# Farmer Participatory Trials (FPT) at Soybean in Romania

## *Bulletin 2023*

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The Bulletin 2023 is part of the Task 6.2 "Participatory farmer field trials" of ECOBREED project *"Increasing the efficiency and competitiveness of organic crop breeding"* financed by Grant Agreement ID 771367 of the Horizon 2020 programme for the period 01.05.2018 – 29.02.2024. The farmer participatory consist, practically, in establishment of on-farm variety evaluation trials via consultation between researchers and farmers. For each DEMO farm/field trial was respected the FPT assessment - a collection and record standard of the environment, field and agronomic (mainly behaviour of varieties) data.

## Materials and Methods

Farmer participatory trials at soy was established in 3 Romanian organic farms: Agro-ecologic Research & Innovation Centre of INCDA (NARDI) Fundulea/county Călărași, ECOFRUCT Ștefan cel Mare/county Călărași and ADAFLOR Zebil/county Tulcea. According to "Map of Romanian ECOBREED Soybean DEMO Farms" (Fig. 1) and information of Table 1, the Romanian organic soybean DEMO farms are located in Development regions South-Muntenia (2) and South – East (1), at different altitudes and geographical coordinates and on chernozemic *(INCDA (NARDI) Fundulea and ECOFRUCT Ștefan cel Mare)* and kastanozem *(ADAFLOR Zebil)* soils.

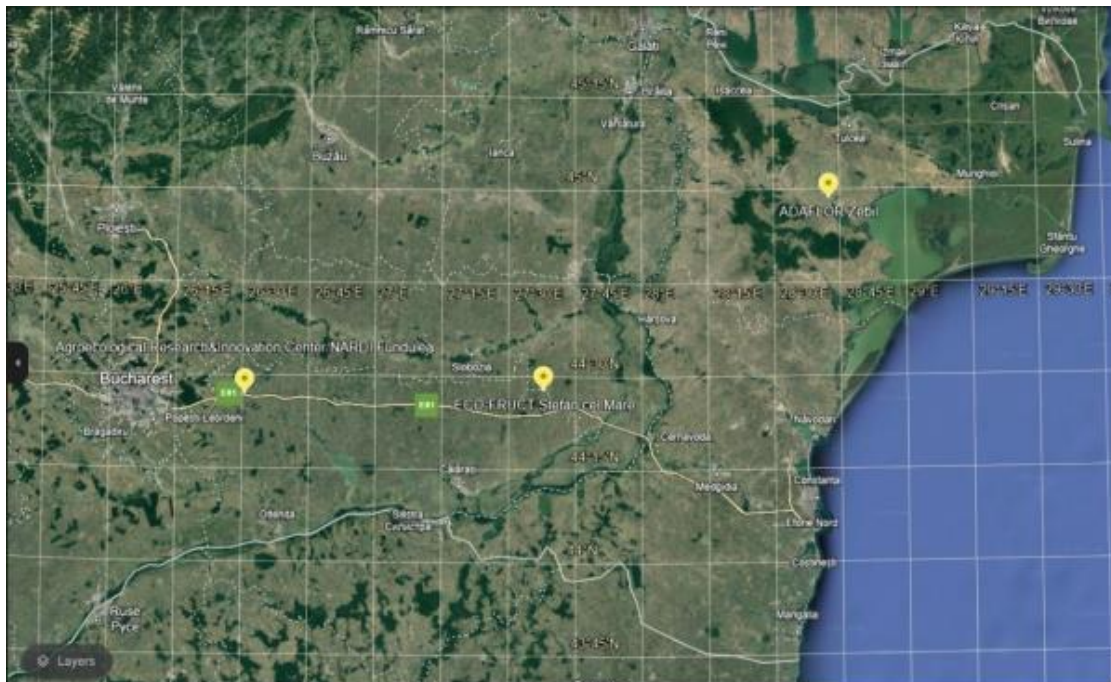Fig. 1. The map of Romanian ECOBREEED Soybean Demo Farms 2023

Table 1. Geographical settlement and soil types of the soybean FPTs 2023

| No | Farm Demo (FPTs) Name | Altitude (m) | Position | Development regions | Soil types |
|---|---|---|---|---|---|
| 1 | Agro-ecologic Research & Innovation Centre/INCDA (NARDI) Fundulea | 66 | N44°26'49.26", E26°30'44.52" | South - Muntenia | Chernozem |
| 2 | ECO-FRUCT Ștefan cel Mare | 32 | N44°27'31.62", E27°37'56.22" | South - Muntenia | Chernozem |
| 3 | ADAFLOR Zebil | 13 | N44°58'20.4", E28°42'32.7" | South – East | Kastanozem |

In all these FPTs, soybean varieties (table 2) belong to different genetics - Serbian (Favorit, NS Mercury and NS CCP), Romanian (Ovidiu F, Fabiana F and Florina F) and American (PR92B63, STK 01 and STK 03) and to 3 maturity groups: 00, 0 and I. Also, in all soybean DEMOs were tested and 3 soybean varieties mixtures: Favorit + Ovidiu F, NS Mercury + Fabiana F and STK 01 + Ovidiu F *(Table 2)*.

Table 2. Names and maturity group (MG) of soybean varieties cultivated in the 3 FPTss

| Variety | | INCDA (NARDI) Fundulea | ECOFRUCT* Stefan cel Mare | ADAFLOR* Zebil |
|---|---|---|---|---|
| Name | Maturity group | | | |
| Favorit | 00 | x | x | x |
| Ovidiu F | 0 | x | x | x |
| NS Mercury | I | x | x | x |
| Fabiana F | I | x | x | x |
| Favorit + Ovidiu F | 0? | x | x | x |
| NS Mercury  + Fabiana F | I? | x | x | x |
| STK 01 + Ovidiu F | 0? | x | x | x |
| NS CCP | ? | x | - | - |
| STK 01 | 0.6 | x | - | - |
| STK 03 | I.3 | x | - | - |
| PR92B63 | 00 | - | x | - |
| Florina F | 0 | - | - | x |

*irrigated

The soybean Demos was sow on different dates: 05.05.23 at ECOFRUCT Ștefan cel Mare, 13.05.23 at INCDA *(NARDI)* Fundulea and 17.05.23 at ADAFLOR Zebil. Also, each variety was placed in strips of 2 rows at a distance between rows of 70 cm at INCDA *(NARDI)* Fundulea, of 3 rows at distance between rows of 50 cm at ECOFRUCT Ștefan cel Mare and  of 4 rows at a distance between rows of 70 cm at ADAFLOR Zebil. The soybean varieties were sow along the entire length of the plot and with seeders provided by the DEMOs:: HEGE for experimental plots at INCDA *(NARDI)* Fundulea, MATERMACC at ECOFRUCT Ștefan cel Mare, HEGE for experimental plots at INCDA *(NARDI)* Fundulea, and GASPARDO at ADAFLOR Zebil.



Photo 1. Sowing soybean at "ECOFRUCT Ștefan cel Mare" ; Photo 2 Sowing soybean at "ADAFLOR" Zebil

According to organic soybean journal 2022 - 2023, each soybean Demo had specific agricultural technology:

- at INCDA (NARDI) Fundulea: the preceding crop - alfalfa; soil tillage with disc harrow on 14, 17 and 18.12.2022 and ploughing on 11.01.2023; seedbed preparing with Angeloni POKER 300 complex combiner on March 21, 2023 and with the MASCHIO cultivator Gaspardo on 03/05/2023 and 13/05/2023; seeds bacterizing with POLIRIZ S (a mixture of 6 strains of Bradirhizobium); sowing on 13.05.2023; weeding mechanically (once) and manual hoeing (2 times) and mechanically harvesting on September 13, 2023;

- at ADAFLOR Zebil: the preceding crop – winter wheat; ploughing; seedbed preparing with the adjustable tine harrow (GCR) for levelling the soil and combiner; fertilization with 200 kg/ha NPK (5:10:8) organic; seeds bacterizing with POLIRIZ S; sowing; weeding - mechanically with the weeds harrow and cultivator (2 times) and manual hoeing (once); irrigation (4 times x 30 l/m2) and mechanically harvesting on 23 September 2023;

- at ECOFRUCT Ștefan cel Mare: the preceding crop – the soybean; ploughing; seedbed preparing with adjustable tine harrow (GCR) for levelling the soil, and with combiner; bacterization of seeds with POLIRIZ S; sowing;  weeding with rotary hoe (3 times) and manual hoeing; irrigation (4 times x 30 l/m2), and mechanically harvesting on 14.10.2023;

Also, during the periods of emergence - growth and harvesting of soybeans, the observations and measurements provided in the FPT/2023 of T6.2 were carried out:*„seeds germinations (%), sowing density (seeds/m²), emerge (plants/m²), canopy/youth development (%), plant height (cm), lodging (1 to 9 score), maturity water content (%), harvesting date, harvesting yield (dt/ha), protein and oil (fat) content (%) and in addition, monitoring of pests/Agriotes sp. with pheromone traps (photo 3) and estimation of the degree of weeds infestation (%) and pidgeons attack at INCDA (NARDI) Fundulea.*



Photo 3. Pheromone traps for Agriotes sp. at soybean FPT ”INCDA *(NARDI)* Fundulea 2023

## RESULTS

The monthly air temperatures (Fig. 2) recorded at INCDA (NARDI) Fundulea from September 2022 to August 2023 were higher than the multiannual average values (LTA), except for the months of April and May 2023 when the air temperature was, more or less, similar to LTA, the agriculture year 2022 - 2023 being warmest in the last 60 years

Fig. 2. Average monthly air temperatures recorded at NARDI Fundulea, in the period September 2022 – August 2023 compared to Long Term Average (LTA)
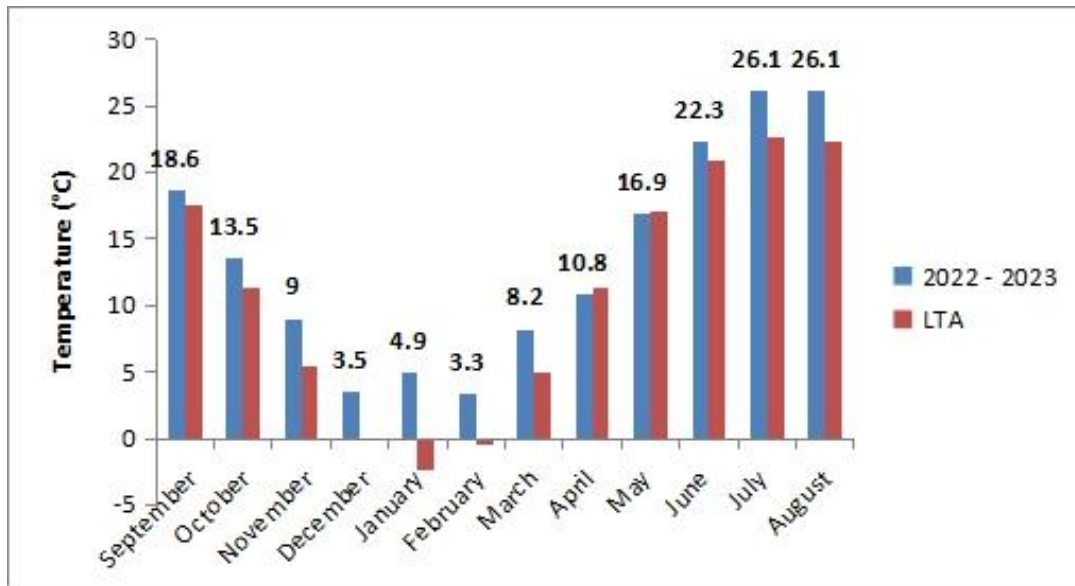


Regarding precipitation (Fig. 3), in the period considered, only in two month – January and April 2023, the sum of precipitations were higher than LTA. In the rest of months the sum of precipitations in the agricultural year 2022 - 2023 were below of the multiannual average (LTA), the monthly precipitation deficit varying between *13,1 – 43,1 mm*, the year precipitation deficit *(- 222,1 mm)* being the second biggest in the last 60 years.

Fig. 3 The amount of monthly precipitation from September 2022 – August 2023 and the multi-year monthly averages (LTA) recorded at NARDI Fundulea
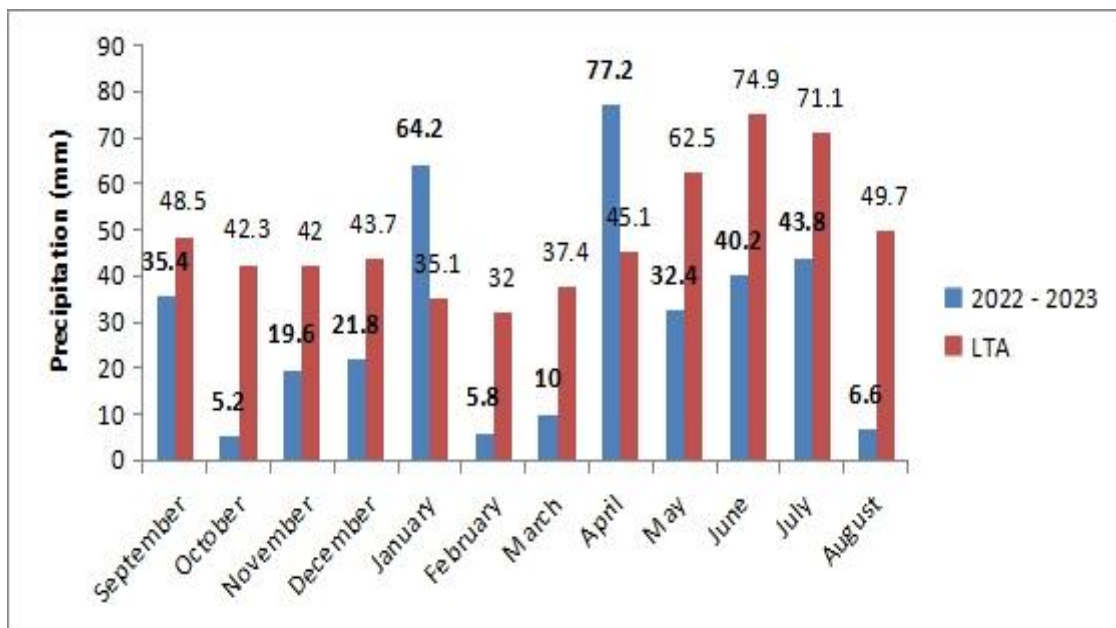
Also, the Fundulea climatic scenario 2022 – 2023 was similar in all DEMO centres, but ECOFRUCT Ștefan cel Mare and ADAFLOR Zebil solved most of climate problems by irrigation.

In the next part of this bulletin is presented and discussed the characteristics and behaviour of the Demo soybean varieties in organic system in 2023 such as: seeds germination energy and capacity (%), plants canopy cover (%), plants height (cm), plants density at harvest (no.), yield (dt/ha) and protein and oil content (%) of soybean grains.

### *1. Germination energy and germination capacity*
Germination energy and germination capacity refer to the ability of seeds to germinate fast and together, respectively the percentage of seeds that would normally germinate under optimal conditions for the each species.

The seed germination energy and germination *(table 3)* of the soybean varieties are approximately equal, but the best soybean varieties as germination were at Ovidiu F (92%) and PR92B63 (90%), at Favorit, Favorit+Ovidiu F, NS Mercury, STK01+Ovidiu F, NS CCP and Florina F with germination rates between 56 – 80% and on the last place Fabiana F and the varieties mixture NS Mercury + Fabiana F with the germination rates between 28 – 48%.

Table 3. The seeds germination of soybean varieties cultivated in 3 Romanian FPTs

| Variety name | Maturity Group (MG) | Germination energy (%) | Germination capacity (%) |
|---|---|---|---|
| Favorit | 00 | 56 | 56 |
| Ovidiu F | 0 | 92 | 92 |
| NS Mercury | I | 64 | 68 |
| Fabiana F | I | 44 | 48 |
| Favorit + Ovidiu F | 0? | 52 | 60 |
| NS Mercury + Fabiana F | I? | 28 | 28 |
| STK 01 + Ovidiu F | 0? | 68 | 68 |
| NS CCP | ? | 75 | 75 |
| PR92B63 | 00 | 90 | 90 |
| Florina F | 0 | 80 | 80 |

The lowest energy and germination capacity (28%) of the mixture of varieties NS Mercury + Fabiana F compared to the germination indices of the component varieties - NS Mercury (68%) and Fabiana F (48%) confirms the conclusion of the Bulletin 2022 that the mixture of soybean varieties is only effective if there is affinity between varieties, such as between STK 01 and Ovidiu F, which was the best in both 2022 and 2023.
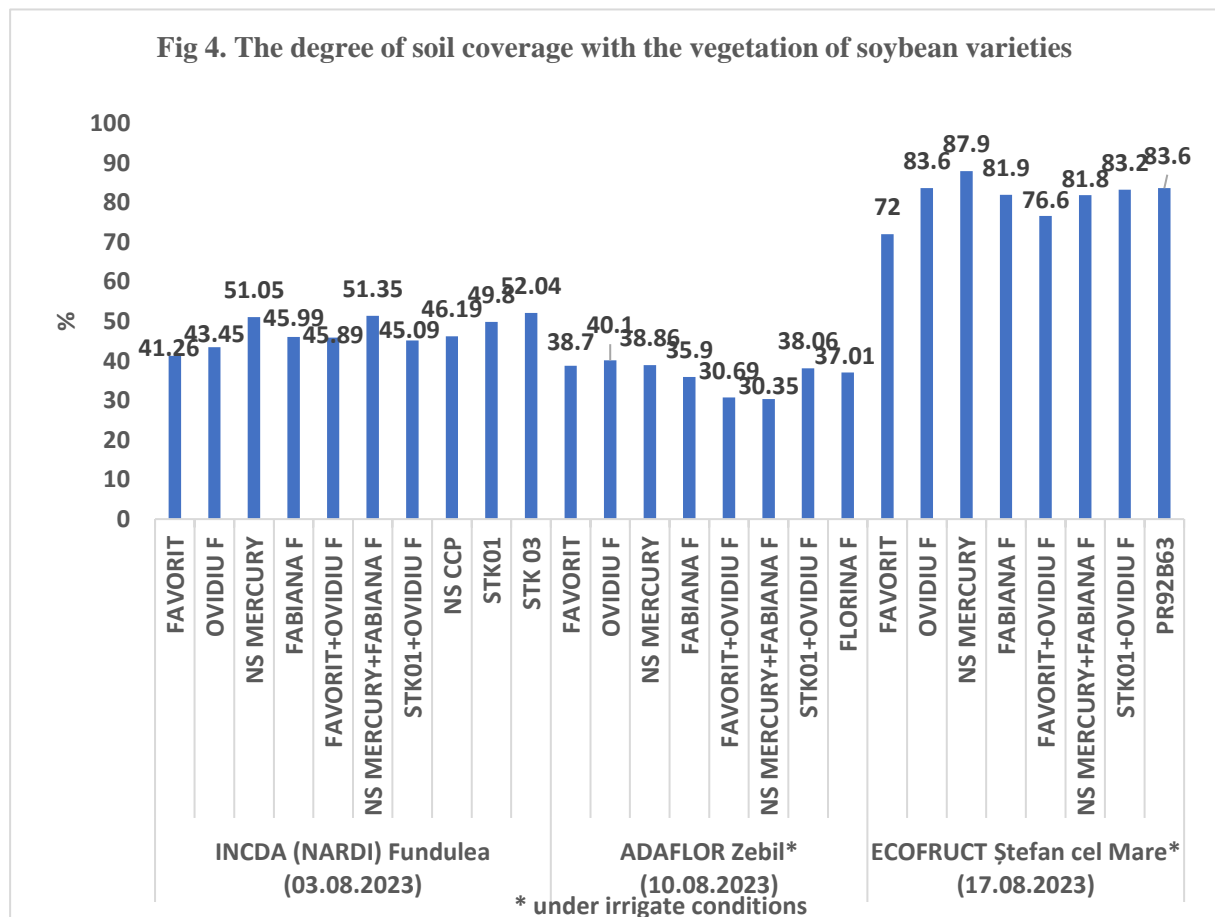
### *2. Canopy cover*
Measurement of canopy cover of soybeans was made with Canopeo, a tool developed by Oklahoma State University to quickly and accurately measure ground cover with green vegetation. This application is use to quantify the percentage of vegetation cover green for any agricultural crop, lawn or pasture based on photos taken with a mobile device - phone or tablet, facing down.

Measurements of the degree of soil coverage by the canopy of soybean plants were carried out in several phases of vegetation, but below we present the results of Canopeo measurements in the phase of maximum plant development - 03.08.2023 at INCDA (NARDI) Fundulea, 10.08.2023 at ADAFLOR Zebil and 17.08.2023 at ECOFRUCT Stefan cel Mare.

According to Fig. 4, the variability in the degree of ground cover by the canopy of soybean plants is very high among DEMO lots and moderate among soybean cultivars. Thus, the lowest values of canopy cover (30.35 - 40.1%) where registered at ADAFLOR Zebil and the highest values (72 - 87.9%) at ECOFRUCT Stefan cel Mare. The soybean canopy cover values at INCDA (NARDI) Fundulea were a little beat higher (41.26 - 52.04%) than at ADAFLOR Zebil, but very low than at ECOFRUCT Ștefan cel Mare.

-    Regarding the variability of ground cover by vegetation of the soybean genotypes, it was specific to each Demo field: at INCDA (NARDI) Fundulea, first 2 genotypes with lowest values of canopy cover were Favorit (41,26%) and Ovidiu F (43.45%). The genotypes with highest values were STK 03 (52.04%), NS Mercury + Fabiana F (51.35%) and NS Mercury (51.05%);



Fig 4. The degree of soil coverage with the vegetation of soybean varieties

-    at ADAFLOR Zebil: the lowest values of canopy cover were mixture varieties NS Mercury + Fabiana F (30.35%) and Favorit + Ovidiu F (30.69%) and the highest values at Ovidiu F (40.1%), NS Mercury (38.86%) and to Favorit (38.7%);

- at ECOFTRUCT Ștefan cel Mare: the lowest canopy cover values were at Favorit (72%) and Favorit + Ovidiu F (76.6%), respectively and the highest values were measured at NS Mercury (87.9%), Ovidiu F (83.6%) and PR92B63 (83.6%).

### *3. Plants height*

Tle soybean plants height was carry out before harvesting, on 18.08.2023 at INCDA (NARDI) Fundulea, 10.08.2023 at ADAFLOR Zebil and 11.10.2023 at ECOFRUCT Ștefan cel Mare. Also, soybean plant height variability (Fig. 5) is more or less similar to soybean vegetation ground cover variability, very high among DEMO sites and moderate among soybean cultivars. Thus, the lowest height of soybean plants (38.25 - 48.87 cm) was recorded at ADAFLOR Zebil and the highest (56.88 - 96.2 cm) at ECOFRUCT Ștefan cel Mare.

The soybean plants height at INCDA (NARDI) Fundulea were a little beat higher (41.50 - 53.8 cm) than at ADAFLOR Zebil, but more low than at ECOFRUCT Stefan cel Mare.



Fig. 5 Height of the soybean plants in varieties trials 2023
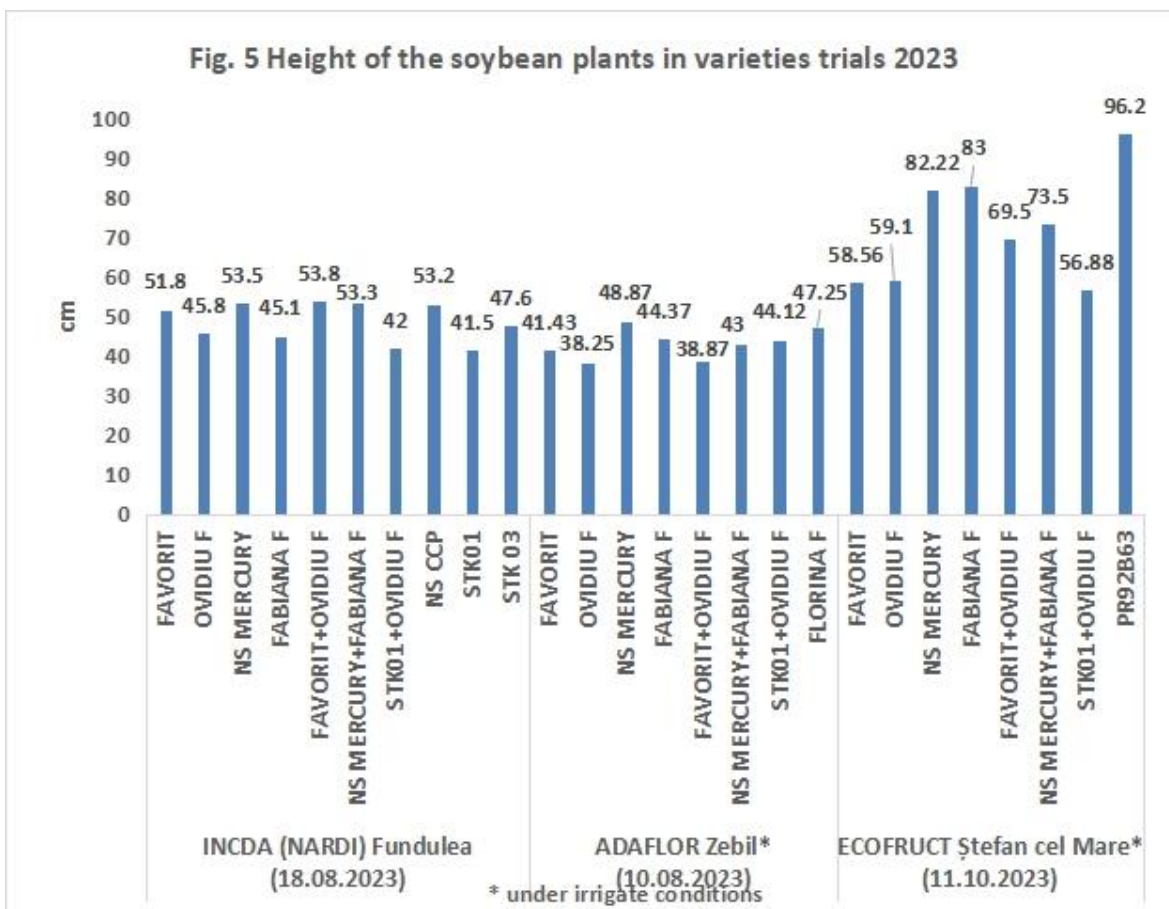
Also, variability of the soybean genotypes heights, it seems to be specific to each Demo place:

- at INCDA (NARDI) Fundulea: STK 01 (41.5 cm) and mixture STK 01 + Ovidiu F (42,0 cm) had the lowest height, respectively, the mixture Favorit + Ovidiu F (53.8 cm), NS Mercury (53.5 cm) and NS CCP (53.2 cm), were the highest varieties;

- at ADAFLOR Zebil: first two lowest height varieties were Ovidiu F (38,25 cm) and mixture Favorit + Ovidiu F (38,87 cm), and the highest varieties were NS Mercury (48.87 cm), and Florina F (47,25 cm);

- at ECOFRUCT Ștefan cel Mare: the shortest height varieties were Favorit (47,25 cm) and mixture STK 01 + Ovidiu F (56.88cm) and the highest varieties were PR92B63 (96.2 cm), Fabiana F (83,0 cm) and NS Mercury (82,22 cm).



Photo 4. Soybean DEMO "INCDA (NARDI)"



Photo 5. Soybean DEMO "ADAFLOR"



Photo 6. Soybean DEMO "ECOFRUCT" Ștefan cel Mare/17.08.2024

### 4. Soybean grains yield

The soybean grains yield was measure during harvesting of soybean DEMOs varieties – on 12.09.2023 at INCDA (NARDI) Fundulea, 10.08.2023 at ADAFLOR Zebil and 11.10.2023 at ECOFRUCT Ștefan cel Mare. The variability of soybean production (Fig 6) is significant, the lowest grain productions being recorded at INCDA (NARDI) Fundulea (81 – 326 kg/ha) under non-irrigated conditions, and slightly higher grain yields at ADAFLOR Zebil (500 – 1290 kg/ha) and the highest grain productions. (2140 – 3096 kg/ha) at ECOFRUCT Ștefan cel Mare, both under irrigation conditions.



Fig. 6 Soybean grains yield 2023
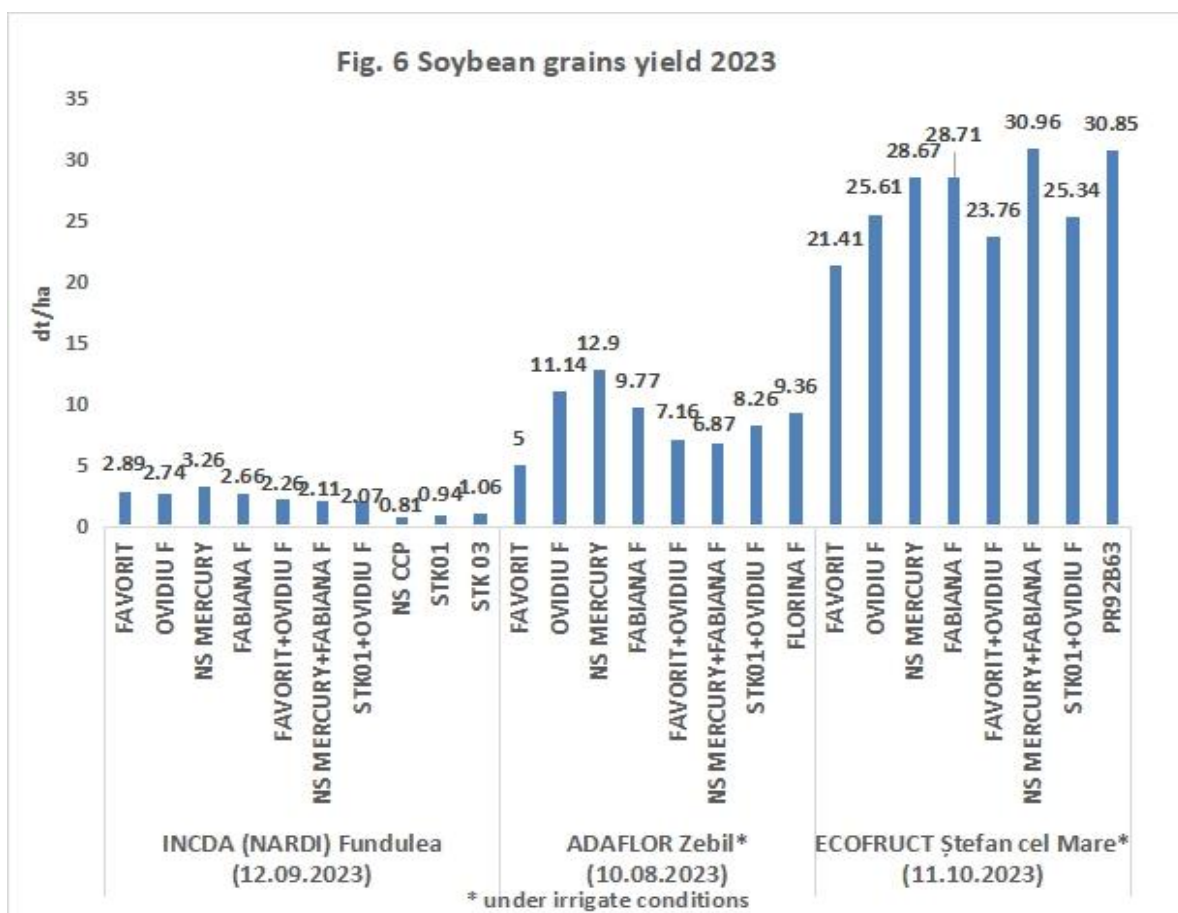
The variability of the soybean varieties yields is also specific to each Demo place, as follows:

- at INCDA (NARDI) Fundulea: the lowest grain productions were obtained at NS CCP (81 kg/ha) and STK 01 (94 kg/ha), and the highest at NS Mercury (326 kg/ha) , Ovidiu F (274 kg/ha) and Fabiana F (266 kg/ha);

- at ADAFLOR Zebil: first two soybean varieties with lowest grains yields were Favorit (500 kg/ha) and mixture NS Mercury + Fabiana F (687 kg/ha), and varieties with largest yields were NS Mercury (1290 kg/ha), Ovidiu F (1140 kg/ha) and Fabiana F (977 kg/ha);

- at ECOFRUCT Ștefan cel Mare: the soybean varieties with lowest yields were Favorit (2141 kg/ha) and mixture Favorit + Ovidiu F (2376 kg/ha), and the varieties with largest grains yields were the mixture NS Mercury + Fabiana F (3096 kg/ha), PR92B63 (3085 kg/ha) and Fabiana F (2871 kg/ha) and NS Mercury (2867 kg/ha).

### 5. *Soybean grains protein content*

The protein content of soybeans was determined on 07.12.2023 at INCDA (NARDI) Fundulea, 05.12.2023 at ADAFLOR Zebil and 06.12.2023 at ECOFRUCT Ștefan cel Mare, with the Dickey-John "Instalab 660" equipment, a near-infrared reflectance analyser, according to the Instalab protocol for analysis of soy proteins.



Fig. 7 Protein content of soybean grains in DEMO trials 2023
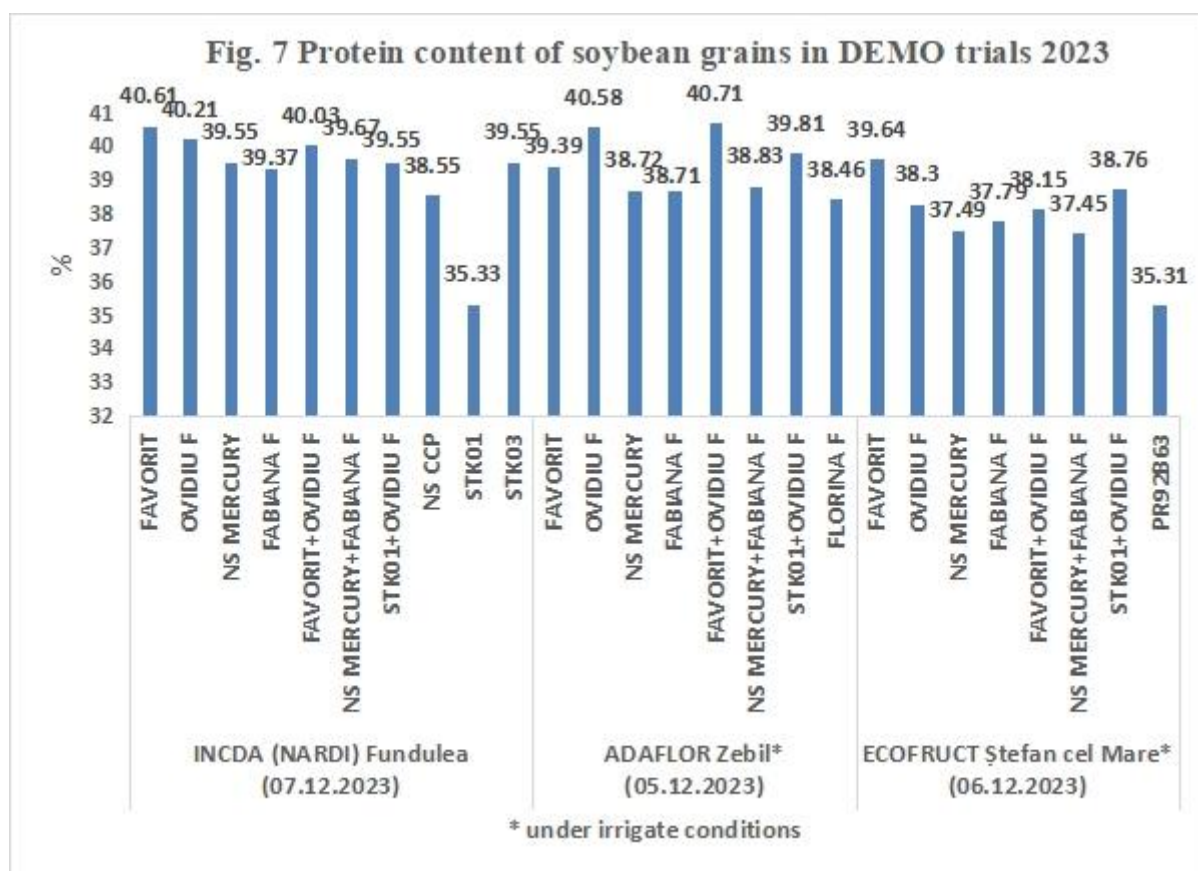
The results concerning protein content of soybean grains in DEMO trials 2023 (Fig. 7) are very variable at INCDA (NARDI) Fundulea (35.33 – 40.61%), variable at ADAFLOR Zebil

(38.71 – 40,71%) and very variable at ECOFRUCT Ștefan cel Mare (35,31 – 39.64%), main factor of variability being the soybean genotype.

Thus:
- at INCDA (NARDI) Fundulea, only STK 01 (35,33%) had the lowest protein content, the other varieties having a good and close protein content (38.55 – 40.61%), with Favorit (40.61%), Ovidiu F (40.21%) and the mixture of Favorit + Ovidiu F (40.03%) with the highest protein content;

- at ADAFLOR Zebil, the lowest protein content was determined in Florina F (38.46%), Fabiana F (38.71%) and NS Mercury (38.72%), and the highest content in the mixture Favorit + Ovidiu F (40.71%) and Ovidiu F (40.58%);

- at ECOFRUCT Ștefan cel Mare, the soybean protein content was, in general, lower, but the lowest was recorded at PR92B63 (35,31%), and the highest at Favorit (39,64%) and mixture STK 01 + Ovidiu F (38.75%).

## 5. Soybean grains oil (fat) content

The oil (fat) content of DEMO soybeans determined with the same Dickey-John "Instalab 660" was higher than that reported in the literature (12 – 18%), but varied mainly according to environmental and agrotechnic characteristics of each DEMO (Fig.8).
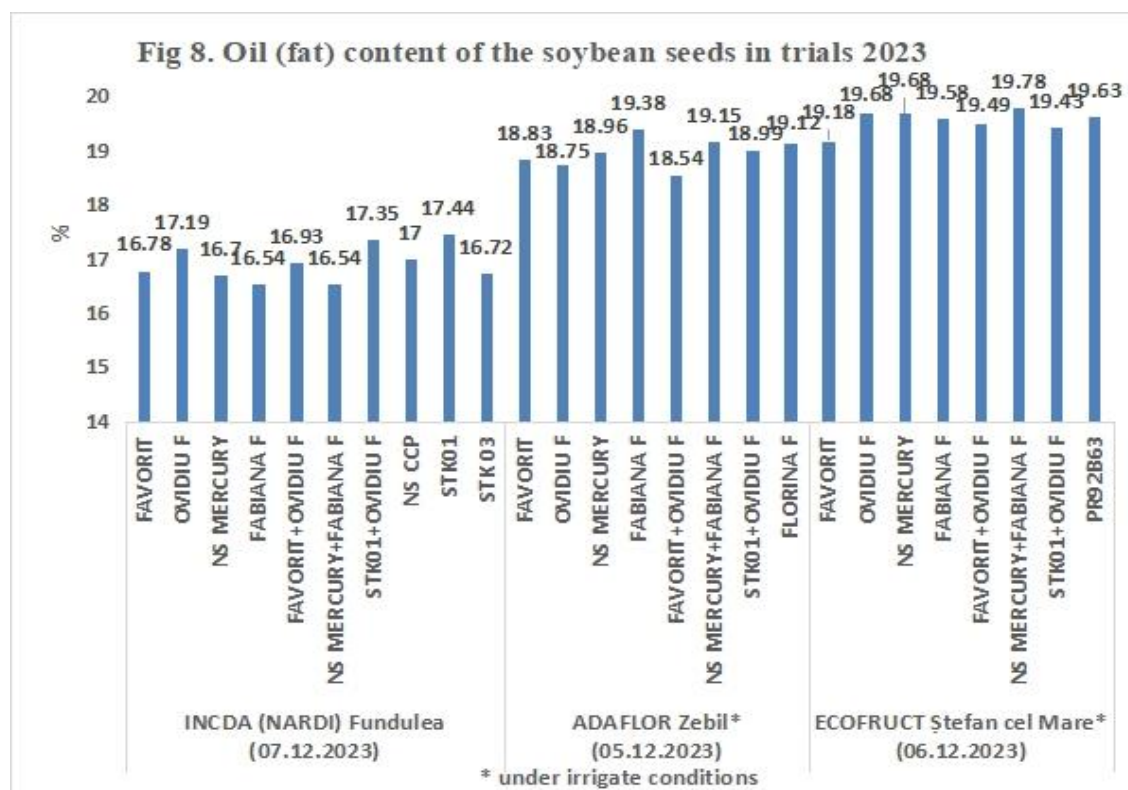
The smallest oil (fats) content (16.54 – 17.44%) was registered at soy cultivated at INCDA (NARDI) Fundulea in dry farming system and the highest (19.18 – 19.78%) for soybeans grown at ECOFRUCT Ștefan cel Mare under irrigation conditions.

Also, at soybean cultivated at ADAFLOR Zebil under irrigate conditions, the oil (fats) content varied between 18.54 – 19.38%, with 2% more than at INCDA (NARDI) Fundulea and less with 0,40 – 0.64% than at ECOFRUCT Ștefan cel Mare.

The oil (fat) content differences between soy varieties were not significant (CV= 0.96 – 1.90) but some varieties were noted with smallest oil content – Fabiana F and mixture NS Mercury+Fabiana F at INCDA (NARDI) Fundulea, the mixture Favorit+Ovidiu F and Ovidiu F at ADAFLOR Zebil and Favorit and the mixture STK 01+ Ovidiu F at ECOFRUCT Ștefan cel Mare. Other varieties, as STK01 and the mixture STK01 + Ovidiu F at INCDA (NARDI) Fundulea, Fabiana F and the mixture NS Mercury+Fabiana F at ADAFLOR Zebil, as well as the mixture NS Mercury+Fabiana F, Ovidiu F and NS Mercury at ECOFRUCT Ștefan cel Mare had the highest oil (fat) content.

### 6. Dynamic of wireworms (Agriotes spp.) infestation in soybean DEMO at INCDA (NARDI) Fundulea in 2023;

The wireworms (Agriotes spp.) in soybean plots at INCDA (NARDI) Fundulea were first reported last year (2022). In 2023, monitoring of Agriotes sp. was done with 3 male pheromone traps, one for the each species of Agriotes - A. obscurus, A ustulatus and A. lineatus. Also, the wireworms monitoring started on 30.05.2023, after soybean plants emergence and it was stopped in the middle of July when the flight of Agriotes sp, stopped.

According to table 4, in Fundulea area, the species with early (maybe on the beginning of May) and very long flight and quite numerous is Agriotes obscurus. Important was Agriotes ustulatus too, mainly since second period of June and till in the middle of July. The *Agriotes lineatus* was present in soybean fields in the last day of monitoring, but nonsignificant as number and maybe by chance.

Table 4

Pheromonal monitoring of wireworms (Agriotes spp.) at INCDA Fundulea in 2023

| Date | *Agriotes obscurus* | *Agriotes ustulatus* | *Agriotes lineatus* | Date | *Agriotes obscurus* | *Agriotes ustulatus* | *Agriotes lineatus* |
|---|---|---|---|---|---|---|---|
| 30.05.2023 | 128 | 0 | 0 | 23.06.2023 | 69 | 100 | 0 |
| 02.06.2023 | 368 | 0 | 0 | 27.06.2023 | 99 | 83 | 0 |
| 06.06.2023 | 213 | 0 | 0 | 04.07.2023 | 2 | 24 | 0 |
| 09.06.2023 | 69 | 0 | 0 | 04.07.2023 | 80 | 53 | 0 |
| 13.06.2023 | 218 | 0 | 0 | 07.07.2023 | 666 | 15 | 0 |
| 16.06.2023 | 62 | 35 | 0 | 11.07.2023 | 98 | 3 | 3 |
| 20.06.2023 | 35 | 19 | 0 | | | | |

The presence and abundance of the wireworms *(Agriotes spp)* in the agriculture fields of the INCDA (NARDI) Fundulea seems to be according of their biology, which in case of the A. ustulatus correlate positive with air temperature.

### 7. Correlations of performance descriptors of the soybean varieties studied in ECOBREED DEMOs 2023.

The correlation or mutual connection of the performance descriptors (variables) of the soybean varieties studied in 2023, in the 3 Romanian DEMOs (Table 5) was:

- insignificant in the case of seed germination and all other performance descriptors studied;
- positive highly significant and significant between the degree of soil cover by soybean plants and grain production (0.876***), plant height (0.856***), number of harvested plants (0.544**) and oil content ( fats) (0.481*), respectively negatively significant in relation to protein content (- 0.668$^{00}$);
- highly significant positive between grain production and oil (fat) content (0.814***), as well as the other descriptors above – degree of soil cover with vegetation, plant height and number of harvested plants and highly significant negative with protein content (-0.731$^{00}$);
- positively significant between the number of harvested plants and grain production (0.471*);
- negative significant between protein content and oil (fat) content (-0.577$^{00}$).

Table 5. Correlation coefficients of performance soybean descriptors in Romanian ECOBREED FPTs 2023
*(Case studies: 24)*

| Descriptors | Canopy cover | Plants height | Harvest plant number | Grains yield | Protein content | Oil (fat) content |
|---|---|---|---|---|---|---|
| Seeds germination | 0.078 | 0.02 | 0.295 | 0.067 | - 0.046 | 0.066 |
| Canopy cover | | **0.856***** | **0.544**** | **0.876***** | **- 0. 668$^{00}$** | **0.481*** |
| Plants height | | | **0.407*** | **0.799***** | **- 0.824$^{000}$** | **0.425*** |
| Harvested plant number | | | | **0.471*** | - 0.211 | 0.235 |
| Grains yield | | | | | **- 0.731$^{00}$** | **0.814***** |
| Protein content | | | | | | **-0.577$^{00}$** |

Correlation coefficients that can be significantly different from zero at the level of: 5% = 0.40 and 1% = 0.52.

**Conclusions**

1. The 2022 - 2023 agricultural year was the warmest and the second driest in the last 60 years;
2. Agricultural technologies are specific to each FPT and depend on the equipment endowment, soil and climate characteristics and farmers' experience in organic farming, except for soybean varieties which, for the most part, are common to the 3 FPTs;
3. The soybean varieties tested belong to three genetics - Serbian *(Favorit, NS Mercury and NS CCP)*, Romanian *(Ovidiu F and Fabiana F)* and American *(STK 01, STK02 and PR92B63)*. Also, in all Demos it was studied and the effect of 3 soybean variety mixtures: *Mercury + Fabiana F; Favorit + Ovidiu F and STK 01 + Ovidiu F*;
4. The number of soybean plants lost during the vegetation period is significantly high, due to the attack of wireworms *(Agriotes spp.)* and European rabbits and, especially during the plant emergence phase, by wild pigeons.
5. If soybean ground cover and height at flowering are high, good to very good soybean production is expected.
6. Soybean grain yield is strong influenced by the date of sowing, early sowing being in favour of high yields.
7. The soybean grain yield is strongly influenced by the date of sowing, early sowing being in favor of high harvested yields.

8. The soybean varieties recommended for each FPT are: in non-irrigated conditions: *NS Mercury and Ovidiu F* in the Fundulea area and in irrigated conditions: *Ovidiu F, NS Mercury and Fabiana F* in the Zebil area and *NS Mercury, PR92B63, Fabiana F and Ovidiu F* in the Ștefan cel Mare area.

9. The mixture of soybean varieties seems to be effective only if there is affinity between the varieties, such as at STK 01 + Ovidiu F, which was the best in both 2022 and 2023.

10. The protein content of soybeans is favored by the drought and the oil content by the rainy weather and irrigation.