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Awareness, Knowledge and Readiness for Climate-Resilient Crop Breeding among Agricultural Science Education Students in North-West Nigeria

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Abstract

Climate variability is reducing crop yields across the Sudan and Sahel savanna belt of North-West Nigeria, and climate-resilient crop varieties are among the most practical responses available to farmers. Agricultural science education students will teach and advise on these varieties, yet little is known about how prepared they are in the science behind them. This study examined awareness, knowledge and adoption readiness regarding climate-resilient crop breeding among Nigeria Certificate in Education (NCE) agricultural science education students in North-West Nigeria. An empirical cross-sectional design was used with 204 students drawn proportionately from three colleges of education in Sokoto, Kebbi and Zamfara States. Six purposes, six research questions and six null hypotheses guided the work. Data came from a 36-item structured questionnaire (α = .88 to .89 across scales) and were analysed with means, standard deviations, one-sample *t* tests, Pearson product-moment correlation and one-way analysis of variance. Awareness of breeding approaches (M = 2.49) and knowledge of resilience traits (M = 2.48) did not differ from the 2.50 benchmark; students knew conventional selection but not mutation breeding or genome editing. Readiness was high (M = 3.10). Awareness (r = .54) and knowledge (r = .49) each correlated positively with readiness ($p < .001$), whereas readiness did not differ by state, $F(2, 201) = 0.69$, $p = .504$. The curriculum should add structured units on modern breeding methods and link them to practical sessions with research institutes.

Keywords: climate-resilient crops, plant breeding, science education, agricultural science, adoption readiness, North-West Nigeria

1 Introduction

Climate change has become a central production risk for crop farmers in sub-Saharan Africa. Rising temperatures and erratic rainfall are already lowering yields, and the Intergovernmental Panel on Climate Change (2022) identifies African food systems as highly exposed to further warming. Global evidence points the same way: Lobell et al. (2011) found that climate trends since 1980 had pulled maize and wheat production below what it would otherwise have been. For maize, a staple across Nigeria, Cairns et al. (2013) projected an average temperature rise of about 2.1 °C by 2050 across the maize mega-environments of sub-Saharan Africa and argued that germplasm tolerant to drought and heat deserves research priority because cultivars take years to reach farmers. Breeding offers an adaptation option that reaches farmers as seed. Challinor et al. (2014) showed in a meta-analysis that adaptation measures, including changes of cultivar, raised simulated yields under climate change. Resilient varieties still depend on people to explain, demonstrate and distribute them. Fisher et al. (2015) surveyed 3,700 households in six African countries and found that uptake of drought-tolerant maize ranged from 9% of maize plots in Zimbabwe to 61% in Malawi, which suggests that availability alone does not secure adoption. Information, trust and local advice matter.

The question is pressing in North-West Nigeria. The zone lies mainly in the Sudan and Sahel savanna, where rainfall is short and uneven and farmers depend on millet, sorghum, cowpea, maize and rice. Ayanlade et al. (2017) reported that about two-thirds of the farmers they surveyed in south-western Nigeria had already noticed changes in climate, and that maize was among the crops most affected. If perceived change is that widespread in a wetter zone, the risk in the drier North-West is unlikely to be smaller. Plant breeding is also science content. It draws on genetics, plant physiology and biotechnology, and it is part of what school science and agricultural science teachers are expected to explain. Agricultural science education students in Colleges of Education occupy a particular place in this chain. After graduation many will teach agricultural science in junior secondary schools, supervise school farms, work as extension agents or farm themselves. Whether they can explain why a drought-tolerant or early-maturing variety is worth planting depends on what their programme taught them about plant breeding and climate. The Nigeria Certificate in Education (NCE) agricultural

education programme covers crop production and plant science, but it is not clear how far it prepares graduates to deal with newer breeding methods such as marker-assisted selection and genome editing. Studies of climate adaptation in Nigeria have concentrated on farmers; the preparedness of the students who will advise them has received much less attention.

The study draws on two frameworks. Rogers (2003) describes adoption as a sequence in which knowledge of an innovation precedes persuasion, decision and implementation, so awareness and knowledge are expected to shape readiness. Ajzen (1991) proposes that intention follows attitudes, perceived norms and perceived control, and readiness to teach or promote a variety can be read as an intention of this kind.

1.1 Purpose of the Study

The study examined awareness, knowledge and adoption readiness regarding climate-resilient crop breeding among agricultural science education students in colleges of education in North-West Nigeria. The purposes were to:

1. determine the level of students' awareness of climate-resilient breeding approaches;
2. determine the level of their knowledge of climate-resilience traits in crops;
3. determine the level of their readiness to teach, promote and use resilient varieties;
4. establish the relationship between awareness and readiness;
5. establish the relationship between knowledge and readiness; and
6. find out whether readiness differs across Sokoto, Kebbi and Zamfara States.

1.2 Research Questions

Each purpose was matched by one research question:

1. What is the level of students' awareness of climate-resilient breeding approaches?
2. What is the level of students' knowledge of climate-resilience traits in crops?
3. What is the level of students' readiness to teach, promote and use resilient varieties?
4. What is the relationship between students' awareness and their readiness?
5. What is the relationship between students' knowledge and their readiness?
6. How does students' readiness differ across Sokoto, Kebbi and Zamfara States?

1.3 Hypotheses

Six null hypotheses, one for each question, were tested at the .05 level of significance:

H_{o1}: Students' mean awareness of climate-resilient breeding approaches does not differ significantly from the benchmark of 2.50.

H_{o2}: Students' mean knowledge of climate-resilience traits does not differ significantly from the benchmark of 2.50.

H_{o3}: Students' mean readiness to teach, promote and use resilient varieties does not differ significantly from the benchmark of 2.50.

H_{o4}: There is no significant relationship between students' awareness and their readiness.

H_{o5}: There is no significant relationship between students' knowledge and their readiness.

H_{o6}: There is no significant difference in students' readiness across the three states.

2 Method

2.1 Design and Area of the Study

The study adopted an empirical cross-sectional design. Information on awareness, knowledge and readiness was gathered once, directly from students, and then used both to describe each variable and to test hypotheses about it. The study covered North-West Nigeria, one of the six geopolitical zones, and was carried out in Sokoto, Kebbi and Zamfara States, which share a savanna climate and a heavy dependence on rain-fed cropping.

2.2 Population and Sample

The population was 420 NCE II and NCE III students of agricultural education in three colleges of education, one each in Sokoto, Kebbi and Zamfara States, referred to here as Colleges A, B and C. The sample size followed the table of Krejcie and Morgan (1970), which gives 201 for a population of this size; 204 students were retained after proportionate allocation to each college. Respondents were then chosen by simple random sampling from class registers. Table 1 shows the distribution.

Table 1

Population and Sample of the Study by College

College (State)	Population	Sample
College A (Sokoto State)	155	76
College B (Kebbi State)	122	60
College C (Zamfara State)	143	68
Total	**420**	**204**

Note. Sample sizes were allocated in proportion to each college's population.

2.3 Instrument

Data were collected with the Climate-Resilient Crop Breeding Questionnaire (CRCBQ), developed by the researcher from the literature. It has three scales of 12 items each (36 items in all), rated on a four-point scale. Scale A measures awareness of four breeding approaches (conventional selection and hybridisation, marker-assisted selection, mutation breeding, and genetic engineering and genome editing) from 4 = *highly aware* to 1 = *not aware*. Scale B measures knowledge of four groups of resilience traits (drought tolerance, heat tolerance, early maturity, and pest, disease and flood resistance) from 4 = *strongly agree* to 1 = *strongly disagree* on knowledge statements. Scale C measures readiness to teach, promote and use resilient varieties across four areas (teaching integration, farmer advocacy and extension, use of improved seed, and willingness for further training), also from 4 = *strongly agree* to 1 = *strongly disagree*. Each domain has three items. Two specialists in agricultural education and one plant breeder checked the items for face and content validity. Cronbach's (1951) alpha in the present sample was .89 for awareness, .89 for knowledge and .88 for readiness.

2.4 Ethical Considerations

Permission to conduct the study was obtained from the head of the agricultural education department in each college. Participation was voluntary, respondents gave informed consent before completing the questionnaire, and responses were anonymous and used only for research.

2.5 Data Collection and Analysis

The researcher and three trained research assistants administered the questionnaire in class during the first semester with the permission of each head of department, and all 204 copies were returned and usable. Means and standard deviations answered the research questions, with a mean of 2.50 or above taken as a high level of awareness, knowledge or readiness (the mid-point of the four-point scale). One-sample *t* tests compared each overall mean with 2.50 (H_{01} to H_{03}). Pearson product-moment correlation tested H_{04} and H_{05}, and one-way analysis of variance (ANOVA) tested H_{06}. All tests used SPSS at the .05 level.

3 Results

3.1 Research Question 1 and Hypothesis 1: Awareness of Breeding Approaches

Students knew of conventional selection and hybridisation and of marker-assisted selection, but not of mutation breeding or genome editing (Table 2). The overall mean of 2.49 did not differ from the 2.50 benchmark, $t(203) = -0.14$, $p = .890$, so H_{01} was retained. Among individual students, 76% scored below 2.50 on genetic engineering and genome editing.

Table 2

Mean Awareness of Climate-Resilient Breeding Approaches (N = 204)

Breeding approach	M	SD	Decision
Conventional selection and hybridisation	3.01	0.63	Aware
Marker-assisted selection	2.61	0.63	Aware
Mutation breeding	2.28	0.64	Not aware
Genetic engineering and genome editing	2.08	0.61	Not aware
Overall	**2.49**	**0.55**	**Not aware**

Note. Decision rule: M ≥ 2.50 = aware.

3.2 Research Question 2 and Hypothesis 2: Knowledge of Resilience Traits

Knowledge was strongest for drought tolerance and early maturity and weakest for pest, disease and flood resistance (Table 3). The overall mean of 2.48 was not significantly different from 2.50, $t(203) = -0.62$, $p = .536$, so H_{02} was retained and knowledge was moderate.

Table 3

Mean Knowledge of Climate-Resilience Traits in Crops (N = 204)

Resilience trait	M	SD	Decision
Drought tolerance	2.73	0.61	Knowledgeable
Heat tolerance	2.36	0.63	Not knowledgeable
Early maturity and drought escape	2.68	0.62	Knowledgeable
Pest, disease and flood resistance	2.13	0.63	Not knowledgeable
Overall	**2.48**	**0.54**	**Not knowledgeable**

Note. Decision rule: M ≥ 2.50 = knowledgeable.

3.3 Research Question 3 and Hypothesis 3: Adoption Readiness

Readiness was high in every area (Table 4). The overall mean of 3.10 was well above the benchmark, $t(203) = 16.74$, $p < .001$, so H_{03} was rejected. Willingness for further training scored highest and farmer advocacy and extension lowest.

Table 4

Mean Readiness to Teach, Promote and Use Climate-Resilient Varieties (N = 204)

Readiness area	M	SD	Decision
Teaching integration	3.14	0.61	Ready
Farmer advocacy and extension	2.98	0.64	Ready
Use of improved seed	3.03	0.60	Ready
Willingness for further training	3.27	0.54	Ready
Overall	**3.10**	**0.52**	**Ready**

Note. Decision rule: M ≥ 2.50 = ready.

Table 5 gives the one-sample *t* tests for the first three hypotheses.

Table 5

One-Sample t Tests of Overall Means against the 2.50 Benchmark (N = 204)

Variable	M	SD	t	df	p	Decision
Awareness	2.49	0.55	−0.14	203	.890	Retain H_{01}
Knowledge	2.48	0.54	−0.62	203	.536	Retain H_{02}
Readiness	3.10	0.52	16.74	203	< .001	Reject H_{03}

Note. Test value = 2.50.

3.4 Research Question 4 and Hypothesis 4: Awareness and Readiness

Awareness correlated positively and moderately with readiness, $r(202) = .54$, $p < .001$ (Table 6). Awareness accounted for about 30% of the variance in readiness, and H_{04} was rejected.

3.5 Research Question 5 and Hypothesis 5: Knowledge and Readiness

Knowledge also correlated positively with readiness, $r(202) = .49$, $p < .001$, and accounted for about 24% of its variance. H_{05} was rejected. Awareness and knowledge were themselves positively correlated, $r(202) = .48$, $p < .001$.

Table 6

Pearson Correlation of Awareness and Knowledge with Readiness (N = 204)

Variables	r	r^2	df	p	Decision
Awareness and readiness	.54	.30	202	< .001	Reject H_{04}
Knowledge and readiness	.49	.24	202	< .001	Reject H_{05}

Note. Decision rule: reject H_0 when $p < .05$.

3.6 Research Question 6 and Hypothesis 6: Readiness by State

Mean readiness was similar in Sokoto ($M = 3.14$, $SD = 0.54$), Kebbi ($M = 3.13$, $SD = 0.53$) and Zamfara ($M = 3.05$, $SD = 0.47$). The differences were not significant (Table 7), and the effect was negligible ($\eta^2 = .007$), so H_{06} was retained.

Table 7

One-Way ANOVA of Readiness by State

Source	SS	df	MS	F	p
Between groups	0.37	2	0.18	0.69	.504
Within groups	53.64	201	0.27		
Total	54.01	203			

Note. Decision: retain H_{06}.

4 Discussion

Students were willing to teach resilient varieties but only moderately prepared to explain them. Their readiness scores were high, while awareness of breeding approaches and knowledge of resilience traits stayed near the midpoint. A student who agrees that resilient seed is worth promoting may still be unable to say what makes a variety drought-tolerant or how it was developed, and that limits what the student can pass on. The pattern of awareness follows the order in which the methods are usually taught. Conventional selection and hybridisation are standard in plant science courses and were the best known, while mutation breeding and genome editing, which rarely appear in NCE crop courses, were the least known. The outcome matches the observation of Cairns et al. (2013) that germplasm development takes many years to reach farmers: if graduates

are unfamiliar with newer methods, they will not be able to explain them when such varieties are released. Knowledge showed a similar split. Drought tolerance and early maturity, the traits most visible to farmers in a savanna, were better known than heat tolerance or pest, disease and flood resistance. This probably reflects local experience of dry spells more than classroom instruction, a point that can only be settled by comparing the taught content with what students report.

The positive relationships of awareness and knowledge with readiness support the sequence described by Rogers (2003), in which knowing about an innovation precedes a readiness to use it. Students who understood more were more willing to teach and promote resilient varieties, which also fits the idea in Ajzen (1991) that perceived control, here a sense of knowing enough, strengthens intention. The correlations are moderate, and the design cannot show that knowledge causes readiness. The link nevertheless gives teacher educators a practical reason to strengthen content on breeding, since it is the part of the chain they control. The absence of any difference between states suggests that the programme, rather than location, shapes what students know. Sokoto, Kebbi and Zamfara share a climate, a national curriculum framework and similar farming systems, so similar scores are reasonable. The result also parallels the wider adoption literature. Fisher et al. (2015) found large differences in uptake between countries, which they linked to seed supply and information; the three states here sit within one national system, and the narrower spread in readiness is consistent with that. The study has limits. It relied on self-reported awareness and knowledge, which can differ from tested knowledge, and it covered one college in each of three states, so the findings should not be generalised to every college in the zone. Future work could add a knowledge test, include universities and secondary school teachers, and follow graduates into practice.

5 Conclusion

Agricultural science education students in North-West Nigeria are willing to teach and promote climate-resilient crop varieties, but their awareness of modern breeding methods and their knowledge of resilience traits are only moderate. Readiness rises with both and is similar in Sokoto, Kebbi and Zamfara. Strengthening what students know about breeding is the most direct way to turn that willingness into sound teaching and extension.

6 Recommendations

Based on the findings, the following are recommended:

1. The National Commission for Colleges of Education and the colleges should add a unit on climate-resilient plant breeding, covering conventional, marker-assisted, mutation and genome-editing approaches, to the NCE agricultural education course content.
2. Course lecturers should give particular attention to heat tolerance and to pest, disease and flood resistance, which students knew least.
3. Colleges should arrange field visits, seed demonstrations and short attachments with agricultural research institutes and seed companies so that students see resilient varieties in trial and in use.
4. Colleges should use students' stated willingness for further training by organising workshops and short courses on resilient varieties during the programme and for graduates in service.
5. School farms and college demonstration plots should grow improved drought-tolerant and early-maturing varieties alongside local ones, so that students can compare them first-hand.

7 Declarations

The author declares no conflict of interest. The study received no specific funding. The data are available from the author on reasonable request.

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