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Farmers' Awareness of Cassava Green Mite and Preferred Traits of Cassava Cultivars in North-Western Zambia

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Abstract

Farmers are the custodians of valuable indigenous knowledge concerning wild and domesticated plants and over the years farmers have discovered various means of coping with plant pests in their farm lands. Through individual interviews and focus group discussions r traditional knowledge was gathered on plant attributes that are associated with reduced pest population and/or damage in cassava fields, with a view to identify traits that can be promoted through conventional breeding. Termites, moles and cassava green mites (CGM) were recognized as the most prevalent pests that contribute to low yields and abandonment of certain cassava cultivars by farmers. Apparently farmers depend on traditional cultural practices such as de-topping, selective pruning, intercropping, and burning of cassava fields to reduce CGM, mealy bug and termites in their fields. Plant canopy size and other related attributes such as number of branches, and leaf retention, were perceived to have a negative relationship with CGM damage. Farmers desire cultivars which combine the following traits: earliness, high storage root yield and storage root dry mass percentage, resistance to CGM, moles, termites and storage root rots. There is need to look for genetic sources for these farmer-desired traits and incorporate them into new cultivars through plant breeding.

Keywords: Cassava pests; Indigenous knowledge; Participatory plant breeding

Introduction

Cassava is a robust and reliable crop which tolerates a wide range of climatic conditions and is able to grow under marginal soil fertility. Its production is largely concentrated among the small scale, resource-limited farmers who have no access to credit facilities, and cannot afford expensive agrochemicals to control pests and diseases. Normally there is no break in the production cycle of cassava; farmers have to plant a new field of cassava every rainy season to have a continuous supply of food. This continuous production coupled with the long growth cycle of cassava creates a continuum of cassava pests and diseases. Under such farming conditions cassava green mite (CGM) (*Mononychellus tanajoa* Bondar (Acari: Tetranychidae)) becomes the key herbivorous arthropod pest [1], causing significant yield losses [2,3]. National activities aimed at controlling CGM through resistance breeding and biological control have been carried out as independent units and without active participation of farmers. Consequently, despite the releases of exotic natural enemies of CGM in farmers' fields [4-6], the pest has continued to devastate cassava production in Zambia [7].

Participation of farmers in integrated pest management (IPM) research is thought to empower local farmers by enhancing local management capacity, increasing confidence in their own abilities [8]. This kind of empowerment increases the sense of ownership among farmers for the developed technology and the likelihood of that technology being embraced [9,10]. Using PRA as an integral part of conventional breeding is likely to speed up the rate of development and adoption of cassava varieties [11-13]. Use of participatory approaches in conventional plant breeding has enabled researchers to respond more precisely and efficiently to the needs and preferences of resource-poor farmers [10,14-16].

Therefore, the current study was conducted to achieve the following objectives:

a. Gather information on farmers' perception of the distribution and importance of major cassava pests and traditional coping strategies thereof.

b. Gather traditional knowledge on plant attributes that are associated with reduced pest population and or damage in cassava fields, with a view to identifying traits that can be improved through conventional breeding;

c. Gather information on desirable and non-desirable cassava varietal attributes in relation to various uses of cassava.

Materials and Methods

Study sites

Individual and focus group interviews were conducted with 120 farmers in Solwezi and Mwinilunga districts in Zambia (Figure 1). The farmers in Mwinilunga have a long history of growing cassava as a staple crop. Consequently large cassava fields with a wide diversity of cultivars, and highly experienced cassava growers are prevalent in Mwinilunga [4]. The district has a long history of on-farm research activities which has over the years afforded a good number of local farmers exposure to improved technologies and cultural practices. There is a long history of releases of exotic biological predatory mites and parasitoidsto control CGM and cassava mealybug (CM) (*Phenacoccus manihoti* Matile-Ferrero (Homoptera: Pseudococcidae)), respectively in Mwinilunga [5]. However the natural enemies for CGM have not established well in the district [6].

Figure 1: Agricultural camps sampled in the Mwinilunga and Solwezi districts for the participatory survey.

Sorghum (*Sorghum bicolor (L.)* Moench) is traditionally grown in Solwezi district, where people have recently migrated from areas where cassava is grown. Therefore, cassava is a relatively new crop in Solwezi where farmers grow cassava mainly for the sale of storage roots and leaves.

A PRA study was conducted in six agricultural camps in each of the two districts. In Mwinilunga farmers were interviewed in Sailunga, Nyangombi, Kawiko, Kanyama, Kampemba, and Lwau agricultural camps (Figure 1). In Solwezi, the camps included Mutoma, Lamba, Kisasa, Kayonge, Meheba, and Manyama. The survey team included a plant breeder, a social economist, one agricultural extension officer, and one field research assistant from the national Root and Tuber Improvement Programme (RTIP).

Individual interviews

A loosely structured questionnaire was used to obtain the required information. From each of the above named agricultural camps, an extension officer who was familiar with the local language was trained on the techniques of administering the questionnaire. The questionnaire was administered to about 10 farmers who were randomly selected along atransect in each camp [17]. Cross-checking was done in the field by the researcher to ensure that information collected was accurate. An inventory of abandoned cultivars was compiled in each locality, and information about desirable and non-desirable traits attributed to each cultivar was collected and reasons for abandonment of certain cultivars were also obtained.

Focus Group Discussion

Figure 2: Farmers conducting preference scoring and ranking of desirable attributes of cultivars and uses of cassava at Mutanda research station, Zambia.

A sub-sample consisting of 60 farmers was randomly selected from the 120 previously interviewed cassava growers and they were gathered together for focus group discussions. These farmers were then sub-divided into 10 groups of six members each. Each group was assigned one trained extension officer who served as a guide. Farmers were asked to describe symptoms of damage caused by pests affecting cassava, and to provide a list of plant attributes that were considered to confer some level of plant resistance, as well as the traditional cultural practices that are used to manage such pests in their respective localities. Well-

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labelled live infested plants or plant parts as well as photographs of major pests and associated damage symptoms were provided as a guide to assist farmers in matching their descriptions with names of pests. Using preference scoring, farmers were asked to rank the pests in their order of importance (Figure 2). Similarly the effectiveness of various plant attributes and traditional cultural practices in minimizing pest population and crop damage was also ranked by farmers.

Data Analysis

Data collected were subjected to descriptive statistics analysis using SPSS version 10, statistical software.

Results

Table 1: Cassava cultivars abandoned by farmers in Mwinilunga and Solwezi districts, Zambia.

District	Abandoned Cultivars	% Farmers Abandoning	Reasons for Abandonment
Mwinilunga	Neti,	90	Attracts insects and easily damaged by frost and hail storm
	Bunguta	60	Few and small storage roots
	Loja	45	Prone to theft and monkey damage
	Kapumba	80	Prone to moles damage, and root rots
	Nyauseya	50	Prone to root rots
Solwezi	Bunganabutu	80	Very prone to mole damage, plus low storage root yield
	Kapumba	80	Highly prone to mole damage, storage roots highly fibrous, and prone to frost damage and theft
	Tangala	75	Prone to frost and insect damage
	Chamala	90	Very poor growth and storage root yield
	Kundamanga	100	Few leaves and prone to insect damage
	Bangwele	50	Too bitter, susceptible to diseases, yellow flour

Over a period of 20 years, all the farmers interviewed (100%) have abandoned the landrace Kundamanga (Table 1). Ninety percent of the farmers said they have abandoned the cultivar Chamala. The cultivars Bunganabutu and Kapumba, though still planted by some farmers, have been abandoned by 80% of the farmers. The cultivar Bangwele has been abandoned by 50% of the respondents in Mwinilunga. Reasons for abandonment of cultivars included poor fresh storage root yield (FSRY), low storage root dry mass(SRDM) and high storage root fibre content (SRF), susceptibility to moles, insect damage, and storage root rot (SRR) or poor underground storability (UGS), and susceptibility to frost and hail storm damage among others (Table 1).

Ranking the uses of cassava

Cassava is mostly consumed in the form of flour which is used to make nshima (thick porridge which is eaten with sauce). Leaves are also consumed as a green vegetable both in Mwinilunga and Solwezi (Figures 3 & 4). Cassava is considered a good source of income for local farmers. Fresh and dry cassava storage roots as well as cassava flour are sold for money or exchanged with farm labour which is used to either maintain or expand fields planted to cassava or other crops such as maize, bean, and sorghum. Cassava was said to have some medicinal properties and is used as a natural remedy for diarrhea and skin diseases. The other use for cassava which was mentioned by male farmers only was for brewing local beer called Kachasu, and soft drink called Munkoyo. Men who drink local cassava beer elaborated that the beer serves as energizer but delays ejaculation and therefore could be remedial formula for men suffering from the problem of early ejaculation. The use of cassava in making local beer was ranked fifth by farmers in Mwinilunga and Solwezi.

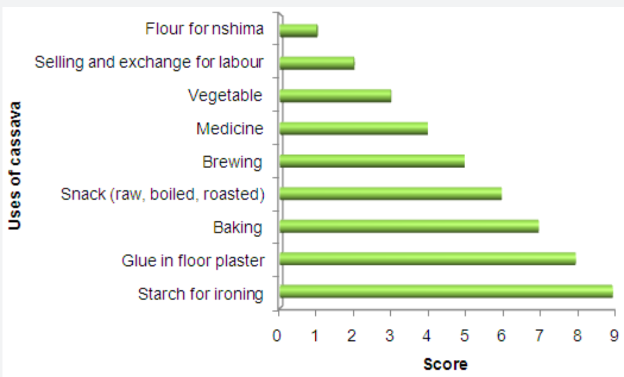

Figure 3: Ranking of uses of cassava by farmers in Mwinilunga district, Zambia.

Score 1 = most important, 10 = least important

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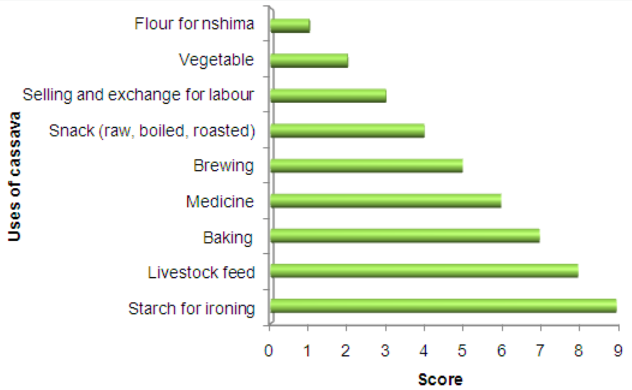

Figure 4: Ranking of uses of cassava by farmers in Solwezi district, Zambia.

Score 1 = most important, 9 = least important

Ranking the uses of cassava and desirable varietal attributes

The process of extracting cassava flour involves soaking of cassava storage roots in water, drying and milling. The soaking and fermentation help to get rid of the bitter taste and cyanide. Therefore, for the purpose of extracting cassava flour, farmers do not bother about the taste of storage roots as both bitter and sweet cassava can be used. However, cultivars which combine high FSRY with high SRDM and resistance to SRR are most preferred for nshima. Cassava flour is sometimes mixed with clay and water to plaster mud brick houses in villages. For this purpose SRDM/starch content is the most important. Therefore cultivars which combine high FSRY with high SRDM are most preferred. For use of cassava in brewing, farmers like cultivars with high SRDM, high FSRY and extended UGS.

Table 2: Ranking of uses of cassava and associated varietal attributes by farmers in Mwinilunga, Zambia.

Uses	Desirable Varietal Attribute							
	High FSRY	High SRDM	Good UGS	Early Bulking	Sweet Roots	High Yield Of Planting Material	Frost/ Hail Storm Tolerance	Pest/ Disease Resistance
Nshima	2	1	4	3	ns	9	7	8
Baking	5	1	2	5	3	ns	ns	ns
Glue/plaster	9	3	ns	ns	ns	ns	7	4
Brewing	4	2	5	ns	ns	ns	ns	ns
Source of income	1	2	3	3	ns	2	ns	2
Starch for ironing	7	1	9	6	ns	ns	ns	8
Making glue	3	1	2	ns	ns	ns	ns	ns
Vegetable	ns	ns	ns	ns	ns	1	2	3
Medicine	ns	8	9	7	ns	ns	ns	ns

Table 3: Ranking by farmers of uses of cassava and associated varietal attributes in Solwezi, Zambia.

Uses	Desirable Attributes						
	High FSRY	High SRDM	Early Bulking	Purple Inner Root Skin	Sweet Roots	High Yield Of Planting Material	Pest/Disease Resistance
Nshima	1	2	3	ns	ns	ns	Ns
Baking	3	2	ns	4	1	ns	Ns
Brewing	1	3	2	ns	ns	ns	Ns
Source of income	5	5	ns	5	5	ns	Ns
Livestock feed	5	ns	2	ns	5	8	5
Snack	5	5	3	2	10	ns	Ns
Vegetable	ns	ns	4	ns	ns	15	6
Medicine	12	8	5	ns	ns	ns	Ns

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The SRDM is the most important attribute of cassava cultivars preferred by farmers for most uses of cassava. Cultivars which are tolerant to frost, pests and diseases are preferred as a leafy vegetable which is another source of income for farmers in the North-Western Province of Zambia (Table 2 & 3).

Ranking of negative varietal attributes

In Mwinilunga, farmers scored susceptibility to SRR, low FSRY, and susceptibility to hail storm, moles, frost and insect damage in that order as the major negative attributes of cassava cultivars (Figure 5). In Solwezi, farmers scored the tendency of certain cultivars to yield few or only small roots even after two years as the most undesirable attribute which was responsible for abandonment of most cultivars. Susceptibility of a cultivar to insect damage was scored as the second most undesirable attribute (Figure 5). The third negative attribute and cause for cultivar abandonment is bitterness of storage roots, while susceptibility of a cultivar to foliar diseases, and poor UGS followed as the fourth and fifth most undesirable attributes, respectively.

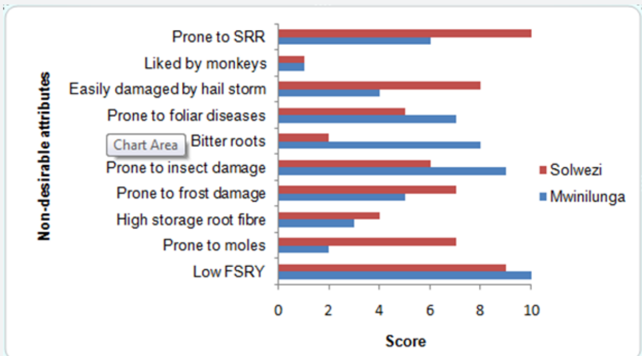

Figure 5: Ranking of reasons for abandonment of some cassava cultivars by farmers in Mwinilunga and Solwezi districts, Zambia.
Score 1 = least non-desirable, 10 = most non-desirable

Ranking of desirable varietal attributes

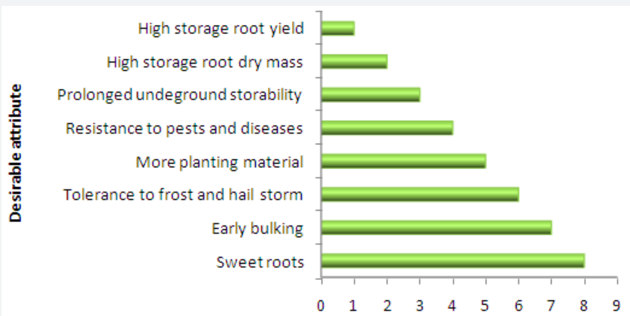

Figure 6 : Ranking of positive varietal attributes by farmers in Mwinilunga district, Zambia.
Score 1 = most important, 8 = least important

Eight prominent positive attributes were listed for the different cultivars by farmers in Mwinilunga (Figure 6) and Solwezi (Figure 7). In Mwinilunga, high FSRY was considered the most important positive attribute (25.0%), followed by high SRDM (20.2%) prolonged UGS (17.0%), resistance to pests and diseases (15.5%), early maturity (10.4%), fast growing and more planting material (7.2%) tolerance to frost and hail storm (3.7%), and sweet taste of storage roots (1.0%). In Solwezi, high FSRY was also considered the most important positive attribute (35.0%), followed by high SRDM (25.3%), sweetness (12.0%), early maturity (9.8%), resistance to pests and diseases (7.0%), more planting material (5.2%), purple storage root inner skin colour (3.5%), and tolerance to frost (2.5%).

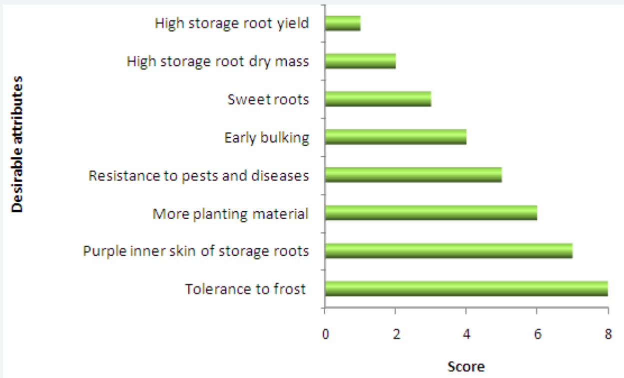

Figure 7: Ranking of positive varietal attributes by farmers in Solwezi district, Zambia.
Score 1 = most important, 8 = least important

Farmers' awareness about cassava green mite

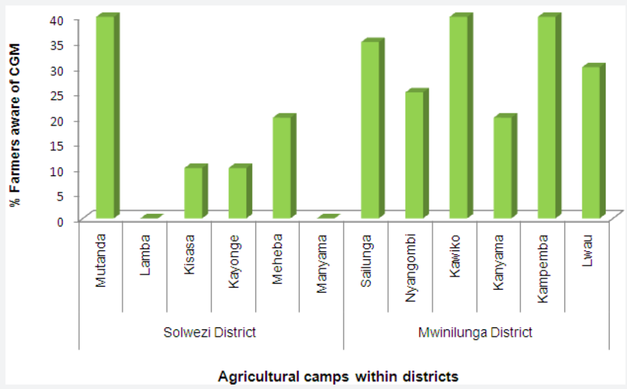

Figure 8: Farmers awareness about cassava green mite.

Most of the farmers had no knowledge about CGM and were not able to describe or identify its damage symptoms. Nevertheless, Mutanda, Kampemba, and Kawiko camps recorded the highest number (40%) of farmers who had knowledge about CGM, followed by Sailunga and Lwauwhere 30 and 35% of the farmers, respectively, were knowledgeable about CGM, (Figure 8). None of the farmers interviewed in Lamba and Manyama camps of Solwezi district had knowledge about CGM. The farmers who had some knowledge about CGM had attained at least junior secondary level of education and had interacted with

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researchers either during on-farm research or farmer training. These farmers were able to recognize and describe symptoms of the pest and were even able to distinguish CGM from cassava mosaic disease (CMD) symptoms. The majority of such farmers were found in Mutanda, Kampemba, and Kawiko camps where research trials are usually conducted (Figure 8). However, all the farmers realized that they had seen CGM in their fields after looking at the photographs and live plant samples, based on which they were then able to estimate the extent of CGM spread and damage in their own fields.

Farmers' level of education

Table 4: Percentage distributions of farmers according to the levels of education and field training in 12 agricultural camps in Solwezi and Mwinilunga districts of Zambia.

District	Camp	% Farmers By Levels of Formal Education Attained				Training in Root Crops	
		No Formal Education	Primary School	Secondary School	Post-Secondary	No Field Training	Trained
Solwezi	Mutanda	0	50	20	30	30	70
	Lamba	2	75	23	0	95	5
	kisasa	10	70	5	15	80	20
	Kayonge	10	80	10	0	100	0
	Meheba	20	50	25	5	80	20
	Manyama	1	80	19	0	100	0
	Mean	7.2	67.5	17	8.3	80.8	19.2
Mwinilunga	Sailunga	0	20	80	0	25	75
	Nyangombi	2	70	20	8	50	50
	Kawiko	5	30	65	0	30	70
	Kanyama	10	70	15	5	80	20
	Kampemba	15	35	45	5	15	85
	Lwau	0	50	40	10	75	25
	Mean	5.3	45.8	44.2	4.7	45.8	54.2

Most of farmers interviewed had attained primary education up to Grade Seven. In Mwinilunga, 45.8% of the farmers had attained primary school education, 44.2% had attained secondary school education, and 4.7% had post-secondary school formal education, while 5.3% of the farmers interviewed had no formal education at all. In Mwinilunga 54.2% of the farmers interviewed said they had attended some field training on root and tuber crops in the past, while in Solwezi only 19.2% of the farmers had attended such training (Table 4). In Solwezi, 67.5% of the farmers had only attained primary school education, 17% had attained secondary school education, and 8.3% had post-secondary school formal education, while 7.2% of the farmers interviewed never had any formal education (Table 4).

Distribution and importance of cassava pests in farmers' fields

Farmers were able to estimate the importance of pests experienced in their own fields. Major pests of cassava included moles, termites, CGM, scale insects (*Aonido mytilusalbus* Ckll), and CM. Data obtained from focus group discussions indicate that CGM and termites (*Microtermes sp*) are the most widely distributed pests. Farmers attributed most losses in planting materials and leaves to termites and CGM, respectively (Figure 9). These pest were said to be most serious in the dry season, while moles were also reported to be found in all cassava fields mostly early in the rainy season. According to the farmers, moles cause about 45% crop damage, while termites and CGM cause 25 and 20% crop damage in cassava fields, respectively (Figure 10).

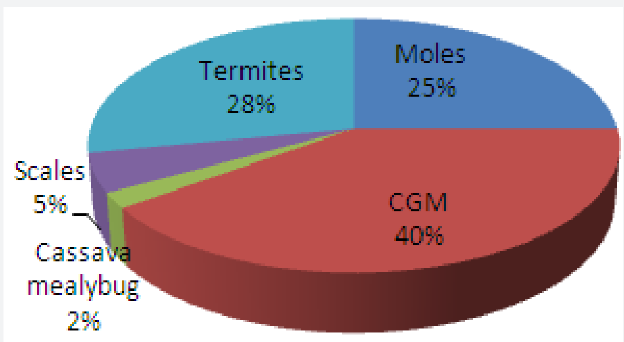

Figure 9 : Distribution of major cassava pests in farmers' field as estimated by farmers
CGM = cassava green mite
CM = cassava mealybug

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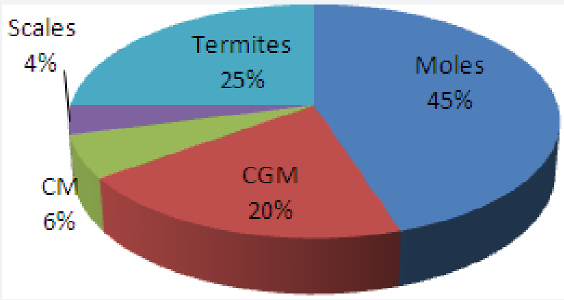

Figure 10 : Extent of damage caused by major cassava pests in farmers' fields as estimated by farmers
CGM = cassava green mite
CM = cassava mealybug

Plant attributes associated with reduced pest damage in cassava

Table 5: Ranking of cassava plant attributes associated with reduced damage of cassava by green mite, mealybug, termites, and scale insects as ranked by farmers.

Plant Attribute	Pests			
	Cgm	Cm	Termites	Scale Insects
Highly dense canopy	7	8	2	1
Highly branching	8	4	3	2
High retention of green leaves	2	1	3	3
Big and hairy shoot tips	1	2	9	7
Hairy leaves	3	3	8	7
Glabrous leaves	9	10	7	9
Leaf folding trait	4	5	5	10
Broad hairy leaves	5	9	6	5
Purple or pink cassava	6	6	10	4
Bitter roots	10	7	1	6

Among the plant attributes that were mentioned by farmers as being associated with reduced pest damage, large heads (shoot apices), leaf hairiness, and extended leaf retention (LR) and the ability to stay green were highly associated with reduced damage caused by foliar pests such as CGM and CM. Canopy size and other related attributes such as number of branches, and plant height, were also said to have a negative relationship with pest damage. A direct positive relationship was, however, reported between glabrous leaves and CGM leaf damage. Canopy size and LR were also said to be highly associated with reduced damage due to termites and scale insects in cassava fields. Farmers are aware of variations in response to pest damage among cultivars. Cassava cultivars that have pink or purple leaves, petiole and stems which farmers called "purple or pink cassava" was said to be not attacked by CGM, but such leaf type is not considered as a good vegetable. Farmers also cited that bitter cassava cultivars are less preferred by termites and moles as compared to sweet ones, when grown in a mixture (Table 5).

Cultural practices associated with reduced pest damage in cassava

Through a participatory process and by consensus by farmers, focus groups listed cultural practices that are associated with reduced pest population and/or damage thereof in cassava fields (Figure 11). De-topping of cassava tips of all plants in a field, just after the rainy season, was the most widely used traditional strategy to escape insect and frost damage in cassava fields. A total of 15.8% of the farmers interviewed said they practice selective pruning of infested plant shoots, while 13.4% intercrop cassava mainly with cereals such as maize and sorghum, and with tephrosia (*Tephrosiavogelii* Hook f.) to reduce the population of pests. A total of 11.2% of the farmers affirmed the observation that keeping cassava fields free of weeds helps to reduce pest infestation and damage, while 10.2% of the farmers also mentioned that ratooning of cassava shoots just before the on-set of the cold season helps to reduce the population of insect pests and loss of planting materials through cold injury.

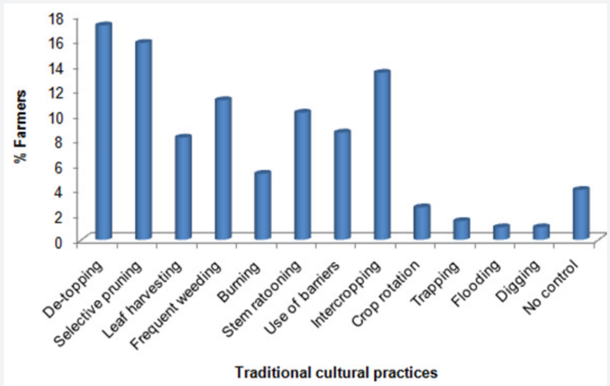

Figure 11 : Traditional cultural practices to reduce pest damage in cassava fields as identified by farmers in Mwinilunga and Solwezi districts in Zambia.

Apart from use of barriers of *T.vogellii*, and milk bush (*Euphorbia tirucalliL*. (Euphorbiaceae))planted as edge rows around the field of cassava as mentioned by 8.6% of the farmers, 2.5% of the farmers said they manage moles by setting traps underground along the tunnels, while 2.0% depend on flooding and digging out the tunnels. However, 5.3% of the farmers cited the use of fire which was primarily meant to clear weeds in cassava fields as an indirect way of destroying insect pests. They elaborated that fire is only used in old fields of cassava with the intention to completely uproot the crop shortly after burning, while 4.0% of the farmers said they did not practice any control measures against any pest in cassava fields.

Ranking of the effectiveness of cultural pest management practices

Farmers believe that the effectiveness of the aforementioned cultural practices varies with the pest. Removal of cassava shoot tips and selective pruning of infested shoots were cited to be the most effective in reducing the population of both CGM and CM

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(Table 6). Crop rotation was also cited as an effective measure against CGM and termites. Selective pruning was considered to be the most effective measure against white scale insects, while low infestations of termites are normally encountered in frequently weeded fields. In this regard, farmers also said that land preparations which involve burying grass and planting cassava before trash decomposition tend to predispose cassava to termite attack allowing termites to chew and girdle through planted cuttings from underground resulting in poor establishment of the crop. However, farmers clearly mentioned that the intensity of termite damage varies with location and soil type. The abundance of termite hills was said to be a direct indicator of the potential termite problem in a given area as is commonly the case in the North-Western Province. However, farmers pointed out the observation that plants that survive near atermitehill grow with vigour and give better yields.

Table 6: Ranking of traditional cultural practices associated with reduced damage of cassava by CGM, CM, termites, scale, and moles by farmers.

Cultural Practice	Pests				
	CGM	CM	Termites	Scale insects	Moles
De-topping	1	1	9	7	8
Selective pruning	2	2	8	1	8
Leaf harvesting	4	4	9	8	8
Frequent weeding	5	6	1	5	8
Burning	6	5	2	2	7
Stem ratooning	7	2	11	3	8
Use of barriers	8	8	5	8	1
Intercropping	3	7	3	4	2
Crop rotation	4	6	3	5	6
Trapping	9	9	11	9	4
Flooding	9	9	7	9	3
Digging	9	9	6	9	5

Burning the fields of cassava before harvest was said to be the second most effective traditional measure for reducing termites and scale especially for the succeeding. The use of underground root barriers and trenches were cited as the most effective measure against moles followed by intercropping with *T. vogellii* and milk bush. Half of the farmers interviewed were knowledgeable about the negative consequences of burning cassava fields, and said it is only used as a last resort where there is a fear of further pest population build-up in situations where the infestation is alarmingly high.

Discussion

Slight variations were observed in the ranking of varietal attributes between farmers in the two districts. Farmers in Solwezi put more emphasis on factors affecting the quality of both the leaves and storage roots, while farmers in Mwinilunga were more concerned with factors affecting the physical quantity of storage roots and planting materials. The former group of farmers is interested in sweet roots which are preferred for eating as raw snacks, while the latter group of farmers normally process cassava into flour for nshima. Farmers in Solwezi are not familiar with the processing of cassava, and because of readily available market for unprocessed cassava in the locality, farmers cannot afford to leave the storage roots in the ground beyond 16 months as is normally the case in Mwinilunga.

This could explain why farmers in Mwinilunga are more concerned about SRR (poor UGS) and SRF than their counter-part in Solwezi. High incidences of SRR and SRF are mostly associated with delayed harvesting of cassava [18]. Foliar diseases and insects are a major concern to the farmers, because of their detrimental effect on the quality and quantity of planting materials and cassava leaves, which are a valuable source of income for women especially in Solwezi. The differences in ranking of varietal attributes between farmers indicate that farmers' knowledge and needs are mainly location specific and end use dependent [19]. The weights attached to various production constraints vary with production conditions, and the cultural, and socio-economic values of the participating farmers. Therefore in order to obtain proper representation of farmers' perception of constraints, the sample size of participants needs to be large enough [20].

This study has revealed that many farmers are aware that pests and diseases are the major contributing factors to low yields of cassava in Zambia. It is also evident from the study that in Mwinilunga and to a lesser extent in Solwezi, farmers are very observant of the influence of various cultural practices on pests. However, they pay attention to larger pests which are easily seen with the naked eye, and much more attention is paid to pests that cause direct damage and thus negatively affect the quality of edible parts of the plant [21]. The non-conspicuous nature of CGM, however, makes it difficult for traditional farmers to clearly identify and define it. Consequently, its effect is under-estimated and limited attention is given to it by farmers.

Good understanding of pest damage symptoms by farmers is crucial for an effective study of indigenous knowledge about traditional coping strategies. Supervised field tours conducted with individual farmers revealed that the co-existence of CGM and cassava mosaic disease on same plant makes it difficult for some farmers and inexperienced extension officers to isolate symptoms of especially CGM and, therefore, the two are usually considered as one. This complication has earlier been reported by Gutierrez [22] who stated that "for someone who is not an expert, symptoms produced by the CGM in cassava (chlorosis of young leaves followed by defoliation of young shoots) can be confused in the field with those produced by the cassava mealy bug, *Phenacoccus manihoti* Matt-Ferrero, or by the African cassava mosaic virus (ACMV)".

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Normally women prefer young and tender cassava leaves which are found in the top third of the plant shoot as leaf vegetable [23]. The competition between human and CGM for such leaves is increasing the urgency to contain CGM in Zambia. Protecting younger and tender leaves not only increases the vegetable supply but also enhances photosynthesis and hence increase production of planting materials, FSRY, SRDM [2,3,24,25], and starch quality [26]. However, for the lack of better alternatives, farmer have resorted to de-topping, selective pruning, harvesting of tender leaves, and burning of cassava fields as ways of reducing pest populations.

One controversial issue concerning such practices lies in their interference with the survival of predatory mites and other beneficial herbivores which are natural enemies of CGM. In the Congo, the findings of the collaborative cassava study in Africa (COSCA) indicated that frequent harvesting of cassava leaves and de-topping of cassava plants is likely to lead to loss of shelter and even loss of the natural enemies [27]. Though a harvesting interval of 60 days in cassava has been suggested [28], to allow for the maintenance of populations of predatory mites, farmers have reduced the harvesting interval due to increased demand for leafy vegetables. These coping strategies are destructive in nature and have retarding effects on plant growth, leading to loss of valuable planting materials and may not help so much in controlling CGM.

Though the new leaves which emerge after de-topping and burning of cassava plants in the field, look healthier and are apparently free of CGM damage, it does not take long before they become re-infested with CGM. Yaninek [3] reports that CGM has the ability to survive on detached cuttings, and buds for up to two months, which contributes to the rapid colonization of the newly emerging young leaves. Therefore the tendency of farmers to plant tender sections of cassava stems with leaves still attached could also be responsible for transferring CGM from one planting to the next. Similarly, CGM has been reported to survive on bundles of cassava leaves that are displayed for sale as a leaf vegetable.

On the other hand, farmers are aware about the potential of pubescent cassava cultivars to reduce CGM damage. Leaf pubescence has also been reported to limit the movement of whiteflies (*Bemisiatabacci*) which translates to limited spread of CMD [29]. Farmers also observed that this protective effect of pubescence is more pronounced in broad-leaved cultivars which exhibit high density of hairs per unit leaf area. Similar results have been reported by Byrne et al. [2] who observed that cultivars with leafy habit (high leaf area index) seem to sustain lower CGM lead damage, resulting into higher FSRY for such cultivars when compared to their glabrous counterparts. Highly pubescent cultivars of cassava tend to have more tender leaves, and are considered to be more palatable and therefore preferred for vegetables by women. Enhancement of leaf pubescence in cassava will not only reduce CGM, but will improve the quality of cassava as a leaf vegetable for Zambian consumers. However there is urgent need to inform farmers about indirect and direct plant defense mechanisms and biological control initiatives for the fight against CGM to be successful.

Intercropping cassava with cereals and legumes is a popular practice among local farmers in North-Western Province. Since cassava takes more than one season to yield reasonable marketable storage roots in Zambia [30], intercropping is only practicable in the first season of cassava cropping. Maize is normally provided with inorganic fertilizer which enables it to grow much faster than cassava and within four months provides some kind of a barrier to the movement of many small pests and insect vectors, the movement of which is highly influenced by wind [31]. In the case of mites, pollen produced from maize for instance could provide an alternative diet on which CGM might spend much of its time consuming, sparing the cassava in the process [32,33]. However, once maize is harvested, CGM can easily move to cassava. This could probably partly explain why there is a rapid rise in the population of CGM in cassava fields shortly following the harvest of maize, which also coincides with the beginning of the season [34,35].

Farmers complained that early-branching cassava varieties do not fit well in the traditional cropping pattern, which commonly involves intercropping cassava with many other crops including cereals and legumes. Early branching cultivars not only make weeding very difficult in intercropped fields, but also suffer more damage from CGM as compared to tall varieties [36]. The short distances between branching levels in short cultivars facilitate easy movement of CGM between branches and leaves within the cassava plant, in search of suitable leaves. This high branching habit also provide better protection for CGM against wind and rain effects, enabling it to continue colonizing the same host plants for a long period of time as long as suitable leaves are available, and consequently causing more leaf damage, and low FSRY [37].

Agreeing with this observation, farmers added that CGM damage tends to be worse when short cultivars are grown in weed infested fields. The reason for this could be that, the weeds tend to provide a bridge for the CGM to walk from one cassava plant to the other in search for tender leaves. This facilitates easy establishment of contacts between male and female mites, hence increasing the reproductive capacity and rate of spread of CGM [3]. Research by Agboton et al. [38] have shown a positive association between weed density and CGM population in Southern-Benin, which seems to agree with the Zambian farmers' observations. These authors have also reported reduced frequency of the natural enemy *Typhlodromalusaripo* in weedy cassava fields. The current study therefore presents a challenge to breeders to develop fast-growing cassava cultivars that rapidly outgrow and suppress weed populations, supporting farmers' preference for cultivars that have a wider canopy and extended leaf longevity [39].

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Conclusion

This study has shown that any research work towards combating CGM in cassava will be very challenging and requires a multi-dimensional consideration of cultural, socio-economic and environmental factors. Once successful this work will go a long way to increasing the supply of a cheaper source of protein, vitamins and minerals to rural communities, as well increasing the yield of cassava, and raising the living standards of rural communities. Farmers have valuable knowledge about the biotic constraints to cassava production and they are doing a great deal within their own means to solve pest problems. However, for lack of better alternatives, farmers are using destructive methods which are potentially detrimental to beneficial predators in cassava fields and to the agro-ecosystems in general. There is urgent need to sensitize farmers about CGM and the associated damage this pest causes, the importance of which has been underestimated, due to its non-conspicuous nature. Emphasis should be placed on farmer training and sensitization about the benefits of natural enemies to CGM and the requirements for their effective presence in cassava fields. Active involvement of both learned and unlearned farmers at the planning, implementation and evaluation stages of an IPM programme for CGM is likely to contribute to its effectiveness and sustainability.

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