# AN INCLUSIVE PARTICIPATORY DIAGNOSIS OF CONSTRAINTS LIMITING SMALLHOLDER CROP PRODUCTIVITY IN NIGER

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## ABSTRACT

Small-scale farmers face enormous constraints and challenges that affect their capability to produce more in the Sahelian context of Niger. This situation tends to be worsened by the lack of adaptive and resilient technologies that help farmers to overcome these challenges and constraints. This study therefore highlighted factors limiting crop productivity at small-scale farmers' fields through an inclusive participatory diagnosis approach. Constraints were identified through the focus group method using structured questionnaires within seventy-seven (77) villages with a sample size of 2,165 farmers. The respondents were constituted of 1,083 males and 1,082 of females. The results of the diagnosis revealed that the main crops cultivated across the five regions were pearl millet, sorghum, cowpea and groundnut, with secondary crops including rice, maize, sesame, fonio millet, bambara groundnut, roselle, okra, bean and tiger nut. The findings also showed that the most important constraints limiting crop productivity at the farmer field level across the regions were insect pests and diseases, the parasitic weed Striga, drought and the lack of mechanization. This variation reflects agroecological and socio-economic heterogeneity in which these farmers thrive. However, for most the constraints identified, farmers would like to use indigenous knowledge, some agroecological approaches, and to the extent possible research opportunities to overcome these challenges. Furthermore, the results revealed a highly significant positive relationship between limited rainfall and soil degradation constraints in these regions. Addressing constraints limiting crop productivity through an inclusive participatory approach is key for co-creation and a successful transition of smallholder farming systems towards greater resilience.

**Key words:** constraints, inclusive diagnosis, indigenous knowledge, research opportunities.



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## INTRODUCTION

Niger, one of the Sahelian countries where natural disasters have occurred frequently, faces several agricultural development challenges that expose vulnerable populations to food and nutrition insecurity (World Bank, 2016). Food insecurity is a major cause of malnutrition in Niger, where the number of people affected by moderate and severe food insecurity has fluctuated between 3 and 7 million (20% and 48% of the population) over the past five years (FEWS NET, 2024). As a result of growing population and climate change, gross cereal balances are in deficit one out of every three years. Regardless of the outcome of the agricultural season, household production covers food needs for only five to six months of the year (IFRC, 2023). These recurring deficits are largely due to the lack of access by many farmers to innovative and resilient technologies, which results in the low agricultural productivity observed among producers in the country (Issoufou *et al.*, 2017). Many authors reported that one of the biggest obstacles to lifting farmers out of poverty is still low agricultural productivity combined with a lack of adoption of innovative technologies (Asfaw *et al.*, 2011; Daniso, 2022; Dhillon and Moncur 2023). According to Lidder *et al.*, (2025), these innovative technologies reduce malnutrition, boost smallholder farmers' incomes, provide jobs in rural areas, and mitigate the effects of climate change.

Despite the efforts of the government in the development of a policy based on the dissemination of innovative and climate-resilient technologies, there are still factors that limit crop productivity in the fields of smallholder farmers

(MAG/EL, 2018). Some constraints related to biophysical factors associated with management and infrastructure, as well as institutional aspects, that limit crop productivity have been reported by many authors in Sub-Saharan Africa (Tolassa and Jara, 2022; Etana *et al.*, 2023; Savari *et al.*, 2024; Touch *et al.*, 2024). However, participatory diagnostics to address constraints limiting crop productivity in the Sahelian context particularly in Niger were very limited.

In light of the lack of efficiency in addressing these challenges, participatory approaches are promoted in order to address livelihood complexity, produce data at the level of the community, and obtain empowerment (Mahajan *et al.,* 2022; Eelderink *et al.*, 2025). Participatory approaches are thought to be crucial for bringing about change (Sherman and Ford, 2014) and for delegating as many tasks as possible to participating farmers in order to foster a collegial kind of engagement (Biggs, 1989).

For the purpose of designing interventions that aim at improving agricultural production and, consequently, improving livelihoods, it is crucial to identify crop productivity constraints and potential opportunities through an inclusive participatory approach. Thus, this paper intends to respond to the following questions: i) What are the constraints limiting crop productivity at farmers' fields? ii) How are they facing these challenges with local resources? iii) What are their expectations for the research opportunities? This study aims to identify constraints hindering crop productivity along with local strategies and to understand their expectations regarding the research opportunities. We hypothesized that crop productivity was hindered by many constraints, including biophysical, management, infrastructural and institutional factors.

## MATERIALS AND METHODS

**Study area and village sampling:** The study was conducted within seventy-seven (77) villages in five regions namely Dosso, Maradi, Tahoua, Tillaberi, and Zinder (**Fig. 1**). The villages were randomly selected with the support of non-governmental organizations (NGOs) working with the Research and Development Project for Food Security and Climate Change Adaptation of Production Systems in Niger (REDSAACC) operating in these regions. These NGOs are implementing Farmers Field Schools (FFS) in partnership with CARE-Niger and the National Institute of Agronomic Research of Niger (INRAN). A total of 2,165 farmers constituted of 1083 male and 1082 of female were selected randomly from thirty-nine (39) districts and seventy-seven villages (77) within the five regions. Table 1 below shows the number of villages and the number of respondents per region used in this study.

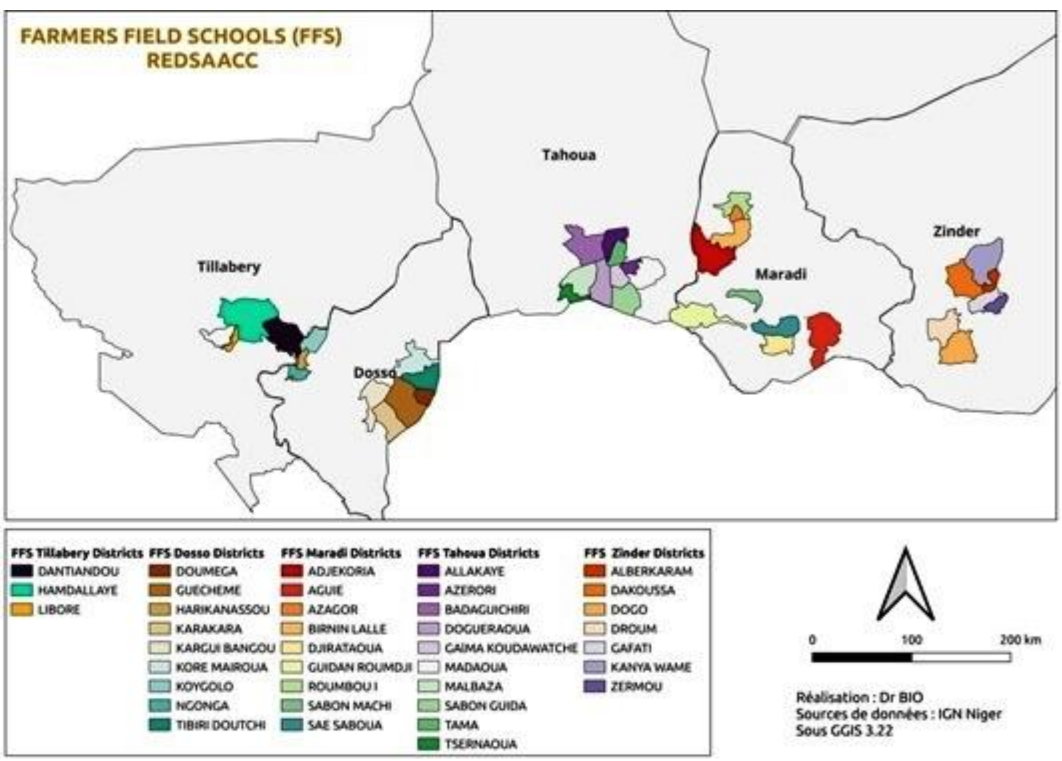



**Fig 1. Locations of the study**

**Table 1. The number of regions, districts, villages, and respondents (males and females) per region**

| Region | District | Village | Number of respondents | | Total |
|---|---|---|---|---|---|
| | | | Male | Female | |
| Dosso | Harikanassou, Tibiri, Doumega, Guéchémé, Karakara, Koygolo, Kardji Bangou, N'Gonga, Koré Mairoua | Kouringuel, Niébéré Djambé, Afolé, Kiada, Boutana, Doumega, Guéchémé, Bawada, Bourgami, Angoual Mayau, Karma Zarma, Koygolo, Fari, Tamokoira, Kannaré, Boula Korgui, Maiherama, Koré Mairoua | 225 | 225 | 450 |
| Maradi | Azagor, Roumbou, Dakoro, Birnin Lallé, Ajékoria, Sabon Machi, Guidan Roumdji, Saé Saboua, Djirataoua, Aguié | Zongon Marafa, Maigochi, Garin Bouzou, Ayouba, Garin Moussa, Guidan Bara, Farara, Dan Amaria, Koukout, Tsamiya Kadi, Nazama, Oubandawatchi, Agoulou, Allah Kabani, Konta, Garin Kassagui, Katchinawa, Kori, Rijial Baguari, Radi Magagi, Roubabia, Guidan Galadima | 254 | 311 | 565 |
| Tahoua | Malbaza, Doguéraoua, Galma, Sabon Guida, Madaoua, Azarori, Badaguichiri, Tsernaoua, Allakaye, Tama, | Tchouroutt, Mouléla, Katoria, Guidan Bahago, Galmi, Kochimaoua, Maiwatan, Koundougué, Guidan Batchiri, Nakoni, Tsoungalé, Azarori Sédentaire, Jangabi, Badaguichiri, Tambass, Tsernaoua, Kadé Badé, Chilbé, Yatsé, Tunfafi, Ayyawane | 294 | 248 | 542 |
| Tillaberi | Dantchandou Hamdallaye, Libore | Falanga Bockssaye, Boktchilli, Fataboki, Tiendifarou, Bangoubanda | 63 | 125 | 188 |
| Zinder | Gaffati, Zermou, Dogo, Droum, Dakoussa, Alberkaram, Kanya Wamé | Kirchia, Dankeni, Angoual Magagi, Bakin Birgi, Makokia, Dan Fountouwa, Droum, Akatangou, Angoual Djimrao, Dalli, Alberkaram, Kassama, Rahin Zomo, Bariki | 247 | 173 | 420 |
| Total | 39 | 77 | 1,083 | 1,082 | 2,165 |

**Data collection:** The study was conducted from April to May 2024 before the implementation of the FFS in the five regions of REDSAACC's Project. The basic diagnosis is carried out through interviews with the farmers (in a general meeting, through group consensus) at different sites selected to conduct learning activities using the FFS approach. This work was conducted by an FFS trainer in the presence of trained facilitators (NGO facilitator and extension agent). Data were collected through focus group method using structured questionnaires administrated to respondents to identify factors limiting crop productivity in the farmer's field. Farmers were also asked to give local strategies to overcome these challenges and potential research opportunities. Table 2 below summarizes the five (5) steps used to complete the questionnaire.

The first step was to enumerate the crops grown and score them from 0 to 20 according to their importance to the farmers in each village, while the second step was to identify the main constraints that hinder the productivity of these crops. The third step was to fill in the solution matrix, including local solutions using farmers' indigenous knowledge and potential research opportunities. The farmer capacity building curriculum was discussed in step 4, followed by the discussion of the experimental protocol (step 5). The proportion of each crop by region was calculated after scoring.

**Table 2. Forms to fill out during the diagnosis**

| Step | Activity |
|---|---|
| 1 | Choice of crop that should be the subject of the study for dissemination |
| 2 | Identification of constraints that hinder cultivation or that are responsible for poor production of this crop |
| 3 | Fill in the solution matrix (local solutions and research opportunities) |
| 4 | On-site learner training curriculum |
| 5 | Discuss the experimental protocol |

**Learner training curriculum:** During the general assembly, the following steps are taken to identify the training curriculum related to each constraint:

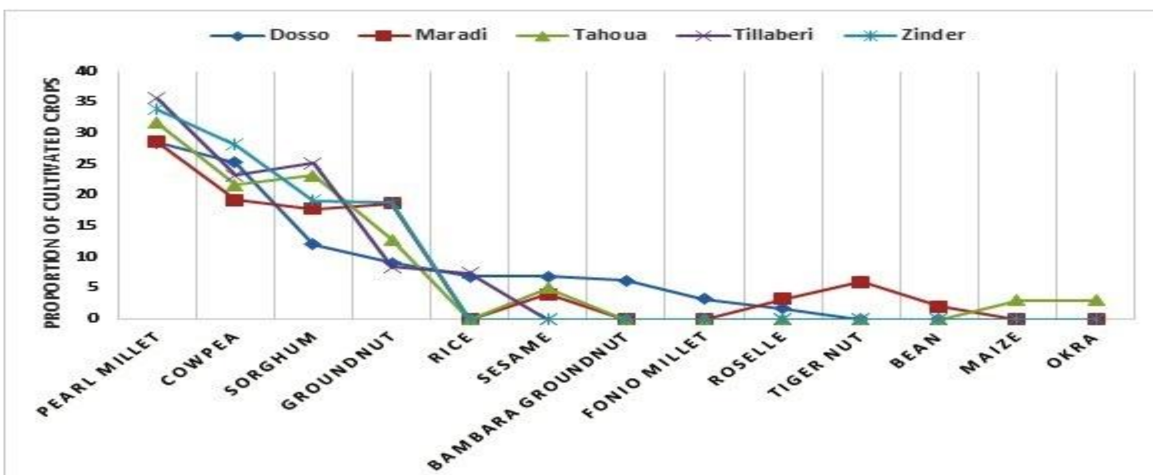
• Identifying the FFS group, which will consist of 25 to 30 learners with whom the FFS will be implemented,
• Identifying a learning site (a field of 600 to 1,000 m²) representative of the landscape (according to several criteria),
At the end before setting up the learning site, a session is organized to present the results of the data analysis, and synthesis of the collected data.

**The experimental protocol:** In this final step, the group of farmers identified the constraint to be discussed by providing the context and justification, the objectives, the methodology, and the materials to be used in solving this constraint. Results of the group work from the previous table for the village of Bawada (Dosso region) are illustrated in the supplementary material (S1).

**Data analysis:** Data collected from each village were recorded and the proportions of respondents were calculated at the region level. To enable a methodical comparison of the five regions, radial diagrams for constraints were created for each region. Descriptive statistics such as frequencies, and percentages were used to analyze the data. The chi-square test was used to compare the proportions of respondents regarding production constraints within each region and the multiple regression approach was used to identify the most limiting constraints hindering crop productivity. The Pearson correlation coefficient was also used to test the relationship between different constraints (Pearson, 1895).

# RESULTS

**Main cultivated crops:** The main crops grown in the five regions were pearl millet (*Pennisetum glaucum*), cowpea (*Vigna unguiculata*), sorghum (*Sorghum bicolor*), and groundnut (*Arachis hypogaea*). The higher proportion of pearl millet was recorded in the Tillaberi region (36%), followed by the Zinder region (34%) and Tahoua region (32%), while Dosso and Maradi regions had the same proportion of 29%. For cowpea, the Zinder region (28%) and the Dosso region (25%) had a higher proportion, followed by the regions of Tillaberi, Tahoua and Maradi with 23%, 22% and 19%, respectively. The regions of Tillaberi (25%) and Tahoua (23%) recorded higher proportions of sorghum, while Maradi and Zinder also recorded higher proportions of groundnut at 19% (**Fig. 2**). Sesame (*Sesamum indicum*) was cultivated in three regions: Dosso (7%), Tahoua (5%) and Maradi (4%). For the two crops, rice (*Oryza sativa*) and roselle (*Hibiscus sabdariffa*), cultivation was dominant in the regions of Dosso (7%) and Tillaberi (7%), followed by the regions of Maradi (3%) and Dosso (2%). In addition, the results showed that some crops were region-specific, including tiger nut (*Cyperus esculentus*) (6%) and bean (*Phaseolus vulgaris*) (2%) in the Maradi region, and maize (*Zea mays*) (3%) and okra (*Abelmoschus esculentus*) (3%) in the Tahoua region.




**Constraints limiting crop productivity**

## Fig 2. Crops cultivated in the five regions

The radial diagrams showed that the high proportions of pests and diseases were dominant in Zinder (41%) and Tillaberi (35%), while the high proportions of Striga were observed in Tahoua, Maradi and Dosso with 38%, 23% and 21% respectively (**Fig. 3D, 3C, 3A**). Regarding drought, the regions with the highest proportion were Maradi (26%) and Tahoua (18%) (**Fig. 3C, 3D**). With regard to land degradation, it was Tillaberi region that recorded the highest proportion (35%), while the Zinder region recorded the highest proportion for limited access to quality seeds (23%). Furthermore, the results showed that some constraints were region specific including wind (Dosso=12%), flooding (Dosso=1%), lack of improved varieties (Tillaberi=10%) and lack of mechanization (Zinder=5%) (**Fig. 3A, 3B, 3E**).

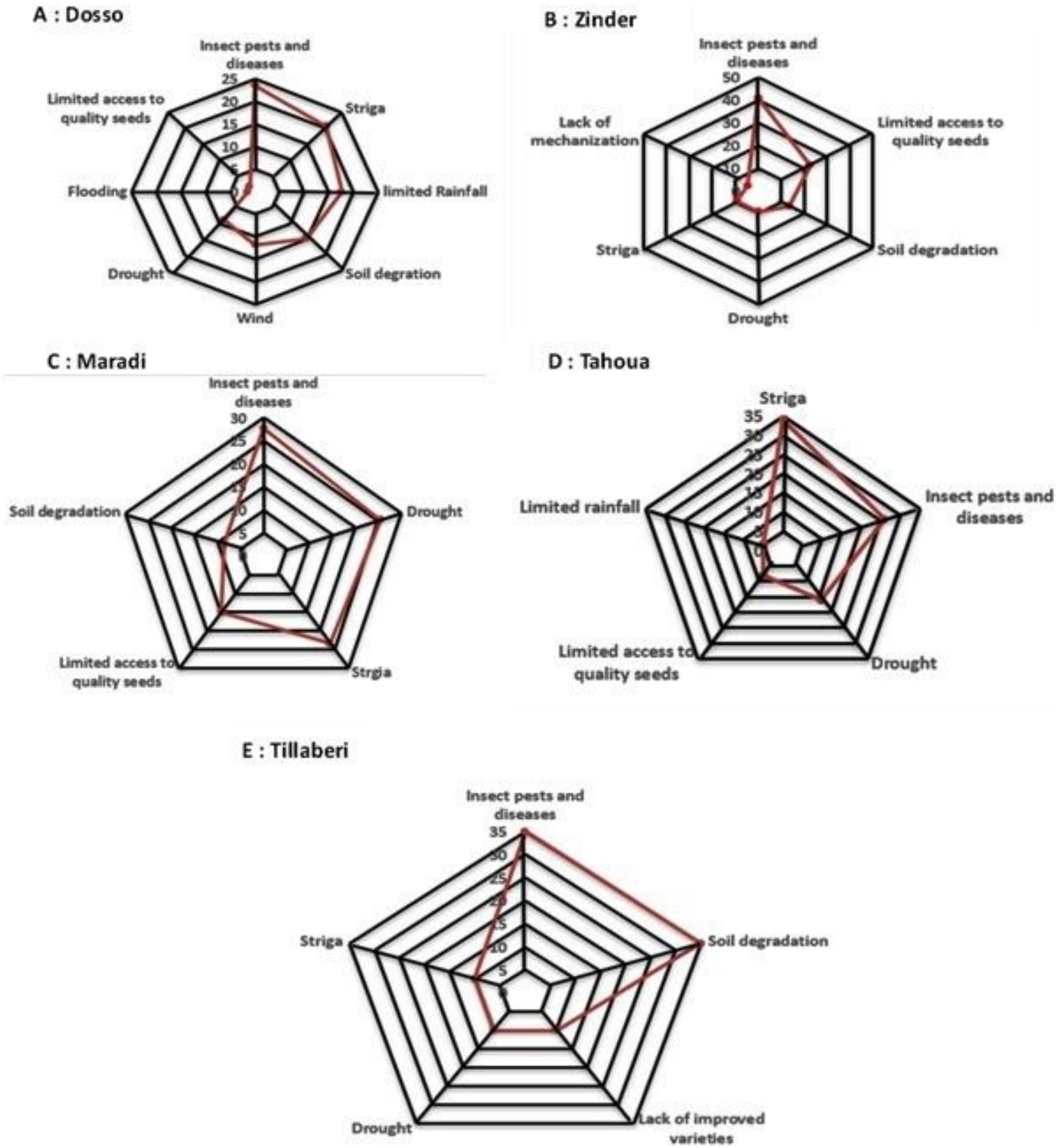



**Fig 3. Identification of constraints at region levels**

According to the respondents, constraints that limit crop productivity at the farmer field level across the regions were insect pests and diseases (31.47%), followed by the parasitic weed Striga (20.2%), soil degradation (18%), and drought (14.4%). The remaining factors specific to some regions, including limited access to quality seeds, limited rainfall, wind, lack of improved varieties, lack of mechanization, and flooding, accounted for 12%, 12%, 12%, 10%, 5%, and 1%, respectively (Table 3). Furthermore, the results showed that the most important constraints limiting crop productivity at the farmer field level across the regions were insect pests and diseases, the parasitic weed Striga, drought and lack of mechanization. Factors including soil degradation, limited access to quality seeds, and lack of improved varieties also impacted negatively crop productivity in this study (Table 4).

**Table 3. Proportion of respondents with respect to production constraints by region**

| Proportion (%) | Dosso | Maradi | Tahoua | Tillaberi | Zinder |
|---|---|---|---|---|---|
| Insect pests and diseases | 24 | 28 | 29 | 35 | 41 |
| Striga | 21 | 23 | 38 | 10 | 9 |
| Drought | 9 | 26 | 18 | 10 | 9 |
| limited rainfall | 18 | - | 6 | - | - |
| Soil degradation | 15 | 9 | - | 35 | 14 |
| Limited access to quality seeds | 1 | 15 | 9 | - | 23 |
| Wind | 12 | - | - | - | - |
| Flooding | 1 | - | - | - | - |
| Lack of improved varieties | - | - | - | 10 | - |
| Lack of mechanization | - | - | - | - | 5 |
| Chi-squared test | $\chi^2$=42.80 *** | $\chi^2$ = 12.64 * | $\chi^2$ = 35.75 *** | $\chi^2$ = 37.5 *** | $\chi^2$ = 60.16 *** |

**Table 4. Regression results of constraints limiting crop productivity**

| Terms | Coefficients | Standard Error | Pr(>\|t\|) |
|---|---|---|---|
| Intercept | 64.08 | 2.69 | *** |
| Insect pests and diseases | 0.10 | 0.23 | *** |
| Striga | 0.94 | 0.98 | *** |
| Drought | 0.66 | 0.60 | *** |
| Limited rainfall | 0.20 | 1.08 | ns |
| Soil degradation | 0.23 | 0.82 | ** |
| Limited access to quality seeds | 0.22 | 0.88 | * |
| Wind | 0.21 | 0.54 | ns |
| Flooding | 0.19 | 0.71 | ns |
| Lack of improved varieties | 0.70 | 2.84 | * |
| Lack of mechanization | 0.24 | 0.40 | *** |
| ***=highly significant, **=significant at 1%, *=significant at 5%, ns=not significant, Multiple $R^2$ = 0.9589, Adjusted $R^2$ = 0.9535, p-value = < 2.2e-16. | | | |

**Relationship between constraints that limit crop productivity:** The Pearson correlation analysis revealed a high correlation between factors including limited rainfall and soil degradation, drought and striga, flooding and lack of quality seeds. (**Fig 4**).


**Fig 4. Relationship between constraints.**

IPD=Insect pests and diseases, STR=Striga, DHT=Drought, LRF=Limited Rainfall, SD=Soil degradation, LQS=Limited access to quality seeds, WD=Wind, FLG=Flooding.

**Farmers' strategies to mitigate factors that limit crop productivity:** The results in Table 5 below revealed many strategies adopted by farmers to overcome challenges responsible for the poor performance of their crops including biophysical, agronomic, as well as socio-cultural categories. Farmers used almost the same strategies across the regions to face constraints related to insect pests and diseases (head miner, yellow millet aphid, millet stem borer, aphis, grasshoppers, downy mildew, elongated smut, zoned leaf spots, fall armyworm, nematode attack, cowpea bugs, beetles, sorghum midge, bruchids, etc..). These included prayers, mixing seeds with ash before sowing, mixed cropping, fumigation, and use of unapproved chemicals. The use of tolerant varieties, biopesticides and crop rotation, authorized chemicals (fungicides and pesticides), as well as application of biological control are what farmers expect from research.

Concerning Striga (*S. hermonthica* and *S. gesneroides*), farmers used prayers, hand pulling before flowering, and organic fertilizer to control this parasitic weed, while the research opportunities for farmers would be the use of crop rotation, cultivation in association with *Sesamum indicum*, application of base and top dressing, and use of strip cultivation. Farmers from Dosso and Maradi regions also used *Parkia biglobosa* and *Sesamum indicum* powders to control Striga as local strategies.

To overcome the two constraints related to the rainy season, including drought (early, intermittent, and terminal) and limited rainfall, farmers in all regions prayed, used their local varieties and practiced dry sowing as local strategies, while farmers from the Zinder region practiced an additional strategy which was shifting the sowing date. Producers agree that improved early maturing varieties could be used to solve these problems related to the rainy season in terms of research opportunities.

To improve soil fertility, farmers from Dosso, Tahoua, Tillaberi and Zinder regions, except for the Maradi region, used organic manure and some fallow as local strategies. Farmers in all regions would like to use compost, apply fertilizer through micro-dosing technology, and use crop rotation and strip cropping as research opportunities. In addition, farmers from Dosso and Tahoua regions used natural assisted regeneration to allow rapid rehabilitation of degraded areas and contribute to biodiversity diversification.

Farmers in all regions are using their local varieties to address challenges such as lack of improved varieties and lack of access to quality seed. For research opportunities, farmers from these regions would like to have access to quality seed of improved varieties. Farmers from the Zinder used rudimentary tools (hoe, hilt and daba) for cultivation and would like to use animal traction and a seed drill to overcome the constraint of lack of mechanization.

Finally, the two region specific constraints, including wind and flooding, farmers from the Dosso region prayed and used live hedges as local strategies to face these challenges. Strip cultivation and assisted natural regeneration, and the dam and water pipeline would be used to protect and minimize the risk of wind and flooding, respectively.

**Table 5. Crop cultivated, constraints, local strategies and potential research opportunities**

| Region | Main crop cultivated | Constraint | | Local strategies | | Research opportunities |
|---|---|---|---|---|---|---|
| Dosso | Pearl millet, sorghum, rice, maize, groundnut, cowpea, roselle, sesame, fonio millet, Bambara groundnut | Biophysical | Insect pests and diseases | biophysical, agronomic, socio-cultural | Prayers, mixing seeds with ash before sowing, mixed cropping, fumigation, corn stalk ash, use of unapproved chemicals | Use of tolerant varieties, biological control, biopesticides, crop rotation, use of approved chemicals (fungicides and pesticides), |
| | | | Striga | | Prayers, hand pulling before flowering, Organic manure input, use of *Parkia biglobosa* powder, use of *Sesamum indicum* powder | Crop rotation, cultivation in association with *Sesamum indicum*, application of base and top dressing, use of strip cultivation, |
| | | | Drought | | Prayers, use of local varieties, dry sowing, shift in sowing date | Use of improved early maturing varieties |
| | | | limited Rainfall | | Prayers, dry sowing | Use of improved early maturing varieties |
| | | | Soil degradation | | Use of organic manure, fallow | Use of zaï, use of half-moon, use of compost, application of fertilizer through micro dose technology, assisted natural regeneration (ANR) |
| | | | Wind | | Prayers, use of live hedges | Use of strip cultivation, assisted natural regeneration (ANR) |
| | | | Flooding | | Prayers | Dam and Water Pipeline |
| | | Institutional | Limited access to quality seeds | | Use of landraces | Produce and make available quality seeds |
| Maradi | Pearl millet, sorghum, maize, groundnut, cowpea, roselle, sesame, fonio millet, bean, tiger nut, and okra | Biophysical | Insect pests and diseases | | Prayers, sowing with ash, use of unapproved chemicals | biological control, use of approved chemicals (fungicides and pesticides), |
| | | | Striga | | Prayers, hand pulling before flowering, Organic manure input, use of *Sesamum indicum* powder | Crop rotation, cultivation in association with *Sesamum indicum*, application of base and top dressing, use of strip cultivation, |
| | | | Drought | | Prayers, use of local varieties, dry sowing, | Use of improved early maturing varieties |
| | | | limited rainfall | | Prayers, dry sowing | Use of improved early maturing varieties |

| | | | | | | |
|---|---|---|---|---|---|---|
| | | Institutional | Limited access to quality seeds | | Use of landraces | Make available quality seeds |
| Tahoua | Pearl millet, sorghum, maize, groundnut, cowpea, sesame, okra | Biophysical | Insect pests and diseases | | Prayers, sowing with ash | Use of tolerant varieties, use of approved chemicals (fungicides and pesticides) |
| | | | Striga | | Prayers, hand pulling before flowering | Crop rotation, cultivation in association with *Sesamum indicum*, application of base and top dressing, use of organic manure |
| | | | Drought | | Prayers, use of local varieties, dry sowing | Use of improved early maturing varieties |
| | | | Soil degradation | | Use of organic manure | Use of Zaï, use of half-moon, use of compost, application of fertilizer through micro dose technology, assisted natural regeneration (ANR) |
| Tillaberi | Pearl millet, sorghum, rice, groundnut, cowpea | Biophysical | Insect pests and diseases | | Prayers, use unapproved chemicals | Use of tolerant varieties, biological control, biopesticides, use of PICs bags, use of approved chemicals (fungicides and pesticides), |
| | | | Striga | | Prayers, hand pulling before flowering | Crop rotation, application of organic manure |
| | | | Drought | | Prayers, use of local varieties, | Use of improved early maturing varieties |
| | | | Soil degradation | | Fallow, use of organic manure | Use of compost, application of fertilizer through micro dose technology, crop rotation, strip cropping |
| | | Institutional | Lack of improved varieties | | Use of landraces | Use of improved varieties |
| Zinder | Pearl millet, sorghum, groundnut, cowpea | Biophysical | Insect pests and diseases | | Prayers, mixing seeds with ash before sowing, uprooting diseased plants, fumigation, use of unapproved chemicals | Use of tolerant varieties, biological control, biopesticides, crop rotation, use of approved chemicals (fungicides and pesticides) |

| | | | | | | |
|---|---|---|---|---|---|---|
| | | | Striga | | Prayers, hand pulling before flowering, Organic manure input | Crop rotation, application of base and top dressing, use of strip cultivation, |
| | | | Drought | | Prayers, shift in sowing date, dry sowing, | Use of improved early maturing varieties |
| | | Institutional | Limited access to quality seeds | | Use of landraces | Produce and make available quality seeds |
| | | | Lack of mechanization | | Use of basic equipment: hoe, hilt, and daba | Use of animal traction and seed drill |

**Table 6. Training curriculum according to the constraint**

| Constraints | | Option to be tested | What to do? | Means | Timeline | Responsibility |
|---|---|---|---|---|---|---|
| Biophysical | Insect pests and diseases | Use of biopesticides, Use of chemicals | Comparative study through demonstration plots | Aqueous extract of neem (leaves and grains), aqueous extract of jatropha, synthetic chemical, absolute witness | June to October | Group of famers + facilitators |
| | Striga | Comparative study of two striga management methods | Demonstration plots | - Use of *Parkia biglobosa*,<br>- Application of basal and top dressing,<br>- Use of sesame ash,<br>- control plot | May September | Group of famers + facilitators |
| | Limited rainfall and drought | Use of early maturing varieties | Comparative study through demonstration plots | 3 improved early varieties and 1 local variety, training materials | June to October | Group of famers + facilitators |
| | Soil degradation | - Making zaï<br>- Use microdose (compost; NPK; Urea) | Comparative study | Seeds, fungicides/pesticides, fertilizers, organic manure, educational materials | May to September | Group of famers + facilitators |
| | Wind | Strip cultivation, natural assisted regeneration | Comparative study | Cereals + legume varieties, trees and shrubs, training materials | April to September | Group of famers + facilitators |
| | Flooding | Use of tolerant varieties | Comparative study | Seed of improved varieties + local check | June to October | Group of famers + facilitators |
| Institutional | Lack of improved varieties and limited access to quality seeds | Use seeds of improved varieties | Comparative study | Seeds of improved varieties + seeds of landrace | June to October | Group of famers + facilitators |
| | Lack of mechanization | Use of animal traction and seed drill | Comparative study | Seeds and soil amendments (fertilizer, compost,) | May to September | Group of famers + facilitators |

## DISCUSSION

The reality faced by smallholder farmers is distinct. Our results demonstrated how well farmer groups were able to investigate and recognize local complexity. The results indicated that pearl millet, sorghum, rice, maize, cowpea, and groundnut were the main crops cultivated by farmers in the regions of Maradi, Dosso, Tahoua, Tillaberi and Zinder. However, alongside these staple food crops, minor or orphan crops i.e. fonio millet, sesame, bambara groundnut, okra, roselle, and tiger nut were also cultivated by farmers highlighting their critical role in enhancing food and nutrition security in the country. This finding was consistent with that of Mabhaudhi *et al.,* (2019), who reported that global food and nutrition security depends heavily on orphan crops, which also help create sustainable food systems in the face of climate change. These crops, which are often indigenous or local, offer increased resilience to changing climatic conditions and contribute to food and nutritional security. They are also beneficial for biodiversity and the natural environment, due to their adaptation to local conditions and their ability to thrive in environments where conventional crops fail. Thus, crop diversification with neglected and underutilized species (NUCS) is a key strategy for mitigating risks related to climate change (Tadele *et al.,* 2024).

The results of the diagnosis revealed that the main constraints across regions limiting crop productivity were insect pests and diseases, the parasitic weed striga, drought, soil degradation, limited access to quality seeds, lack of improved varieties, and lack of mechanization. Three constraints were identified in all regions, including pests and diseases, drought, and striga, whereas lack of improved varieties and lack of mechanization were region-specific. This shows that the results for the various regions varied according to type of opportunity or limitation and the extent to which the constraints were seen to have a relative impact. This is probably due to the complex socio-cultural and economic contexts in which these farmers work. Similar statements were reported earlier by Kraaijvanger *et al.,* (2016) who used focus group discussions to identify limits and potential to agricultural productivity in different locations of Tigray (Ethiopia). These authors stated that their findings for different locations differed with respect to the type of constraint because producers do not have the same farming practices that differ from one agroecology to another. Touch *et al.,* (2024) reported that weeds, pest infestations, and drought had significant issues and problems for smallholder farmers in Northwest Cambodia. Furthermore, these results confirmed the findings of many authors (Kirui, 2019; Mwalongo *et al.,* 2020; Mesele *et al.,* 2025) who reported that the main causes of low agricultural output in Sub-Saharan Africa were soil degradation, lack of access to and use of seeds of improved varieties, and lack of mechanization. In the Sahel region, limited rainfall accelerates soil degradation which in turn impacts negatively agricultural productivity. This statement is consistent with that of Norzagaray et al., (2024) who explained the damage to soil's granulometric structure caused by unpredictable rainfall patterns attributed to climate change in Mexico. These results highlight the inability of producers to cope with the constraints limiting their productivity. Moreover, the constraints are complex and multifaceted, making them even more vulnerable due to a lack of means of mitigation. Hence, the need to develop an adaptation strategy that aims at improving their livelihoods.

The results showed that farmers used sociocultural strategies (prayers) to address most of the constraints identified during the diagnosis demonstrating their vulnerability to the uncertainties associated with agriculture. However, prayer as a local approach to agricultural issues should not be used in place of workable answers. Our findings also highlighted the use of unapproved chemicals to control insect pests and diseases by farmers in most regions as local strategies implying the lack of sustainable and integrated pest management (IPM). This is supported by the statement of Bertrand (2019) who reported that farmers in Africa are increasingly depending on chemical pesticides, which pose hazards to the health of people and the environment, due to the lack of widespread access to sustainable and integrated pest management (IPM) options. Across regions, farmers believed that the use of tolerant varieties, the application of biological control (i.e. *Abrobracon hebetor* for controlling pearl millet head miner), the use of biopesticides (i.e. aqueous extract of crop plants for controlling aphis, flower thrips, etc..) and PIC bags (i.e. to control pest insects in stocks) could potentially enhance their resilience. Srinivasan *et al.,* (2022) argued that although they are quite inconsistent, IPM initiatives focused on habitat management, biological control, and resistant cultivars have proved successful in Africa. For the control of striga, farmers from all regions used the technique of hand pulling before flowering and apply organic manure as local strategies and they believed that some technologies developed by research including crop rotation, cultivation in association with *Sesamum indicum,* application of base and top dressing, and strip cultivation could potentially limit the proliferation of this parasitic weed in their fields. However, even though research has developed striga-tolerant varieties, no farmers have been able to mention this opportunity. Regarding soil degradation constraint, famers across regions applied organic manure to improve soil fertility as local strategies despite the scarcity of this input.

The reason why farmers estimate that the agroecological approach (use of compost, application of micro dose, use crop rotation and strip cultivation) could be the unique opportunity to improve soil fertility. Thus, enhancing soil fertility and water-retention capabilities in agroecological systems reduces water demand while preserving agricultural output (Roohi *et al.,* 2022). This is consistent with the recent report by Vikas and Ranjan (2024) that agroecology promotes soil health, carbon sequestration and greenhouse gas reduction, leading to resilient farming systems. Additionally, even though organic manure is utilized to address constraints linked to soil degradation, it is also used to prevent striga field infestation, demonstrating that farmers employ multiple strategies concurrently to manage the complexity of constraints. According to Walia e*t al.*, (2024), low agricultural output in dry farming regions is caused by social, institutional, climatic, and soil constraints. Access to improved technologies may be crucial to strengthening the resilience of subsistent farmers (Chimwamurombe & Mataranyika; 2021).

Farmers from all regions believed that the development and use of early-maturing varieties through research could potentially solve the challenges caused by drought and limited rainfall constraints instead of using local varieties. The same trend was observed for the two constraints of lack of improved varieties and lack of access to quality seeds by farmers, where in the absence of seeds of improved varieties, farmers preferred to use their own recycled varieties as local strategies. This indicates the low adoption of agricultural innovations, especially seeds of improved varieties by farmers in the country. This outcome aligns with previous study which demonstrates that Niger's limited adoption of agricultural innovations, such improved crop varieties, remains a significant obstacle to raising production and productivity (Issoufou *et al.*, 2017).

Concerning the three region specific constraints including wind and rainfall (Dosso region) and the lack of mechanization (Zinder region), farmers would like to use strip cultivation, to apply assisted natural regeneration, to have a dam and a water pipeline, and to use animal traction and a seed drill to overcome these challenges. The results highlighted here show the perception of farmers of climate change and variability associated with its adverse effects. However, despite the climate information broadcast by the national meteorology service, few farmers use this important information due to limited access to climate information services for agriculture. According to Savari *et al.*, (2024), Climate Information Services (CIS) are thought to be the most crucial way for the agriculture sector to adapt over the long term to the challenges caused by climate change.

In addition, this finding shows the extensive nature of agriculture, which uses rudimentary tools that are characterized by low productivity. To achieve sustainable intensification, farmers should adopt mechanization, which offers benefits such as easier application of organic fertilizer, more accurate input delivery, and timelier sowing of dryland cereal crops, which increases crop productivity and reduces drought susceptibility (Nourou *et al.*, 2020). Furthermore, this finding revealed gender inclusivity regarding the identification of crops cultivated and constraints in the regions, the proposition of local strategies and the determination of research opportunities. However, the results presented by Minasyan *et al.*, (2020) showed that women and men make decisions differently and women tend to make decisions in groups, whereas men tend to make decisions alone. These barriers that hold back smallholders' profitability and production capacities are often interconnected, making it difficult to solve them with a single approach. Hence, the need to develop an inclusive and holistic approach.

Even though the results of this study, are subjected to misunderstanding that can distort the outcome of the research data derived from the experimental design, the participatory diagnosis shows that all research activities are planned and implemented with farmers iteratively and inclusively leading to a co-design process.

**Conclusion:** Pearl millet, sorghum, cowpea and groundnut were the primary crops grown by farmers in the five regions (Maradi, Dosso, Tahoua, Tillaberi and Zinder), with rice, maize, sesame, fonio millet, bambara groundnut, roselle, okra, bean and tiger nut being the secondary crops. The findings also demonstrated that farmers are attempting to minimize the use of synthetic inputs using agroecological approaches to address the majority of biotic and abiotic constraints such as insect pests and diseases, drought, and striga. However, policymakers should assist smallholder farmers in implementing an integrated soil-water-seed-IPM strategy which is essential for a successful agroecological transition, to boost food production, reduce environmental effects, and enhance the system's overall resilience.

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**Authors' contributions:** ARIBY and HAKK conceptualized the study. ARYBY and MIG conducted the survey. ARIBY and HAKK wrote the manuscript. ARIBY and HAKK edited the manuscript. BA, BCA, GS and JBA contributed in critically revising the draft and updating the manuscript for publication.

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