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Report of Training

Methodological approach for the assessment of dissemination approaches on adoption of improved production technologies

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held between Feb 25th – March 25th, 2019

In ICARDA-Tunis

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OVERVIEW

This document is the report of a training undertaken between February 25th and March 25th, 2019 in ICARDA-Tunis and in the frame of the activity "Young Agricultural Scientists Program, session 2019" of the project "Enhancing Food Security in Arab Countries (Phase III) led by ICARDA in Collaboration with INGC.

The subject of the training is "**Methodological approach for the assessment of dissemination approaches on adoption of improved production technologies**" (See the invitation letter in appendix 1).

I- Goal

According to the production theory, the production function gives the technological relation between quantities of physical inputs and quantities of output of goods. Although it has different possible expressions, we can agree that in general the technical package used determines the level of performance of an enterprise.

On the other hand and according to the Diffusion of Innovation theory (DOI), communication channel used in the diffusion of innovation process affects the level of innovation adoption and thus the level of inputs used in the technical package.

We try in this report to test the possible influence of dissemination tools, seen as communication channels, on the production function and thus on the performance of wheat enterprises.

Specific objectives

We aim to gain a better understanding of

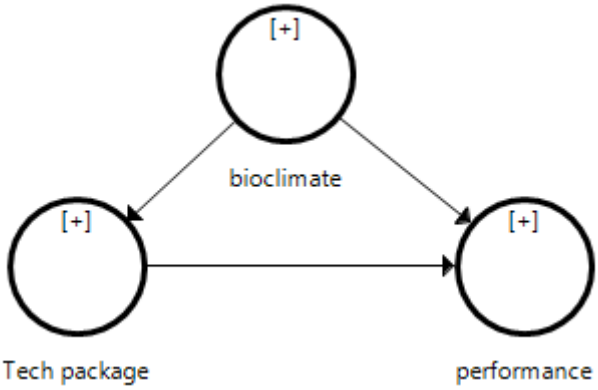
(1) inputs/technologies that construct better the technical package used
(2) the influence that have dissemination tools on the relation between the technical package used and the performance level

II- Conceptual Model

The structural model used is as:

We describe the above graph as the independent variable “technical package” affects (and can causes) the dependant variable “performance”.

We assume also that bioclimatic conditions affect both the technical package used and enterprise/farm performance. Hence, the structural model is as:



Hypotheses to be tested are:

(1) the technological package used has a positive effect on the performance of wheat enterprise
(2) the dissemination tool “sms” moderates the positive effect of technical package on performance
(3) the dissemination tool “demonstration plots” moderates the positive effect of technical package on performance
(4) the dissemination tool “training” moderates the positive effect of technical package on performance
(5) the dissemination tool “field days” moderates the positive effect of technical package on performance

III- Research methods

Data

We used here a survey results conducted by INGC in 2017 across its intervention zones in Tunisia. The survey covered 907 wheat producing farmers distributed between 3 Bioclimatic regions: humid and sub-humid, semi-arid superior and semi-arid inferior.

Estimation technique

Structural equation modeling (SEM) is a form of causal modeling that includes a diverse set of mathematical models, computer algorithms, and statistical methods that fit networks of constructs to data.

We used the structural equation modeling (SEM) regression technique with its sub-technique called Partial Least squares (PLS) as described by Hair et al. (Hair et al., 2014). The technique is frequently named PLS-SEM.

Software

We used **SmartPLS (v.3.2.8)** (Ringle et al., 2015).

IV- RESULTS

1- Constructs compositions

The table below presents the constructs used in our model: bioclimate, technical package and performance, and their constructing indicators.

Tab 1 : List of the constructs and their corresponding indicators

Construct	Indicator	Label	Min	Max
Performance	yield	Yield of wheat (Ql/ha)	4.4	75
	Wheat price	Wheat price (DT/Ql)	61	75.5
Bioclimate	bioclm	Bioclimatic region: 1 for sub humid, 2 for semi-arid superior and 3 for semi-arid inferior	1	3
Technical package used	recom var	using the recommended seed variety: 0 for no and 1 for yes	0	1
	seeder	using a seeder: 0 for no and 1 for yes	0	1
	recom seed rate	using the recommended seed rate: 0 for no and 1 for yes	0	1
	recom N fractions	using the recommended N fractions: 0 for no and 1 for yes	0	1
	seed quality	using certified seeds: 0 for no and 1 for yes	0	1
	seed rate	seed rate (Ql/ha)	1	2.4
	DAP	DAP rate (Ql/ha)	0	3
	N	N rate (QL/ha)	0	5
	herb cost	herbicide cost (DT/ha)	0	288
	fong cost	fongicide cost (DT/ha)	0	336
	irrigation	irrigated : 0 no and 1 yes	0	1

2- Model validation

2.1. Measurement model validation and discussion

The measurement model is the "outer model" consisting of the indicators and the paths connecting them to their respective factors. Both weights and loadings are output for both reflective and formative models respectively.
Outer model weights are the focus in formative models, as we have in current model, representing the paths from the constituent indicator variables to the composite factor. Outer weights represent the relative contribution of the indicator to the definition of its corresponding latent variable (component or composite).
Outer model loadings are the focus in reflective models, representing the paths from a factor to its representative indicator variables. Outer loadings represent the absolute contribution of the indicator to the definition of its latent variable

Tab 2 : List of indicators' weights

	constructs		
Indicators	bioclimate	performance	tech package used
N			0.157
bioclm	1.000		
dap			-0.108
fong cost			0.293
herb cost			0.520
irrigation			0.265
recom N fractions			0.136
recom seed rate			0.134
recom var			0.064
seed quality			-0.110
seed rate			0.076
seeder			-0.406
wheat price		0.319	
yield		0.865	

The table above presents the weights of the indicators. Except the construct "bioclimate" that is represented by one indicator, the higher the absolute value of the weight the higher it represent the variance of its construct. Hence, 'yield' represents the variance of the performance 2.7 times more than does 'wheat price'. For the construct 'tech package used", the indicators 'herb cost', seeder, 'fong cost' and 'irrigation' are the top 4 constructing indicators. We can eliminate the indicators with low levels of weights but since we want not to loose in constructs' explained variance, we prefer not to do so (in fact we can keep only 6 out of the 11 indicators of 'tech package used' without loosing much in construct variance)

2.2. Structural model validation and discussion

The results of the model are shown in Figure 1. Goodness of fit for structural models or Structural fit is examined only after measurement fit is shown to be acceptable. The structural or inner model consists of the factors and the arrows that connect one factor to another (Garson, 2016).

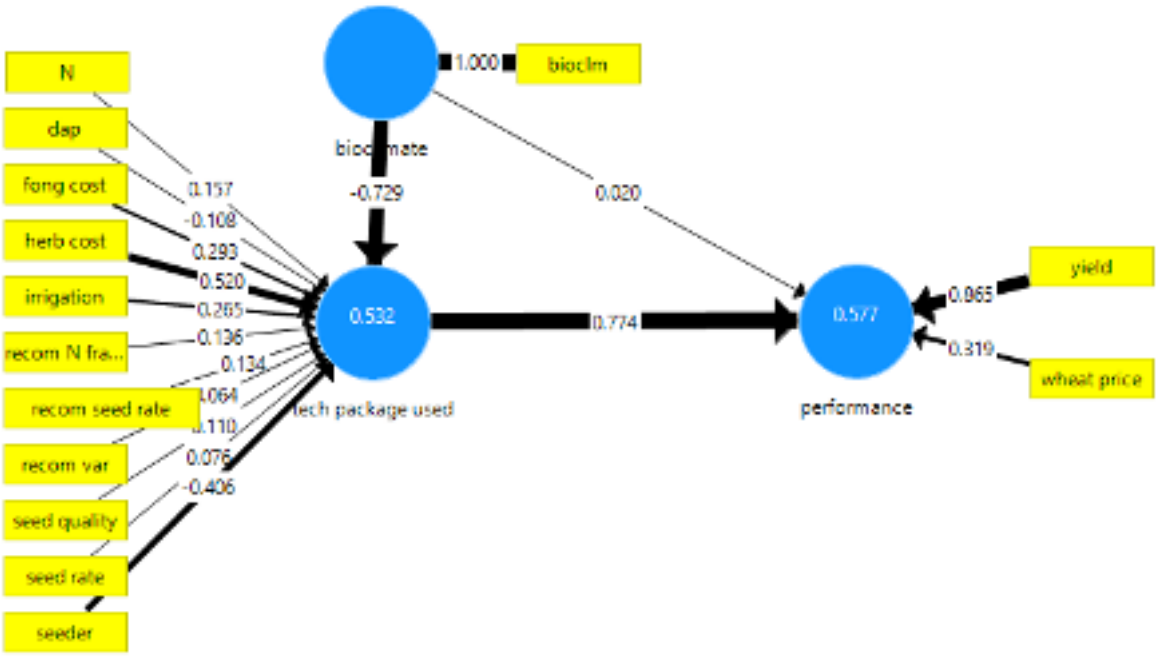


Figure 1: Model results

The tests used to validate the structural model are: collinearity test (VIF); path coefficients and their significance; R square, path coeficicent and SRMR (Hair et al., 2014).

- **Collinearity test**

  The collinearity test is to test assure not to have constructs dealing with the same concept. Each predictor construct's tolerance (VIF) value should be higher than 0.20 (lower than 5). Otherwise, consider eliminating constructs, merging predictors into a single construct, or creating higher-order constructs to treat collinearity problems (Hair et al., 2014).

  The table below shows that all VIF values exceed the value of 0.2. So, we have not collinearity problem between latent variables.

Tab 3 : Inner VIF values (collinearity test)

	bioclimate	performance	tech package used
bioclimate		2.137	1.000
performance			
tech package used		2.137	

- **The coefficient of determination R square**

  PLS-SEM aims at maximizing the *R*2 values of the endogenous latent variable(s) in the path model.

Tab 4: Coefficients of determination of the constructs

Construct	R Square	R Square Adjusted
performance	0.577	0.577
tech package used	0.532	0.532

For the endogenous variable performance, the R-square value is 0.577, meaning that about 57% of the variance in performance is explained by the model (that is, jointly by tech package used and bioclimate).
Also, for the endogenous variable tech package used, the R-square value is 0.532, meaning that about 53% of the variance in tech package used is explained by the model (including bioclimate).
While the exact int erpretation of the *R*2 value depends on the particular model and research discipline, in general *R*2 values of 0.75, 0.50, or 0.25 for the endogenous construct can be described as respectively substantial, moderate, and weak (Hair et al., 2014).
We can accept 50% of variance explained for each construct for the current model and then the R square test validated.

- **The path coefficient**

Paths are the arrows connecting variables. Theirs coefficients represents the strength of the effect the have one variable on an other. Effects can be direct, indirect and total. Path coefficients are always standardized path coefficients. Given standardization, path weights therefore vary from -1 to +1. Weights closest to absolute 1 reflect the strongest paths. Weights closest to 0 reflect the weakest paths. Above, coefficients placed on the arrows are direct effects (also shown in Tab 5). A path coefficient having an absolute value above 0.7 is considered as strong effect. Hence bioclimate has a strong direct effect on tech package used and it's significant (p=0.000) and a non significant direct effect on performance. And 'Tech package used' has a strong and significant direct effect on 'performance'.

Tab 5 : direct effects of the inner model and their significances

	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	T Statistics (|O/STDEV|)	P Values
bioclimate -> performance	**0.020**	0.025	0.043	**0.466**	**0.641**
bioclimate -> tech package used	**-0.729**	-0.731	0.018	**39.583**	**0.000**
tech package used -> performance	**0.774**	0.780	0.034	**22.995**	**0.000**

Tab 6 shows the only indirect effect in our model which relates bioclimate to performance. It is a moderate indirect effect mediated by the tech package used.

Tab 6 : Indirect effect of the iner model

Indirect effect	bioclimate	performance	tech package used

bioclimate		-0.565	
performance			
tech package used			

The total effects of our model join direct and indirect effects. Tab 7 shows that the performance is strongly affected by the tech package used and moderately affected by bioclimate.

Tab 7 : Total effects of the inner model

Total effect	bioclimate	performance	tech package used
bioclimate		-0.545	-0.729
performance			
tech package used		0.774	

- **SRMR**

SRMR is used for theory testing. SRMR value less than 0.08 indicates a good fit. The model fit function in SmartPLS provided us with an SRMR value equal to 0.087. We can say that we passed this test.

3. Moderation Hypothesis validation and discussion

After validating the model, we can proceed with moderation tests. The moderators we tested are:

Tab 8 : list of moderators to be tested

Moderator	**Label**	**Min**	**Max**
training	did you benefit from INGC training? 0 for no and 1 for yes	0	1
demo	did you benefit from INGC demonstration plots? 0 for no and 1 for yes	0	1
sms	did you benefit from INGC sms? 0 for no and 1 for yes	0	1
field days	did you benefit from INGC field days? 0 for no and 1 for yes	0	1

To test heterogeneity across groups with SmartPLS, the Multi-Group Analysis function (MGA) and the Moderating Effect function are used to compare the difference between paths of different groups and hence the existence of moderating effect. We use here MGA function since our moderators are dummy variables. Then the two-stage approach is used since formative measures are involved.

The MGA function was run for each type of groups regarding the use of each dissemination tool.

The significance of the difference between path models is tested using Welch-Satterthwait test.

(a) Sms

Figure 2 and Figure 3 shows the model results for the group receiving SMS (sms=0) and the group not receiving SMS (sms=1).

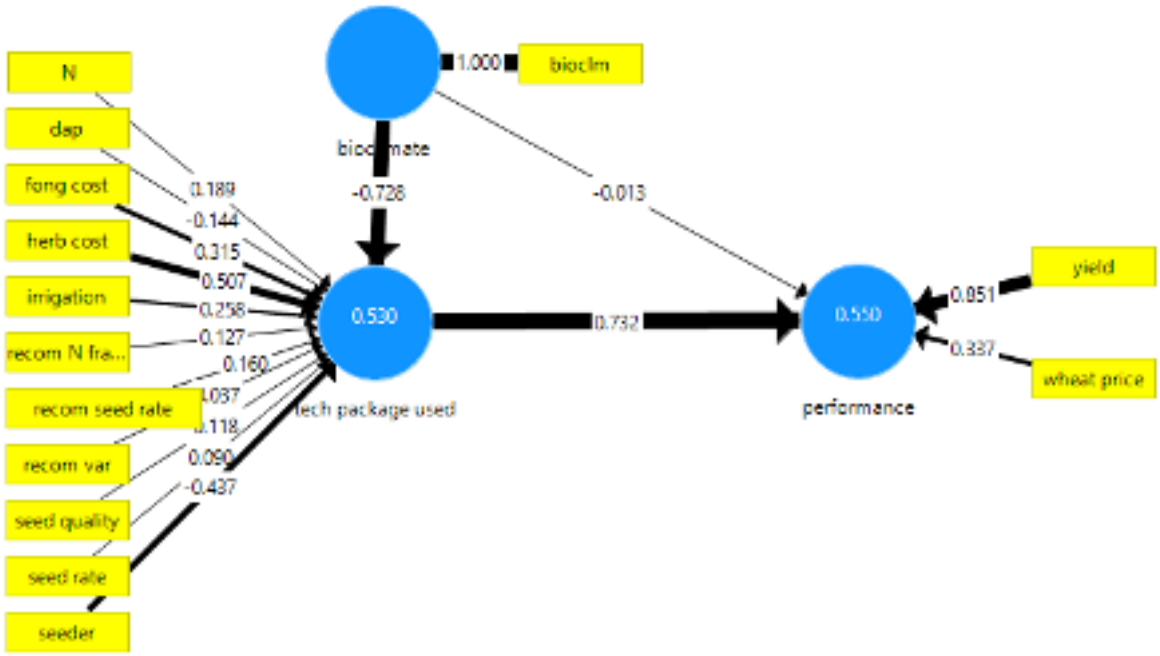


Figure 2 : Model results for sms=0

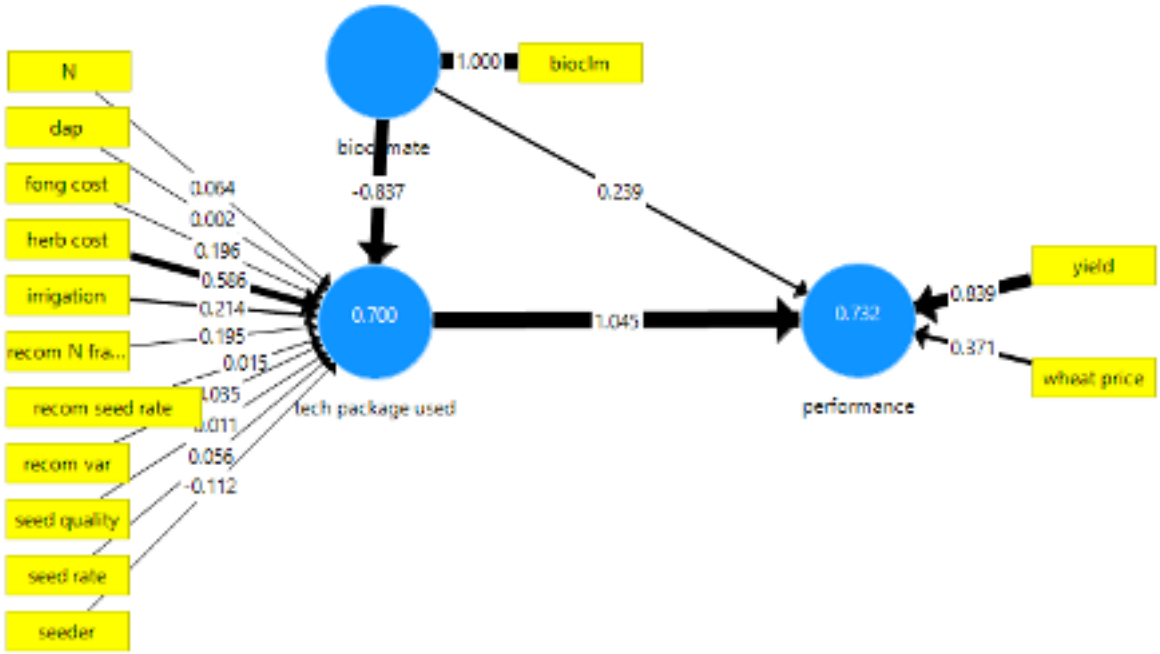


Figure 3 : Model results with sms=1

The table below shows that path differences according to Welch-Satterthwait test are significant for paths relating bioclimate -> tech package used and for tech package

used -> performance. We conclude that SMS tool strengthens the positive effect that have tech package used on performance.

Tab 9 : Welch-Satterthwait test results for the moderator SMS

	Path Coefficients-diff (| GROUP_sms(0.0) - GROUP_sms(1.0) |)	t-Value (GROUP_sms(0.0) vs GROUP_sms(1.0))	p-Value (GROUP_sms(0.0) vs GROUP_sms(1.0))
bioclimate -> performance	0.252	1.809	0.073
bioclimate -> tech package used	0.109	3.180	0.002
tech package used -> performance	0.314	2.643	**0.009**

(b) Demonstration plots

Figure 4 and Figure 5 shows the model results for the group benefiting from demonstration plots (demo=0) and the group not benefiting from demonstration plots (demo=1).

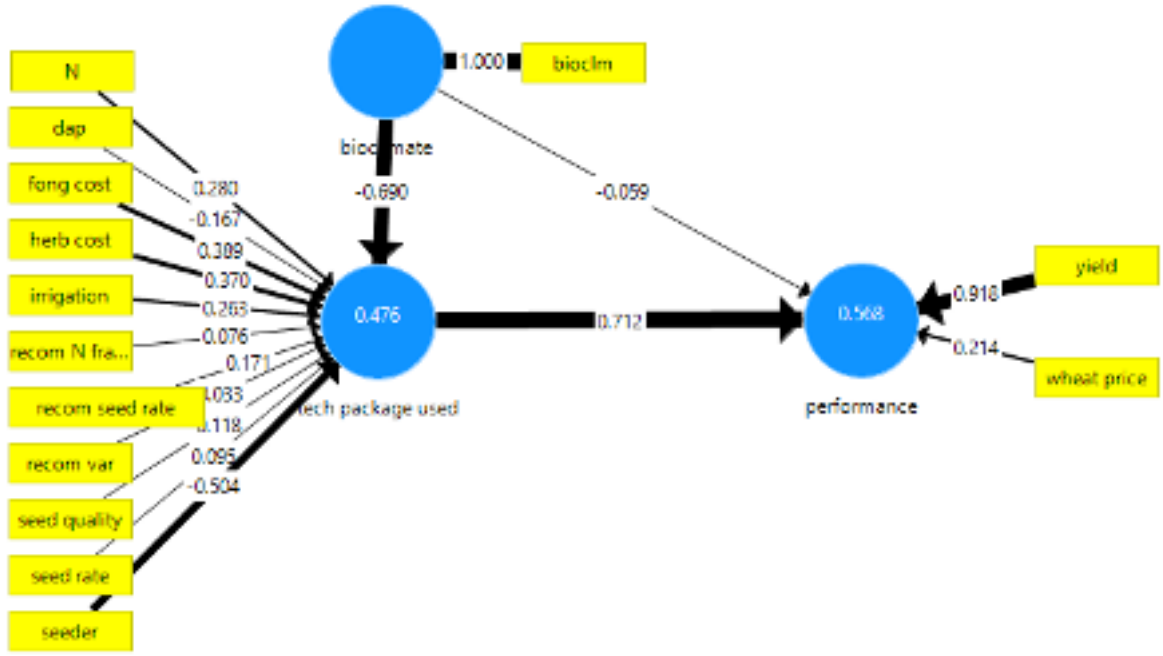


Figure 4 : Model results with demo = 0

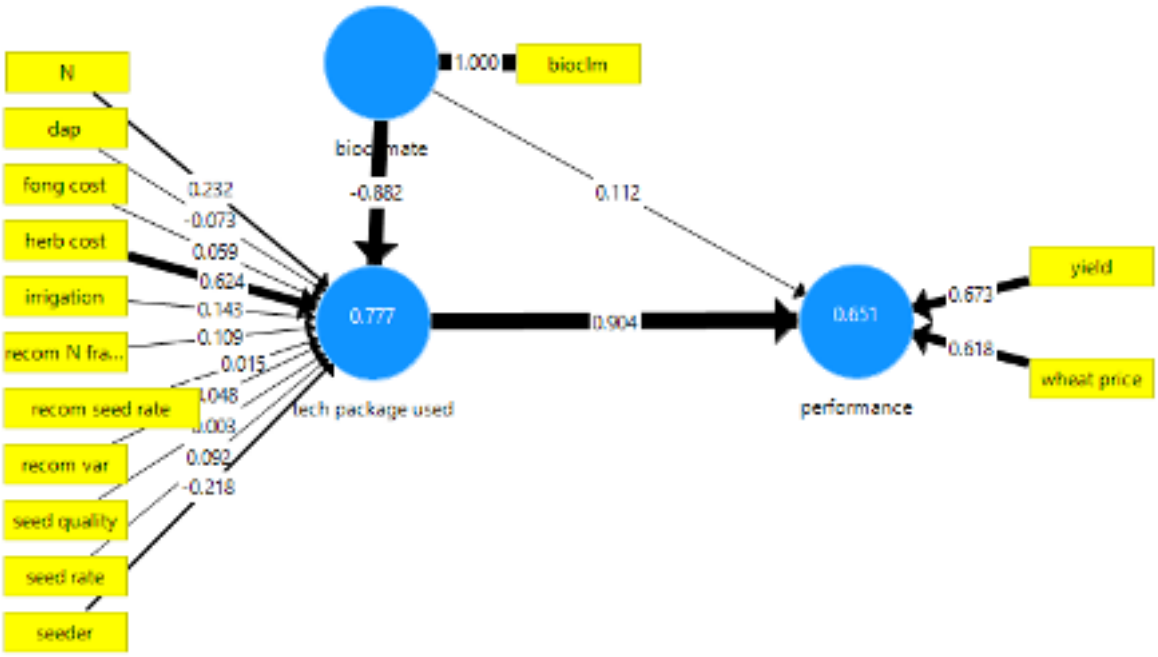


Figure 5 : Model results with demo = 1

The table below shows that path differences according to Welch-Satterthwait test are significant for path relating bioclimate -> tech package used and not significant for path relating tech package used -> performance. We conclude that demonstration plot tool is not proven to moderate/strengthen the positive effect that have tech package used on performance.

Tab 10 : Welch-Satterthwait test results for the moderator demo

	Path Coefficients-diff (| GROUP_demo(0.0) - GROUP_demo(1.0) |)	t-Value (GROUP_demo(0.0) vs GROUP_demo(1.0))	p-Value (GROUP_demo(0.0) vs GROUP_demo(1.0))
bioclimate -> performance	0.171	1.189	0.236
bioclimate -> tech package used	0.192	6.317	0.000
tech package used -> performance	0.192	1.408	**0.160**

(c) Training

Figure 6 and Figure 7 shows the model results for the group of farmers having benefited from training (training=0) and the group of farmers haven't benefited from training (training=1).

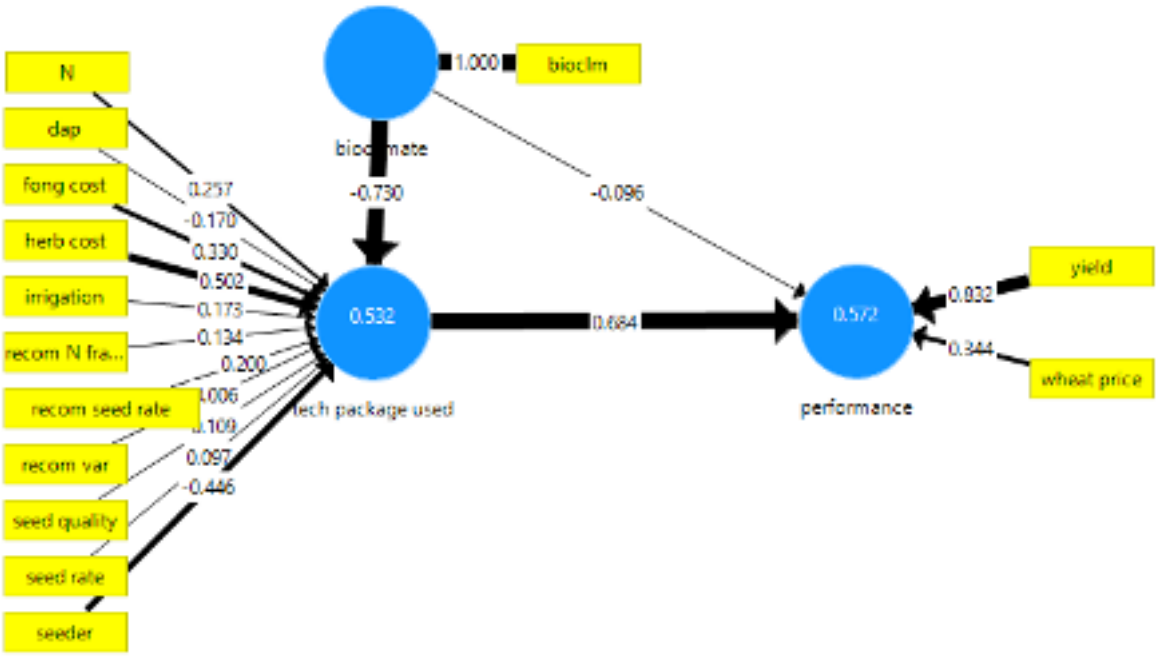


Figure 6 : Model results with training = 0

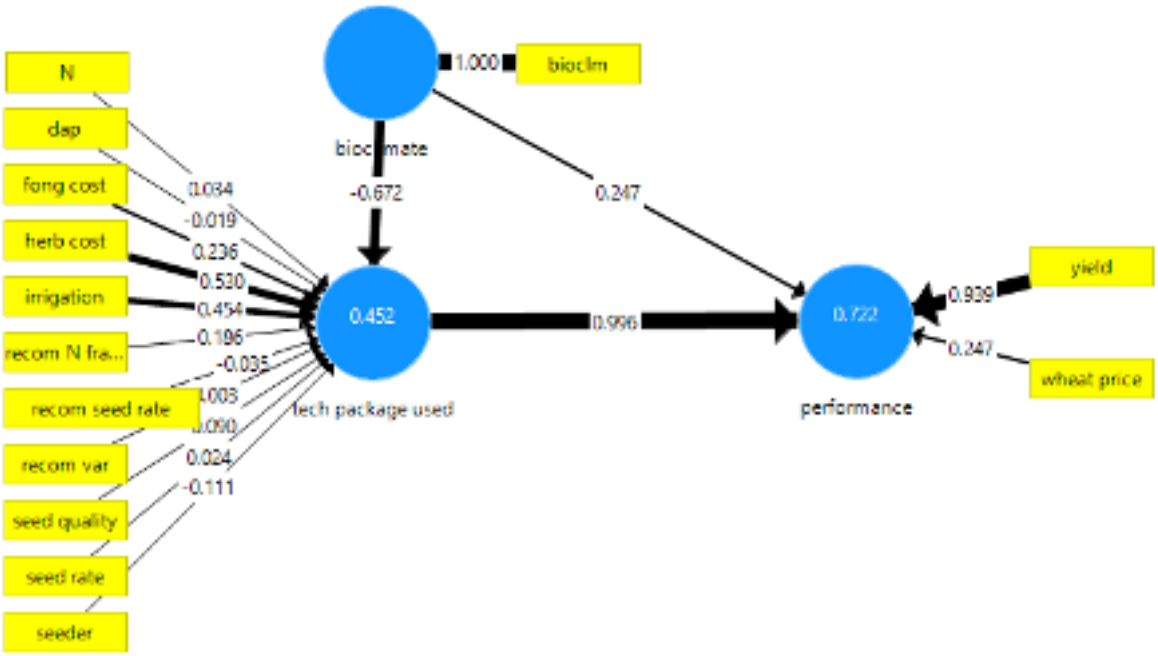


Figure 7 : Model results with training = 1

The table below shows that path difference according to Welch-Satterthwait test is significant for path relating tech package used -> performance. We conclude that training tool is proven to moderate/strengthen the positive effect that have tech package used on performance.

Tab 11 : Welch-Satterthwait test results for the moderator training

	Path Coefficients-diff (| GROUP_training(0.0) - GROUP_training(1.0) |)	t-Value (GROUP_training(0.0) vs GROUP_training(1.0))	p-Value (GROUP_training(0.0) vs GROUP_training(1.0))
bioclimate -> performance	0.343	2.969	0.003
bioclimate -> tech package used	0.057	0.800	0.425
tech package used -> performance	0.312	3.670	**0.000**

(d) Field days

Figure 8 and Figure 9 shows the model results for the group of farmers having benefited from field days (field days =0) and the group of farmers haven't benefited from field days (field days=1).

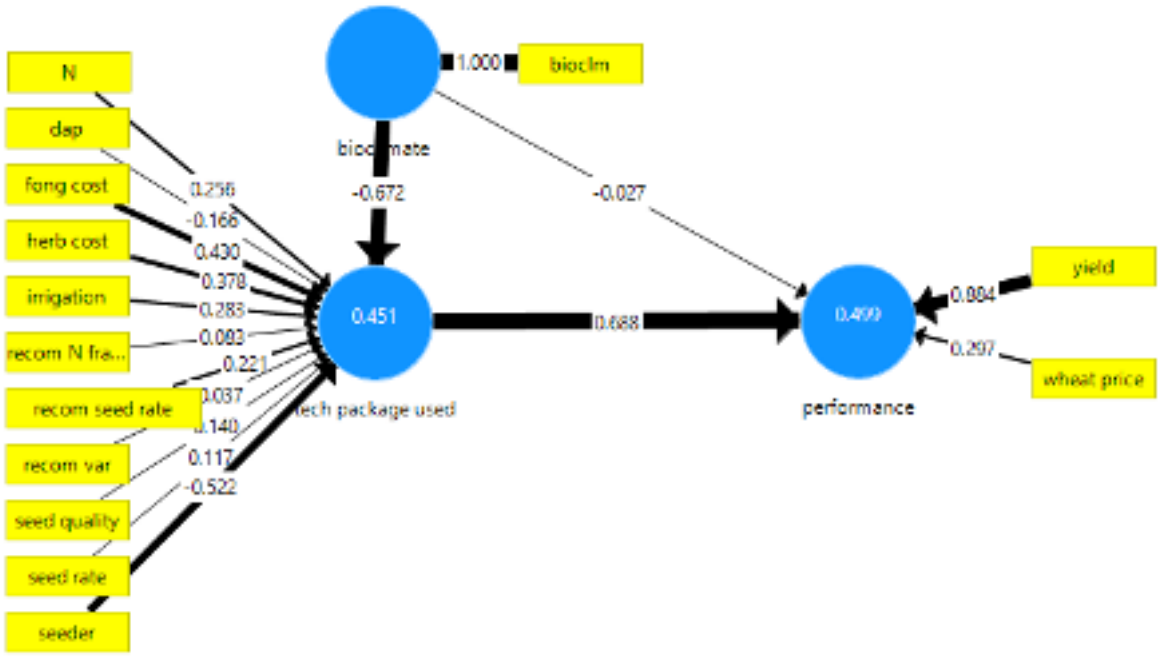


Figure 8 : Model results with field days = 0

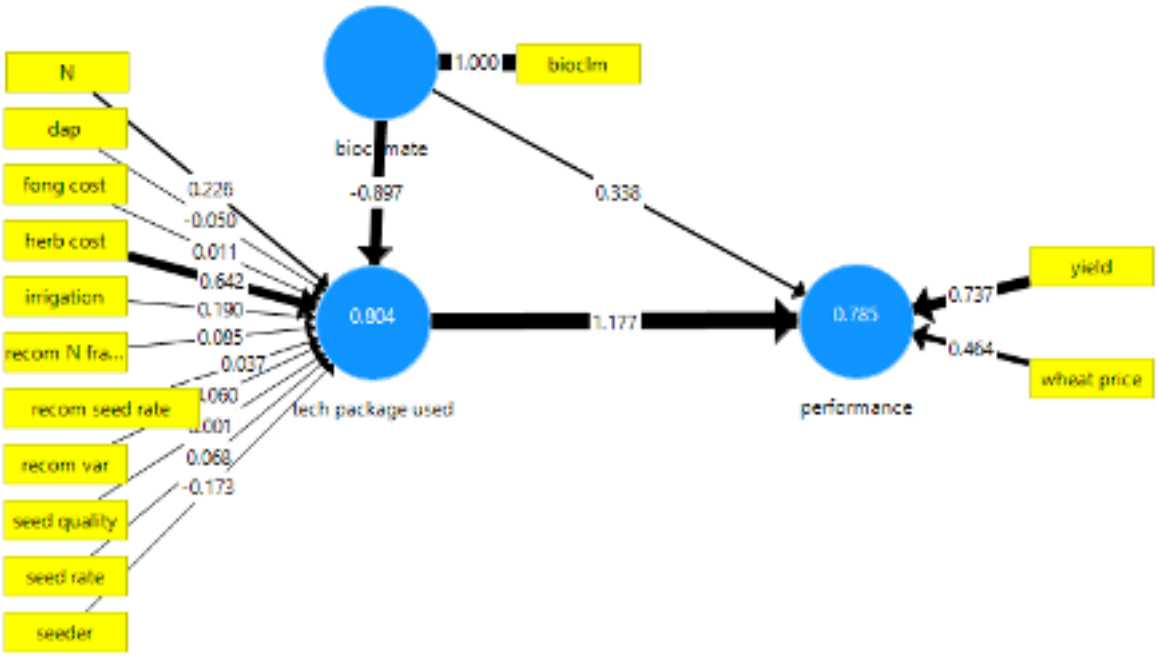


Figure 9 : Model results with field days = 1

The table below shows that path difference according to Welch-Satterthwait test is significant for path relating tech package used -> performance. We conclude that field days tool is proven to moderate/strengthen the positive effect that have tech package used on performance

Tab 12 : Welch-Satterthwait test results for the moderator training

	Path Coefficients-diff (| GROUP_field days(0.0) - GROUP_field days(1.0) |)	**t-Value** (GROUP_field days(0.0) vs GROUP_field days(1.0))	**p-Value** (GROUP_field days(0.0) vs GROUP_field days(1.0))
bioclimate -> performance	0.366	3.047	0.003
bioclimate -> tech package used	0.225	7.424	0.000
tech package used -> performance	0.489	4.534	**0.000**

V- CONCLUSION

The overall objective of this work is to test/propose a data-driven methodology to evaluate dissemination approaches. This work has proposed the use of the PLS-SEM technique to detect possible differences between the effect of the technical package used by wheat producing farmers in INGC's intervention zones on their performances (mainly on yield) in different dissemination tools situations.

After we assured that our model is valid i.e that the technical package has a significant effect on the performance (H1 supported), we tested moderation hypotheses and found that the use of sms tool, training tool and field days tool have a significant positive moderation effect of the relation between technical package used and performance whereas demonstration plots tool is not proven here to have a significant moderation effect.

References

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Hair, J., Hult, G.T., Ringle, C., Sarstedt, M., 2014. A Primer on Partial Least Squares Structural Equation Modeling (PLS-SEM). 2014 Faculty Bookshelf.
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Appendices

Appendix 1: invitation letter of the training