Status and Current Research Strategies for Management of the Coffee Berry Borer (H*ypothenemus hampei* Ferr) in Africa

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ABSTRACT:

Coffee production in Africa has largely stagnated over the past two decades. While the continent had attained a production level of 19.5 million 60kg bags of coffee in 1997, production in 2008 was only 17.5 million 60kg. This stagnation has been attributed to a number of factors including poor management practices and losses due to damage by insect pests and diseases (Musoli *et. al*, 2001). The coffee berry borer (CBB) (*Hypothenemus hampei* Ferr), considered endemic to the African continent, is undoubtedly the most important insect pest of coffee in Africa causing significant damage to yield and quality of the crop in many producer countries. In Africa CBB is regarded as the most prevalent and important coffee pest and a problem for the coffee industry. In Kenya, infestation levels of 80% during the peak season with significant losses in yield and quality has been reported (Masaba *et. al*., 1985). Severe infestation may result in up to 80% of berries being attacked in Uganda and Ivory Coast, and 96% in Congo and Tanzania (Waterhouse and Norris, 1989). In Uganda, damage has been found to vary mainly due to the uneven distribution of bio-control agents, and differences in cropping systems and farmer practices (Kucel and Orozco-Hoyos, 1998).

While considerable efforts have been made by research institutions in many African countries to address the problem, control recommendations have principally relied on cultural methods that are on their own inadequate and cumbersome for peasant farmers to apply with due diligence. Similarly, lack of concerted research interventions and limited knowledge about CBB in most countries aggravates the situation. International partnership between Uganda, Kenya, Colombia and CABI with support from USDA/ARS made considerable progress towards enabling the integration of use of the parasitoid *Heterospilus coffeicola* Schmeid in biological control programmes (Kucel *et. al*., 2004).
The way forward for CBB management in Africa is therefore to increase awareness among stakeholders through trainings, search for varietal resistance among the vast African robusta germplasm stocks. Increased generation and transfer of effective IPM technologies, better insight into the African coffee agro-ecosystems, addressing the issue of gender concerns in pest management in the African context, and fully integrating the use of the hitherto unexploited bio-control agents *H. coffeicola*, *B. bassiana* and *M. anisopliae* are considered critical components of an effective CBB management strategy in Africa.

Key words: Africa; CBB; Coffee-berry-borer; Hypothenemus-hampei; Heterospilus-coffeicola; Bio-control; Farming-systems; Farming practices; IPM; B-bassiana; M-anisopliae

1.0 Introduction:

1.1 Coffee production in Africa:

Coffee remains the most important export crop for many African countries both in terms of the earnings and its impact on socio-economic life of the rural folk engaged in its production. Many African producer countries depend almost entirely on foreign exchange earnings from coffee exports, while large sections of their population draw their livelihood from coffee cultivation, processing and marketing establishments (Table 1).

Table 1. Coffee Production Statistics of African Exporting Countries

	Type of Coffee	Production (000 bags)					
		2003	2004	2005	2006	2007	2008
World Production		*104 079*	*115 558*	*109 630*	*126 820*	*116 212*	*134 163*
Angola	(R)	38	15	25	35	36	50
Benin	(R)	0	0	0	0	0	0
Burundi	(A/R)	338	437	285	387	169	583
Cameroon	(R/A)	900	727	849	836	602	800
Central African Rep.	(R)	43	45	46	78	64	60
Congo, Dem.Rep. of	(R/A)	427	360	336	378	397	400
Congo, Rep. of	(R)	3	3	3	3	3	3
Côte d'Ivoire	(R)	2 689	2 301	1 962	2 847	2 150	2 500
Ethiopia	(A)	3 874	4 568	4 003	4 636	4 906	6 133
Gabon	(R)	0	0	1	1	0	0
Ghana	(R)	13	16	20	29	25	25
Guinea	(R)	366	316	525	473	387	335
Kenya	(A)	673	736	660	826	652	950
Madagascar	(R/A)	435	522	599	587	579	600
Malawi	(A)	48	21	24	17	19	25
Nigeria	(R)	46	45	69	51	44	50
Rwanda	(A)	266	450	300	254	252	383
Sierra Leone	(R)	36	15	60	31	41	20
Tanzania	(A/R)	612	763	804	822	810	917
Togo	(R)	144	166	140	134	125	130
Uganda	(R/A)	2 599	2 593	2 159	2 700	3 250	3 500
Zambia	(A)	100	110	103	56	61	70
Zimbabwe	(A)	92	120	66	45	29	50
Total African Production		*13742*	*14329*	*13039*	*15226*	*14601*	*17,584*
% of World Production		*13.2*	*12.4*	*11.9*	*12.0*	*12.6*	*13.1*

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Major coffee producer countries in order of importance are Ethiopia, Uganda, Ivory Coast,

Kenya, Tanzania, Cameroon, Madagascar, Burundi and Democratic Republic of Congo. Benin, Angola, Central African Republic, Congo (Brazzaville), Gabon, Togo, Equatorial Guinea, Ghana, Guinea, Liberia, Nigeria and Sierra Leone produce smaller quantities. African coffee production for much of the early 1990s averaged 15,274.8 million 60 kg bags, accounting for 20.1% of total world production. Production from 2003 to 2008 averaged 14,753.5 million 60 kg bags contributing 12.5 % of the total world output. While Africa had attained a production level of 19.5 million 60 kg bags in 1997 (Rwendeire, 1998), the output for 2008 was only 17.584 million 60 kg bags (Rwendeire, 1998; ICO website, 2008). Coffee production in Africa has therefore stagnated over the years, while Africa's share of the world market has drastically declined (Table 2).

Table 2. Contribution of African coffee production to world total output

Year	Production (,000)	% World Production
2008	17,584	13.1
2007	14,601	12.6
2006	15,226	12.0
2005	13,039	11.9
2004	14,329	12.4
2003	13,742	13.2
Mean	**14,753.5**	**12.5**

1.2. Major constraints to coffee production in Africa:

The strategic and vital African coffee sector is unfortunately beset by enormous problems that have evidently resulted in the decline in world market share values - from 30 percent in the early 1970s to about 20 percent in the late 1980s, to an all time low of 12.5% in 2008. Favourable IMF supported macro-economic policy reforms in some African countries in the late 1980's and early 1990's tremendously benefited the coffee sector leading to marked increase in production. However, as in the case of Uganda, the gains were soon reversed by the advent of the coffee wilt disease in 1993. The downward trends have continued to-date in many African producer countries, and unless comprehensively addressed, African coffee production is destined for further decline.

Due to limited research interventions, low yielding plant materials for both Arabica and Robusta as well as their exploitation, spacing and density are major constraints to coffee production in many member countries. These, together with aging plantations, difficulty in reproducing and distributing homogenous planting materials, insufficient certified plant materials, insect pests and diseases constituted important obstacles to coffee production. For many years, countries such as DR Congo, Uganda and Angola suffered civil strife, while a number of African producer countries experienced macro-economic mismanagement and these have had serious negative effects on the coffee industry.

Of great concern are also the poor extension and field services, problems of management of mixed food crops/coffee farming systems, unfavourable land tenure systems, and reticence of farmers to innovations, and poor production and marketing policies, all of which have greatly contributed to poor production performance in most countries.

2. The Coffee berry borer situation in Africa:

2.1 Status of CBB in Africa:

The majority of African coffee producer countries currently rank the coffee berry borer *Hypothenemus hampei* (Ferr.) as the single most important phyto-sanitary production constraint. Some countries such as Uganda, Cameroon, D.R. Congo and Kenya have over the years seen steady increases in berry borer damage levels, perhaps due to the inability or lack of naturally occurring biological control agents to restrain CBB populations. Cameroon, D.R. Congo, Central African Republic and Ivory Coast consider their CBB profile as getting worse or much worse. In Kenya, infestation levels of 80% during the peak season with similar magnitude of crop losses with reduction in quality of the remaining yield have been reported (Masaba *et. al*., 1985). Severe infestation may result in up to 80% of berries being attacked in Uganda and Ivory Coast, and 96% in Congo and Tanzania (Waterhouse and Norris, 1989). In Uganda, CBB is a serious pest of Robusta, and may also be important on Arabica at low altitudes (Musoli *et. al*., 2001). Field surveys conducted in the 1960''s, 1980's and 1990's (Le Pelley, 1969; Bardner, 1985; Ngambeki *et. al*., 1993) showed that damage by *H. hampei* is most severe on coffee at low altitude, seldomly serious at over 1370m, rare at 1525m, and non-existent at 1680m. However, recent observations on Arabica coffee in Eastern Uganda (Kyamanywa *et. al*, 2009) have found the borer at altitudes as high as 1864 masl, raising speculations about the effects of global temperature rise on the distribution of coffee pests and diseases in Uganda. A damage level assessment conducted during 1996-97 showed that about 9 percent of the country's coffee is lost to attack by the borer annually. CBB is commonly found in wild forest coffees in Uganda, and for this matter, is considered indigenous to Uganda (Kucel and Orozco, 2000).
The coffee berry borer menace in Africa is therefore evidently significant and hence is a high priority phyto-sanitary problem that calls for a renewed resolve towards a long term redress.

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2.2 Effect of farming practices, cropping systems and altitude on borer infestation in Africa:

The majority coffee farmers in Africa are small holders with farm sizes hardly exceeding 2 hactres. In Uganda for instance, nearly all the Robusta and most of the Arabica is grown by local cultivators in small individual plots, with average farm size of 0.36 hectares for Robusta and 0.23 for Arabica, where it is usually planted at variable spacing, often mixed with other crops such as bananas, frequently lightly shaded and rarely mulched. Apart from a few coffee estates, it is rare that coffee is grown as a pure stand.
Differences in cropping systems and farming practices may therefore create variations in field conditions that may favour or disfavour multiplication of *H. hampei*. Several studies have attributed some out-breaks of the CBB to these factors. Attacks have been found to be more severe where the coffee is grown under heavy shade or is closely planted and un-pruned or inadequately de-suckered. A single, very large, dense shade tree can cause a serious local infestation. Intercropping with crops such as bananas that shade coffee trees is believed to favour higher borer infestations, although this is yet to be verified (Le Pelley, 1968; Jameson,

1970; Bardner, 1985). Studies have also shown that careless harvesting of coffee that does not follow a frequent and regular schedule, and that leaves ripe or dried berries on trees or ground into period of the next crop provides source of borer infestation with higher subsequent infestation levels (Jameson, 1970).
Any strategies towards addressing the CBB menace in Africa therefore ought to be packaged in the context of the African coffee farming systems and practices, in order to deliver meaningful successes.

3. Approaches to CBB management in Africa:

The fact that CBB has remained a problem for coffee farmers in many African producer countries, the situation getting worse in some cases, is enough evidence that control measures have generally been ineffective. Although damage of up to 80% in some countries is cause for concern, CBB management had, until recently, not been given a deserving attention. In most African producer countries, control recommendations heavily rely on cultural measures that are on their own inadequate and cumbersome to apply, while in countries such as D.R. Congo and Ivory Coast, farmers are indifferent to the presence of CBB in their coffee plantations. Chemical control of CBB is discouraged in Uganda by policy that promotes production of specialty coffee, but is widely applied in plantation coffee in Kenya and some other African countries. The fact that chemical control requires insecticides with reasonable systemic properties and persistence, coupled with the occurrence of peak incidences close to harvest renders chemical control unsuitable due to concerns over health and environment. Integrated pest management (IPM) approaches are non-existent in many instances, and where available, they are hardly applied as is the case in Kenya, Tanzania, Angola and Uganda. No meaningful attempts have been made towards developing CBB resistant varieties by the African national coffee research institutions. Matters are further complicated by the lowly educated small scale cultivators of African coffee who are largely reticent to new innovations and therefore do not diligently follow management packages developed by research scientists. Similarly, knowledge about the pest is regarded as poor in all African countries. Hopes are therefore pinned on successful large scale biological control programmes that are fully supported by governments and development partners.

4. Way forward for coffee berry borer research and management in Africa:

4.1 Cultural control:

Considerable progress has been made by some African countries, particularly those in East and Central Africa towards developing sustainable cultural management options for CBB. Uganda, Kenya and Tanzania have particularly invested considerable resources towards this effort with several recommendations available to farmers. The reliance on cultural control recommendations has however not been adequate to address the CBB problem in Africa. It is therefore imperative that the available cultural control recommendations are judiciously integrated with other control options for increased efficiency. Further elucidation of the African coffee agro-ecosystem also is proposed and the determination of the underlying factors for CBB prevalence in Africa need be done in order to refine the available cultural

control recommendations.

4.2 Varietal resistance:

Varietal resistance is ultimately the desired solution to the CBB menace in Africa. However, no meaningful attempts have been made by Africa's research institutions to develop varieties that are resistant to CBB, the vast diversity of coffee materials both on-farm and in the wild forests not-with-standing,. In Uganda, an intensive Robusta coffee breeding programme since 1996 in search of varietal resistance to coffee wilt disease (CWD) has led to the development of thousands of lines that are currently undergoing screening and/or evaluations. Researchers at NARO/COREC have embarked on screening the new lines and other germplasm materials for other characteristics including resistance to CBB. A more comprehensive search for varietal resistance ideally requires the collective participation of other African countries that are themselves located within the centres of origins of both Arabica and Robusta coffee. These include countries such as Ethiopia, DR Congo, Cameroom and Central African Republic.

4.3 Chemical control:

While a few African countries have adopted chemical control of CBB using insecticides, farmers are advised to apply chemical control only if advised by qualified extension workers. The principal drawback with this procedure is the difficulty in delivering the pesticide to the location of the borers inside the beans. Again, heavy infestation occur on mature beans close to ripening, and therefore requiring that the insecticide is quickly degraded before time of harvest to minimise pesticide residues in beans. Problems of availability and affordability of pesticides by small scale peasant farmers further complicate recommendations for their use.
However, the limited prospects for further development in chemical control of CBB in Africa has been severely curtailed by policies in some countries such as Uganda designed to promote production of specialty coffee, and to protect the environment and human health. Research in this area therefore ought to particularly strike an acceptable balance between efficiency, environmental responsibility and human health considerations.

4.4 Biological and ecological studies of the natural enemies of CBB*:*

Both Arabica and Robusta coffee are native to Africa and it is also generally agreed that the CBB is endemic to the African continent. This therefore makes Africa the most logical location for an intensive search for natural bio-control agents. Several surveys in Uganda in collaboration with a number of national and international institutions such as CABI, CENICAFE (Colombia), CIRAD, ORSTOM, CRF (Kenya), USDA/ARS (USA), OSU and Virginia Tech (USA), DFID (UK) and others have confirmed/uncovered presence of a number of CBB parasitoids and entomo-pathogens (*Beauveria bassiana* and *Metarhizium anisopliae*). *H. coffeicola* is believed to be the most efficient of them all as CBB incidences were quite low in areas where they occurred most abundantly (Kucel and Orozco-Hoyos, 2000).
While P. nasuta, P. coffeae and C. Stephanoderis have been widely adopted in biological

control programmes in many countries world-wide, *H. coffeicola*, *B. bassiana* and *M. anisopliae* are yet to be fully incorporated in CBB bio-control programmes owing to difficulties in mass rearing (*H. coffeicola*) and lack of effective delivery mechanisms (*B. bassiana* and *M. anisopliae*). NARO/COREC in collaboration with CENICAFE and CABI, and with support from USDA/ARS had made considerable progress in unlocking the intricacies essential for the development of mass rearing protocols for *H. coffeicola*. The scientists, for the first time on record, were able to induce in-vitro oviposition by *H. coffeicola*, albeit on a limited scale (Kucel *et. al*., 2004). This success need to be further advanced in order to enable full intergration of *H. coffeicola* in biological control programmes world-wide.

Generally, parasitoids and entomopathogens introduction, conservation and augmentative programmes need to be implemented in areas where they do not occur at all, where they occur and are in good control of borer populations, and where they occur but are not in good control of borer populations respectively.

4.5 CBB regional and international collaborative research and management programmmes:

Most African national coffee institutions lack adequate capital investments for CBB research and management. The ailing economies of most African producer countries are unable to adequately fund research initiatives. The solution therefore lies in regional integration of research projects. In this regard therefore, the East and Central Africa region has in the recent past undertaken joint projects to address coffee production constraints such as CWD, coffee stem borer, quality and marketing concerns with considerable successes. A CFC supported coffee leaf rust project is currently on-going. In the same spirit therefore, the region is currently developing a regional CBB project that embraces the participation of scientists from Uganda, Kenya, Tanzania, DR Congo, Rwanda, Zambia and Burundi.

International collaboration in CBB research has been quite helpful in a few countries, especially in Uganda and Kenya. H. coffeicola collaborative research programme in Uganda was undertaken in partnership with CENICAFE, CABI, USDA/ARS and CRF. Such targeted international cooperation that bring together experts from diverse institutions and background, and focusing on specific critical aspects of CBB management is arguably the best approach to advancing CBB research on common grounds. International collaborative research efforts should therefore be promoted alongside regional cooperation for better impact.

4.6 Trainings and dissemination:

There is dire need in all African producer countries for increased awareness about CBB matters, particularly about agro-ecological pest control techniques and IPM options. This can best be achieved through a concerted effort by national institutions to train all stakeholders and establish other functional mechanisms for technology transfer.

4.7 Gender mainstreaming in CBB research and management:

In Uganda, Women and children provide the bulk of the farm labour necessary to successfully

successfully produce a coffee crop. They are therefore critical for the success of the core labour based cultural control recommendations for control of IPM. Participatory CBB management technology generation and dissemination that gives particular attention to the roles of women and children stands a greater chance of success in Africa. Therefore, this calls for a gender sensitive approach in CBB research and management.

5. Conclusions:

The coffee berry borer is one of the the most serious phyto-sanitary problem afflicting the coffee industry in Africa. Available control recommendations are ineffective and the problem appears to be getting worse in many African countries. General lack of information, reticence of farmers to CBB management innovations and low research inputs by responsible national institutions have aggravated the situation. A renewed effort should be placed in better understanding the African coffee farming systems and practices and their influences on CBB prevalence. The potentials for bio-control and varietal resistance have in many aspects not been fully exploited. These could provide the much sought breakthrough in CBB management. Finally, resources ought to be devoted towards increasing awareness about CBB in the various producer countries, and to promote technology transfer among the various CBB management fraternity. Regional and international partnerships were quite successful in some instances in the East and Central African region and ought to be encouraged to provide more effective fronts for fighting the CBB menace.

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