Crop Protection 142 (2021) 105533

Contents lists available at ScienceDirect

Crop Protection

journal homepage: www.elsevier.com/locate/cropro

Cowpea production constraints on smallholders' farms in Maradi and Zinder regions, Niger

Ibrahim Baoua[a], Mahamane Moctar Rabé[b], Larry L. Murdock[c], Dieudonne Baributsa[c,*]

[a] Département des Sciences et Techniques de Productions Végétales, Université Dan Dicko Dankoulodo de Maradi, Maradi, BP 465, Niger
[b] Faculté des Sciences Agronomiques, Université de Tahoua, BP 255, Tahoua, Niger
[c] Department of Entomology, Purdue University, West Lafayette, IN, 47907, USA

ARTICLE INFO

Keywords:
Improved varieties
Production constraints
Insects
Striga
Disease

ABSTRACT

Cowpea production in Niger is constrained by biotic and abiotic factors that lead to lower yields and incomes for smallholder farmers. For decades now, efforts have been made to improve cowpea production, including the development and release of improved varieties that are high yielding and resistant or tolerant to pests and diseases. The present study assessed cowpea production constraints on 584 smallholders' farms in Maradi and Zinder regions of Niger. Estimated parameters consisted of farm size, varieties used and pests and disease prevalence. We found that the average farm size for both regions was 2.10 ha. Local varieties (63%) and IT90K 372-1-2 (30.5%), an improved variety released 25 years ago, were the most-cultivated cowpea varieties. Two recently introduced varieties were planted on less than 4% of fields. Cowpea was grown in association with millet and sorghum on 96.6% of fields. Average cowpea yield for both regions was 253.4 kg ha^{-1}. Five major insect pests and the plant parasite *Striga*, identified as major production constraints, were negatively correlated with cowpea yields. Diseases were significantly and negatively associated with cowpea yields. To increase cowpea productivity, there is a need to develop and/or promote adapted high-yielding varieties, and to disseminate good agricultural practices to minimize the incidence of pests and diseases.

1. Introduction

Cowpea is an important crop in West Africa that provides food for people, fodder for animals, and income to millions of smallholder farmers (Langyintuo et al., 2003; Manda et al., 2019). Its grain and fresh leaves are important sources of protein, minerals and vitamins, and thus helps to address malnutrition among rural families in West Africa (Maynard, 2010; Nielsen et al., 1997; Santos et al., 2012). Cowpea is often referred to as the meat for the poor (Boukar et al., 2013; Oyewale and Bamaiyi, 2013). In addition to grain, several cowpea varieties are cultivated as fodder for livestock (Kristjanson et al., 2005). The crop is also preferred by smallholder farmers because it is adapted to the poor soils of the dry savannah and has the ability to fix atmospheric nitrogen, contributing to soil improvement (Augustin Do Rego et al., 2015).

Niger, is the second largest cowpea producer in West Africa and in the world after Nigeria (FAO, 2018). Cowpea is the second largest crop in Niger after millet, with an annual production of 2,380,068 tons in 2019 (MAE, 2020a). By volume, cowpea makes up a quarter of the national agricultural production and 80% of cash crops (MAE, 2018). Cowpea is the third agricultural product contributing to GDP after livestock and onions, owing to its economic importance as an export crop (Ibrahim et al., 2018; SNV, 2014). This agricultural output (95%) is produced by smallholder farmers who grow their crops on less than 5 ha and use limited inputs during production. As a result, crop yields in Niger are very low (Mortimore et al., 1997), with averages stagnating between 189 and 338 kg ha^{-1} from 2008 to 2012 (INS, 2012). In 2012, Maradi and Zinder regions ranked second (253,000 tons) and fifth (193, 600 tons) in cowpea production, but their yields were the lowest (243 kg ha^{-1} and 193 kg ha^{-1}), respectively, among the eight regions that produce cowpea in Niger (INS, 2012).

Cowpeas are highly susceptible to pests and diseases, and drought conditions (Inaizumi et al., 1999; Jackai and Adalla, 1997). Insects and other pests represent the most important biotic constraints during cowpea production, especially under changing weather patterns. Pests compromise plant growth and reduce yields by inflicting substantial damage to the crop if no protective measures are taken (Dugje et al., 2009; N'Gbesso et al., 2013). Production losses caused by these pests and diseases are among the major constraints that have reduced farmers'

* Corresponding author.
E-mail address: dbaribut@purdue.edu (D. Baributsa).

https://doi.org/10.1016/j.cropro.2021.105533
Received 27 October 2020; Received in revised form 30 December 2020; Accepted 2 January 2021
Available online 5 January 2021
0261-2194/

interest in growing cowpea (Habiba, 2004; Tamo et al., 2003). However, several technologies are available for pest management including improved cowpea varieties that are resistant or tolerant to these challenges, and biopesticides (Harouna et al., 2019; Omoigui et al., 2019; Rabe et al., 2017a; Salifou et al., 2019; Zakari et al., 2018).

Different efforts have been made to improve cowpea production. Over the years, several bilateral and multilateral projects were launched to increase adoption of improved varieties, promote the use of yield-improving inputs, postharvest management and access to international markets (Doka, 2010). More than 16 improved varieties currently available in Niger have yield potentials ranging from 1 to 3 tons ha^{-1} (Ibrahim et al., 2018). A network of more than 725 private seed multipliers has been established with annual capacity to produce 791 tons of certified cowpea seed (MAE, 2020b). Despite efforts to introduce high yielding and pests and disease resistant/tolerant varieties, the productivity of cowpea on farmers' fields in Niger is generally low due to poor production management practices (Mignouna et al., 2013).

Cowpea production can be improved, if there is a better understanding of the pests, diseases and performance of commonly used varieties (Sawadogo, 2009). We conducted the present study to (i) identify production practices and cowpea varieties used and their yields in both Maradi and Zinder regions; and (ii) determine production constraints, including pests and diseases. Identifying cowpea varieties grown on smallholder farms would serve as an indicator of the degree to which improved varieties have been adopted and how they have performed against pests and diseases. This would provide information useful to researchers, government and development agencies interested in reaching farmers with new varieties to improve cowpea production and productivity.

2. Material and methods

2.1. Study area

This study was carried out in Maradi and Zinder regions of Niger from October 4th to 29th, 2019 (Fig. 1). Both regions account for about 31% of the cultivated land in the country and 42% of the national cowpea production (MAE, 2020b). Cowpea is generally grown on dune soils. Both regions have rainfalls ranging from 400 to 600 mm per year and average annual temperatures between 23 °C and 33 °C (PADESA, 2018).

2.2. Data collection

We collected data on a total of 584 fields belonging to smallholder farmers from 19 to 20 villages in the Maradi and Zinder regions, respectively. The villages were chosen from departments (districts) with high cowpea production that had earlier benefited from efforts to disseminate improved cowpea varieties by the Niger National Institute of Agricultural Research (INRAN) and other development efforts. Villages were selected in collaboration with local offices of the ministry of agriculture. The number of fields surveyed in Maradi and Zinder were 303 and 281, respectively. Fields belonged to farmers randomly selected among cowpea producers who were present in the villages during the visit. Owners of the cowpea farms provided information on the varieties cultivated in their fields and the size of their farms.

After interacting with each farmer, the surveyors moved to the field to assess its size and collect data on varieties grown, cropping system (sole or intercropping), crop density, pests and diseases, and crop yields. A 5 m × 5 m square quadrat was used in the middle part of the field to assess crop density, the proportions of plants with different pests (insects, diseases and *Striga*), and damage to the pods associated with different insect pests. To assess the level of infestations, five cowpeas hills were randomly selected in the quadrat. The average density of insect species and tufts of the parasitic plant *Striga gesnesrioides* (Willd) were determined. To identify insect pests, we developed an illustrated guide with pictures of commonly known pests and plant symptoms. In addition, cowpea plants were scored for the most common diseases following the details in Table 1 (Dugje et al., 2009; Savary et al., 1987; Singh and Allen, 1979).

To estimate yields, we collected samples from the most predominant cultivated variety in the field. The average number of pods (Np) was determined on 10 randomly selected cowpea hills (zigzag pattern) in the quadrat. A sample of 20 pods was also collected to determine their

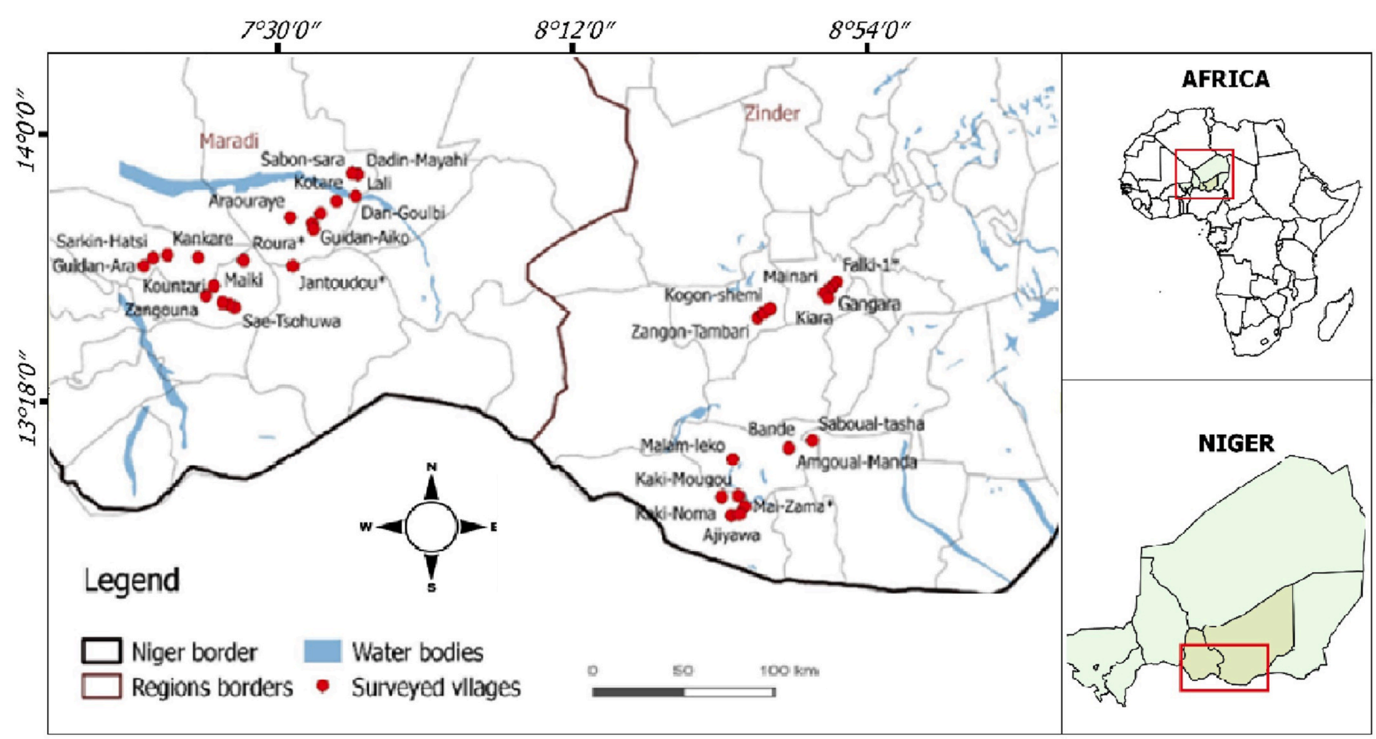

Fig. 1. Map showing the area where the study was conducted. Each dot represents a village in both Maradi (left) and Zinder (right) regions, Niger.

Table 1
Main cowpea diseases and their symptoms.

Disease	Symptoms
Anthracnose (*Colletotrichum destructivum*)	Rounded or oval spots, appearance of pink or cream spots, diamond-shaped or squared spots on the leaf veins
Stem rot (*Sclerotium rolfsii*)	Plant wilt, stem canker
Neck/root rot (*Pythium aphanidermatum*)	Softening, soft oily rot and neck necrosis, root rot
Cercospora (*Cercospora canescens*)	Round or irregular spots up to 10 mm in diameter. They are brown, red in color on both sides of the leaf.
Leaf spots (*Septoria vignae*)	Light brown spots necrosis in a diamond-shaped center and bordered by chlorosis on the leaves
Fusarium wilt (*Fusarium oxysporum*)	Plant wilt, yellowing and necrosis

average seed weight (Psw). As the plant density of each field was known, the yield of each field was estimated with the following formula:

$$Yield\ (kg) = \frac{(\text{Nth x Np x Psw})}{1000}$$

$$Nth = \frac{\text{number of cowpea hill}}{\text{ha}} = \frac{\text{density of cowpea hill}}{\text{m}^2 \text{ x } 10,000}$$

where Np = Average number of pods per cowpea hill, Psw = Average seed weight of a pod (g)

2.3. Data analysis

The data were entered into Microsoft Excel and analyzed using SPSS version 20 software (IBM Corp., 2016, New York, NY, United States). Depending on the data type, the proportions, means, and standard errors (SE) were calculated. Normality tests were performed before the analysis. The Chi-square test and Student's t-test were used to compare the data between the two regions (field characteristics, cowpea varieties, pests, and diseases). ANOVA test followed by SNK was used to compare variety yields in each region. Linear regression analysis and correlation tests were used to identify variables (varieties, pests and diseases) that could influence the cowpea yields. Average pest (insects and *Striga)* densities were correlated with cowpea yields. Cowpea varieties and diseases were converted into dummy variables taking the value 1 if the farmer planted a given variety or a farm had a disease and 0 otherwise.

3. Results

3.1. Characteristics of cowpea farms

The size of the farms varied from 1 to 15 ha, with an average of 2.1 ha (Table 2). The majority of farmers' fields (69.5%) grew one cowpea variety, while 30.5% farmers grew two varieties. When two varieties were grown in the same field, one of them was always local. Most farmers' fields (97%) had semi-erect and prostrate (trailing) varieties, while erect varieties were observed on only 3% of farms. Cowpea density varied from 1 to 4 plants per hill with an average of two plants per hill. Most farms (96.6%) had cowpea intercropped with millet and/or sorghum; only 2.4% of the farms grew cowpea in pure stand. Cowpea intercropped with millet was the most common practice in both Maradi and Zinder regions (Table 2). Cowpea intercropped with sorghum or sesame was more frequent in Zinder compared to Maradi region (Table 2).

3.2. Cowpea varieties grown and yields

Local varieties were predominant and cultivated on 67.8% of farms. Improved varieties were cultivated on 32.2% of the farms, with three improved varieties identified (Table 3). Across both regions, the use of improved cowpea varieties was 0.7, 1.0, and 30.5% for KVX 30-309-6G, UAM09-1055-6, and IT90K 372-1-2, respectively. Local varieties were used about 2 times more in Zinder compared to Maradi, while IT90K 372-1-2 was about 4 times more common in the Maradi region than

Table 3
Proportion of cowpea grown and yields of 584 farms assessed in both Maradi and Zinder regions of Niger.

	Varieties grown (%)			Cowpea yields (Mean ± SE; kg ha^{-1})	
	Maradi	Zinder	Significance[a]	Maradi	Zinder
Local variety	48.8	88.3	***	236.8 ± 138.3 ab	245.3 ± 168.2a
IT90K 372-1-2	47.9	11.7	***	288.6 ± 172.7 ab	229.3 ± 176.3a
UAM09-1055-6	2.0	0	**	191.2 ± 58.4b	–
KVX 30-309-6G	1.7	0	**	387.0 ± 185.4a	–
ANOVA				F = 3.99; df = 5/299; P = 0.008	F = 0.42; df = 2/279; P = 0.5

*,**, *** difference between regions significant at levels 0.05, 0.01, and 0.001, respectively.
[a] Significance based on Chi-square test.

Table 2
Field characteristics and proportion (%) of farms where cowpea is intercropped with other crops in both Maradi and Zinder regions, Niger.

	Variable	Regions (Mean ± SE)			Significance[a]
		Maradi	Zinder	Overall Mean	
Field characteristics	Farm size (ha)	2.21 ± 1.1	1.97 ± 1.3	2.10 ± 1.2	*
	Number of cowpea varieties	1.12 ± 0.7	1.16 ± 0.6	1.14 ± 0.7	ns
	Number of hills m^{-2}	0.86 ± 0.3	1.02 ± 1.0	0.94 ± 0.7	**
	Number of plants/hill	2.31 ± 0.6	2.06 ± 0.7	2.19 ± 0.7	***
		Percentage (%)			Significance[b]
Intercropping	Cowpea + Millet	95.5	79.9	87.9	***
	Cowpea + Sorghum	42.2	62.5	52	***
	Cowpea + Sesame	7.7	24.2	15.6	***
	Cowpea + Groundnut	5.2	3.7	4.5	ns
	Cowpea + Bambara groundnut	2.4	0	1.3	**

*,**,*** difference between regions significant at levels 0.05, 0.01, and 0.001, respectively.
[a] Significance based on Student's t-test.
[b] Significance based on Chi-square test.

Zinder. Estimated yields were comparable between both regions, ranging from 262.7 ± 157 kg ha^{-1} and 243.4 ± 168.9 kg ha^{-1} in Maradi and Zinder, respectively, with an average yield of 253.4 ± 163.3 kg ha^{-1} across both regions. KVX30-309-6G had significantly higher yields compared to other varieties. A linear regression analysis showed a correlation between cowpea varieties and yields ($F = 6.027$; df = 1/583; $P = 0.014$; $R^2 = 0.010$) only at $p \geq 0.05$.

3.3. Cowpea insect pests

Five major insect pest species were identified during the field surveys (Table 4). A cowpea defoliator (*Amsacta moloneyi* Druce) and the pod sucking bug (*Clavigralla tomentosicollis* Stal) were the most predominant field insect pests in both regions. The infestations by *Aphis craccivora* Koch, *A. moloneyi*, *Maruca vitrata* Fabricius et *Mylabris* sp. were predominant in more fields in Zinder than in Maradi. The proportion of fields infested by *C. tomentosicollis* was similar in both regions. About half of the pods in farms showed signs of insect damage in Maradi (42.5%) and Zinder (52.6%). Damage included aborted flowers, shriveled, perforated or partially consumed seeds that provided openings for diseases to enter. The densities of each of the insect pest species differed between the two regions. The density of four of the insect pests were negatively and significantly correlated with cowpea yield. Correlations were significant for all insects, but the coefficient was above 0.5 only for *M. vitrata*.

3.4. Cowpea diseases

Field observations indicated symptoms of 7 diseases (Table 5), with Cercospora as the most predominant disease. Anthracnose, stem rot, stem and collar rot, and fusarium wilt were observed more often in the Zinder region than in Maradi region. Among the seven identified diseases, all negatively and significantly influenced cowpea yields, except for root rot and fusarium.

3.5. Cowpea infestations by Striga (S. gesnesrioides)

The parasitic weed *Striga* was observed in similar proportions in both regions ($\chi^2 = 0.86$; $p < 0.5$). *Striga*-infested cowpea fields comprised 49.2% in Zinder and 53% in Maradi. The average density was 2.0 ± 2.5 and 4.0 ± 6.8 of *Striga* plants per cowpea hill in Maradi and Zinder, respectively. The average density was higher in the Zinder region compared to Maradi ($t = -3.40$; $p < 0.01$). The tuft density of *Striga* plants per cowpea hill was negatively and significantly correlated with cowpea yields ($R^2 = -0.312$ **, $p < 0.001$). About 40.4% of the infested cowpea plants per hill were yellowish and had stunted growth.

4. Discussion

This study provides an insight into cowpea production on smallholder farms in Maradi and Zinder, Niger. Cowpea fields were on average 12.2% larger in the Maradi region compared to Zinder. The average field size for both regions was twice of that reported by other studies in both regions and in Nigeria (Djido and Shiferaw, 2018; Saka et al., 2018). Based on the number of hills m^{-2} and the number of plants per hill, cowpea densities were about 19,866 and 21,012 plants ha^{-1} for Maradi and Zinder, respectively. These plant densities are about 3–4 times lower compared to the recommended planting density for prostrate varieties of 60,000 plants ha^{-1} in intercropping and 88,889 ha^{-1} in pure stand (Dugje et al., 2009). Increasing plant density would undoubtedly enhance cowpea production. The low planting density might be due to inadequate planting systems and producer-specific strategies to minimize interplant competition given that these smallholder farms grow traditional varieties on soil with low fertility (Ajeigbe et al., 2010; Kamara et al., 2018a; Kanté, 2001).

About 90% of smallholder farmers planted a single variety, particularly when cowpea was intercropped. Intercropping of cowpea with millet or sorghum is the common practice in Niger. In contrast to our findings, a study conducted in southern Nigeria where rainfall is much higher found that about 36–49% of the fields of cowpea were grown as a sole crop (Saka et al., 2018). Smallholder farmers practice intercropping to mitigate the risks associated with biotic and abiotic constraints such as drought, pests, and diseases (Masvaya et al., 2017; Singh et al., 2018). However, other studies have shown that cultivating cowpea in association with cereals in arid and semi-arid zones leads to competition for soil nutrients, water and light, which can then lead to a decrease in productivity of both crops (Nelson et al., 2018; Ntare and Williams, 1992; Olufajo and Singh, 2002). The adoption of improved crop management such as strip intercropping (two lines of cereals and four lines of cowpeas) combined with the use of fertilizers and improved varieties can substantially increase cowpea yields up to 300% (Ajeigbe et al., 2010; Mohammed et al., 2008; Saidou et al., 2011).

Overall, the use of improved cowpea varieties by 30.5% among smallholder farmers in both regions in Niger was close to the 36–38%

Table 5
Proportion of farms with cowpea diseases symptoms and linear regression analyzes between occurrence of cowpea disease and yields of 584 farms assessed in both Maradi and Zinder regions of Niger.

Disease	% Cowpea farms with diseases			Slope of the regression between disease and yield
	Maradi	Zinder	Significance[a]	
Constant				408.0
Cercospora	33.1	39.9	ns	−148.1***
Anthracnose	27.2	39.5	**	−91.5***
Leaf spots	19.1	22.1	ns	−63.7**
Neck/root rot	14.2	22.8	**	−5.7
Stem rot	14.9	21.7	**	−147.6**
Gall	74.5	74.4	ns	−87.6**
Fusarium	14.2	21.4	**	201.5

*,**,***difference between regions significant at levels 0.05, 0.01, and 0.001, respectively.
[a] Significance based on Chi-square test.

Table 4
Proportion of farms infested by different insect pest species, average density of insect pests per cowpea hill and, correlation between pest densities and cowpea yields of 584 farms assessed in both Maradi and Zinder regions of Niger.

Insect species	% farms infested by insect pests			Number of insects per cowpea hill (Mean ± SE)			Correlation between insect densities and cowpea yield
	Maradi	Zinder	Significance[a]	Maradi	Zinder	Significance[b]	
A. craccivora	27.2	36.7	**	3.1 ± 5.8	0.42 ± 1.7	**	−0.375*
A. moloneyi	65.6	80.4	***	0.24 ± 1.3	0.05 ± 0.2	*	−0.132
C. tomentosicollis	65.2	67.3	ns	6.25 ± 4.1	6.13 ± 6.0	**	−0.306**
M. vitrata	31.5	45.9	***	5.16 ± 6.6	7.41 ± 7.8	**	−0.536**
Mylabris sp.	26.2	36.3	**	0.59 ± 1.2	0.67 ± 1.1	ns	−0.388**

*,**,*** difference between regions significant at levels 0.05, 0.01, and 0.00,1 respectively.
[a] Significance based on Chi-square test.
[b] Significance based on Student's t-test.

reported in Nigeria (Manda et al., 2020; Mbavai et al., 2019). Four genotypes, including three improved cowpea varieties, were grown by smallholder farmers in the study area. Among improved varieties, IT90K 372-1-2 was the most used by smallholder farmers thanks to its large-scale dissemination by several projects (Rabe et al., 2017a; Salifou et al., 2017). This variety was introduced in Niger about 25 years ago by the PEDUNE project and then by the International Institute of Tropical Agriculture (IITA) (Gbaguidi and Coulibaly, 2013; Nathaniels, 2005). IT90K 372-1-2 is early maturing, tolerant to pests and has potential for high yield (Dugje et al., 2009; Saidou et al., 2011). The variety IT90K 372-1-2 was the most multiplied in Niger during the 2019 season, as it accounted for 70.7% of the certified seed produced in the country (MAE, 2020b). While there appeared to be a limited use of KVX-30-309 and UAM09-1055-6, these two varieties accounted for 10.4% and 11.8% of the national seed stocks, respectively. These varieties were bred for precocity, high yield, and resistance to pests (Ekhuemelo et al., 2019; Omoigui et al., 2019). To optimize production risks, farmers who grew more than one variety had a local variety combined with an improved one in the same field.

The high proportion of farmers using local varieties may be linked to low seed multiplication, lack of awareness, and poor dissemination of improved cowpea varieties, together with limited seed distribution channels to make them available in rural areas (Ojiewo et al., 2020). Out of the 16 cowpea varieties listed in the national seed catalog, 10 were available (MAE, 2020b), and only three were used by farmers in this study area. Cowpea seed in Niger is produced by 243 farmers' organizations, 412 individual farmer seed growers and 43 private seed companies (MAE, 2020b). Among farmer-seed producers, Zinder accounted only for 11.5%. By contrast, the Maradi region had about 43.2% of farmers' seed producers, 23.9% of individual farmer seed growers, and 64.3% of private seed companies. The 2020 available national seed stock of improved cowpea varieties was estimated at 1,036,220 kg, of which 39.4% was in the Maradi region and 1.9% in the Zinder region. With more than 5 million hectares in cowpea production and a seeding rate of 10 kg ha^{-1}, this represents only about 2% of the national need in improved seed. The low capacity in seed production is reflected in the limited capacity in seed technology adoption among smallholder farmers. This may explain why a high proportion of smallholder farms in Zinder were using local varieties.

Averaged cowpea yields observed in this study (262.7 and 243.4 kg ha^{-1} for Maradi and Zinder, respectively) were far below the regional averages of 404–414 kg ha^{-1} estimated by the National agricultural statistics (MAE, 2020a). Improved cowpea varieties (except KVX30-309-6G) did not perform better than local varieties, despite having potential yields ranging from 1.5 to 3.0 tons ha^{-1} (Boukar and Fatokun, 2009; Karungi et al., 2000; Singh, 2014). Lower yields of these improved varieties may be due to poor management practices including low plant density, lack or limited use of fertilizer, and inadequate pest management (Boukar et al., 2013). Smallholder farmers in both regions were using the same management practices for local and improved varieties, as there was no difference in plant densities among genotypes. Studies conducted in northern Nigeria over two years showed that the use of improved varieties at a density of 266,666 plants ha^{-1} yielded between 2.5 and 3 tons ha^{-1} of cowpea grains (Kamara et al., 2018b). Understanding what is required to close the gap between yields obtained in experimental studies and those achieved by farmers is needed to improve the adoption and use of improved cowpea varieties.

Insect pest infestations have shown to be one of the major limiting factors for cowpea production (Inaizumi et al., 1999). More than 85 species of insects attack cowpeas during production (Booker, 1965), but the five species identified in this study are among 20 species of economic importance (Oyewale and Bamaiyi, 2013). Several pests caused damages but *M. vitrata* had the most negative correlation coefficient with yields; suggesting that *M. vitrata* may have had the greatest impact on cowpea during production, as described by other studies (Abdourahamane et al., 2020; Zakari et al., 2019). The cowpea defoliator *A. moloneyi,* though predominant in both regions, was not associated with yields. *C. tomentosicollis* has two or three generations during a cropping season and is responsible for reducing cowpea yields by 17.5–26.5% (Dabire et al., 2005; Harouna et al., 2018). The cowpea pod borer *M. vitrata* is responsible for the destruction of cowpea flowers and pods (Ba et al., 2019) and its damage is severe in years of high rainfall. In the Maradi region, yield losses caused by the pod borer have been estimated between 20 and 82% (Zakari et al., 2019). Insect damage is significant, because 37% of producers do nothing for pest control (Zakari et al., 2019). Chemical control is out of reach for many smallholder farmers given the high cost of pesticides and limited availability of good quality products (Haggblade et al., 2019). Biopesticides made from neem seeds have been successfully tested in both regions and shown to be effective at controlling cowpea field pests, but their use is limited to between 7.4 and 15.6% of producers (Harouna et al., 2019; Rabe et al., 2017b; Zakari et al., 2018).

Diseases are common on cowpea fields and are part of production limiting factors facing smallholder farmers (Dugje et al., 2009; Mbavai et al., 2015). It is important to note that a participatory rural appraisal conducted in Niger showed that less than 2% of smallholder farmers identified diseases as one of their production constraints (Salifou et al., 2017). Most diseases observed in the present study were negatively correlated with cowpea yields. Cercospora and anthracnose are common in West Africa and can be responsible for cowpea yield losses of up 75% (Ganiyu et al., 2018; N'Gbesso et al., 2013; Schneider, 1973). Studies conducted in Nigeria showed that most improved cowpea varieties grown by farmers were susceptible to diseases (Ekhuemelo et al., 2019; Omoigui et al., 2019). Extracts of three plants were evaluated to control anthracnose and showed positive results with an increase of 77% in yield when compared to control (Ganiyu et al., 2018). Genetic improvements have also been used to address cowpea diseases (Ekhuemelo et al., 2019; Omoigui et al., 2019).

The parasitic weed *S. gesnesrioides* (Striga), commonly found in West Africa, has been identified as a major constraint during cowpea production (Salifou et al., 2017). It can cause yield losses varying between 30 and 100% (Aggarwal and Ouedraogo, 1989; Singh and Emechebe, 1997). Observed in half of the fields in our study, *Striga* has been shown to lead to chlorosis, growth delay, and reduction in the number of leaves (Hayatu and Bala, 2012). Infestations observed in Maradi and Zinder were lower than the 68% of cowpea-infested fields in Nigeria (Dugje et al., 2006). The increase in plant density of *Striga* in the study area was associated with reduced cowpea yields. Approaches to reduce the impact of *Striga* on cowpea yields have included the use of genetic resistance, crop rotation, fallow, and the application of fertilizer (Gbehounou and Adango, 2003; Mourik et al., 2011; Rector, 2009; Westerman et al., 2007). Several improved varieties screened in Niger showed significant variations in response of cowpea genotypes to *Striga* (Salifou et al., 2019).

Cowpea is an important crop that has potential to lift smallholder farmers out of poverty (Alene and Manyong, 2006, 2007; Manda et al., 2019). It can also help Sahelian countries earn the cash needed to improve their economies. Research, particularly plant breeding, has made efforts to develop improved varieties that exhibit genetic traits needed to address some production constraints. These genetic traits include early maturation, pest and disease tolerance or resistance (e.g. insects, *Striga*), and drought tolerance. Though these varieties are being produced, renewed efforts are needed to scale their availability and use by smallholder farmers. Actions needed include (i) strengthening seed multiplication to increase the quantity of seed available for sale or distribution to farmers; (ii) large-scale awareness and dissemination of these improved varieties to increase use among farmers; (iii) capacity building of producers to improve production practices (e.g. increased plant density, pest control using biopesticides, fertilization, etc.) for optimizing cowpea yields, and (iv) increase smallholder farmers access to cowpea markets (Adekoya and Babaleye, 2009; Alene and Manyong, 2007; Harouna et al., 2019; Mbavai et al., 2015; Varshney et al., 2019;

Zakari et al., 2018). It does little good if improved cowpea varieties are developed by researchers but are not used by most smallholder farmers. In addition, to increase the adoption of improved seed, there is need to address structural and technical barriers such as unavailability and higher input costs (Mbavai et al., 2015, 2019; Wossen et al., 2019). Application of inputs such as fertilizers and pesticides would help maximize the productivity of improved cowpea varieties.

5. Conclusion

We assessed cowpea production constraints in two important producing regions of Niger, Maradi and Zinder. Cowpea has very low productivity despite its economic and food security importance. An improved cowpea variety popularized more than 25 years ago was the one most used on the 584 farms surveyed. Insects, *Striga* and diseases are major challenges during cowpea production. To increase cowpea productivity, there is a need to develop and or promote cowpea varieties that have genetic characteristics for minimizing pests (insects and *Striga*) and disease incidences, and improve agricultural practices.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgments

We thank William I. and Judith D. Jones for their generous donation to the PICS Program at Purdue University that supported this study. We also thank Sahel Bio for facilitating data collection in both Maradi and Zinder regions. We are also grateful to the farmers for volunteering their time and cowpea fields.

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