Journal of Agricultural Science and Technology B 10 (2020) 274-285
doi: 10.17265/2161-6264/2020.05.002

Adoption Levels of Certain Tomato Cultivation Practices by Farmer Field Schools in Sudan

Simon Demaya Baka

Department of Agricultural Science, College of Natural Resources and Environmental Studies, University of Juba, P.O. Box 82, Juba, South Sudan

Abstract: This study assessed the effect of Integrated Pest Management/Farmer Field Schools (IPM/FFS) extension approach on adoption of some tomato (*Lycopersicon esculentum* Mill.) cultivation practices in Gezira Scheme, Sudan. A stratified random sampling technique was used to collect data from 100 tomato growers (50 FFS participants and 50 non-FFS participants), through personal interviews using a structured questionnaire. The data were statistically analyzed and interpreted using frequency distribution, percentage and Chi-square test. The study found that adoption rates for the use of improved tomato seed variety, sowing date and method, urea application, were higher among the FFS participants compared to the non-FFS participants (20%, 90% and 50%) compared to 12%, 76% and 36%, respectively. The result showed lower adoption rate (50%) in FFS participants for intercropping with companion plant compared to non-FFS participants (64%). Chi-square test showed that there was significant difference between FFS participants and non-FFS participant farmers in adoption of recommended sowing date and method, and intercropping at 95% confidence level, 0.05 margin of error. There was no significant difference in adoption of urea application and use of recommended seed variety. This demonstrated that adoption of these two cultivation practices for tomato in the study significantly depended on FFS approach. To improve adoption rates of IPM innovations, the study recommends that FFS in the Gezira Scheme should be revitalized and later introduced in the other states in the country, with extensive and effective system of FFS trainings and follow-up.

Key words: Integrated Pest Management, Farmer Field Schools, adoption, tomato.

1. Introduction

This study was carried out in Gezira Scheme, Sudan to assess the effect of Integrated Pest Management/Farmer Field Schools (IPM/FFS) extension approach on adoption of some tomato (*Lycopersicon esculentum* Mill.) cultivation practices.

In Sudan, tomato is one of the important vegetables cultivated among others like onion, okra, eggplant, potato, cucumber, watermelon, carrot, sweet pepper, and hot pepper. According to Guddoura [1], vegetables contribute directly to the GDP at rate of nearly 40%. This contribution is, however, compromised by major problems affecting vegetable production in the country thus reducing their yield. Ahmed [2] reported the insects such as whitefly (*Benicia tabaci*), American bollworm (*Helicoverpa armigera*) and onion thrips (*Thrips tabaci*) and the diseases tomato yellow leaf curl virus (TYLCV) and powdery mildew in tomato, as major retarding factors to its production. To facilitate the control of pests and diseases on tomato, and bearing the concept of Entomology Society of America 2017 [3], the Board of Gezira Scheme introduced the idea of applying IPM options using FFS extension approach. The Entomology Society of America defines IPM as "a science based approach that combines a variety of techniques. By studying their life cycles and how pests interact with the environment, IPM professionals can manage pests with the most current methods to improve management, lower costs, and reduce risk of people and the environment". Adoption of IPM can help reduce dependence on pesticides without sacrificing crop yields [4].

According to Rahman and Hamid [5], IPM options

Corresponding author: Simon Demaya Baka, Ph.D., assistant professor, research fields: agricultural extension and insect pest management.

for tomato and onion were validated in FFS in order to help farmers in controlling these most important pests and diseases. These selected IPM options for tomato include land preparation using deep ploughing and disc harrowing in addition to leveling and ridging, use of improved seed variety, sowing methods using direct seeding, fertilizer/ha using recommended dose 86 kg N, intercropping using coriander and other companion plants considered attractants or repellents to whitefly, use of soft chemicals (pyrethroids) if necessary, weed control by removal of all weeds especially alternative hosts for TYLCV and IPM, irrigation every 4-5 d and stoppage of spraying pesticides at 50% fruit setting [5]. The application of the FFS approach to implement IPM objectives in Gezira Scheme started in 1993/1994 cropping season [6] in advance to reduce reliance on pesticides but control the pests leading to production of healthy vegetables and Sudan was considered the first country in Africa to implement IPM/FFS. At the time of conducting this study, many IPM/FFS schools were already established and operated in the three blocks of Gezira Scheme (El-Hush, Centre and Miselamia).

More than 100 tomato farmers participated in the FFS training sessions for two consecutive cropping seasons (1994/1995, 1995/1996). Various FFS project reports of the Gezira Scheme highlighted many challenges facing the IPM/FFS programme, including the non-adoption of innovations which attracted some studies to be made in order to validate the effectiveness of the new extension approach (FFS).

The FFS approach was developed at the end of the 1980s by Food and Agriculture Organization (FAO) in South East Asia, as a way for small-scale rice farmers to investigate and learn for themselves the skills required for and the benefits to be obtained from adopting IPM practices in their fields. Since that time, the FFS model has been adapted to various other crops, other countries and continents [7]. FAO used IPM/FFS models in the small-scale rice farmers of Indonesia to facilitate IPM technology transfer and decision making by farmers themselves in managing their fields. IPM/FFS then were established as "bottom-up" learning institutions that emphasized both the training and diffusion of innovations from farmer to farmer. Over 90 countries currently use FFS and there is increasing demand from different stakeholders, governments, non-governmental organizations (NGOs) and technical agencies to the private sector [8]. In Sudan, FFS is still not a unified extension approach, but it is drawing a lot of interest from many institutions to conduct further validation studies on its effectiveness. This growing interest and demand has implications for management and support for FFS development, instead of relying on the conventional extension frequently referred in the literature as "traditional" extension approach [9] which is characterized by poor organizational and administrative issues such as, decisions being made from above, few extension personnel, and lack of resources for extension workers among others.

Many researches indicate that FFS improves knowledge and adoption of better practices, and increases agricultural production and income especially on the FFS participants. Mancini and Jiggins [10] conducted a study for two years in twenty villages in Andhra Pradesh, Maharashtra and Karnataka, states of India to analyze the effect of IPM/FFS on adoption of cotton innovations. The result found that the participants of IPM/FFS have reduced pesticide use as much as 78%. In India, thousands of successful IPM/FFS were established outside the regular activities of the national extension services after a cadre of competent field trainers were trained [11]. In the Cordillera region of the Philippines, farmers' training in IPM has been carried out, using discovery-based learning techniques. A study conducted a year after, found that, the training had increased farmer capacity to learn and it was concluded that FFS can lead to more successful agriculture in the presence of institutional support, strong organization and a mechanism of follow-up, including continued participatory research after the training is over [12]. In the Dawhenya region of

Ghana, two groups of farmers' experiences in controlling pests were compared. At the end of the growing season, the result revealed that the yield showed no significant difference between the two systems, but the cost of inputs was much less with a ratio of 2:3 in the IPM plot. Not only did farmers benefit from higher profits, but they also reduced health risks to themselves [13]. This situation is similar to the experience in Sudan where a drop in expenditure to purchase pesticides was realized during successive IPM/FFS implementation in Sudan between 1993 and 1995 [14].

The impact of extension approach on adoption of innovations depends on an appropriate message, delivered with an understandable extension method. From the classical work of Rogers [15] and the contemporary studies of Dill *et al.* [16], the rate of adoption is accelerated by several factors namely: relative advantage in the view of user about the usefulness of an innovation, compatibility, i.e., suitability of an innovation in the perspective of users, the level of complexity of an innovation in the perspective of users, compared to an existing practice, trial ability of an innovation in the user perspective, and observability, which is the result of an innovation that appears visible. Sometimes the innovation is adopted if it meets these factors. The innovation may be short lived with the farmer if it was not transmitted appropriately. For example, in the scramble to adopt Bt cotton in Warangal district, in Andhra Pradesh, India, farmers may be led to plant genetically modified cotton because of clever marketing. Some farmers planted a new cotton seed after being taken to the field of an influential farmer, and given lunch [17].

Cultural practices constitute the overall measures performed in the garden to produce a crop. Other studies showed that cultural control presented no toxicity or residues problems (in contrast to the use of pesticides) and harmful effects on non-target organisms are minimal [18]. Four cultivation practices considered fundamental cultural control practices to cultivate tomato were included in this study:

(1) Use of improved seed variety: Farmers who used the seed variety "Peto 86" were considered adopters at varying levels of frequency as opposed to those non-adopters who used non-recommended seed varieties such as "Strain B" and other traditional varieties. A cultivar has to be adapted to the local agro-climatic conditions and after genetic resistance to specific pests and diseases [19] or at least tolerant to pests, good yielding and attractive to consumers [20].

(2) Sowing date and method: The recommended practice is to sow tomato seeds first in the nursery and transplant the seedlings to the secondary field 6-7 weeks later. Other studies suggest contradicting recommendation that direct planting yields robust tomatoes, resistant to TYLCV infection. However, in this study, the non-adopters of sowing date and method were those who preferred the traditional practice of sowing directly in the permanent field. Tomatoes are best produced when seedlings are first propagated in the nursery, then transplanted in their permanent site. This has several advantages. Economically, a lower quantity of seeds is used to establish a hectare than direct sowing, i.e., 200 g versus 500 g of seeds. It is handier to observe abnormalities in small areas and take remedial action than in large areas where direct sowing is practiced. In addition, tomato is beset by TYLCV disease, the damage being greater the younger plants are at the time of infection [14]. Hence, they are better managed when in a small area (nursery) than in the permanent site. The TYLCV disease is a DNA virus of genus *Bigomovirus* and family Geminiviridae. It causes the most destructive disease of tomato causing severe economic losses. It is transmitted by a vector from the Aleyrodidae family, order Hemiptera, the whitefly *Bemisia tabaci*. The symptoms of TYLCV infection include severe stunting, reduction of leaf size, upward curling of leaves, chlorosis on leaves and flowers and reduction of fruit production. The virus can lead to yield losses from 90%-100% [21]. Because of high cost

of insecticides used to control the disease, other methods to control the spread of TYLCV include planting resistant tolerant varieties among other cultivation practices.

(3) The third cultivation practice for tomato in the study is intercropping with companion plants considered repellents or attractants to insect pests. Effective plant species are those that will reduce whitefly or other insets on tomato. "Lubia" and onion were recommended to be effective because they repelled whitefly populations away from the tomato. In Southern Blue Nile region, tomato intercropped with onion showed less whitefly population on the tomato crop. In Khartoum state, coriander (*Coriandrum sativum*) and fenugreek (*Trigonella foenumgraecum*) came out as the most promising plant species for intercropping with tomato [5]. A reduction in whitefly population was attained and suppression of TYLCV disease was realized [22].

(4) The fourth cultivation practice in the study is application of fertilizer (urea). The recommended dosage of urea for tomato is 80 kg per "feddan" at two equal doses, one, two weeks after transplanting, and the other, one week before flowering [23]. Applications of 40 kg of urea as a single dose after flowering or 80 kg as a single dose before flowering are classified as non-recommended doses of urea application.

This study was undertaken to find out the effectiveness of IPM/FFS extension approach on adoption of some cultivation practices for tomato, evaluated on the basis of adoption rates and significant difference between FFS participants and non-FFS participants in their adoption of tomato cultivation practices (use of tomato seed variety, sowing date and method, intercropping with repellents or attractants and urea application).

2. Materials and Methods

2.1 Geographical Area Locations

The study was carried out in Gezira Scheme at Wad Medani, Gezira state, Sudan, after the two consecutive cropping seasons (1994/1995 and 1995/1996). It involved three of the administrative divisions of the Gezira Scheme: Miselamia, Centre and El-Housh (South) (Fig. 1) which formed the first region in the Scheme where IPM/FFS for vegetables was first introduced in Sudan in 1993, and subsequently implemented for another two cropping seasons in 1994/1995 and 1995/1996, respectively.

2.2 Data Collection

The stratified random sampling technique was used to take a representative sample of 100 farmers (Table 1) encompassing 50 FFS participant farmers and 50 non-participant farmers. A total of 100 farmers were interviewed by the author and trained enumerators using a structured questionnaire tool. The tool contains 16 questions. The first section of the tool is to take personal information of the respondent. The other part of the tool addressed questions about the dependent variables under study, with 3-5 response options for each of the questions, for the respondents to choose according to the practice they used to cultivate tomato. The criterion to determine whether the farmer adopted the practice or not is that, only one choice from options 3-5 is the recommended practice to cultivate tomato. A respondent who chooses it is considered an adopter. The other alternative options are non-recommended practices and considered non-adoption. For example, referring to the dependent variable use of improved tomato seed variety, the question in the tool was: what are the names of the tomato seed variety that you planted in the 1997/1998 cropping season? The alternative answers were: (a) Peto 86, (b) Strain B, (c) traditional variety, (d) others (specify). In this case, the option (a) is the recommended practice and in frequency analysis considered adoption while the other choices are non-adoption. About intercropping with companion plants, the question is: what are the names of plants that you used for intercropping your tomato? The optional choices were: (a) Lubia, (b) Kasbra, (c) others (specify), (d) did not intercrop. The choice of Lubia is regarded as adoption. If they specified

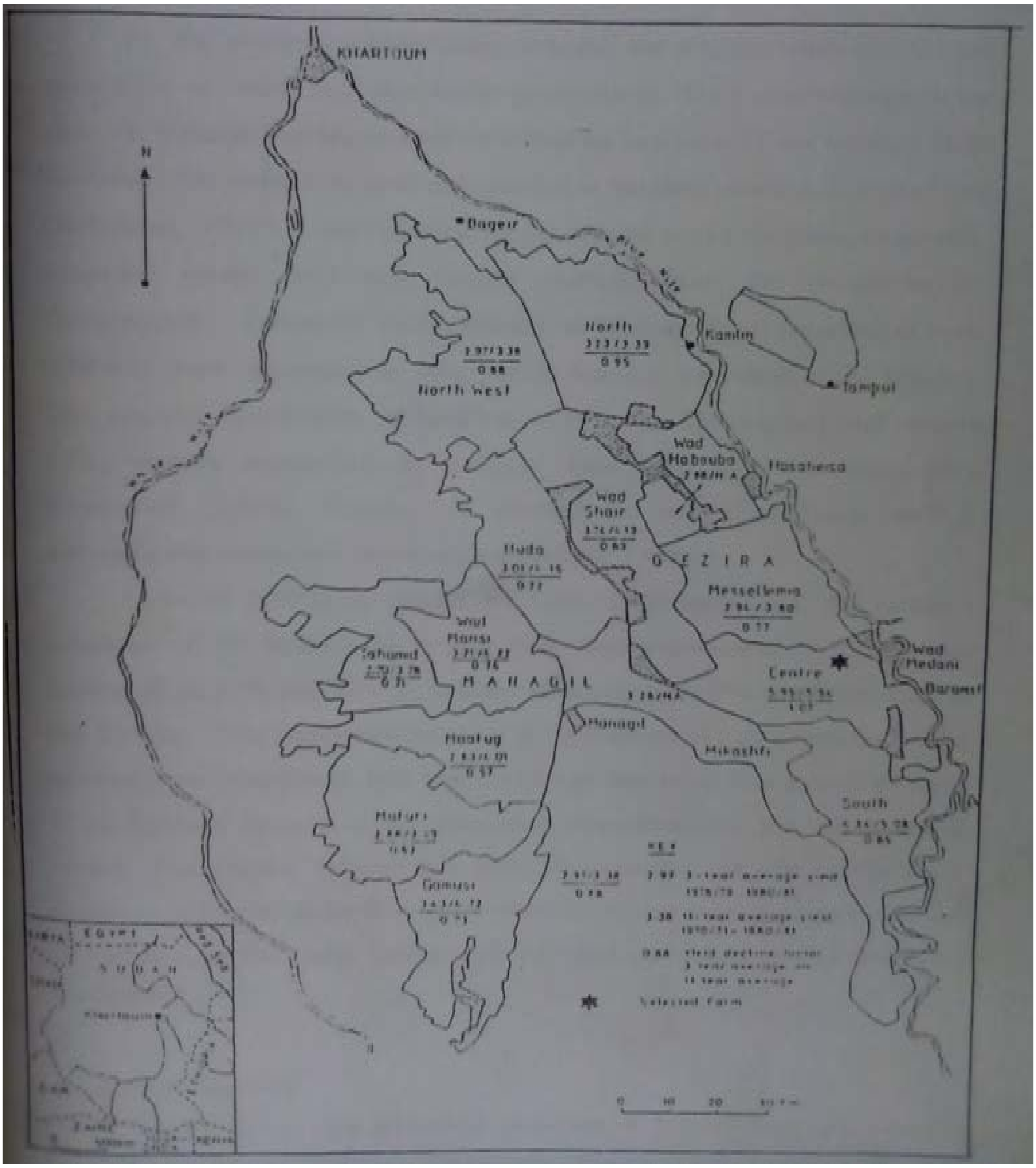

Fig. 1 Location map of Gezira Scheme (Source: Zahlan and Magar [24]).

Table 1 Sampling procedure of Integrated Pest Management/Farmer Field Schools (IPM/FFS) participants and non-participants in three groups of Gezira Scheme.

Group	Block	IPM/FFS village (Strata)	Registered FFS participants	Sample size	
				Participants	Non-participants
Ei-Housh	El Roof	El Roof	24	12	12
		Wad Numan	26	13	13
Centre	Hamad El Nil	Wad El Hadi	20	10	10
Misselamiya	Tayba	Bashkar	30	15	15
Total			100	50	50

Source: Compiled from annual reports of the Extension Department Gezira Scheme (1994-1996).

in others a repellent such as "fenugreek", it is also recorded as adopted. The question about sowing date and method is: how did you plant your tomato in 1997/1998 season? Optional choices: (a) direct in July, (b) direct in August, (c) sow first in the nursery in June and transplant to the permanent site 6-7 weeks later, (d) planted during off season, (e) others (specify). Choice (c) is the one which is considered adoption. For urea application, the question is: how many kilograms of urea/feddan did you apply on your tomato in how many doses and at what plant stages? (a) 80 kg in two doses: one two weeks after transplanting and the other before flowering, (b) 40 kg as a single dose after transplanting, (c) 80 kg as a single dose before flowering, (d) 80 kg in two doses: one before flowering and the other after fruit setting, (e) others (specify). The choice considered as adoption is (c).

The in-depth discussion with respondents tries to understand why the famers made the choices and to know further if there were specific challenges they faced while cultivating tomato.

2.3 Data Analysis

The data were analyzed using Statistical Product and Service Solution (SPSS). The adoption levels of both categories of farmers were presented in the form of frequencies and percentages. Chi-square contingency table χ^2 test was used to determine the significance of differences between groups of farmers who adopted the recommended sowing date and method, intercropping with repellent plants, use of seed variety and, fertilizer (urea) application, and those who did not, according to the postulated hypothesis.

3. Results and Discussion

3.1 Results

3.1.1 Distribution of Farmers by Adoption of Tomato Cultivation Practices

The study revealed that the adoption rates for use of improved tomato seed variety were high in both categories of farmers (90%) in participants and (76%) in non-participants, respectively (Fig. 2). The adoption rates for recommended sowing date and method were very low (20%) for FFS participants and (12%) for non-FFS participants, respectively, with the percentage of non-adopters being higher (88%) in the non-participant group compared to 80% in the participant group (Fig. 3).

With regards to intercropping, the Lubia bean, the recommended repellant crop revealed moderately high adoption rates among participants (50%) and non-participants (64%), respectively (Fig. 4).

Generally, the recommended dose for urea application in tomato is 80 kg of urea per acre (feddan) applied at two equal separate doses of 40 kg each: one two weeks after transplanting and the other before flowering. The study revealed that majority of FFS participants (58%) adopted the recommended dose of urea application compared to the non-FFS participants (36%) (Fig. 5).

Furthermore, the study clearly indicates that adoption rates for tomato seed variety, sowing date and method and urea application, were higher among the FFS participants (20%, 90%, 58%) than among the non-FFS participants (12%, 76% and 36%), respectively (Table 2).

3.1.2 Test of Significance in Adoption of Tomato Cultivation Practices

Chi-square test was used to determine significant difference between participants and non-participants in their adoption of recommended cultivation practices for tomato. The study revealed that there were significant differences between FFS participants and non-participants in adoption of sowing date and method, and intercropping of tomato (χ^2 = 6.8323; 4.8913). On the other hand, there were no significant differences between FFS participants and non-participants in adoption of seed variety and urea application (χ^2 = 0.2331; 3.2727) (Table 3).

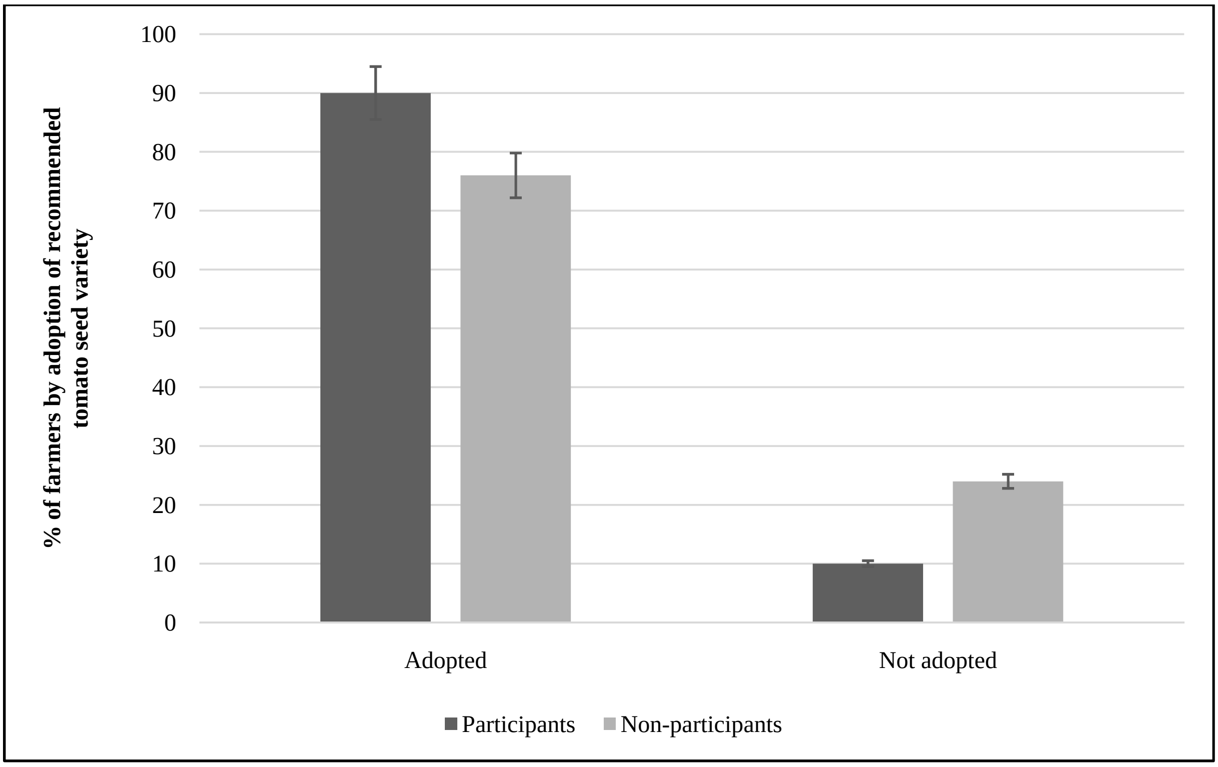

Fig. 2 Distribution of farmers by adoption of recommended tomato seed variety.

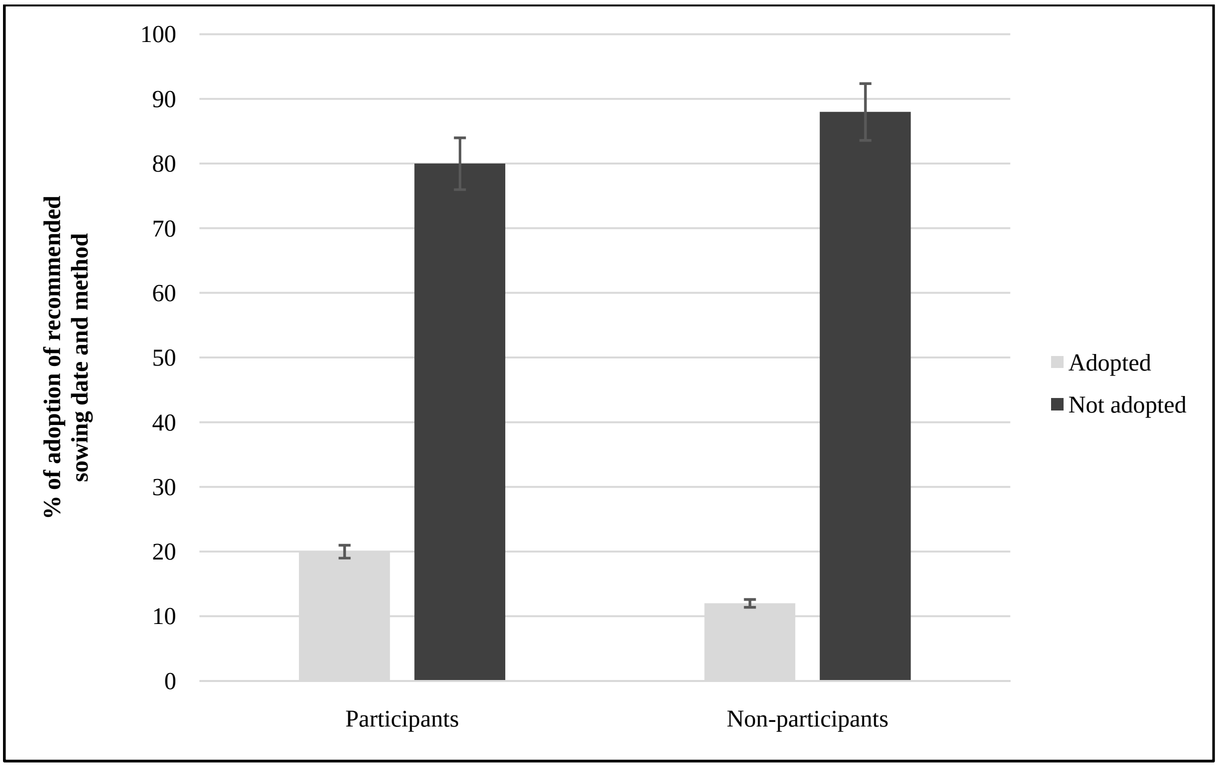

Fig. 3 Distribution of farmers by adoption of recommended sowing date and method.

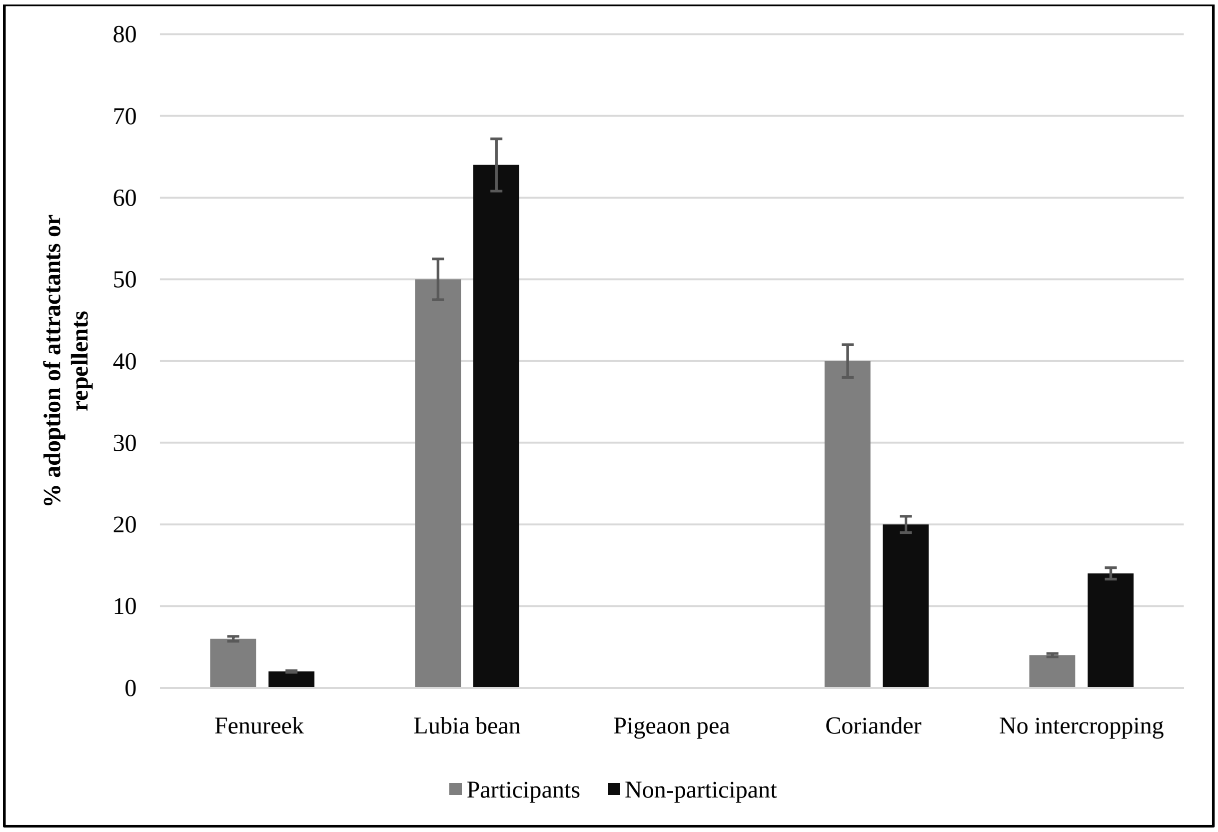

Fig. 4 Distribution of farmers by adoption of attractants or repellents.

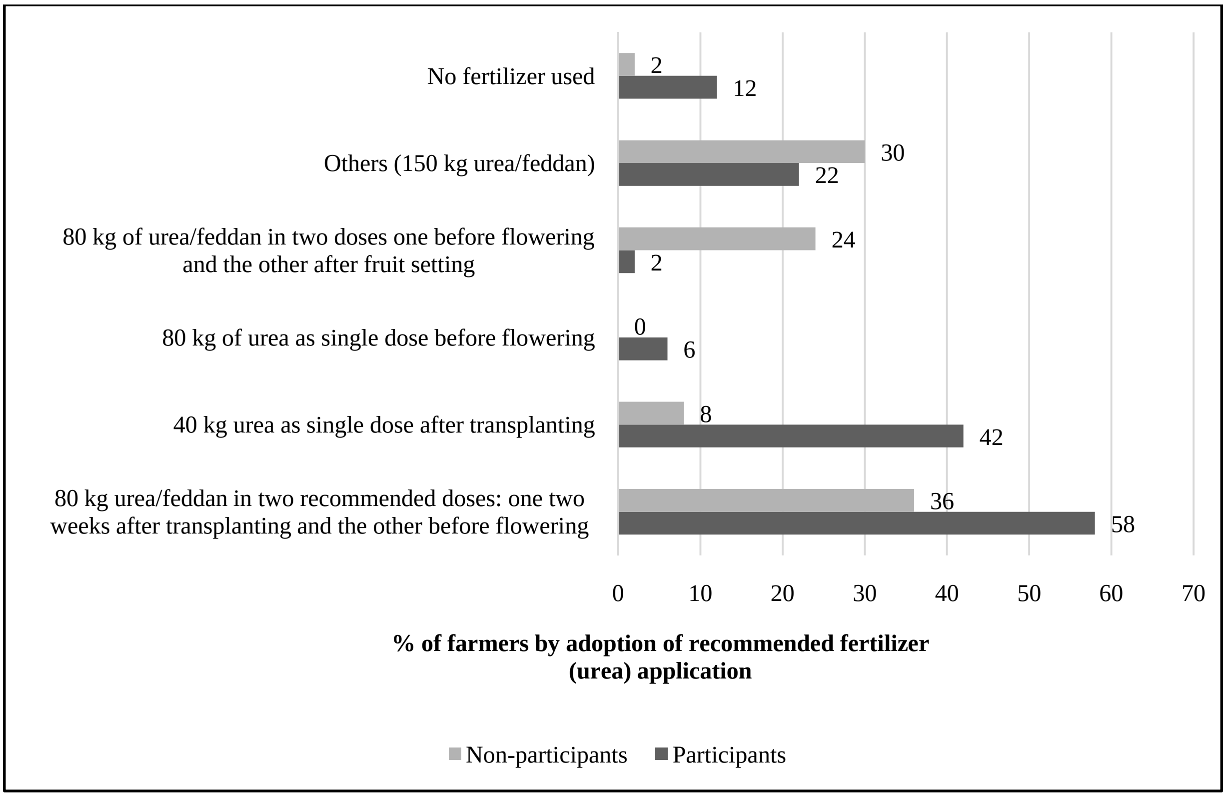

Fig. 5 Distribution of farmers by adoption of recommended fertilizer (urea) application.

Table 2 Distribution of farmers by adoption of cultivation practices for tomato.

Recommended tomato cultivation practice	Adopted				Not adopted			
	Participants		Non-participants		Participants		Non-participants	
	Frequency	%	Frequency	%	Frequency	%	Frequency	%
Tomato seed variety	10	20	6	12	40	80	44	88
Sowing date & method	45	90	38	76	5	10	12	24
Intercropping	25	50	32	64	25	50	18	36
Urea application	29	58	18	36	21	42	32	64

Table 3 Chi-square test for adoption of recommended sowing date and method, intercropping of tomato, seed variety and urea application.

Recommended tomato cultivation practice	Participation	Adoption frequencies		Total	Significance
		Adopted	Not adopted		(χ^2 calculated)
Sowing date and method	Participants	17	33	50	
	Non-participants	6	44	50	
	Total	23	77	100	6.8323*
Intercropping	Participants	49	1	50	
	Non-participants.	43	7	50	
	Total	92	8	100	4.8913*
Seed variety	Participants	40	10	50	
	Non-participants	38	12	50	
	Total	78	22	100	0.2331
Urea application	Participants	27	23	50	
	Non-participants	18	32	50	
	Total	45	55	100	3.2727

* Means significant at 95% level of confidence and 0.05 margin of error.

3.2 Discussion

Many studies indicate that IPM/FFS results in higher adoption rates or leads to positive impact among FFS participants than the non-participating farmers. According to Rahman and Hamid [5], the participatory approach suggests that effective agricultural extension can be achieved only by participation of farmers and other stakeholders in all aspects of agricultural extension activities because it has positive effect on group learning and executions. Participation in FFS activities throughout the growing season plays important role in farmer’s adoption of new technologies. The result of this study reveals that adoption rates for tomato seed variety, sowing date and method and urea application were higher among the FFS participants (20%, 90% and 58%) than among the non-participates (12%, 76% and 36%), respectively (Table 2). This result agrees with the study of Rahman and Hamid [5] who investigated the impact of FFS on farmers’ adoption of IPM/FFS options in Gezira state. They found that the majority of FFS participants (55.56%), compared to 22.22% of non-participants, adopted the recommended sowing date and method. The study of Rahman and Hamid [5] further found that the majority of FFS participants (68.89%), compared to 38.89% of non-participants respectively, adopted the recommended plant species (coriander) for intercropping with tomato.

FFS is a new achievement in the agricultural preaching enterprise that helps farmers to show their stable and full participation in all levels of innovations and act like experts in their farms [25]. Many researchers have found significance of difference between FFS participants and non-participants in adoption of IPM packages. The statistical evidence in Table 3, regarding the Chi-square test for adoption of sowing date and method of intercropping, suggests that the IPM/FFS training sessions had a significant impact on the adoption behavior of farmers with respect to sowing date and method and intercropping, i.e., the adoption of recommended sowing date and method, intercropping of tomato that depended on participation in FFS training. This result is similar to the findings of Sadaabi [26] who found that there was a significant difference between FFS participants and non-participants in their adoption of eight out of 13 tomato options including intercropping tomato with plants considered repellent to whitefly (*Bemicia tabaci*). This finding is also in line with the study of Davies *et al*. [27] which examined impacts on production by women in East Africa. The study showed that women FFS participants did benefit more than non-participant women in Tanzania, where women's participation made up one-third of the FFS programme intake. FFS has been proven to empower participants with knowledge and skills to make informed decisions. The study of Dinpanah and Zand [28] confirms this fact when they reported significant difference between the area under cultivation, pest control knowledge, adoption of IPM technologies and approaches in farmers who have participated in FFS and those that did not participate in FFS so that all the above variables in farmers who have participated in the FFS schools are more [28].

According to Table 3, the Chi-square test for adoption of recommended tomato seed variety and urea application did not show significant difference. This meant that although the two categories vary in many attributes of FFS experience, their adoption rates are relatively uniform. This could be explained by the fact that the non-participants who were neighbors of the FFS participants might have quickly learned the benefits of adopting the recommended practices thus narrowing the difference in adoption rates.

The low adoption rates for sowing date and method (20% and 12%) in this study in both participants and non-participants (Table 2) prove that there were more non-adopters in both categories of farmers for only one cultivation practice of tomato (sowing date and method). This is explained by the fact that the majority of the farmers in both categories preferred the direct sowing method compared to planting first in the nursery method because the Sudan Gezira Board (SGB) usually delays in providing vital services needed on the farm (such as irrigation water, pest control, etc.) and that the nursery first method is too expensive in terms of labor requirement (respondents during in-depth interviews with author).

The non-adoption rates (80% and 88%) for sowing date and method among FFS participants and non-participants could have been attributed to several factors including (i) lack of incentives, (ii) stoppage of IPM/FFS programme, (iii) lack of contact with extension workers among others. Among other reasons the low adoption of urea application, time and method of sowing among the farmers might have been due to the fact that the specifications about dosage and timing of sowing dates, were too technical for farmers to comprehend. They would require repeated explanations and guidance for longer periods of time if they were to produce desired results.

4. Conclusions and Recommendation

On the basis of higher adoption rates for three of the cultivation practices in the study (out of four), among FFS participants compared to non-participants, significant difference between FFS participants and non-participants for adoption of two cultivation practices for tomato in the study (out of four); the author concludes that participation in FFS training sessions had a significant impact on the adoption behavior of farmers. Therefore, FFS is an effective extension approach in the transfer of innovations to farmers. In order to increase adoption of crop innovations, FFS in Gezira Scheme should be revitalized and later included in the national policy as the extension approach in the other states of the country with extensive and effective system of trainings and follow-up.

Acknowledgment

The author is grateful to Prof. Sampson A-Koi Binyason for his technical editing and encouragement to publish this work. Thanks also go to the editorial team, Journal of Agricultural Science and Technology A & B for their professional comments that made this paper what it is.

References

[1] Guddoura, E. 1997. "Sustainable Integrated Pest Management and Integrated Services for Vegetable and Fruit Farmers in the Sudan." In *Proceedings of the National Conference on Integrated Pest Management in Vegetables, Wheat and Cotton in the Sudan: A Participatory Approach*, Wad Medani, Sudan. Nairobi, Kenya: ICIPE Science Press, 206-10.

[2] Ahmed, A. T. 1997. "Economic Evaluation of Tomato IPM Options." In *Proceedings of the National Conference on Integrated Pest Management in Vegetables, Wheat and Cotton in the Sudan: A Participatory Approach*, Wad Medani, Sudan. Nairobi, Kenya: ICPE Science Press, 137-40.

[3] Sitti, B., Rahamadanih, R., and Andi, N. 2020. "Rice Farmer's Adoption and Economic Benefits of Integrated Pest Management in South Sulawesi Province, Indonesia." *Journal of Agricultural Extension* 24 (2): 31-9.

[4] Dabrowski, Z. T. 1997. "The Impact of the FAO/ARC Integrated Pest Management Project on Vegetables, Wheat and Cotton in the Sudan." In *Proceedings of the National Conference on Integrated Pest Management in Vegetables, Wheat and Cotton in the Sudan: A Participatory Approach*, Wad Medani, Sudan. Nairobi, Kenya: ICPE Science Press, 25-39.

[5] Rahman, A. M. A., and Hamid, M. E. 2012. "Impact of FFS on Farmers' Adoption of IPM Options for Tomato: A Case Study from Gezira State, Sudan." *International Journal of Development and Sustainability* 1 (2): 338-49.

[6] Abdelrahman, A. A. 1994. "Prospects of Vegetable IPM Implementation in the Sudan." In *Integrated Vegetable Crop Management in the Sudan,* edited by Dabrawski, Z. T. Nairobi: ICIPE Science Press.

[7] Sitti, B., Rahamadanih, R., and Andi, N. 2020. "Rice Farmer's Adoption and Economic Benefits of Integrated Pest Management in South Sulawesi Province, Indonesia." *Journal of Agricultural Extension* 24 (2): 34.

[8] Food and Agricultural Organization (FAO). 2019. *Farmers Taking the Lead: Thirty Years of Farmer Field Schools*. Rome Licence: CC BY-NC-SA 33.0 IGO, 60.

[9] Van Den Ban, A. W., and Hawkins, H. S. 1996. *Agricultural Extension,* 2nd ed. Oxford: Blackwell Science Ltd., 294.

[10] Mancini, F., and Jiggins, J. 2008. "Evaluation of Methods to Evaluate Farmer Field Schools." *Development in Practice* 18 (4-5): 539-50.

[11] Fliert, V., Pontius, J., and Roling, N. 1995. "Searching for Strategies to Replicate a Successful Extension Approach. Training of IPM Trainers in Indonesia." *European Journal of Education and Extension* 1 (4): 41-63.

[12] Stock, T. 1995. "Farmer Field Schools—Impact for Integrated Pest Management in the Philippines: Implications for Sustainable Agriculture." *Journal of Extension Systems* 11 (2): 46-60.

[13] Mboob, S. 1996. *Turning Science into Sense*. In *Spore No. 64*, July-August, 1996, CTA Wageningen, 11.

[14] Abdelrahman, A. A. 1996. "Sustainability of the IPM Project in the Sudan." In *Proceedings of the Third Annual Review and Planning Meeting,* June 10-12, 1994, Agricultural Research Corporation Conference Hall, Wad Medani, 23.

[15] Rogers, E. M. 1983. *Diffusion of Innovation,* 3rd ed. New York: The Free Press, 107-62.

[16] Dill, M., Emvalomatis, G., Saatkamp, H., and Ao, H. 2015. "Factors Affecting Adaptation of Economic Management Practices in Beef Cattle Production in Rio Grande do Sul State, Brazil." *Journal of Rural Studies* 42: 21-8.

[17] Stone, G. D. 2007. "Agricultural Deskilling and the Spread of Genetically Modified Cotton in Warangal." *Current Anthropology* 48 (1): 67-103.

[18] Dent, D. 1991. *Insect Pest Management*. Wallington, UK: CABI Publishing.

[19] Dabrawski, Z. T. 1994. *Integrated Pest Management in the Sudan.* Nairobi: ICIPE Science Press, 24-32.

[20] Schultein, G. M. 1994. "The Need for Integrated Pest Management in Vegetables and Its Implementation." In *Integrated Vegetable Crops Management in the Sudan,* edited by Dabrowski, Z. T. Nairobi: ICIPE Science Press, 24-32.

[21] Tomato Yellow Leaf Curl Virus (TYLCV). Wikipedia. Accessed October 25, 2020. https://en.wikipedia.org/wiki/Tomato_yellow_leaf_curl_virus.

[22] Hein, A. 1984. "The Leafcurl Virus in Tomatoes and Possibilities of Its Control: A Review." *Acta Horticulture* 143: 439-50.

[23] Ahmed, A. A., Hamid, G., and Sadaabi, N. H. 1997. "IPM-Farmer Field Schools and Rural Women Schools: Present and Future." In *Integrated Pest Management in Vegetables, Wheat and Cotton in the Sudan: A*

Participatory Approach, edited by Dabrawski, Z. T. Nairobi: ICIPE Science Press, 245.

[24] Zahlan, A. B., and Magar, W. Y. 1986. *The Agricultural Sector of Sudan. Policy and Systems Studies*. London: Ethaca Press, 145-61.

[25] Godtland, E. M., Sadoulet, E., de Janvry, A., Murgai, R., and Ortiz, O. 2004. "The Impact of Farmer Field Schools on Knowledge and Productivity. A Study of Potato Farmers in the Peruvian Andes." *Economic Development and Cultural Change* 53 (1): 63-92.

[26] Sadaabi, N. H. 1996. "The Impact of the Weekly Field Training of Integrated Pest Management Farmer Field Schools (IPM-FFS) on Adoption Rate of Tomato IPM Options by the Blue Nile Bank and Gezira Scheme Tomato Growers." M.Sc. thesis, University of Gezira.

[27] Davis, K., Nkonya, E., Kato, E., Mekonnen, D. A., Odendo, M., Miiro, R., Nkuba, J., and Okoth, J. 2012. "Impact of Farmer Field Schools on Agricultural Productivity and Poverty in East Africa." *World Development* 40 (2): 402-13.

[28] Dinpanah, G., and Zand, F. 2012. "Regression and Discriminative Analysis Effect of Farmer Field Schools Approach on the Adoption of Biological Control in Sari Township, Iran." *Annals of Biological Research* 3 (4): 1739-46.