FEED THE FUTURE
The U.S. Government's Global Hunger & Food Security Initiative

FEED THE FUTURE GHANA AGRICULTURE POLICY SUPPORT PROJECT (APSP)

Assessment of the Preparedness of Potential State Institutions to Conduct Distinctiveness, Uniformity and Stability (DUS) and Value for Cultivation and Use (VCU) Testing in Ghana

FEBRUARY 2017

USAID
FROM THE AMERICAN PEOPLE

FEED THE FUTURE GHANA AGRICULTURE POLICY SUPPORT PROJECT (APSP)

Assessment of the Preparedness of Potential State Institutions to Conduct Distinctiveness, Uniformity and Stability (DUS) and Value for Cultivation and Use (VCU) Testing in Ghana

Contract No. 641-C-14-00001

Contents

List of Tables

List of Figures

Executive Summary

- **Introduction**

There have been various efforts in the past few years by the Government of Ghana and its partners both private sector and donors to re-vitalize the seed industry, which is key to ensuring food security. One of the major steps a plant breeder must take in availing newly developed or improved crop varieties to farmers is to have the developed variety pass the Distinctiveness, Uniformity and Stability (DUS) Tests as well as Value for Cultivation and Use Tests (VCU). A new system of DUS and VCU Testing has been proposed for Ghana. This system ensures that only institutions who are accredited for crop variety testing accordingly conduct tests. However, the question remains as to whether the various potentials institutions that will perform this function are prepared in terms of both human and infrastructural capacity. It was therefore important that the status of the potential institutions, that are likely to be accredited to undertake DUS and VCU testing, be evaluated and necessary recommendations made.

- **Major Findings**

1. The major plant breeding techniques employed by agricultural research institutions and the universities in Ghana include 40% conventional breeding, 26% molecular breeding, 20% mutation breeding, and 13% tissue culture.
2. The Plant breeding activities of the NARIs and Universities involve all food crops and fruit tree crops, except cocoa and sheanut.
3. CSIR-CRI and SARI were identified to contribute about 90% of all improved crop varieties in Ghana. The two institutes combined had developed and released about 25 new plant varieties in the last 10 years**.**
4. There is evidence of availability of human resource and trained personal to conduct DUS and VCU tests for varietal release and registration in Ghana. However, there are still gaps to be filled as well as the need for continuous capacity building to keep these professionals updated on new and improved procedures on DUS and VCU testing.
5. Almost all the institutions have basic infrastructural capacity for the conduct of DUS and VCU tests such as experimental fields, irrigation facilities, offices, and seed processing sheds, screenhouses, and storage barns. However, one major infrastructural deficiency across the institutions, with the exception of CRI, is the lack of a functioning seed testing laboratories.
6. The identified equipment gap that exists in the institutions, with the exception of KNUST, is lack of functional apparatus for determining physical and chemical properties of new plant varieties, a requirement under VCU tests.
7. Finally, there is generally high level of awareness among the professionals of the varietal release and registration procedures and the Plant Breeders' Right Bill; however, their level of knowledge on provisions in the bill is generally low. Key factors that could enhance awareness and knowledge include education and provision of short trainings for professionals on the VRRS.

- **Recommendation**

i. In order to reach out to all professionals about the VRRS, there is the need for policy makers to undertake institution wide sensitisation of the professionals.
ii. Institutions such as the PPRSD, National Seed Council, GSID and the National Agricultural Research Institutions need to take the lead in this sensitisation for increased awareness of the VRRS across professional.

iii. These sensitisations could be implemented through workshops, forums, and short trainings. This could come with practical sessions to ensure participants have hands-on experience on the processes.
iv. DUS tests could be limited to only one growing cycle and VCU test should be optional.
v. There is also the need to provide educational trainings both locally and internationally to enrich professional experience in conducting the DUS testing.
vi. For a more effective, efficient and transparent VRRS, it is recommended that independent institutions are accredited to conduct DUS and VCU tests. These institutions must be independent of the applicant of the new plant variety.

Acronyms and Abbreviations

APS	-	Agriculture Policy Support
CSIR	-	Council for Scientific and Industrial Research
CRI	-	Crops Research Institute
DUS	-	Distinctiveness, Uniformity and Stability
ECOWAS	-	Economic Community of West African States
KNUST	-	Kwame Nkrumah University of Science and Technology
MoFA	-	Ministry of Food and Agriculture
NSC	-	National Seed Council
NVRRC	-	National Varietal Release and Registration Committee
OPRI	-	Oil Palm Research Institute
PGRRI	-	Plant Genetic Resources Research Institute
PBR	-	Plant Breeders' Rights
VCU	-	Value for Cultivation and Use
VRRS	-	Varietal Release and Registration System
WAIFOR	-	West African Institute of Oil Palm Research

1. Introduction

There have been various efforts in the past few years by the Government of Ghana and its partners both private sector and donor agencies to re-vitalize the seed industry, which is key to ensuring food security. One of the major steps a plant breeder must take in availing newly developed or improved crop varieties to farmers is to have the varieties pass the Distinctiveness, Uniformity and Stability (DUS) Tests as well as Value for Cultivation and Use (VCU) Tests. In Ghana, this process has over the years been carried out using administrative procedures to guide the release and registration of crops varieties. To ensure that this process is streamlined, several efforts have been made to develop a harmonized system of crop variety release and registration not only in Ghana but the ECOWAS sub-region as a whole.

Currently, the USAID Feed the Future Agricultural Policy Support Project (APSP) is spearheading a process to fill in the gaps in the current crop variety release and registration system to ensure that all the necessary procedures and roles are functional and transparent. This process will make the implementation of the Plant and Fertilizer Act, 2010 (Act 803) and its regulation functional. To achieve this goal, a new system of DUS and VCU Testing has been proposed by the Ministry of Food and Agriculture (MoFA). This system ensures that only institutions who are accredited for crop variety testing are allowed to conduct such tests. Hitherto, the institutions that develop or apply to release crop varieties conduct these tests themselves and submit the results to the National Variety Release and Registration Committee (NVRRC). The NVRRC makes its decisions based on the data submitted to it by the applicant (the Plant Breeder). This often raises the issue of conflict of interest and questions the credibility of the test results upon which the NVRRC bases its decisions. The proposed system will ensure that the testing institution is independent of the plant breeder (applicant), hence more transparent and trustworthy.

In as much as the newly proposed system ensures transparency, builds trust and confidence, the challenge is whether the potential institutions that will be accredited for DUS and VCU testing have the requisite capacity in terms of human and infrastructure resources among others, to carry out these tests. A study by Bortey and Mpanju (2016) to assess the implication for the implementation of the Plant Breeders' Rights Bill of Ghana, observed that there exists some level of capacity in terms of human resources but there is lack of some basic but critical infrastructure for DUS testing purposes. However, the study looked at only two of the potential institutions.

Hence, in order to be accredited to implement independent testing on the national scale, it is very important that the status of more state institutions that have the potential to undertake DUS and VCU testing be evaluated and necessary recommendations made. This will serve as a crucial source of information to guide the accreditation process. It will also bring about transparency and ensure the effective implementation of the varietal release and registration procedures that are being developed. More importantly, this study is in tandem with USAID-APSP's goal of strengthening the capacities of local research and academic institutions to contribute to policy making process through evidence-based research. This study rightly fits in that goal.

1.1 Objective

To evaluate the preparedness of national agricultural research institutes (NARIs) and the universities for DUS and VCU Testing under the newly proposed Variety Release and Registration System

1.2 Specific objectives

1. To document plant breeding activities of seven (7) potential DUS, VCU testing institutions in Ghana
2. To identify the human resource capacity and existing gaps (plant breeding, and related fields) of these selected institutions
3. To identify existence of trained personnel in evaluation of specific crop varieties
4. To identify the infrastructural capacity (e.g. experimental fields, offices, seed store, seed processing shed) and existing gaps of these institutions
5. To identify equipment used in variety testing such as irrigation facilities (DUS site only), transport, computer, printer, fridges, cold room, scanner, digital camera, measuring tape, ropes, hoes, sprayer, weighing scales, moisture metre, GPS and statistical software.
6. To assess the level of awareness and knowledge on the variety release and registration procedure among plant breeders/seed technologists/agronomists in these institutions
7. To proffer recommendations on how the identified gaps can be addressed to make DUS and VCU Testing in Ghana functional, transparent and efficient.

2.0 Status of varietal release and registration system in Ghana

It is generally agreed that some regulation is necessary to make sure only good, appropriate and new crop varieties are promoted by both public and private sector to enhance crop productivity. To this end, many countries around the world have established systems for regulating varietal development, release and registration. It has however, been observed that these regulations and systems differ from country to country including those in Africa (Sanni *et al*., 2013).

Variety regulation primarily seeks to guide the release of new varieties developed by both public and private sector breeding programmes. According to a study by Louwaars (2002), the varietal release regulations in most countries have common features such as; i) a mandatory procedure for testing varieties proposed for release, ii) National Varietal Release and Registration Committee (NVRRC), which often recommends or rejects release based on test results and iii) an official register of released varieties, recording names and major traits of the varieties that have successfully been recommended for release. In most countries, the national seed laws establish the authority to control this process. In Ghana, it is the National Seed Council that is responsible for receiving, verifying and examining the applications for the registration of a new variety. It must be noted however, that the institutions responsible for new variety development in Ghana over the years have been largely public sector research institutes. Particularly, Crops Research Institute (CRI) and the Savanna Agricultural Research Institute (SARI) under the Council for Scientific and Industrial Research (CSIR) have been responsible for the development and release of majority of crop varieties in the country.
The Faculties of Agriculture in some public universities have occasionally developed and released some new varieties as well.

In Ghana, the National Variety Release and Registration Committee (NVRRC) of the NSC verifies whether the new variety fulfils the distinctiveness, uniformity and stability (DUS) as well as the Value for Cultivation and Use (VCU) examinations through a designated institution. Both DUS and VCU tests are required before release and registration of a new variety under the Ghana system. DUS tests must be two (2) growing seasons with about 36 traits or characteristics to be measured in the case of Maize (*Zea mays*). The duration for DUS tests however, vary across the sub-region, Nigeria and Mali require the DUS test to be conducted for a minimum of three seasons while in Zimbabwe only one season is required Setimela *et*

al., (2009). It must be noted that the accepted traits for DUS examinations are not affected by environmental conditions and thus one season is sufficient to provide the needed data to demonstrate the distinctiveness of a variety from existing ones. Data collection is an expensive exercise and efforts to minimise this cost is essential for both the applicant and the consumers as well. Another observation in the Ghana's varietal release and registration system which needs review is the requirement of DUS data for inbred lines in addition to OPVs and Hybrids. As concluded by Setimela *et al.* (2009), seed companies offer for sale only hybrids or OPVs. Moreover, it is not easy for other companies to know the inbred combinations of a particular hybrid. Hence to avoid the associated cost of time and resources, such a data requirement must be discontinued.

Similarly, Ghana's system requires VCU to be conducted at 6 trial sites across the agro-ecological zones and 36 traits for two seasons (DTMA National variety testing and release survey 2007/2008). This requirement is time consuming and expensive and can be avoided as pertains in other jurisdictions like South Africa, where the value of the new variety is determined by the consumer; the market forces determines the value of the new variety (Setimela *et al.,* 2009). According to a study by Setimela *et al.* (2009) on variety release system, Ghana is one of the few countries in which economic analysis data is required as part of the VCU test. All these add to the cost of variety development, which currently is largely possible due to donor funding. In the absence of donor funding for crop variety development in Ghana, which currently stand at about 90% (Bortey and Mpanju, 2016), it will be expensive for breeders to bear all the costs for variety release and registration?

3.0 Methodology

Desk studies to review relevant literature on earlier studies was conducted to provide a thorough understanding of key concepts and proposed methods of analyses for the study. It involved both electronic and print resources such as reports and other relevant publications. This was followed by an informal reconnaissance study to the selected institutions to establish contact and explain the rationale for the study. This was followed by a formal survey to gather data on the individual institutions as well as the professionals. Primary data was collected using semi-structured questionnaire with both open and closed-ended questions where applicable. To ensure reliability and validity of the data collected, about 85% of the questionnaires were administered through face to face interviews while the remaining 15% were sent to the institutions to be answered and sent back in situations where key respondents for the institutional questionnaire were absent at the time of visit.

3.1 Ethical considerations

The researcher ensured that the traditional key concepts associated with conducting ethical social science research such as informed consent, confidentiality and anonymity were complied with. Thus, an introductory letter/Consent Form, which indicated the purpose of the study and the background of the researcher was first sent to or read to a respondent for his/her approval before interview commenced or questionnaires were administered. The confidentiality and anonymity requirements were also satisfied in that none of the questions in the questionnaire required respondents to specify their names and the final document also did not cite any respondent's real name. Respondents also had the option not to participate in the study if they so wished to meet the ethical requirements of informed consent.

3.2 Sampling technique and scope of study

Purposive random sampling technique was used in the study. The selection of the institutes was purposively done. The respective professional (Plant breeders, seed technologists etc.),

were randomly selected from each of the institutions. This study involved stakeholders who were directly likely to be accredited for the conduct of DUS and VCU Testing under the newly proposed variety release and registration system. These include the National Agricultural Research Institutes (NARIs) and Public Universities who are involved in plant breeding activities. A total of 7 organizations namely:

i) Crops Research Institute (CRI),
ii) Savanna Agricultural Research Institute (SARI),
iii) Oil Palm Research Institute (OPRI),
iv) Plant Genetic Resources Research Institute (PGRRI),
v) Kwame Nkrumah University of Science and Technology - Faculty of Agriculture,
vi) University of Cape Coast-School of Agriculture
vii) University for Development Studies (UDS), Nyankpala-Tamale.

At least 10 professionals were interviewed from each of the NARIs and 5 each from the public universities. In addition, the administrative head or representative each of the organization was interviewed. Thus, a total of 47 respondents participated in the present study in addition to 7 institutional questionnaires.

3.3 Data Management and analytical procedure

The data was first cleaned where necessary and coded before input into statistical package for analysis. With respect to the open-ended questions of the questionnaire, the researcher initially transcribed all responses and then analysed in relation to other responses from other participants in the context of the study's objectives.
Descriptive statistics was used to summarize characteristics of respondents in the analysis and data were presented in frequency distribution tables and charts and graphs where appropriate.

The probit regression and truncated regression models were used to examine the factors influencing awareness and knowledge of existing variety release system amongst the crop improvement professional in the selected institutions in Ghana.

3.3.1 Analytical framework for examining the factors influencing awareness and knowledge of VRRS

Being aware and having knowledge of varietal release and registration procedures among professionals was modelled as a decision-making process and is engrained on the utility maximization theory of Rahm and Huffman (1984), in which a professional becomes aware of or obtain knowledge about the VRRS only when the utility obtained from becoming aware and using gaining knowledge is greater than the utility he obtained from not becoming aware and not obtaining knowledge.

Accordingly, this is a binary decision involving two mutually exclusive alternatives. The professional is either aware of the VRRS or not, or obtain knowledge of VRRS or not. Subsequently, resulting in a binary dependent variable A_i for awareness and *K* for knowledge such that A_i takes the values of 0 if the professional is not aware and 1 if she/he does is aware of VRRS. Similarly, K_i takes on the values of 1 if the professional has full knowledge of VRRS and 0 if she/she does not.

Thus, in terms of awareness, the probability of observing 1 will be:

$$P_r = (A_i = 1/x_i\alpha_i) = 1 - F(-x_i\alpha_i) \quad (1)$$

and that for observing 0 is given by;

$$P_r = (A_i = 0 / x_i\alpha_i) = F(-x_i\alpha_i)\,. \quad (2)$$

Similarly, for the knowledge model, the probability of observing 1 will be;

$$P_r = (K_i = 1 / x_i\alpha_i) = 1 - F(-x_i\alpha_i) \quad (3)$$

and that for observing 0 is given by

$$P_r = (K_i = 0 / x_i\alpha_i) = F(-x_i\alpha_i) \quad (4)$$

where F is a continuous and strictly increasing cumulative distribution function, which takes a real value and returns a value which ranges from 0 to 1.

Consequently, the parameters in the models in equations (1) and (2) and equations (3) and (4) are obtained using the maximum likelihood estimation approach. The dependent variable is an unobserved latent variable that is related to A_i and K_i as:

$$A_i = \alpha_j X_{ji} + \delta_i \quad \text{and} \quad K_i = \alpha_j X_{ji} + \varepsilon_i \quad (5)$$

where δ_i and ε_i are a random disturbance terms.

The observed dependent variable is determined by whether the predicted A_i^* or K_i^* is greater than 1 or otherwise:

$$A_i = 1 \text{ if } A_i^* > 0 \text{ and } A_i = 0 \text{ if } A_i^* \le 0 \quad (6)$$

$$K_i = 1 \text{ if } K_i^* > 0 \text{ and } K_i = 0 \text{ if } K_i^* \le 0 \quad (7)$$

where A_i^* and K_i^* is the threshold value for A_i and K_i assumed to be normally distributed.

Following from Madala (2005), the probit models adopted for the study are specified as:

$$P_i = P(A_i^* < A_i) \;=\; P_i = P(A_i^* < \alpha_0 + \alpha_j X_{ji}) \quad (8)$$

$$P_i = P(K_i^* < K_i) \;=\; P_i = P(K_i^* < \alpha_0 + \alpha_j X_{ji}) \quad (9)$$

where P_r is the probability that an individual will make a certain choice (become aware or not) and A_i and K_i are the dependent variables.

3.3.2 The empirical model

The empirical models are thus explicitly specified as;

$$\Pr_i(A_i = 1 \mid x) = \alpha_0 + \sum_{i=1}^{6} \alpha_i X_i \quad (10)$$

$$\Pr_i(K_i = 1 \mid x) = \alpha_0 + \sum_{i=1}^{6} \alpha_i X_i \quad (11)$$

where X_i is a set of explanatory variables included in the model such as being a plant breeder, agronomist, education, gender training and professional experience.

4.0 Results and Discussions

4.1 Brief background of the selected institutions

The study was conducted across research institutions that have potential role in crops improvements and conducting or have the potential to conducting DUS and VCU testing for varietal release and registration in Ghana. These institutions include the relevant departments

in the universities such as Faculty of Agriculture in Kwame Nkrumah University of Science and Technology (KNUST), School of Agriculture in University of Cape Coast, and the Faculty of Agriculture in University for Development Studies. The Faculty of Agriculture at the University of Ghana was part of the institutions, however, all effort at getting the information from the university was unsuccessful, hence could not participate in this study. Further, four (4) national research institutions mainly under the Council for Scientific and industrial research namely CSIR-Crops Research Institute, CSIR-Plant Genetic Resources Research Institute (PGRRI), CSIR-Oil Palm Research Institute (OPRI) and CSIR-Savannah Agricultural Research Institute (SARI) were part of the study. Thus, in all, the sample consists of 4 research institutions and 3 university departments. The subsequent paragraphs present brief background of these institutions.

4.1.1 CSIR-Savanna Agricultural Research Institute (SARI)

CSIR-SARI is among the thirteen national research institutes under the Council for Scientific and industrial research. Before it gained autonomy as a full-fledged institute, it was an outpost of CSIR-Crops Research Institute, Kumasi. It was originally known as the Nyankpala Agricultural Experimental Station (NAES). In 1994, after it has become autonomous, it was renamed Savanna Agricultural Research Institute-SARI. SARI is located 16 kilometres west of Tamale in the Tolon/Kumbubgu District of the northern region of Ghana.

4.1.2 CSIR-Crops Research Institute (CRI)

CSIR-Crops research institute (CRI) is one of the thirteen (13) research institutes under the Council for Scientific and Industrial Research. The Insitute, prior to 1964 was Crops Research Unit (CRU) and became full-fledged institute in that year. The institute is located at Fumesua near Kumasi in the Ashanti region. It has outstations in the various agro-ecological zones where research findings /new technologies are tested before they are recommended to farmers. These outstations are located in: Pokuase, Ohawu (coastal savannah), Akumadan, Assin Fosu, Aiyinase (forest Zone) Ejura and Kpeve (Forest-Savannah) and Kwadaso.

The vision of the institute is to become a centre of excellence for agricultural research, innovation and capacity building for development. Its mission is to develop and disseminate environmentally-sound and demand-driven technologies and build capacity for increased and sustainable food and industrial crop productivity to enhance livelihoods.

CRI has a broad research mandate covering all food and industrial crops except cocoa, coffee, Sheanut. Current research programmes seek to improve on yields of the mandate food crops as well as their resistance to biotic and abiotic stresses, develop varieties that would adapt to climate change and be suitable for various end-users needs, increase income and improve livelihoods of consumers (farmers, private sector, partners and general public).

4.1.3 CSIR-Oil Palm Research Institute (OPRI)

CSIR-OPRI began as a substation of the West African Institute of Oil Palm Research (WAIFOR) headquartered in Nigeria, and first established their research oil palms in 1961 at Okumaning, near Kade, Eastern Region in Ghana, Coordinates: 06°05′N 00°50′W about 120km from Accra.

In the early 1960's, WAIFOR split into national institutes that have since evolved into the Nigerian organisation now known as the Nigerian Institute for Oil Palm Research (NIFOR), and the Ghana's Oil Palm Research Institute. The WAIFOR substation in 1964 became a division of the Crops Research Institute under the umbrella of Ghana's Council for Scientific and Industrial Research (CSIR) when they took over the Ghanaian responsibilities of

WAIFOR. Later, OPRI was upgraded to a centre and gained autonomy from the Crops Research Institute in 1979 and became a fully-fledged institute in 1988 as one of the thirteen (13) institutes under the Council for Scientific and Industrial Research.

The OPRI is responsible for oil palm research within Ghana and has departmental expertise in agronomy, breeding and crop protection. Since 1992 OPRI's remit was extended to include similar work in coconuts. Its vision is to become a center of excellence in oil palm and coconut research and a major supplier of improved planting materials of oil palm, coconut and relevant technologies in the sub-region. It seeks to develop capabilities to generate marketable technologies for sustainable production of oil palm and coconut, and the efficient exploitation of the palm kernel and coconut oils through downstream processing and biomass utilization as well as development of technologies to manage wastes from oil palm and coconut industries.

4.1.4 CSIR-Plant Genetics Resources Research Institute (PGRRI)

The Plant Genetic Resources Research Institute is one of the thirteen (13) research institutes under the council for scientific and industrial research. It originally started as plant introduction and exploration in 1964. The institute is mandated to collect and conserve the plant genetic resources of Ghana and abroad. The commercialization activities are geared towards the production of planting materials (seedlings of fruits, farm produce and sale of farm produce), rendering of consultancy services, ecotourism and training in plant genetic resources conservation and utilization. PGRRI is located at Bunso, Eastern Region.

4.1.5 Kwame Nkrumah University of Science and Technology-Faculty of Agriculture

The Faculty of Agriculture, which is in the College of Agriculture and Natural Resources of Kwame Nkrumah University of Science and Technology, was established in 1953. It started as a Department of Agriculture and later as the School of Agriculture to provide a number of ad-hoc courses in Agriculture for personnel of the then Ghana's Ministry of Agriculture. It also provided tuition in Rural Science for teachers of Agriculture. A four-year diploma programme in Tropical Agriculture was started in January 1958, but was upgraded to a three-year BSc degree programme in 1961. In1968, the three-year programme was replaced with a four-year programme.

The faculty seeks to be a centre of excellence for teaching, entrepreneurship training, research and the dissemination of knowledge in sustainable agriculture. It seeks to provide its graduates with the requisite academic and entrepreneurial skills in the area of sustainable agricultural production so that they can contribute effectively to national development. In addition the faculty will conduct demand-driven research and disseminate appropriate technologies to farmers and relevant policy-making agencies of government.

4.1.6 University for Development Studies – Faculty of Agriculture

Established in May 1992 by the Government of Ghana to "blend the academic world with that of the community in order to provide constructive interaction between the two for the total development of Northern Ghana, in particular, and the country as a whole" (PNDC Law 279, Section 279). It began academic work in September 1993 with the admission of forty (40) students into the Faculty of Agriculture, (FoA), Nyankpala.

The Faculty of Agriculture, which is located in Nyankpala within the Tolon/Kumbumgu District, about 20 km South-West of Tamale, the capital of Northern Region of Ghana is arguably the largest Agricultural Faculty in the Country. It was the first Faculty to be

established in the University and it offers a four-year general degree programme, with very limited specialization, leading to B.Sc. (Agric. Technology). The Faculty currently runs Post-graduate programmes and plans are far advanced in the expansion of both post and under-graduate programmes.

The Faculty of Agriculture has nine (9) existing departments, namely: Animal Science, Agricultural Mechanization and Irrigation Technology, Agricultural Economics and Extension, Horticulture, Agronomy, Biotechnology, Family and Consumer Science, Agricultural Science Education, and Food Science and Technology. The Faculty kick started its proposed new programmes in Biotechnology and Molecular Biology, Food Science and Technology and currently in collaboration with the Pong Tamale Veterinary College, the Faculty also ventured into Veterinary Nursing.

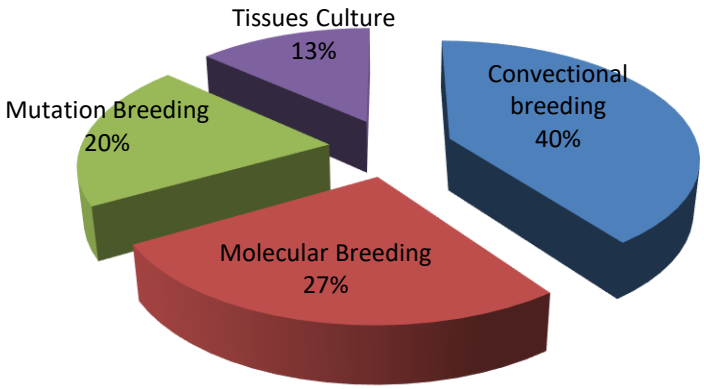
4.1.7 University of Cape Coast – School of Agriculture

The School of Agriculture was set up in 1975 with the initial responsibility of training graduates to teach agriculture in the educational system of the country at the pre-university level. The School has, since its inception, undisputedly identified itself with this primary role. The School functions in its teaching, research and extension activities through five departments and three specialized units. The Departments are Agricultural Economics and Extension, Agricultural Engineering, Animal Science, Crop Science and Soil Science. The Specialized Supporting Units are the Teaching and Research Farm, Technology Village and Meat Processing Unit.

The School seeks to be an outstanding international institution that provides leadership in agricultural education, engages in cutting edge research and to provide innovative extension services while its mission is to have a school that trains and equips students, farmers and other stakeholders with relevant knowledge, professional skills and affection to carry out research to address current and emerging agricultural related issues and provide extension services for development.

4.2 Existing plant breeding activities in the national research institutes and universities

Figure 1: Plant Breeding Techniques applied in National Research Institutes and Universities

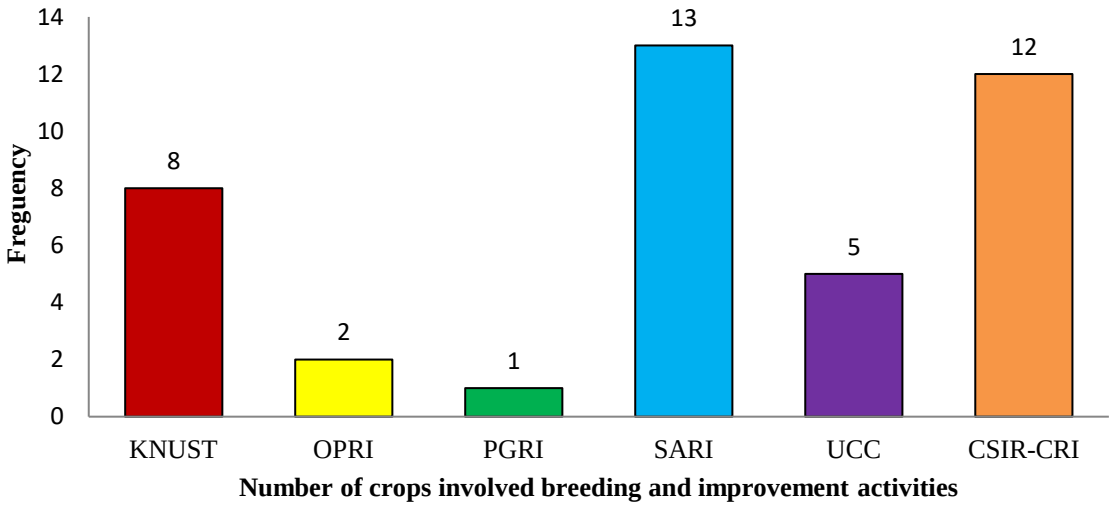


As practiced among plant breeding institutions across the world, the conventional breeding accounts for 40% (Figure 1) of techniques employed in crop development in Ghana among all research institutes and universities. This is followed by molecular breeding (27%); where modern biotechnology tools such as marker-assisted techniques are applied, specifically to aid transfer of essential traits. This technique is more or less new in the system. However, CSIR-Crops research institute possess both infrastructural and human capacity to apply this technique to reduce the duration of crop variety development. Other techniques practice by NARs in Ghana include Mutation breeding (20%) and Tissue Culture (13%)

4.2.1 Number of Crop Specific Plant Breeding Activities in Selected Institutions

The numbers of crops for which plant breeding activities are focused on in the selected institutions are presented in Figure 2. The results suggest that CSIR-SARI and CSIR-CRI are involved in 13 and 12 crops respectively, indicating their substantial role in crop improvements and varietal development in Ghana. This is however not surprising because of the mandate for their establishment. This supports the findings of Setimela *et al.,* (2009), the two institutions are the major institutes in Ghana that account for almost 90% of the crop varieties developed and released in Ghana. Besides these institutions, the KNUST is engaged in the breeding of 8 crops whereas UCC is involved in 5 crops and the remaining OPRI and PGRRI breeding 2 and 1 crop, respectively.

Figure 2: Number of Crop-specific Plant Breeding Activities in Selected Institutions

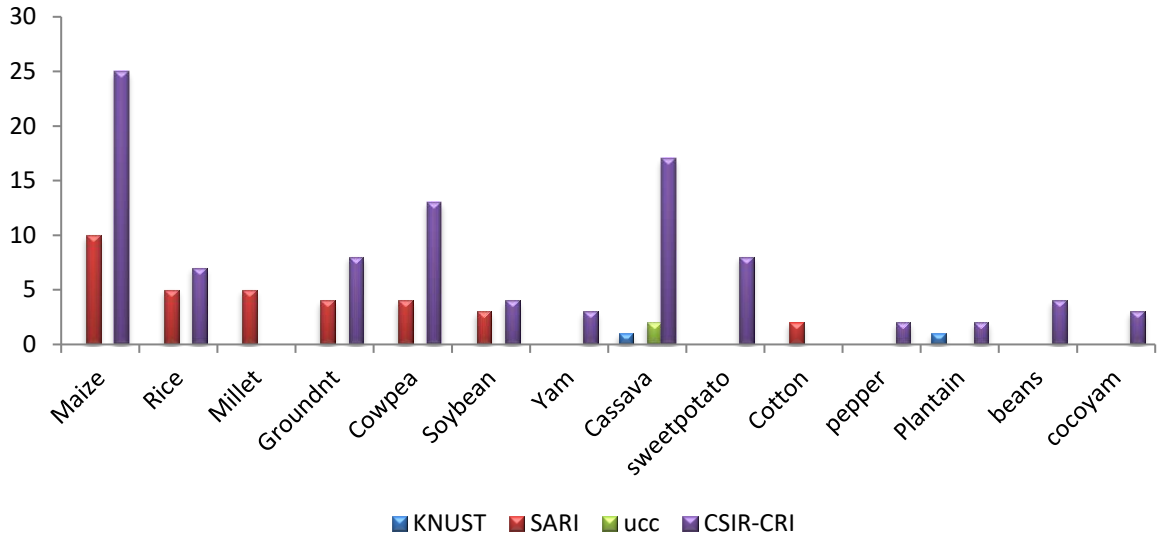


Specifically, KNUST are involved in the breeding and improvement maize, rice groundnut, cowpea, soybean, cowpea, yam cassava and sweetpotato. OPRI, are involved in the development of improved varieties of oil palm and coconut, which take several years to mature and breeding of such crops are challenging, leading to fewer varietal releases compared with the other institutions. PGRRI are involved in mainly in the improvement of vegetables, although their role in conversing plant genetic materials cuts across all other crops. SARI's plant breeding and crop improvement activities covers crops such as maize rice sorghum, millet, groundnut, cowpea, soybean, Bambara groundnut, yam, cassava, sweetpotato, cotton and vegetables. UCC are involved in maize, cowpea, yam, cassava and vegetables. CRI are involved in maize, rice, cowpea, groundnut, soybean, Bambara groundnut, yam, cassava, sweetpotato, cocoyam, vegetables, plantain and banana.

4.2.3 Varieties released by participating institutions and universities in the past 10 years

The number of varieties released in the past ten years is presented in Figure 3. It indicates that, the CSIR-CRI has over the period released 10 maize, 5 rice, 3 soybean, 4 cowpea and 4 groundnut varieties. However, the support in terms of funding for most of these varieties are obtained from donor partners, except for cassava, yam, sweet potato and cocoyam for which in past 10 years have enjoyed some support from government through the West African Agricultural Productivity Program (WAAPP). The faculties of agriculture of the universities however, for the past 10 years have released 1 cassava each (KNUST and UCC) and 1 plantain (KNUST). This phenomenon could be attributed to the fact that most of the universities concentrate on teaching than research, specifically plant breeding or crop improvement activities. The lack of human resource capacity who could be assigned with the sole responsibility of plant breeding activities are absent in the universities. For the universities to be competitive in the field of plant breeding and crop improvement programmes, there should be efforts to recruit scientists who core mandate will be plant breeding with less teaching roles. One of the critical gaps in the plant breeding activities in Ghana which the universities can focus their resources on is vegetable crops, which currently suffers from lack of improved varieties in Ghana.

Figure 3: Number of Improved varieties released for the past 10



4.2.4 Trends in Government funding for research in selected institutions (2005-2015)

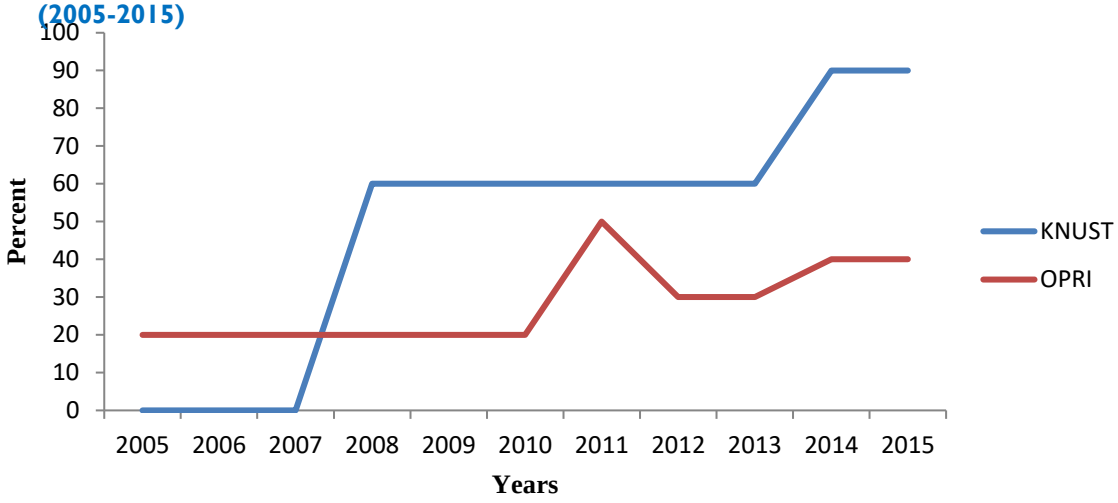
Figure 4 presents the trends in government funding for research in the selected institutions. It was revealed that among the institutions studies, only KNUST and OPRI indicated they have received some form of funding for research through government for the past 10 years for plant breeding and related activities. The trends in the respective percentages of such funding to the total funding received are presented in the line graphs.

It shows a generally increasing trend in government funding to these institutions. However, further interrogation of the funding source of KNUST-Faculty of Agriculture plant breeding program revealed that although, the government of Ghana played a critical role in receiving the funding, the actual budget was from the Alliance for Green Revolution in Africa (AGRA). They started receiving some funding from 2008 through the AGRA project which constituted about 60 percent of their total research funding. This continued steady till 2013 where, the percentage increased from 60% to 90% and remain there till 2015. Further, it must be noted in the case of KNUST that, the funding support have not been directed to plant breeding or crop variety development per se but for training of students at the postgraduate level in Plant Breeding and Seed Science and Technology. This could justify why the increasing funding trend has not resulted in the release and registration of new crop varieties.

Conversely, CSIR-OPRI started receiving 20% contributions to research from government from 2005. In 2011, this percentage increased from 20% to 50% and dropped back to 30% in 2012 and then increased to 40% from 2013 to 2015.

The funding source from government for the others institutions particularly the national research institutes (CRI, SARI, PGRRI) have for the past 10 years have been negligible for plant breeding or crop development activities. Funding sources mainly has been from donor partners and private sector (about 90% and 5-10% respectively). This finding is in tandem with that of Bortey and Mpanju (2016). Majority of the institutions, however, for some reason could not indicate the percentage of budget allocated specifically for plant breeding activities. The only budget allocation from GoG according to these institutions are for administrative expenses.

Figure 4: Trends in Government Funding for Research in the selected institutions (2005-2015)



4.3 Human Resource and infrastructural capacity and gaps

4.3.1 Human resource capacity and existing gaps

The results of the human resource capacity and existing gaps for the institutions are presented in Table 1. The results indicate that, except for KNUST, SARI and CRI, the remaining institutions have adequate human resource capacity. However, for those institutions where gaps exist, the number of staff required varied substantially. The human capacity gaps that need to be filled across institutions are include plant breeders, crop physiologists, seed scientists, agronomists, molecular biologists, biotechnologists, plant protectionists, socio-economists.

The results suggest that, there currently exist some level of human capacity to conduct both DUS and VCU tests for the purposes of varietal release and registration. This notwithstanding, the gaps identified shows there is still the need to build capacity for a more effective, efficient and transparent varietal release and registration system in Ghana. Unfortunately, further interactions with heads of interviewed institutions indicated there is a temporary freeze in recruitment; the reason these identified gaps have not been filled. Efforts at filling these gaps is thus eminent for the smooth implementation of an efficient and effective DUS and VCU testing for varietal release and registration in Ghana.

4.3.2 Infrastructural capacity and existing gaps

The infrastructural capacity of the institutions and existing gaps are resented in Table 2. The results shows there exist basic infrastructure to conduct both DUS and VCU tests in the institutions. All institutions possess experimental fields and at least a source of irrigation. In some cases the irrigation system needs to be upgraded to more efficient types. The only major equipment which were lacking in most of the institutions included a functioning Seed Testing Laboratory and the Biotechnology laboratory at KNUST requires an upgrade.

4.3.3 Equipment capacity for evaluation of crop varieties and existing gaps

Often public institutions may have the necessary infrastructure in place but lack basic equipment to ensure the effective running of such structures. This study thus further sought to catalogue the existing equipment that are essential to the conduct of DUS and VCU tests

in the various institutions. The results are presented in Table 3. There are some equipment available such as vehicles and basic office equipment across institutions.

Table 1: Human Resource Capacity and Existing Gaps

Professional	*CRI*		*UCC*		*OPRI*		*SARI*		*KNUST*		*PGGRI*	
	Existing	Gap	Existing	Gap	Existing	Gap	Existing	Gap	Existing	Gap	Existing	Gap
Plant breeders	14	**7**	5	**0**	8	**0**	16	**3**	3	**2**	3	**1**
Crop Physiologist	2	**2**	1	**0**	0	**0**	1	**2**	1	**2**	2	**0**
Seed Scientists	2	**2**	2	**0**	0	**0**	0	**2**	3	**3**	0	**0**
Agronomist	9	**4**	2	**0**	6	**0**	7	**3**	3	**2**	1	**0**
Molecular Biologist/related fields	2	**4**	4	**0**	1	**0**	0	**2**	1	**2**	0	**0**
Biotechnologist	2	**4**	3	**0**	0	**0**	0	**2**	1	**2**	1	**0**
Plant protection Scientist	13	**5**	6	**0**	7	**0**	12	**0**	3	**2**	5	**0**
Socio-Economists	7	**3**	5	**0**	2	**0**	5	**2**	2	**0**	0	**0**
Biochemists/Food Scientists	5	**3**	4	**0**	0	**0**	0	**2**	1	**0**	0	**0**

Table 2: Infrastructural capacity to conduct DUS and VCU Testing and Existing Gaps

Infrastructure	CRI		UCC		OPRI		SARI		KNUST		PGRRI	
	Aval.	Gap	Avail.	Gap	Avail.	Gap	Avail.	Gap	Avail.	Gap	Avail.	Gap
Offices	13	**5**	0	**5**	0	**5**	10	**4**	3	**1**	5	**2**
Seed Cleaning Equipment	2	**1**	0	**1**	0	**1**	1	**2**	0	**2**	1	**1**
Seed Treatment Equipment/Plant	2**	**1**	0	**1**	0	**1**	0	**3**	0	**2**	1	**1**
Cold rooms for storage of seed	3*	**1**	0	**1**	0	**1**	1	**0**	0	**1**	2	**2**
Seed processing Sheds	1	**1**	1	**1**	1	**1**	1	**2**	1	**1**	2	**1**
Sellers/threshers	2	**5**	1	**5**	1	**5**	5	**5**	2	**1**	0	**1**
Seed Dryers	1	**2**	1	**2**	1	**2**	0	**0**	1	**1**	0	**2**
Winnowers	1	**3**	0	**3**	0	**3**	1	**0**	1	**1**	0	**2**
Screenhouse	12	**5**	0	**5**	0	**5**	5	**0**	3	**0**	2	**1**
Biotechnology Labs	1	**1**	0	0	0	0	0	0	1‡	0	0	0
Storage barns	1	**1**										
Weather data equipment	1	**0**										
Seed Testing Laboratory	1	**0**	0	1	0	1	0	1	0	1	1**	1

[*] *Frequent Breakdown, hence not fully functional,* [**] *Not functioning properly (requires repairs or replacement)* [‡] *Needs to be upgraded*

Table 3: Equipment used in Testing and Existing Gaps

	CRI		*UCC*		*OPRI*		*SARI*		*KNUST*		*PGRRI*	
General Equipment	**Aval.**	**Gap**	**Aval.**	**Gap**	**Aval.**	**Gap**	**Aval.**	**Gap**	**Aval.**	**Gap**	**Aval.**	**Gap**
Vehicles	10	6	4	1	0	1	30	0	2	1	1	0
Computers	9	6	10	0	1	0	60	0	4	1	4	2
Printers	5	10	6	0	1	0	60	0	2	1	2	1
Fridges	4	3	3	2	2	0	5	0	2	1	9	6
Cold rooms*	2[*]	1	0	2	1	0	1	0	0	1	2	0
Scanner	2	2	3	0	0	0	4	0	2	1	1	0
Digital camera	5	10	2	1	0	0	10	0	1	2	1	1
Weighing scales	3	5	2	2	0	0	50	0	1	2	2	0
Moisture meters	2	3	1	1	0	0	5	0	0	2	1	1
GPS	0	4	1	1	2	0	20	0	0	2	2	1
Equipment for proximate Analyses												
Complete digestion and distillation set up (protein)	0	1	1	1	0	0	0	0	1	1	0	0
Complete filtration set up (Fibre)	0	1	1	2	0	0	0	0	1	1	0	0
Furnace (Ash)	1	1	1	1	0	0	0	0	1	1	0	0
Oven	2	3	1	1	0	0	0	0	2	1	0	0
Soxlete apparatus (crude fat)	0	2	1	1	0	0	0	0	1	1	0	0
Statistical Software	2	3	1	2	0	0	0	0	2	1	0	0
Assorted Field Equipment (rope tape measure, sprayers etc.)	50	0	1	2	0	0	0	0	2	2	0	0

[*] Not functioning properly

However, with the exception of CRI and PGRRI, none of the institutions have a functioning cold room facility for effective maintenance of plant germplasm, released varieties and reference materials for the purposes of conservation. Even in the case of CRI, there is frequent breakdown and needs major repairs. Very critical to a more reliable data on VCU test is the equipment used for proximate analysis (physical and chemical properties). With exception of KNUST and in some cases CRI, the other institutions lack this basic equipment. The existence of such gaps puts these institutions at a much compromised position in terms of effectiveness, reliability of data and timely submission of same for the purpose of varietal release. It is therefore, essential for such equipment gaps to be addressed for smooth implementation of the requisite testing to enhance varietal release and registration in Ghana.

4.3.4 Professional capacity for DUS and VCU Testing for specific crops and existing gaps

Figure 5: Professional capacity for DUS and VCU Testing for specific Crops for CSIR-CRI

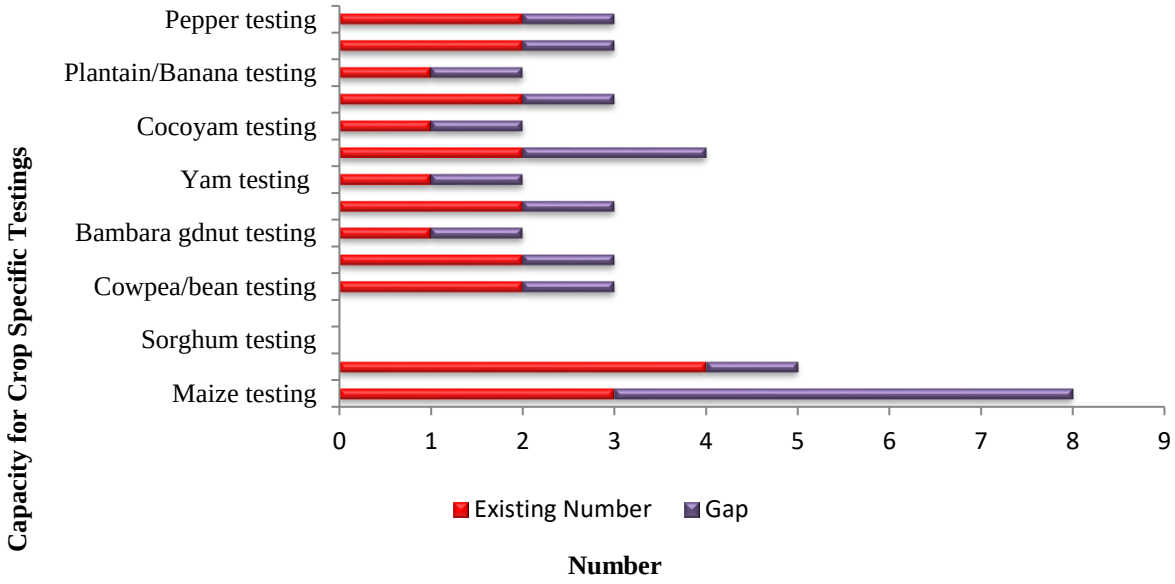


Figure 6: Professional capacity for DUS and VCU Testing for specific Crops for KNUST

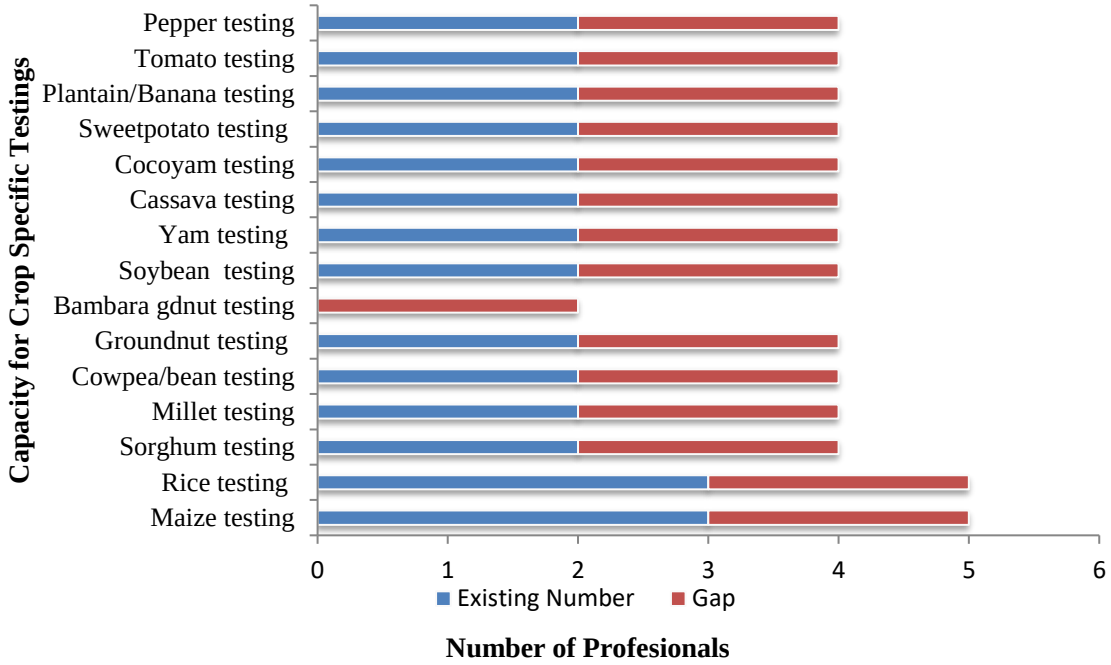


Figure 7: Professional capacity for DUS and VCU Testing for specific Crops for UCC

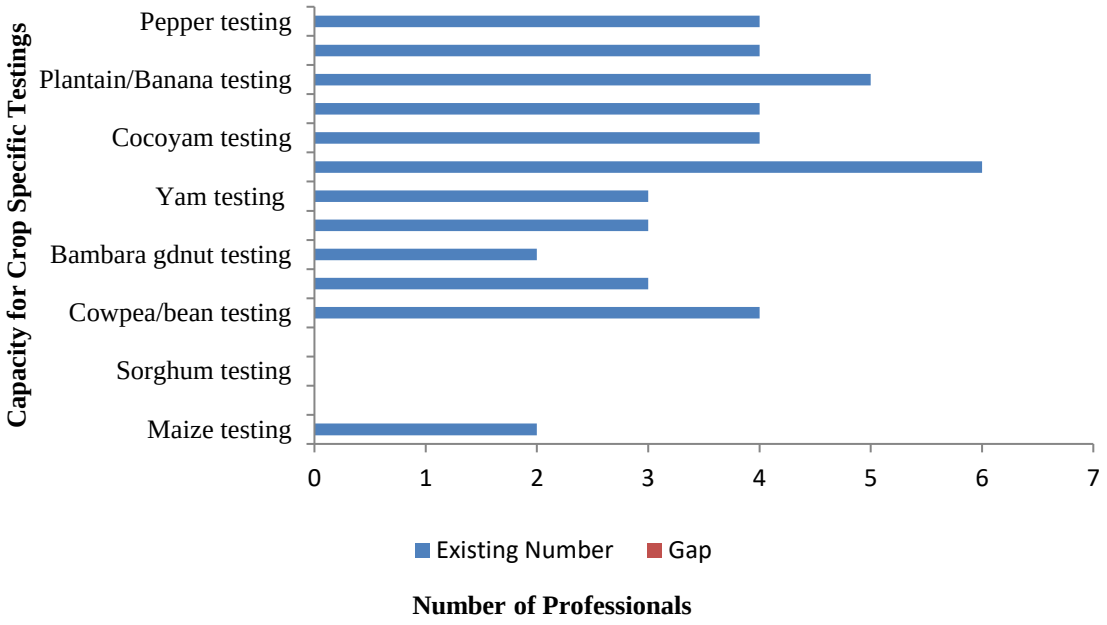
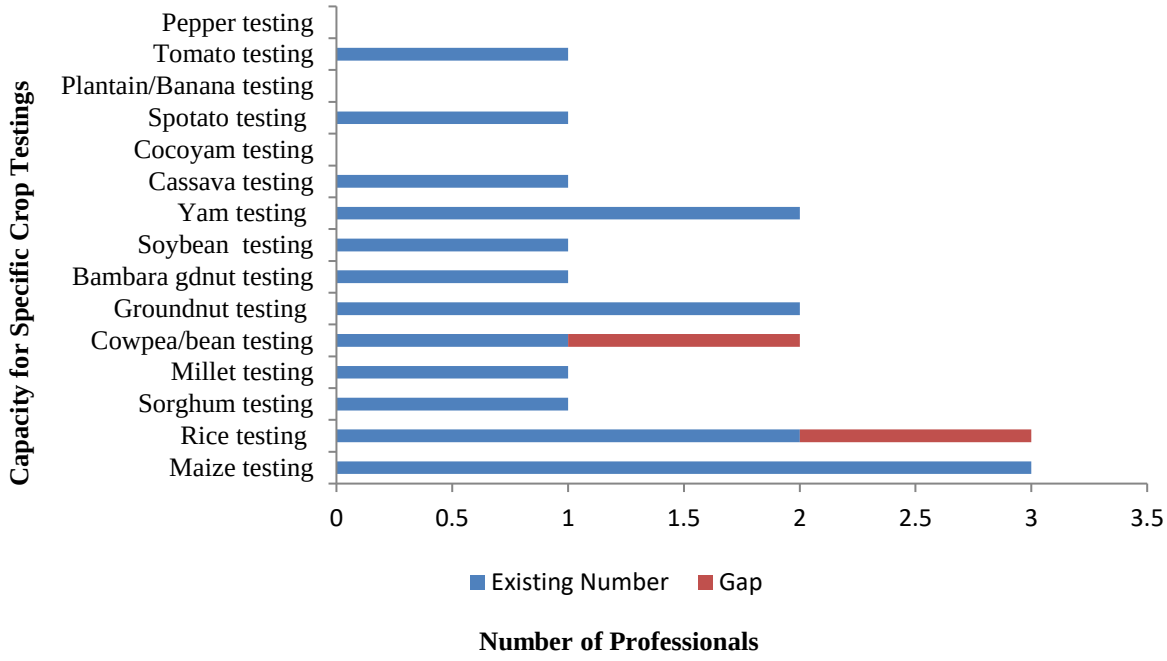


Figure 8: Professional capacity for DUS and VCU Testing for specific Crops for CSIR-SARI

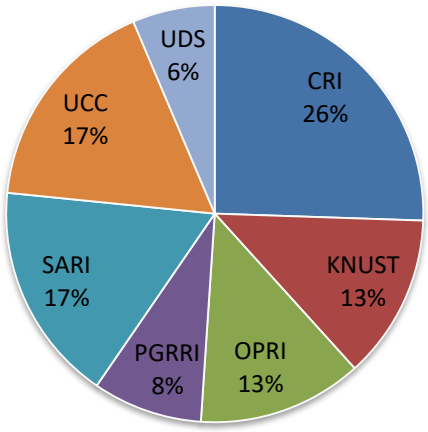


Figures 5 to 8 indicate the professional capacities for DUS and VCU testing across institutions for specific crops. PGRRI and OPRI do not have enough staff capacity to undertake specific DUS and VCU testing for crops indicated and did indicate the need for such capacity. This is reflective of their mandate, which do not directly involve plant breeding and crop development (PGRRI) or limited to Oil palm and Coconut (OPRI). Although, the professionals in the various research institutions and universities have specialized skills in specific crops, there is still the need to frequently build their capacity to keep abreast with current trends in DUS and VCU testing.

4.4 Background of professionals in the existing institutions

The distribution of professionals by institution is presented in Figure 9. Majority of the respondents were from CRI (26%) and SARI (17%), and followed by UCC., These two institutions have generally large population of professionals involved in the development of new plant varieties in Ghana. More so, their mandate crops are much wider that the other NARIs. The distribution also gives a broad participation of stakeholders that are involved in the variety development, release and registration system in Ghana used for this study.

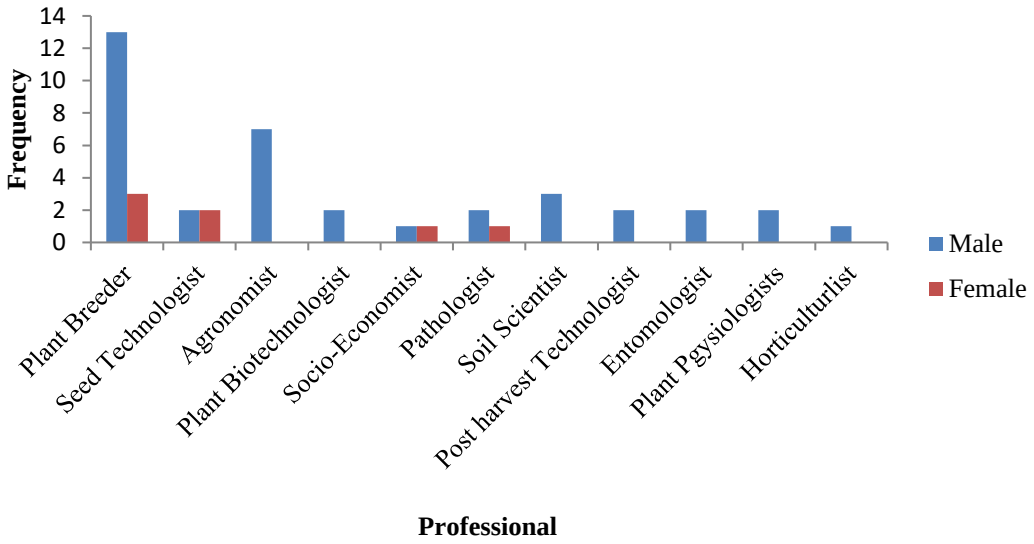
Figure 9: Distributions of Respondents by Institution



4.4.1 Gender distribution of professionals

The distribution of crop improvement professionals in the respective institutions are presented in Figure 10. In all, majority of the professionals were males (85%) while 15% were females. However, the most common professionals among them were plant breeders, followed by agronomists, soil scientists and post-harvest technologist and seed technologists in that order. It is evident that the female population in research institutions that are specifically related to agriculture and plant breeding in both universities and national research institutes are low. Efforts to encourage more females into this field are recommended.

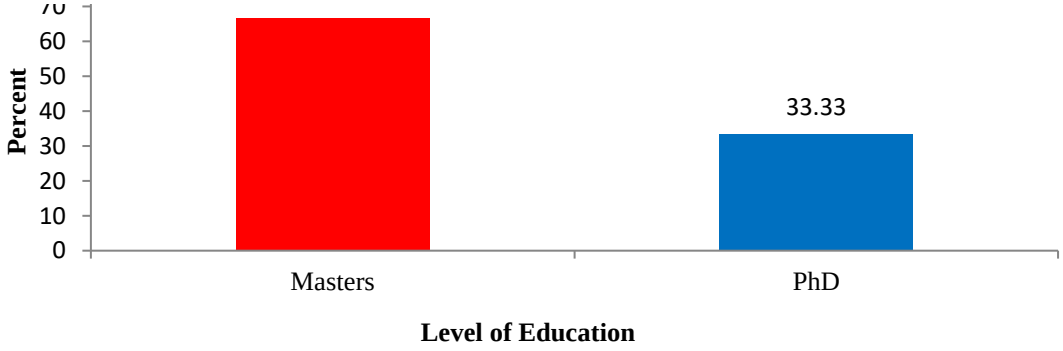
Figure 10: Distribution of professionals by Gender



4.4.2 Educational level of respondents

Figure 11 presents the distribution of the level of education of crop improvement professionals. Sixty-seven percent (67%) of the professionals had their masters' degrees with the remaining 33% having PhDs. It should be noted that the minimum qualification accepted by these institutions for the research grade category is Master's degree. The current trend as revealed in this study also gives an indication of the existing potential of young research scientists across the various institutions available to develop and release new crop varieties to mitigate future challenges.

Figure 11: Educational Level of Respondents



4.5 The level of awareness and knowledge on VRRS among major stakeholders

4.5.1 Awareness of the components of the VRRS in Ghana

Table 4 presents the level of awareness and knowledge of the professionals in the various components of the varietal release and registration procedures. Over 70% of the professionals were aware of the existence of the varietal release and registration procedures in Ghana. While 68 percent of them were aware of the national seed council, an overwhelming majority (92%) of them were aware of the national varietal release and 77% of them have knowledge of the procedure. Conversely, in terms of the awareness of a new varietal release and registration procedure, only 42 percent of the professional have heard of it. There is therefore the need to sensitize professionals of the institutions about the proposed varietal release and registration procedures for successful implementation. It is also essential to examine further how the knowledge of the varietal release and registration procedures varied across institution for proper targeting of such sensitisation programmes for effective implementation.

Table 4: Awareness and knowledge of varietal release and registration procedures in Ghana

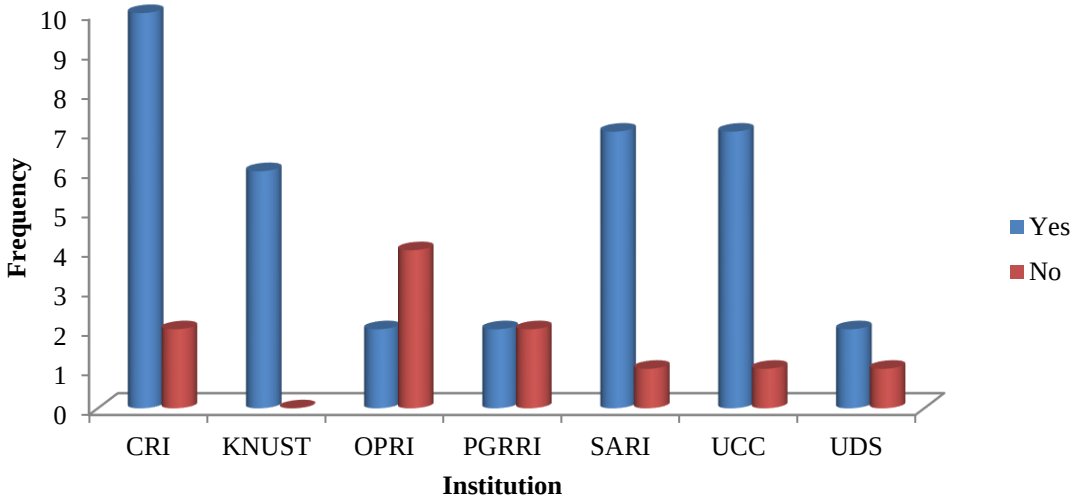
Awareness and knowledge (%)	Mean
Awareness of variety release and registration procedure	0.809 (0.398)‡
Awareness of National Seed Council	0.696 (0.465)
Awareness of National Varietal Release	0.935 (0.250)
Awareness of New variety release and registration procedure	0.468 (0.504)
Knowledge of the varietal release and registration procedure in Ghana	0.766 (0.428)

‡The figure in parenthesis represents the standard deviations.

4.5.2 Knowledge of varietal release and registration procedures

It is generally possible to be aware of a concept and still not have full knowledge of it. Figure 12 represents the professionals' knowledge of the existing varietal release and registration procedures by institution. The level of knowledge of the varietal release and registration procedures are presented in Figure 5. The significant chi square test in Figure 4 indicates that institutions had significant influence on the professionals' knowledge of the varietal release and registration procedures. For instance, most of the respondents from CRI, SARI and KNUST know about the procedure. However, OPRI recorded that lower number of respondents with no knowledge of the procedure. This isn't surprising because of the mandate of OPRI which is mainly into only two crops -oil palm and coconut, which takes a long period to release a new variety and this could have contributed to low participation in the VRR system. CRI, SARI and KNUST on the other hand have been key participants on the NVRRC and are highly involved in the development and release of new crop varieties.

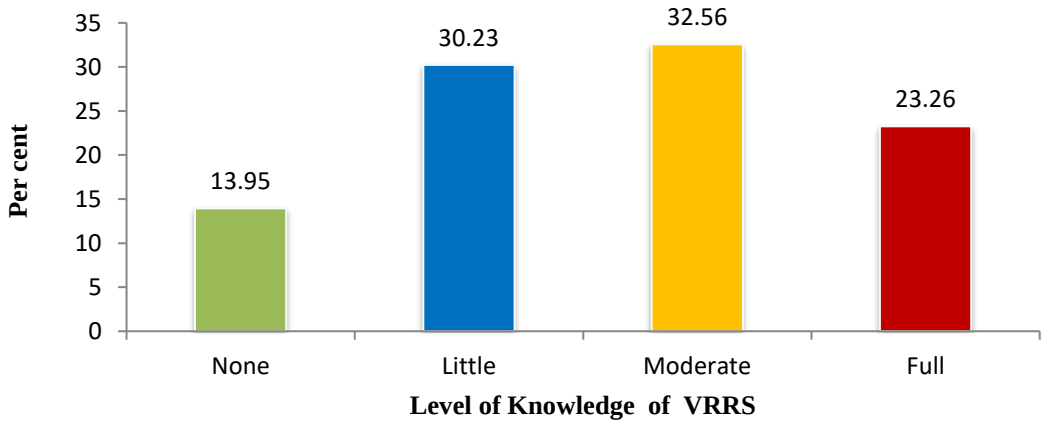
Figure 12: Knowledge of the Varietal Release and Registration Procedures by Institution



Pearson chi2(6) = 11.2060 Pr = 0.082

Figure 13 depicts that, about 35% of the respondents had no knowledge, whiles the remaining 65% had knowledge of the procedures. However, among those who did know about the procedure, 19 % have very little knowledge of it, whereas moderate and full knowledge accounted for 23% each. This is a good indication that professionals are generally becoming more informed about the varietal release and registration procedures. This notwithstanding, a more conscious sensitization program is needed to bring all key players especially the scientific community on board to fully understand the system. This will ensure active participation and corporation in the effective implementation of the varietal release and registration system.

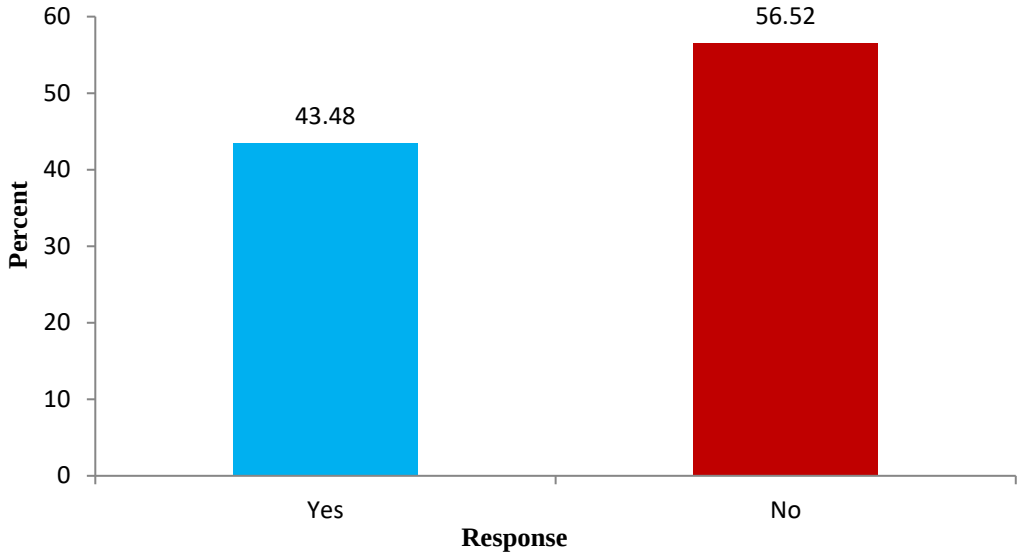
Figure 13: Level of Knowledge of Varietal Release and Registration Procedures



4.5.3 Participation in the release and registration of an improved crop variety

The results of the participation in release and registration of an improved crop variety among professionals is presented in Figure 14. Majority of professionals (56%) had not participated in the release of at least one crop variety with only 44% who have. This could buttress the low level of knowledge of the VRRS by these professionals. Those who have participated in the release of at least one crop variety were related to crops such as cassava, yam, cocoyam, sweetpotato, maize, rice, cowpea and soybean.

Figure 14: Participation in the Release of a Crop Variety



The reason for having less percentage of professionals participating in the crop variety release process could be attributed to the fact that, majority of the released crop varieties in Ghana at the various national research institutions are centred mostly on plant breeders. Other significant professionals such as Seed Technologist, Biometrician and in some cases agronomists are not fully involved in the core team or if they do, at the latter stage of the release process. In the case of the universities, the reason could be that these faculties since their establishment had seldom developed and released crop varieties. They are more focus on teaching and research in other areas as compared to crop improvement or variety development. Further, the respondents who indicated their participation in the release of a crop variety could have either been part of the core breeding team or the post-release team such as Socio-economists, Postharvest/Food Scientists, Seed Technologists among others.

These findings lend support to the assertion that the level of awareness and knowledge of the VRRS is low and that key professionals must be sensitize to effectively play their roles in the entire system. This ultimately will enhance the effectiveness, efficiency and transparency of the system.

4.5.4 Understanding and Perception about the existing VRR procedures

The results of the understanding and perceptions of respondents about the existing varietal release and registration procedures are presented in Table 5. In all, 73% of the professionals believe that the applications for varietal release and registration are made to the national seed council (NSC). Over 60% of them assert to the fact that the NSC directs the affairs of the national varietal release and registration committee (NVRRC), whiles, 70% concur that NVRRC prepares technical report based on data for minimum 2 growing cycles. Over 80% agree that the NSC can reject application if not satisfied with DUS and VUC data, however only 30% believe that applications can be appealed within 20 days from date of notification. Over 50% of the professionals are of the view that, the existing varietal release and registration procedures is effective and efficient, while less than half of them think that the procedure is transparent (48%) and expensive (36%).

Table 5: Understanding and Perception about the existing varietal release and registration procedures

Level of Awareness (%)	Mean
Applications are made to the NSC	0.681 (0471)†
NSC directs the National Varietal Release and Registration Committee	0.681(0.471)
NVRRC prepares technical report based on data for minimum 2 growing cycles	0.681(0.471)
NSC can reject application if not satisfied with DUS and VUC data	0.787 (0.414)
Applicants can appeal rejection within 20 days from date of notification	0.400 (0.495)
NSC notifies applicants and registers the new variety within 21days of approval	0.457 (0.504)
Is the existing varietal release and Registration procedure effective	0.594 (0.499)
Is the existing varietal release and Registration procedure efficient	0.606 (0.496)
Do you think the current procedure is transparent	0.515 (0.508)
Do you think the current procedure is expensive	0.387 (0.495)

† The figure in parenthesis represents the standard deviations.

In as much as the current varietal release and registration procedure is deemed effective and efficient by about half of the professionals (50%), the underlying issue of transparency (48%) and being expensive (36%) requires critical attention. The issue of the system not being transparent could be a perception that is further fuelled by the low level of awareness and knowledge as revealed in this study. It must however, be indicated that Ghana is one of few countries in Africa in addition to Kenya, Ethiopia, Tanzania, Uganda and Madagascar among over 30 countries who have their DUS protocols published (Sanni *et al,* 2013). This adds to the issue of transparency in the release system. Where there is better understanding of a system, there is likely to be very little perception on transparency. One other critical issue that requires a review is the cost of conducting both DUS and VCU tests in Ghana. Personal communication with some selected breeders across major crop commodities indicate that an average cost of Forty Thousand Cedis (Gh. ₡40,000.00) (approx. USD 10,000) is spent on the release of a crop variety. This amount is way too expensive for the current dwindling funding support from governments (Bortey and Mpanju, 2016) and even donor partners.

For instance the required two (2) growing cycles for DUS can be reduced to one (1) cycle. It must be noted that DUS traits are not affected by environmental conditions and thus one season is sufficient to provide the needed data to demonstrate the distinctiveness of a variety from existing ones. This recommendation is particularly for cereals, legumes and vegetables and may not be feasible for the vegetatively propagated crops. This is corroborated by Setimela *et al.,* (2009) in their review of the variety release system in Africa. Data collection is an expensive exercise and efforts to minimise this cost is essential for both the applicant and the consumers as well. Another observation in the Ghana's varietal release and registration system, which adds to the cost component and calls for review, is the requirement of DUS data for inbred lines in addition to OPVs and Hybrids. As concluded by Setimela *et al.* (2009), seed companies offer for sale only hybrids or OPVs. Moreover, it is not easy for other companies to know the inbred combinations of a particular hybrid. Hence to avoid the associated cost of time and resources, such a data requirement must be discontinued.

Similarly, Ghana's system requires VCU to be conducted at 6 trial sites across the agro-ecological zones and 36 traits for two seasons (in the case of Maize). This requirement is also expensive and can be avoided as pertains in other jurisdictions like South Africa, where the value of the new variety is determined by the consumer. VCU test is an expensive, time consuming exercise. Ghana according to a study by Setimela *et al.* (2009) on variety release system is one of the few countries where economic analysis data is required as part of the VCU test. All these add to the cost of variety development, which currently is largely possible

due to donor funding. Dartey *et al.,* (2016) makes a similar argument that the cost of DUS and VCU tests must be reviewed downwards to encourage local private sector participation to facilitate the release of new crop varieties. They are of the view that in the absence of public funding and donor partners funding for the development and release of new crop varieties, who is going to fund the cost of variety release and registration? Using the case of newly developed rice varieties, the authors are of the view that reducing the cost of DUS and making VCU test optional for potential consumers to decide could encourage private sector participation in crop variety development and release.

4.5.5 Awareness, knowledge and perceptions of the Plant Breeders Rights

To better understand the level of awareness and knowledge of professionals about the existing variety release and registration procedure, an evaluation of their level of awareness, knowledge and perceptions of the Plant Breeders Right (PBR) bill is essential, hence, the results are presented in Table 6.

The results reveal that, an overwhelming majority (92%) of the professionals are aware of the PBR bill. However, out of these, only 50% of them had been educated about the provisions of the PBR bill. Nearly 80 % of them are aware that the PBR bill gives the breeder or breeding institution exclusive right to the variety, while only 25% know that the bill allows others to use their variety without permission. Over 60% of the professionals have the perception that the adoption of the PBR bill will help the institutes have access to foreign plant germplasms hence a good recipe for crop improvement. The results from this study corroborates well with the findings of Bortey and Mpanju (2016) in their study to evaluate the perceived implication of adopting and implementing the PBR Bill of Ghana. In their study, majority of professionals (64 -100%) such as those who participated in this study were aware while majority of farmers (61%) were not aware.

Further, 90% agree to the use of DUS data submitted for varietal release also for the purpose of seeking plant variety protection. This according to them will minimize cost and reduce the associated bureaucracies that usually characterised such system. More than 90% of the professionals agree that PBR bill will enhance the release of improved crop varieties. Over 80 % of them believe that the PBR bill will increase private sector investment in plant breeding activities while almost all respondents (96%) support the course that PBR bill will enhance private-public partnership in crop variety development. Furthermore, 69% of the professionals believe that the PBR bill will lead to establishment of more seed companies, whereas, 96% have the perception that the PBR bill will incentivize local breeders to develop and release more improved crop varieties

Table 6: Awareness, Knowledge and perceptions of the Plant Breeders Rights

Item (%)	Mean
Awareness of Plant Breeders Right bill	0.930 (0.258)§
Have been educated or sensitized on the provisions of the PBR bill	0.976 (3.360)
PBR bill gives the breeder or breeding institution exclusive right to the variety	0.833 (0.377)
PBR bill allows others to use your variety without permission	0.333 (0.477)
Adoption of the PBR bill will help institute have access to foreign plant germplasms	0.595 (0.497)
DUS data submitted for varietal release be used to seek for PBR bill	0.865 (0.347)
PBR bill will enhance the release of improved crop varieties	0.976 (0.154)
PBR bill will increase private sector investment in plant breeding activities	0.860 (0.351)
PBR bill will enhance private-public partnership in crop variety development	0.951 (0.218)
PBR bill will lead to establishment of more seed companies	0.725 (0.452)
PBR bill will incentivize local breeders to develop and release more improved crop varieties	0.881 (0.328)

[§]The figure in parenthesis represents the standard deviations.

4.5.6 Professional capacity to conduct DUS testing

The results of the capacity of professionals to conduct DUS testing are presented in Table 7. The result indicates that only 22% of the professionals have received training on how to conduct DUS testing. Most of the trainings received were organised in Kumasi and Tamale in Ghana and a few in IITA in Nigeria. It also shows that half of the professionals who received the training on DUS testing have indeed applied the knowledge acquired particularly in conducting testing for crops such as maize, rice, sorghum, cowpea, soybean and groundnut. Consequently, 37% of the professionals have the capacity to conduct DUS testing.

This level of capacity is low and inadequate if the variety release system is to be more efficient and effective. It was also revealed further in this study that majority of the professionals with capacity to conduct DUS testing are mostly those on major crops such as Maize, Rice, Cassava, Yam, and Soybean. There is thus the urgent need to build the capacity of especially young breeders, seed technologists and agronomists on how to conduct DUS and VCU testing both locally and internationally. Short courses to continuously update their knowledge on current and best practices are also required. This notwithstanding, an amendment to reduce the number of data for DUS and VCU tests as argued earlier could help to professionals to specialize on certain key crops. This will consequently make them more efficient and effective.

Table 7: Capacity of professionals to conduct DUS testing

Capacity for DUS testing	Mean
Have you had any training on how to conduct DUS test	0.209 (0.412)[æ]
Have you been applying the skills and knowledge learnt on this training	0.214 (0.418)
Do you have adequate capacity to conduct DUS and VCU	0.378 (0.492)

[æ] The figure in parenthesis represents the standard deviations.

4.5.7 Factors influencing awareness and knowledge in existing variety release system

The probit estimates of the factors influencing awareness and knowledge of variety and registration systems in Ghana among the professionals are presented in Table 8. The significant Wald chi sq. values for the two models indicate that indeed the model is a good fit for the sample data. The factors influencing awareness of the existing variety release system are having a masters' degree, training and professional experience in varietal release and registration and are all positive. Obtaining a masters' degree increases the probability of awareness by 0.69. The significant effect of obtaining a masters' degree on the likelihood of becoming aware of the VRRS is because most of the masters holders across the institutions are generally young and hence are more enthused and inclined to exploring new ideas hence are more likely to be aware of the VRRS. Obviously, obtaining training in DUS and VCU testing will expose participants to the varietal release procedures and hence will be fully aware of the VRRS. Participation in training in DUS and VCU courses increases the probability of becoming aware of VRRS by 0.60. The positive significant effect of years of experience on the probability of awareness of the VRRS is because more experienced professionals are more likely to come across and be aware of the VRRS process in their professional life hence increasing their probability of becoming aware of the VRRS. Thus, years of experience increases the probability of awareness by 0.06. Conversely, the knowledge of the VRRS is determined by obtaining a master's degree and professional experience. The predicted probability of awareness and knowledge of VRRS are 04606 and 0.6314, indicating, that,

awareness and knowledge are likely to increase by 46 and 63 percent, respectively among the professionals, should these factors be taken into consideration.

Table 8: Probit estimates of the factors influencing awareness and knowledge of VRRS

Variables	Awareness model			Knowledge model		
	Coeff.	Robust S.E	ME	Coeff.	Robust S.E	ME
Plant Breeding	0.894	0.599	0.345	0.301	0.480	0.112
Agronomist	-0.072	0.511	-0.029	0.113	0.566	0.042
Masters	2.070***	0.611	0.696	0.825**	0.430	0.304
Female	0.538	0.765	0.211	0.012	0.537	0.0044
Training	1.707***	0.534	0.602	-0.033	0.430	-0.012
Professional Experience	0.128**	0.057	0.051	0.065*	0.038	0.024
Constant	-3.293***	0.855		-0.760*	0.391	
Observations	47			47		
Wald chi2(6)	19.76***			11.37**		
Pseudo R^2	0.5935			0.2298		
Predicted Pr.	0.4606			0.6314		

5.0 Recommendations for addressing identified challenges in the existing VRRS

5.1 Challenges with the existing VRRS

Some of the challenges of the existing VRRS as identified by the respondents include; inadequate resources for the NSC and NVRRC, the number of growing cycles and site locations for DUS and VCU tests respectively, the cost of DUS and VCU tests, low level of awareness and knowledge of the VRRS and PBR system. Others are related to both human and infrastructural gaps.

5.2 Recommendations for improving the VRRS

Awareness should be created through frequent sensitization workshops and seminars to both educate key stakeholders on the VRRS. Institutions such as the PPRSD, National Seed Council, GSID and the National Agricultural Research Institutions need to take the lead in this sensitisation for increased awareness of the VRRS across professional. The NSC and NVRRC must be well resourced to play their respective functions of regulatory. There is the need for NSC to also raise funds to support the DUS and VUC process of proposed candidate.

To reduce the cost and duration for the release of new plant varieties, there is the need to review the DUS and VCU tests requirement. Specifically, DUS examinations could be limited to one growing cycle and VCU test may be optional for the potential consumers to decide on the value of the released crops. Moreover, the number of characteristics for DUS tests could be limited to the major traits that are likely to affect the decision of determining distinctiveness among varieties.

To further enhance transparency in the VRRS, the guidelines should be made available (possibly published) to all stakeholders in the release and registration process. This study thus recommend that, based on the identified capacities of the various state institutions, the DUS and VCU test could be conducted by an institution which is independent of the applicant for a new plant variety release. This independent verification will enhance transparency, and improve efficiency and effectiveness of the VRRS in Ghana.

5.3 Human resource capacity

Generally, there exist some human resource capacity at the various institutions to conduct DUS and VCU tests for the purposes of varietal release and registration, there is still the need to continuously build the capacity of professionals on DUS and VCU examinations through short courses both nationally and internationally. This will enhance their efficiency and effectiveness. Specifically, scientists or institutions are encouraged to specialize on specific crops for which they can be more efficient and effective.

5.4 Infrastructural resource capacity

There is the need for bridging the existing gaps in infrastructural and equipment capacity to enhance the effectiveness and efficiency of the VRRS. For instance the lack of seed testing laboratories, cold rooms and major equipment for proximate analysis must be acquired by these institutions. This could be achieved through donor support and public-private partnership with interested private investors where necessary.

6.0 Conclusion

This study evaluated the preparedness of national agricultural research institutes and universities for conducting DUS and VCU testing under the newly proposed Variety Release and Registration System in Ghana. Purposive sampling techniques were used to select seven national institutions and universities for the study. Data for the study was collected using structured interview of the heads of institutions and professionals using semi-structured questionnaires.

The results showed that the institutions are indeed adequately prepared to participate in the DUS and VCU testing for VRRS. Although some capacity exists in terms of human resources, infrastructure and equipment, gaps still exists in these institutions, which prevents them from delivering an efficient and effective DUS and VCU testing to facilitate the entire VRRS. Major professionals in the varietal release and registration procedures include, plant breeders, seed technologists, agronomists, biotechnologists, food scientists, socio-economists, entomologist and crop physiologist.

The result suggests that, key factors that influence awareness and knowledge of VRRS among professionals in Ghana are level of education and years of professional experience and training.

References

Bortey, H. M. and F. Mpanju (2016). Adoption of Plant Breeders' Rights System: Perceived Implication for Food, Seed Security and Sovereignty in Ghana. *Journal of Intellectual Property Rights.* Vol 21, March 2016, pp 96-104.

Dartey, P.K.A., S.A. Ennin and H.M. Bortey (2016). In the absence of State funding, private sector participation in development, testing and adoption of rice varieties in Ghana calls for changes to release and registration procedures - case study of newly developed upland rice varieties. SATREPS International Symposium, Kenya, KARLO HQ, 6th December, 2016, pp.17

Louwaars, N.P. (2002). Variety Controls. In: Louwaars, N.P. (ed.) Seed Policy, Legislation and Law: Widening a narrow focus. The Haworth Press, New York, pp. 131-142.

Maddala GS (2005). *Introduction to Econometrics.* 3rd Edition, John Wiley & Sons Ltd, The Atrium, Southern Gate, England p. 318-323.

Rahm, M.R., & Huffman, W.E. (1984). The adoption of reduced tillage: The role of human capital and other variables. *American Journal of Agricultural Economics,* 66(4), 405–413.

Sanni, K.A, Ali A. Toure, Aliou Diagne, Fatimala Bachabi, Rosemary Muori, Rakesh Kumar Singh and Moussa Sie (2013). Rice Varietal Release Systems in Africa

Setimela P.S., B. Badu-Apraku, and W. Mwangi (2009). Variety testing and release approaches in DTMA project countries in sub-Saharan Africa. Harare, Zimbabwe, CIMMYT.

Appendix I: Questionnaire for Institutions

Questionnaire for Assessing the Preparedness of Potential State Institutions to conduct Distinctiveness, Uniformity and Stability (DUS) and Value for Cultivation and Use Tests (VCU) in Ghana among public Research Orgs. and Universities

Background information

1. Name of institution: ……
2. Type of institution: A. University ( ) B. Research ( )
3. Location: ……
4. Kindly, list your research stations (if any) and their agro-ecological zone (s) (e.g. Tamale-Nyankpala- Guinea Savanna zone).
   ……..

Plant breeding activities

5. Is your institution involved in plant breeding/cultivar development activities?
   a. Yes ( ) b. No ( )
6. What type of crop (s) does your institution work on?
   ……
7. Kindly tick the type of breeding technique (s) practiced by the researchers in your institution? (You may tick more than one)
   A. Conventional breeding ( ) B. Molecular breeding ( ) C. Mutation breeding ( )
   D. Tissue Culture-based techniques (*somaclonal variation, somatic hybridization etc.)* ( ) E. Genetic Engineering (GE) ( ) F. Others (specify) ……
8. Is your institution involved in any other activities that relates to varietal development that is not captured above? Yes ( ) No ( )
9. If yes, please indicate, ……..

Level of Investment in Plant breeding activities

10. How many varieties per crop has your institute released within the last 10yrs (2005-2015) and what is the source of funding? NB. Tick as many sources as may apply, (if more than one type is involved)

Crop	**Number of varieties**	**Type of Funding (source of funding)**			**Comments**
		Private sector	Public/GoG	Donor	
Maize					
Rice					
Sorghum					
Millet					
Soybean					
Cowpea					
Groundnut					
Beans					
Yam					
Cassava					
Sweetpotato					
		Type of Funding (Source of Funding)			
Crop	Number of varieties	Private Sector	GoG/Public	Donor	Comment
Cocoyam					
Plantain					
Vegetables					
Others					

11. Has your institution in the last 10yrs been receiving funding for plant breeding activities/crop variety development from government of Ghana (aside salaries)?
    a. Yes ( ) b. No ( )
12. If yes, kindly indicate the percentage of your total budget allocation that goes specifically to plant breeding activities since 2005.

Year	% Fund allocation for Plant breeding activities	Any comment
2005		
2006		
2007		
2008		
2009		
2010		
2011		
2012		
2013		
2014		
2015		

Human resource capacity and existing gaps

13. Please indicate how many of each of the following professionals is currently employed by your institution and available for work in their respective areas

Professional	**Existing number**		**Extra needed**			**Study Leave**	
	M	**F**	**M**	**F**		**M**	**F**
How many Plant breeders?							
How many Crop physiologists?							
How many Seed Scientists?							
How many Agronomists"							
How many Molecular biologists or related experts?							
How many Biotechnologists?							
How many Plant protection Scientists?*							
How many Socio-Economists?							
How many Biochemist/Food Scientist?							

***Entomologist, pathologist, virologist, nematologist**

Examining the existence of trained personnel & Qualification in evaluation of specific crop varieties (DUS & VCU Tests)							
	Existing number		**Extra needed**			**Study Leave ***	
How many trained personnel in the Evaluation of the following crops	**M**	**F**	**M**	**F**		**M**	**F**
Maize varieties							
Rice varieties							
Sorghum varieties							
Millet varieties							
Cowpea varieties							
Groundnut varieties							
Bambara groundnut							

Soybean varieties							
Yam varieties							
Cassava varieties							
Cocoyam varieties							
Sweetpotato varieties							
Plantain/Banana varieties							
Tomato varieties							
Pepper varieties							
Others (specify)							

**indicate how many are on study leave, sabbatical or on an official assignment elsewhere at the time of the interview*

14. From your institutions perspective, how do you think the existing gaps in human resource capacity can be addressed? .....

Infrastructural capacity and existing gaps

Item	Existing number	Any extra needed	Gap
How many offices do you have (related to plant breeding activities)			
How many seed cleaning equipment			
Seed Treatment equipment/plant			
How many cold rooms for seed storage			
How many seed processing sheds do you have			
Shellers/Threshers			
Seed dryers			
Winnowers			
Screenhouse			
Others (specify)			

15. Do you have a well-functioning seed testing laboratory? a. Yes ( ) b. No ( )
16. If Yes, what equipment is/are lacking? Kindly list here or as an attachment?
    ……
17. From your institutions perspective how do you think the gaps in infrastructural capacity can be bridged? .....

Equipment used in variety testing and gap in DUS sites

18. Does your institute have a parcel of land for DUS/VCU Testing?
    a. Yes ( ) b. No. ( )
19. Does the land have readily access to irrigation facility? a. Yes ( ) b. No ( )
20. Kindly indicate the number of each of the following equipment your institution has related to plant breeding activities.

Equipment	Existing number	Extra needed	Gap
Vehicles			
Computers			
Printers			
Fridges			
Cold rooms			
Scanner			

Digital camera			
Weighing scales			
Moisture metres			
GPS			
Proximate analysis equipment (protein, fibre, ash, fat, moisture etc.) Below			
A Complete Digestion & Distillation set-up (protein)			
A complete filtration set-up (Fibre)			
A Furnace (ash)			
Oven			
Soxlete apparatus (Crude fat)			
Statistical software			
Assorted Field Equipment* (Rope, Tape measures, sprayers etc.			
Other (*please indicate*)			

21. From your institutions perspective how do you think the equipment gaps can be addressed or bridged? .....

Appendix II: Questionnaire for Professionals

Questionnaire for assessing the level of awareness and knowledge on the variety release and registration procedure among Plant breeders, seed technologists, agronomists and related professionals

Background information

1. What category of professional are you?
   A. Plant breeders ( ) B. Seed technologists ( ) C. Agronomists ( ) D. Plant Biotechnologist/Molecular Biologist ( ) E. Others (specify) ……
2. Gender: a. Male ( ) b. Female ( )
3. Educational background
   A. First Degree ( ) B. Post graduate Diploma ( ) C. Master's Degree ( )
   D. PhD ( )
4. How many years have you been involved in Plant breeding and crop variety development or related activities? ……

Awareness and knowledge on variety release and registration procedure

5. Are you aware of the variety release and registration procedure in Ghana?
   a. Yes ( ) b. No ( )

6. Are you aware of the existence of the National Seed Council? If yes, do you know their role? ……
   ……A
   re you aware of the existence of the National Varietal Release & Registration Committee? If yes do you know their role in the varietal release procedure?
   ……
7. Are you aware of the existence of the new "Procedures for the release and registration of crop variety"? a. Yes ( ) b. No ( )
8. Do you have knowledge on the variety release and registration procedure in Ghana?
   a. Yes ( ) b. No ( )

9. If yes to the immediate above question, how would you categorize your level of knowledge in the variety release and registration procedure?
   A. little knowledge ( ) B. Mid way ( ) C. Full knowledge ( )
10. Have you participated in any variety release procedure before? a. Yes ( ) b. No ( )
11. If Yes, what was your level of participation? Tick the appropriate level in the table below.

Varietal development, release and registration procedure	**Level of participation**			
	No *	**Very little****	**Moderate *****	**Full** **
a. Acquisition/development of genetic material				
b. Pre-breeding evaluation of genetic materials (may incl. pot experiments)				
c. On-station evaluation of genetic materials (Morphological and molecular characterization of the genetic material (DUS characterization of materials proposed for registration)				
d. On-farm evaluation of genetic materials (DUS & VCU characterization of materials proposed for release)				
e. Proximate analysis of the economic part of the genetic material				
f. Economic analysis of cultivation of the genetic material				
g. Sensory evaluation of the genetic material				
h. Application to National Seed Council (NSC)				

**No: You have never participated* ***very little: you assisted scientist doing the activity*
****Moderate: participated (hands-on) but not the responsible officer for the activity*
*****Full: you were the response officer conducting the activity*

12. Are you aware of the following process in the variety release and registration procedures?
    a. Applications are made to the National Seed Council (NSC)? Yes ( ) No ( )
    b. National Seed Council directs the National Varietal Release and Registration Committee to verify DUS and VCU data submitted by the Breeder?
    Yes ( ) No ( )
    c. The National Varietal Release and Registration Committee prepare technical report based on data from minimum 2 growing cycles? Yes ( ) No ( )
    d. NSC can reject application if not satisfied with DUS and VCU data?
    Yes ( ) No ( )
    e. Applicant can appeal rejection of application within 20 days from the date of notification?
    Yes ( ) No ( )
    f. If application is approved, NSC notifies applicant and registers the new variety within 21 working days of approval? Yes ( ) No ( )
13. Have you participated in the release of any crop variety in Ghana? Yes ( ) No ( )
14. If yes, please indicate the crop (s) .....
15. Have you collaborated with any institution other than your own to release a crop variety?
    Yes ( ) No ( )
16. What challenges do you have with the current procedures of variety release and registration? ……..

17. Do you think it is effective? Yes ( ) No ( )
18. If No, what do you think can be done? …….
19. Do you think the current procedure is efficient? (things are done right)
    a. Yes ( ) b. No. ( )
20. If No, what do you think can be done? ……
21. Do you think the current procedure is transparent? Yes ( ) No ( )
22. If No, what do you think can be done? ……
23. Do you think the current procedure is expensive? Yes ( ) No ( )
24. If Yes, what do you think can be done? ……
    ……

Awareness and Knowledge on Plant Breeders Right Bill

25. Are you aware of the existence of a Plant Breeders' Rights Bill? a. Yes ( ) b. No ( )
26. If yes, how did you become aware? a. Awareness Workshop/seminar ( ) b. Consulted for your input ( ) c. Radio discussion ( ) d.TV discussion ( ) e. Newspaper ( ) f. Internet/Website ( ) g. Other (specify) ……
27. Have you been educated or sensitized on the provisions of the PBR Bill? a. Yes ( ) b. No ( )
28. If Yes, what medium was used? a. Sensitization Workshop ( ) b. Conference ( ) c. TV/Radio discussion ( ) d. Other …….
29. Do you know the PBR gives a Breeder/Breeding institute the exclusive right to produce or reproduce, offer for sale, condition for the purpose of propagating, import, export, sell his protected variety? a. Yes ( ) b. No ( )
30. Are you aware under the same Law, others can use your protected variety for private purposes or experimental purposes and do not need your permission? a. Yes ( ) b. No ( )
31. Do you know that adoption of PBR will help the institute have access to foreign plant germplasm for further research work? a. Yes ( ) b. No ( )
32. DUS data is required for varietal release purposes and also required for Plant Breeders' right. Do you support the idea that DUS data submitted for varietal release purposes be used to seek for Plant Breeders' Right? Yes ( ) No ( )
33. In your own opinion, how will the PBR bill affect plant breeding activities in your institute? (Tick as many as may apply) Yes No
    a. Enhance release of improved crop varieties ( ) ( )
    b. Increase private sector investment in plant breeding activities ( ) ( )
    c. Enhance private-public partnership in crop variety development ( ) ( )
    d. Lead to establishment of more seed companies ( ) ( )

e. Incentivize local plant breeders to develop and release more improved varieties ( ) ( )
f. Others (specify), ……...

Level of capacity to conduct DUS/VCU Tests

34. Under clause 14 (5) of the PBR Bill, the Registrar may arrange with a relevant authority or person within the country to carry out a Distinct, Uniform and Stable Tests (DUS). Have you had any training on how to conduct DUS test?
    a. Yes ( ) b. No ( )
35. If yes, how long was this training? …….. and where? ……
36. On which crop (s)?. …….. ……
37. Have you been applying the skills and knowledge learnt on this training since you had it? a. Yes ( ) b. No ( )
38. Do you think you have adequate capacity to conduct DUS & VCU?
    a. Yes ( ) b. No ( )
39. Would you like to be trained in this area/field? a. Yes ( ) b. No ( )

Appendix III: Respondent's Consent Form

Dear Sir/Madam,

Invitation to participate in a Survey for "Assessing the Preparedness of Potential State Institutions to conduct Distinctiveness, Uniformity and Stability (DUS) and Value for Cultivation and Use Tests (VCU) in Ghana"

I am **Hillary Mireku Bortey,** a Research Scientist at CSIR-Crops Research Institute and Intellectual Property Professional, acting as the Principal Investigator for the above Study. I am carrying out a study to **"assess the Preparedness of Potential State Institutions to conduct Distinctiveness, Uniformity and Stability (DUS) and Value for Cultivation and Use Tests (VCU) in Ghana.** I am kindly asking you to participate in this study by answering the following questions in the questionnaire attached.

Purpose of Study

This study investigates the preparedness of the existing institutions in terms of human and infrastructural capacity to undertake DUS and VCU tests under a newly proposed varietal release and registration system.

Procedures and duration

If you decide to participate you will respond to the questions provided in the questionnaire, indicate your choice and provide your own opinion where necessary, especially with the open-ended questions. It is expected that this will take about 20-30 minutes.

Risks and discomforts

I duly recognize the discomfort and inconvenience of spending part of your busy schedule for attending to responding to this questionnaire and accordingly appreciate it.

Benefits and/or compensation

The benefit of this study is for the generality of Ghanaians, as the study seeks to benefit all major players involve in ensuring an effective, efficient and transparent system for crop variety development, release and registration. The study will also help to guide agricultural policy, specifically related to investments needs in plant breeding activities in the country.

Confidentiality

Any information that is obtained in the study that can be identified with your person will not be disclosed without your permission.

Voluntary participation

Participation in this study is voluntary. Should there be for any personal reason decide not to participate in this study, your decision will not in any way affect your future relationship with the Council for Scientific and Industrial Research-Crops Research Institute; the Principal Investigator and his partners.

Offer to answer questions

Before you sign this form, please ask any questions on any aspect of this study that is unclear to you.

Authorization

If you have decided to participate in this study please sign this form in the space provided below as an indication that you have read and understood the information provided above and have agreed to participate.

---------- ----------

Name of Participant (please print) Date

……

Signature of Participant or legally authorized representative