

# FielDHub: A Shiny App for Design of Experiments in Life Sciences

Didier A. Murillo<sup>1</sup>, Salvador A. Gezan<sup>2</sup>, Ana M. Heilman<sup>1</sup>, Thomas C. Walk<sup>1</sup>, Johan S. Aparicio<sup>3</sup>, and Richard D. Horsley<sup>1</sup>

1 North Dakota State University 2 VSN International 3 CIAT (International Center for Tropical Agriculture)

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#### Software

- Review I<sup>A</sup>
- Archive I<sup>2</sup>

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- @Prof-ThiagoOliveira
- Ødlebauer

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# **Summary** FielDHub is an R Shiny design of experiments (DOE) app that aids in the creation of traditional, unreplicated, augmented and partially-replicated (Cullis et al., 2006) designs applied

ditional, unreplicated, augmented and partially-replicated (Cullis et al., 2006) designs applied to agriculture, plant breeding, forestry, animal and biological sciences. One of the problems that life scientists often face is the lack of freely available and user-friendly interactive tools to create designs that fit their needs. A few open-source DOE R packages options exist including agricolae (de Mendiburu & Yaseen, 2020) and blocksdesign (Edmondson, 2021), but they require users to be familiar with the R programming language and do not have a graphical user interface (GUI).

# Statement of need

FielDHub allows users to perform randomizations of field, laboratory, and greenhouse experiments, while providing output via interactive field layouts and tables that can be extracted and saved. This app has a novel design that offers DOE options and features that are not currently available in most software applications. Users are guided in each step of the DOE platform in an interactive interface, which includes a feature that helps to generate randomizations with an option to simulate data for a response variable. This last feature makes it suitable for teaching and evaluation purposes, where instructors can use the graphical dynamic user interface and/or use the functions included in the R package for teaching R scripting courses. This app also provides a graphical workflow to import treatment lists and export field books. For field experiments with a strict spatial arrangement, it allows users to specify the dimensions of the field (the number of rows and columns), while controlling the percentage of check plots, and obtaining field maps and field books that can be used directly as templates and input files for centralized databases.

FielDHub is currently being used by different breeding programs at NDSU and in graduate courses to teach the concepts of randomization, blocking, replication and simulations. The combination, in a single application, of novel and traditional designs, an interactive user interface, visualizations, and generation of templates and field layouts will enable the discovery of outstanding genotypes, while using efficient experimental designs that meet the requirements of the research being conducted.

Some of the features and designs implemented in FielDHub are summarized below:

1. Novel Designs: FielDHub has implemented a class of experimental designs known as augmented designs, partially replicated, and unreplicated designs. Examples are provided for each of the options with a default input data to demonstrate the functionalities of the app.



- 2. Reactive Interface: FielDHub provides output via an interactive interface, where users enter values that automatically generate tables, layouts, and output files within seconds.
- 3. Modularization: FielDHub was built in Shiny modules using the golem framework (Guyader et al., 2020). Modularity makes the app easy to test, maintain, and deploy.
- 4. Local and Remote Deployment: FielDHub can be deployed either to a local computer or to a server for online use. Currently it has been used within a server instance that has been utilized by graduate students and researchers alike in NDSU.
- 5. Simulations: FielDHub allows users to simulate a response variable along with the randomization. This feature can be used to define the corresponding linear model and to assess the efficiency of the experimental design, particularly in relation to its spatial components, or it can also be used to teach statistical concepts.

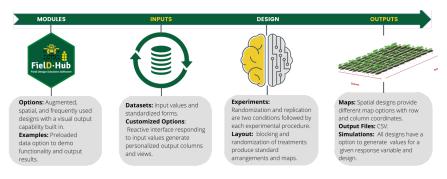


Fig 1. Overview of FielDHub main features.

## Usage

Plant breeding field research projects at NDSU are using FielDHub to refine experimental techniques in order to obtain unbiased and more precise estimates of the true treatment effects and their differences using unreplicated designs (Clarke & Stefanova, 2011; Federer, 1955). Often these projects face limitations of seed quantity and available field space in conducting trials with large numbers of genotypes and opt for the use of partially replicated or unreplicated designs (Clarke & Stefanova, 2011). As an example (Fig. 2), we consider here 270 genotypes arranged in a field of 15 rows by 20 columns. These genotypes are grouped in three different experiments/sites. In addition, we used four checks that are replicated in a systematic diagonal arrangement to fill 27 plots that represent 9% of the total experimental plots. An option to include filler plots is also available.



elDHub 🏫 Welcome!	Unreplicated Designs +	Augmented D	esigns -	Par	tially F	Replica	ated De	esigns	Latt	ice De	signs •	• Ot	her Des	igns -	Abou	t Us							
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Decision Block Unreplicated	Design with Diagonal Checks	•	He	atma	p																		
Import entries' list?			Show	15 ~	entries															Search:			
○ Yes ● No				<b>V1</b> 0	<b>V2</b> 0	V3 (	V4 (	V5 0	V6 (	<b>V7</b> 0	<b>V8</b> (	V9 (	V10	V11 0	V12 0	V13 0	V14 0	V15 0	V16 🕴	<b>V17</b> 0	V18 🕴	V19 0	V20
Input # of Entries:	Input # Entries per Exp	t	15	231	3	217	237	270	266	244	248	271	238	255	239	4	252	259	206	226	Filler	Filler	Filler
270	100,100,70		14	215	229	269	210	1	263	233	260	251	243	224	246	257	230	235	2	212	245	219	254
Input # of Rows:	Input # of Columns:		13	249	222	236	221	247	272	274	2	234	208	207	258	213	227	273	253	220	232	1	268
15	20		12	264	216	256	228	223	250	240	267	218	265	4	211	205	242	214	209	261	241	262	225
Choose % of Checks:	Input # of Checks:		11	107	109	2	197	148	105	151	144	134	164	172	157	120	4	150	123	132	178	118	121
9	<b>-</b> 4	•	10	191	162	169	160	126	3	142	106	156	122	108	159	199	188	173	203	1	163	177	141
Blocks Layout:	Plot Order Layout:		9	161	195	131	124	149	202	179	181	4	189	175	166	115	136	165	140	194	201	174	1
By Row	serpentine	•	8	2	186	171	200	170	110	146	184	182	193	117	3	133	154	128	112	167	119	198	111
			7	183	127	176	4	135	152	192	113	204	185	145	147	130	137	1	116	196	139	129	155
Which Blocks will have Fil:		6	190	114	180	153	138	168	4	158	125	187	143	14	59	28	36	74	61	2	70	20	
3			5	12	97	35	66	15	87	99	80	40	3	49	25	43	34	58	65	102	56	83	72
Seed Number:	Input Experiment Nam	e:	4	68	3	9	38	48	79	69	16	95	37	73	90	3	64	103	5	11	29	44	50
17	Expt1		3	41	23	104	22	4	98	24	78	86	89	67	85	21	101	31	1	96	47	6	63
Starting Plot Number:	Input the Location:		2	30	26	94	17	46	88	8	2	81	93	42	53	45	60	82	75	76	84	4	91
1	FARGO		1	57	51	27	18	13	100	39	7	55	52	2	32	71	77	54	62	19	10	33	92
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Fig 2. Unreplicated design with checks in a systematic diagonal arrangement.

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## Availability and Community Guidelines

The software is available at the GitHub repository. The GitHub repository also contains the source code for this paper. Users and contributors are welcome to contribute, request features, and report bugs in this GitHub repository.

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