

Read me: Easy Micro Plot Extraction

This help guide is about the code EasyMPE_main.py

Made by Tokyo University Field Phenomics Laboratory, 2018 - 2019

ENVIRONMENT

This code requires:

- Python (downloadable on Anaconda, tested on v. 3.6.8)
- Fiona (available on Anaconda, tested on v. 1.8.4)
- OpenCV package (available on Anaconda, tested on v. 3.4.3)
- PyQt package (available on Anaconda, tested on v. 5.9.2)
- scikit-image package (available on Anaconda, tested on v. 0.14.1)
- pyshp package (available on Anaconda, tested on v. 2.0.1)
- rasterio package (available on Anaconda, tested on v. 1.0.13)
- Fiona package (available on Anaconda, tested on v. 1.8.4)
- rasterstats package ; to install it, please refer to : <https://pythonhosted.org/rasterstats/installation.html> and use Anaconda Prompt (tested on v. 0.13.0)

BASE IMAGE REQUIREMENTS

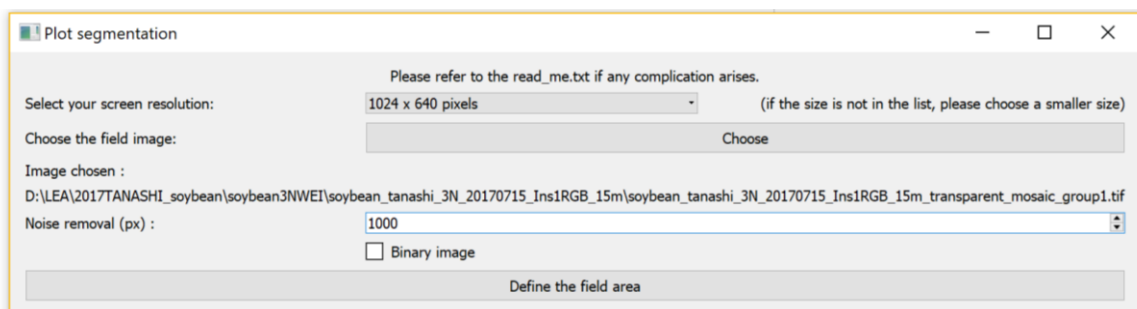
Not every image is fitted to go through this code. The field image has to have grown vegetation i.e. the rows have to be visible **but the rows should not touch each other** much. It is best if the rows are homogeneous, that is to say there if the plants are sowed on a same line without moving aside from that row and approximately the same density. A few weeds are acceptable if not predominant and smaller than the rows.

Inputs can be both RGB or binary image. If the latter, please do not forget check the related box.

Examples of images that fit the requirements and the inputted parameters are in Annex 1.

GUI INPUTS

Once the GUI code is launched, several inputs will be asked.



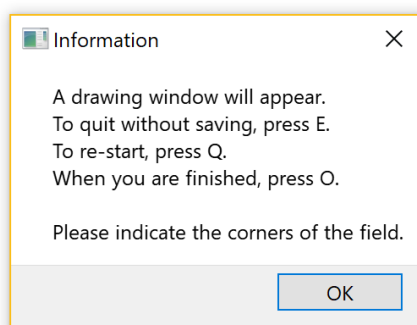
Select your screen resolution: as most field images are big pictures, they need to be resized so you can select the region of interest on your screen. If your screen resolution is not in the list, please choose a smaller size so that the whole image can be displayed.

Choose the field image: this is the image that will be processed. Once you chose one file, the path will be displayed under the button and the “Define the field area” button will be available. This image does not need to be cropped beforehand as you will draw your region of interest afterwards.

Noise removal (px): minimal size in pixels for objects to be kept during binarization. It aims at erasing the smaller weeds. The value depends of the image size and the average size of the rows. Please check the binary output after this step to make sure the noise input fits the image! If not, you can re-do this step after changing the noise value. This value is important as it is the only way the user can **influence** the image manipulation.

Binary image: if your input image (i.e. field image) is a binary file, check this box. Otherwise, do not. This option is handy if the user is not convinced by the binary image automatically calculated by the program (using Excess Green and Otsu threshold) or if some weeds need to be removed.

Once everything is completed, the button `Define the field area` is available. Click on it. An informative window pops up.

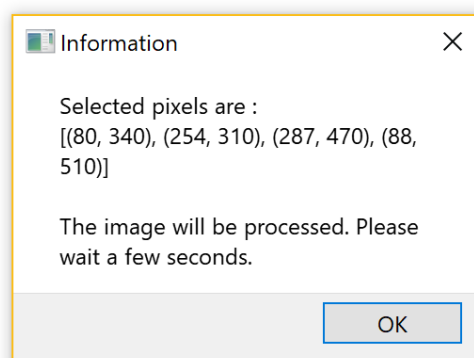


It gives the instruction to go through the drawing process. To get started, click OK and wait for the field image to be displayed. Now, simply click on the corners of your wanted ROI. At every click, a red circle will be drawn and a magenta line will link the points. Press O to close the drawing (as showed on the right image)



Please point out the region logically i.e. all points clockwise or counter-clockwise. You can add as many points as you want and select the region you want. Everything outside the region will not be processed. Please make sure that the wanted rows are directly next to the selection, i.e. that there is no weed or ground check point that would be appear on the binary image around the plot. If there is, make sure to select a region closer to the rows.

After pressing O, another informative window will pop up, indicating the corners you selected. The binarization of the image is then starting, which takes a bit of time depending on the region's size. You can redraw the region of interest as much as you want even after this step if it does not satisfy you or if you need to change the noise value.



After this step, the main window changed to this:

Plot segmentation

Please refer to the read_me.txt if any complication arises.

Select your screen resolution: 3200 x 1800 pixels (if the size is not in the list, please choose a smaller size)

Choose the field image: Choose

Image chosen :
D:\LEA\2017TANASHI_soybean\soybean3NWEI\soybean_tanashi_3N_20170715_Ins1RGB_15m\soybean_tanashi_3N_20170715_Ins1RGB_15m_transparent_mosaic_group1.tif

Noise removal (px) : 1000

☐ Binary image

Define the field area

Plot parameters :

Number of column(s) per plot: 1

Number of row(s) per plot: 3

Global orientation of the columns : ☐ Horizontal ☒ Vertical

Apply

Plot parameters are already known by the user.

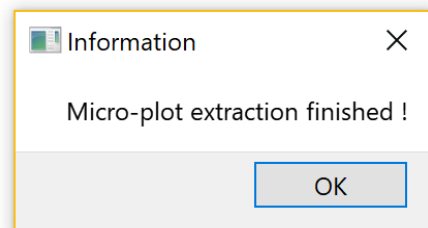
Number of columns(s) per plot: the number of column that are in a plot. Usually 1.

Number of row(s) per plot: the number of rows per plot. Usually more than 1, but can be 1.

Global orientation of the columns: either horizontal or vertical. If the orientation is in between, check the one that seems the most intuitive.

Then, click “apply”. Once the code ran, the window on the right will pop.

After clicking “OK”, you can start over with other parameters if needed. You do not need to re-define the region of interest if you want the same as before.



If your original field image is not georeferenced, this is the last step of the program. A pop-up window will inform you of that.

Otherwise, the main window changes again to be displayed as :

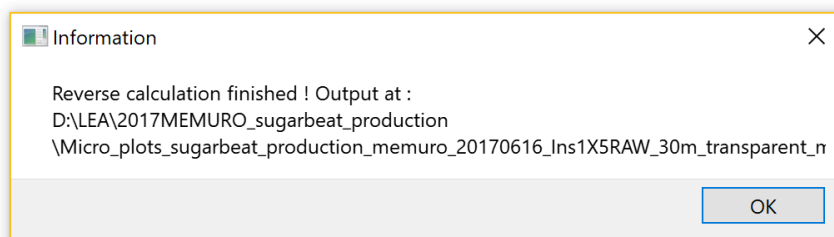
The last part is about reverse calculation. The goal and process is explained below in the “Reverse calculation” part.

Several inputs are needed here:

- a digital surface model (DSM) of the field image you chose in the first part ; it is a .tiff file
- the offset of the image ; it is either a .txt or a .xyz file
- PMatrix file of the translation of raw image into a whole image ; it is a .txt file
- the folder containing the raw images i.e. the direct drone images used to make the PMatrix and offset files

Once you inputted all the needed files, click “Apply”. The reverse calculation will be done quite quickly, depending on the number of raw images and plots.

After this, a pop-up window appears as displayed below. This is the end of the GUI. You can obviously redo as much as you want the different steps, as long as you have the right inputs.



FOLDERS ORGANISATION

All the saved files are in the same repertory, which you can find in the folder of your field image. The repertory is called “Micro_plots_ORIGINALIMAGENAME”.

About the files:

- if the original file was georeferenced (i.e. GeoTIFF with a CRS), then the *.shp files generated by the code are saved in the same coordinates system *Intersection_points_georeferenced.csv*
- If the original file was not georeferenced (i.e. *.jpg, *.png or unreferenced *.tiff), the *.shp files have the pixel coordinates of their regions on the original image in the file *Intersection_points_non_georeferenced.csv*. The origin is in the upper left-hand corner of the image and the y-axis is oriented up (the image is in the negative area of y). The reverse calculation is not possible in this case. The *.shp might also not be usable for other dates, depending on the image size compared to the inputted image.

The output files are as follows, in the folder “Micro_plots_ORIGINALIMAGENAME”:

- *All_plots.shp* is the shapefile of all the individual plots. Individual shapefiles can be found in the folder “SHP_files”.
- *Binary_columns_straight.jpg* is the binary image on which the vertical columns are clearly delimited by vertical lines
- *Binary_core.png* is the binary image of only the center of the columns (i.e. without possible inter-column weeds and without the end of each column)
- *Binary_core_columns.jpg* is the *binary_core* image rotated so that the column are vertical
- *Binary_image.tiff* is the binary version of the field area image, using Excess Green and Otsu threshold to discriminate between plants and background. The noise removal is applied here.
- *Binary_straight.jpg* is the *binary_image* rotated so that columns are vertical
- [if the inputted field image is not a binary image] *ExcessGreen.tiff* is the Excess Green version of the field image, used then to produce the binary image. The plant areas are supposed to be darker than the background. If it is not the case, it might be because the original image settings were not good for a binarization. In this case, please use a binary image as an input.
- [if the inputted field image is not a binary image] *Field_area.tiff* is the original image cropped as delimited by the user.
- *Field_points.jpg* is the original image with the region of interest delimitations, as drawn by the user.
- [if the original image is georeferenced] *Intersection_points_georeferenced.csv*: *.csv file containing the coordinates of each micro-plot according to the original image coordinate system
- *Intersection_points_non_georeferenced.csv*: *.csv file containing the pixel coordinates of each micro-plot in the images
- *Metadata.txt*: text file containing all the inputs, files paths and some calculated parameters
- [if the reverse calculation has been done] *Reverse_cal_outputs.csv*: *.csv file containing the coordinates of each plot in the raw data images
- *Skeleton_manipulated.jpg* is the image used to identify the columns; it has been manipulated so that each column is well defined and identifiable
- *Skeleton_original.jpg* is the skeleton of the binary image without any modification

As for the output folders:

- *Horizontal_columns*: *.jpg files of the identified columns, rotated to be horizontal, based on the *Plot_columns_all_clusters* images. These files are used to identify the rows.
- *Plot_columns_binary*: *.jpg files of the identified columns, cropped, in the binary image
- *Plot_columns_core*: *.jpg files of the center area of the identified columns, cropped, in the binary image

- [If the original picture is not a binary] *Plot_columns_original*: *.jpg files of the cropped identified columns, here based on the inputted field image [RGB]
- *Plot_rows_binary*: *.jpg files of the microplots cut out from the binary image and not resized, i.e. with black background
- [If the original picture is not binary] *Plot_rows_original*: *.jpg files of the identified micro-plots, here cut out from the original image [RGB] and resized to fit the plot size
- [If the original image is not binary] *Plot_rows_original_whole*: *.jpg files of the identified micro-plots, here cut out from the original image [RGB] and not resized, i.e with black background
- *SHP_files*: *.shp files and annex files (*.dbf, *.shx) of the identified micro-plots

IF THE CODE IS NOT WORKING

If the rotation of the image is not good, please re-select your region of interest closer to the plot. If you look at the binary image, there might be something that prevent the bounding box, generated by the code to get the angle of the field, to stick to the rows.

If the columns are not well identified, it is probably because of the weeds. You can provide a weed-free binary image if you know of any weed discriminator program, or even do it quickly by hand by erasing the biggest weeds. No need for the field to be strictly weed-free.

A field on which the code is not working is displayed in Annex 2 as an example.

REVERSE CALCULATION

Reverse calculation's goal is to find the pixels associated with each plot in each original images, i.e. go back up from the orthomosaic to the raw drone image. This allows to avoid a diminution in the pictures' quality. For example, the reverse calculation provides a more precise estimate of ground cover compared with the orthomosaic¹.

Here are the equations used to do the reverse calculation for a camera without distortion, using Pix4D mapper² outputs³:

$$(1) \quad (x, y, z)^t = PMat \times (X, Y, Z, 1)^t$$

$$(2) \quad u = \frac{x}{z}$$

$$(3) \quad v = \frac{y}{z}$$

With: (x, y, z) intermediate coordinates

(X, Y, Z) the coordinates of the 3D point cloud (already offset-corrected)

(u, v) the coordinates of the plot in the raw image

PMat the transformation matrix

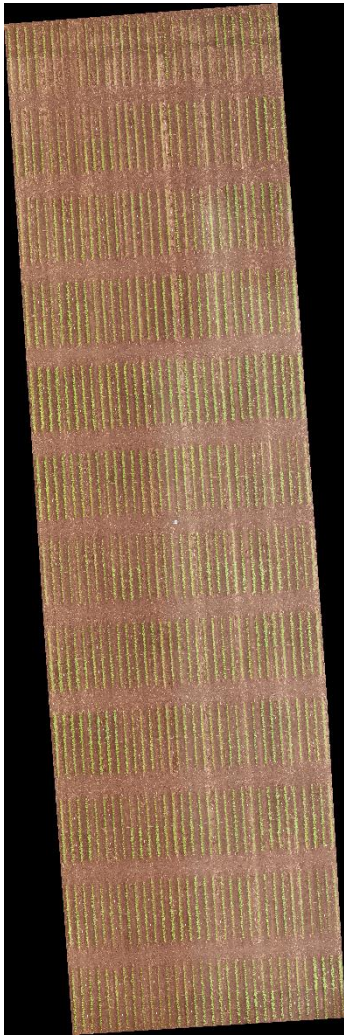
The code has been build using Pix4D outputs, but using another free software can be imagined.

¹ Duan T., Zheng B., Guo W., Ninomiya S., Guo Y. and Chapman S. C. (2016), Comparison of ground cover estimates from experiment plots in cotton, sorghum and sugarcane based on images and ortho-mosaics captured by UAV, *Functional Plant Biology* 44(1) 169-183. <https://doi.org/10.1071/FP16123>

² Pix4D S.A., Lausanne (Switzerland), <https://www.pix4d.com/>

³ Pix4D Support, *What does the Output Params Folder contain?* Available at: <https://support.pix4d.com/hc/en-us/articles/202977149-What-does-the-Output-Params-Folder-contain-#label12>

ANNEX 1: example fields



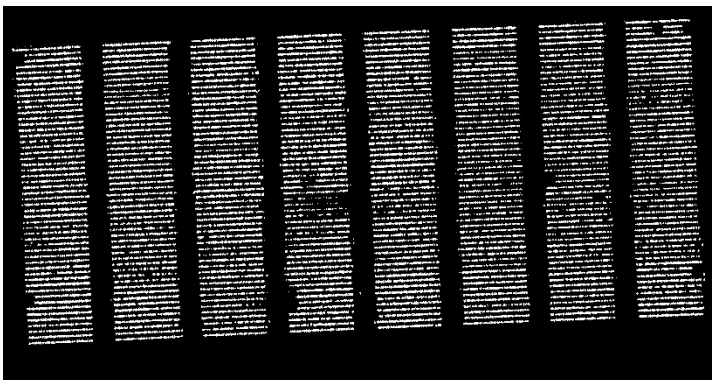
Soybean
[approx. 1 month after sowing]

Parameters:
Noise: 200
Orientation: horizontal



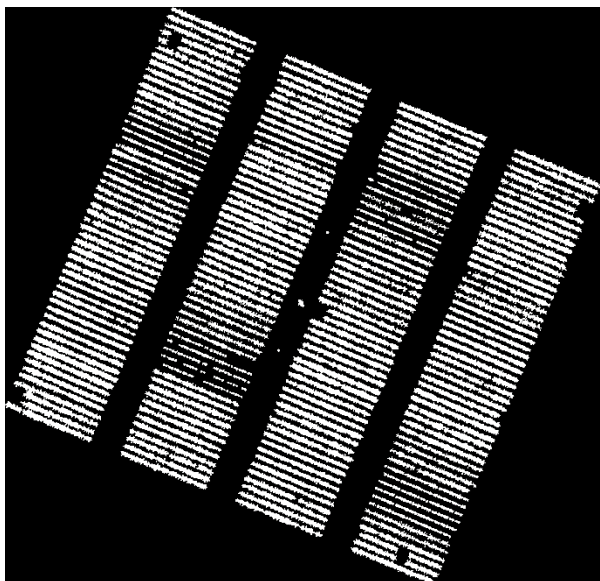
Sugar beet [1 month after sowing]

Parameters:
Noise: 500
Orientation: vertical



Sugar beet [1 month after sowing]

Parameters:
Noise: 100
Orientation: vertical

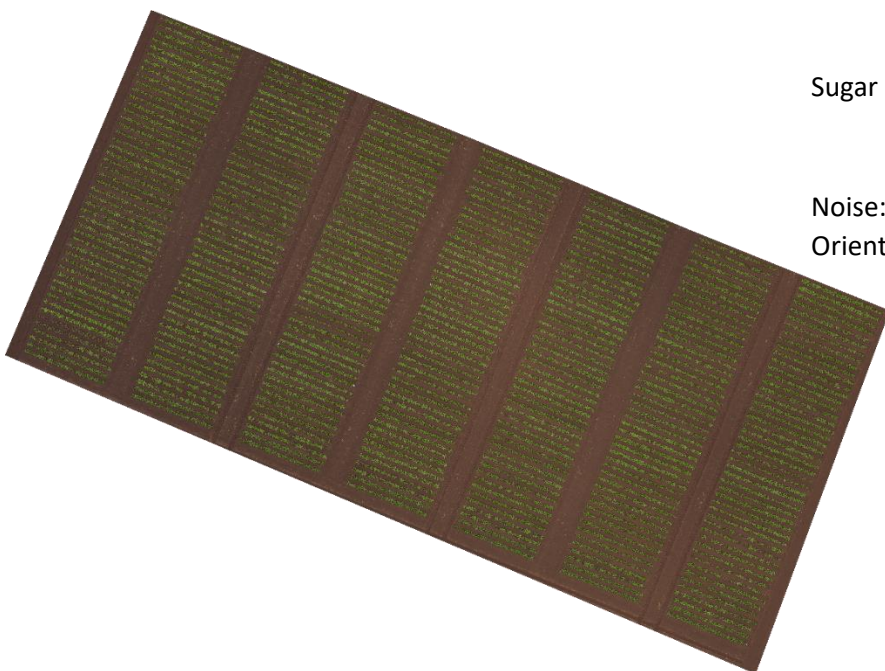


Sugar beet [1 month after sowing]

Parameters:

Noise: 500

Orientation: vertical

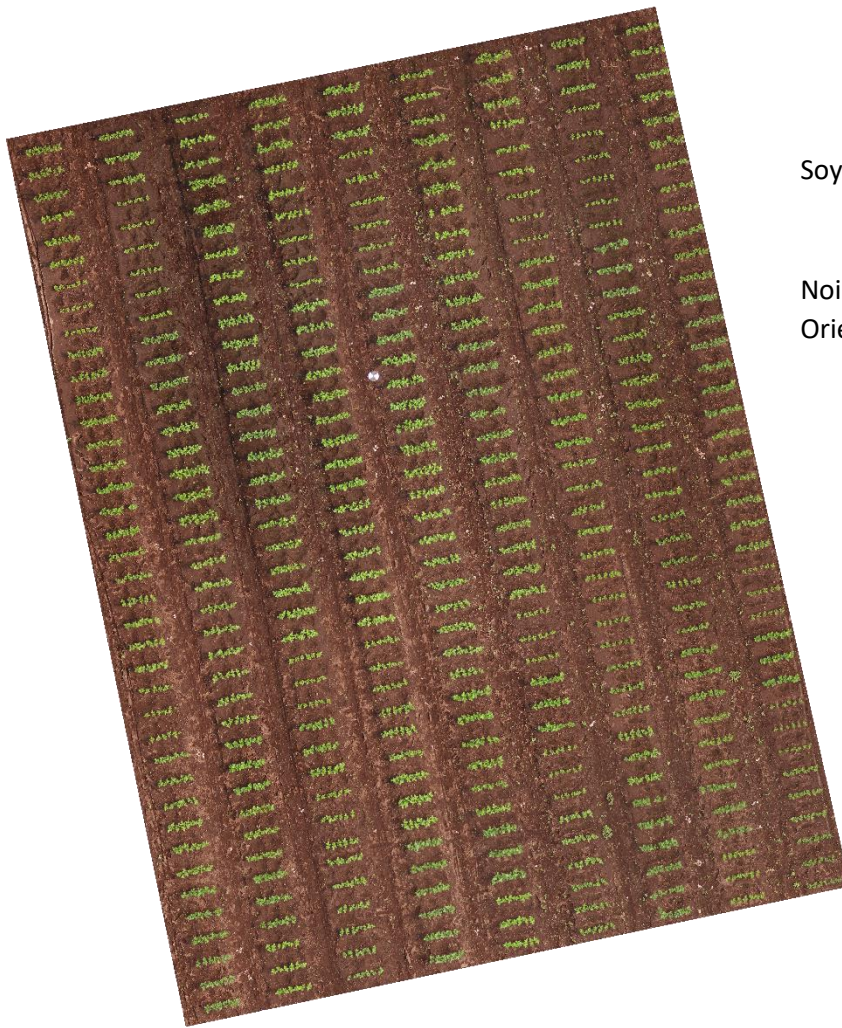


Sugar beet [1 month after sowing]

Parameters:

Noise: 100

Orientation: vertical



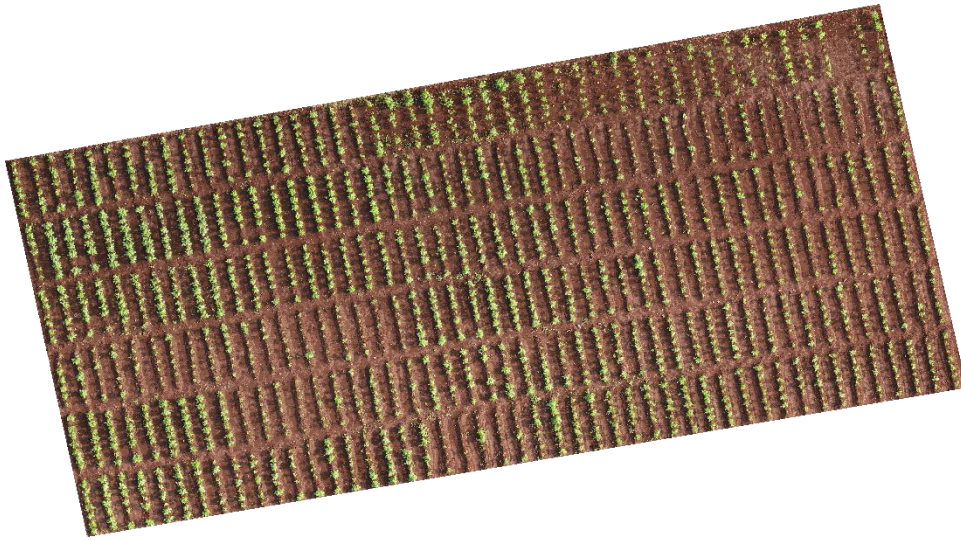
Soybean [1 month after sowing]

Parameters:

Noise: 1000

Orientation: vertical

ANNEX 2: field with too many weeds for the program to work



Whole crop image

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119	120	121	122	123	124	125	126	127	128	129	130	131	132	133	134	135	136	137	138	139	140	141	142	143	144	145	146	147	148	149	150	151	152	153	154	155	156	157	158	159	160	161	162	163	164	165	166	167	168	169	170	171	172	173	174	175	176	177	178	179	180	181	182	183	184	185	186	187	188	189	190	191	192	193	194	195	196	197	198	199	200	201	202	203	204	205	206	207	208	209	210	211	212	213	214	215	216	217	218	219	220	221	222	223	224	225	226	227	228	229	230	231	232	233	234	235	236	237	238	239	240	241	242	243	244	245	246	247	248	249	250	251	252	253	254	255	256	257	258	259	260	261	262	263	264	265	266	267	268	269	270	271	272	273	274	275	276	277	278	279	280	281	282	283	284	285	286	287	288	289	290	291	292	293	294	295	296	297	298	299	300	301	302	303	304	305	306	307	308	309	310	311	312	313	314	315	316	317	318	319	320	321	322	323	324	325	326	327	328	329	330	331	332	333	334	335	336	337	338	339	340	341	342	343	344	345	346	347	348	349	350	351	352	353	354	355	356	357	358	359	360	361	362	363	364	365	366	367	368	369	370	371	372	373	374	375	376	377	378	379	380	381	382	383	384	385	386	387	388	389	390	391	392	393	394	395	396	397	398	399	400	401	402	403	404	405	406	407	408	409	410	411	412	413	414	415	416	417	418	419	420	421	422	423	424	425	426	427	428	429	430	431	432	433	434	435	436	437	438	439	440	441	442	443	444	445	446	447	448	449	450	451	452	453	454	455	456	457	458	459	460	461	462	463	464	465	466	467	468	469	470	471	472	473	474	475	476	477	478	479	480	481	482	483	484	485	486	487	488	489	490	491	492	493	494	495	496	497	498	499	500	501	502	503	504	505	506	507	508	509	510	511	512	513	514	515	516	517	518	519	520	521	522	523	524	525	526	527	528	529	530	531	532	533	534	535	536	537	538	539	540	541	542	543	544	545	546	547	548	549	550	551	552	553	554	555	556	557	558	559	560	561	562	563	564	565	566	567	568	569	570	571	572	573	574	575	576	577	578	579	580	581	582	583	584	585	586	587	588	589	590	591	592	593	594	595	596	597	598	599	600	601	602	603	604	605	606	607	608	609	610	611	612	613	614	615	616	617	618	619	620	621	622	623	624	625	626	627	628	629	630	631	632	633	634	635	636	637	638	639	640	641	642	643	644	645	646	647	648	649	650	651	652	653	654	655	656	657	658	659	660	661	662	663	664	665	666	667	668	669	670	671	672	673	674	675	676	677	678	679	680	681	682	683	684	685	686	687	688	689	690	691	692	693	694	695	696	697	698	699	700	701	702	703	704	705	706	707	708	709	710	711	712	713	714	715	716	717	718	719	720	721	722	723	724	725	726	727	728	729	730	731	732	733	734	735	736	737	738	739	740	741	742	743	744	745	746	747	748	749	750	751	752	753	754	755	756	757	758	759	760	761	762	763	764	765	766	767	768	769	770	771	772	773	774	775	776	777	778	779	780	781	782	783	784	785	786	787	788	789	790	791	792	793	794	795	796	797	798	799	800	801	802	803	804	805	806	807	808	809	810	811	812	813	814	815	816	817	818	819	820	821	822	823	824	825	826	827	828	829	830	831	832	833	834	835	836	837	838	839	840	841	842	843	844	845	846	847	848	849	850	851	852	853	854	855	856	857	858	859	860	861	862	863	864	865	866	867	868	869	870	871	872	873	874	875	876	877	878	879	880	881	882	883	884	885	886	887	888	889	890	891	892	893	894	895	896	897	898	899	900	901	902	903	904	905	906	907	908	909	910	911	912	913	914	915	916	917	918	919	920	921	922	923	924	925	926	927	928	929	930	931	932	933	934	935	936	937	938	939	940	941	942	943	944	945	946	947	948	949	950	951	952	953	954	955	956	957	958	959	960	961	962	963	964	965	966	967	968	969	970	971	972	973	974	975	976	977	978	979	980	981	982	983	984	985	986	987	988	989	990	991	992	993	994	995	996	997	998	999	1000
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Column identification: notice that the two columns on the left are considered as one because of inter-column and overall weed presence