 and 45 years, mean education index of

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**Corresponding author: E-mail: adeyemi.ajao@kwasu.edu.ng;*

4.1 and 4.6 years respectively, household size of 8 and adjusted size of 7 for both and average annual income of ₦120550 ($430.54) and ₦135600 ($484.29) respectively. The empirical results also revealed there is a significant difference in average annual farm income and crop yields among watermelon and soybean farmers who adopt bee pollination services and non-adopters. The study recommends the need to enlighten and assist farmers through extension agents to imbibed bee pollination service for insect dependent crop production.

Keywords: Crop yield; extension agents; constraints; self-sufficiency; 1$ = ₦280.

1. INTRODUCTION

Honeybee (Hymenoptera: Apidae) is a social insect known as the most economically valuable insect because of its honey production and pollinating activities [1,2] *Apis mellifera* otherwise known as western honeybee is naturally spread in Europe, Africa and Western Asia [3,4] In most ecosystems, bees (Hymenoptera: Apidae) are the primary pollinators of flowering plants. Pollination is the transfer of pollen from the anthers to the stigma of a flower. Plants rely on wind, water, or animals to move pollen between the different flowers. Many agricultural crops and natural plant populations are dependent on pollination and often on the services provided by wild and managed pollinator communities with potential effects on plant reproduction, food supply and security [5].

According to give authors' names [6], an estimated 35% of crop production is as a result of insect pollination all over the world. The majority of crop pollination services are provided by the honey bee (*Apis mellifera*) valued annually to be worth $14.6 billion in United State of America [7]. Apart from the honey bee, there are over 4,000 species of other native pollinators engaged in crop pollination service capable of providing pollination services to a wide variety of crop species with an estimated annual contribution valued at $3.1 billion [8]. Despite the critical role Pollinators play in the United State economy and the world at large, the descriptions of pollinator communities in flowering crops are available for only a limited number of plant species [6] and almost not available in most developing countries including Nigeria.

Suffice to note that bees feed on flowering plants, derive all nutritional elements necessary for survival, growth, and reproduction. For example, adult honey bee obtained carbohydrates from nectar to meet the daily cost of flying and foraging [9]. An adult worker needs approximately 4 mg of useable sugar per day for survival [10]. According to give the author's names [9], nectar satisfies quotidian energetic requirements, the long term growth and reproduction of the honey bee colony is dependent on pollen intake. And as the only natural protein source for honey bees, pollen is necessary for brood and young worker development. Within the hive, foraged-pollen is mixed with regurgitated nectar and glandular secretions to produce brood food, a substance of high protein value that is fed to developing larvae. Other pollen-derived nutrients include lipids, amino acids, starch, sterols, vitamins, and minerals [11]. The nutritive importance of pollen makes it one of the primary factors influencing colony longevity.

The species *(Apis mellifera)* has shown great adaptive potential, as it is found almost everywhere in the world and in highly diverse climates. In a context of climate change, the variability of the honey bee life history traits as regards the environment shows that the species possesses such plasticity and genetic variability that this could give rise to the selection of development cycles suited to different environmental conditions [12,13,2].

Estimates place the annual global value of pollination services, including those of wild and managed bees, at $216 billion or about ₦64 trillion per year, or 9.5% of the worldwide annual crop value [14,15,16]. According to [6], an estimated 35% of crop production is as a result of insect pollination all over the world. The majority of crop pollination services are provided by the honey bee (*Apis mellifera*) valued annually to be worth $14.6 billion to United State of America alone [7].

Therefore, to sustainable increase the production and productivities of watermelon and soybean, this study examines the factors affecting farmers' knowledge, attitude and perception of bee pollination of watermelon and soybean production in North-Central, Nigeria. The study also examined the constraints of farmers' towards imbibing Bee Pollination Service (BPS) practices and develops possible suggestions for its promotion in the North Central Nigeria.

2. MATERIALS AND METHODS

2.1 The Study Area

Opinion survey through structure questionnaire and group discussion of the watermelon and soybean farmers was conducted to assess knowledge, attitude and perception of Bee Pollination Service (BPS) at ten Local Government Areas (LGAs) of Kwara State: Asa (Ballah); Baruteen (Okuta); Edu (Lafiagi); Ifelodun (Buari); Ilorin East (Iponrin); Irepodun (Ajasse); Kaiama (Adena); Moro (Bode-Saadu); Oyun (Ojoku) and Patigi (Lade). The State lies on Latitude $8°5^{1}$ and $10°4^{1}$ N and Longitude $4°55^{1}$ and $6°5^{1}$E in North Central Nigeria [2].

2.2 Sampling Techniques and Data Collection

A total of 160 consisting of 80 watermelon and 80 soybean farmers were proportionally and randomly sampled from ten Local Government Areas (LGAs) of Kwara States, Nigeria and constituted the sample population. One hundred and sixty questionnaires were administered to the two categories of farmers to investigate their knowledge, attitude and perception of Bee Pollination Service (BPS) rendered by insect pollinator, especially bees and its impact on watermelon and soybean yield and production. A Pre-test study was conducted before the actual opinion survey. This was to familiarize the researcher with the participants in the study areas. The results and reactions to these were used to further improve and perfect the questionnaires before the actual study. Interviews started with group discussions with farmers and later administration of the questionnaire. The information sought by the questionnaire includes demographic, knowledge, attitude and perception of the role of pollinators and impact of pollination on the two crops. Also expected constraints on the adoption of Bee Pollination Service and suggestions for promotion of the concept in the country was sought.

2.3 Analytical Techniques

Both Descriptive and inferential analysis were employed for the collected data. t-statistic was used to find if there is significant difference between the demographic profile of male and female in watermelon and soybean farmers in the study area. Data on constraints to bee pollination Service (BPS) were collated and measured through a 5-point Likert scale method: very severe = 5, moderately severe = 4, severe = 3, less severe =2 and least severe = 1. Thereafter, the weighted scores were calculated to obtain the mean score which was used to rank the constraints.

The double - difference analytical tool was employed to measure the difference in value of output as a result of adopting bee pollination services. The double difference estimator according to [14] compares changes in outcome measures (changes from before to after the project) between project participants and non – participants rather than simply comparing outcome levels at one point in time. The impact of a policy on an outcome can be estimated by computing a double difference, before and after a project or across subjects: between users and non – users of Bee Pollination Services (BPS).

3. RESULTS

3.1 Socio-economic Status of Water-melon and Soybean Farmers

The result in Table 1 revealed that 62(77.5%) of watermelon farmers were males and 18 (22.5%) are females. About half (49%) had an age range of 31-40 years while 21% of sampled farmers were above 50 years of age. The t-statistic shows marginally significant between the age of male and female farmers. However, soybean farmers had a diverse age ranged. About 49% had a range of 31-40 years while 36% had 41-50 years. The males are relatively older than the female. The t-value of age of male and female soybean farmers was statistically significant at 5%. The bulk of farmers (69%), both male and female had between 1-5 years' experience in watermelon production and only 6% of the respondents had at least 11 years. The t-statistic shows there was no significant difference in experience between both genders in watermelon production.

The bulk of farmers growing watermelon and soybean either had no formal education (43% and 56% respectively) or had primary education (36% and 25%). However, there are more educated respondents among male farmers than female ones in watermelon cropping. The t-statistic was statistically significant at 1% and 10% between male and female watermelon and soybean farmers respectively. More than half (52.5%) of watermelon farmers had the only farm size of between 0.1-1.0 ha with 1% statistically significant difference between farm size of male and female watermelon farmers. A large sampled soybean farmer (63%) had between 0.1-1.0 ha, but a sizeable number of male farmers (26%) had 1.1 to 2.0 ha, with high statistically significant difference in farm size between both sexes.

3.2 Institutional Profile of Watermelon and Soybean Farmers

The institutional profile depicted in Table 2 revealed that about half (49%) of both watermelon and soybean farmers had adjusted family size of 5-8 members per household and more than 12% of watermelon farmers or about 23% of soybean farmers had at least 8 or more persons in a household. A sizeable number of watermelon farmers (40%) or 43% of soybean farmers engaged in the trading of agricultural commodities during off farm season, about 20% of formal or 23% of latter practice beekeeping and 12% and 11.3% are employed in government job respectively. The bulk of both watermelon and soybean farmers (74% and 80%) had no access to extension services and only one farmer had access of 1-3 times in a cropping season. The t-value male and female access to extension services was statistically significant at 5%.

In addition, majority of watermelon farmers (about 72%) had 1-10 years cooperative membership and about 27% or 20% of watermelon or soybean farmers had up to between 11-20 years. Only one farmer had been a cooperator for at least 20 years among watermelon farmers and 2 of them in soybean farmers. The t-statistic revealed a statistically significant difference of 1% between male and female watermelon farmers' cooperators and 5% in soybean farmers.

3.3 Farmers' Awareness, Attitude and Knowledge of Bee Pollination Service (BPS)

The results of various statements on awareness, attitude and knowledge about bee pollination service in Table 3 indicates that the bulk of sampled farmers were not only aware that the honey bee is an insect pollinator (mean score = 4.2) but also that there are other insects pollinator which had a mean score of 4. Farmers were able to identify honeybee and other insects' pollinator from all other bee species and pests in the farm. Farmers are also had an impulse of crop-bee interaction with a mean score of 3.7; had the notion that insects and crop pollen and nectars have mutual benefits (3.8); confirmed bees and other insects pollinators play a significant role in fruiting and seed formation (3.4). The finding is at variance with [15] that observed that majority of farmers in Uganda were not aware of the role played by insect pollinators in coffee yield and production.

Table 1. Socio-economic characteristics of the respondents (t-value between socio-economic profile of male and female farmers were calculated)

Parameters	Range	Watermelon			Soybean		
		Male F (%)	Female F (%)	t-value	Male F (%)	Female F (%)	t-value
Age	20-30	9(11.25)	-		4(5.0)	1(1.25)	
(years)	31-40	28(35.0)	11(13.75)		27(33.75)	12(15.0)	
	41-50	12(15.0)	3(3.75)		23(28.75)	6(7.5)	
	>50	13(16.25)	4(5.0)		5(6.25)	2(2.5)	
Sub-total		**62(77.5)**	**18(22.5)**	**1.82***	**59(73.75)**	**21(26.25)**	**2.40****
Experienc	1-5	43(53.75)	12(15.0)		7(8.75)	4(5.0)	
(years)	6-10	16(20.00)	4(5.0)		39(48.75)	11(13.75)	
	11-15	3(3.75)	2((2.5)	**1.09**^{NS}	13(16.25)	6(7.5)	**6.84*****
Education	No formal	27(33.75)	7(8.75)		31(38.75)	13(16.25)	
(years)	Primary	21(26.25)	8(10.0)		16(20.0)	5(5.0)	
	Secondary	10(12.5)	3(3.75)		12(15.0)	3(3.75)	
	Tertiary	4(5.0)	-	**2.8*****	-	-	**1.99****
Farm size	0.1-1.0	29(36.25)	13(16.25)		35(43.75)	15(18.75)	
(ha)	1.1-2.0	23(28.75)	5(6.25)		21(26.25)	6(7.5)	
	2.1-3.0	7(8.75)	-		1(1.25)	-	
	> 4.0	3(3.75)	-	**13*****	2(2.5)	-	**21.50*****

Source: Field survey, 2015; t-value between Socio-economic profile of male and female farmers were calculated

Table 2. Institutional profile of the respondents

Parameters	Range	Watermelon			Soybean		
		Male F (%)	**Female F (%)**	**t-value**	**Male F (%)**	**Female F (%)**	**t-value**
Adjusted	1-4	22(22.75)	9(11.25)		16(20.0)	7(8.75)	
Household	5-8	34(42.5)	5(6.25)		31(38.75)	8(10.0)	
Size	> 8.0	6(7.5)	4(5.0)	**0.99^{NS}**	12(15.0)	6(7.5)	**1.29^{NS}**
Sub-total		**62(77.5)**	**18(22.5)**		**59(73.75)**	**21(26.25)**	
Subsidiary	Trading	24(30.0)	8(10.0)		27(33.75)	7(8.75)	
Occupation	Beekeepn	12(15.0)	4(5.0)		13(16.25)	5(6.25)	
	Govt. job	12(15.0)	-		4(5.0)	5(6.25)	
	Others	14(17.5)	6(7.5)	**1.43^{NS}**	15(18.75)	4(5.0)	**0.52^{NS}**
Extension	nil	45(56.25)	14(17.5)		47(58.75)	17(21.25)	
service	**1-3**	16(20.0)	4(5.0)		12(15.0)	4(5.0)	
	>3	1	-	**1.92****	-	-	**1.76***
Coop. soc.	**1-10**	43(53.75)	14(17.5)		44(55.0)	14(17.5)	
(yrs)	**11-20**	18(22.5)	4(5.0)	**3.06**	13(16.25)	7(8.75)	**2.04****
	> 20	1	-	*******	2(2.5)	-	

Source: Field survey, 2015; t-value between an institutional profile of male and female farmers were calculated). F = Number of farmers

Although, the bulk of framers are not aware of the BPS but had a positive attitude and had knowledge and willing to imbibe PBS (4.3) because of the believe that BPS enhance crop yield (4.30) and improve adoption (3.9). Results in Table 3 also showed that farmers' knowledge about BPS could have multiplier effects by enhancing access to land for farming (3.9); improve and increase investment in agriculture (4.3); increases diversification of likelihood (4.0) and could bring about residual increase in your farm (4.0). However, access to BPS through extension service was rated poor by sampled farmers (2.5) and the majority of the respondents assumed that BPS is not simple to adopt. These results are similar and comparable to the studies of [16,17,18].

Table 3. Farmers' Awareness, Attitude and Knowledge of Bee Pollination Service (BPS)

Statements on BPS related (pooled data) n=160	Weighted scores					Mean score
	SA	**A**	**UD**	**D**	**SD**	
Honey bee is an insect pollinator	315	328	12	12	5	4.2
Aware of other insect pollinators	280	268	63	18	7	4.0
crops attract bees to the crops for interaction	280	160	96	38	13	3.7
Bees visiting crop flowers are from wild or managed bees living around crop fields	380	188	12	42	5	3.9
Crops flower visitors/insects are mutually beneficial	315	152	87	36	12	3.8
Bees and other insect pollinators play important role in fruit, seed and pod set	237	150	92	48	14	3.4
Crop yield cannot be obtained without participation of pollinating insects	205	148	183	28	5	3.6
Harvest is reduced if bees and other insects do not pollinate flowers of crops	260	156	87	54	13	3.6
Awareness of BPS	180	156	93	76	16	3.3
Willingness in BPS by farmers after explaining explicit meaning of BPS	445	188	45	12	3	4.3
BPS enhance crop yield	415	208	51	12	2	4.3
Uses of BPS improve adoption	250	304	36	38	3	3.9
Uses of BPS enhances access to land for farming	235	252	108	24	2	3.9
Access to BPS through extension serv.	75	40	66	202	14	2.5
BPS improves investment in agric.	460	188	21	18	5	4.3
Beekeeping & BPS increases diversification of livelihood	320	228	54	30	6	4.0
BPS are simple to adopt	150	176	30	100	26	3.0
BPS could bring about residual increase in your farm income	335	208	51	34	7	4.0

Source: Field survey, 2015; Likert-type scale: Strongly Agree (SA) =5, Agree (A) =4, Undecided (UND) =3, Disagree (D) =2, Strongly Disagree (SD) =1.

The bulk of the watermelon farmers (65%) and soybean farmers (60%) got their information about BPS through informal source such as their personal experiences, relative and friends as depicted in Table 4. In addition, a handful of these farmers were informed through Non-Governmental Organistions (NGOs) and extension agents. The result also revealed that the level of information of BPS was low in both farming sectors as about 53% and 51% of watermelon and soybean farmers respectively affirmed it. Result further revealed that the bulk of both farming units either had low usage or practice BPS and about 53% of watermelon farmers or 50% of soybean farmers had never ventured into BPS while only 14% or 22% of respondents practice BPS for at least 10 years. The findings are comparable to the studies of Sharma, [19].

3.4 Effect of Bee Pollination Services on Gross Margin of Users

The mean difference between Gross Margin of users and non-users of watermelon and soybean farmers as a result of BPS in Table 5 had a positive mean difference of ₦23870.04 ($85.25) and ₦2907.52 ($10.38) respectively. It is evidence that the difference in gross margin could be attributed to BPS as observed in the double difference evaluation method used. The difference in Gross Margin was statistically significant at the 1% level for both farmers. It is therefore obvious that there was an impact of BPS on users' farmers in the study area. This corroborates the studies of [19,17] who observed a positive significant difference between BPS users and non-users' income in Kullu valley (India) and Western Kenya respectively. The study therefore, revealed that BPS technology had a significant impact on the users in the study area based on the improvement in their net farm income.

3.5 Identified Farmers' Constraints on the Adoption and Application of BPS

The result of analysis of constraints in Table 6 encountered by BPS farmers in the study area ranked from most critical to the least showed that low level of farmers awareness of importance of BPS in crop yield improvement (mean score = 4.7) and, lack of relevant knowledge and skill to successfully take up BPS (4.1) are the two most critical constraints towards adoption and application of BPS. It may be concluded that these two constraints and possibly the third in hierarchal constraint are looked into; other impediments with a lower mean score may cease to exist or reduce to the minimum in the study area.

Table 4. Distribution of Farmers' knowledge and Attitude towards Acceptance and Adoption of BPS

Items	Rating	Watermelon		Soybean		Pooled	
		F	%	F	%	F	%
Information of BPS	Informal	52	65.0	57	71.3	109	60.6
	Extension	9	11.3	6	7.5	15	9.4
	NGOs	11	13.7	9	11.2	20	12.5
	Others	8	10.0	8	10.0	16	10.0
Sub total		**80**	**100**	**80**	**100**	**160**	**100**
Level of information in BPS	Very high	23	28.8	18	22.5	41	25.6
	High	15	18.7	23	12.7	38	23.8
	Low	42	52.5	39	48.8	81	50.6
Usage & practice of BPS (acceptance)	Very high	6	7.5	14	17.5	20	12.5
	High	13	16.2	17	21.2	30	18.7
	Low	61	76.3	49	61.3	110	68.8
Period of BPS practice (yrs)	Nil	42	52.5	37	46.3	79	49.4
	1.0 - 5	27	33.8	21	26.3	48	30.0
	5.1 - 10	9	11.2	13	16.2	22	13.7
	> 10	2	2.5	9	11.2	11	6.9
Inadequacy of intervention program on BPS	Very high	49	61.3	42	52.5	91	56.9
	High	17	21.2	15	18.7	32	20.0
	low	14	17.5	23	28.8	37	23.1

Source: Field survey, 2015, F= Number of farmers

Table 5. Double difference result of BPS practice on users

Crops	Variable	Mean	Std. dev.	t-value	SE	p-value
Watermelon	DD	23870.04	110.13	4.06	9.97	0.0002***
Soybean	DD	2907.52	46.87	13.92	17.04	0.0006***

Table 6. Responses & identified farmers' Constraints on adoption & application of BPS (Pooled data)

S/no	Farmers' Constraints on adoption & application of BPS (n=160)	Weighted score	Mean score	Ranking
(i)	Low level of farmers awareness of importance of BPS in crop yield improvement	752	4.7	1st
(ii)	Lack of relevant knowledge and skill to successfully take up BPS	651	4.1	2nd
(iii)	Lack of training by relevant agencies promoting BPS	458	2.9	3rd
(iv)	Lack of policy to promote awareness of pollinators and pollination in crop production	385	2.4	4th
(v)	Ministry of Agriculture and other food agencies not been proactive in promoting the awareness of BPS	370	2.3	5th
(vi)	Lack of Government Regulatory Policy on management of insect-dependent crops	299	1.9	6th
(vii)	Bad farm management practices like bush burning, deforestation that causes decline to pollinators conservation.	230	1.4	7th
(viii)	Application of dangerous chemicals and pesticides that kills pollinators	196	1.2	8th

Source: Data analysis, 2015

Table 7. Respondents suggested ways of improving and promoting awareness and adoption of BPS

S/n	Suggestions for improvement and increase awareness of insect crop pollination activity (n=160)	Weighted score	Mean score
(i)	Government should through Ministry of Agric. to develop policy to promote awareness and adoption of Bee pollination Service for insect dependent crop production	582	3.6
(ii)	Practice and adoption bee pollinator friendly farming system	509	3.2
(iii)	Enhance farmers adopting system that will protect and conserve Pollinators from physical, chemical and biological agents	486	3.0
(iv)	Providing needed education and awareness-raising for targeted key pollinated crops	698	4.4
(v)	Provide through outreach program training needs on bee/pollinator conservation and promotion of pollination service	560	3.5
(vi)	Organizations and institutions should encourage farmers to grow flower-rich crops and fodder trees to attract bee to crops and boost honey production and high crop yield.	633	4.0

Source: Data analysis, 2015

3.6 Respondents Suggested Ways of Improving and Promoting Awareness and Adoption of BPS

The fundamental principle of bottom up approach was demonstrated in Table 7 above where respondents suggested ways of improving and promoting awareness and adoption of BPS program. The pilot suggestion was that stakeholders should be educated and train on importance of BPS, liaises with various agencies of government to create and promote needed education awareness and gradual adoption of BPS program.

4. CONCLUSION AND RECOMMENDATIONS

The study revealed that the bulk of watermelon and soybean farmers were aware of the importance of bee pollination. It is evidence that the difference in gross margin could be attributed to BPS as observed in the double difference evaluation method used. The difference in Gross Margin was statistically significant at the 1% level for both farmers. The result of analysis of constraints revealed that low level of farmers' awareness of importance of BPS in crop yield improvement and, lack of relevant knowledge and skill to successfully take up BPS were the most critical constraints towards adoption and application of BPS. The pilot suggestion was that stakeholders should be educated and train on the importance of BPS, liaises with various agencies of government to create and promote needed education awareness and gradual adoption of BPS program. There is a need for extension services to educate farmers about the importance of bee pollination service as well as diversity and management of bee-food plants in the farming system.

DISCLAIMER

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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