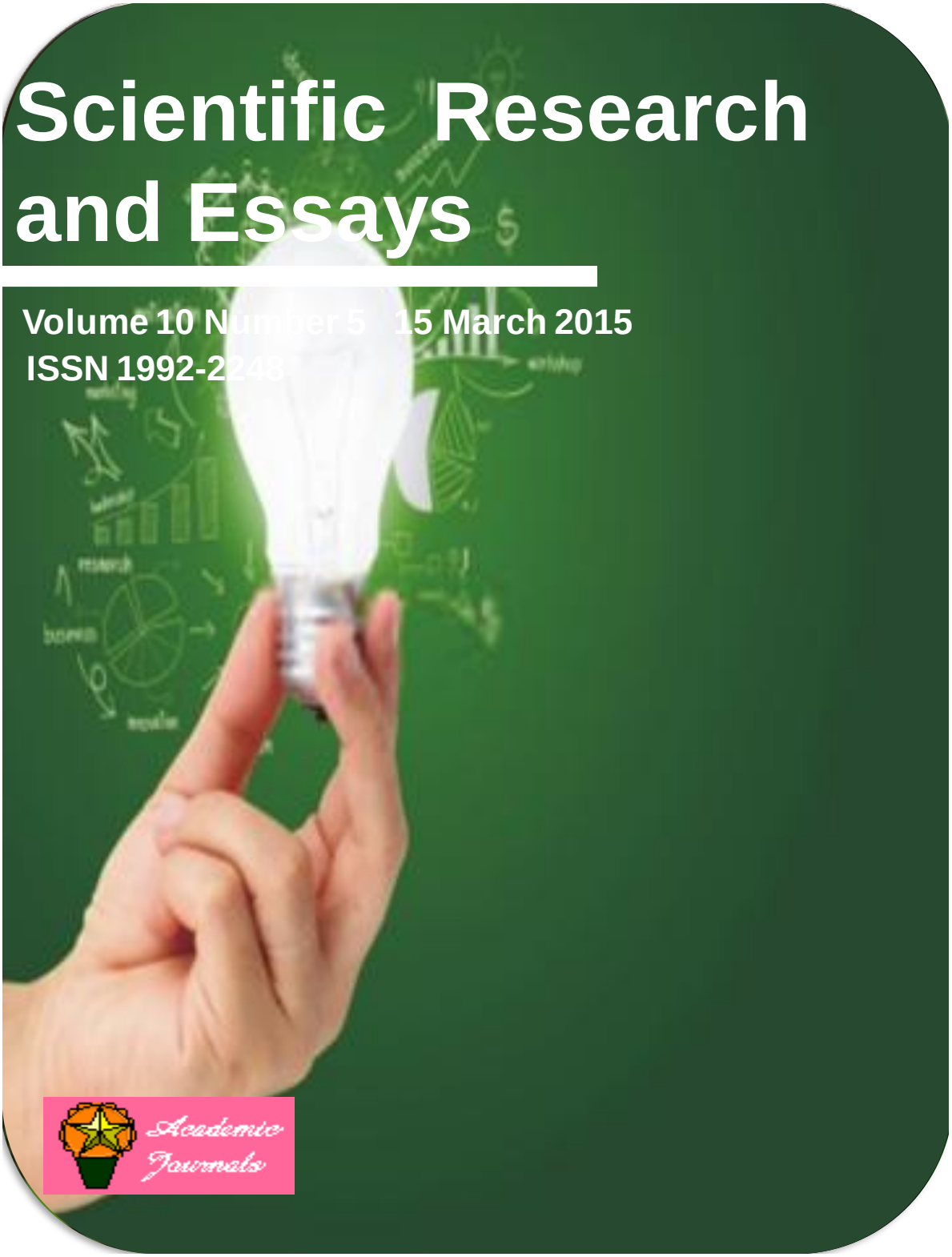
Scientific Research and Essays

Volume 10 Number 5 15 March 2015
ISSN 1992-2248



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Vol. 10(5), pp. 164-167, 15 March, 2015
DOI: 10.5897/SRE2015.6184
Article Number:A638B0A51265
ISSN 1992-2248

http://www.academicjournals.org/SRE

Scientific Research and Essays

Full Length Research Paper

Front line demonstrations on need based plant protection in pulses for enhancing productivity and profitability under farmer's condition

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Received 9 February, 2015; Accepted 2 March, 2015

Pulses have high nutritional value and worldwide commercial importance because these are rich source of protein and fibers. The productivity of pulses is lower in comparison to potential yield due to several biotic and abiotic stress. To show the productivity potential and profitability of need based plant protection in pulse crops (Black gram, Pigeonpea, Gram, pea and Lentil) total 74 front line demonstrations (FLDs) were conducted in 08 villages of Chhatarpur and Sagar districts of Madhya Pradesh under rain fed and partially irrigated condition. The pod borer (*Helicoverpa armigera*) population in Pigeonpea decreased by 56.6% with increase in seed yield (17.26%), net return Rs. 27430 and B:C ratio 5.03 with improved technology (IT) while larval population of pod borer in chick pea reduced by 80 per cent (from 1.5 to 0.3 per plant) with increase in yield of 28.1%. Yellow mosaic disease incidence in blackgram decreased significantly by application of Improved Technology by 61.5% (32.8 to 12.3%) which ultimately gave 50.7% higher grain yield. Seed treatment and soil application of *Trichoderma viride* decreased incidence of wilt disease by 68.6% in lentil and 68.1% in Gram, which also increased seed yield by 20.7 and 37.3% respectively. The management practice also gave net return of Rs. 15,230 and B:C ratio 3.37 in lentil crop and Rs. 25,650 net return and B:C ratio 4.0 in Gram as compared to FP plots (Rs. 11520 net profit and B:C ratio 3.08 for lentil and Rs. 17300 net profit and 3.27 B:C ratio for chickpea).

Key words: Pigeonpea, gram, blackgram, IPM, *Trichoderma viride*, demonstration.

INTRODUCTION

In India, pulses are the primary source of protein and fibers for the poor and vegetarians within the majority of population. Majority of farmers are small and marginal, cultivating pulse crops under rainfed conditions. India is the largest producer and consumer of pulses in the world. India produces 17.21 million tonnes of pulses from an area of 24.78 million ha. The average productivity of country is about 689 kg/ha against the global productivity of 857 kg/ha (GOI, 2010). In the rainfed area of Bundelkhand region of Madhya Pradesh (Chhatarpur,

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Tikamgarh, Panna, Sagar, Damoh) pulses grows as cash crop by the farmers. In general, average productivity of Pigeonpea, gram and lentil continues to be lower (670, 1070 and 422 kg/ha respectively) mainly due to its cultivation on marginal lands under poor management, inappropriate production technology (wilt susceptible varieties, under dose of fertilizers, application of poor plant protection measures) and heavy infestation of insect pest at various stage of crop. Gram, lentil and Pigeonpea are attacked by various insects at different growth stages but wilt and pod borer are the key pest that causes heavy economic loss throughout the country. One larva of *Helicoverpa armigera* is capable of damaging 30 to 40 pods in its life time. Estimates indicate that 8 larva reared on 10 plants (in 1 m row) caused up to 39% yield loss (Sharma et al., 2006; Agrawal et al., 2003; Goyal et al., 1991).

The continuous cultivation of pulse crops without proper crop rotation has led to increase in pest and disease incidence causing 40% yield loss. There is potential to increase production of pulses by using best production practices and proper plant protection measures at right time. One way of managing such pest effectively is to grow resistant cultivars. Intensive efforts are underway to develop high yielding and resistant cultivars of pulses in India. Another important approach by which these insect pest and diseases could be managed is adoption of integrated management practices (Agrawal et al., 2002). Several technologies and management options have been developed for pulses, that can significantly reduce the losses due to insect pest and diseases, but adoption of these technologies by farmers has been far less than anticipated. Realizing the importance of extending these technologies for managing insect pest and diseases in pulse crops at farmer's level, front line demonstrations (FLDs) were conducted to show the productivity potential and profitability of need based plant protection measures. It is believed that these FLDs would enhance the adoptability of technologies based on plant protection measures in pulse crops amongst the farmers of Bundelkhand region and Chhattarpur and Sagar districts in particular.

MATERIALS AND METHODS

The improved technology (IT) that is, need based plant protection including seed treatment with pesticides (insecticide and fungicide) and prophylactic sprays (biological and chemical) and spray of safer pesticides as and when required based on the nature of pest and its damage symptoms. The IT was demonstrated on 0.40 ha plots in comparison with farmers practice (FP) of no spraying or indiscriminate use of pesticides, in order to provide farmers an opportunity to compare, evaluate and choose themselves the best practice based on their own criteria. The details of IT are presented in Table 1. The 74 FLDs were conducted in 08 villages of Chhatarpur and Sagar districts of Madhya Pradesh under rainfed or partially irrigated condition during 2009 to 2013. The data on incidence of disease, population of insects, seed yield, cost of cultivation and gross monetary return were collected from IT plots and FP plots. The following formulae were used to calculate the parameters:

1. Insect incidence/ plant = Number of damaging stage of the insect/ plant
2. Increase in grain Yield=Grain yield form IT plot– Grain yield from FP plot /Grain yield from IT plot X 100
3. Net Return= Gross Return – Cost of cultivation
4. Benefit/ Cost Ratio= Net Return / Cost of Cultivation * 100

RESULTS

The results indicate that IT plots recorded mean productivity improvement of 30% as compared to FP plots (Table 2). The pod borer (*H. armigera*) population in Pigeonpea decreased by 56.6% with increase in seed yield (17.26%), net return Rs. 27430 and B:C ratio 5.03 with improved technology as compared to farmers practice. IPM practices reduced the larval population of pod borer in Gram by 80% (from 1.5 to 0.3 per plant) with increase in yield of 28.1% and net profit of Rs. 23390 and 3.85 in comparison to net profit of FP Rs. 17360 and B:C ratio 3.63. Yellow mosaic disease incidence of Blackgram significantly decreased by IT (Seed treatment with Thimethoxam 70 WP at 5 gm/kg followed by spray of dimethoate 35 EC at 750 ml/ha) by 61.5% (32.8 to 12.3%) which ultimately given 50.7% higher seed yield (4.18 to 6.3 q/ha), Rs. 14200 net profit per hectare and 4.02 cost benefit ratio. Seed treatment and soil application of *T. viride* decreased wilt disease incidence by 68.6% in lentil and 68.1% in chickpea which increased seed yield by 20.7 and 37.3%, respectively over farmers practice (seed treatment by carbendazim). Application of *T. viride* also given net return of Rs. 15230 and B:C ratio 3.37 in lentil crop and Rs. 25650 net profit and B:C ratio 4.0 cost benefit ratio in chickpea gram as compared to FP plots (Rs. 11520 net profit and B:C ratio 3.08 for lentil and Rs. 17300 net profit and 3.27 B:C ratio for gram)(Table 3).

DISCUSSION

The reduction in the population of Pod borer may be due to trapping of male insects and timely spray of insecticides which ultimately resulted in the reduction in the insect incidence, increased yield and net return. Similar findings have also been reported by Agrawal et al. (2003), Rao and Reddy (2003) and Tripathi (2014). Their results revealed the reduced incidence of pod borer in Pigeon pea by installation of pheromone trap; spray of insecticide or NPV and at pre-flowering or podding stage with increase in yield of Pigeon pea at farmer's field.

Application of neem oil works as repellent for *H. armigera* and spray of profenophos destroys eggs and larvae thereby reducing their population. Singh et al. (2009) also reported that IPM modules (Installation of bird perches and pheromone trap, spray of insecticide at podding stage) are significantly superior over the untreated control both in term of protection (pod damage 10.86%) and production (Yield 1449 kg/ha) of gram.

Table 1. Crop wise target pest and diseases and the improved technology demonstration (2009-2010 to 2012-2013).

Crop	Target pest/disease	No. of locations	Year	Details of demonstration	Farmers practice
Pigeonpea	Pod borer	14	2010-2012	Improved variety ICPL 87119, Installation of pheromone trap 10/ha, Spray of NPV at 250 LE/ha, followed by dimethoate at 750 ml/ha	Improved variety ICPL 87119, Spray of quinolphos at 1000 ml/ha
Gram	Pod borer	30	2009-2010	Installation of bird perchers, pheromone trap 10/ha, Spray of neem oil 1500 ml/ha, followed by Profenophos at 1000 ml/ha	Spray of Trizophos or quinolphos at 1000 ml/ha
Blackgram	Yellow mosaic disease	10	2010-2011	Seed treatment with Thimethoxam 70 WP at 5 gm/kg followed by spray of dimethoate at 750 ml/ha	Spray of Trizophos at disease appearance at 750 ml/ha
Lentil	Wilt	10	2009-2010	Soil application of *Trichoderma viride* with FYM at 2.5 kg/ha + seed treatment with the same at 5 gm/kg seed	Seed treatment carbendazim at 2 gm/kg seed
Gram	Wilt	10	2009-2013	Soil application of *Trichoderma viride* with FYM at 2.5 kg/ha + seed treatment with the same at 5 gm/kg seed	Seed treatment carbendazim at 2 gm/kg seed

Table 2. Productivity potential of need based plant protection in pulses under rainfed semi-irrigated condition during 2009-2010 to 2012-2013.

Crops	No. of demonstrations	Insect incidence/Plant		Increase %	Grain yield (qtl/ha)		Increase in yield (%)
		Demo	F P		Demo	FP	
Pigeonpea	14	0.65	1.5	56.6	9.78	8.34	17.26
Gram	30	0.30	1.5	80.0	10.53	8.22	28.1
Disease incidence (%)							
Blackgram	10	12.3	32.8	61.5	6.3	4.18	50.71
Lentil	10	9.4	30.0	68.6	6.18	5.12	20.7
Gram	10	7.2	22.6	68.1	11.4	8.30	37.3
Total/Mean	74				8.84	6.80	30.0

Table 3. Economics of need based plant protection in pulses (2009 to 2012).

Crops	Cost of cultivation (Rs./ha)		Gross return (Rs./ha)		Net return (Rs./ha)		B:C ratio	
	Demo	FP	Demo	FP	Demo.	FP	Demo.	FP
Pigeonpea	6800	6200	34230	29190	27430	22990	5.03	4.7
Gram	8200	7300	31590	24660	23390	17360	3.85	3.36
Blackgram	4700	4100	18900	12540	14200	8440	4.02	3.05
Lentil	6400	5800	21630	17320	15230	11520	3.37	3.08
Gram	8550	7600	34200	24900	25650	17300	4.0	3.27

Market prize: Pigeonpea- Rs.3500, Gram -3000, Blackgram-3000, Lentil-3500 per quintal.

Seed treatment with Thiamethoxam 70 WP controlled sucking pest up to 15-20 days after germination in black gram and spray of Dimethoate 35 EC checks further spread of white fly (insect vector of the disease) which ultimately reduces the incidence of yellow mosaic disease due to which yield of black gram increases.

Tomar et al. (2009) also found 117% and Raikwar et al. (2012) found 58% higher yield with improved package of practice of black gram under frontline demonstrations in comparisons to farmers practice.

The quality of fast multiplication and myco-parasitism of *T. viridae* reduces the population of fusarium spp. In gram and lentil fields which results in lower incidence of wilt. Results are in accordance with Sharma et al. (2008) and Tripathi (2014) who reported that soil application of *T. viride* effective in inhibiting the growth of *Fusarium oxysporum* f. Sp. ciceri under field condition which reduced the wilt incidence from 10.45 to 4.05.

Conflict of Interest

The authors have not declared any conflict of interest.

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Vol. 10(5), pp. 168-176, 15 March, 2015
DOI: 10.5897/SRE2015.6172
Article Number:563632D51269
ISSN 1992-2248

http://www.academicjournals.org/SRE

Scientific Research and Essays

Full Length Research Paper

A study on current status of herbal utilization in Bulgaria: Part 1 - Application of herbal medicines

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Received 31 January, 2015; Accepted 18 February, 2015

Despite increasing interest in phytotherapy, little is known about patterns of herb utilization in modern society. Ethnobotanical studies are useful tool to evaluate the dynamics of traditional knowledge. To our knowledge, there is no study focused on collection of information about herbal utilization from a wide range of people in Bulgaria. 1) the attitudes toward benefits of medicinal plants; 2) the most popular herbal application; 3) the manner in which herbs are being obtained; 4) how specific demographic features of the participants related to their attitude. This survey was carried out in different regions in Bulgaria, between May and July 2013 using the face-to-face interview technique. A descriptive statistic procedure and chi-square test were employed for data analysis. Simple linear coefficient test is calculated to determine the correlation between herbal knowledge and demographic features of the informants. The results revealed that 93.89% of the respondents believed that herbs are beneficial for their health; age exerted impact on this statement. A larger proportion of the respondents uses herbs frequently and if necessary. About 60% of the informants use medicinal plants for disease treatment and prophylaxis. Only 11.37% of respondents reported to gather herbs from natural habitats; impact of age and place of residence was established. Self-gathering is preferred by the respondents belonging to groups with low socio-economic status. More than a half of the respondents (61.92%) prefer to buy herbs from the pharmacy. The survey shows the persistence of traditional knowledge in contemporary Bulgarian population. The impact of modern society on herbal application is obvious. Demographic features exerted negligible influence on the attitudes toward herbal utilization.

Key words: Ethnobotanical survey, traditional knowledge, herbal utilization.

INTRODUCTION

Plants have been used by people since ancient times to treat diseases worldwide. Recently a tendency of increasing utilization of medicinal plants in developing and industrialized countries has been reported (Fakeye et al., 2009; Popat et al., 2001; Staines, 2011; van Andel and Carvalheiro, 2013). Despite widespread use, little is

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known about patterns of herbal utilization and why people choose to use herbs. Nowadays ethnobotany as interdisciplinary subject is focused on use of food and medicinal plants (Alcorn, 1995). One of the main goals of the ethnobotanical studies is to document the dynamics of traditional knowledge about plants (Pardo-de-Santayana et al., 2013). Different factors lead to changes of herbal utilization in modern society: globalization, migration from villages to cities, cultural changes etc. (Yeşilada et al., 2003; Vandebroek and Balick, 2012). Therefore, a matter of interest from an ethnobotanical viewpoint is to establish how specific demographic features of people related to their opinion on benefits of herbal utilization.

The statement that the plants have beneficial health effects is widely accepted, but the empirical data which supported this idea is limited (Heinrich, 2003). Herbal utilization in Bulgaria has a long tradition (Nedelcheva, 2012). In the past transmission of knowledge of medical practices has been documented by teachers, university professors, naturalists, folklorists and physicians (Kozuharova et al., 2013). Some recent etnobotanical studies provide data on current medicinal plants knowledge regarding the most popular herbs and their therapeutic use (Ivancheva and Stancheva, 2000; Ploetz, 2000; Leporatti and Ivancheva, 2003; Ploetz and Orr, 2004; Kültür and Sami, 2009; De Boer, 2013; Bertsch, 2011; Kozuharova et al., 2013). Target groups usually included people known to be interested in medicinal plants, but a random sample of people were also interviewed. To our knowledge there is no study focused on collection of information about herbal utilization from a wide range of people in Bulgaria.

The aim of our study was to establish the statement of a representative random sample of Bulgarian people about herbal utilization in order to find out: 1) the attitudes toward benefits of medicinal plants; 2) the most popular herbal application; 3) the manner in which herbs are being obtained; 4) how specific demographic features of the participants related to their attitude.

MATERIALS AND METHODS

Interview

This survey was carried out in different regions in Bulgaria during May to July 2013 using the face-to-face interview technique as described in similar studies (Akaydin et al., 2013; Seid and Aydagnehum, 2013). The interviewed people were chosen randomly. As a first step of the study, the demographic characteristics of the people who accepted to participate in the interview were determined. The second part of the questionnaire included questions on the herbal utilization.

Education of interviewers

Ethnobotany Club student members (Faculty of Natural Sciences, University of Shumen, Bulgaria) contributed to the survey. The students were trained to conduct an ethnobotanical survey. They were acquainted with: the stages of the study, the questions in the questionnaire, the tasks and responsibilities of interviewers, the tasks and responsibilities of the controller and the protocol survey. A pilot study was carried out with 30 respondents in order to improve the questionnaire: abstruse questions were edited, arrangement of questions was changed, the number of possible answers was increased etc. The interviewers were able to explain issues which are unclear to some respondents.

Check for logic errors

Data from each questionnaire were checked for inconsistencies. Questionnaires containing logical errors were excluded from the study.

Statistical analisys

A descriptive statistic procedure like percentage and frequency distribution were employed for data analysis. The chi-square test was used to compare different groups of data. Moreover, simple linear (Pearson correlation) coefficient test is calculated to determine the correlation between medicinal plant knowledge and demographic features of the informants. Depending on the values of the Pearson's contingency coefficient (r) the following types of correlation were differentiated: $r = 0$ lack of correlction, $0 < r \leq 0.3$ weak correlation, $0.3 < r \leq 0.5$ moderate correlation, $0.5 < r \leq 0.7$ significant correlation, $0.7 < r \leq 0.9$ strong correlation, $0.9 < r < 1$ very strong correlation, $r = 1$ means functional dependence.

RESULTS AND DISCUSSION

In present survey a total of 563 interviews were conducted. 88 of the completed questionnaires were excluded due to established logical errors. So, the final sample included 475 respondents from 20 urban and 23 rural areas in Bulgaria (Figure 1).

To ensure that the results of such kind of surveys are representative, the sample should reproduce the structure of the population. The analysis revealed that the sample in present study was representative of the Bulgarian population in terms of sex, age, level of education and place of residence (Figures 2, 3, 4 and 5).

The attitude toward the medicinal plants utilization could be influenced also by occupation and marital status of respondents (Aydin et al., 2008; Fakeye et al., 2009; Akaydin et al., 2013). These demographic features of the participants in the present survey are presented in Figures 6 and 7.

Data on the attitudes of informants toward the benefits and utilization of herbs are given in Table 1. Influence of specific demographic variables of the participants on the responses to the inquiry was presented in Table 2. In order to determine the correlation between items questioned and demographic variables; standardized Pearson correlation coefficient was calculated.

The results revealed that 93.89% of the respondents believed that herbs are beneficial for their health (Table 1). This data is in accordance with increasing popularity

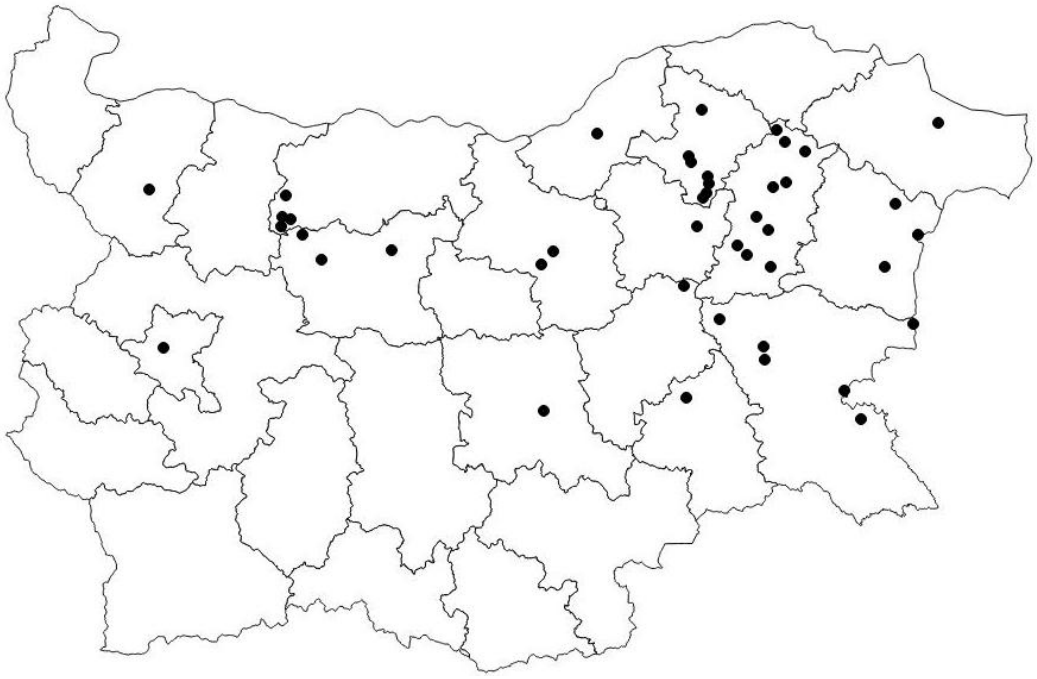

Figure 1. Regions in Bulgaria where the interviews were conducted.

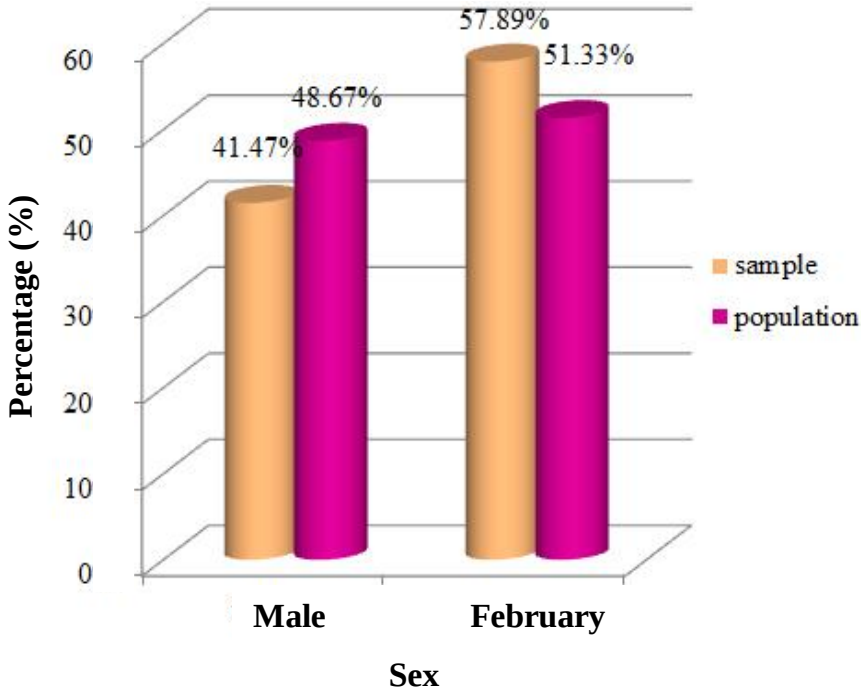

Figure 2. The distribution of the respondents and Bulgarian population according to sex ratio.

of phytotherapy reported in the last decades worldwide (Aydin et al., 2008; Samojlik et al., 2013; Osemene et al., 2011; Sim et al., 2013; Wu et al., 2011; Wachtel-Galor and Benzie, 2011). The data analysis show that only age predicted the answers to the question “Do you think that herbs are beneficial for your health?”, other variables had

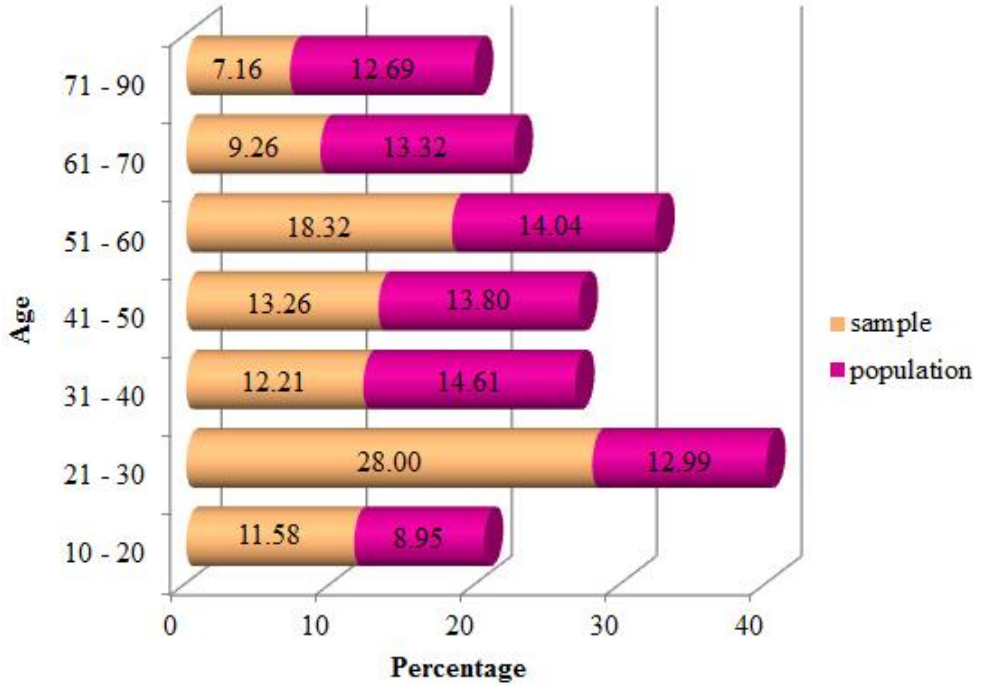

Figure 3. The distribution of the respondents and Bulgarian population according to age.

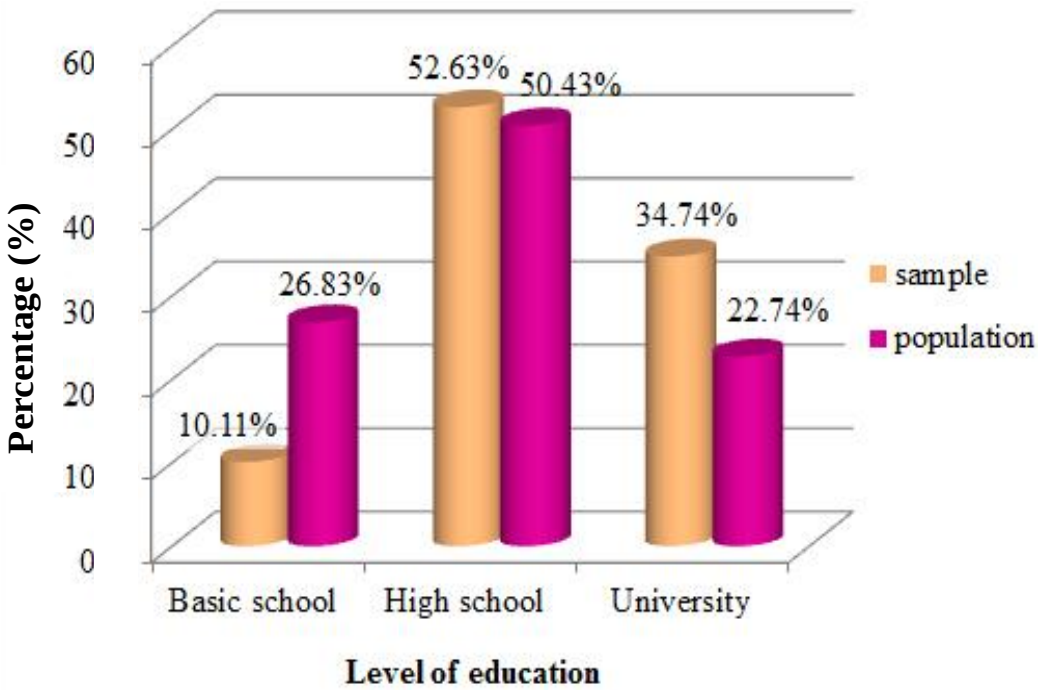

Figure 4. The distribution of the respondents and Bulgarian population according to level of education.

no sufficient influence (Table 2). The respondents belonging to the age groups 41 to 50 and 71 to 90 have given higher percent of negative answers as compared with the whole sample, respectively 7.94 and 5.88%

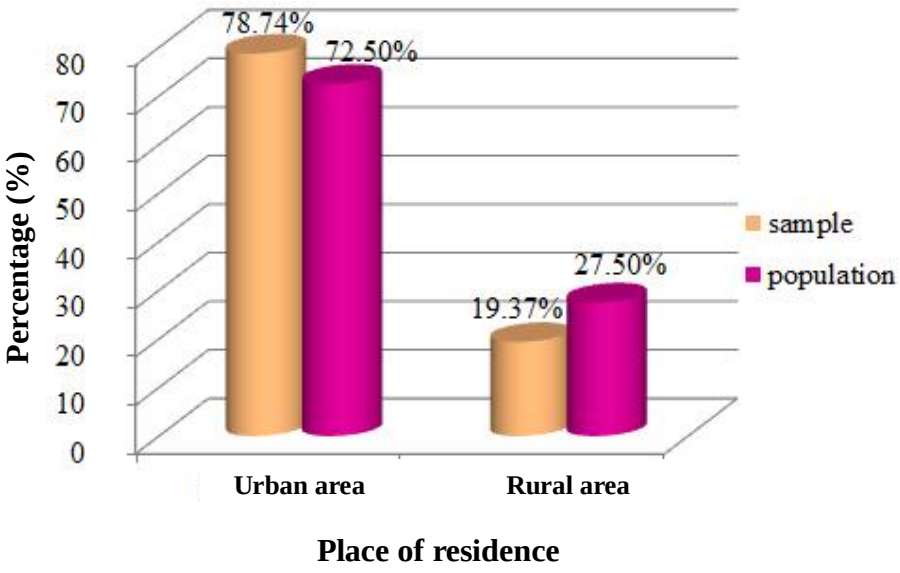

Figure 5. The distribution of the respondents and Bulgarian population according to place of residence.

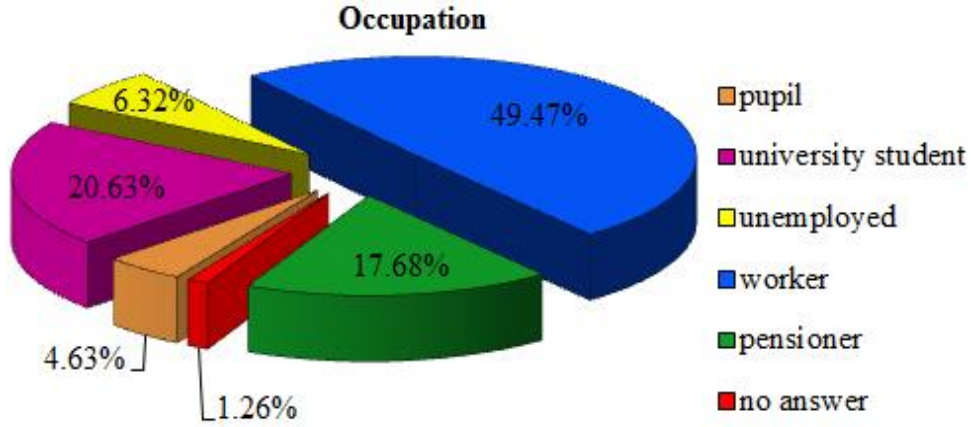

Figure 6. The distribution of the respondents according to occupation.

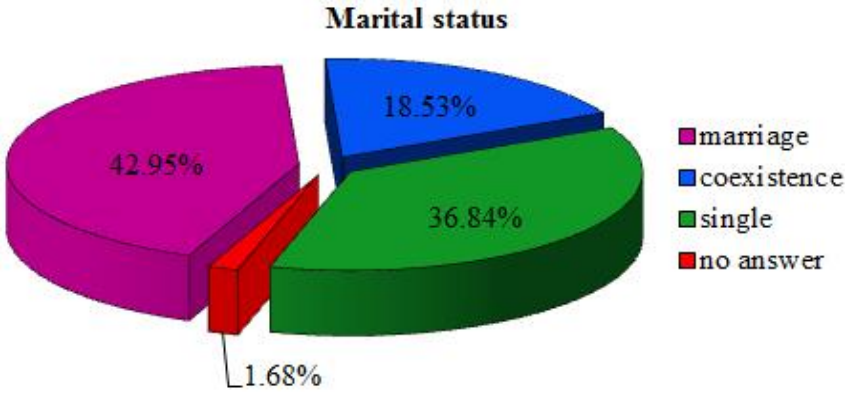

Figure 7. The distribution of the respondents according to marital status.

Table 1. Responses of the respondents to the inquiry.

S/N	Question	Responses	Number (%)
1	Do you think that herbs are beneficial for your health?	Yes	446 (93.89%)
		No	13 (2.74%)
		No answer	16 (3.37%)
2	How frequently do you use herbs? *	If necessary	248 (53.91%)
		Seasonally	58 (12.61%)
		Frequently	154 (33.48%)
3	For what purposes do you use herbs? *	Prophylaxis	112 (14.07%)
		Aromatherapy	39 (4.90%)
		Treatment	366 (45.98%)
		As spices	266 (33.42%)
		Ornamental	13 (1.63%)
4	From where do you obtain herbs:	Self-gathered from natural habitats	54 (11.37%)
		Purchased	189 (39.79%)
		Self-gathered or purchased	193 (40.63%)
		No answer	39 (8.21%)
5	From where do you purchase herbs:*	Pharmacy	296 (61.92%)
		Bazaar	80 (16.74%)
		Supermarket	102 (21.34%)

* The percent differs from 100% since more than one answer was marked.

(Figure 8). The lower percent of the respondents above 70 years, which believe in herbal medicines, could be explained by a generally poor health status in oldest age group. That might be a reason to lack a trust in possibilities to cure successfully diseases. Interestingly, the lowest positive attitudes towards herbs benefits were reported by informants at age 41 to 50. Further studies must be provided in order to explain this observation.

Responses to the questions “How frequently do you use herbs?” and "For what purposes do you use herbs?" could serve as an indicative of persistence of traditional knowledge in Bulgaria (Table 1). The frequency of herbal utilization reported confirmed existence of traditions of phytotherapy among Bulgarian population, since a larger proportion of the respondents declare to use herbs frequently and if necessary. About 60% of participants in the survey use medicinal plants for disease treatment and prophylaxis. Aromatherapy is reported to be used by 4.90% of respondents. It must be noticed that aromatherapy also is defined as a kind of complementary and alternative medicine (Pimenta, 2012). Herbs have been used for treatment and prevention of illness for centuries, but recently diminution of traditional knowledge has been established in some studies (Kozuharova et al., 2013). On the opposite of this statement, the results from our survey clearly demonstrated the persistence of local knowledge of herbal medicine in contemporary Bulgarian population. Herbs have been reported to be used as spices by 33.42% of respondents. According to Mann (2011) the terms “herb” and “spice” are often used interchangeably, since different parts of the medicinal plant are used as a spice: buds (cloves), bark (cinnamon), rhizomes or roots (ginger), berries (pepper), aromatic seeds (cumin) and even the stigma of a flower. This kind of herbal utilization is summarized by the well-known Hippocratic statement: "Let food be thy medicine and medicine be your food" (Hasler, 1998). A small proportion of interviewed people (1.63%) recognized herbs, but utilize them for ornamentation. Such utilization of medicinal plants has been reported in other studies (Bele et al, 2011).

The Bulgarian flora is remarkable for its diversity (Evstatieva et al., 2007) and the renewed interest in traditional medicine leads to increasing demand for medicinal plants. The most of the herbs are still gathered from wild habitats (Soetan and Aiyelaagbe, 2009; Verma et al., 2012). Nowadays, the necessity of medicinal plants conservation strategies has been widely discussed (Okigbo et al., 2008; Soetan and Aiyelaagbe, 2009). The actual information about abovementioned ecological aspects of herbal utilization in Bulgaria could be obtained from the responses to the question “From where do you obtain herbs?”. In our survey, only 11.37% of respondents reported to gather herbs from natural

Table 2. Influence of demographic variables of the respondents to their responses to the questions (n=475).

S/N	Question	Demographic variables											
		Sex		Age		Level of education		Occupation		Place of residence		Marital status	
		SD	r	SD	r	SD	r	SD	r	SD	r	SD	r
1	Do you think that herbs are beneficial for your health?	NS	0.09	S	0.37	NS	0.21	NS	0.18	S	0.21	NS	0.14
2	How frequently do you use herbs?	NS	0.09	NS	0.22	NS	0.19	NS	0.18	NS	0.08	NS	0.19
3	For what purposes do you use herbs?	NS	0.12	NS	0.19	NS	0.18	NS	0.19	S	0.19	NS	0.17
4	From where do you obtain herbs?	NS	0.17	S	0.37	S	0.3	NS	0.31	S	0.35	S	0.23
5	From where do you purchase herbs?	NS	0.12	NS	0.22	NS	0.12	NS	0.19	NS	0.05	NS	0.12

SD – Statistical difference between expected and observed frequencies; NS – Non significant; S – Significant; r – Pearson's contingency coefficient: 0 < r < 0.3 weak correlation, 0.3 < r < 0.5 moderate correlation.

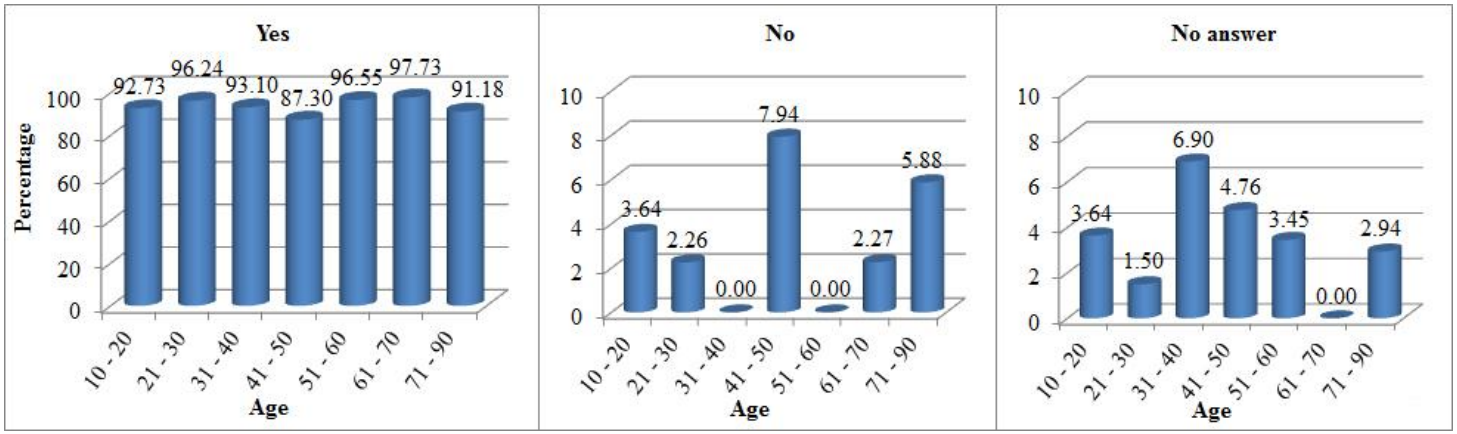

Figure 8. Cross-relationship between the demographic variable age of the respondents and their responses to the question "Do you think that herbs are beneficial for your health?".

habitats (Table 1). In similar study in Turkey (Akaydin et al., 2013) 52.8% of the informants reported to collect plant materials themselves from nature. The main reason for the significant difference in these observations is difference in number of rural inhabitants: 68.9% in the survey in Turkey and 27.50% in present survey. On the contrary, in the same study (Akaydin et al., 2013) only 21.1% preferred to purchase herbs, in comparison with 39.79% of Bulgarians which declared they prefer to purchase herbs. These results reveal impact of changes in modern Bulgarian society in terms of migration from rural to urban areas.

The data analysis shows impact of the demographic variables age and place of residence on responses to the question "From where do you obtain herbs?" (Table 2). Self-gathering is preferred

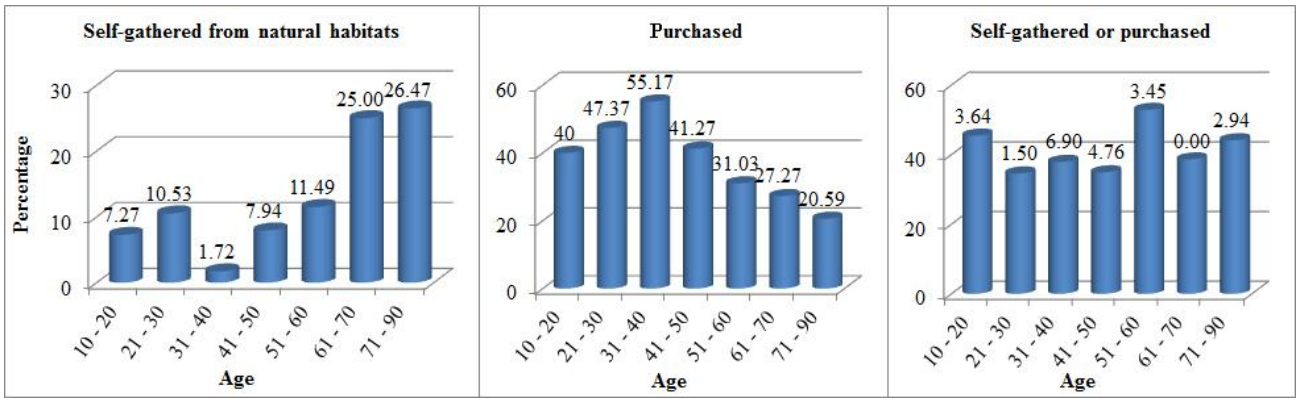

Figure 9. Cross-relationship between the demographic variable age of the respondents and their responses to the question "From where do you obtain herbs?".

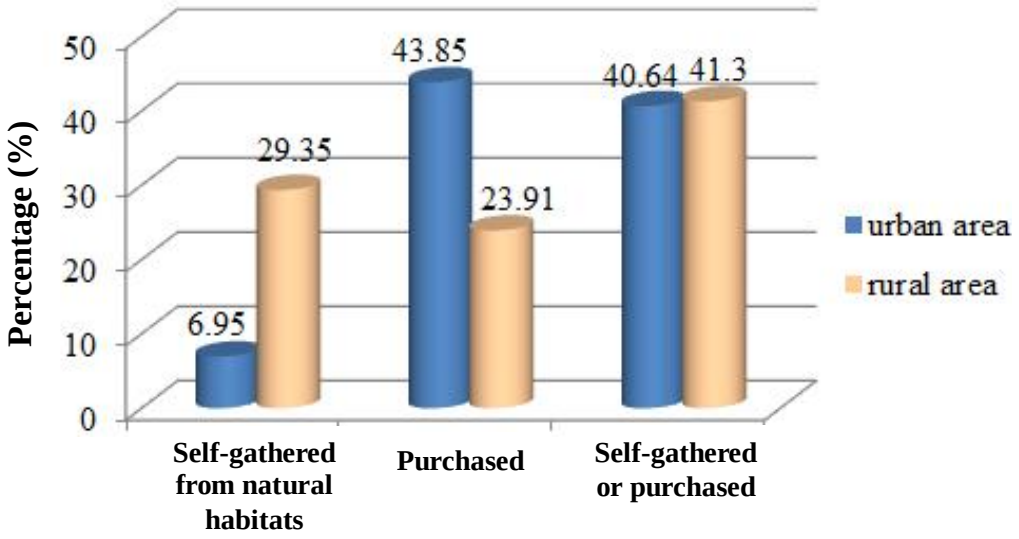

Figure 10. Cross-relationship between the demographic variable place of residence of the respondents and their responses to the question "From where do you obtain herbs?".

by the older respondents (Figure 9) and villagers (Figure 10). Further data analysis revealed that herbal gathering is preferred by the respondents with basic school education (25.00%), unemployed (23.33%) and pensioners (23.81%). It must be noticed that all of the abovementioned respondents belong to groups with low socio-economic status in Bulgaria.

The observation that the greatest proportion of respondents prefer to purchase herbs draws attention to the question "From where do you purchase herbs?" (Table 1). More than a half of the respondents (61.92%) prefer to buy herbs from the pharmacy. Supermarkets are the second preferred source (21.34%). Although, medicinal plants are available also at the traditional bazaars, they are the least preferred source (16.74%). A possible explanation to these results is the impact of modern society: nowadays people have faith in the pharmacies and supermarkets, where reputable and trustworthy firms sell their products.

Conclusion

Using data from a current nationally representative survey, we have examined the distribution of the attitudes toward benefits of medicinal plants, most popular application of herbs, manner of herbal obtaining and demographic factors associated with herbal use. The data obtained in the survey could reveal the contemporary status and critical points that need to be investigated in more details.

The results from present survey clearly show the persistence of traditional knowledge in contemporary Bulgarian population: about 94% of respondents believe

that herbs are useful for their health and about half of them use herbs for disease treatment and prevention. The impact of modern society is evident since only 11.37% of respondents obtain herbs themselves from natural habitats. A larger proportion of respondents prefer to purchase herbs from officially authorized sources as pharmacies and supermarkets. Demographic features exerted negligible influence on responses to the questionary. Only two demographics – age and place of residence exerted moderate influence on herbal utilization.

ACKNOWLEDGEMENTS

This work was supported by the “European Social Fund 2007-2013, Human Resources Development Operational Programme” under Grant [BG051PO001-3.3.06-0003] and the Bulgarian Ministry of Education and Science under Grant [RD-08-213/10.03.2014].

Conflict of Interest

The authors have not declared any conflict of interest.

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Vol. 10(5), pp. 177-183, 15 March, 2015
DOI: 10.5897/SRE2013.5764
Article Number:F70B56451271
ISSN 1992-2248

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Scientific Research and Essays

Full Length Research Paper

Antimicrobial activity and phytochemical screening of crude water extract of the stem bark of *Ficus glumosa*.

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Received 3 December, 2013; Accepted 3 July, 2014

Water and methanol extracts of the stem bark of *Ficus glumosa* were screened for their antimicrobial properties against *Salmonella* species. Preliminary results showed that the active compound was in the water extract. Therefore, the water extracts (hot and cold) were subjected to column chromatographic fractions and antibacterial screening. The most active fraction was subjected to phytochemical screening and finally Gas Chromatography Mass Spectrography (GC/MS) analysis. The result indicated that the most active fraction was the 3rd hot water extract and its GC/MS analysis was narrowed down to 3,3'-(4-methyl-1,3-phenylene)bis(1-heptylurea), isothujol and Terbuthyl azine.

Key words: Phytochemical screening, *Ficus glumosa,* column chromatography and antimicrobial activity.

INTRODUCTION

Due to the prevalent claims of typhoid fever infections around Sokoto, Nigeria and high patronage of traditional medicines, different mixtures are being used to treat typhoid fever. Plants like *Cassia occidentalis* are very popular for the treatment of typhoid fever. However scientific investigation could not establish its *in vitro* activity against the causative organism of typhoid fever (Faruq et al., 2006). Therefore, other plants commonly used for the treatment of typhoid fever were collected and screened to verify their efficacy. Many drugs commonly in use today are of herbal origin. Higher plants as source of medicinal compound have been playing a dominant role in the maintenance of human health since the antiquities (Suffnes and Dowos, 1982). Medicinal plants are the best source for obtaining a variety of newer herbal drugs. Therefore, such plants should be investigated to better understand their properties, safety and efficacy (Doss and Rangasamydhanabalan, 2008).

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The stem bark of *Ficus sycomorus* is used traditionally to treat fungal diseases, jaundice and dysentery (Hassan et al., 2007). *Ficus glumosa* can be used to prepare numerous traditional medicines. In Cote d'Ivoire, Central African Republic and Zimbabwe, the latex is applied to alleviate pain from sprains, treat diarrhoea and sore eyes. In Central Africa, Senegal (Casamanca), East Africa and Tanzania, the bark is used as mouth wash against toothache; it is used to prevent conjunctivitis, stomach disorders and wash sores daily until recovery. In Senegal and Cote d'iviore, the roots and fruits are used to cure female sterility (Jansen, 2005). The gums of *F. glumosa* also have pharmaceutical and industrial applications as demulcents, adhesives in pill manufacturing and lithography, paints, ink, corrosion inhibitors and as emulsifying agents (Ameh, 2013). On the other hand, the methanolic extract of the stem bark of *F. glumosa* has demonstrated *in vivo* anti-diabetic and *in vitro* anti-oxidant activities (Nana et al., 2012). Additionally, the methanolic leaf extract of *F. glumosa* significantly lowers blood glucose level and has anti-lipidemic and hepatotoxic effects (Zayyanu, 2010). *F. glumosa* leaves and stem bark are used for treating skin disease (Olaokun et al., 2013) and also the methanol leaf extract exhibits pharmacological activity against diarrhoea (Tanko et al., 2012,). The stem bark of *F. glumosa* is particularly used for treating typhoid fever among traditional healers in Sokoto, Nigeria (Discussion). The bark is used either as cold or hot water decoction.

This study was designed to evaluate the anti-microbial efficacy of *F. glumosa* and to determine the active component in the plant extract.

MATERIALS AND METHODS

Collection and treatment of sample

Dried stem bark of *F. glumosa* was obtained from the Traditional Medicine Department of Usmanu Danfodiyo University, Sokoto. The sample stem bark was pulverized into moderately coarse powder and subjected to aqueous extractions.

Test organism

The bacterial organisms used were *Salmonella paratyphi* and *Salmonella typhi*. They were all isolates obtained from Microbiology Department of Usmanu Danfodiyo University, Sokoto, Nigeria and cultured in appropriate media.

Extraction of plant material

The extraction was carried out by soaking 50 g of the powder in 250 cm^3 of methanol and distilled water for 24 h at room temperature. The extract was decanted and concentrated by evaporating on water bath at 100°C for 12 h to obtain crude extract.

Initial anti-salmonella screening of crude extract

The antimicrobial activity of the extracts was tested on the test isolate, using the agar well diffusion inhibition test. The organism was aseptically introduced and evenly spread on the solidified media in a Petri dish as described by Opara and Ansa (1993). Four wells were made in each solidified agar plate with a sterile 12 mm diameter cork borer allowing at least 30 mm between adjacent wells and between peripheral wells and the edge of the Petri dish. On each of the four wells created in the nutrient agar plate, the mixture of the plain agar and extracts were aseptically filled. Tetracycline of 3.30 mg/cm^3 was used as a positive control. The plates were left on the work bench for 20 min to allow the extract to solidify. The plate was then inverted and incubated at 37°C for 24 h. Zones of inhibition around the wells indicated antibacterial activity against the bacteria. The diameter of these zones was measured by the use of transparent plastic ruler and then recorded.

Chromatographic separation of crude extract

A piece of glass wool was inserted at the bottom of a glass column, and then 40 g silica gel powder (80 to 120 µm mesh) was packed into the column; and glass wool was inserted just above the silica gel surface. The column was washed with 35 cm^3 distilled water. The sample (5 cm^3 of water extract) was transferred onto the column and sequentially eluted with 35 cm^3 of distilled water, water/methanol mixture (1/1 v x v) and 100% ethanol. Flow rate was observed and fractions were collected at 10 cm^3/fraction.

Antisalmonella screening of the chromatographic fraction

The chromatographic fractions were subjected to anti-*Salmonella* activity as described above.

Phytochemical screening of the active fraction

Each of the active fractions was subjected to phytochemical analysis as described by Trease and Evan (1989), Oloyede (2005) and Sumitra et al. (2006).

Gas Chromatography Mass Spectrography (GC/MS) analysis of the active fraction

The active chromatographic fraction was subjected to GC-MS analysis using SHIMADZU QP2010 GC-MS.

RESULTS AND DISCUSSION

Crude water extract of the bark of the plant was subjected to antibacterial activity test on *Salmonella typhi* and *Salmonella paratyphi* pathogens. The result of that test (Table 1) revealed that the extract is active on both *Salmonella* species; it was even more active on *S. typhi* than *S. paratyphi* pathogens. Kitzberger et al. (2006) reported that the antibacterial activity can be considerate when the diameter of

Table 1. Result of the anti- *Samonella* activity of crude water extracts.

Test organisms	Diameter of inhibition zones (mm)			
	Methanol extract		Water extract	
	30 mg/cm^3	60 mg/cm^3	30 mg/cm^3	60 mg/cm^3
Salmonella paratyphi	0.0	0.0	0.0	15.3
Samonella typhi	0.0	0.0	0.0	16.5

Diameter of cork borer used= 12 mm.

inhibition zone observed is 9 mm or more around the paper disc. Our findings of 15.3 and 16.5 mm are consistent with the above findings. However, activity was only observed in the water extract, which indicates that the active compound was extractible by water as against methanol (Figure 1). Therefore, subsequent investigations were narrowed down to the water extract only.

In the subsequent work, two water extracts were employed, (that is, hot and cold water extracts). The essence was to identify the best extraction method of the active compound. In a similar research, Indranil et al. (2006) and Gideon et al. (2012) indicated a promising potential for hot water extract compared to cold water extract. Onuh et al. (2008) also prove this in their findings for *Jatropha curcus* leaves in the management of plant diseases. On the contrary, the methanol extract showed no activity. It could be the nature of biological active components whose activity cannot be enhanced in the presence of methanol. Although, Talko et al. (2012) reported that methanol extract of *F. glumosa* exhibited a significant anti-diarrheal activity. In addition, the stronger extraction capacity of water could have produced greater number of active constituents responsible for antimicrobial activity. Each of the two water extracts was subjected to column chromatographic separations, where nine fractions were obtained for each (Figures 2 and 3). During the chromatographic separation, there were no clearly separated coloured bands; therefore, the fractions were collected in aliquots of 10 cm^3 each. Each of the chromatographic fractions was subjected to anti-bacterial activity tests against the *S. typhi*. The result (Tables 2 and 3) revealed that the third fraction of hot water extract (H3) as the most active has relatively high antibacterial activity. This indicates that the infusion will be more effective in infectious diseases than the cold water decoction. The result of the phytochemical screening of the active chromatographic fractions (Table 4) revealed the presence of phenolic compound(s), saponins and steroids. Tanko *et al., (*2012), in their study, reported the presence of flavonoids, tannins, saponins, cardiac glycosides and triterpenes in their phytochemical analysis of *F. Glumosa,* which is similar to our study in terms of phenol (tannins) and saponins. Phenolic compounds were found to have antioxidant and antibacterial effect (Ouattara et al., 2011). Some mechanisms of antimicrobial activity of phenolic compounds include their ability to denature microbial proteins as surface active agents.

In order to ascertain the identity of the active fraction, it was subjected to GC/MS analysis. The GC chromatogram gave eleven peaks (Table 5 and Figure 4). Each of the eleven compounds represented by the peaks was fragmented by the MS and the mass spectra compared with those in the e-library (NIST library) to come up with compound matching. The matching revealed that two of the compounds (RT; 47.65, and 55.99) were esters of phthalic acid, three of the fractions (RT; 52.167, 51.77 and 51.37) correspond to 3,3-(4-methyl-1,3-phenylene)bis(1-heptylurea),one of the fractions (RT; 53.62) was isothujol, still another one (RT; 50.32) was Terbuthyl azine and the rest were fatty acid derivatives and hydrocarbons (Figure 4). The phthalic acids derivatives are not plant based compounds but are rather components of plastic materials; therefore, they must have found their way into the sample through dissolution of some plastic materials used in the process by organic solvents. Fatty acids and hydrocarbons are not known to posses pharmacological activities. Therefore, the observed antibacterial activity must have been from either of the remaining three identified compounds (mentioned above) or combination of two or more of them. However, this work did go further to isolate each of these compounds and study them individually. That will be reported in the follow-up work.

Conclusion

The study has shown that the observed anti-*Salmonella* effects of *F. glumosa* stem bark, though *in vitro*, appear interesting and promising. This work has successfully narrowed down the observed effect to three compounds but falls short of isolating them individually for further studies.

Conflict of Interest

The authors have not declared any conflict of interest.

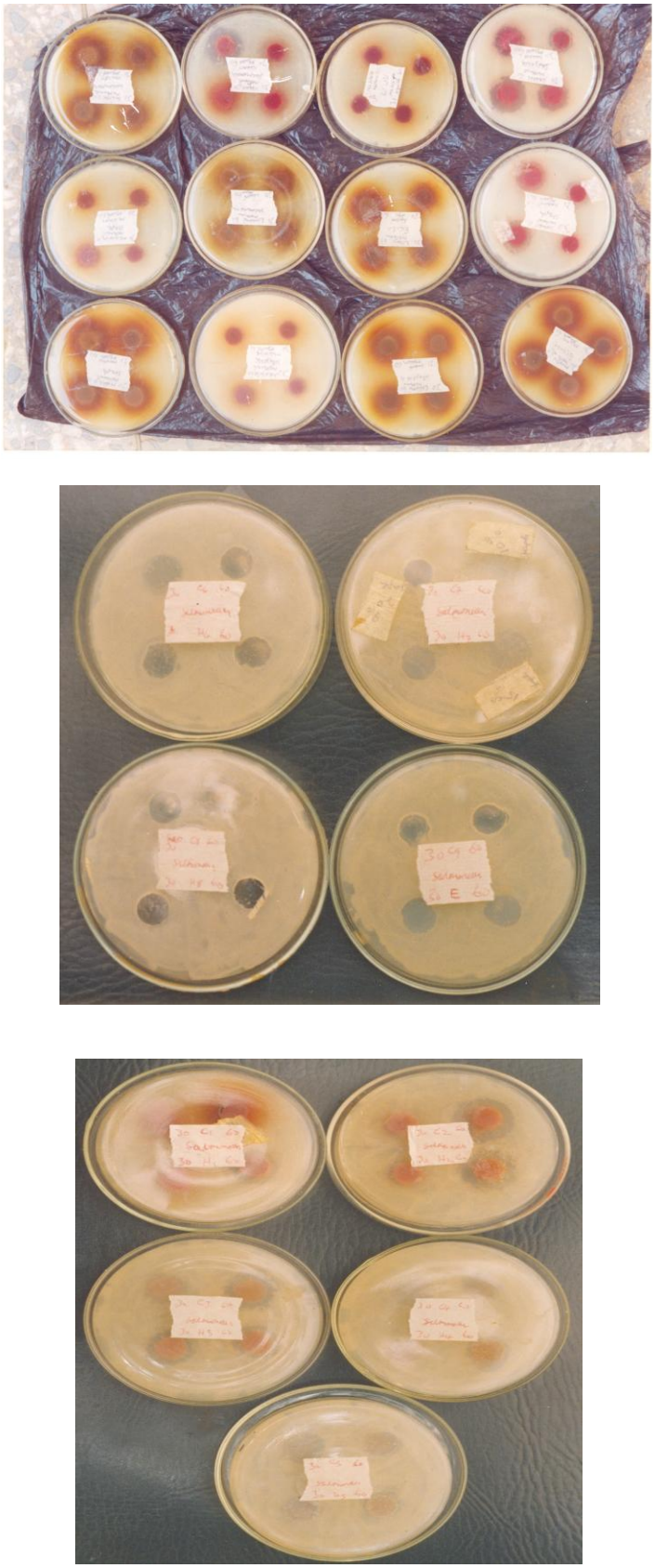

Figure 1. Anti-bacterial activities of methanol and Water extract of *F. glumosa* stem back extract.

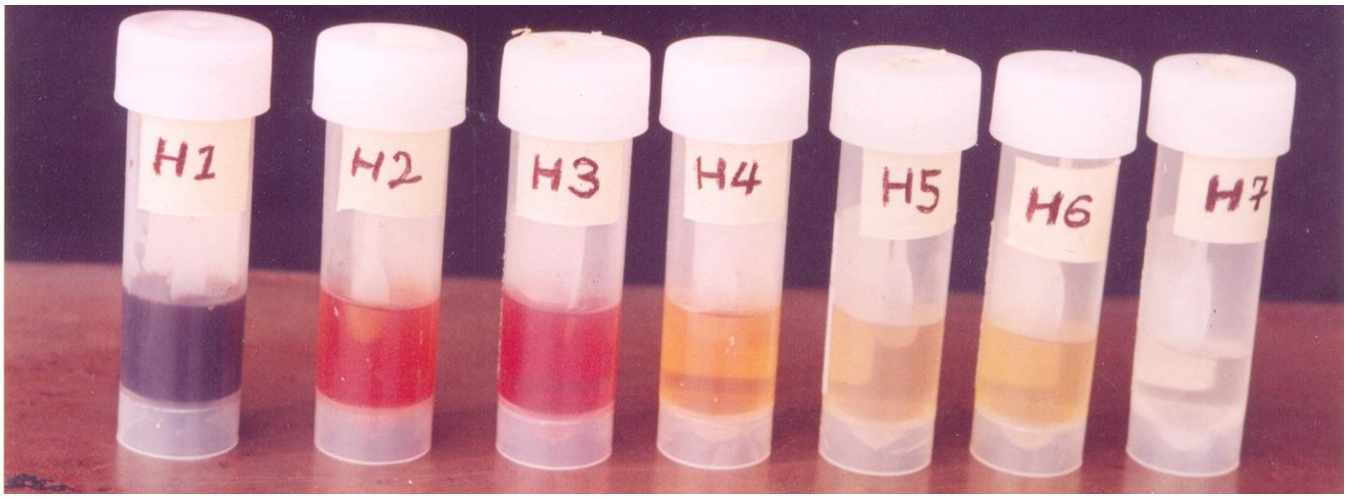

Figure 2. Column chromatographic fractions of boiled water extract of *F. glumosa.*

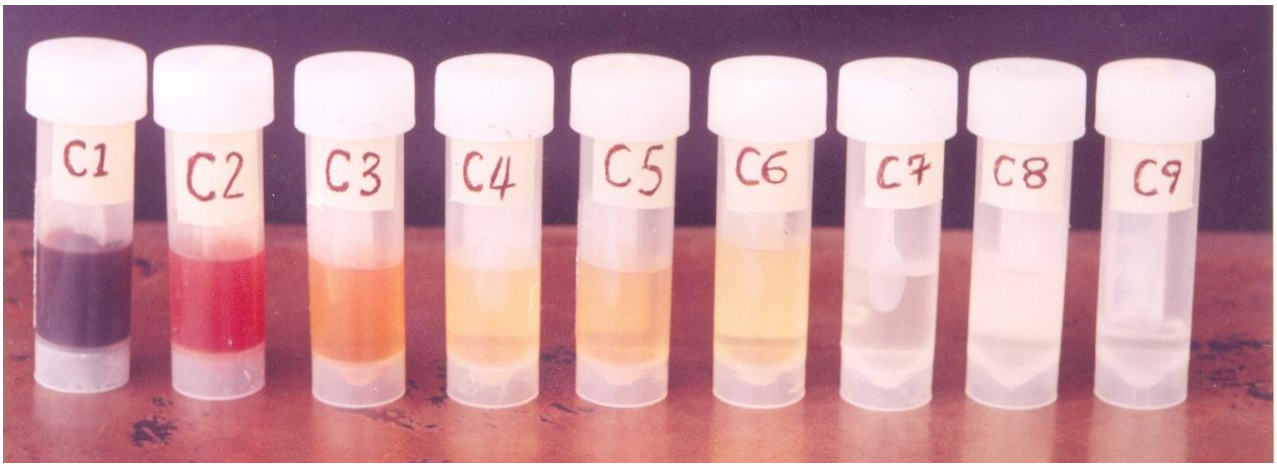

Figure 3. Column chromatographic fractions of cold water extract of *F. glumosa.*

Table 2. Result of antibacterial activity test on the column chromatographic fractions of cold water extract against *S. typhi*.

Concentration in mg/cm^3	C1	C2	C3	C4	C5	C6	C7	C8	C9
30	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
60	0.0	16.0	17.5	0.0	0.0	0.0	0.0	0.0	0.0

C- Means cold water extract.

Table 3. Result of Antibacterial Activity Tests on the Chromatographic Fractions of Hot Water Extract against *Salmonella typhi.*

Concentration in mg/cm^3	H1	H2	H3	H4	H5	H6	H7	H8	H9
30	0.0	0.0	18.0	0.0	0.0	0.0	0.0	0.0	0.0
60	16.5	17.5	19.0	0.0	0.0	0.0	0.0	0.0	0.0

H- Hot water extract.

Table 4. Result of phytochemical analysis on the active chromatographic fraction.

Components	H3
Phenolics	+
Saponins	+
Alkaloids	?
Cardiac glycosides	?
Steroids	+
Flavonoids	?
Anthraquinone glycosides	?

Key: + Means present, ? Means absent.

Table 5. GC/MS result of the most active fractions.

GC/MS peak number	Retention time (Indexes) (Min)	Base peak	Molecular ion peak	Identified compounds
1	56.0	57	354	Esters of phthalic acid
2	53.6	93	354	Isothujol
3	52.2	148	354	3,3-(4-methyl-1,3-phenylene)bis(1-heptylurea)
4	51.8	148	280	3,3-(4-methyl-1,3-phenylene)bis(1-heptylurea)
5	51.7	81	280	
6	51.6	81	280	
7	51.4	148	342	3,3-(4-methyl-1,3-phenyle ne)bis(1-heptylurea)
8	50.3	199	326	Terbuthyl azine
9	47.7	148	374	Esters of phthalic acid
10	47.3	79	300	
11	40.7	93	300	

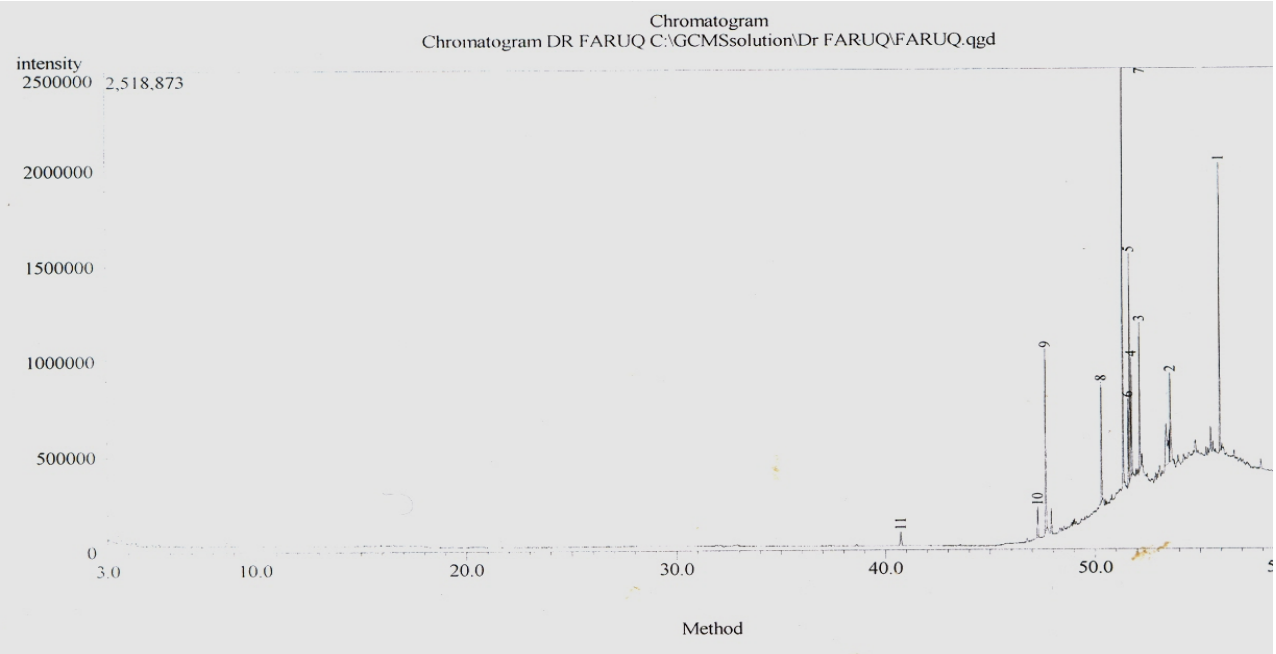

Figure 4. GCMS result.

ACKNOWLEDGEMENT

The authors are grateful to all people that directly and indirectly contributed to the success of this research.

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Vol. 10(5), pp. 184-195, 15 March, 2015
DOI: 10.5897/SRE11.862
Article Number:CEE470D51274
ISSN 1992-2248

http://www.academicjournals.org/SRE

Scientific Research and Essays

Full Length Research Paper

Sharing healthcare information based on privacy preservation

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Received 7 May, 2011; Accepted 19 November, 2014

The evolution and development of information technology have facilitated greater sharing of data and knowledge management for the collection of electronic information by data owners such as governments, corporations, and individuals. Therefore, they have created huge opportunities for knowledge management and information retrieval. Recent develoments have helped improve decision making especially in the fields of medical information, research, and public health organization, among others. Recently, the control and sharing of data or knowledge management has received notable attention in research communities. Many approaches have been proposed for different data publishing needs in different fields. The sharing of data needs control and management to ensure system integration. Integration is required especially in the management of patient data to secure sensitive information such as patient identification. Several studies have focused on the management of data in medical applications to ensure system integration. However, the management and sharing of data in different fields may result in misuse of information. Therefore, there is a need to build models or design certain algorithms to manage shared data efficiently and to avoid misuse. The goal is to ensure authenticity of the data system. In the present study, we systematically summarize and evaluate different approaches to control the sharing of data and knowledge management in order to ensure system integration. Moreover, we study the challenges in controlling the sharing of data and clarify the differences and conditions that distinguish the control of sharing of data from other related problems. Finally, we correspondingly propose future research directions in the conclusion.

Key words: Knowledge management, electronic information, information retrieval, decision making integration, authenticity.

INTRODUCTION

The use of information and communication technology (ICT) in healthcare is increasing (Ernstmann et al., 2009) because of its potential to improve the effectiveness and efficiency of healthcare (Kohn et al., 1999). Health information systems (HISs) help ensure that patients immediately receive appropriate treatment. Aggelidis and Chatzoglou (2009) mentioned that the use of information systems in the healthcare sector is widely accepted,

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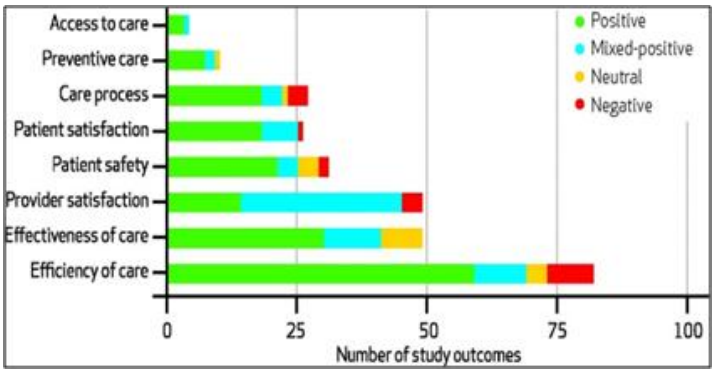

Figure 1. Evaluations of outcome measures of health information technology, by type and rating (Buntin et al., 2011).

particularly in hospitals (Aggelidis and Chatzoglou, 2009). Information systems (ISs) improve the quality of services being provided (Scott, 2007). Researchers reported that the failure of hospitals to adopt new ISs increases inconvenience and loss of the trust among patients (Ammenwerth et al., 2003; Lu et al., 2005). Thus, HISs have gradually replaced traditional hospital procedures (Ammenwerth et al., 2003; Lu et al., 2005), and studies have proposed various frameworks for building trustworthy IS solutions for hospitals.

Healthcare information systems (HISs) in healthcare organizations such as hospitals is important for providing and sharing healthcare information among medical staff, especially physicians and researchers (Yang et al., 2010). In addition, collaboration is an important requirement for HISs (Ahmed and Yasin, 2012). The term “collaboration” in the field of healthcare is defined as the communication that occurs among healthcare practitioners when sharing information and skills regarding patient care (Gaboury et al., 2009; Scandurra et al., 2008; Weir et al., 2011). Furthermore, healthcare information is valuable to many organizations for scientific research or analysis (Chen et al., 2012). Sharing these healthcare data among different organizations can significantly benefit both medical treatment and scientific research in relevant sectors (Hillestad et al., 2005; Wang et al., 2003; Yang et al., 2010). Nevertheless, healthcare data typically contains considerable private information. Sharing this data directly would pose a threat to patient privacy. Thus, developing practical models to balance healthcare data sharing utility and privacy preservation is necessary in order to improve collaboration among physicians (Chen et al., 2012; Fung et al., 2010; Gkoulalas-Divanis and Loukides, 2011; LeFevre et al., 2006; Wang and Yang, 2011). In this context, collaborative in sharing healthcare information using HISs based on privacy preservation rarely handles healthcare information sharing among physicians and researchers at different places need to collaborate and communicate with each other to provide safer and more accessible to improve research findings that lead to enhanced care to patients. The need to address such collaboration among physicians and researchers in research activities based on privacy preservation is of utmost importance. A number of studies on the benefits of HISs have been conducted in the healthcare sector. These studies determined their effect on outcomes, including quality, efficiency, and provider satisfaction. Three systematic reviews of peer-reviewed studies about the benefits of adopting HISs in healthcare systems have been conducted and covered from 1994 to 2010 (Buntin and Burke, 2011; Goldzweig et al., 2009; Wu et al., 2006). Buntin and Burke (2011) cover the findings of these reviews and mentioned that 92% of recent articles on health IT reached conclusions that were generally positive (Buntin and Burke, 2011). Moreover, they found that the benefits of this technology were beginning to emerge in smaller practices and organizations as well as in large organizations that were early adopters. However, dissatisfaction with EMRs among some providers continued to hinder the potential of health IT. These realities highlight the need for studies that document the challenging aspects of the more strategic implementation of health IT and how these challenges may be addressed. Figure 1 summarizes the aforementioned findings on the benefits of health IT to the healthcare sector.

The collaboration among physicians in sharing information using HISs in the patient treatment or research activities within the hospital environment in many developing countries is very weak (Organization, 2010; Reddy et al., 2011). This weak occurs due to decentralized and autonomous units and lack of shared goals within healthcare systems; many HISs are isolated from one another because of the fragmented nature of healthcare systems (Fried et al., 2011). Disintegrated HISs and manual systems hinder information sharing and collaboration among physicians, thus impeding optimal use of healthcare resources and delaying because large amounts of data are difficult to manage and control in a

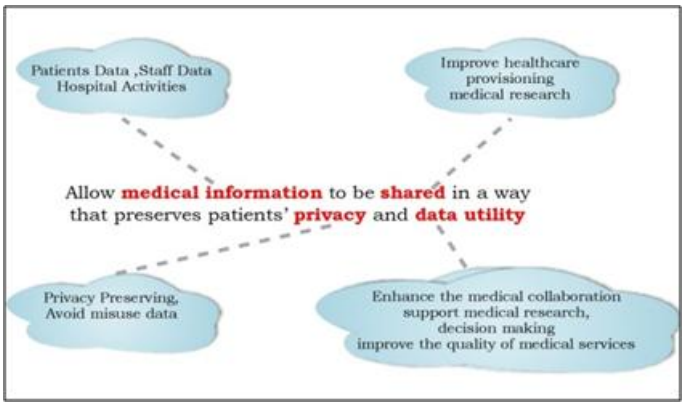

Figure 2. Research motivation (Gkoulalas-Divanis and Loukides, 2011).

system that uses paper (Tierney et al., 2010; Van Vactor, 2012) introduced another important factor that affects collaboration among physicians, that is, privacy concerns raise the necessity of improving collaboration among medical staff through HISs. Effective implementation of HISs requires trust from both the providers who use them and the patients they serve (Blumenthal, 2009;Chen et al., 2012; Goldzweig et al., 2009). In such cases, sharing information regarding patients' treatment and medical researches among hospitals is difficult. The aforementioned factors critically affect technology acceptance in hospitals and collaboration among physicians, which can lead to poor patient outcomes (Reddy et al., 2011). The bigger challenge is strengthening sharing of healthcare information among physicians and researchers in same or different hospital, many of which still rely on paper-based records. As such, introducing new activities to hospitals is a difficult process. These activities are important in enhancing healthcare services. Collaborative HISs based on privacy preservation rarely handles healthcare information sharing among physicians and researchers at different places need to collaborate and communicate with each other to provide safer and more accessible to improve research findings that lead to enhanced care to patients. The need to address such collaboration among physicians and researchers in research activities based on privacy preservation is of utmost importance.

The privacy preservation is an important issue when dealing with personal data and can be considered as the backbone for the sharing data process. There are numerous real-world applications which require sharing data while meeting specific privacy constraints. Consequently, the literature review in this section aims to clarify the privacy preservation data sharing challenges.

The recent studies refer to the increase privacy and security consciousness has lead to increased research and development of methods that compute useful information in a secure fashion (Clifton et al., 2004; Fung et al., 2010). Data sharing have been a long standing challenge for the database community. This need has become critical in numerous contexts, including integrating data on the Web and at enterprises, building ecommerce market places, sharing data for scientific research, data exchange at government agencies, monitoring health crises, and improving homeland security (Clifton et al., 2004). Additional to large amounts of personal health data are being collected and made available through existing and emerging technological media and tools. While use of these data has significant potential to facilitate research, improve quality of care for individuals and populations, and reduce healthcare costs, many policy-related issues must be addressed before their full value can be realized. These include the need for widely agreed-on data stewardship principles and effective approaches to reduce or eliminate data silos and protect patient privacy (Hripcsak et al., 2014).

Unfortunately, data integration and sharing are hampered by legitimate and widespread privacy concerns (Clifton et al., 2004; Fung et al., 2010). Companies could share information to boost productivity, but are prevented by fear of being exploited by competitors or antitrust concerns. Sharing healthcare data could improve scientific research, but the cost of obtaining consent to use individually identifiable information can be prohibitive and these efforts must engage patients as partners (Hripcsak, et al., 2014). Sharing healthcare and consumer data enables early detection of disease outbreak (Tsui et al., 2003), but without provable privacy protection it is difficult to extend these surveillance measures nationally or internationally. Besides effective public safety and health care, collaboration and sharing between public agencies, and public and private organizations, can have a strong positive impact on public safety.

The continued exponential growth of distributed personal data could further fuel data integration and sharing applications, but may also be stymied by a privacy backlash. It is critical to develop techniques to enable the integration and sharing of data without losing privacy. As noted above, there is widespread agreement on the value of personal health data for many uses beyond direct patient care and treatment. Thus, discussions about the privacy preservation data sharing are more important than ever. As part of the overall problem, the literature review in this study aims to cover the privacy preserving data sharing as mentioned in the recent studies. The recent studies indicate to the emergent privacy issues of healthcare data are important issue. According to Gkoulalas and Loukides (2011) mentioned that 62% of individuals worry that their electronic medical records will not remain confidential (Gkoulalas-Divanis and Loukides, 2011), and 35% expressed privacy concerns regarding the collaboration (publishing and sharing) of their data (Ludman et al., 2010), Figure 2 shows the motivation for this work.

The literature review in this study aims to cover the privacy preserving data sharing as mentioned in the recent studies, in order to improve the collaboration among medical staff (relation management) with regard to medical data sharing for research through review and classification methods of privacy protection. The recent studies indicate to the emergent privacy issues of healthcare data are important issue. In the sections that follow, we briefly explain the related works and highlight related literature, collaboration in sharing healthcare information based on privacy preservation (relation between sharing and privacy), state of the art privacy preserving, privacy preservation and technical contribution, privacy preservation models, and proposed model to sharing healthcare information based on control privacy preservation.

RELATED WORKS

Privacy protection is an important issue particularly with regards to personal data that must have stringent policies on sharing. A definition on privacy protection has specified that access to published data should not allow potential attackers to learn anything beyond what target victims had permitted to disclose, which is in contrast to having no access to the database or the background knowledge of the potential attacker that he has obtained from other sources (Dalenius, 1977). The development of information technology and the collection of electronic information by data owners, such as governments, corporations, and individuals, have facilitated higher instances of data sharing and knowledge management. Driven by mutual benefits, these data owners have created broad opportunities for knowledge management and for information retrieval. Recent developments have helped improve decision making, particularly in the fields of medical information, research, and public health organization, among others. Many approaches have been proposed for different data publishing needs in different fields. Data sharing requires control and management to ensure system integration. Integration is required specifically in the management of patient data to secure sensitive information such as the identity of the patients (Gkoulalas-Divanis and Verykiosc, 2009; Qi and Zong, 2012). Several studies had focused on the management of data, such as in medical applications, to ensure system integration. However, management and sharing of data in different fields can lead to misuse of information, disclosure of the identification of the data owner, and other related problems (Clifton et al., 2004; Rashid et al., 2012). The primary goal in privacy preservation is the protection of sensitive data before they are released for analysis or for re-publication. Data may be kept at centralized or at distributed data storage areas. In this scenario, appropriate algorithms or techniques should be used to protect any sensitive information during the knowledge discovery process. Many approaches can be adopted for privacy-preserving data mining (Kaye et al., 2010).

An important aspect on privacy-preserving data mining algorithms and on tools for development and evaluation is to select the appropriate evaluation criteria. The reality, however, is that privacy-protected data mining algorithms with a variety of indicators are not better than other algorithms. Generally, an algorithm may be practical in terms of performance or may be slightly better than others. Users must be provided with a set of metrics to enable them to choose the best appropriate algorithms for data privacy preservation. Subsequently, we formulated a simple introduction on algorithm performance, data utility, privacy protection degree, and on the difficulty of different data mining techniques (Qi and Zong, 2012). In algorithm performance, the algorithm with O(n2) complexity polynomial time is more efficient than those with O(en) index of complexity. An alternative approach is necessary to evaluate time requirements in terms of average number of operations to reduce the frequency of sensitive information appearing below a specified threshold. Possibly, this value does not provide an absolute measure, but it can be capable of performing a fast comparison among different algorithms (Qi and Zong, 2012). Data utility is a very important issue in the implementation of data privacy protection. To hide sensitive information, false information may be inserted into the database or data values can be blocked. Although sample techniques do not modify the information stored in the database, they can exhibit a reduction because of the presentation of incomplete information (Qi and Zong, 2012). In the degree of privacy protection, the privacy protection policy prevents the downgrade of information to a certain threshold, though hidden information can be derived by some uncertainty. The uncertainty reconstructed by hidden information can evaluate the sanitation algorithm. A solution can set a maximum on perturbation information from the execution perspective, and then consider achieving the degree of uncertainty by measuring the constraints of different purification methods. We intend to define an algorithm that can achieve the highest uncertainty and that is better than all other algorithms (Qi and Zong, 2012). In difficulty of different data mining techniques, we must measure the difficulty of data mining algorithms, which differ from the purification method, to provide full estimation on the purification method called parameter horizontal difficulty. Parameter estimation must consider the data mining classification, which is important to the test. Alternatively, we may need to develop a formal framework that can ensure privacy assurance for an entire class of sanitization algorithms upon testing one against pre-selected data sets (Qi and Zong, 2012).

The recent studies refer to the increase privacy and security consciousness has lead to increased research and development of methods that compute useful

information in a secure fashion (Clifton et al., 2004; Fung et al., 2010). Data sharing have been a long standing challenge for the database community. In other words, great concern has been directed on the control of data and it's sharing to make it available to their owners. Some reviewers and researchers have even suggested the use of covert techniques which isolate data such as encryption technology. Different ways of protecting data have been dealt with in recent research. The methods previously introduced include information on how to spread and use data in research, decision making, scientific analyses, and other purposes (Fung et al., 2010). First, the concern is how to control data sharing and management and avoid the risk of publishing data that may lead to revealing the real data. Second, there is lack of unity among the collected data, and their sources vary as they are collected from various points such as governments, hospitals, companies, and so on. Third, the data collected may contain errors. How data are processed and formatted before access requires a high level of analysis techniques to extract and determine knowledge and relationships hidden.

To identify the relationships among different data and their influence on the results, they must be accurate and correct, as one type of data relies on the results of the analysis. Examples are the reasons for the spread of a particular disease in a particular area in the medical field, the losses incurred by a company after a change in business strategy, and the low standards of living in a society. The main objective of the present research is to control management and sharing of data in the medical field, which mainly involves "patient data". The main objectives of the present research is to sharing healthcare information based on privacy preservation and keep data utility for secondary purposes such as research.

COLLABORATION HEALTHCARE INFORMATION BASED ON PRIVACY PRESERVATION

Recently, many healthcare organizations are adopting Customer relationship management (CRM) as a strategy, which involves using technology to organize, automate, and coordinate business processes, in managing interactions with their patients. CRM with the Web technology provides healthcare providers the ability to broaden their services beyond usual practices, and thus offers suitable environment using latest technology to achieve superb patient care (Anshari and Almunawar, 2012).

There are two basic types of healthcare CRMs, one is for a healthcare organization to stay in contact with their patients, and the other is for a healthcare organization to stay in contact with referring organizations. In other hand, privacy is critical factor when patients' information used in other treatment purposes (Fung et al., 2010; Gkoulalas-Divanis and Loukides, 2011).

One of the most interesting aspects in medical care is how to manage the relationship between healthcare providers and patients (Anshari and Almunawar, 2012). Fostering relationship leads to maintain loyal customer, greater mutual understanding, trust, patient satisfaction, and patient involvement in decision making (Glanz et al., 2008). Furthermore, effective communication is often associated with improved physical health, more effective chronic disease management, and better health related quality of life (Arora, 2003). On the other hand, failure in managing the relationship will affect to the patient dissatisfaction, distrust towards systems, patient feels alienated in the hospital, and jeopardize business survivability in the future.

In this context, Usually, CRM is applied in the business field but not in the medical one. The application of the CRM model can result in desirable results through collaboration among hospital in patients treatment and other purposes such as data analysis, research. In other hand, Data mining has been used intensively and extensively by many organizations (Anshari and Almunawar, 2012). In healthcare, data mining is becoming increasingly popular, if not increasingly essential. Data mining applications can greatly benefit all parties involved in the healthcare industry. For example, data mining can help healthcare insurers detect fraud and abuse, healthcare organizations make customer relationship management decisions, physicians identify effective treatments and best practices, and patients receive better and more affordable healthcare services The huge amounts of data generated by healthcare transactions are too complex and voluminous to be processed and analyzed by traditional methods. Data mining provides the methodology and technology to transform these mounds of data into useful information for decision making (Koh and Tan, 2011). In healthcare, data mining is becoming increasingly popular, if not increasingly essential. Several factors have motivated the use of data mining applications in healthcare. The existence of medical insurance fraud and abuse, for example, has led many healthcare insurers to attempt to reduce their losses by using data mining tools to help them find and track offenders (Anshari and Almunawar, 2012; Christy, 1997). Fraud detection using data mining applications is prevalent in the commercial world, for example, in the detection of fraudulent credit card transactions. Recently, there have been reports of successful data mining applications in healthcare fraud and abuse detection (Milley, 2000). Another factor is that the huge amounts of data generated by healthcare transactions are too complex and voluminous to be processed and analyzed by traditional methods. Data mining can improve decision-making by discovering patterns and trends in large amounts of complex data (Biafore, 1999). Insights gained from data mining can influence cost, revenue, and operating efficiency while maintaining a high level of care (Silver et al., 2001).

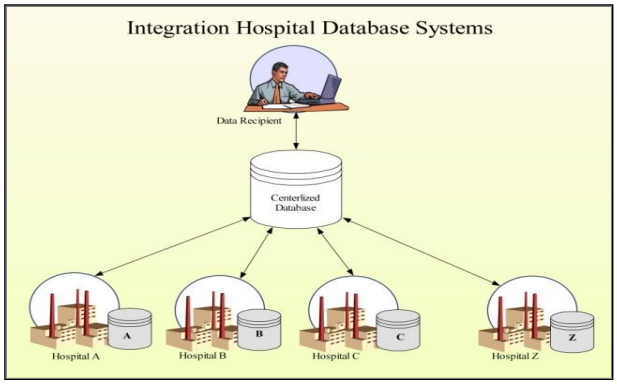

Figure 3. Integration hospital database system.

Healthcare organizations that perform data mining are better positioned to meet their long-term needs, Benko giving an illustration of a healthcare data mining application; and finally, highlighting the limitations of data mining and offering some future directions Cios and Moore31 have argued that data problems in healthcare are the result of the volume, complexity and heterogeneity of medical data and their poor mathematical characterization and non-canonical form. Further, there may be ethical, legal and social issues, such as data ownership and privacy issues, related to healthcare data. The quality of data mining results and applications depends on the quality of data (Koh and Tan, 2011).

Recent studies have shown that the development of effective collaborative HISs to support collaborative work among medical staff, especially among physicians and researchers, requires the use of real data. This result is based on the fact that the collaborative HIS approach requires appropriate, flexible, and comprehensive healthcare information based on user (Kuziemsky et al., 2012; Kuziemsky and Varpio, 2011; Lezzar et al., 2012; Reddy et al., 2011; Ruxwana et al., 2010; Scandurra et al., 2008). The findings of the review here indicate strong relationship between collaboration in sharing healthcare information and privacy preservation as mentioned in recent studies, in order to development of effective collaborative HISs to support collaborative work and improve patients outcome. Many researchers in this area proposed healthcare system models for healthcare information sharing among medical staff, and few studies focused on the research on healthcare system and privacy preservation in health sector. However, such models are not flexible in structure and are difficult to manage and control because of the enormous data in complex healthcare systems. The Figure 3 shows the Integration HISs.

In the past few years, research communities have responded to the challenges of privacy preservation through collaborative activities in sharing data as mentioned in (Clifton and Atallah, 2007) to eliminate privacy concerns from patients and help medical institutions or participants comply with privacy protection regulations. These approaches encompass several fields of research. The problems they are trying to address could be classified into three categories:

The first category focuses on privacy protection in data sharing during data usage. These kinds of approaches attempt to protect patient privacy by transforming the healthcare data before they are shared. The privacy information may be wiped or reduced after the transforming process. The de-identification approach simply detects the private data and deletes them (Neamatullah et al., 2008). To retain the usability of the transformed data as much as possible, many new models and methods are proposed. Privacy-preserving data publishing models, such as K-anonymity and l-diversity (Fung et al., 2010), and privacy-preserving data mining models and methods, such as privacy-preserving decision trees and associate rule mining (Aggarwal and Philip, 2008), have been developed as a result of these studies. The second category focuses on privacy data management. Many access control models and systems have been developed to enhance the flexibility of privacy data management and compliance with regulations. Elements such as access purpose, data content, and personal preferences have been brought into these data access management models (Byun et al., 2005; Smith, 2001). The third category focuses on privacy data storage and management. Privacy for data storage and management in a cloud environment has attracted plenty of attention in recent years. Approaches for privacy-aware data storage and auditing in a cloud environment are proposed to protect private data (Itani et al., 2009; Wang et al., 2010).

All approaches listed above may be used in privacy data sharing or management in some way. Many abstract frameworks have been proposed to realize privacy protection during data sharing, such as a framework for privacy preserving data sharing proposed by Chen (2004). Kennelly (2009) developed an Internet data-sharing framework for balancing privacy and utility. However, to the best of our knowledge, few research works about healthcare data sharing frameworks that preserve the privacy of users offer a practical view for real life application (Chen et al., 2012).

However, one set of methods that would allow health information to be used and disclosed under existing legal frameworks is de-identification. De-identification refers to a set of methods that can be applied to data to ensure that the probability of assigning a correct identity to a record in the data is very low (El Emam and Fineberg, 2009; El Emam et al., 2011). Recent studies (Bayardo and Agrawal, 2005; Campan and Truta, 2009; El Emam et al., 2012; El Emam and Dankar, 2008; El Emam et al., 2009; Goryczka et al., 2011; Jiang and Clifton, 2006; Jurczyk and Xiong, 2009; LeFevre et al., 2005; Parmar et

al., 2011; Sacharidis et al., 2010; Sokolova et al., 2012; Sweeney, 2002a, b; Tassa and Gudes, 2012; Truta and Vinay, 2006) indicate that the K-anonymity model provides a formal way of generalizing this concept because K-anonymity provides a measure of privacy protection by preventing the re-identification of data to fewer than a group of K data items. As stated in Sweeney and Samarati (Samarati, 2001;Sweeney, 2002a, b), a data record is K anonymous if and only if it is indistinguishable from its identifying information from at least K-specific records or entities. The key step in making data anonymous is to generalize a specific value. Generalized data can be beneficial in many situations as stated in (Chen et al., 2012; Jiang and Clifton, 2006). Many applications are used to generalize data in a many areas, including medical research, education studies, and targeted marketing.

STATE-OF-THE-ART PRIVACY PRESERVING

This study covers a review of the most relevant areas below and discuss how our work levels up with recent state-of-the-art systems.

Privacy preservation in data publication

The preservation of privacy when publishing data for centralized databases has been examined intensively in recent years. One thread of work aims at devising privacy principles such as k-anonymity and subsequent principles that address problems, which in turn serve as criteria for judging whether a published data set enables privacy protection (Nergiz and Clifton, 2007; Sweeney, 2002b). Another body of work has contributed to the development of an algorithm that transforms a data set to meet one of the privacy principles (dominantly k-anonymity). However, most of these works have focused only on structured data (Gardner and Xiong, 2009; Li et al., 2007; Xiao and Tao, 2007).

Medical text de-identification

In the medical informatics community, there have been efforts in de-identifying medical text documents (Gardner and Xiong, 2009; Sweeney, 2002b; Zhong et al., 2005). Most of them use a two-step approach which extracts the identifying characters first and then removes or masks the attributes for de-identification purposes. Most of them are specialized for specific document types, for example, pathology reports only (Gardner and Xiong, 2008; Zhong et al., 2005). Some systems focus on a subset of Health Insurance Portability and Accountability Act (HIPAA) identifiers, for example, name only (Aramaki et al., 2006; Gardner and Xiong, 2009), whereas others focus on differentiating protected health information (PHI) from non-PHI (Gardner and Xiong, 2009). Most importantly, most of these studies rely on simple identifier removal or grouping techniques, and they do not take advantage of recent research developments that guarantee a more formalized notion of privacy while increasing data utility.

Information extraction

Extracting atomic identifiers and sensitive characters (such as name, address, and disease) from unstructured text such as pathology reports can be seen as an application of the named entity recognition (NER) problem (Neumann, 2010). NER systems can be roughly classified into two categories, both of which are applied in medical domains for de-identification. The first uses grammar-based or rule-based techniques (Gardner and Xiong, 2008). Unfortunately, such hand-crafted systems may take months of work by experienced domain experts, and the rules will likely change for different data repositories. The second category uses statistical learning approaches such as support vector machine (SVM)-based classification methods. However, an SVM-based method such as that introduced by Sibanda and Unuzer (Sibanda and Uzuner, 2006) only performs binary classification of the terms into PHI or non-PHI. It does not also allow statistical de-identification which requires knowledge on different types of identifying characters.

PRIVACY PRESERVATION AND TECHNICAL CONTRIBUTION

In the following, the researcher explains technical contributions of the survey to data privacy through the control and sharing of data in knowledge management. We focus on six aspects of technical contributions, which we consider to be the most interesting (Xiao, 2009).

Personalized privacy preservation

We examined the work of (Xiao and Tao, 2006) on the publication of sensitive data using generalization, the most popular anonymization methodology in the literature. The existing privacy model for generalized tables (that is, noisy microdata obtained through generalization) exerts the same amount of protection on all individuals in the data set without catering to their concrete needs. For example, in a set of medical records, a patient who has contracted flu would receive the same degree of privacy protection as a patient suffering from cancer, despite the willingness of the former to reveal his/her symptoms directly (mainly because flu is a common disease) (Xiao and Tao, 2006). Motivated by this, we propose a personalized framework that allows

each individual to specify his/ her preferred privacy protection in relation to his/her data. Based on this framework, we devised the first privacy model that considers personalized privacy requests. We also developed an efficient algorithm for computing generalized tables that conform to the model. Through extensive experiments, we show that our solution outperforms other generalization techniques by providing superior privacy while incurring the least possible information loss (Xiao and Tao, 2006).

Republishing dynamic data sets

Data collection is often a continuous process, where tuples are inserted into and deleted from the microdata as time evolves. Therefore, a data publisher may need to republish the microdata at multiple times to reflect the most recent changes. Such republication is not supported by conventional generalization techniques because microdata are assumed to be static (Xiao and Tao, 2007). We address this issue by proposing an innovative privacy model called m-invariance which secures the privacy of any individual involved in the republication process, even against a rival who exploits the correlations between multiple releases of the microdata. The model is accompanied by a generalization algorithm whose space and time complexity are independent of the number n of generalized tables that have been released by the publisher. This property of the algorithm is essential in the republication scenario, where n increases monotonically with time (Xiao and Tao, 2007).

Complexity of data anonymization

We have presented the first study on the complexity of producing generalized tables, which conform to ℓ-diversity, the most commonly adopted privacy model. We note that achieving ℓ-diversity with minimum information loss is NP-hard for any ℓ larger than two and any data set that contains at least three distinct sensitive values. Considering this, we developed an O(ℓ.d)-approximation algorithm, where d is the number of QI characters contained in the microdata (Xiao, 2008). Aside from its theoretical guarantee, the proposed algorithm works fairly well in practice and considerably outperforms state-of-the-art techniques in several aspects (Xiao, 2008).

Transparent anonymization

Previous solutions for data publication consider the idea that the rival controls certain prior knowledge about each individual. However, they overlook the possibility that the rival may also know the anonymization algorithm adopted by the data publisher. Thus, an attacker can compromise the privacy protection enforced by the solutions by exploiting various characteristics of the anonymization approach (Xiao, 2008). To address this problem, we propose the first analytical model for evaluating the disclosure risks in generalized tables under the assumption that everything involved in the anonymization process, except the data set, is public knowledge. Based on this model, we developed three generalization algorithms to ensure privacy protection, even against a rival who has a thorough understanding of the algorithms. Compared with state-of-the-art generalization techniques, our algorithms not only provide a higher degree of privacy protection but also satisfactory performance in terms of information distortion and overhead estimation (Xiao, 2008).

Anonymization via anatomy

While most previous work adopts generalization to anonymize data, we propose a novel anonymization method anatomy which provides almost the same privacy guarantee as generalization does. However, it significantly outperforms it in terms of the accuracy of data analysis on the distorted microdata (Xiao and Tao, 2006). We provide theoretical justifications for the superiority of anatomy over generalization and develop a linear time algorithm for anonymizing data via anatomy. The efficiency of our solution was verified through extensive experiments.

Dynamic anonymization

We propose dynamic anonymization which produces a tailor-made anonymized version of the data set for each query given by users; the anonymized data increases the accuracy of the query result. Privacy preservation is achieved by ensuring that no private information is revealed despite combining all anonymized data (Xiao, 2008). For example, even if the rival obtains every anonymized version of the data set, he/she would not be able to infer the sensitive value of any individual. Through extensive experiments, we show that compared with existing techniques, dynamic anonymization significantly improves the accuracy of queries on the anonymized data (Xiao, 2008).

PRIVACY PRESERVATION MODELS

Recent developments in healthcare technology enable the collection, storage, management, and sharing of massive amounts of medical data (Lau et al., 2011). HISs are increasingly adopted in the healthcare sector (Dean et al., 2010; Makoul et al., 2001). The use of HISs allows specialists to access comprehensive medical information,

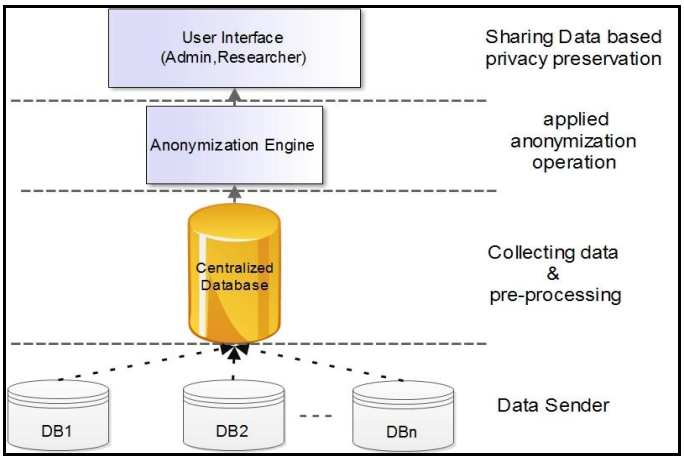

Figure 4. Collaborative healthcare information management system based on privacy preservation.

to extract knowledge and reduce medical errors, as well as to collaborate with other specialists and healthcare entities to improve the diagnosis and treatment of diseases. At the same time, reusing medical data offers the potential to improve medical research findings. However, reusing medical data must be performed in a way that addresses important privacy concerns.

Preserving the privacy of medical data is not only an ethical but also a legal requirement that is posed by several data sharing regulations and policies worldwide. For example, in 1996, the Health Insurance Portability and Accountability Act (HIPAA) title II was enacted in the USA (Act, 1996; Nosowsky and Giordano, 2006). One of the purposes of this act is to increase the protection of patients' medical records against unauthorized usage and disclosure. Hospitals, clinical offices, health insurance companies, and other entities governed by HIPAA are asked to comply with regulations. In 1997, the European Council announced Recommendation R (97) 5 regarding the protection of medical data to enhance the protection of personal healthcare data (DIRECTIVE, 1997). Similar regulations have been enacted in many other countries (Chen et al., 2012). For example, contracts and agreements cannot guarantee that sensitive data will not be carelessly misplaced and end up in the wrong hands. A task of the utmost importance is developing methods and tools for publishing data in a more hostile environment, so that the published data (shared data) remains practically useful while preserving individual privacy. This undertaking is termed privacy-preserving data publishing (Fung et al., 2009; Gkoulalas-Divanis and Loukides, 2011; Gkoulalas-Divanis and Verykiosc, 2009). Privacy-preserving data publishing and information security communities have recently begun addressing these issues. Numerous techniques have been developed to address the first problem, which is avoiding potential misuse posed by an integrated data warehouse (Vaidya et al., 2006). Many abstract frameworks have been proposed to realize privacy protection during data sharing, such as a framework for privacy preserving data sharing proposed by Chen (2004). Kennelly (2009) developed an Internet data-sharing framework for balancing privacy and utility. However, to the best of our knowledge, few research works about healthcare data sharing frameworks that preserve the privacy of users offer a practical view for real life application (Chen et al., 2012).

The finding form this section indicates to K-anonymity model is suitable methods in sharing information in healthcare sector. The main features of the K-anonymity model as mentioned in recent literature: K-anonymity is a simple and effective (Sweeney, 1997, 2002b) model that provides a measure of privacy protection by preventing the re-identification of data to fewer than a group of K data items (Jiang and Clifton, 2006; Narayanan and Shmatikov, 2009), providing a formal way of generalizing this concept (Samarati, 2001; Sweeney, 2002a, b), and minimizing data utility loss while limiting disclosure risk to an acceptable level (Morton et al., 2012). In addition, the K-anonymity model is a simple and practical model for data privacy preservation (Chiu and Tsai, 2007), and it guarantees that the data released are accurate (Barak et al., 2007).

COLLABORATIVE HEALTHCARE INFORMATION SYSTEM: PROPOSED MODEL

The collaborative healthcare information management system, which was based on the k-anonymization model and generalization technique, was developed to achieve the objective of improving collaboration and outcomes based on a privacy preservation approach. The proposed framework comprises four phases. The first phase involves collecting data from different HISs, and then sending the data to a central database. The second phase involves data pre-processing, such as missing values, inconsistent data, data integration, data selection, and data transformation. The third phase involves processing data based on the anonymization engine, which applies the anonymization operation based on the data generalization technique; this phase involves "a strategy for protecting individual privacy in released microdata records". The fourth phase involves sharing data among researchers based on privacy preservation as shown in Figure 4.

The idea is that by reconstructing a more "general" and semantically consistent domain for the attributes and transforming its values to this domain, identifying individuals by linking this attribute with external data would be much more difficult. From the perspective of information communication technology (ICT), the CHIMS construction was developed on the basis of an agent-based technique for linking the CHIMS units in different

departments at hospitals using Web-based application tools; in this stage collecting healthcare data from different HISs departments, and then sending the data to a central database. The second stage pre-processing data in this study the researcher assume the collected data of hospital departments is clear. Stage three collected healthcare data send to anonymization engine in order to privacy preservation; to anonymize data was applied generalization, which transforms attribute values of non-sensitive attributes in the data into values ranges, so as to prevent an adversary from identifying individuals by linking these attributes with public available information. In hospital environment the collaboration among medical staff increases the awareness of team members regarding their respective knowledge and skills, which leads to further improvements in decision making and improve the research findings in healthcare sector. Consequently, Collaboration is an important requirement in health information systems (HISs) because it produces reliable and rigorous evidence that can inform critical decisions related to healthcare services. It aids in the provision of proper, fast treatment to patients, and healthcare information for research.

CONCLUSION

Collaboration in HISs is important in providing proper and fast treatment to patients and suitable medical data for research. Collaboration among current healthcare departments is important in addressing most HISs problems and in satisfying all system requirements. These requirements must maximize information flows and storage among HISs units to provide information in an appropriate and timely manner based on privacy preservation. Anonymization approach has been successfully used to provide privacy preservation and to maintain data utility. Therefore, this study improved the collaboration research among physicians and researchers by developing CHIMS based on the k-anonymization model, which in turn addressed privacy preservation and improved healthcare services through adoption in HISs.

Conflict of Interest

The authors have not declared any conflict of interests.

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Vol. 10(5), pp. 196-209, 15 March, 2015
DOI: 10.5897/SRE2014.5953
Article Number:B6650E851280
ISSN 1992-2248

http://www.academicjournals.org/SRE

Scientific Research and Essays

Review

A review on cashew research and production in Nigeria in the last four decades

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Received 29 April, 2014; Accepted 11 February, 2015

Cashew (*Anacardium occidentale* L.); a tropical nut tree crop, is a source of food, income, industrial raw materials and foreign exchange for many countries of Africa, Asia and Latin America. In Nigeria, current cashew trading and exports is worth 24 billion naira ($160 million) and over one million people depend on the industry. Commercial cultivation of cashew in Nigeria dates back to more than 60 years, while research and development into its production, processing and marketing started in 1972. The past four decades were marked with introduction of exotic cashew genotypes, selection, cultivation and production from local and exotic varieties. Much discrepancies exists in yield records, current national production of raw nuts is estimated at 836,500 MT on 366,000 ha with an average yield of 2,286 kg/ha. Just about 5% of the produced nuts are processed in Nigeria. Unimproved planting materials, aging trees and low yields are part of the production constraints of raw cashew nut in Nigeria. There are records of selection and release of genotypes based on some desirable genetic attributes. Moreover, there are advances towards breeding for yield, quality and hybrid generation. This paper addressed the status of Nigeria cashew production, research efforts, achievements, constraints and areas of possible improvement.

Key words: Cashew, income generation, research, production, Nigeria.

INTRODUCTION

The cashew tree (*Anacardium occidentale* L.) is indigenous to Brazil and is an evergreen nut-bearing tropical plant that grows in latitude 15° north and south of the equator. It is a multipurpose tree crop with great economic importance to third world countries including Benin Republic, Brazil, Cote d'Ivore, Guinea Bissau, Ghana, India, Mozambique, Nigeria, Philippines, Sri Lanka, Tanzania and Vietnam. Morphologically, the architecture of cashew tree makes it a foremost tree crop for reclaiming land area to enhanced productivity, through the prevention of desertification and soil erosion. The drought resistant, evergreen cashew tree is economically grown for its nut, apple and wood. Products derived from the nuts include the world's highly delighted roasted kernel snacks, kernel oil, cashew nut shell liquid, and from the apple: juice, jam and alcohol among others.

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Cashew wood is also used for furniture and fishing boats. Of all, cashew nut is the most economic part of the cashew tree providing foreign exchange earnings for producer countries. In Nigeria cashew nuts exports represent 7 to 8% non-oil export earnings. The estimated export value varies from US$ 25 to 35 million annually (Nugawela and Oroch, 2005). Cultivation and processing activities in cashew provides employment and income generation for women and smallholder farmers in Nigeria (Akinwale, 2000; Topper et al., 2001). It supplements the income of about 50,000 farmers and an additional 55,000 people employed down its' value chain (Nugawela and Oroch, 2005) as harvesters, transporters, processors, marketers, exporters etc. Women are particularly involved in the cashew sub-sector more than in any other cash crop of the nation.

Although cashew was introduced into Nigeria more than 400 years ago, extensive cultivation started only in the early 1950's. From 1965 to 1990 cashew production was relatively static at 25,000 tonnes with estimated land area of 50,000 ha in 1990. Currently, cashew cultivation has spread to about 27 states of the country and in the past 12 years, production has increased almost thirty-fold from 30,000 MT in 1990 to 836,500 MT in 2012 from estimated land area of 366,000 ha (FAOSTAT, 2013).

The many importance of cashew makes it a topmost tree crop for intensive research. Breeding activities on Cashew in Nigeria started with germplasm introductions, followed by evaluations, selections, and release of identified superior varieties to farmers (Akinwale and Esan, 1989). Other research areas included assessments of morphological and molecular characteristics, ploidy status, reproductive biology, development of improved technology for large-scale production of value added cashew products, formulation of comprehensive farm management practices, soil and mineral requirements assessments and effective strategies for pest and disease control (Aliyu, 2012, 2004; Oduwole et al., 2001; Ibiremo et al., 2012; Asogwa et al., 2008). Attempts have also been made to develop rapid methods of propagation, including budding, grafting, marcotting and tissue culture protocols for mass multiplication (Aliyu, 2000, 2001, 2005). Efforts in these directions have broadened knowledge on cashew as a crop and contributed to enhancing its productivity. Presently however, increase in cashew production in Nigeria is attributed to increase in cultivated area, rather than to increase in yield per hectare. Moreover, plantings materials are usually unimproved open pollinated seed nuts that do not breed true to type. There is therefore the need to step up research to produce cashew varieties with improved yields and quality as well as standardise effective propagation techniques to clone them.

It is noteworthy to remark here that the Nigerian cashew nuts sell at a discount in the world market in the region of 20 to 30% (Nugawela and Oroch, 2005; Oroch, 2005; Topper, 2008). Among the limiting factor for good pricing of Nigerian cashew includes: Low quality, small nut and kernel size, and more importantly poor kernel peelability (that is, the difficulty in the removal of the testa from the kernel) which adds more to the cost of processing. Poor peelability may possibly be resulting from the single or complex effect of poor harvest, poor post harvest handling, abiotic factors or inherent genetic composition of the Nigerian cashew. Understanding the cause(s) of this problem would be a relevant research pursuit.

Biologically, *Analeptes trifaciata* (cashew stem girdler) and shoot wilt disease have been identified to cause significant yield reduction of cashew in Nigeria. Identification of effective control measure for this pest and disease is a requisite for enhanced cashew productivity in Nigeria.

Considering the significance of cashew in the livelihood and economy of the nation, a concerted research effort on improving nut quality and increasing production per land area is key. While this may change the place of Nigeria productivity status globally, it will also impact on local processing and consumption. The current status of Nigeria cashew production, research efforts, achievements, constraints and areas of possible improvement are hereby discussed.

BOTANY AND TAXONOMY OF *Anacardium occidentale* L.

Cashew (*Anacardium occidentale* L.) belongs to the order Sapindales, family Anacardiaceae and genus *Anacardium*. The Anacardiaceae family consists of about 75 genera and 700 species (Nakasone and Paull, 1998). Botanically, the Anacardiaceae includes primarily trees and shrubs with resin canals, resinous bark and clear to milky exudates. The trees or shrubs have alternate, often trifoliate or pinnate leaves. Flowers are generally not highly conspicuous and can either be unisexual or bisexual. Only one carpel matures, forming a drupe (a fleshy fruit with a stoney seed). In some cases, the drupy fruits produce an irritant called urushiol. Cashew is related to Mango (*Magnifera indica* L), Pistachio (*Pistacia vera* L), Poison ivy (*Toxicodendron rydbergii*) and Poison oak (*Toxicodendron diversilobum*) which are also in the Anacardiaceae family. In the genus *Anacardium*, nine species are identified under numerical taxonomy (Mitchell and Mori, 1987). These include *Anacardium corymbosum* Barb.Rodr.p, *Anacardium excelsum* L., *Anacardium giganteum* (Bertero & Balb. ex Kunth) Skeels, *Anacardium humile* Hance ex Engl., *Anacardium microcarpum* A.St.-Hil.,,ppp, *Anacardium nanum* A.St.-Hil., *Anacardium negrense* Pires & Froes, *Anacardium occidentale* L. and *Anacardium spruceanum* Benth. ex Engl. Of all, only cashew (*A. occidentale*) is of economic importance because of its edible apple and nutritious kernel.

CASHEW CENTRE OF ORIGIN AND SPREAD

Cashew originated in Latin America, specifically North-eastern Brazil (Ohler, 1979). Portuguese explorers introduced it to the tropics of Asia and Africa from where it spread into other parts of the world. At present, cashew is produced in 32 countries of the world with sufficient warm and humid climate. The main producers however are Brazil, Benin Republic, Cote d'Ivore, Ghana, Guinea Bissau, India, Mozambique, Nigeria, Philippines, Srilanka, Tanzania and Vietnam.

CASHEW IN NIGERIA

History

Cashew was introduced into Nigeria by the Portuguese traders around the 16th century (Woodroof 1967; Ohler, 1979). It was first planted in Agege, Lagos State, from it spread to a few other parts of the country through transfer of nuts by man. For over 400 years after introduction, cashew trees were exploited mainly for apple; no commercial value was attached to the nuts (Aliyu, 2012). Many of the trees flourished in the wild while being utilised for aforestation and erosion control scheme particularly in the escarpment areas of Udi in Anambra state. The first commercial cashew planting in Nigeria was in the mid 1950 at Ogbe, Oji, Udi and Mbala by the defunct Eastern Nigeria Development Corporation (ENDC) and Iwo, Eruwa and Upper Ogun by the defunct Western Nigeria Development Corporation (WNDC) (Akinwale and Esan, 1989; Asogwa et al., 2009). These plantations were established with introduced Indian cashew varieties. Progress in the cashew industry then was low due to general neglect and poor management of the plantations. With the involvement of private entrepreneurs, Federal and State Governments, and affluent farmers more nuts were obtained in 1978, 1980 and 1982 from India, Tanzania, Mozambique and Brazil to broaden the cashew genetic base of the country. Today, cashew cultivation has spread to almost all the states of Nigeria with increased processing, shipping and exporting activities. The major Cashew growing areas in the different parts of Nigeria in the order of the level of productivity with respect to the different regions of the country are: Enugu, Abia, Imo, Anambra, Ebonyi and Cross River States in the east and southern part, Oyo, Osun, Ondo, Ekiti and Ogun States in the western part, Kwara, Kogi, Nassarawa, Benue, Taraba, Niger, Federal Capital Territory (Abuja), Kaduna and Plateau in the Middle Belt and Sokoto and Kebbi States in the North-western of the country (Ezeagu, 2002; Chemonic 2002) (Figure 1). It is noteworthy that the majority of export quality nuts come from the Western and Eastern parts of the country.

Research efforts

Germplasm (different genetic composition) collection or assemblage is the first step in crop improvement programme. Desai (2008) reported that the initial germplasm collection and evaluation for cashew breeding programme in India, Brazil, Tanzania, Australia, and Mozambique started in 1970 and onwards. Similarly, research into the breeding, cultivation and use of cashew in Nigeria started in 1972 by the Cocoa Research Institute of Nigeria (CRIN). Many breeding trials were established from locally collected materials, and half-sib accessions from India, Tanzania, Mozambique, and Brazil (Sanwo et al., 1972; Adebola and Esan, 2002). Some of the trials conducted included grading, planting and evaluation of cashew according to nut weight and size. There were experiments to evaluate the performance of the Brazilian Jumbo nut type at different spacing of 9 × 9 m, 8 × 8 m and 6 × 6 m. The trials facilitated better understanding of the crops morphology and agronomy. Hybridisation trials showed both self and cross compatibility in cashew genotypes, but low percentage fruit set was recorded for hand pollinated flowers (Akinwale and Esan, 1989; Aliyu 2007, 2008). With respect to entomology and pathological research, suitable fungicide and insecticide mixtures were developed and successfully used to control the incidence of ravaging inflorescence blight disease of cashew. The screening and breeding of cashew genotypes for resistance to the disease and others including the cashew stem girdler (*Analeptes trifaciata*) insect pest is a feat to be achieved. Although cashew flourishes in soils where most other crops do not (Ohler, 1979) it does perform better with nutritional assistance. Cashew responded well to fertilizer application, especially during the vegetative growing period (Hammed et al., 2011). The use of organic fertilizer amended with phosphate fertilizer and arbuscular mycorrhizal fungi (AMF) inoculation were found to have positive influence on the growth of cashew and the chemical properties of the soil. Nigerian Sokoto rock phosphate was discovered a viable option to single super phosphate for cashew production (Ibiremo, 2010; Ibiremo et al., 2012). Recent work by Adewale et al. (2013) also revealed that the trend of growth and development of cashew genotypes differed in response to varied combination of soil nutrients.

On-farm evaluation of cashew accessions introduced from India, Tanzania and Mozambique led to the initial selections and subsequent release to farmers of half-sib cashew genotypes called the "G-series" in the 1980s with potential for high yield of 1000 kg nuts/ha (Akinwale and Esan, 1989; Aliyu, 2012). Although, Nigeria was first to release cashew seeds that have been evaluated to a certain degree to farmers compared with other African countries like Guinea, Guinea Bissau, Cote d'Ivoire and Ghana (Topper, 2002); there is still much to be done to improve seeds varieties and production.

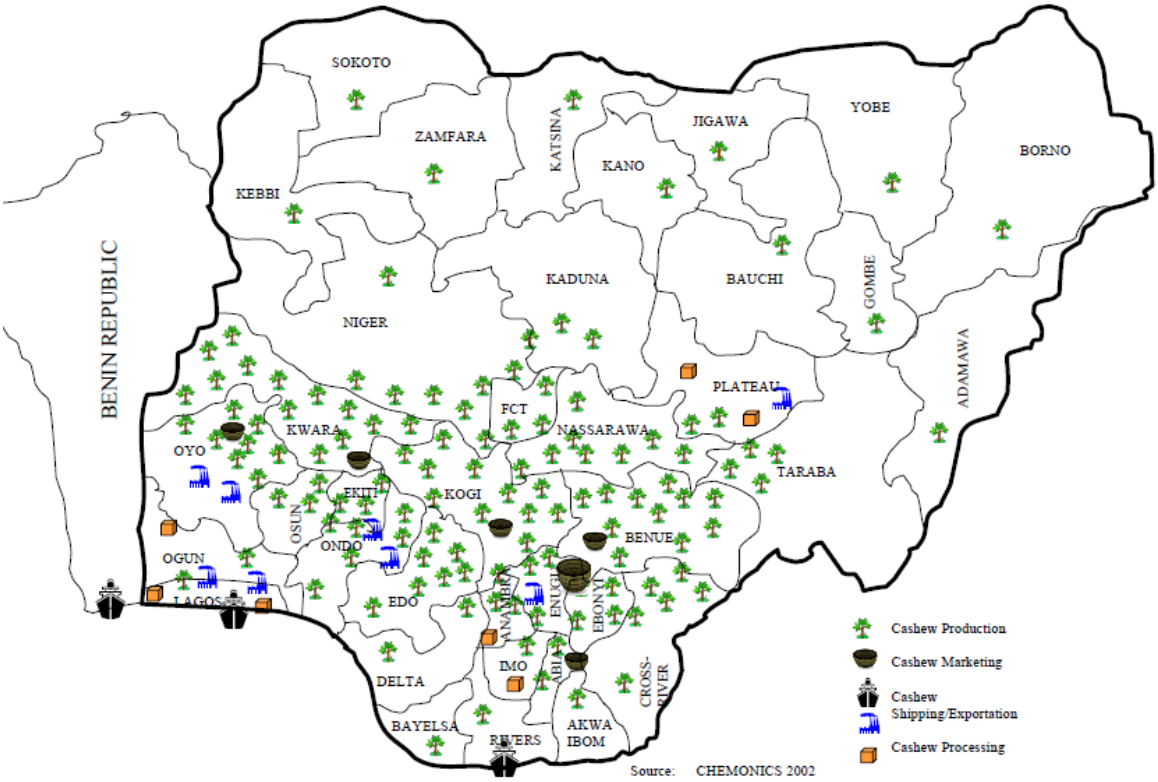

Figure 1. Map of Nigeria showing cashew growing areas. Source: Chemonics (2002).

Cashew nut production

In recent times, there has been a steady increase in Nigeria's annual cashew nut production from 466,000 MT in the year 2000 to 836,500 MT in year 2012. The production figure of 2012 for Nigeria worth 45% of cashew nuts produced in African (FAOSTAT, 2013; Table 1). Africa contributed over 45% of an estimate of 4,152,315 MT of the global cashew production in 2012. Other major cashew producing countries in Africa are Cote d'Ivoire, Tanzania, Mozambique and Guinea Bissau.

There are conflicting records of the position of Nigeria in cashew nut production in Africa and in the World. There are reports that Nigeria has led Africa in cashew nut production in the past decade with about half the African production (Table 1). Nigeria ranked second in the world in 2010, 2011 and 2012 with estimated nut production of 650,000, 813,023 and 835,500 MT respectively (Ogunsina and Lucas, 2008; Aliyu, 2011; FAOSTAT, 2013). African Cashew Alliance (ACA) 2011 report however gave cashew nut production estimates in Nigerian as 70,000 and 90,000MT for 2010 and 2011 respectively. This record placed Nigeria fourth position behind Cote d'Ivoire (9,385,000MT), Guinea-Bissau (190,000MT) and Tanzania (110,000MT) and seventh in the world (ACA 2012; Tables 1 and 2). These records of production may be based on unimproved planting materials in aged plantations and wild grooves. A committed research attention leading to release of better performing genetic materials may revolutionize cashew production in Nigeria. Potentials of Nigeria in cashew production seem promising.

The discrepancies in the above reports on cashew nut production in Nigeria could be largely due to poor commercialization and lack of proper documentations (Chemonics, 2002). Estimated production values cited for Nigeria are reported to be often times obtained from import records of buyers and informal sources (Chemonics, 2002). Since there is a lot of unknown border crossing of raw cashew nuts and unregistered small scale local processors; proper accounting is often inhibited. Production statistics are reported to be difficult to accumulate and only the Food and Agricultural Organisation (FAO) make an attempt at estimating and collating country data (Jaeger, 1999). More concerted efforts is required through a national cashew production survey for assessment and documentation of true production estimates in all producing states and regions of the country.

Cashew nut yield

Cashew tree yield of 1.5 to 4 kg of nuts/tree have been

Table 1. Cashew production (tons) in some African countries, total production for Africa, the world, percentage of Nigeria's production in Africa and Africa's production in the world for the period 2000 to 2012.

Country/year	2012	2011	2010	2009	2008	2006	2004	2002	2000
Angola	2000	2085	1750	1667	2088	1590	1307	1139	800
Benin	170000	70000	69700	49487	62000	55000	45000	46771	40000
Burkina Faso	5750	5876	4800	3168	3969	6141	4904	4364	3732
Cote d'Ivoire	450000	452656	380000	246383	308680	235000	140636	104985	63380
Ghana	36500	35736	28400	35647	44660	34000	25000	9000	7697
Guinea-B	130000	128684	91100	64653	81000	95000	96649	86000	72725
Kenya	29026	20927	8600	8381	10500	11349	9332	10031	12500
Madagascar	700	6677	6200	6072	7607	6700	7289	6349	6500
Mozambique	64731	72263	67200	67846	85000	62821	42988	50177	57894
Nigeria	836500	813023	650000	580761	727603	636000	555000	514000	466000
Senegal	6650	6996	5700	4031	5050	6332	5057	4500	7000
Tanzania	122274	75000	80000	79100	99100	77400	92810	55000	121200
Togo	6800	970	790	559	700	700	550	230	320
Africa Total	1882131	1702951	1399140	1151888	1443557	1235657	1032655	897746	862998
World Total	4152315	4201010	2757598	3350929	3982640	3502184	2900969	2239194	1932142
NPA	**44.44**	**47.74**	**46.46**	**50.42**	**50.4**	**51.47**	**53.74**	**57.25**	**53.99**
APW	**45.33**	**40.54**	**50.74**	**34.38**	**36.25**	**35.28**	**35.59**	**40.09**	**44.67**

NPA, Nigerian percentage in the total African production; APW, African percentage in the total world production. Source: FAOSTAT (2013) - http://faostat.fao.org/site/567/DesktopDefault.aspx?PageID=567#ancor.

Table 2. Different production figures in the top world cashew nut producers in 2010, 2011 and 2012.

Country	Production in Metric tonnes					
	2010		2011		2012	
	FAOSTAT	ACA	FAOSTAT	ACA	FAOSTAT	RRF
India	613000	465000	647600	400000	680000	554000
Cote d'Ivoire	380000	335000	452656	385000	450000	380000
Vietnam	1242000	300000	1272000	360000	1190900	280000
Brazil	104342	300000	230785	230000	80630	265000
Guinea-Bissau	91100	135000	128687	190000	130000	160000
Tanzania	80000	9000	75000	110000	122274	120000
Nigeria	682524	70000	813023	90000	836500	85000
Benin	69700	85000	70000	90000	170000	85000
Mozambique	67200	65000	72263	80000	64731	70000
Indonesia	145082	90000	122100	80000	117400	125000

Source: FAOSTAT (FAO Statistics, 2013); ACA (Africa Cashew Alliance 2012 reports); RRF (Red River Foods Inc., 2012 production estimates).

reported for Africa (ACA, 2011), and 7 to 11 kg of nut/tree for South Asia (ACA, 2011). In Nigeria, mature cashew tree nut yields of <1 kg to over 20 kg of nuts is obtained (Martin and Kasuga, 1995; Aliyu, 2004). Nut yield in the range of 7.82 to 14.04 kg/tree were also observed in some Nigerian cashew germplasm collections (Aliyu and Awopetu, 2007a). Desai (2008) obtained nut yields of 0.25, 2.41, 8.65, 10.02 and 30.50 kg/tree for some Tanzanian varieties. In India, cashew varieties with tree yield capacity of 10 to 13 kg of nuts/tree have been distributed to farmers (The Hindu, 2000). In Nigeria variability in tree yield is observed not only in different fields but also within particular farms and plantations. The wide margin in nut yield per tree is dependent on the genetic source of the materials (Martins and Kasuga, 1998; Aliyu, 2004; Aliyu, 2007). The contribution of environment, especially soil fertility and plant population may be very significant. Desai (2008) summarily attributed differences in nut yield to agro climatic conditions, age, inherent genetic makeup of the genotype or cultivar and the interaction of both with the environment.

Studies on cashew yield in Nigeria and Tanzania showed that about 30% of the tree population in a hectare produced 80% of the nut yield, while 20% of the yield comes from the remaining 70% of the trees (Martin and Kasuga 1995; Aliyu, 2004). This is a reflection of the productive capacity of most Cashew plantations in Nigeria.

Productivity by cashew genotypes in plantations is hinged on the procedure of planting material selection. Cashew cultivation in Nigeria is almost solely by sexual means. The planting materials are the readily available open pollinated and unselected nuts obtained in farmers' field or that of his neighbour (Chemonics, 2002). Continuity in the practise of the use of this type of planting materials may strongly impede the trend of both production and improvement of the crop.

Old age of tree is also implicated as another factor that contributes to low and variable yield. Available reports revealed that about 60% of Nigeria cashew plantations host very old cashew trees which have outlived their productive years with age above 30 years (Chemonics, 2002; Oluyinka, 2012). Research focused on generation and distribution of genotypes with high productive capacity to farmers may enhance cashew productivity in Nigeria. Rejuvenation of old plantations and establishment of new ones with improved varieties is a necessary immediate measure to increase the average cashew nut yield in Nigeria. Planting with clonal seedling as opposed to open pollinated seed and seedling is advised. The use of clonal seedlings has advantage of producing uniformly yielding trees that reaches fruit bearing in about two years after establishment as against the long gestated sexual seedlings from open pollinated nuts (IRD, 2011). The incorporation of bee farming within a cashew plantation has also been reported to enhance pollination for increased fruit set (IRD, 2011), adoption of this technology in Nigeria cashew plantation could improve nut productivity.

Mode of cashew propagation

Cashew is propagated mainly from the seed in Nigeria. Since seed nut incorporate a wide range of genetic diversity, the genetic integrity of a particular clone or genotype can only be preserved through vegetative propagation. Several methods of vegetative propagation have been attempted in cashew *viz.,* air layering, inarching, budding, marcotting or grafting which may be epicotyls, soft wood, or flush side grafting. The degree of success of each varied in different countries with attending limitations. Of all the methods, grafting wasreported to be the best for large-scale clonal seedling production of cashew. Tip or bud grafting is used in East Africa, India, Brazil, and Ghana and up to 100% success rate have been obtained with 10-week old seedlings. Some factors identified to affect the success of grafting includes period of the year or season of grafting. For example, period with high maximum temperature and minimum humidity were marked with higher rate of grafting success. Moreover, the type of propagation structure (mist house, green house, open air and under shade) and the length of the scion have equally been identified as success determining factors (Sagar, 2007).

In Nigeria, standardization of vegetative propagation techniques has been one of the important thrust areas in research. Budding and grafting method were carried out with low level of successes. Earlier trials revealed the effect of age of root stock and defoliation or non defoliation of stock and scion on the success of budding and grafting. In an experiment by Aliyu (2001), grafting on 2, 3 and 4 months old root stock gave better result than the ones on 4, 5, 6 and 7 months old rootstock. In addition, budding success was between 10 to 44% while sprouting percentage was 0 to 14%. In the cleft grafting method, success was 4 to 40%, while sprouting was ranged between 4 to 8%. However in both cases, the sprouts did not reach maturity (Aliyu, 2000, 2001). The significant low success turn out seem to inform the need to standardize the vegetative propagation methods in Cashew for higher success rate to meet commercial demands.

Efforts have been made in the application of tissue culture technique for mass propagation of cashew (Aliyu, 2005; Aliyu and Awopetu, 2005). *In vitro* culture has proved successful for many horticultural fruit species (Ammirato *et. al*., 1984). The recalcitrant nature of cashew, abnormal development of calli from explants, and browning of explants were some of the limiting factors to the tissue culture success observed in cashew in Nigeria (Aliyu, 2005). Browning of explants has been reduced through frequent transfers, addition of activated charcoal and dark treatments. Furthermore, use of explants from *in vitro* germinated seedlings, or fungicidal treated young flush in MS (Murashige and Skog) basal salt medium supplemented with cytokinins was found to improve the *in vitro* success rate of cashew significantly (Aliyu, 2005). However culture to full plant and successful transfer to field has not been achieved.

Cashew varieties

Genetic variability exists in cashew germplasm evaluated in Nigeria. Some of the most important morphological distinguishing characteristics of cashew are: Nut size, form of tree, apple colour (yellow, orange or red), disease resistance, fruit bearing capacity, etc. (Aliyu, 2007). Based on nut size, there are six different size classes capable of meaningful description of cashew characterization (Plate 1). The nut weight significantly correlates with the size, hence the six different sizes of Jumbo (>16 g), extra large (12-15 g), large (8-11 g), medium (6-7 g), small (2-5 g) and madras (≤2 g). Earlier report by Hammed et al. (2008) documented that compensatory nut yield exists among cultivars in the

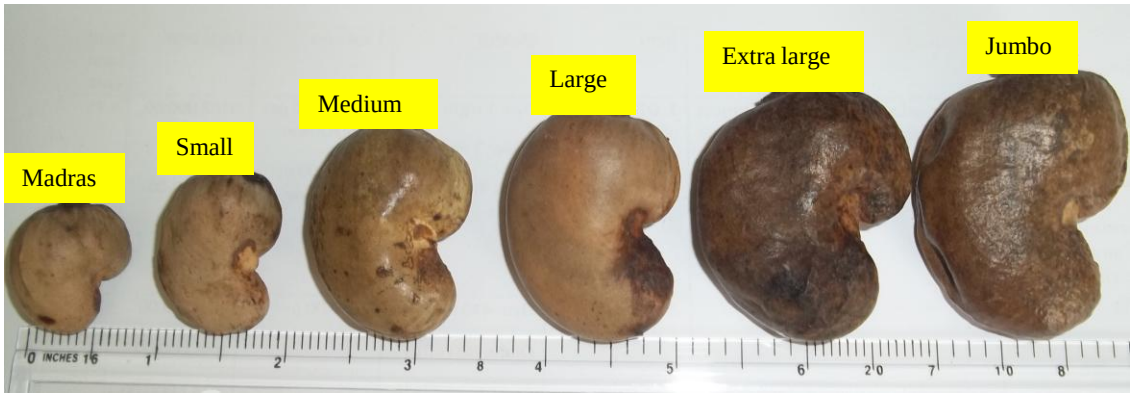

Plate 1. Different sizes of cashew nuts. Source: Adeigbe, 2013 Unpublished.

different size classes: cashew trees with heavier nuts (Jumbo) yield less (8-10 kg/tree) while trees with lighter nuts (e.g. medium and madras) of equal maturity age yields more (30-250 kg/tree). The varieties released in 1980 by the Cocoa Research Institute of Nigeria (Akinwale and Esan, 1989) were characterised with minimum-sized nuts and a yield of 1000kg/ha. Further efforts at evaluating and documenting the existing germplasm in the country lead to the identification of three varieties with superior characters (Table 3). The Indian accessions were found to be highly productive (2500 kg/ha) but produced small sized nuts with kernel quality in the range of W320 to 450. It is noteworthy that the benchmark grade for high quality cashew kernel is W320; this refers to a standard where 320 white cashew kernel amount to a pound by weight. From Table 3, the lesser yielding Jumbo varieties however produce highest exportable cashew kernel grade of W180 and higher volume of apple juice (Aliyu, 2004; 2007, 2011). Presently, majority (about 80%) of Nigerian cashew trees produce small to medium nut size, supposedly obtained from the Asian genetic sources, remaining 20% of trees are grown from large sized (Brazilian) nuts (Aliyu, 2011). Cultivation is recommended for cultivars that have a high kernel grade of W180, 210 and 240 which attract higher prices in the world market. Combining higher nut yield with high kernel grade in one genotype is an important breeding focus to meet up with the global quality challenge and good pricing.

Genetic diversity

For any meaningful genetic improvement programs, a vast understanding of the genetic diversity of existing germplasm is essentially important. DNA based markers in genetic analysis of cashew have been attempted in Brazil (Neto et al., 1995), India (Karihaloo and Archak, 2000), and Tanzania (Mneney et al., 2001). Both morphogenetic marker study and RAPD analysis were used to elucidate the genetic relationship of Indian cashew germplasm (Dhanaraj et al., 2002 Samal et al., 2003). Similarly, phenotypic and molecular markers have been used to quantify the extent of variation among the cashew germplasm collections in Nigeria (Aliyu and Awopetu, 2007a). Application of molecular methods of classification using Simple Sequence Repeat (SSR) markers and the application of Poly Acrylamide gel electrophoresis (PAGE) analysis to some Nigeria cashew accessions (Aliyu and Awopetu, 2007b) revealed results which corroborated those obtained from morphogenetic marker. The analysis also revealed genetic redundancy and existence of narrow genetic base within the Nigeria cashew germplasm (Akinwale and Esan, 1989; Aliyu and Awopetu, 2007a, b). Similar diversity studies undertaken in Tanzania and India revealed a narrow genetic base within geographic cashew variety groups (Mneney et al., 2001; Archak et al., 2003). Further exploration of the Brazilian cashew biotype will broaden its genetic base in Nigeria (Hammed et al., 2008).

CASHEW RESEARCH POTENTIALS AND PROSPECTS

Breeding for improved genotypes

Good planting material is a very important input in crop production because it determines the upper limits on yield and the ultimate productivity of other inputs. Objectives of crop improvement in cashew generally include development of new high yielding commercial varieties with such characters as desired tree size (dwarf / semi dwarf canopy), bold nut size (>8 g) with higher shelling percentage (>28%) and higher kernel grade (180 to 210W), bigger and juicy apple, resistance / tolerance to biotic stress (pests and diseases) and abiotic stress (Bhaskara Rao, 1998; Bhaskara Rao *et al.,* 1998; Harries et al., 1998). Besides the above (with respect to Nigerian cashew quality) breeding for increased testa peelability is very novel so as to improve Nigerian competitiveness in the cashew global market. Screening of the wide

Table 3. Main cashew nut size varieties in Nigeria.

Cashew nut size	Source	Nut weight	Fruits per tree	Nut yield	Period from planting to fruiting	Kernel quality
Small/medium /large	Asian continent	4.5-8.2g	3000	2500kg/ha 30-250kg/tree	Mid season fruiting, fruit matures in March	W320+W450
Large to extra-large	Brazil	8.5-14 g	**	Moderately high yielding**	Early fruit production and short harvesting period	W320+W240
Jumbo	Brazil	16 g and above	300-400	200kg/ha, (also with high vol. of apple juice yield) 8-10kg/tree	Late and irregular flowering and fruiting	W180

*Exact data not available; Source: Aliyu (2012).

germplasm for these and other traits may lead to the identification of some specific genotypes which may be selected, multiplied and released to farmers. While such procedure may lead to short term variety release, wide crossing of parents in a breeding programme would be necessary for introgression of some economic traits with composite features in hybrid varieties. Currently, Nigeria Cashew germplasm consists mainly of exotic varieties (Adebola and Esan, 2002); there is no record of an improved hybrid cashew as is obtained in some other producing countries.

There are reports of improved hybrids in Australia (Blaikie et al., 2002) and developed clones in Tanzania (Masawe et al., 1998). Diversity within the Tanzanian cashew gene pool was improved through the development of over 100 hybrids (NARI, 2008). High-yielding dwarf genotype was reported (Ashante et al., 2002) to have been developed in Brazil; the variety gave good yields, precocious fruiting and bold nuts. Lack of hybrid production in Nigeria may be due to the low rate of fertilization and lack of progression to maturity obtained in previous hybridization trials (Aliyu, 2008). Poor fertilization may be due to incompatibility (Aliyu and Awopetu, 2005), leading to reduced fruit set. From records, fruit-set in cashew can be as low as between 0.7 and 4.1% (Rao, 1956; Aliyu, 2008). In earlier reports, poor fruit set, excessive premature fruit drop have been reported in the crop (Nawale et al., 1984; Patnaik et al., 1985). Another reason for difficulty of hybrid generation in cashew may be due to differences in ploidy level of parents. Polymorphic chromosome number of 2n = 24, 30, 40, 42 have been observed in some cashew populations (Deckers et al., 2001; cited in Aliyu and Awopetu, 2007b). Cytological examination of some Nigeria cashew populations revealed a diploid and haploid chromosomes of 2n = 42 and n = 21 respectively (Aliyu and Awopetu, 2007b), further screening for ploidy levels and particularly of parent before hybridisation may be useful in promoting proper match of chromosome for higher fruit set. Identification of good parental lines is important in enhancing the effectiveness of hybridization programme. Furthermore, adoption of polyploid breeding in cashew might open opportunity for development of improved varieties and widening of the genetic base of the crop.

Cashew quality

Generally, the mode of production, collection and storage practises affect the quality of cashew nuts. Smallholding farmers may harvest apple to meet urgent cash needs, without minding the maturity status of nuts. This practice contributes to about 40% post-harvest losses of cashew nuts. Immature nuts have high moisture content and are unfit for export. Inadequate drying and improper storage, for example, the use of polythene bags instead of jute bags to store harvested cashew nuts enhances the deterioration of stored kernels. Training farmers on good cashew production practises right from the field to storage might help to alleviate defects in nut quality due to these factors. In addition, government support for smallholder farmers to improve their livelihood would reduce the menace of harvesting immature nuts.

Due to poor peelability of cashew testa from the kernel, about 64% of the total labour for processing 180 metric tonnes of raw nuts by a small-scale processing plant per month is expended on peeling testa alone (Chemonics, 2002). This has brought significant losses to processors and indirectly Nigerian Cashew farmers. While this problem explain for loses and poor pricing of the Nigerian Cashew, it equally answers for its poor acceptability in the global market. The possible cause either genetic or environmental needs to be investigated. Solution through research would be most welcome as this would enhance the acceptability and worthwhile pricing of Nigerian Cashew. It would also encourage small-scale cashew processors who cannot afford high cost peeling machines. Probable research activities to solving this problem may include: Exploration and collection of cashew genetic resources, evaluation for peelability and trait-specific selection for onward breeding programme.

Table 4. List of the economic pests of cashew.

S/N	Common name	Scientific name	Region of high importance	Source
1	Cashew stem girdler	*Analeptes trifasciata*	Nigeria	Topper (2002), Chemonics (2002), Asogwa et al. (2011)
2	Red-banded thrips (foliage thrips)	*Selenothrips rubrocinctus*	Nigeria	Asogwa et al. (2008)
3	Leaf miner	*Acrocercops syngramma*	India	Maruthadurai et al. (2012)
4	Fruit scrapper	*Pachnoda cordata*	Nigeria	Asogwa et al. (2008)
5	The tea mosquito	*Helopeltis antonii*	India, Guinea, Guinea Bissau, Cote d'Ivoire and Nigeria (low damage level)	Boma et al. (1998), Topper et al. (1998), Topper (2002), Maruthadurai et al. (2012)
		Helopeltis anacardii, H. schoutedenii and *Pseudotheraptus wayi* Brown	East Africa and Tanzania	Boma et al. (1998), Topper et al. (1998), Agboton et al. (2013)
		Anoplocnemis curvipes	Cote d'Ivoire and Ghana	Topper, 2002
6	Stem and root borer	*Plocaederus ferrugineus* L.	Indian and Nigeria	Maruthadurai et al. (2012), Asogwa et al. (2008)
7	Apple and nut borer	*Thylocoptila panrosema*	Indian	Maruthadurai et al. (2012)
8	Thrips	*Thysanoptera: Thripidae*	Guinea and Ghana	Topper (2002)
9	Flower thrips	*Rhynchothrips raoensis*	India (minor)	Maruthadurai et al. (2012)
10	Mealy bug	*Ferrisia virgata*	India (minor)	Maruthadurai et al. (2012)
11	Leaf roller	*Euprotis faciata*	Nigeria (minor)	Asogwa et al. (2008)
12.	Leaf and blossom webber	*Lamida moncusalis*	India (minor)	Maruthadurai et al. (2012)

Cashew from Benin Republic has the highest kernel peeling ability in Africa (OLAM, per. Comm.).

Pests and diseases

On the field, production of cashew is mostly impaired by insect pest complexes (Hammed et al., 2008). The Entomological unit of Cocoa Research Institute of Nigeria has archived the collection and identification of insect pests of cashew since 1971. Moreover, information on their symptoms was harnessed and protocols to reduce their menace were formulated (Asogwa et al., 2008). The inexhaustible list of the major economic insect pests of cashew in Nigeria is presented in Table 4.

The insect species have been implicated with economic losses estimated between 52 and 75% of the production level (Ojelade, 1998). *Analeptes trifasciata* was reported to produce a significant damage to cashew in Nigeria (Topper, 2002; Chemonics, 2002; Asogwa et al., 2011) while low level of *Helopeltis* incidences is recorded (Topper, 2002); although, they are the main insect pests of cashew in East Africa and India (Boma et al., 1998, Topper et al., 1998; Topper, 2002). A survey in Nigeria showed a wide spread of *Analeptes trifaciata* infestation in almost all cashew producing states; making it an economic pest (Igboekwe, 1984; 1985; Asogwa et al., 2011). In the past, little or no importance was accorded to the insect (Asogwa et al., 2011), but over time, there seemed to be a progress in the pest spread as cashew continued to expand and increase. The life cycle of the insect starts with the brightly coloured adult male and female "longicorn" beetles (black with 3 orange bands on wings). These feed by scrapping the back of cashew stem causing a V- shaped groove which leads to eventual girdling and falling off of the affected stem/branch and loss of all the fruit such branch may be carrying. Cashew yield loss due to *A. trifaciata* infestation could be up to 54.8% (ERLS, 1988). The dead wood tissue so formed provides a breeding site for the eggs laid by the adult female after mating. The eggs mature to larvae which burrow the dead wood and develop through the pupal stage into adults.

Similarly, cashew production is seriously affected by three major diseases (Table 5). Of the disease pathogens, *Lasiodiplodia theobromae* is implicated with up to 70% reduction in nut yield, and more than 50% death of vegetative shoot (Hammed et al., 2008).

Among control measures identified for keeping these insect pests and diseases below economic threshold includes good farm sanitation, picking and burning of infected twigs, and chemical spray. Frequent application

Table 5. List of notable diseases of cashew.

S/N	Common name	Disease type	Causal organism	Region of most severity	Source
1	Floral shoot and twig die-back	Fungal	*Lasiodiplodia theobromae* (Pat) Giffon and Maubl	Nigeria	Olunloyo (1979), Adejumo (2005), Asogwa et al. (2008)
2	Root rot of cashew seedlings	Fungal	*Pythium ultimum*, Trow	Nigeria	Hammed et al. (2011)
3	Anthracnose of shoot	Fungal	*Colletotricum gloespoiroides*	Brazil	Topper (2002)
4	Damping off	Fungal	*Fusarium* sp.	Nigeria	Asogwa et al. (2008)
5	Powdery mildew	Fungal	*Oidium sp.*	Mozambique East Africa	Desai (2008), Davis (1999)

of insecticides was recommended (Topper, 2002) for the control of *Analeptes trifasciata*. The body chemical components or the hard cuticle of the insect may however prevent prompt response to chemical treatment. *Analeptes trifasciata* has been found most responsive to chemical control at the time of the year when the body fat content is low. Removal of alternative hosts (*Adansonia digitata* and *Ficus mucosa*) in addition to burning of infected twigs may be necessary to effectively check the spread and damage of *A. trifasciata* on cashew trees.

Use of botanicals has also been found effective in the control of some pests. Field application of *Pipper guineense* as a spray at 5 and 10% and combination of garlic (*Allium sativum*), *Pipper guineense, Ocimum gratissimum* and *Chromonaena odorata* at 5, 7.5 and 10% have been found to reduce incidence of inflorescence die-back disease (*Lasiodiplodia theobromae*) (Adejumo and Otunoye, 2002; Adejumo, 2005). Furthermore, the use of resistant varieties of Cashew seems a promising option for the control measure programmes. Screening of some genotypes of cashew led to the identification of ten genotypes with relative tolerance to cashew inflorescence blight disease in Nigeria (Olunloyo, 1994; Adejumo, 2005).

Organic cashew

Cashew is grown without the use of agro-chemicals in Nigeria, the organic nature of Nigeria cashew is currently a pride (Hammed et al., 2008). The use of chemicals is mostly on experimental fields. Efforts must be made to uphold the status by breeding Cashew for resistance to major pest and diseases. This will in turn prevent chemical pesticides contamination. Promotion of certified organic cashews will improve the export value of cashew products and open new markets to Nigerian exporters. Organic cashew snack products are in strong demand, with sales increasing at over 80% per year in the US market (Chemonics, 2002).

End use production

Research into end use potentials of cashew promoted the development of various innovative products from its apple and nuts. Value addition through processing of agricultural produce has potential to improve it shelve life and increase income of producers (Lawal and Jaiyeola, 2007). Cashew kernels are roasted, fried, spiced, or honey coated and sold in different packages and sizes as snacks. Oil has been mechanically extracted from the cashew kernel which has higher stability at 80 degrees centigrade compared with other commercial oils like palm oil, groundnut oil, corn oil, or cocoa butter. The cashew kernel oil is promising for food and industrial uses. There has been development of improved technique for processing cashew apples into wine, jam, and non-alcoholic beverage of a high nutritional value with vitamin C content of 170-180 mg/100 ml juice.

Local juice extractor/processor that produces cashew apple juice adaptable for use on a cottage industry scale has been fabricated and found economically viable (Akinwale et al., 2001; Oduwole et al., 2001). Developed cashew meal from the kernel including bread, candy, cake, biscuits coated with chocolate is found to have good and acceptable organoleptic properties. Cashew nut shells have been incorporated in fertilizer composition, ruminant feeds and hydraulic paints. In view of the food, industrial and medicinal uses to which cashew tree and its products can be put (Table 6), it appears to be one of the most intensively utilised plant in the world. It offers continual opportunity for investment, as well as great potential for economic development (Olife et al., 2013).

Toward improved cashew nut production in Nigeria; a lesson from Vietnam

At present, Vietnam is the leading producer of cashew nuts in the world. Cashew was introduced to Vietnam in the 18th century, much later than in Nigeria; where the trees gained significance as the most important plant of the countries' National Poverty Reduction Programme. Cashew was made a greening factor for reproducing bare hills and vacant lands, which lead to rapid expansion of total area of cashew trees. Moreover, high yielding varieties

Table 6. Uses of cashew.

Cashew parts	Products	Uses	Medicinal importance	Source
cashew tree	Leaves and stem back	For making local concoction	Bactericidal, germicidal, and herbal heath benefit: stops diarrhoea, dry secretion, increase the libido; reduce fever, blood sugar and pressure.	Olife et al. (2013), Dahake (2009), Masaki (1999)
Cashew stem and branches	Wood/timber	Furniture, fishing boats and ship rollers (highly resistant to termite attack)		Chipojola et al. (2009)
cashew stem	Ink and vanishes	Indelible ink for marking and printing linens and cottons		
	Glues	Adhesive for woodwork panels, plywood and bookbinding. Insecticidal properties which prevent insects eating new boxes and books		
Apple	Apple concentrate	For making Juice, juice concentrates, liquor, vinegar, jam, and beverages.	Has higher vitamin C content than guava, mango, and oranges (146.6 - 372.0 mg / 100g fresh apple juice)	Olife et al. (2013)
	Apple flesh	For making pickle, chutney and candied products		
	Pressed cake from apple	Used for cattle feed after drying		
Cashew nut	Cashew kernel	For making snacks, confectioneries, butter, milk	High in protein (21%), carbohydrate (22%), oil, vitamins (thiamine), and 47% fat (heart friendly monounsaturated fatty acid); also rich in manganese, potassium, copper, iron, magnesium, zinc, selenium and zea-xanthin for preventing deficiency diseases and serving as antioxidants	Blomhoff et al. (2006)
	Cashew nut kernel oil (CNKO)	Sweet edible oil		
	Pressed cake from CNK (pomase)	Human and animal feed		
Cashew nut shell	Cashew nut shell liquid (CNSL)	Has high proportion of phenolic compounds. Manufacture of vehicle break lining compounds, water proofing agents, preservative, paints, plastics, type writer rollers, oil and acid-proof cements, industrial floor tiles	Potent antimicrobial agent for treating scurvy, sores, warts, ring worm, psoriasis, leprosy, elephantiasis, and corns.	Mc Conville (1997)
	Cashew shell	Manufacture of cashew shell resin and as fuel in processing units		
Cashew inflorescence	Sweet scented flower	Apiary development and honey production		ACA (2012)

cover an area of 305,791 ha, recording higher yields per hectare compared to all other producer countries (Table 7). Survey of cashew production across Nigeria in 2001 revealed that less than 20% of the available crop able lands are under cultivation in most of the Cashew producing states in Nigeria (Topper et al., 2001). Daramola et al. (2005) also reported that only 34.2 million hectares (about 48%) of the cultivable land area (71.2 million hectares) are actually being cultivated out of the total Nigerian land area of 98.3 million hectares. This

Table 7. Cashew yield and area under cultivation in the world and some cashew producing countries.

Cashew yield and area of cultivation in 2012			
Countris	**Production (tonnes)**	**Area under cultivation (Ha)**	**Yield (Kg/Ha)**
World	4152315	5313415	781.5
Vietnam	1190900	305791	3,894.5
Indian	680000	965000	704.7
Brazil	80630	756847	106.5
Nigeria	836500	366000	2,285.5
Cote dlvoire	450000	900000	500.0
Tanzania	122274	410641	297.8
Senegal	6650	17000	391.2
Benin	170000	468000	363.2
Mozambique	64731	80000	809.1
Indonesia	117400	585300	200.6

Source: FAOSTAT 2013.

implies that there are prospect for future expansion of Cashew production in Nigeria. Nigeria has the potential to become the World's number one raw cashew nuts producer if more land is put into the cultivation of improved high yielding and good quality cashew genotypes.

CONCLUSION

Although, Nigeria has a cashew cultivation history of more than four hundred years, research and development into its production, processing and marketing started some forty years ago. Over those years, there have been intensified efforts to boost cashew research for improved production. Increasing demand for cashew nuts as raw materials in the confectionery and industrial trade in Europe has stimulated cashew exportation from Nigeria. As remarked in Adewale et al. (2013), the less health risk from the consumption of cashew is one of the attracting reason for increasing consumption and demand. The protein in cashew is abundant (>20%) and of a high quality probably more than in meat or fish (Soman, 1997), cited in Adavi (2008). The soluble sugar in the kernel is almost as low as 1%; hence, cashew nut consumers are therefore privileged to get a sweet taste without having to worry about excess calories (SasiVarma, 2002). West Africa is now the major supplier of raw materials to the Indian processing sector (Chemonics, 2002). Few among the list of possible ways to increasing cashew production in Nigeria are: development of improved hybrids, establishment of new plantations with genotype of proven quality and yield, rehabilitation of old plantations with improved clones/ varieties, etc. Basic research should focus on: improvement in size grades and overcoming testa-peeling difficulty problems. Improvement in harvest and post-harvest handling protocols through extension programmes would in no measure increase global acceptability and better pricing of Nigerian cashew.

Conflict of Interest

The authors have not declared any conflict of interest.

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