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Full Length Research Paper

Use of indigenous knowledge in the management of field and storage pests around Lake Victoria basin in Tanzania

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Agriculture in Lake Victoria basin (LVB) in Tanzania is predominantly subsistence and is characterised by perennial food deficits, cyclic famines and poverty prompted largely by unreliable rainfall patterns, declining soil fertility and food grains pests and diseases. The pest problem is more pronounced as farmers are yet to fully integrate synthetic pesticides into their insect pest management systems due to subsistence nature of production and high poverty levels that make them rely on indigenous knowledge (IK) systems to meet their needs. The survey was conducted to document farmers' IK on management of key field and storage insect pests in Magu and Misungwi districts in the LVB, Tanzania. Major crops grown were maize, rice, sorghum, finger millet, bean, groundnut, cowpea, green gram, brassicas, chicken pea, cassava, sweet potato, cotton and vegetables. Crops were mainly infested by *Busseola fusca* (Lepidoptera: Noctuidae), *Spodoptera spp* (Lepidoptera: Noctuidae), *Agrotis spp* (Lepidoptera: Noctuidae), *Maruca vitrata* (Lepidoptera: Crambidae), *Rhopalosiphum maidis* (Homoptera: Aphididae), *Aphis fabae* (Hemiptera: Aphididae), and grasshoppers in field and *Stophilus spp* (Coleoptera: Curculionidae), *Prostephanus truncates (*Coleoptera: Bostrichidae), *Tribolium spp* (Coleoptera: Tenebrionidae), *Bruchus rufimanus* (Coleoptera; Bruchidae), *Rhyzopertha dominica* (Coleoptera: Bostrichidae) and rodents on storage. IK based control methods used by farmers ranged from animal by-products (cow's urine and dung), plant parts *(Azadirachta indica* (Meliaceae),*Tephrosia vogelii* (Fabaceae), *Tamarindus indica* (Fabaceae), *Aloe spp* (Asphodelaceae), red pepper, *Capsicum spp* (Solanaceae), *Nicotiana tabasum* (Solanaceae) to ash (general and specific) in the field. They also used neem, *Chenopodium opulifolium* (Chenopodiaceae), *Ocimum suave* (Labiatae), *Senna siamea* (Fabaceae or Caesalpinioideae), tobacco and *Eucalyptus spp* (Myrtaceae) and plant by-products (rice husks, ash from rice husks and red maize cobs and general ash) to control storage pests. Most of these products were used together with one or two others in different formulation mixtures. However, the formulations had variable amount taken during preparation, crop/ crop product treated, preparation times, modes and rates of application. Research is needed to unveil the amount for mixing, appropriate treatment, and application rate to ensure optimum concentration for specific pest. To ensure quality and safety, bio-safety and quality studies are required for quality assessment of resulting product for human health. For understanding of active compounds in the formulations, chemical composition analysis of properly prepared solutions is required.

Key words: Field and storage pests, indigenous knowledge, Tanzania, botanical formulation, Lake Victoria basin.

INTRODUCTION

Agriculture in the Lake Victoria basin (LVB) in Tanzania is predominantly subsistence and is characterised by perennial food deficits, cyclic famines and poverty prompted largely by unreliable rainfall patterns, declining

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soil fertility and food grains pests and diseases. The latter poses the greatest threat to increased food production, storage and handling with insects accounting for 15 - 100 and 10 - 60% pre- and post-harvest food grain losses respectively (Saxena et al., 1990; Wanjekeche, 1997). Although the use of synthetic pesticides have been promoted in the LVB for the past 3 - 4 decades, farmers in the region are yet to fully integrate them into their insect pest management systems due to the subsistence nature of production and high poverty levels (Ogendo et al., 2003a, b). This makes them to rely on indigenous knowledge (IK) systems to meet their daily needs (Mugisha-Kamatenesi, 2004) which are most relevant to the rural poor and marginalized population. The high costs of synthetic pesticides and associated toxicity risks discourage to integrate into insect pest management systems (Mihale and Kishimba, 2004; Ogendo et al., 2004).

Revelations that subsistence farmers in the tropics use traditional methods to preserve their stored agricultural products and the noble promise for the development of suitable, simple, natural and environmental friendly pesticide products has provided impetus for the scientific improvement and packaging of the existing IK base and practices. The realisation that a farmer's IK ("putting the last first") holds the key to the success of any pest management endeavours at farm level has shifted the focus and approach. Despite the enormous potential that has existed for generations, the plant based indigenous pest control practices have remained largely unexploited with limited regional research intervention and resources committed.

Researches in the LVB have identified several indigenous plant based pest management options used for the control of field and storage insect pests (Ogendo et al., 2003a, b; Mugisha-Kamatenesi et al., 2008). The studies indicated that botanical formulations reduced stem-borer load by ≥55% and increased maize yield by ≥60% compared to control (Ogendo et al., 2003a, b). In order to improve food security and alleviate poverty in the LVB, the plant based IK of insect pest management have to be inventoried, scientifically rationalized, standardised and later registered with pesticides regulatory boards in the LVB sister countries before large-scale adoption of the products. In view of this, this research was conducted as an inventory study to document farmers' IK on management of key field and storage insect pests in Magu and Misungwi Districts as representative of the LVB region, Tanzania side. In addition, the study documented farmers' characteristics, major crops grown and the associated key field and storage insect pests and their pest control methods.

METHODOLOGY

A stratified random sampling technique was conducted in Magu and Misungwi districts in July, 2007 as described previously (Ogendo et al., 2004, 2006). Each district was considered as homogenous sampling block. Permission to proceed with the survey was sought from the District Executive Officer, where a district officer responsible for agriculture and/or pest management was assigned to be part of the survey team. The team also included the village executive officer for the smooth execution of the study.

A semi structured questionnaire was prepared to collect information on respondent's residential address (village and ward) within the district, age, farming experience, education and main occupation. In particular, the questionnaire was intended to collect the following information: (a) major crops grown in the area, acreage, yield and losses due to pests, (b) major pest species and farmers' control methods in the field and on storage with emphasis on IK and (c) farmers' perceived efficacy of the indigenous control methods used. The questionnaire was administered to farmers within their area of farming and/or residence.

Identification of field and storage insect and non-insect pests was done by the researchers based on available literature materials during the survey and on respondent's description and ability to recognize the brought pest from amongst other species in pictorial aids (NRI poster, 1999; Hill, 1987) availed by the survey team. Specimens of individual plant species reported to exhibit pesticidal effects on either field crops or stored grains pests were collected, identified and authenticated by the botanist from Department of Botany, University of Dar es Salaam. The voucher plant specimens were deposited in the Herbarium of the Botany Department at the University of Dare s Salaam. All the data collected were subjected to statistical tests using Statistical Package for Social Sciences (SPSS) Version 11. The results of the data analysis were as described in the following section.

RESULTS

General farmers' characteristics

Six villages from the two districts in the LVB, Tanzania were surveyed by the research team. These were Bubinza, Lubugu and Nyambono in Magu and Mwambola, Ng'ombe and Igokelo in Misungwi. Forty six (46) respondents were interviewed in all, 24 from Magu and 22 in Misungwi. Out of all respondents, 35 (76%) were male. The respondents had their ages ranging from 20 - 75 years (mean = 39.02 years). Farming was the primary economic activity to all respondents and it was small scale (that is, subsistence). The farming experience ranged from 2 - 50 years (mean 16.05 years). Majority of the respondents (69.6%) had primary education and 17.4% had no formal education. The remaining percent (13.0%) had secondary and pre-university education.

Seventy one percent (71.7%) of respondents were household heads owning farms and out of these only 21.7% were female. Out of the household heads, 63% were husbands, 19.6% were wives and 15.2% were

siblings. The age of household heads ranged from 20 - 79 years (mean = 40.5 years). All household heads were engaging in farming as their primary economic activity with experience ranging from 2 - 50 years (mean = 16.8 years). About 71% of the household heads had primary education, 17.4% had no formal education, 8.7% had secondary education and 2.2% had pre university and college education.

Major crops grown, their socio-economic importance, acreage and harvest

A variety of crops grown were identified in the study area and all can be categorized into five groups: cereals (maize, rice, sorghum and finger millet), legumes (beans, groundnut, cowpea, green gram, brassicas and chicken pea), tubers (cassava and sweet potato), fibres (cotton) and vegetables. Cereal crops were the most grown crops (61.9%) followed by legumes (13.3%) and root tuber (12.4%). Cereal was the most grown crop type in the area (76.0%), followed by root tubers (10.7%) and legumes (9.4%). Maize, sorghum, finger millet, beans and ground nuts were the most important food crops grown in the study area. Maize was ranking the first as a food crop within the crops grown (94.1%) and within crops grown for food (64%) followed by sorghum (80% and 5.3%) and finger millet (66.7% and 2.7%). Cotton, horticultural crops, green gram and maize were the most important crops grown for income generation. Cotton and vegetables had 22.2% contribution as cash crops followed by green gram (14.8%). Maize contributed 11.1% to income generation while rice and chicken peas contributed 3.7% each. The crops were grown on an area ranging from 0.25 to 8 acres (mean = 2.33 acres). Crop harvest within this acreage ranged from nothing to 40 bags per acre (mean 12.22 bags/acres). It was expected that an acre can to produce between 3 and 72 bags (mean = 17.88 bags).This discrepancy was due to drought, unpredictable rainfall patterns and pest losses, the latter contributing a large proportion on the loss (*ca* 45%).

Crop pest problems and their control methods

Major pest problems in the field

Major field pests identified in the study were stem borers (*Busseola* fusca (Lepidoptera: Noctuidae)), army worms (*Spodoptera spp* (Lepidoptera: Noctuidae)), pod feeders (*Agrotis spp* (Lepidoptera; Noctuidae)), cutworms (*Maruca vitrata* (Lepidoptera: Crambidae), aphids (*Rhopalosiphum maidis* (Homoptera: Aphididae) in maize. In legumes *Aphis* fabae (Hemiptera: Aphididae) and grasshoppers were the most problematic field pests in the studied area. Stem borer, armyworm, pod feeder and cutworms ranked the highest among the field pests mentioned in the area (Figure 1).

Stem borer was a problem to 34.9% of the sample studied while army worm, pod feeder and cutworm were problems to 12.3, 7.5 and 6.6% of the sample population, respectively. Aphids and grasshoppers were a problem to only 4.7%. Whereas maize was the most attacked cereal followed by sorghum, green gram was the most attacked legume followed by cow pea. In root crops, cassava was the mostly attacked and in fibre crops cotton was the most attacked crop. The pest problem emerged mostly during the short rain and when the crops are either in the productive or vegetative stages, which is the stage necessary for good yield.

Pest control methods in the field

Thirty one percent (31.1%) of the population used synthetic pesticides to control the pests in the field and 24.5% used IK in form of general ash, specific plant ash or whole plant for pest control. The remaining proportion had no means to control the field pests. However, few used other means of control such as weeding, traps, burning, scaring and diatomaceous earth as their field control methods (Figure 2).

Major pest problems on storage

With respect to storage pests, larger grain borers, LGB (*Prostephanus truncatus* (Coleoptera: Bostrichidae)), grain weevils (*Stophilus spp* (Coleoptera: Curculionidae)) and flour beetles (T*ribolium spp* (Coleoptera: Tenebrionidae) were the problematic pests in cereals. Bruchid beetles (*Bruchus rufimanus* (Coleoptera: Bruchidae) were a problem in legumes. Grain weevil was a problem to 70% of the respondents in both districts. LGB and flour beetle were reported by 16% and 2.8% of farmers, respectively (Figure 3). The damage in store was more pronounced during the short rains in the post harvest stages.

Root crops such as cassava and sweet potatoes were infected by lesser grain borer (*Rhyzopertha dominica* (Coleoptera: Bostrichidae)). Rodents on the other hand were the multipurpose pests in both districts, where they attacked cereals, legumes and root crop products.

Storage pest control methods

Of all the respondents, 17% were using synthetic pesticides such as actelic super and karate, and 16.9% were using IK based control methods in form of general ash, specific plant ash and whole or dry plant powder (Figure 4). The large proportion (66%) was storing their crop products without any control measures.

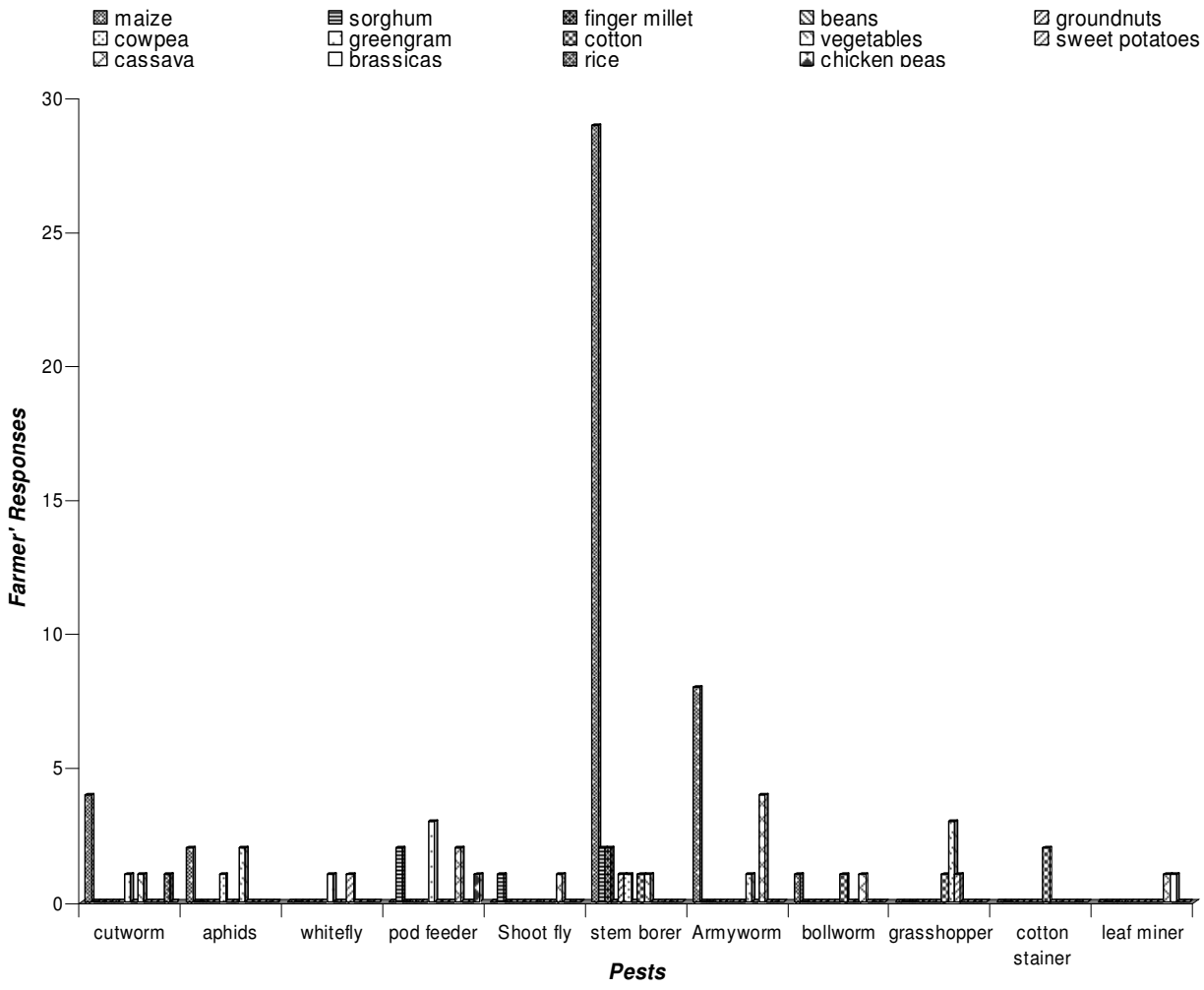

Figure 1. Effects of pests on field crops.

used a variety of means ranging from general ash, specific plant or animal product ash, plant parts, whole plants to plant and animal by-products. Specific plant ash was made from rice husks and/or red maize cobs. Plants used in the field included neem (*Azadirachta indica* (Meliaceae), *Tephrosia vogelii* (Fabaceae), *Tamarindus indica* (Fabaceae), *Aloe spp* (Asphodelaceae), red pepper (*Capsicum spp* (Solanaceae)) and tobacco (*Nicotiana* tabasum (Solanaceae)). Cow urine was used as one of the contents of formulation in the field. During storage, farmers used neem, *Chenopodium opulifolium* (Chenopodiaceae), *Ocimum suave* (Labiatae), *Senna siamea* (Fabaceae or Caesalpinioideae), tobacco and *Eucalyptus spp* (Myrtaceae). Cow dung was used during storage for making ash and plastering storage containers. Most of these products of plant and animal origin were used together with one or two others in a given formulation. Tables 1 and 2 give the different botanical pesticide products formulated by farmers.

Among the materials used in preparation of botanical formulations in the field, neem was the common plant followed by *Tephrosia vogelii* (Fabaceae). Other commonly used plants included *Tamarindus indica, Capsicum spp* and *Nicotiana tabasum* (Table 1). Cow urine was used in the control of field pests but not on a wider scale. On the other hand, neem was the commonly used plant followed by *Chenopodium opulifolium* and *Ocimum suave* in the control of storage insect pests (Table 2). Other plants used were tobacco and *Eucalyptus.* Cow dung was commonly used in store as a plaster of containers so that insect pests cannot get in. Besides the above materials, ash from rice husks was the common botanical product used followed by general ash. These were used to control both field and storage pests.

In order to reduce the effects of pests in the field, farmers

About 49% of the farmers said that indigenous control methods were effective just like synthetic pesticides. A small proportion (6.2%) had their indigenous control methods not effective. The remaining proportion did not provide the estimated rating although they were using the methods.

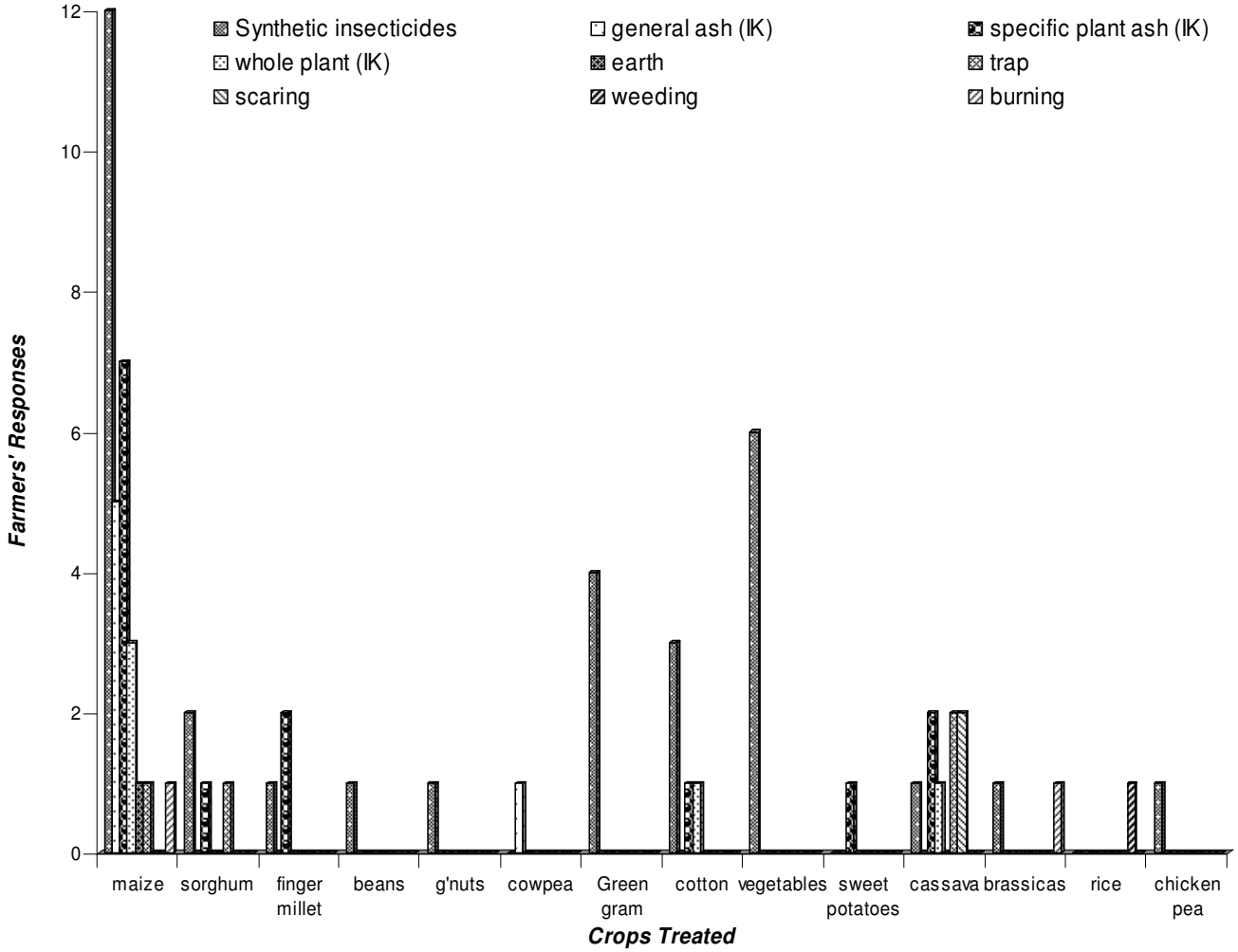

Figure 2. Methods used by farmers to control field pests.

DISCUSSION

The results have shown that farmers in the LVB in Tanzania grow, among other crops, cereals and legumes in small farms for their consumption and that the crops were mostly attacked by field pests during the vegetative or productive stages. This greatly reduced the farmers' crop harvests. The findings have indicated that majority of storage pests problems mentioned were on cereal and root crop products which implies that the crop products are preferentially stored as main food types in the area. The findings have also shown that farmers do use the same stored produce for income generation. This has a great implication on their food security in the future taking into account that the crops harvested were less than the expectations as a result of drought, unpredictable rainfall patterns and pests that accounted a lot.

Results have indicated that about 56 and 34% of the respondents were using insect pest control methods in the field and on storage respectively. Out of these, 50% were using IK based control methods which make IK worth of an important control method in the area especially in subsistence agriculture where majority of farmers cannot afford to get synthetic pesticides for the field and stored crops. Despite the fact that farmers use a variety of means on the control of field and storage insect pests, their efforts were hampered by the large percentage of farmers who do not practise any method. These farmers were leaving the pests to have a share in their crops. In this situation where insects, the highly successful and well adapted group, are left untamed, the magnitude of destruction cannot be underestimated.

The results have unveiled that some farmers were unable to estimate the efficacy of their made formula-

tions. This failure could be due to various reasons including; (a) varied amount of plant part and/or animal product taken in preparing the formulations, (b) lack of common method of preparation and time of treatment of the prepared botanical formulation, (c) varied preparation time before application, (d) variable rates of application of

Table 1. Plant and Animal products used to prepare the botanical pesticide formulations to control field pests.

S/N	Name (English, Swahili) of the plant and/or product used (Scientific name in brackets)	Mode of preparation to get the formulation and its application
1	Neem, Mwarobaini *leaves or seeds mixed with soft rice husks*	The seeds or leaves of neem are grinded and soaked in a litre of water for one day. Thereafter the mixture is filtered. The filtrate is applied by spraying to crops in the field. In most cases this formulation is intended for maize and/ or rice.
2	Red pepper mixed with tobacco leaves	A handful of red pepper fruits is grinded and mixed with a cup of grinded tobacco (*Nicotiana tabasum*) leaves. The mixture is then soaked in five (5) litres of water and left for two days and then filtered. The filtrate is sprayed as an aqueous solution to crops at a rate of two (2) litres per acre.
3	Red pepper and tobacco mixed with neem leaves	The fruits of red pepper and leaves of tobacco and neem are grinded separately and soaked in water in a container.After some days the mixture is filtered and sprayed to cotton and maize.
4	Tobacco leaves mixed with tamarind (*Tamarindus indica)* fruits	The tobacco leaves and *Tamarindus* fruits are soaked in water for some time. Then the mixture is filtered and applied by spraying to cotton at a rate of twenty (20) litres per acre
5	Utupa in Kiswahili *(Tephrosia vogelii)*	The plant (15 g) is grinded and soaked in a litre of water for a given time. The resulting mixture is then filtered and the filtrate is sprayed to crops such as tomatoes, cotton and watermelon.
6	Malumba in Kiswahili *(Chenopodium opulifolium)*	The whole shrub is collected and soaked in water for a given time followed by decantation. The clear solution obtained is then sprayed to finger millet and maize at a rate of twenty (20) litres per acre.
7	Cow urine and detergent soap mixed with neem leaves	Neem leaves (*ca* 200 g) are grinded and put in a twenty (20) litre container. In it about fifty (50) grams of a detergent (clearly stated as OMO®) and cow urine (5 litres) are added. The mixture is then kept undisturbed for four (4) days beforefiltration. Once filtered, the filtrate is sprayed to a variety of crops in the field.
8	Neem leaves mixed with cow dung	The neem leaves and cow dung are soaked in water in one container and stored for two (2) days. Then the mixture is filtered and the resulting solution is sprayed to cotton at a rate of ten (10) litres per acre.
9	*Neem leaves mixed with tobacco powder*	The leaves of neem and powder from tobacco leaves are soaked in water and boiled for some time. After that, the mixture is filtered and kept for three (3) days before being used. After the time, the solution can be applied by spraying to crops.
10	*Neem leaves mixed with cow urine*	The neem leaves are taken, grinded, soaked in water and filtered to prepare about five (5) litres of neem extract. The extract is then mixed thoroughly with cow urine (1 litre). The resulting solution is later applied to maize in the field at a rate of 1.5 litres per acre.
11	Mjohoro in Kiswahili (*Senna siamea*)	A handful of *Senna siamea* roots are taken and soaked in a litre of water for three days until the colour of the solution becomes green. The solution is later decanted and applied to crops at a rate of one (1) litre per acre.
12	*Cow dung mixed with general ash*	Ash originating from any source and cow dung are soaked in water in a container and left for some time.Then the mixture is filtered and the filtrate is diluted in the ratio of 1:2. The diluted solution is then sprayed to any plant.

the same type of formulation to the same crop and (e) use of same type of prepared botanical formulation to the same type of formulation to the same crop and (e) use of same type of prepared botanical formulation to treat different types pests in the field and during storage. Farmers relied mostly on estimation and sightseeing for a

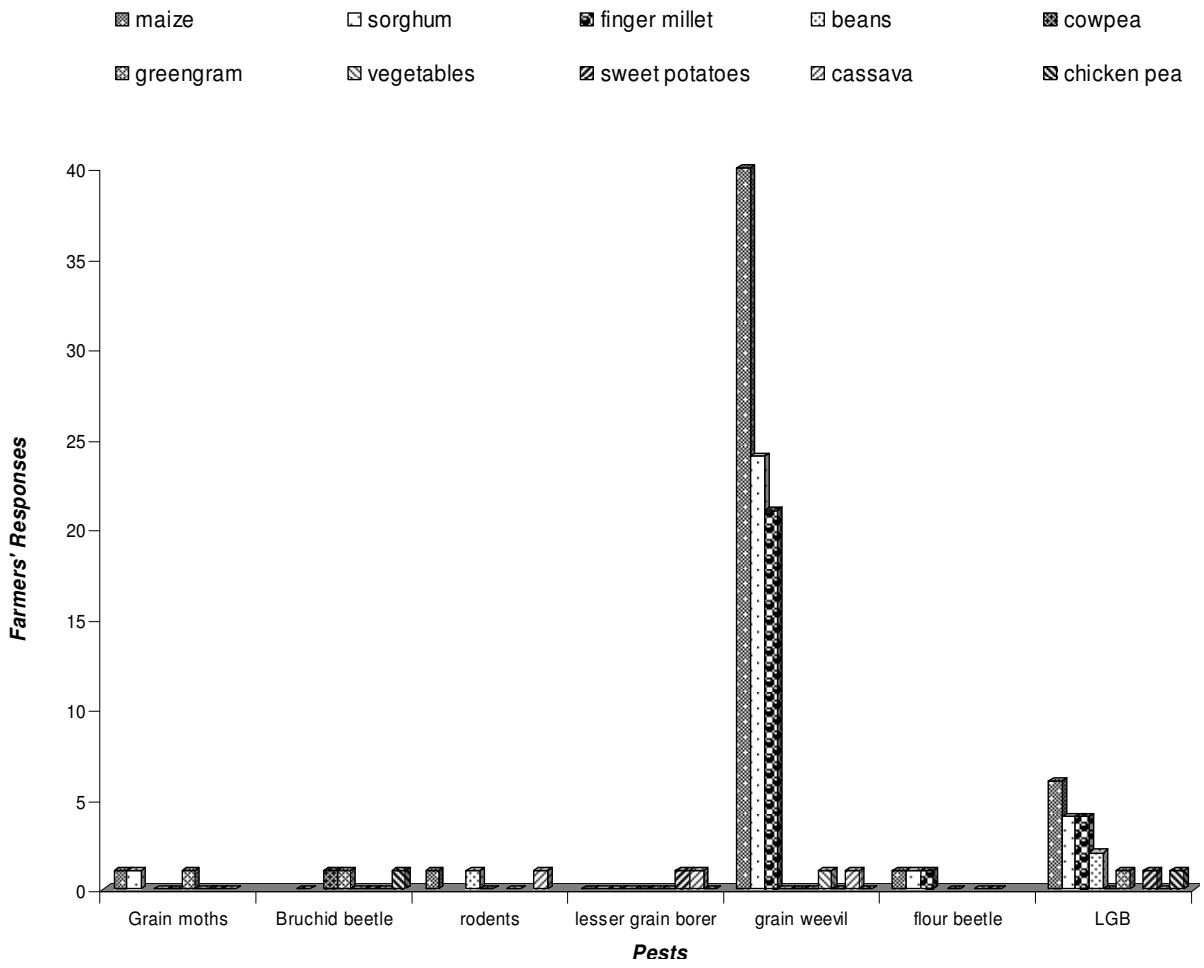

Figure 3. Effects of pests on stored crop products.

Table 2. Plant and Animal products used to prepare the botanical pesticide formulations to control field pests.

S/N	NAME	Mode of preparation and its application as they appear in the Table 1
1	Rice husks mixed with tobacco powder	Ash from rice husks and tobacco powder are soaked in water for a period of time. The resulting solution is sprayed to grains without filtering.
2	Mtumbatu in Kiswahili (*Ocimum suave*)	The leaves of the plant are used with no further treatment. The leaves are just arranged in layers in a bag of millet, maize or legume. One or more layers can be arranged in one bag.
3	Eucalyptus, Mkalatusi in Kiswahili (*Eucalyptus spp*)	Leaves of *Eucalyptus* are taken, air dried and grinded, and the resulting powder is mixed with the grains before or after packing in bags.
4	Cow dung	Cow dung here was prepared in two ways: soaked in water and made into paste or burnt into ash. When made into paste, it is used to plaster storage containers in a way of preventing pest entry. When made into ash, it is mixed with the grains before packed into bags.
5	Neem leaves	The leaves are taken, air dried and grinded. The resulting powder is thoroughly mixed with the grains before or after packing.

6	General or rice husks ash	Any plant parts, whole plant, or plant and animal products (general) or rice husks are burnt into ashes. After cooling, the ash is collected ready for use. During storage, the ash is put in a bag of grains (maize, millet, legumes) in layers or mixed with the grains and then packed in bags.

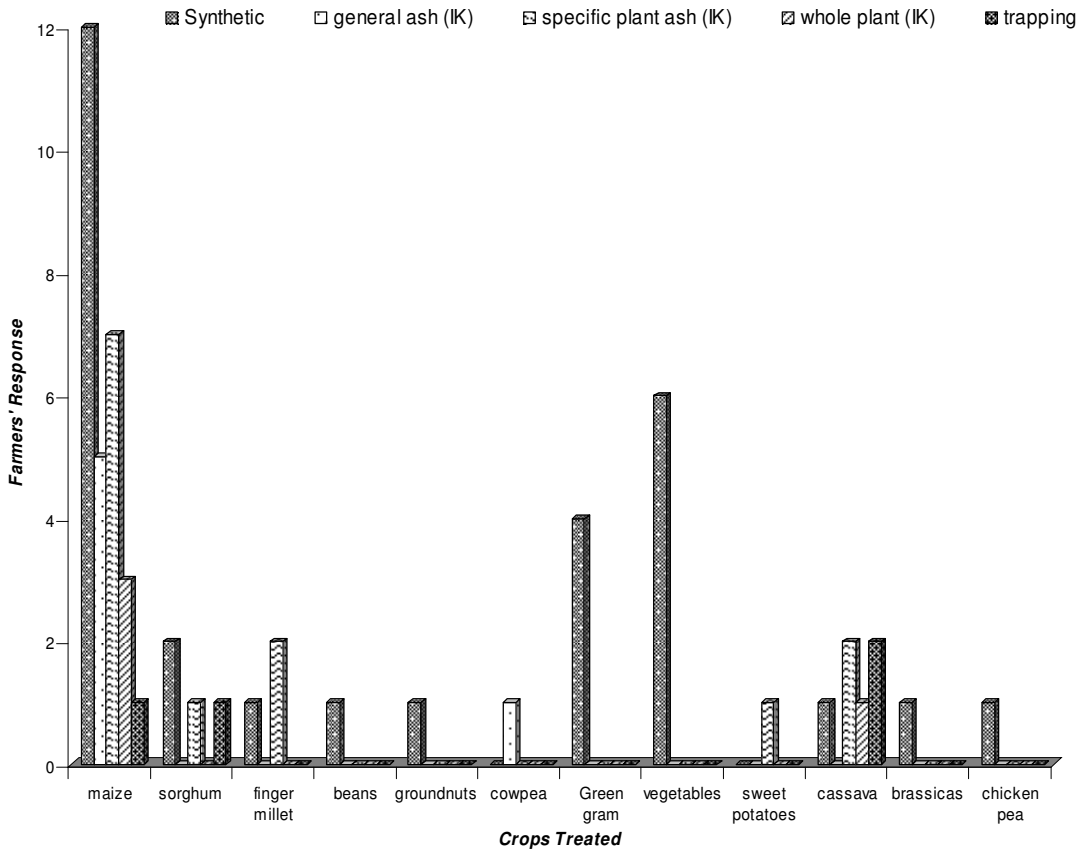

Figure 4. Farmers' storage control methods.

definite and appropriate amount of material taken and concentration required for a given botanical pesticide formulation. For example, formation of a definite colour such as green was regarded as an attainment of the required concentration. In addition, the use of aqueous prepared formulation only could have resulted to the reduced efficacy in some of the prepared botanicals. In absence of a standardized protocol on preparation and application, the IK based formulations will have a varied efficacy at a given time even to the same farmer. In fact, this shows that where there is no specific amount taken, no allocated time and way of preparation and no proper application rate and method, efficacy rating of any pesticide will be compromised.

Conclusion

The findings from the survey have revealed that farmers practice subsistence agriculture in which maize, sorghum, rice, finger millet, cassava, sweet potatoes, green gram and cow peas as major crops are grown. These crops are grown in a mixed cropping system. Whereas stem borers, armyworms, pod feeders and cutworms are the major field pests, grain weevils, LGB and flour weevils are problems in stored cereals. Legumes are infested by pod feeders in the field and bruchid beetles on storage. Root crops are mainly affected during storage and this is due to lesser grain borers and rodents.

Farmers in the LVB in Tanzania use IK based pesticides as formulations containing mixtures of one or more of the following; neem, *Tephrosia vogelii, Aloe spp, Tamarindus indica, Capsicum spp, tobacco,* and *general and rice* husks ash against field pests. On storage farmers use neem*, Chenopodium opulifolium, Ocimum suave, Eucalyptus spp,* tobacco and cow dung. The formulations, however, lacked specificity and appropriate preparation procedures that make them to have variable and often inadequate efficacies. In view of that, the IK based pest control methods would be better when accompanied by

standardised methods of preparation, bio-safety and environmental guidelines for efficacy as well as quality of the crop and crop products.

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