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Arable Crop Farming and Adoption of Bee Pollination Services among Farming Households in Kwara State, Nigeria

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Authors' contributions

This work was carried out in collaboration between all authors. Author YUO designed the study, perform the statistical analysis, wrote the protocol and first draft of the manuscript. Authors AMA and ZA managed the literature searches, analyses of the study and further literature searches and review of the manuscript. All authors read and approved the final manuscript.

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ABSTRACT

The majority of crop pollination services are provided by the honey bee (*Apis mellifera*) but almost not available in most developing countries including Nigeria. This study was undertaken to assess adoption of Bee Pollination Services (BPS) by arable crop farmers in Kwara State, Nigeria. A field survey with questionnaire administration was conducted in 10 Local Government Areas of Kwara State, Nigeria. A total of 160 farmers consisting of 80 watermelon and 80 soybean farmers were randomly sampled in two categories. The first category consist of 17 watermelon and 31 soybean farmers with farms located near apiary while the second category consist of 63 watermelon and 49

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soybean farmers far away from apiary. The tools of analysis were descriptive statistics, net margin model and double difference estimators. The results revealed that the average age of watermelon and soybean farmers were 43 and 45 years, mean education index of 4.1 and 4.6 years respectively, household size of 8 for both and average annual farm income of ₦120550 and ₦135600 respectively. The empirical results also revealed there is a significant difference in average annual farm income among watermelon and soybean farmers who adopt BPS and non-adopters. The result showed that low level of farmers' awareness of importance of BPS and lack of relevant knowledge and skill to adopt BPS are the two most critical constraints towards adoption and application of BPS. The study recommends farmers' enlightenment and training through extension agents to adopt bee pollination service for insect dependent crop production.

Keywords: Bee pollination; adoption value; extension; net margin; 1 US$ =₦400.0 during survey.

1. INTRODUCTION

There should be appropriate strategies to harness potential benefits of improved varieties in diverse agro-ecological and socio-economic environments. [1] Observed that there are many ecosystem services that are associated with agricultural production and pollination service is one of them. Value chain concept as pointed out by Global Value Chain Initiative [2] is an arrangement that describes the linkages of participants and their value creating activities that enhance the movement of goods and services from production, processing to the end user (consumer). The number and the conduct of participants along the chain determine its efficiency, pricing and returns accruing to each participant at every stage [3] Bee Pollination Service (BPS) is a way by which pollination is effected through beekeeping in which crop growers obtain at a rate healthy populous bee hives from the beekeeper to help pollinate their crops. This is the practice in many advanced countries but poorly understood and less exploited in African countries. In many developed countries, insect pollinator-dependent crops often require the services of commercial bee hives, which growers rent from beekeepers and then place the hives in cultivated fields and orchards at prescribed price [3].

In most ecosystems, bees (Hymenoptera: Apidae) are the primary pollinators of flowering plants. 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 bees 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 [4,5,6]. 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 [7]. According to [3], 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 [8].

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 [9]. Despite the critical role Pollinators play globally particularly in developed countries, the descriptions of pollinator communities in flowering crops are available for only a limited number of plant species [10] and almost not available in most developing countries including Nigeria.

Therefore, it may be difficult for farmers to invest in the conservation of ecosystem services without knowing and being convinced of their importance. Farmers can not consider managing their lands for the conservation of ecosystem services delivered by pollinator biodiversity if they are not aware or convinced of the importance of these services for their livelihoods. Most Nigeria small scale farmers including watermelon and soybean farmers are not aware of the role of insect's pollinator. Furthermore, the value and advantages associated with role of pollinators in crop, especially watermelon and soybean productions remain largely poorly researched. Yet, such information is necessary for developing suitable management plans to conserve agro-ecosystems and services delivered in and from these agro-ecosystems for crop productivity, stability and improvement.

Therefore, to sustainable increase the production and productivities of watermelon and soybean crops, this study assessed the adoption value of bee pollination services of *Apis mellifera* by watermelon and soybean farmers in Kwara State, Nigeria. The study also examined the constraints of farmers' towards imbibing Bee Pollination Service (BPS) practices and highlights possible suggestions for its promotion in the Kwara State, Nigeria.

1.1 Hypothesis

There is no significant difference in the profitability of farmers who employed BPS and non–usage of BPS.

2. MATERIALS AND METHODS

2.1 The Study Area

The State lies between latitude 8° 10' and 19° 50'N and longitudes 3° 10' and 6° 05'E. The area is located in tropical savannah zone of Nigeria with mean annual rainfall ranges from 800mm to 1500mm and means annual temperature is between 31.5℃ and 35℃ characterized by tall grasses growing and intermixed with deciduous and scattered trees which serves as a condition that facilitates bee-keeping activities for honey production [10,11]. Opinion survey through structure questionnaire and group discussion of the watermelon and soybean farmers was conducted to assess the value of adoption 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).

Common tree plants forage by honeybees includes *Acacia albida, Acacia nilitica, Berlima grandiflora, Blighia unijugata* Sapindaceae, *Bombax bounpozense*, *Vittellaria paradoxa*, *Parkia biglobosa,, Mangifera indica, Citrus sinensi, Butyrospermum parkii, Azadiracta indica, Delonix regia, Anacardium occidentale and Khaya senegalensis*. These species of trees provide nests and forage for the bees. Food and cash crops grown in the study area include: watermelon (*Citrullus lanatus)*, beans (*Phaseolus vulgarus* L.), groundnut (*Arachis hypogea* L.); soybean *Glacine max*, pigeon pea, maize (*Zea mays*), sorghum (*Sorghum bicolor*), Cassava (*Manihot esculentum* L.), Sweetpotato, (*Ipomoea batatus*, L.) Fruits and vegetables crops which include: *Vernonia amygdalina* (bitter leaf), melon (*Cucumis melo*), *Talinum triangulare* (water leaf), *Spinacia oleracia* (spinach), *Amaranthus spinosus* (green amaranth), *Abelmoschus esculentus* (okra), *Lycopersicum esculentum* (tomatoes), *Lactuca sativa* (lettuce), *Telfairia occidentalis* (pumpkin), and *Capsicum annum* (pepper) are also cultivate in the study area.

2.2 Sampling Techniques and Data Collection

A total of 160 consisting of eighty (80) watermelon and eighty (80) soybean farmers were randomly sampled from ten Local Government Areas (LGAs) of Kwara State, Nigeria. Both watermelon and soybean farmers were of two categories. The first category of respondents consist of 17 watermelon and 31 soybean farmers with farms located near apiary while the second category were randomly selected far away from apiary in the study area consisting of 63 watermelon farmers and 49 soybean farmers. One hundred and sixty questionnaires were administered to the two categories of farmers to investigate the value of adoption 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 locate LGAs and settlements that have apiaries and traditional beekeeping farms and, farmers that grow watermelon and soybean within the vicinity of the apiaries and far away from apiaries in the study area.

The information sought by the questionnaire includes socio-economic characteristics of the respondents, knowledge and adoption of the role of pollinators and value 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 were sought. Specifically, this study was meant to collect information from watermelon and soybean farmers that had their farms located or surrounded by beekeeping farms not necessarily owned by them but are beneficiary of bee pollination services at a cost or no cost depending on the farms. Some of the notable apiaries in the study area include: Beekeeping Training and Research Centre with apiaries at Amberi and Buhari, Kwara State University apiary, University of Ilorin apiary and numerous traditional and individual beekeeping farms located in Tanke, Patigi, Lafiagi, Lade, Lanta Nna, Malete, Yowere, Oyun riverside, Kokodo and Ilemona in the study area.

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 (Gross Margin) of farms surrounded by bee farms (BPS users) and farms that far from bee farms (Non-users of BPS) in the study area. Adopting [12], to determine adoption of BPS, the respondents were asked to indicate the extent of their agreement on each indicator using 5-point Likert-type continuum scale of Strongly Agree (SA), Agree (AG), Undecided (UN), Disagree (DA) and Strongly Disagree (SD) with assigning a weight of 5, 4, 3, 2 and 1, for positive statements S, respectively and vice versa for negative statements. *The indicator weighted* mean was obtained as follows:

$$WM = [(fSA*5) + (fAG*4) + (fUN*3) + (fDA*2) + (fSD*1) / n \tag{1}$$

Where: WM = weighted mean; F = frequency; Values 5, 4,3,2,1.

[13,14] perception/adoption analysis used by [12] was used to draw inferences as follows: 1.00-1.49 = Non-adopters (NO_{ad}), 1.50-2.49 = Least adopters (LE_{ad}); 2.50-3.49 = Moderate adopter (MD_{ad}); 3.50-4.49 = High adopters (HG_{ad}) and 4.50-5.00 = Very High adopters (VH_{ad});.

The model for estimating the Net Farm Income (NFI) was represented by:

$$NFI = \sum P_i\ Y_i\ -\ \sum P_{xj}\ X_j\ -\sum F_k \tag{2}$$

Where:

NFI = Net Farm Income (₦) per ha; $\sum P_i\ Y_i$ = Gross margin per ha; $\sum P_{xj}\ X_j$ = Total variable cost per ha and $\sum F_k$ = Total fixed cost if any.

The double - difference analytical tool was employed to measure the difference in value of output (₦) as result of adopting bee pollination services. The double difference estimator compares changes in outcome measures (changes from before to after the project) between project participants and non – participants rather than simply comparing outcomes levels at one point in time [15]. 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). Therefore, to evaluate the users and non-users, Verners in their double difference estimator model version gave the model as:

$$DD = \left(Y_{P_1} - Y_{P_0}\right) - \left(Y_{nP_1} - Y_{nP_0}\right) \tag{3}$$

Where:

Y_{P_1} = Gross margin of users after Bee Pollination Service (BPS); Y_{P_0} = Gross margin of users before BPS: Y_{nP_1} = Gross margin of non – users after BPS and Y_{nP_0} = Gross margin of non - users before BPS.

Data on constraints to bee pollination Service (BPS) were collated and also 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.

2.4 Hypotheses for the Independent-Samples t-test of Watermelon and Soybean Farmers

The independent-samples t-test is refer to as a robust test, evaluates the difference between the means of two independent or unrelated groups. That is, evaluating whether the means for two independent groups are significantly different from each other. The independent-samples t-test also commonly referred to as a between-groups design, can also be used to analyze a control and experimental group. The hypotheses for independent sample t-test for watermelon and soybean farmers were stated below:

Watermelon farmers

$$H_o: \mu_{\mathbf{1w}} = \mu_{\mathbf{2w}} \tag{4}$$

$$H_\alpha: \mu_{\mathbf{1w}} \neq \mu_{\mathbf{2w}} \tag{5}$$

Where:

μ_{1w} = Mean for the watermelon farmers near apiary

μ_{2w} = Mean for the watermelon away from apiary

Soybean farmers

$$H_o: \mu_{1s} = \mu_{2s} \quad (6)$$

$$H_\alpha: \mu_{1s} \neq \mu_{2s} \quad (7)$$

μ_{1s} = Mean for the soybean farmers near apiary

μ_{2s} = Mean for the soybean farmers away from apiary.

3. RESULTS

3.1 Socio-economic Characteristics of Watermelon and Soybean Farmers

The result in Table 1 revealed that 87% of watermelon farmers were males and 82% were married with mean age of 45. More than half (53%) had up to 15 years in farming while 69% had 5-9 members in the household. In addition, 69% had no primary education, 91% had no extension contact, 56% had no association but 83% engaged in full time farming. However, 79% of soybean farmers were male, about 75% were married with mean age and farm experience of 47 and 21 years respectively. Furthermore, 73% of soybean farmers had no contact, 52% had no association but 74% engaged in full time farming. This findings are in agreement with the studies of [16,17,11] that most Nigerian farmers had small farm holdings of 2.5 ha or less and the bulk of farmers in Kwara State were in their productive age and had gain wide experience in farming.

3.2 Farmers' Awareness and Knowledge of Bee Pollination Service (BPS)

The results of various statements on awareness, attitude and knowledge about bee pollination service in Table 2 indicates that the bulk of sampled farmers are not only aware that 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 also had impulse of crop-bee interaction with a mean score of 3.7; had the notion that insect and crop pollen and nectars have mutual beneficial (3.8); confirmed bees and other insects' pollinators play a significant role in fruiting and seed formation (3.4). Finding is at sharp contast with [1] that observed that majority of farmers in Uganda were not aware of the role played by insect pollinators in coffee yield and production.

Although, the bulk of framers are not aware of the BPS but had positive attitude and had knowledge and willing to imbibe PBS (4.3) because of believe that BPS enhance crop yield (4.30) and increase productivity (3.9). Results in Table 2 also showed that farmers knowledge about BPS could have multiplier effects by enhance access to land for farming (3.9); improve and increase investment in agriculture (4.3); increases diversification of likelihood (4.0)

Table 1. Dominance indicators of socio-economic characteristics of watermelon and soybean farmers in Kwara State, Nigeria

Description	Watermelon farmers		Soybean farmers	
		Mean		Mean
Gender	87% were male	na	79% were male	na
Marital status	82% were married	na	75% were married	na
Age (years)	65% below 50 years	45	68% below 50 years	47
Level of education (yrs)	69% had no primary sch.	2.5	65% had no pri. sch.	2.9
Farm Experience (yrs)	53% had up to 15 years	16	69% had > 15 years	21
Adj. household size	69% had 5-9 persons	7	55% had <5-9 persons	7
No. of extension contacts	91% had no contact at all	0.3	73% had no contact (s)	1.8
Cooperative soc. (yrs)	56% had no association	8	52% had no association	11
Major occupation	83% engage in farming	na	74% engage in farming	na
Family labour/season	65% used family labour	63	63% used family labour	43
Hired labour/season	35% used hired labour	26	37% used hired labour	21
Area devoted to BP farm	69% had < 1.5 ha	0.9	76% had < 1.5 ha	0.8
Access to credit (₦)	89% had no access to Cr.	56000	67% had no access to	76 th
Farm income/season (₦)	78% earn <₦80th/season	120th	72% earn >₦135th/s.	118th

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 majority of the respondents assumed that BPS is not simple to adopt. These results are similar and comparable to the studies of [18,7,1].

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 depicts in Table 3. In addition, a handful of these farmers were informed through Non-Governmental Organizations (NGOs) and extension agents. 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 venture into BPS while only 14% or 22% of respondents practice BPS for at least 10 years. The findings are comparable to the studies of [19].

3.3 Gross Margin Analysis

The mean gross margin of users and non-users of BPS in both crop sectors indicated in Table 4 shows that farmers who used BPS had a higher gross margin. There was 1% statistically significant difference in the profitability of BPS users than non–users in both farming units. The study confirms the findings of [20,19,1] who found that pollination services increase economic value of coffee and vegetable crops such as pollination services delivered to coffee approximated US $ 650/ha/year on average [20]. also attributed approximately 60% (US $ 149 million) of economic value to pollination services delivered by bees to coffee in Uganda.

In addition, Table 5 depicted the result of an independence t-test to confirm the difference in gross margin between users and non-user of Bee Pollination Services among watermelon and soybean farmers. The t-value obtained between the two watermelon farmers' groups was 4.20 at 1% level of significant which implies that there was a statistically significant difference between the two groups as a result of usage and non-usage of bee pollination services. Similarly, the

Table 2. Farmers' awareness 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

Table 3. 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

Table 4. Difference in gross margins of users and Non – users of BPS

Items	Watermelon		Soybean	
	Users	**non-users**	**Users**	**non-users**
Mean	120550.50	98750.5	135600.4	109500.0
Variance	632.03	390.70	1004.6	698.4
Observations	17	63	31	49
Pooled Variance	1109.502		20641.00	
Hypothesized Mean Difference	107.92		342.8	
Df	78		78	
t Stat	**7.0946*** **		**29.2092*** **	

Source: Data Analysis, 2015

t-value for soybean farmers was 3.7 which was also an indicator that soybean farmers located near the apiary have higher yield than their counterpart away from apiary. The assumption of homogeneity between the users and non-users of BPS was not met hence, the result presented limit itself to interpretation of outcome of result of output with unequal variance [21,22].

3.4 Effect of Bee Pollination Services on Gross Margin of Users versus Non-Users

The mean difference between Gross Margin of users and non users of watermelon and soybean farmers as a result of BPS in Table 6 had a positive mean difference of ₦21800.0 and ₦26100.4 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 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, 18] 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 Adoption and Application of BPS

The result of analysis of constraints encountered by BPS farmers in the study area in Table 7 ranked from most critical to the least showed that low level of farmers awareness of importance of

Table 5. Independence t-test of difference in gross margins of users and Non – users of BPS

Unequal variance	t-value	df	Sig. (2-tail)	Mean dif	SE diff.	95% conf. int. of diff.	
						Lower	Upper
GM test of BPS users and non-users of h2oelon farmers	4.2	78	0.000	105.9	1022.3	1.09	0.83
GM test of BPS users and non-users of soybean farmers	3.9	78	0.001	325.9	1108.6	1.80	0.97

Source: Data Analysis, 2015, degree of freedom was calculate using (n_1 -1) + (n_2 -1) where n_1 and n_2 denote user and non-user respectively.

Table 6. Double difference result of BPS practice on users and non-users

Crops	Variable	Mean	Std. Dev.	t-value	SE	p-value
Watermelon	DD	23870.04	110.13	4.06	10.4	0.0002***
Soybean	DD	2907.52	46.87	13.92	6.6	0.0006***

Source: Data analysis, 2015

Table 7. 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 e.g. bush burning 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 8. 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

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 lower mean score may cease to exist or reduce to minimum in the study area.

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 8 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 RECCOMENDA-TIONS

The study revealed that awareness, attitude and knowledge about bee pollination service, their pollination activities and impulse of crop- bee interaction were high, yet lack information about Bee Pollination Services hence had low usage or practice BPS. The mean gross margin of users and non-users of Bee Pollination Service (BPS) in both watermelon and soybean crops revealed that farmers that had access to bee pollination had a higher yields and gross margin than non-users. The result of analysis of constraints encountered by BPS farmers in the study area ranked from most critical to the least showed that low level of farmer's awareness of importance of BPS in crop yield improvement and lack of relevant knowledge and skill to successfully take up BPS are the two most critical constraints towards adoption and application of BPS. The study recommends farmers' enlightenment and training through extension agents to imbibed bee pollination service for insect dependent crop production such as watermelon and soybean which could bring about increase in farm income.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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