



# West African Crop Wild Relative Checklist, Prioritization and Inventory

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**Abstract:** Crop wild relatives (CWR) are wild plant taxa genetically related to domesticated crops with trait diversity that can be used in plant breeding to sustain food security. Prioritization is a prerequisite for the cost-effective conservation of CWR as it allows CWR in a checklist to be reduced to a manageable number for active conservation action. In this study, a partial CWR checklist comprising 1651 taxa was compiled for West Africa. Prioritization of the annotated CWR checklist was based on three criteria: (i) economic value of the related crop in West Africa, (ii) CWR genetic closeness to its related crop and (iii) threat status. After applying the three criteria using the parallel method of prioritization, 102 priority CWR were selected for active conservation action. The priority CWR are related to food crops that are nationally, regionally and globally important, such as white guinea yam (*Dioscorea cayenensis* subsp. *rotundata* (Poir) J. Miège), cassava (*Manihot esculenta* Crantz), rice (*Oryza sativa* L.), wheat (*Triticum aestivum* L.), cowpea (*Vigna unguiculata* (L.) Walp.), sweet potato (*Ipomea batatas* (L.) Lam.), common bean (*Phaseolus vulgaris* L.) and sorghum (*Sorghum bicolor* (L.) Moench). This CWR checklist and prioritization will help in the development of a regional conservation action plan for West Africa.

**Keywords:** Crop wild relative, checklist, prioritization, inventory, crop improvement, conservation

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## Introduction

The significant effects of climate change on agriculture and livelihood in West Africa recently show the need to develop varieties of crops that can adapt to the rising temperatures, desertification, unpredictable rainfalls, floods and droughts and new diseases and pests, as well as meet the yield quality and quantity requirements of producers and consumers (Maxted *et al.*, 2015; Mousavi-Derazmahalleh *et al.*, 2018; Allen *et al.*, 2019). Climate change has led to yield losses in different crops and will continue to adversely affect agriculture with considerable yield decline predicted in West Africa (Sultan *et al.*, 2019). IPCC reported that the duration of the growing season in West Africa may

be reduced by 20% in 2050, resulting in about 40% yield reduction in cereals (Zougmore *et al.*, 2016). The increasing population in the Western Africa region may further limit the ability of the region to meet the food and nutrient security needs of its growing population. CWR are wild plant taxa genetically related to domesticated crops and are widely recognised as a major reservoir of valuable diversity that can be used in plant breeding to sustain food and nutrient security in the future (Maxted *et al.*, 2006; Magos Brehm *et al.*, 2017; Herden *et al.*, 2020; Kioukis *et al.*, 2020). Many CWR thrive in marginal environments (Jarvis *et al.*, 2015; Phillips *et al.*, 2017; Vincent *et al.*, 2019), making them better suited to withstand changing climate conditions. The extensive genetic diversity in CWR has been used globally in plant breeding programmes to produce crop cultivars with traits for high yield, drought tolerance, disease resistance, good handling quality, seed

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weight, early flowering time, cooking quality and better storage quality (Maxted and Kell, 2009; USDA, 2011).

CWR conservation and use contributes to the Sustainable Development Goal (SDG) of the United Nations (United Nations, 2015). Also, the United Nations' Intergovernmental Science – Policy Platform on Biodiversity and Ecosystem Service (IPBES), described CWR as vital for future food and nutrient security, ameliorating ecosystems and adapting crops to marginal environments (IPBES, 2019).

There are about 45,000 plant species in Sub-Saharan Africa (Linder, 2014). In Nigeria alone, there are thought to be 7,895 different plant species (Federal Republic of Nigeria, 2010). However, the diversity of CWR is widely threatened by unsustainable use of natural resources, urbanization, deteriorating environmental conditions, the introduction of exotic species and climate change (Maxted and Kell, 2009; Magos Brehm et al, 2017). Several CWR thrive on farmlands and are therefore threatened by agrochemical inputs and intensive agricultural systems (Jarvis et al, 2015; Capistrano-Gossmann et al, 2017; Vincent et al, 2019). Also, increasing population, poverty, habitat destruction, overgrazing, lack of land use planning and deforestation causes biodiversity loss in West Africa (Adejuwon, 2000). There is therefore the need for active *in situ* and *ex situ* conservation of CWR in West Africa, to ensure they continue to provide profitable genes to produce plant cultivars to meet the growing demand for ample food supply for the people of West Africa and beyond.

Developing a regional and national conservation plan is essential if poverty alleviation and food provision is to be maximised. This starts with making an inventory of CWR. Several countries already have CWR inventory, such as UK (Fielder et al, 2012), USA (Khoury et al, 2013), China (Kell et al, 2015) and Indonesia (Rahman et al, 2019). A CWR checklist is a list of CWR taxa found in a defined geographical area. A CWR checklist may contain additional information on the priority CWR which are important for conservation planning including taxon distribution, reproduction and conservation status, turning the checklist into a CWR inventory. As reported by Magos Brehm et al (2017) the steps involved in the generation of a CWR inventory are: (i) compilation of a national flora, (ii) matching the national flora against an existing digitized list of crop genera to obtain a list of taxa of the same genera as the list in the national flora, thereby producing the CWR checklist, (iii) prioritization of the CWR checklist to generate a realistic and manageable number of priority CWR, and (iv) annotation of the priority list of CWR with additional information for active conservation action to produce a CWR inventory (Maxted et al, 2007; Magos Brehm et al, 2017). Prioritization involves reducing the number of taxa in the CWR checklist into a number manageable for active conservation actions due to resource constraints and funding limitations. The prioritization criteria may include crop socio-economic value, CWR genetic closeness and ability to donate genes

to the related crop, endemism, occurrence, threat status and other related parameters (Magos Brehm et al, 2017; Thormann et al, 2017). There is presently no complete CWR checklist or inventory for West Africa.

This paper aims at the generation of a regional CWR checklist for West Africa, prioritization of this CWR checklist and the compilation of a CWR inventory, using the method described by Maxted et al (2007).

## Materials and Methods

### Creation of a CWR checklist for West Africa

A monographic approach (for selected crop genera) was carried out in order to produce a digitized CWR checklist (Magos Brehm et al, 2017) for West Africa, including the following countries: Benin, Burkina Faso, Cape Verde, Cote d' Ivoire, Gambia, Ghana, Guinea, Guinea-Bissau, Liberia, Mali, Mauritania, Niger, Nigeria, Senegal, Sierra Leone and Togo. A digitized flora for families known to contain CWR taxa was compiled for 12 selected plant families. WCSP (2020) was used for the *Araceae*, *Arecaceae*, *Convolvulaceae*, *Dioscoraceae*, *Euphorbiaceae*, *Musaceae*, *Poaceae* and *Zingiberaceae*, while the regional printed flora (Huchinson and Dalziel, 1958) was used for the *Malvaceae*, *Papilionaceae*, *Sterculiaceae* and *Caricaceae*.

The following steps were involved in generating the CWR checklist:

(i) Produce a digitized list of regional flora:

All taxa (i.e. species, subspecies, and varieties) belonging to the selected plant families were included in the floristic checklist. Information related to the different taxa of the regional flora was entered in the CWR checklist and inventory data template v.1 (Thormann et al, 2017), including: family, genus, species and authorities, various sub-ranks, taxon, sub-taxon, taxon common name, synonyms, related crop(s) and common name of the related crop (Thormann et al, 2017; Rahman et al, 2019).

(ii) Produce a digitized list of crops:

A digitized list of crop genera was produced from the following sources: (i) all crops cultivated in the world (FAO, 2021), (ii) major and minor food crops from the World Atlas of Biodiversity (Groombridge et al, 2002), and (iii) Annex 1 of the International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA) for both forage and food crops (FAO, 2009). The digitized list of crop genera was obtained from a published crop and crop genus list for CWR checklist and prioritization (Kell, 2016).

(iii) Match the crop genera against the floristic checklist to produce the CWR checklist:

The digitized list of crops was matched against the floristic list to produce the CWR checklist (Magos Brehm et al, 2017). Taxa cultivated but with no wild relatives in West Africa such as cocoyam (*Colocasia esculenta* (L.) Schott), coconut (*Cocos nucifera* L.), oil palm (*Elaeis guineensis* Jacq) or maize (*Zea mays* L.) were removed. The draft CWR checklist was sent to

experts and agricultural stakeholders for validation. The draft CWR checklist was approved by the experts and agricultural stakeholders for prioritization.

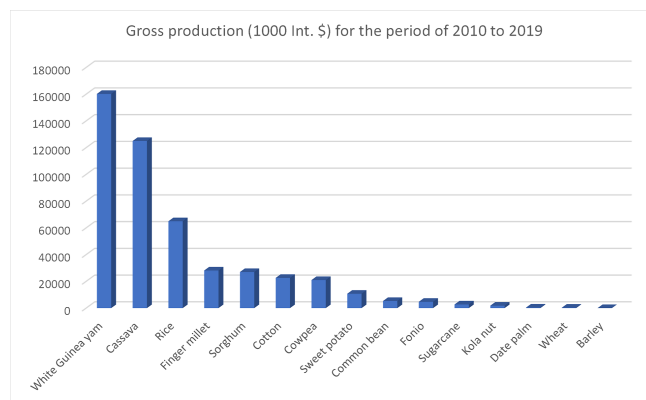
## CWR Prioritization

Different criteria and methods have been used to prioritize CWR checklists in the past for several countries and regions of the world, depending on the country and who will fund the CWR conservation action (Magos Brehm *et al.*, 2017). In this work, three criteria were applied in the prioritization of the CWR checklist for West Africa (Maxted *et al.*, 2013): (i) crop value in West Africa from FAOSTAT, (ii) CWR closeness to the crop from the Harlan and de Wet CWR diversity (<https://www.cwrdiversity.org/checklist/>) and (<https://npgsweb.ars-grin.gov/gringlobal/taxon/taxonomysearchcwr.aspx>), with CWR closeness restricted to gene pool or proven use in breeding within tertiary gene pool (GP3) (Maxted and Kell (2009), and (iii) global threat status according to IUCN (<https://www.iucn.org/>).

A parallel method was used through a point scoring process in which taxa were scored for all criteria, ranked according to their total score, and selected based on a 'cut off' score. For all criteria, taxa with a score of  $\geq 3$  were selected for prioritization. In assigning scores to criterion one (value), human food crops were scored (7 points), crops used as food additive (5), material (3), animal feed (1) and environmental use (1). Food crops (important for nutrition and food security), food additives and materials were selected for prioritization, excluding animal feed and environmental use crops. In assigning scores to the second criterion (genetic closeness), GP1 was scored (9 points), GP2 (7), GP3 (3), and CWR that lack this information [i.e. those belonging to Taxon Group 4 (TG4)] were scored (1 point). TG4 are CWR that belong to the same genus with their related crop. Applying the second criterion, CWR belonging to the primary gene pool (GP1B), secondary gene pool (GP2), and tertiary gene pool (GP3) with proven use in crop improvement were selected for prioritization (Ford-Lloyd *et al.*, 2008). Based on the third criterion (threat status), all evaluated CWR were selected for prioritization, excluding CWR that have not been evaluated (Maxted *et al.*, 2013).

## Results

The monographic CWR checklist for West Africa contains 1651 taxa from 379 genera. After the digitized list of crop genera was matched with the floristic list, a total of 392 CWR (and crops) resulted, belonging to 46 genera. Cultivated taxa without wild relatives in West Africa were removed, bringing the number to 379 taxa belonging to 33 genera. After applying the three criteria of the parallel method for prioritization (Kell *et al.*, 2017; Ng'uni *et al.*, 2019), the CWR checklist was reduced to a total of 102 priority CWR from 18 genera with 24 sub-taxon (subspecies/varieties). The priority CWR are related to 15 crops or crop groups important for



**Figure 1.** Gross Production Value for the period 2010-2019 of socio-economically valuable crops in West Africa. Data source: FAO (2021).

the West African region. The families with the highest number of CWR species are *Poaceae* (39), *Papilionaceae* (26), *Dioscoreaceae* (15) and *Convolvulaceae* (13). The genus with the highest number of CWR are *Vigna* (23), *Dioscorea* (15), *Ipomoea* (13), *Oryza* (6) and *Cola* (5) (Table 1).

## Socio-economic Value of Related Crops

Yam (*Dioscorea cayenensis* subsp. *rotundata* (Poir) J. Miegé) is the most economically valuable crop in West Africa, with the highest gross production value (Supplemental Table S3). It is followed by cassava (*Manihot esculenta* Crantz), rice (*Oryza sativa* L.), finger millet (*Eleusine coracana* (L.) Gaertn), sorghum (*Sorghum bicolor* (L.) Moench), cotton (*Gossypium hirsutum* L.) and cowpea (*Vigna unguiculata* (L.) Walp.) (Figure 1). Yam (*Dioscorea cayenensis* subsp. *rotundata* (Poir) J. Miège) also has the second largest number of CWR (15) after cowpea (23). Cassava (*Manihot esculenta* Crantz) and rice (*Oryza sativa* L.) which are the second and third in gross production value, have five and six CWR, respectively in the inventory (Table 1).

## CWR Closeness to Related Crops

Forty-five 45 (44 %) of the taxa were selected for prioritization using the criterion of taxa belonging to gene pools GP1B, GP2 or proven use of GP3 in crop improvement. Among the CWR selected, 21 (20.58 %) belong to GP1B, 28 (27.4%) are GP2 while 53 (51.9%) belong to GP3 or Taxon Group 4 (Supplemental Table S1). Among the 53 CWR belonging to GP3/Taxon Group 4, three (2.9%) have potential and confirmed use in crop improvement. Twenty-two (21.7%) of the CWR have confirmed use in crop improvement for crops such as wheat, rice, yam, sorghum, cassava, cowpea, millet and cotton, contributing to yield improvement, drought tolerance and resistance to several diseases in different crops as well as fibre quality in cotton (Table 2). Out of the 14 CWR taxa in the genus *Dioscorea*, five have confirmed use in crop improvement against various diseases such as anthracnose, yam mosaic virus (YMV) and yam nematode. Four CWR out of six

**Table 1.** Numbers of priority CWR for West Africa and their related crops.

Family	Genus	Related crop	No. of CWR taxa
Areceae	<i>Phoenix</i>	Date palm	1
Convolvulaceae	<i>Ipomoea</i>	Sweet potato	13
Dioscoreaceae	<i>Dioscorea</i>	White yam	15
Euphorbiaceae	<i>Manihot</i>	Cassava	5
Malvaceae	<i>Gossypium</i>	Cotton	3
Papilionaceae	<i>Phaseolus</i>	Common bean, kidney bean	3
	<i>Vigna</i>	Cowpea	23
Poaceae	<i>Digitaria</i>	Fonio	4
	<i>Eleusine</i>	Finger millet	3
	<i>Eragrostis</i>	Teff	4
	<i>Hordeum</i>	Barley	2
	<i>Oryza</i>	Rice	6
	<i>Saccharum</i>	Sugarcane	2
	<i>Sorghum</i>	Sorghum	4
	<i>Triticum</i>	Wheat	2
	<i>Echinochloa</i>	Barnyard millet, Japanese millet	5
	<i>Panicum</i>	Proso millet	2
Sterculiaceae	<i>Cola</i>	Kola nut	5
		Total CWR	102

in the genus *Manihot* have confirmed utilization for crop improvement against cassava brown streak disease (CBSD).

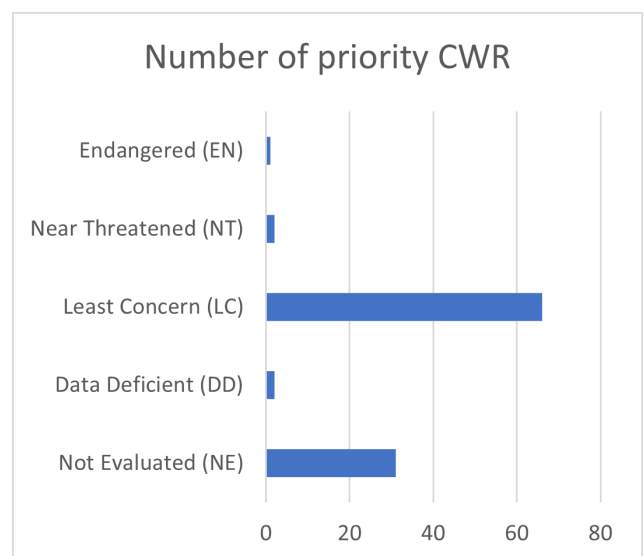
### Threat Status of CWR

The threat status of 71 (69.6%) of the priority CWR has been determined under the IUCN threat assessment criteria (IUCN, 2012). All the priority CWR were globally assessed. *Vigna desmodioides* R. Wilczek is the only Endangered (EN) priority CWR. Two priority CWR are Near Threatened (NT): *Dioscorea sensibarensis* Pax and *Gossypium anomalum* Wawra. Two CWR are Data Deficient (DD): *Gossypium herbaceum* var *acertifolium* (Guill & Perr.) A. Chev. and *Oryza brachyantha* A. Chev. & Roehr. Sixty-six (64.7%) of the priority CWR are Least concern (LC) while 31 (30.4%) were Not Evaluated (NE) (Figure 2). Rice (*Oryza sativa* L.) was the only socio-economically valuable crop that had all its CWR assessed for threat status (Huchinson and Dalziel, 1958).

### CWR Distribution

Eighty-four (69%) of the priority taxa were regionally endemic to West Africa, and 10 (8%) were nationally endemic. The nationally endemic priority taxa included: *Oryza eichingeri* Peter and *Cola attiensis* Aubrév. & Pellegr. (Cote D' Ivoire), *Cola angustifolia* K.Schum. (Sierra Leone), *Ipomoea intrapilosa* Rose, *Ipomoea prismatosyphon* Welw., *Vigna ambacensis* Welw. ex Bak., *Vigna macrorhyncha* (Harms) Milne-Redh., *Cola altissima* Engl. and *Cola argentea* Mast. (Nigeria) (Huchinson and Dalziel, 1958) (Supplemental

Table S2). Six priority taxa (5%) were found in all 15 countries in West Africa and include: *Echinochloa colona* (L.) Link, *Echinochloa pyramidalis* (Lam.) Hitchc. & Chase, *Eragrostis japonica* (Thunb.) Trin., *Eragrostis pilosa* (L.) P.Beauv., *Oryza barthi* A. Chev. and *Eleusine indica* (L.) Gaertn. (Huchinson and Dalziel, 1958; WCSP, 2020) (Supplemental Table S2).



**Figure 2.** Number of priority taxa in the IUCN categories. Data source: IUCN (2020).

**Table 2.** Confirmed and potential use of priority CWR for Nigeria and West Africa in crop improvement.

Crop	CWR	Confirmed and potential use
White Guinea yam	<i>Dioscorea abyssinica</i> Hochst. ex Kunth	Yam mosaic virus (YMV) and anthracnose resistance (Lopez-Montes <i>et al</i> , 2012)
	<i>Dioscorea praehensilis</i> Benth.	Yam mosaic virus (YMV) and anthracnose resistance (Lopez-Montes <i>et al</i> , 2012)
	<i>Dioscorea alata</i> L.	Anthracnose resistance, improved cooking quality and reduced tuber oxidation (Lopez-Montes <i>et al</i> , 2012)
	<i>Dioscorea bulbifera</i> L. <i>Dioscorea cayennensis</i> Lam	Yield improvement (Saini <i>et al</i> , 2016) Anthracnose and yam nematode resistance, drought tolerance (Lopez-Montes <i>et al</i> , 2012)
Cassava	<i>Manihot esculenta</i> subsp. <i>peruviana</i> Crantz	Cassava brown streak disease (CBSD) resistance (Kawuki <i>et al</i> , 2016)
	<i>Manihot carthagenensis</i> subsp. <i>glaziovii</i> (Müll. Arg.) Allem	
	<i>Manihot dichotoma</i> Ule	
	<i>Manihot esculenta</i> subsp. <i>flabellifolia</i> Crantz	
Cotton	<i>Gossypium barbadense</i> L.	High fibre quality (Zamir, 2001; Shi <i>et al</i> , 2008)
Barnyard millet,	<i>Echinochloa crus-galli</i> (L.) P. Beauv.	High yield (Sood <i>et al</i> , 2015)
Japanese millet	<i>Echinochloa frumentacea</i> Link	
Finger millet	<i>Eleusine africana</i> Kenn.-O' Byrne	High yield (Dida and Devos, 2006)
Barley	<i>Hordeum bulbosum</i> L.	Barley mild mosaic virus resistance (Walther <i>et al</i> , 2000; Ruge <i>et al</i> , 2003; Wendler <i>et al</i> , 2015); barley yellow dwarf virus resistance (Scholz <i>et al</i> , 2009; Wendler <i>et al</i> , 2015) barley yellow mosaic virus resistance (Ruge-Wehling <i>et al</i> , 2006); leaf rust resistance (Shtaya <i>et al</i> , 2007; Johnston <i>et al</i> , 2013; Park <i>et al</i> , 2015); leaf scald resistance (Pickering <i>et al</i> , 2006); powdery mildew resistance (Pickering and Johnston, 2005; Johnston <i>et al</i> , 2009); stem rust resistance (Fetch-Jr <i>et al</i> , 2009); potential use for soil salinity tolerance (Tavili and Biniiaz, 2009); potential use for high yield (Kakeda <i>et al</i> , 2008)
Rice	<i>Oryza eichingeri</i> Peter	Potential use for brown planthopper resistance, green leafhopper resistance and white backed planthopper resistance (Jena, 2010), submergence tolerance (Atwell <i>et al</i> , 2014)
	<i>Oryza barthii</i> A.Chev.	Potential use for drought tolerance (Atwell <i>et al</i> , 2014)
	<i>Oryza glaberrima</i> Steud.	rapid leaf canopy establishment (Jones <i>et al</i> , 1997); drought tolerance (Hajjar and Hodgkin, 2007); iron tolerance, potential for acid soil tolerance (Brar, 2004); potential for heat tolerance (Atwell <i>et al</i> , 2014)
	<i>Oryza longistaminata</i> A. Chev. & Roehr.	Drought tolerance (Hajjar and Hodgkin, 2007); yield improvement (Brar, 2004); bacterial blight resistance (Brar, 2004; Jena, 2010)

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Table 2 continued

Crop	CWR	Confirmed and potential use
Sorghum	<i>Oryza punctata</i> Kotschy ex Steud.	Potential use for drought resistance (Atwell et al, 2014); brown planthopper resistance and zigzag leafhopper resistance (Jena, 2010)
	<i>Sorghum purpureosericeum</i> (Hochst. ex A. Rich.) Schweinf. & Asch.	Sorghum shoot fly resistance (Nwanze et al, 1990)
	<i>Sorghum bicolor</i> subsp. <i>verticilliflorum</i> (L.) Moench	Leaf rust resistance (Park et al, 2015); spot blotch resistance (Yun et al, 2006); stem rust resistance (Fetch-Jr et al, 2009); drought tolerance (Nevo and Chen, 2010); seed weight (Pillen et al, 2004)
Common bean, kidney bean	<i>Phaseolus vulgaris</i> var. <i>aborigineus</i> (Burkart) Baude	Drought tolerance (Blair et al, 2016); plant height, seed size (Blair et al, 2006); yield improvement (Wright and Kelly, 2011); bruchid resistance (Osborn et al, 2003); common bacterial blight resistance, web blight resistance (Beaver et al, 2012); white mold resistance (Mkwaila et al, 2011); potential for bean rust resistance (Acevedo et al, 2006); potential for fusarium root rot resistance (de Ron et al, 2015)
Cowpea	<i>Vigna unguiculata</i> subsp. <i>dekindtiana</i> (Harms) Verdc.	Pod bug resistance (Timko and Singh, 2008)
	<i>Vigna unguiculata</i> var. <i>spontanea</i> (Schweinf.) Pasquet	Yield improvement (Andargie et al, 2014)
	<i>Vigna unguiculata</i> subsp. <i>stenophylla</i> (Harv.) Marechal & al.	Potential for aphid resistance (Badiane et al, 2014)
Wheat	<i>Triticum turgidum</i> L.	Stripe rust resistance, powdery mildew resistance (Chaudhary et al, 2014)

## Discussion

Adejuwon (2000) reported that 20 species of plants in Nigeria were extinct, 431 were endangered species while 20 were vulnerable. Urbanization, soil degradation, natural calamities, deforestation, forest fires, over-grazing and other anthropogenic activities, particularly climate change, are reducing the availability of CWR for sustainable agricultural productivity (Maxted *et al.*, 1997; Moore *et al.*, 2008; Mounce *et al.*, 2017). For an effective and sustainable regional conservation strategy and its subsequent implementation, a priority CWR inventory is essential. A CWR inventory serves as a guide for a sustainable conservation action plan. The outcome of this research will form the blueprint for a systematic conservation and use strategy for West Africa. It will provide a starting point for a coordinated policy in the conservation and sustainable utilization of CWR diversity in the West African region. In this study, 379 taxa were identified as priority plant taxa, of which 122 were subsequently prioritized for urgent active conservation action. The remaining 257 plant species and their CWR could be considered for active conservation in the future as and when resources become available.

CWR of socio-economic valuable crops in West Africa have been reportedly used in crop improvement. For instance, Sood *et al.* (2015) reported the use of *E. crusgalli* (P. Beauv) and *E. frumentacea* (Link) to increase yield quality in Barnyard millet. *D. abyssinica* (Hochst ex Kunth) and *D. praehensilis* have been reported to show resistance to yam mosaic virus and anthracnose, while *D. bulbifera* showed resistance to yam nematode and tolerance to drought (Lopez-Montes *et al.*, 2012). Similarly, Kawuki *et al.* (2016) reported the use of *M. esculenta* subsp. *peruviana* Crantz, *M. carthagenensis* subsp. *glaziovii* (Müll. Arg.) Allem, *M. dichotoma* Ule and *M. esculenta* subsp. *flabellifolia* Crantz in breeding against cassava brown streak disease in cassava (Table 2). Traits for drought tolerance (Hajjar and Hodgkin, 2007), yield improvement (Brar, 2004) and bacterial blight resistance (Brar, 2004; Jena, 2010) have been transferred from *O. longistaminata* A. Chev. & Roehr. to rice, while *O. glaberrima* Steud. has been reported to show drought tolerance (IRRI, 2006), iron tolerance (Brar and Khush, 2002), rapid leaf canopy establishment (Jones *et al.*, 1997) and potential for tolerance to acid soil (Brar and Khush, 2002) and heat (Atwell *et al.*, 2014). Also, *S. bicolor* subsp. *verticillifolia* (L.) Moench has reportedly shown resistance to leaf rust (Park *et al.*, 2015), spot blotch (Yun *et al.*, 2006), stem rust (Fetch Jr *et al.*, 2009) and tolerance to drought (Nevo and Chen, 2010). Resistance to white mold (Mkwaila *et al.*, 2011), bruchids (Osborn *et al.*, 2003), common bacterial blight and web blight (Beaver *et al.*, 2012), and tolerance to drought have been documented in *Phaseolus vulgaris* var. *aborigineus* L. Chaudhary *et al.* (2014) reported stripe rust and powdery mildew resistance in *T. turgidum* L. (Table 2).

Maxted *et al.* (2015) and Kell *et al.* (2017) have opined that regional conservation is supplemental to national efforts as some CWR may be lacking in some countries in a region. West Africa, being a region dominated by agricultural nations, will find the implementation of the conservation plan from this inventory useful, as it will enhance the region's global relevance in agricultural productivity. As reported by Maxted *et al.* (2008) and Engels and Thormann (2020), collaboration by neighboring nations could enhance the extensive and effective conservation of CWR genetic diversity. It is therefore the collective responsibilities of the neighboring nations where this CWR diversity is found to regionally conserve it (Maxted *et al.*, 2008, 2015; Kell *et al.*, 2017; Allen *et al.*, 2019).

## Conclusion

This study shows that West Africa harbours CWR diversity that can contribute significantly to sustainable agricultural development in the region. Kell *et al.* (2015) noted that countries should widen their utilization of CWR across national boundaries and all nations are inter-independent in the quest for food security. Similar to an existing CWR inventory for the North African region (Lala *et al.*, 2018), the CWR checklist, prioritization and prioritized inventory presented in the study will help in the development of a CWR conservation plan for West Africa. The conservation and utilization of CWR in this inventory for crop improvement has the potential to significantly reduce the over-dependence on synthetic agrochemicals and fertilizers in the region, which negatively impacts on its biodiversity and agricultural productivity. There is an urgent need to take a systematic and pragmatic approach in the conservation and sustainable utilization of CWR diversity in West Africa to ensure food security.

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## Supplemental data

**Supplemental Table 1:** Related crop and concept level of priority CWR for West Africa.

**Supplemental Table 2:** Endemicity and International Union for Conservation of Nature and Natural Resources (IUCN) category of priority CWR.

**Supplemental Table 3:** Gross production value of socioeconomically valuable crops in West Africa.

## Author contributions

Nigel Maxted and Joana Magos Brehm designed the study. All authors were involved in checklist compilation and prioritization. Michael Nduche wrote

the manuscript while all authors discussed the results, commented on the manuscript, read and approved the final manuscript.

### Conflict of interest statement

The authors declared that there is no conflict of interest.

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