SUPPLEMENTARY MATERIAL

Estimation of the 2D cross-sectional area of the wetting pattern under drip irrigation and spatio-temporal variation of the components of the wetting pattern

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PART A: ADDITIONAL RESULTS

In this investigation, water was applied to the clay soil from the emitter at a discharge of 2.1 L/h during a period of 170 min. The following results are given here:

- Maximum depth of the wetting pattern measured in the experiment and obtained from the formulas devised
- The momentary rate of change of variation of the maximum depths of the wetting pattern as calculated by the formulas devised and as measured in the experiment
- The average rate of change of variation of the maximum depths of the wetting pattern as calculated by the formulas devised and as measured in the experiment
- The momentary acceleration of variation of the maximum depths of the wetting pattern as calculated by the formulas devised and as measured in the experiment
- The average acceleration of variation of the maximum depths of the wetting pattern as calculated by the formulas devised and as measured in the experiment
- Schematic view of the rate of change (V_y1 and V_y2) of the wetting diameter $b1$ and $b2$ which was calculated separately by the formulas devised for cross-sections I and II respectively, and the rate of change (*Vay*) of the wetting diameter ay which was measured as a whole in the experiment
- The comparison between the momentary values of (V_y1+V_y2) and (*Vay*) calculated by the formulas devised and measured in the experiment
- The comparison between the average values of (V_y1ort + V_y2ort) and (*Vayort*) calculated by the formulas devised and measured in the experiment
- The comparison between the momentary values of (I_y1 + I_y2) and (*Iay*) calculated by the formulas devised and measured in the experiment
- The comparison between the average values of (I_y1ort + I_y2 *ort*) and (*Iayort*) calculated by the formulas devised and measured in the experiment
- The cross-sectional areas of cross-sections I and II in the wetting pattern
- Temporal variation of the cross-sectional areas of cross-section I and cross-section II
- The momentary rate of change of the size of the wetted area in the soil profile
- The momentary acceleration of variation of the size of the wetted area in the soil profile
- The average acceleration of variation of the size of the wetted area in the soil profile

Table S1. Maximum depth of the wetting pattern measured in the experiment and obtained from the formulas devised

Elapsed time (min)	Maximum depth of the wetting pattern measured in the experiment (cm)	Maximum depth of the wetting pattern obtained from the formula devised (cm)	Elapsed time (min)	Maximum depth of the wetting pattern measured in the experiment (cm)	Maximum depth of the wetting pattern obtained from the formula devised (cm)
5	7.6	7.3	90	37.0	34.7
10	11.0	11.5	95	37.9	35.1
15	12.5	13.8	100	38.6	35.6
20	15.6	17.9	105	39.0	36.6
25	17.5	19.4	110	40.1	37.0
30	19.5	21.9	115	41.2	38.0
35	21.5	24.8	120	42.4	39.0
40	22.9	29.0	125	43.5	40.7
45	24.4	31.9	130	44.7	41.1
50	26.5	34.1	135	45.8	42.1
55	27.7	32.7	140	47.0	43.1
60	29.8	29.7	145	48.1	44.6
65	31.3	30.4	150	49.3	49.3
70	32.1	30.9	155	50.4	51.9
75	33.2	31.2	160	51.6	53.3
80	34.5	32.7	165	52.7	55.2
85	35.3	33.5	170	53.9	57.7

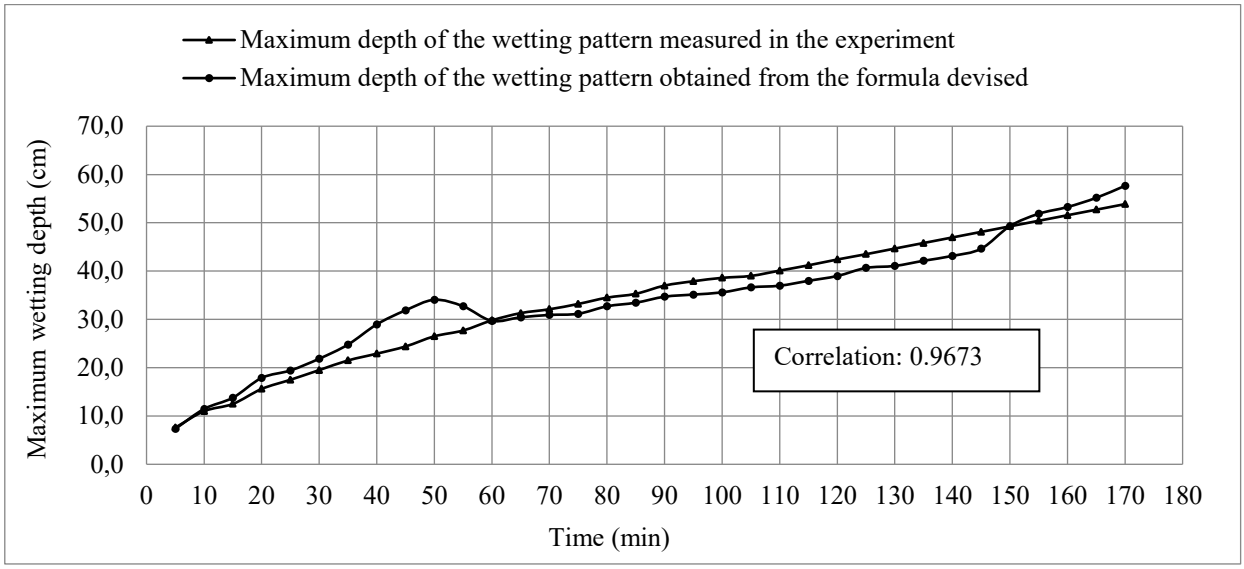

Figure S1. *Maximum depth of the wetting pattern measured in the experiment and obtained from the formulas devised*

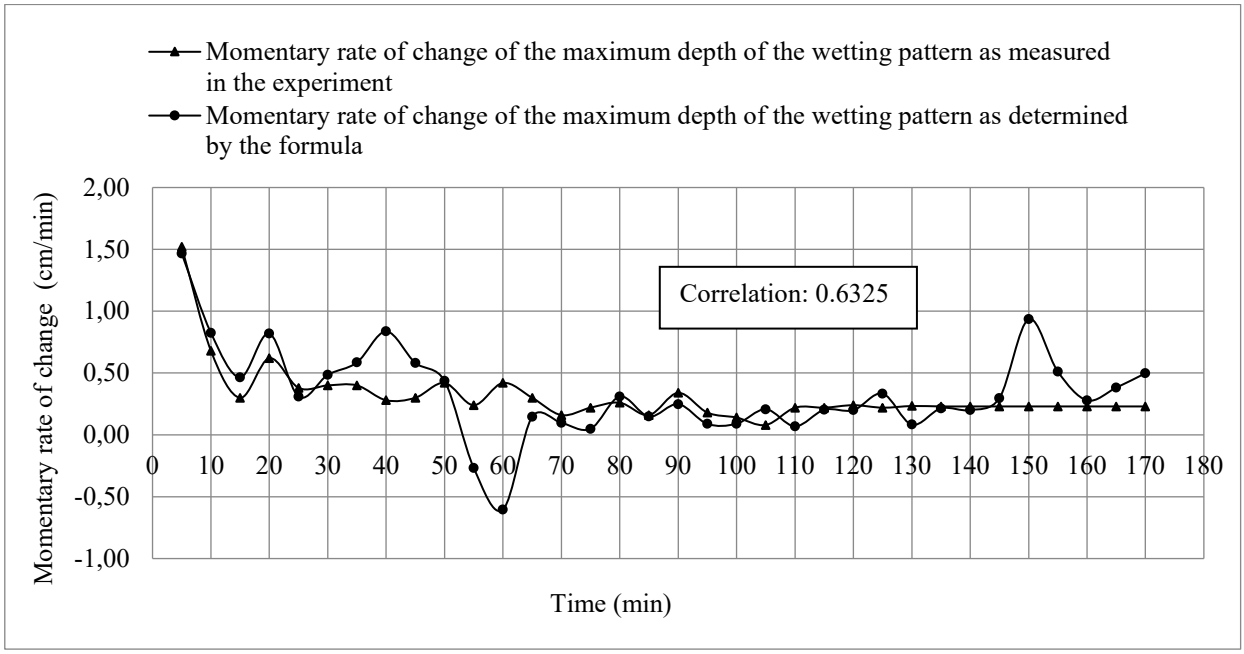

Figure S2. *The momentary rate of change of variation of the maximum depths of the wetting pattern as calculated by the formulas devised and as measured in the experiment*

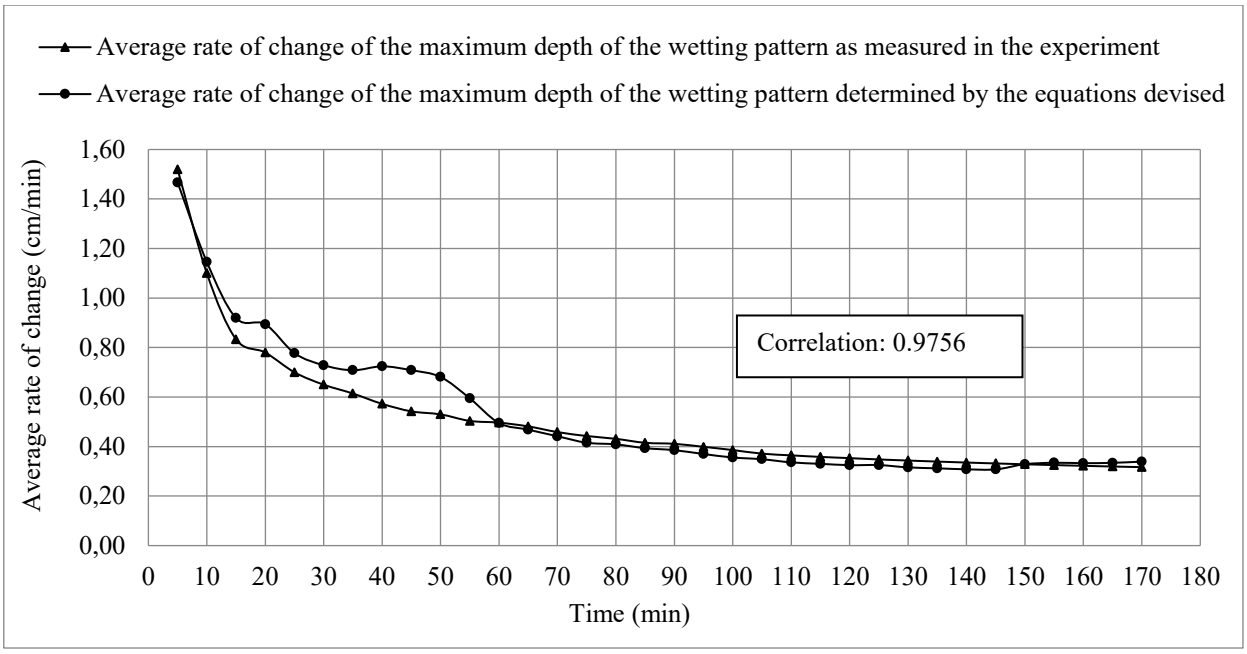

Figure S3. *The average rate of change of variation of the maximum depths of the wetting pattern as calculated by the formulas devised and as measured in the experiment*

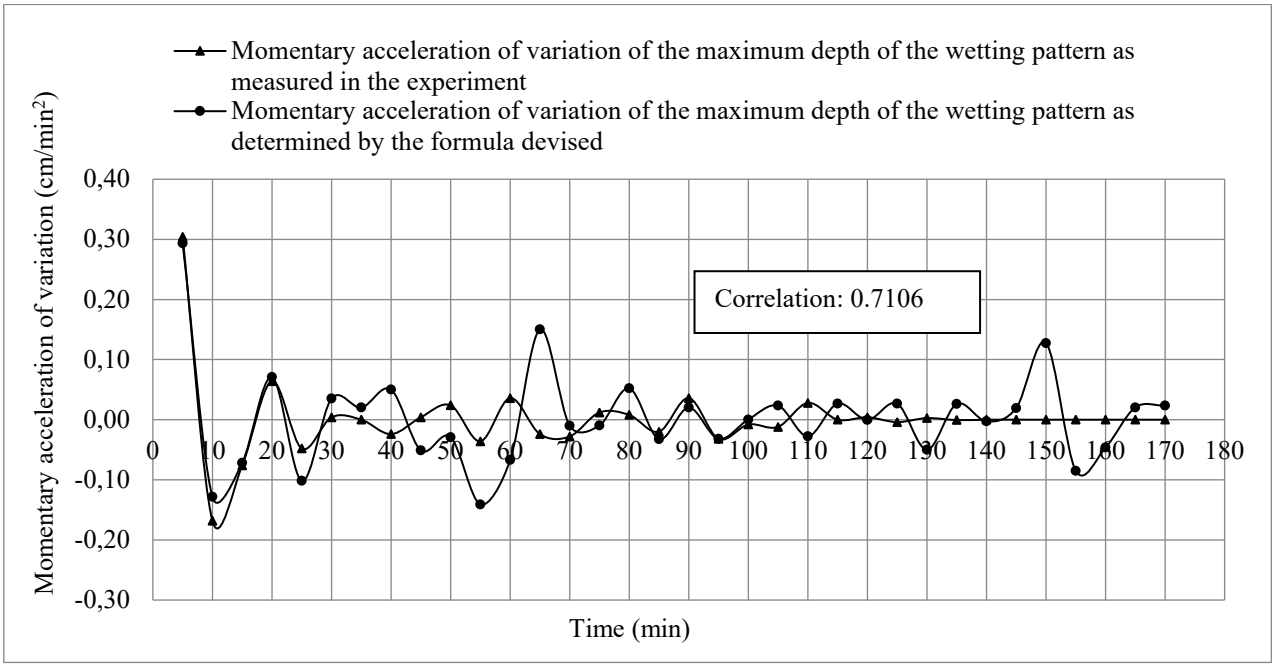

Figure S4. *The momentary acceleration of variation of the maximum depths of the wetting pattern as calculated by the formulas devised and as measured in the experiment*

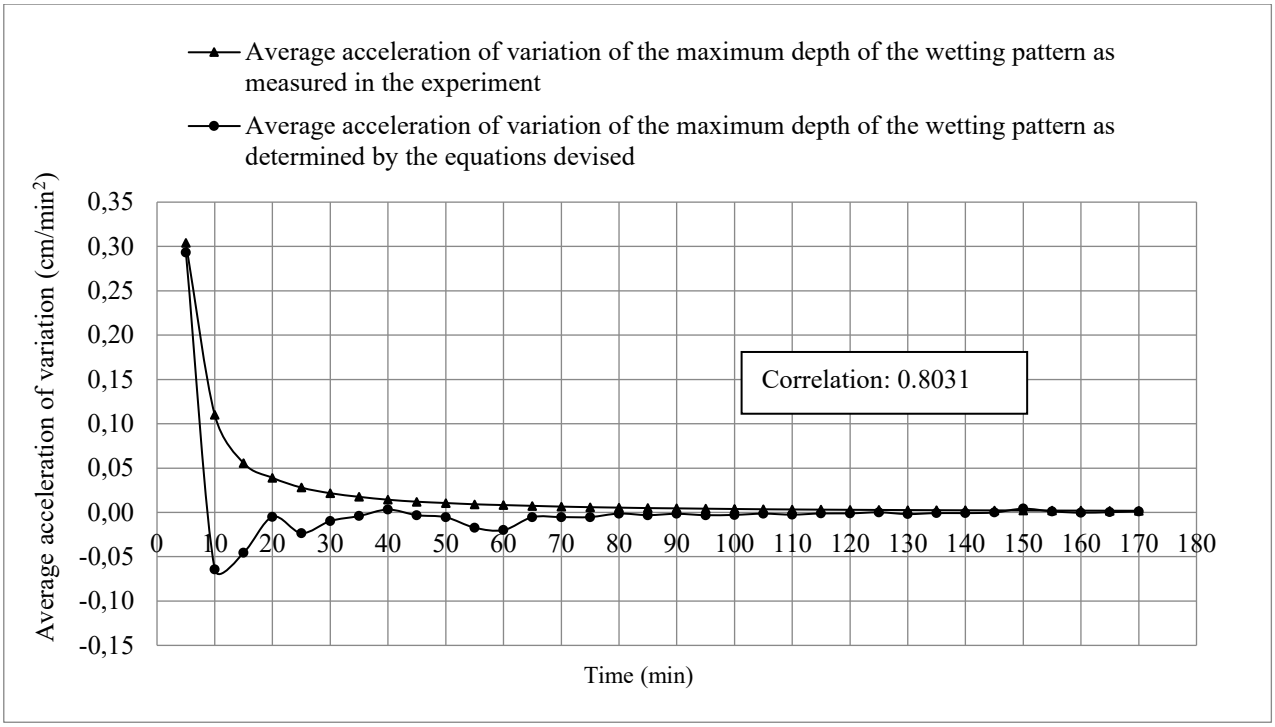

Figure S5. *The average acceleration of variation of the maximum depths of the wetting pattern as calculated by the formulas devised and as measured in the experiment*

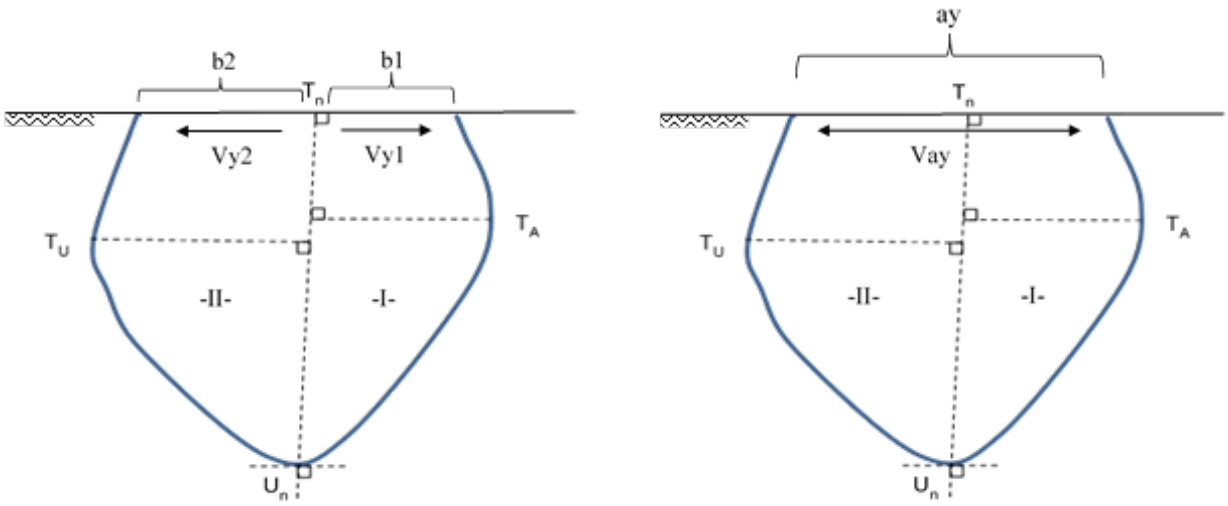

Figure S6. *Schematic view of the rate of change (*V_y1 *and* V_y2*) of the wetting diameter* b*1 and* b*2 which was calculated separately by the formulas devised for cross-sections I and II, respectively, and the rate of change (*Vay*) of the wetting diameter* ay *which was measured as a whole in the experiment*

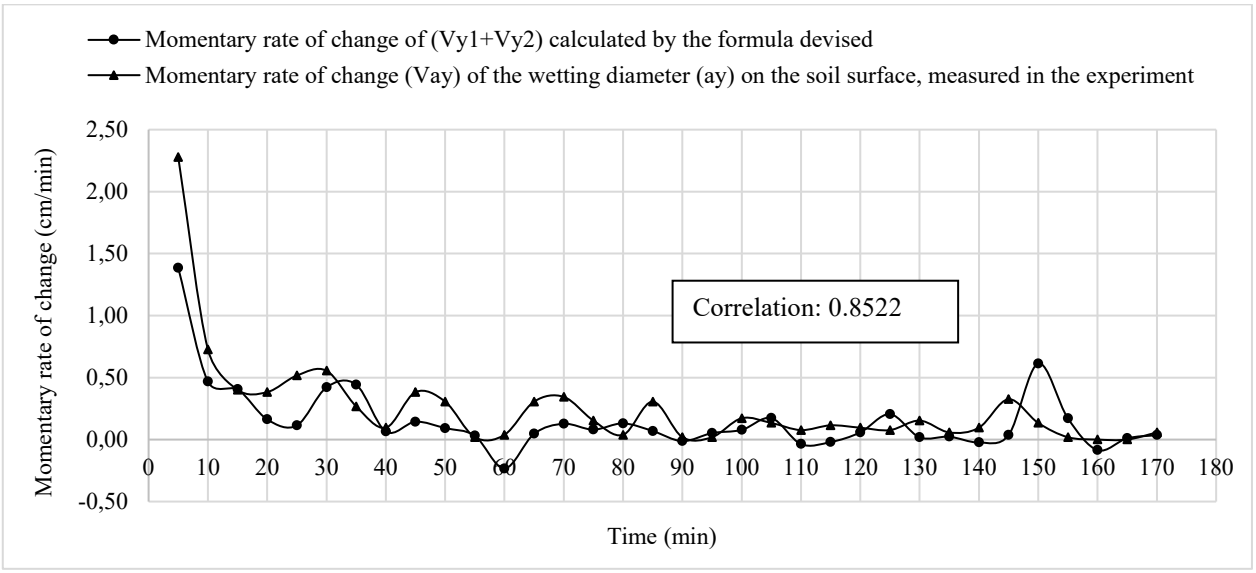

Figure S7. *The comparison between the momentary values of (*V_y1 *+* V_y2*) and (*Vay*) calculated by the formulas devised and measured in the experiment*

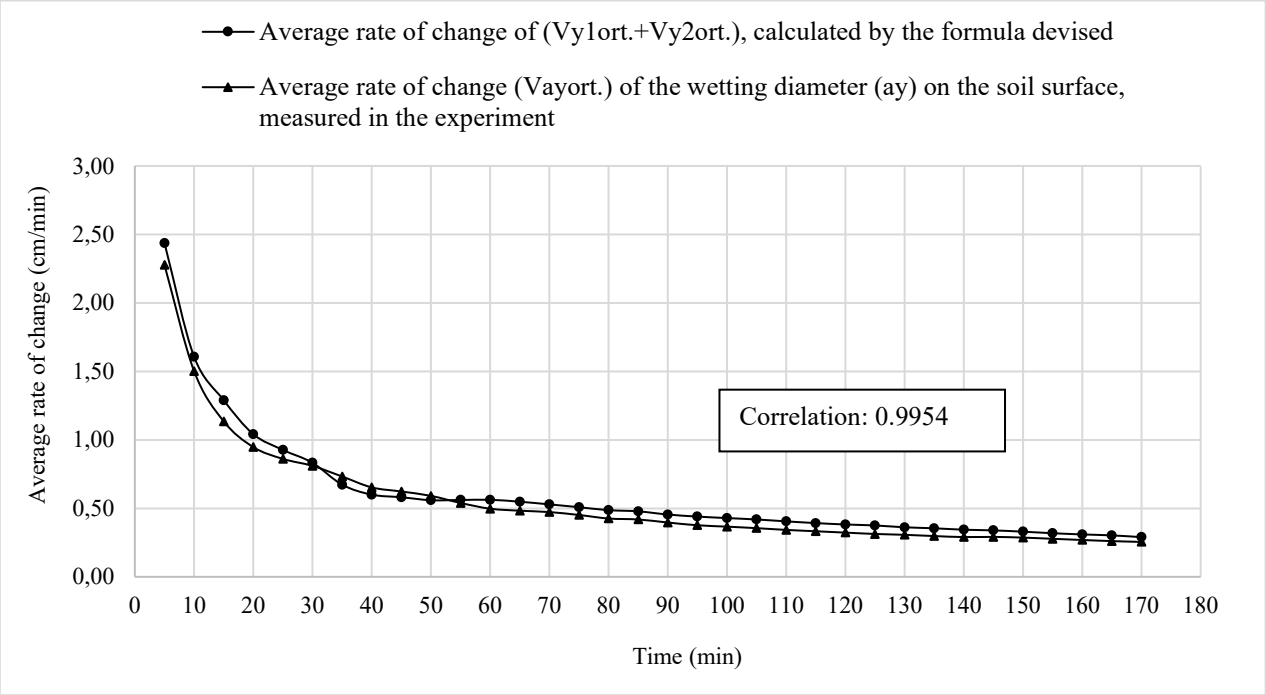

Figure S8. *The comparison between the average values of (*V_y*1ort + *V_y*2ort) and (*Vayort*) calculated by the formulas devised and measured in the experiment*

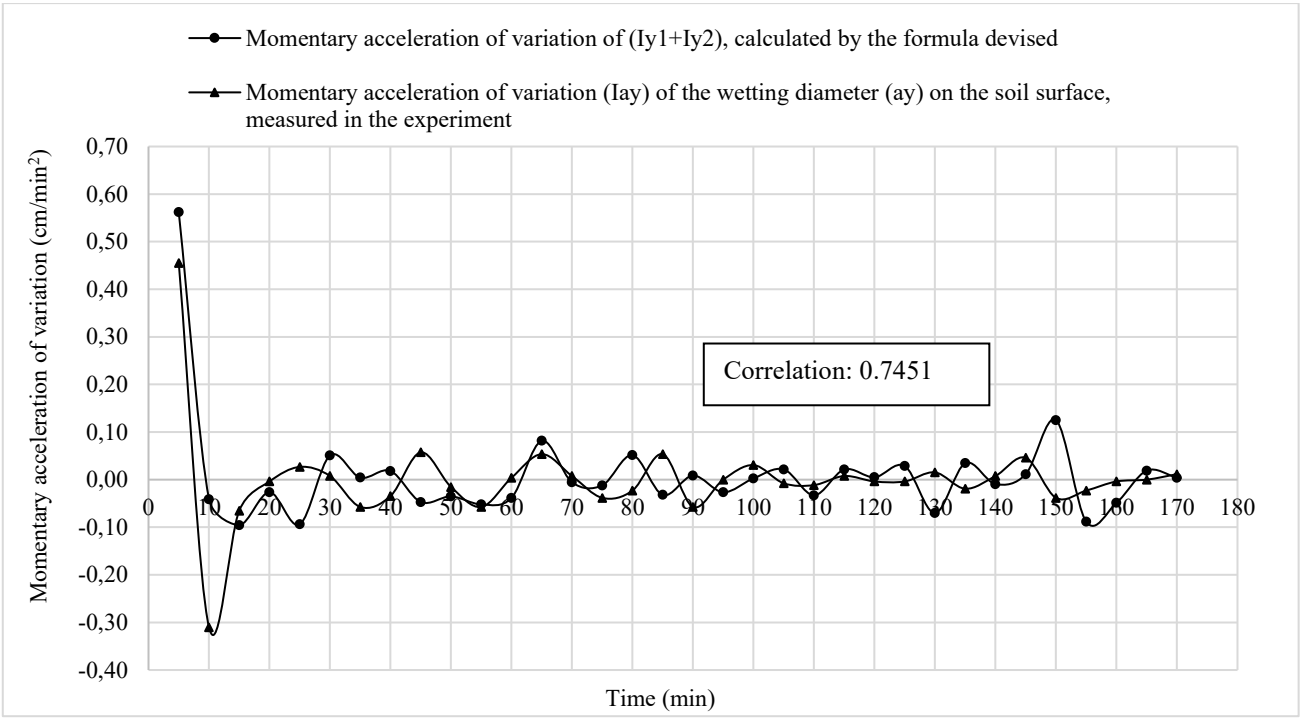

Figure S9. *The comparison between the momentary values of (*I_y*1 + *I_y*2) and (Iay) calculated by the formulas devised and measured in the experiment*

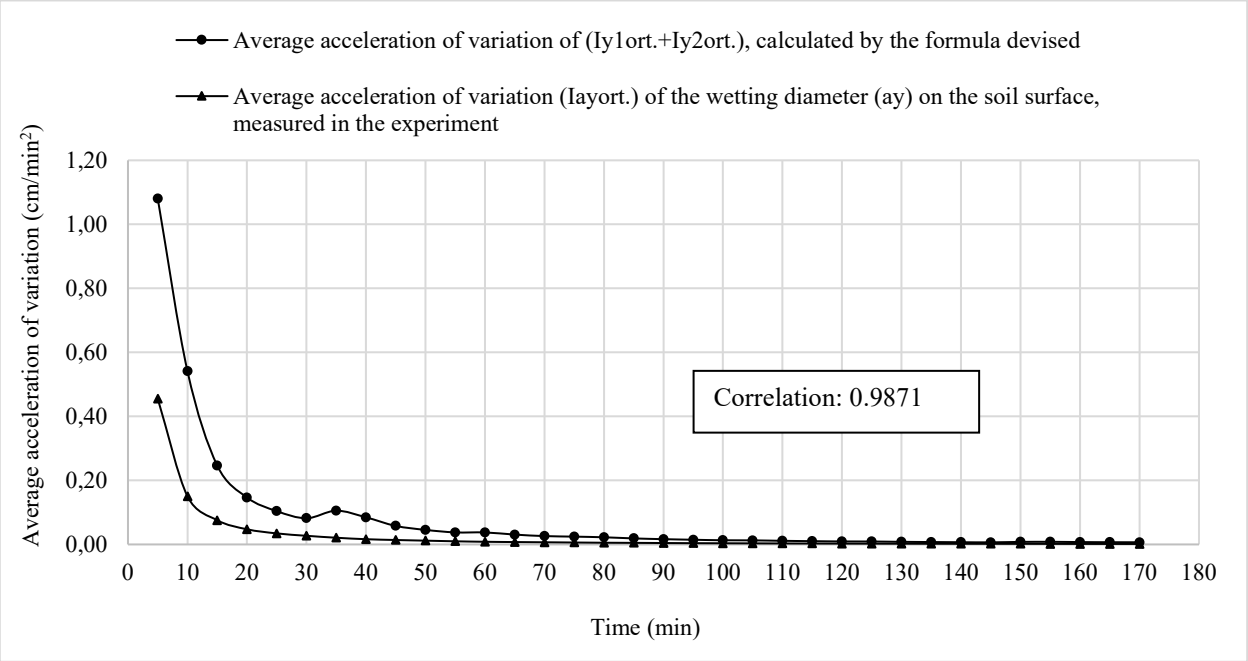

Figure S10. *The comparison between the average values of (*I_y*1*ort *+* I_y*2*ort*) and (*Iayort*) calculated by the formulas devised and measured in the experiment*

Table S2. The areas of Cross-sections I and II in the wetting pattern

Elapsed time (min)	Size of the cross-section I (cm^2)	Size of the cross-section II (cm^2)	Elapsed time (min)	Size of the cross-section I (cm^2)	Size of the cross-section II (cm^2)
5	31.49	36.96	90	507.62	536.02
10	62.49	72.67	95	524.24	565.01
15	97.32	96.66	100	542.41	599.95
20	135.00	119.63	105	560.74	644.30
25	155.10	160.84	110	567.74	677.61
30	193.94	184.37	115	589.88	714.79
35	206.52	207.84	120	619.81	743.04
40	251.20	239.72	125	671.63	770.81
45	298.78	257.54	130	666.50	810.80
50	334.87	294.71	135	694.82	856.22
55	364.05	328.40	140	715.47	884.18
60	361.19	346.44	145	744.35	951.85
65	387.69	392.85	150	833.39	985.74
70	408.14	415.96	155	879.00	1 017.36
75	413.93	446.92	160	908.93	1 050.46
80	447.38	477.24	165	958.54	1 084.68
85	477.74	519.41	170	995.84	1 085.74

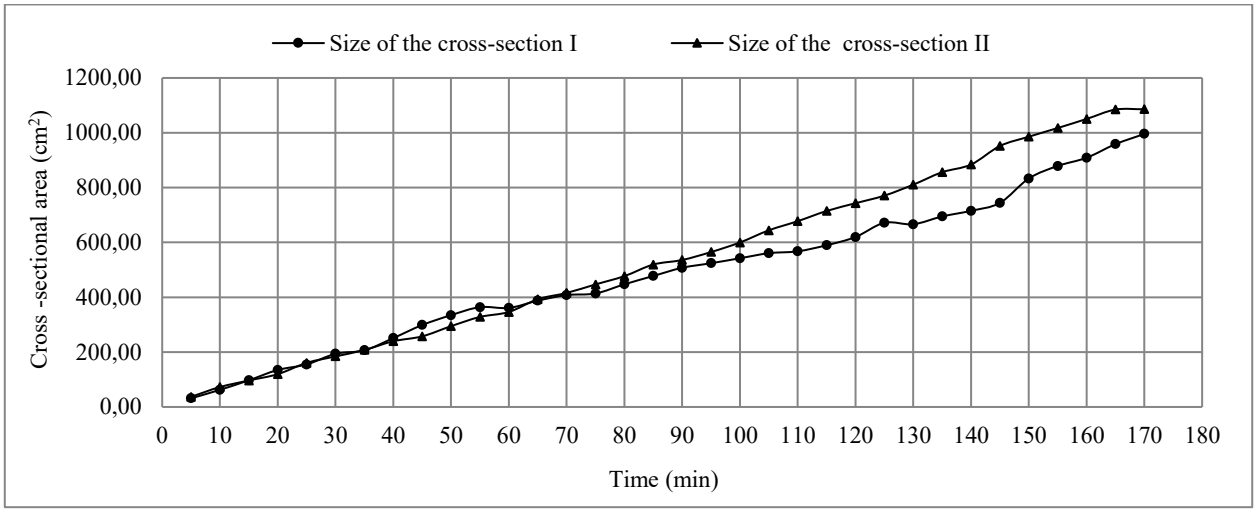

Figure S11. *Temporal variation of the areas of cross-section I and cross-section II*

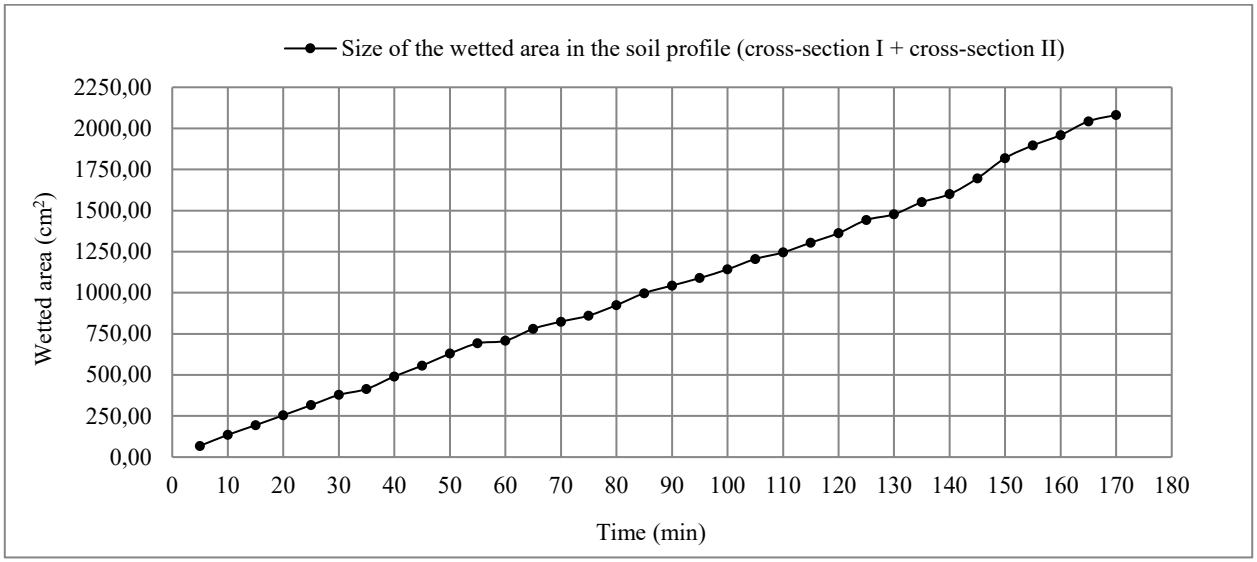

Figure S12. *The size of the wetted area in the soil profile and its temporal variation in a drip irrigation system*

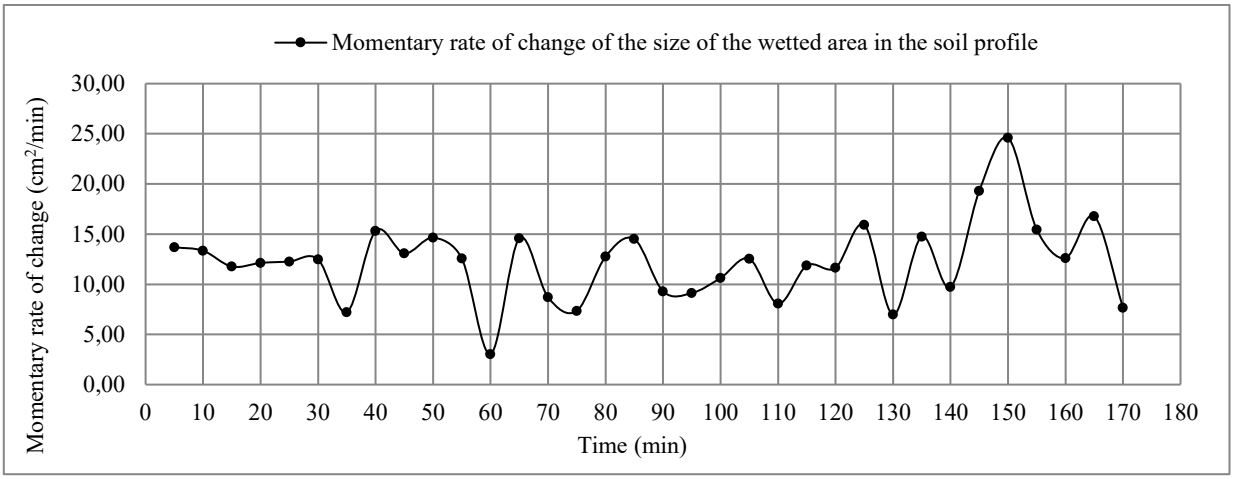

Figure S13. *The momentary rate of change of the size of the wetted area in the soil profile*

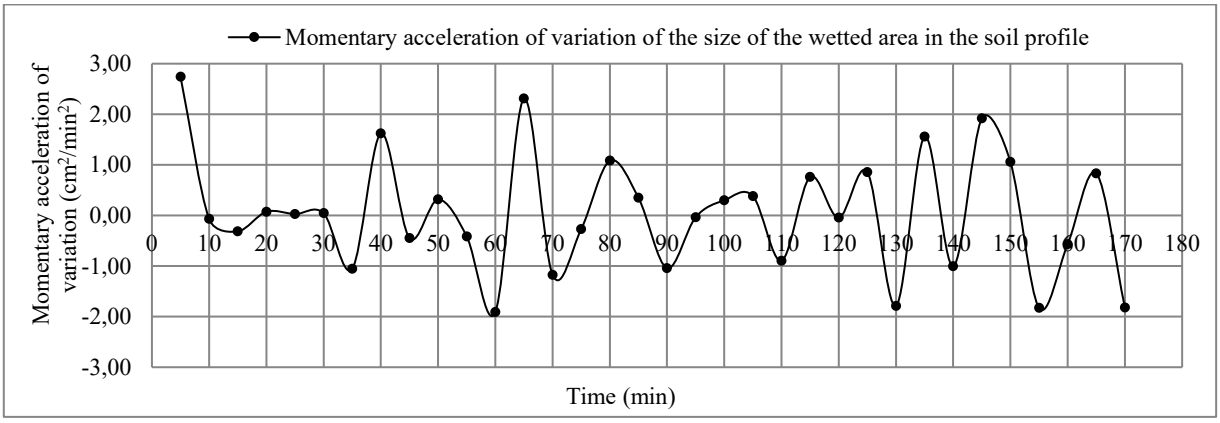

Figure S14. *The momentary acceleration of variation of the size of the wetted area in the soil profile*

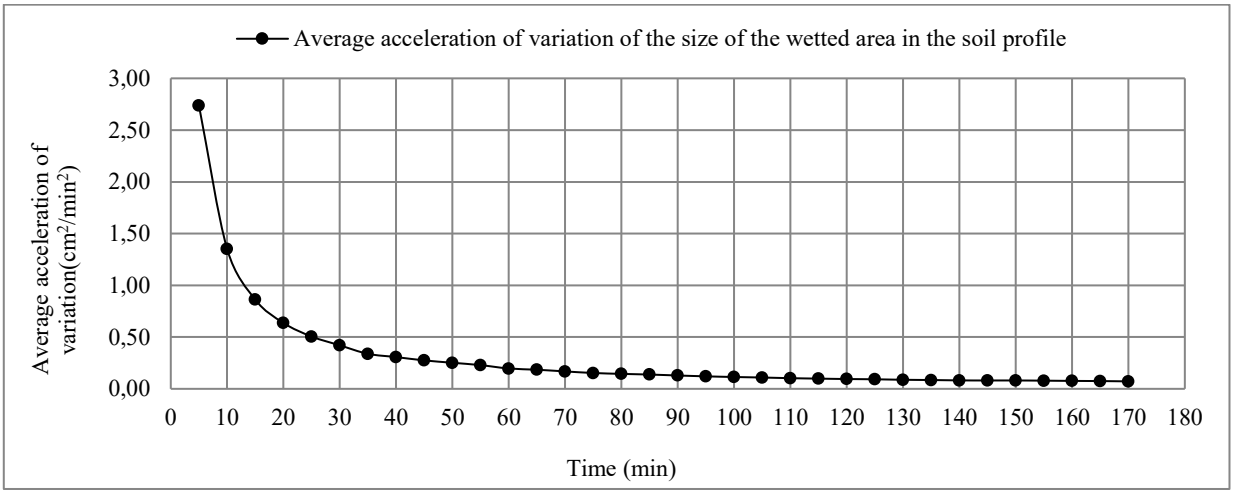

Figure S15. *The average acceleration of variation of the size of the wetted area in the soil profile*

PART B: CONFIRMATION OF MODEL VALIDITY BY FIELD EXPERIMENTS AND DIGITAL PLANIMETER MEASUREMENTS

Model solutions and digital planimeter measurements for field experiments

Three different experiments were carried out under field conditions where the soil samples were taken for the laboratory experiments. The experiments under field conditions are carried out for two different soils with the textures clay loam (Field Experiments 1 and 2) and clay (Field Experiment 3). The measured container method is used in determining the dripper discharges. These measurements are carried out in two repetitions in field conditions. Digital planimeter measurements were performed by two repetitions for all the 2D cross-sectional areas of the wetting patterns from the field experiments.

Field experiment 1

Water application period: 20 min. Dripper discharge: 0.78 L/h.

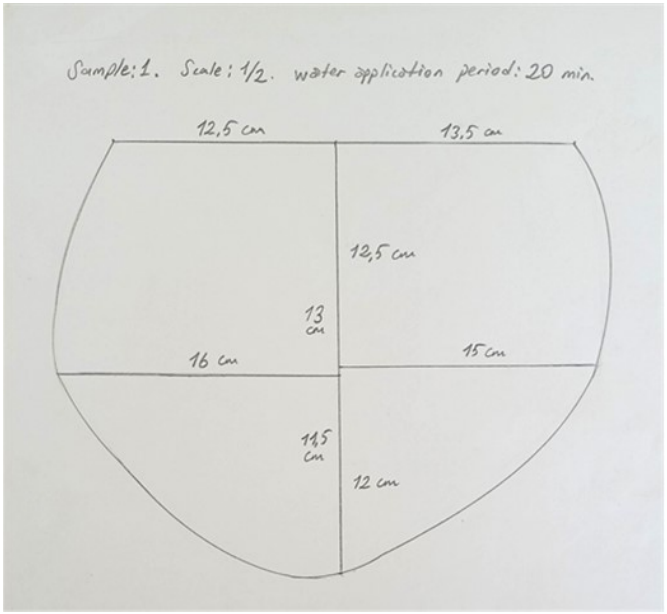

Figure S16. *Drawing the 2D cross-sectional area of the wetting pattern which occurs under field conditions, on the paper by making it smaller according to a definite scale*

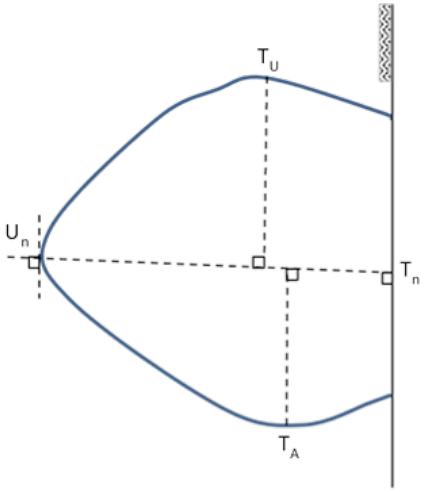

Figure S17. *Placing the 2D cross-sectional area of the wetting pattern on the coordinate system (this figure is given in the paper as Figure 3)*

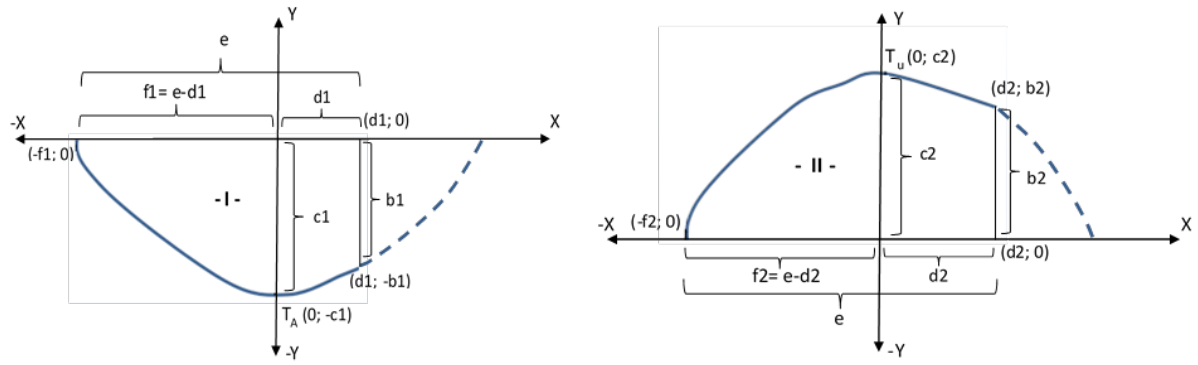

Figure S18. *Schematic description of the components of the 2D cross-sectional area (this figure is given in the paper as Figure 5)*

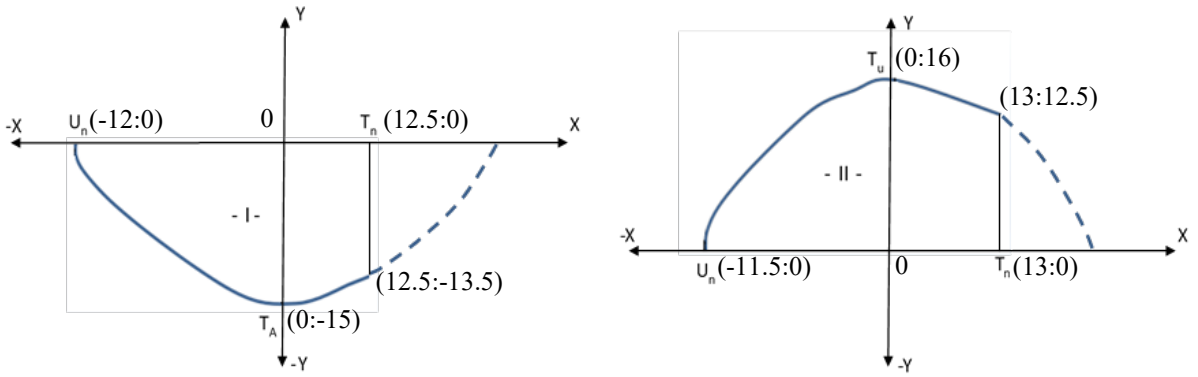

Figure S19. *Analytical description of the 2D cross-sectional area of the wetting pattern for field experiment 1*

Running of the proposed model for field experiment 1

Cross-section I

$$y = ax^2 - 15$$

The values of *a* were calculated according to the coordinates (−12; 0) and (12.5; −13.5) for cross-section I. Next, the arithmetic mean of *a* was used in the equation above. The value of *a* was determined as 0.057. The equation of cross-section I is given below.

$$y = 0.057x^2 - 15$$

Cross-section II

$$y = ax^2 + 16$$

The values of *a* were calculated according to the coordinates (−11.5; 0) and (13; 12.5) for cross-section II. The arithmetic mean of *a* was determined as −0.071. The equation of cross-section II is given below.

$$y = -0.071x^2 + 16$$

The size of the area of cross-section I

$$A_{\mathrm{I}} = -\int_{-12}^{12.5} (0.057x^2 - 15)\, dx = 297.559\ \mathrm{cm}^2$$

The size of the area of cross-section II

$$A_{\mathrm{II}} = \int_{-11.5}^{13} (-0.071x^2 + 16)\, dx = 304.01\ \mathrm{cm}^2$$

Total size of the cross-sectional area of the entire 2D wetting pattern

$$\sum A = A_{\mathrm{I}} + A_{\mathrm{II}} = 297.559 + 304.01 = 601.569\ \mathrm{cm}^2$$

Digital planimeter measurement for field experiment 1

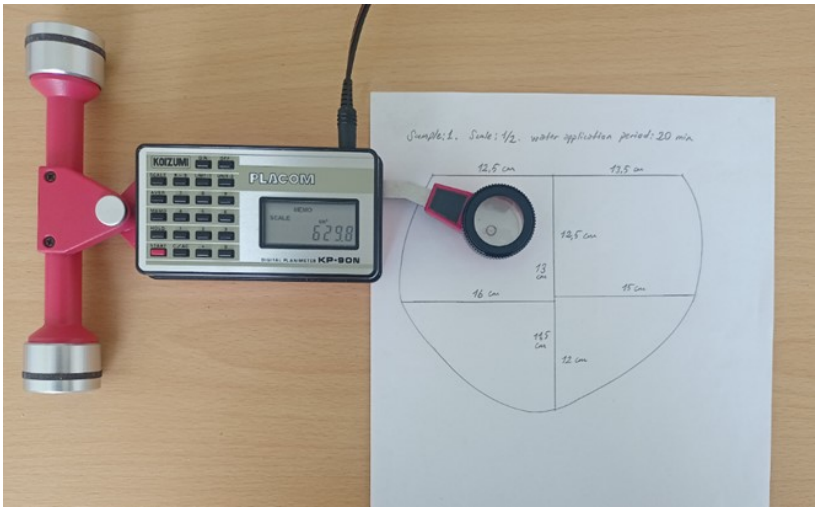

Figure S20. *Digital planimeter measurement for field experiment 1*

The difference between the size of the 2D cross-sectional area determined by the proposed model (601.569 cm^2), and the measurement by the digital planimeter (629.8 cm^2) was 4.48%. The accuracy of the model result was 95.52%.

Field experiment 2

Water application period: 30 min. Dripper discharge: 1.2 L/h.

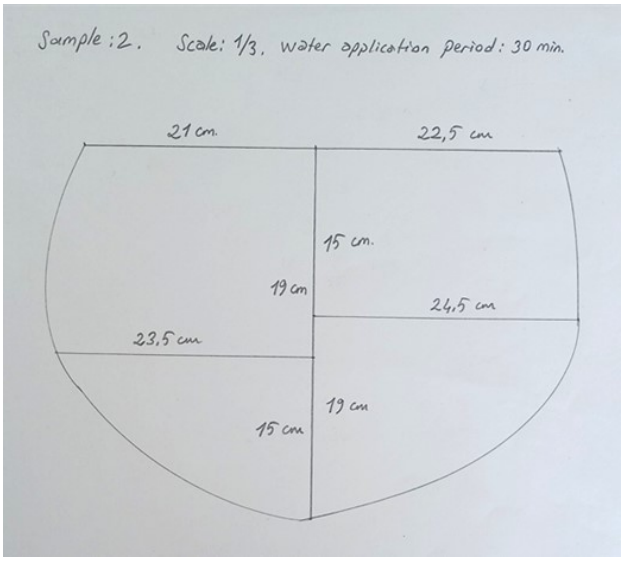

Figure S21. *Drawing of the 2D cross-sectional area of the wetting pattern which occurs under field conditions on the paper by making it smaller according to a definite scale*

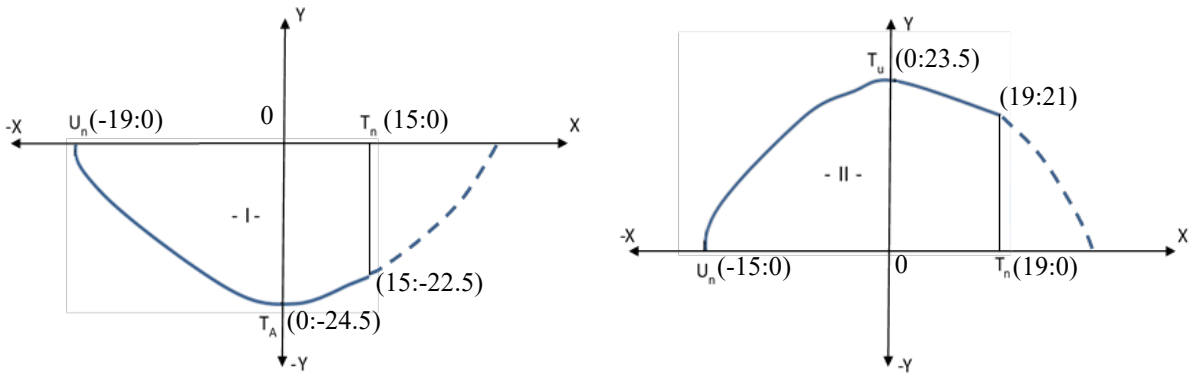

Figure S22. *Analytical description of the 2D cross-sectional area of the wetting pattern for field experiment 2*

Running of the proposed model for field experiment 2

$$y = ax^2 - 24.5$$

The values of *a* were calculated according to the coordinates (−19;0) and (15; −22.5) for cross-section I. Next, the arithmetic mean of *a* was used in the equation above. The value of *a* was determined as 0.038. The equation of cross-section I is given below:

$$y = 0.038x^2 - 24.5$$

<u>Cross-section II</u>

$$y = ax^2 + 23.5$$

The values of *a* were calculated according to the coordinates (-15;0) and (19;21) for cross-section II. The arithmetic mean of *a* was determined as 0.056. The equation of cross-section II is given below.

$$y = -0.056x^2 + 23.5$$

The size of the area of cross-section I

$$A_{\mathrm{I}} = -\int_{-19}^{15} (0.038x^2 - 24.5)\,dx = 703.369\ \mathrm{cm}^2$$

The size of the area of cross-section II

$$A_{\mathrm{II}} = \int_{-15}^{19} (-0.056x^2 + 23.5)\,dx = 607.965\ \mathrm{cm}^2$$

Total size of the cross-sectional area of the entire 2D wetting pattern

$$\sum A = A_I + A_{II} = 703.369 + 607.965 = 1311.334\ cm^2$$

Digital planimeter measurement for field experiment 2

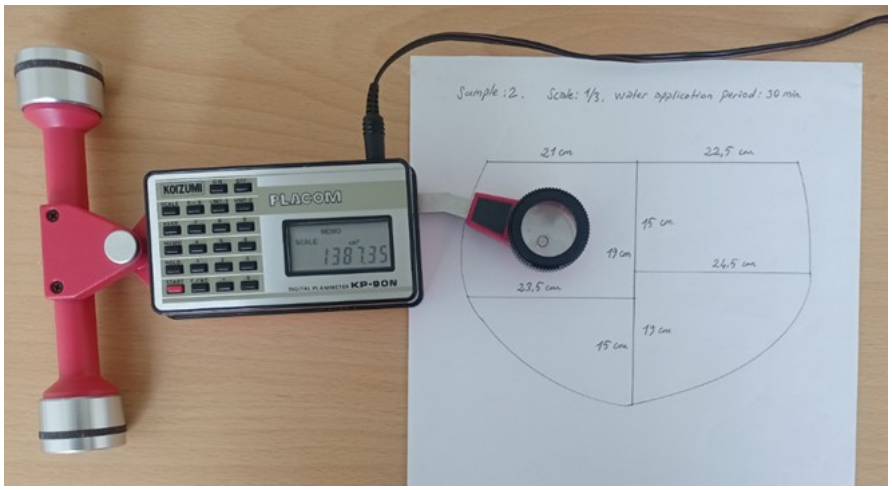

Figure S23. *Digital planimeter measurement for field experiment 2*

The difference between the size of the 2D cross-sectional area determined by the proposed model (1 311.334 cm^2) and the measurement by the digital planimeter (1 387.35 cm^2) was 5.48%. The accuracy of the model result was 94.52%.

Field experiment 3

Water application period: 40 min. Dripper discharge: 0.79 L/h.

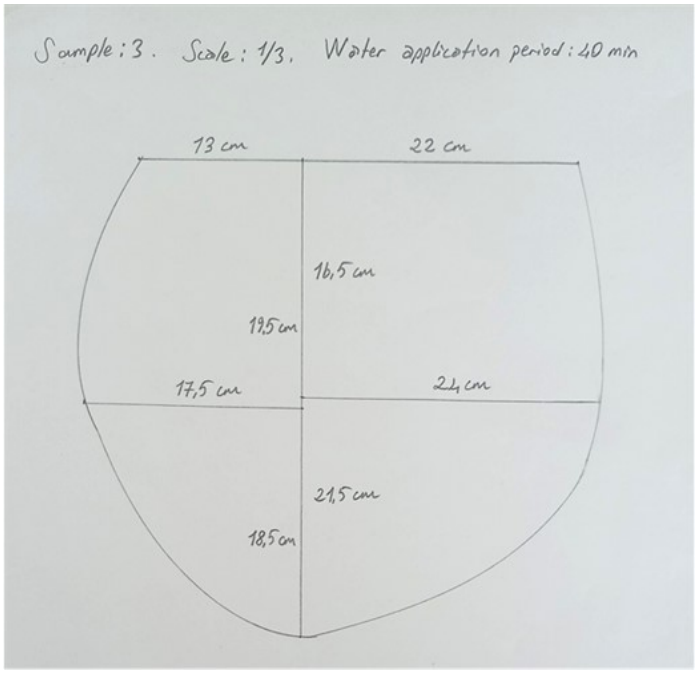

Figure S24. *Drawing of the 2D cross-sectional area of the wetting pattern which occurs under field conditions on paper by making it smaller according to a definite scale*

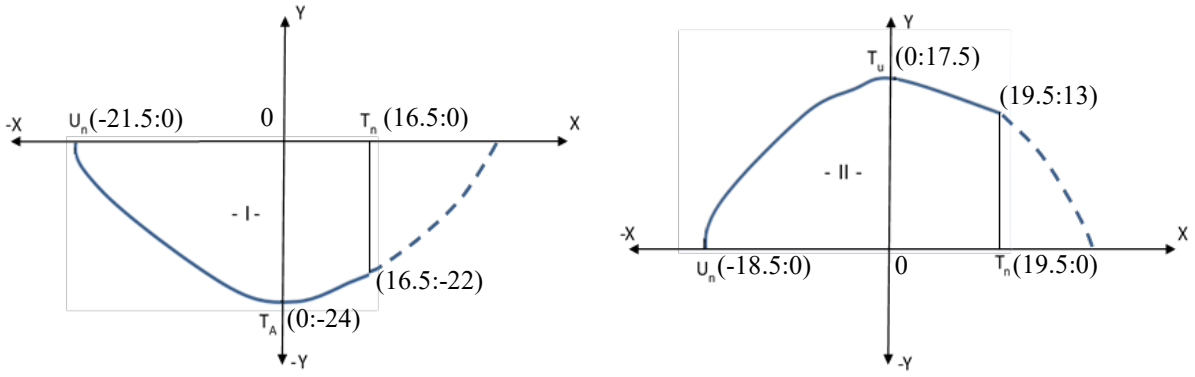

Figure S25. *Analytical description of the 2D cross-sectional area of the wetting pattern for field experiment 3*

Running of the proposed model for field experiment 3

<u>Cross-section I</u>

The values of a were calculated according to the coordinates (−21.5; 0) and (16.5; −22) for cross-section I. Next, the arithmetic mean of *a* was used in the equation above. The value of *a* was determined as 0.030. The equation of cross-section I is given below.

$$y = 0.030x^2 - 24$$

Cross-section II

$$y = ax^2 + 17.5$$

The values of a were calculated according to the coordinates (−18.5:0) and (19.5:13) for cross-section II. The arithmetic mean of a was determined as −0.032. The equation of cross-section II is given below.

$$y = -0.032x^2 + 17.5$$

The size of the area of cross-section I

$$A_I = -\int_{-21.5}^{16.5} (0.030x^2 - 24)\, dx = 767.695 \text{ cm}^2$$

The size of the area of cross-section II

$$A_{\text{II}} = \int_{-18.5}^{19.5} (-0.032x^2 + 17.5)\, dx = 518.371 \text{ cm}^2$$

Total size of the cross-sectional area of the entire 2D wetting pattern

$$\sum A = A_{\text{I}} + A_{\text{II}} = 767.695 + 518.371 = 1\,286.066 \text{ cm}^2$$

Digital planimeter measurement for field experiment 3

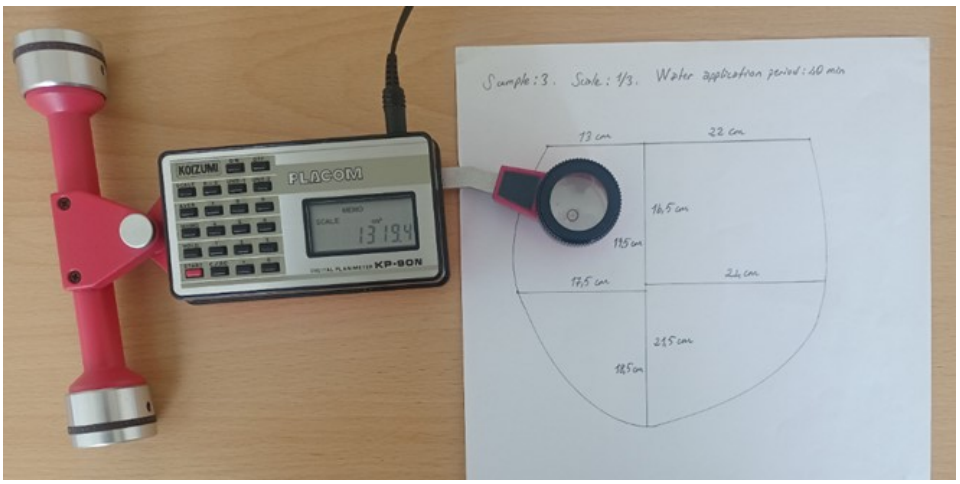

Figure S26. *Digital planimeter measurement for field experiment 3*

The difference between the size of the 2D cross-sectional area determined by the proposed model (1 286.066 cm^2) and the measurement by the digital planimeter (1 319.4 cm^2) was 2.53%. The accuracy of the model result was 97.47%.

These results indicate that the proposed model can be used with high rate of accuracy to determine the 2D cross-sectional area of the wetting pattern which occurs under field conditions under a surface dripper.