

# The CropAndWeed Dataset: a Multi-Modal Learning Approach for Efficient Crop and Weed Manipulation

## Supplementary Material

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### A. Detection performance by instance size

As an extension to Table 3 of the main paper the complete list of detection performances for individual weed classes is shown in Table 1. The omitted value for *Labiata* results from insufficient representation of according large instances in the test data. Analogously, performance for crop classes by size of all models is presented in Tables 2, 3, 4 and 5.

	S	M	L	Overall
Grasses	19.1	40.9	67.0	<b>34.5</b>
Amaranth	19.4	38.5	66.2	<b>40.8</b>
Goosefoot	33.6	56.9	78.3	<b>51.8</b>
Knotweed	20.6	56.3	66.9	<b>47.7</b>
Corn spurry	24.7	49.4	75.0	<b>41.8</b>
Chickweed	8.4	20.5	53.9	<b>23.0</b>
Solanales	21.9	41.0	76.9	<b>50.9</b>
Potato weed	39.7	45.9	63.5	<b>43.3</b>
Chamomile	27.9	61.2	76.4	<b>58.9</b>
Thistle	40.7	64.5	88.6	<b>62.6</b>
Mercuries	36.8	47.0	31.2	<b>38.6</b>
Geranium	30.5	39.3	41.6	<b>33.7</b>
Crucifer	25.9	61.6	66.5	<b>45.7</b>
Poppy	35.0	66.6	86.4	<b>65.4</b>
Plantago	21.1	56.7	57.2	<b>45.1</b>
Labiata	43.0	48.2	-	<b>45.4</b>
	<b>28.0</b>	<b>49.7</b>	<b>66.4</b>	<b>45.6</b>

Table 1. Performance (mAP) of the *Fine24* detection model by instance size and overall for all weed classes.

### B. Complete label specification

A complete overview of all species currently included in the CropAndWeed dataset, along with their occurrence in recording sessions, images and instances is given in Tables 6 and 7. Furthermore, each plant type is assigned a group

ID for mapping it to the dataset variants presented in Section 4.1 of the main paper, as presented in Table 8.

### C. Extended qualitative results

Figures 1 and 2 show additional qualitative results on the test set for combined detection, segmentation and stem localization, analogous to Figure 6 of the main paper.

	<b>Maize</b>	<b>Sugar beet</b>	<b>Bean</b>	<b>Pea</b>	<b>Sunflower</b>	<b>Soy</b>	<b>Potato</b>	<b>Pumpkin</b>
<b>S</b>	35.1	40.9	45.4	36.3	33.7	41.6	73.4	40.4
<b>M</b>	73.0	75.8	83.4	69.3	78.4	56.2	67.4	80.4
<b>L</b>	84.5	90.2	96.8	73.8	95.6	73.4	73.3	93.9
<b>Overall</b>	<b>76.5</b>	<b>79.0</b>	<b>82.7</b>	<b>66.9</b>	<b>80.6</b>	<b>53.9</b>	<b>70.8</b>	<b>89.2</b>

Table 2. Performance (mAP) of the *Fine24* detection model by instance size for all crop classes along with overall values presented in the main paper.

	<b>Maize</b>	<b>Sugar beet</b>	<b>Bean</b>	<b>Pea</b>	<b>Sunflower</b>	<b>Soy</b>	<b>Potato</b>	<b>Pumpkin</b>
<b>S</b>	40.0	37.2	38.8	28.0	24.9	43.3	39.9	5.3
<b>M</b>	71.4	73.3	71.3	70.5	79.6	57.1	67.6	81.7
<b>L</b>	84.7	94.0	91.1	71.0	98.0	73.8	88.0	95.3
<b>Overall</b>	<b>76.1</b>	<b>81.1</b>	<b>73.6</b>	<b>67.5</b>	<b>81.4</b>	<b>53.9</b>	<b>70.8</b>	<b>88.7</b>

Table 3. Performance (mAP) of the *CropsOrWeed9* detection model by instance size for all crop classes along with overall values presented in the main paper.

	<b>Maize</b>	<b>Sugar beet</b>	<b>Bean</b>	<b>Pea</b>	<b>Sunflower</b>	<b>Soy</b>	<b>Potato</b>	<b>Pumpkin</b>
<b>S</b>	35.1	40.9	45.4	36.3	33.7	41.6	73.4	40.4
<b>M</b>	73.0	75.8	83.4	69.3	78.4	56.2	67.4	80.4
<b>L</b>	84.5	90.2	96.8	73.8	95.6	73.4	73.3	93.9
<b>Overall</b>	<b>76.5</b>	<b>79.0</b>	<b>82.7</b>	<b>66.9</b>	<b>80.6</b>	<b>53.9</b>	<b>70.8</b>	<b>89.2</b>

Table 4. Performance (mAP) of the *Crop2* detection models by instance size for all crop classes along with overall values presented in the main paper.

	<b>Maize</b>	<b>Sugar beet</b>	<b>Bean</b>	<b>Pea</b>	<b>Sunflower</b>	<b>Soy</b>	<b>Potato</b>	<b>Pumpkin</b>
<b>S</b>	33.9	30.4	37.7	0.0	8.3	27.6	0.0	0.0
<b>M</b>	71.7	72.1	68.1	35.6	66.4	55.2	10.5	42.1
<b>L</b>	83.1	88.7	81.0	16.1	75.3	72.1	29.5	85.0
<b>Overall</b>	<b>75.0</b>	<b>74.4</b>	<b>68.3</b>	<b>29.4</b>	<b>62.9</b>	<b>52.8</b>	<b>21.2</b>	<b>74.3</b>

Table 5. Performance (mAP) of the *Crop1* detection models by instance size for all crop classes along with overall values presented in the main paper.

Species	Botanical Classification	Crop/Weed	Sessions	Images	Instances	Mapping
Soil	Soil	-	-	-	-	-
Maize	<i>Zea mays</i>	C	167	1834	6018	1
Sugar beet	<i>Beta vulgaris</i> subsp. <i>vulgaris</i>	C	133	1210	6161	2
Pea	<i>Pisum sativum</i>	C	18	176	621	6
Courgette	<i>Cucurbita pepo</i> subsp. <i>p. c. g.</i>	C	1	18	22	-
Pumpkins	<i>Cucurbita</i>	C	11	317	615	8
Potato	<i>Solanum tuberosum</i>	C	15	108	371	5
Flat leaf parsley	<i>Petroselinum stivum</i>	C	1	14	35	-
Curly leaf parsley	<i>Petroselinum crispum</i>	C	1	10	35	-
Cowslip	<i>Primula veris</i>	C	1	19	108	-
Poppy	<i>Papaver</i>	C	1	2	25	22
Sunflower	<i>Helianthus annuus</i>	C	62	590	1879	4
Sage	<i>Salvia</i>	C	1	2	23	-
Common bean	<i>Phaseolus vulgaris</i>	C	2	13	109	7
Faba bean	<i>Vicia faba</i>	C	20	216	952	7
Hybrid goosefoot	<i>Chenopodium hybridum</i>	W	72	205	329	11
Black-bindweed	<i>Fallopia convolvulus</i>	W	15	45	195	12
Cocksbur grass	<i>Echinochloa crus-galli</i>	W	118	270	1280	10
Red-root amaranth	<i>Amaranthus retroflexus</i>	W	203	491	3484	10
White goosefoot	<i>Chenopodium album</i>	W	322	1121	3180	11
Thorn apple	<i>Datura stramonium</i>	W	46	167	469	15
Potato weed	<i>Galinsoga parviflora</i>	W	219	636	2563	16
German chamomile	<i>Matricaria chamomilla</i>	W	102	300	2113	17
Creeping thistle	<i>Cirsium arvense</i>	W	86	410	2693	18
Field milk thistle	<i>Sonchus arvensis</i>	W	202	513	2623	18
Purslane	<i>Portulaca oleracea</i>	W	22	30	70	-
Black nightshade	<i>Solanum nigrum</i>	W	9	9	14	15
Mercuries	<i>Mercurialis</i>	W	253	812	1147	19
Geraniums	<i>Geranium</i>	W	41	90	667	20
Cleavers	<i>Galium aparine</i>	W	8	20	35	-
Meadow-grass	<i>Poa</i>	W	232	763	3785	10
Frosted orach	<i>Atriplex laciniata</i>	W	1	1	1	11
Black horehound	<i>Ballota nigra</i>	W	1	1	1	24
Shepherd's purse	<i>Capsella bursa-pastoris</i>	W	4	5	8	21
Field bindweed	<i>Convolvulus arvensis</i>	W	57	161	533	15
Common mugwort	<i>Artemisia vulgaris</i>	W	2	2	2	-
Hedge mustard	<i>Sisymbrium</i>	W	19	22	29	21
Speedwell	<i>Veronica</i>	W	37	53	108	23
Broadleaf plantain	<i>Plantago major</i>	W	9	12	12	23
White ball-mustard	<i>Calepina irregularis</i>	W	1	1	2	21
Peppermint	<i>Mentha piperita</i>	W	18	84	602	24
Field pennycress	<i>Thlaspi arvense</i>	W	22	79	118	21
Corn spurry	<i>Spergula arvensis</i>	W	19	125	922	13
Purple crabgrass	<i>Digitaria sanguinalis</i>	W	9	81	473	10
Common fumitory	<i>Fumaria officinalis</i>	W	11	73	227	22
Ivy-leaved speedwell	<i>Veronica hederifolia</i>	W	10	60	237	23
Annual meadow grass	<i>Poa annua</i>	W	6	24	447	10
Redshank	<i>Persicaria maculosa</i>	W	30	129	428	12
Rough meadow-grass	<i>Poa trivialis</i>	W	4	17	405	10

Table 6. Full list of annotated species included in the CropAndWeed dataset and corresponding numbers of sessions, images and instances depicting them as well as mapping ids for deriving dataset variants presented in Table 8 (part 1).

Species	Botanical Classification	Crop/Weed	Sessions	Images	Instances	Mapping
Green bristlegrass	<i>Setaria viridis</i>	W	287	1648	12132	10
Small geranium	<i>Geranium pusillum</i>	W	42	406	4428	20
Cornflower	<i>Cyanus segetum</i>	W	27	270	1780	18
Common corn-cockle	<i>Agrostemma githago</i>	W	20	211	1601	18
Wall barley	<i>Hordeum murinum</i>	W	16	88	466	10
Annual fescue	<i>Festuca myuros</i>	W	4	9	85	10
Purple dead-nettle	<i>Lamium purpureum</i>	W	27	39	47	24
Ribwort plantain	<i>Plantago lanceolata</i>	W	14	100	943	23
Pineappleweed	<i>Matricaria discoidea</i>	W	25	69	608	17
Common chickweed	<i>Stellaria media</i>	W	36	86	219	14
Hedge mustard	<i>Sisymbrium officinale</i>	W	25	121	917	21
Soft brome	<i>Bromus hordeaceus</i>	W	8	47	368	10
Wild pansy	<i>Viola tricolor</i>	W	46	96	263	-
Yellow rocket	<i>Barbarea vulgaris</i>	W	19	81	379	21
Common wild oat	<i>Avena fatua</i>	W	22	105	390	10
Red poppy	<i>Papaver rhoeas</i>	W	15	39	630	22
Rye brome	<i>Bromus secalinus</i>	W	8	66	594	10
Knotgrass	<i>Polygonum aviculare</i> agg.	W	43	67	408	12
Prickly lettuce	<i>Lactuca serriola</i>	W	3	5	5	18
Copse-bindweed	<i>Fallopia dumetorum</i>	W	194	858	1790	12
Common buckwheat	<i>Fagopyrum esculentum</i>	W	19	83	211	12
Garlic	<i>Allium sativum</i>	C	1	1	2	-
Soybean	<i>Glycine max</i>	C	42	336	4039	3
Wild carrot	<i>Daucus carota</i> supsp. <i>carota</i>	W	18	42	69	-
Field mustard	<i>Sinapis arvensis</i>	W	28	49	402	21
Common dandelion	<i>Taraxacum</i> sect. <i>Ruderalia</i>	W	1	1	1	-
Vegetation	Vegetation	W	788	5066	33000	26
<b>Overall</b>			<b>929</b>	<b>8034</b>	<b>111953</b>	

Table 7. Full list of annotated species included in the CropAndWeed dataset and corresponding numbers of sessions, images and instances depicting them as well as mapping ids for deriving dataset variants presented in Table 8 (part 2).

Mapping	Fine24	CropsOrWeed9	CropOrWeed2	Coarse1	Maize2	Maize1
1	Maize	Maize	Crop		Maize	Maize
2	Sugar beet	Sugar beet				
3	Sunflower	Sunflower				
4	Bean	Bean				
5	Pea	Pea				
6	Soy	Soy				
7	Potato	Potato				
8	Pumpkin	Pumpkin				
9	Grasses	Weed	Weed	Vegetation	Other	-
10	Thistle					
11	Geranium					
12	Knotweed					
13	Amaranth					
14	Goosefoot					
15	Potato weed					
16	Chamomile					
17	Crucifer					
18	Plantago					
19	Poppy					
20	Corn spurry					
21	Mercuries					
22	Solanales					
23	Chickweed					
24	Labiata					

Table 8. Mapping of species listed in Tables 6 and 7 to the classes of the defined dataset variants. The mappings for all other crop-specific variants summarized as *Crop[2/1]* (*Sugar beet, Sunflower, Bean, Pea, Soy, Potato* and *Pumpkin*) are analogous to *Maize2* and *Maize1*.

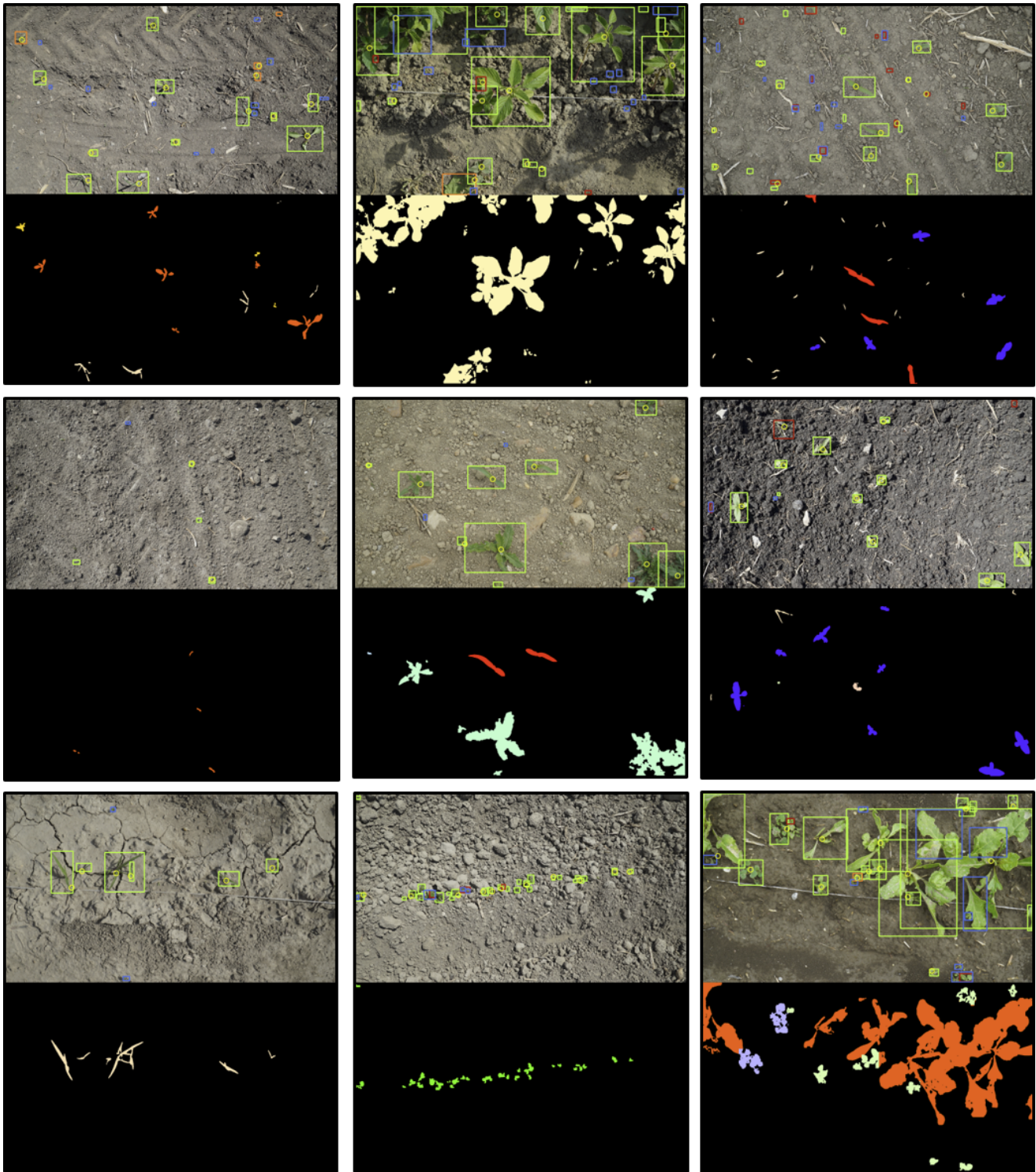


Figure 1. Representative selection of combined qualitative results on the test set for detection, segmentation and stem localization. Top rows show detection results of the *Fine24* model (green: correct detection (*TP*), orange: correct localization, but incorrect class, red: incorrect detection (*FP*), blue: undetected ground-truth object (*FN*)). The detections are then used as inputs for stem localization (yellow) and the *Coarse1* segmentation model. Results of the latter are demonstrated in the bottom rows, with colors corresponding to the detected classes.



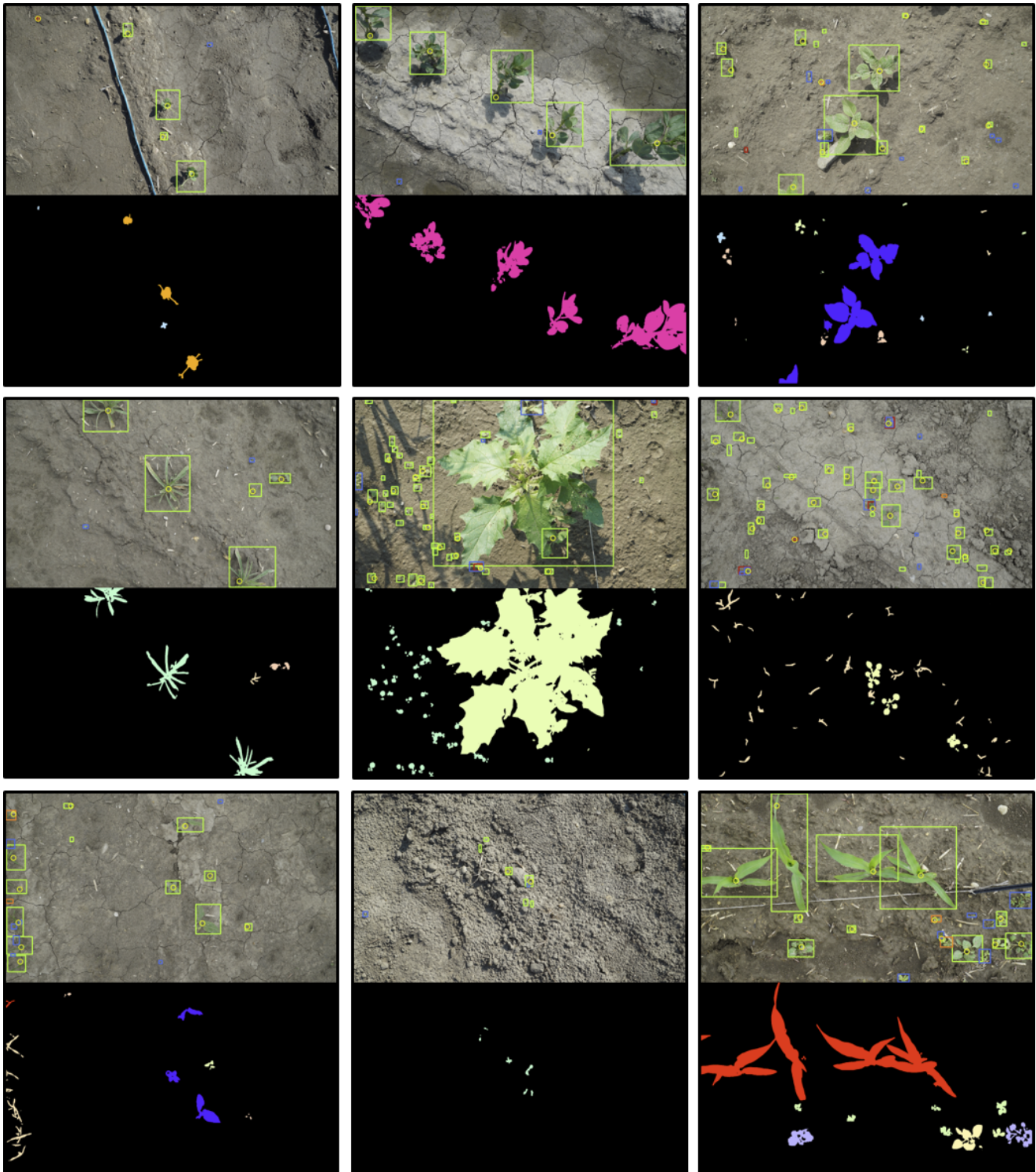


Figure 2. Representative selection of combined qualitative results on the test set for detection, segmentation and stem localization. Top rows show detection results of the *Fine24* model (green: correct detection (*TP*), orange: correct localization, but incorrect class, red: incorrect detection (*FP*), blue: undetected ground-truth object (*FN*)). The detections are then used as inputs for stem localization (yellow) and the *Coarse1* segmentation model. Results of the latter are demonstrated in the bottom rows, with colors corresponding to the detected classes.