Agrometeorological Requirements of Maize Crop Phenology for Sustainable Cropping—A Historical Review for Romania

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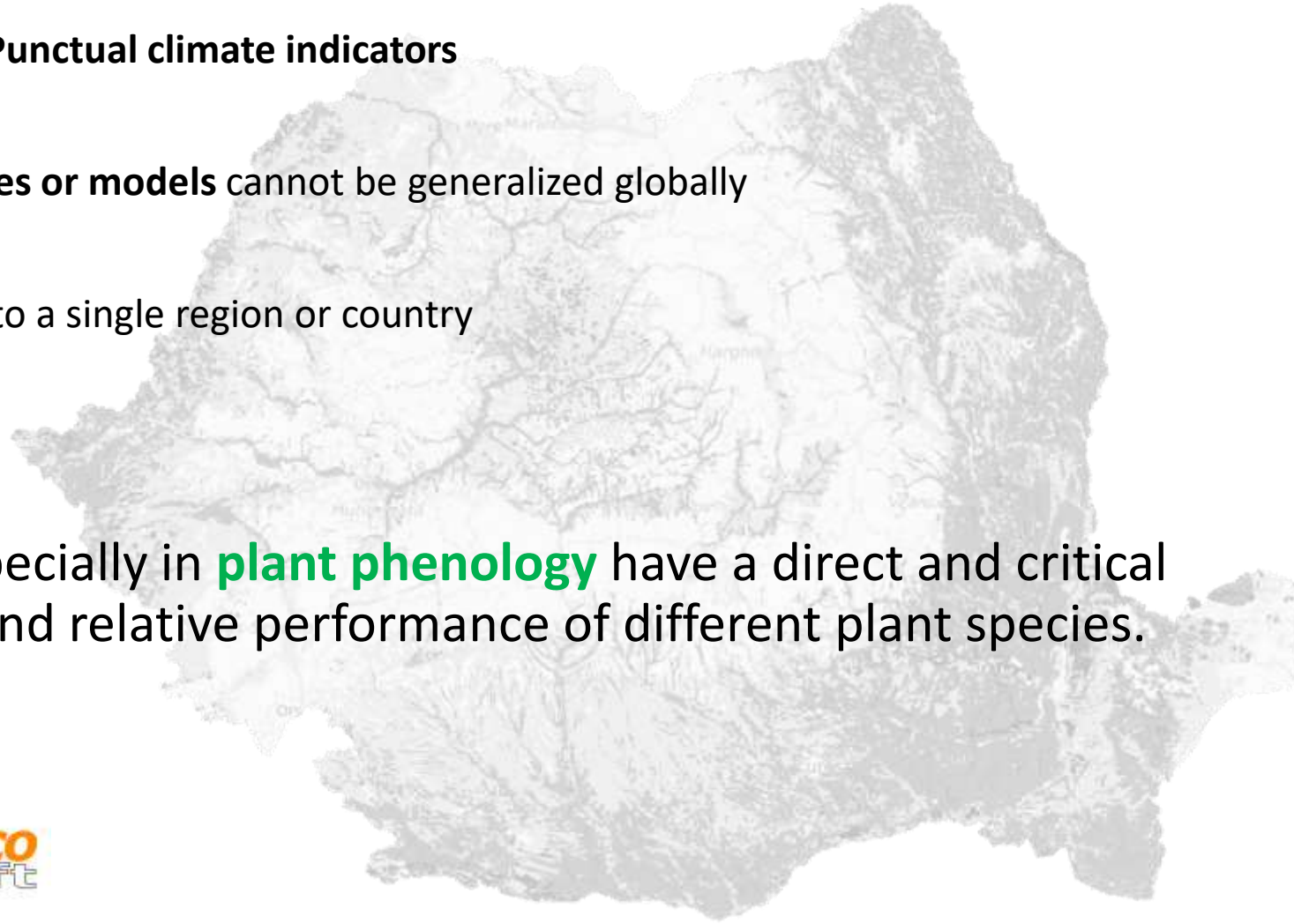
Brief introduction

Agrometeorological concept

- Assessment of **suitable crop distribution**
- **Punctual climate indicators**
- Evaluation **scales or models** cannot be generalized globally
- Models must be **specific** to a single region or country

Observed changes especially in **plant phenology** have a direct and critical effect on crop yield and relative performance of different plant species.

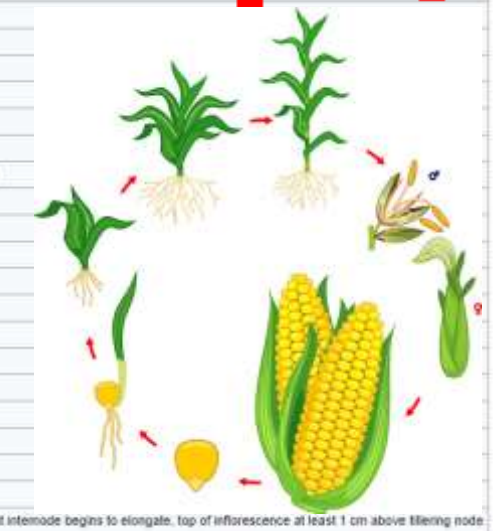


Maize plant phenology - BBCH (Meier, 2018)

The phenological growth stages and BBCH-identification keys of cereals are:

Tm ? PP ?

Growth stage	Code	Description
0: Germination	00	Dry seed (caryopsis)
	01	Beginning of seed imbibition
	03	Seed imbibition complete
	05	Radicle emerged from caryopsis
	06	Radicle elongated, root hairs and/or side roots visible
	07	Coleoptile emerged from caryopsis
	09	Emergence: coleoptile penetrates soil surface (cracking stage)
1: Leaf development[1, 2]	10	First leaf through coleoptile
	11	First leaf unfolded
	12	2 leaves unfolded
	13	3 leaves unfolded
	1.	Stages continuous till ...
	19	9 or more leaves unfolded
2: Tillering[3]	20	No tillers
	21	Beginning of tillering: first tiller detectable
	22	2 tillers detectable
	23	3 tillers detectable
	2.	Stages continuous till ...
	29	End of tillering: Maximum no. of tillers detectable
3: Stem elongation	30	Beginning of stem elongation: pseudostem and tillers erect, first internode begins to elongate, top of inflorescence at least 1 cm above tillering node
	31	First node at least 1 cm above tillering node
	32	Node 2 at least 2 cm above node 1
	33	Node 3 at least 2 cm above node 2
	3.	Stages continuous till ...
	37	Flag leaf just visible, still rolled
	39	Flag leaf stage: flag leaf fully unrolled, ligule just visible
4: Booting	41	Early boot stage: flag leaf sheath extending
	43	Mid boot stage: flag leaf sheath just visibly swollen
	45	Late boot stage: flag leaf sheath swollen
	47	Flag leaf sheath opening
	49	First awns visible (in awned forms only)



Soil ?

5: Inflorescence emergence, heading	51	Beginning of heading: tip of inflorescence emerged from sheath, first spikelet just visible
	52	20% of inflorescence emerged
	53	30% of inflorescence emerged
	54	40% of inflorescence emerged
	55	Middle of heading: half of inflorescence emerged
	56	60% of inflorescence emerged
	57	70% of inflorescence emerged
	58	80% of inflorescence emerged
	59	End of heading: inflorescence fully emerged
6: Flowering, anthesis	61	Beginning of flowering: first anthers visible
	65	Full flowering: 50% of anthers mature
	69	End of flowering: all spikelets have completed flowering but some dehydrated anthers may remain
7: Development of fruit	71	Watery ripe: first grains have reached half their final size
	73	Early milk
	75	Medium milk: grain content milky, grains reached final size, still green
	77	Late milk
8: Ripening	83	Early dough
	85	Soft dough: grain content soft but dry. Fingernail impression not held
	87	Hard dough: grain content solid. Fingernail impression held
	89	Fully ripe: grain hard, difficult to divide with thumbnail
9: Senescence	92	Over-ripe: grain very hard, cannot be dented by thumbnail
	93	Grains loosening in day-time
	97	Plant dead and collapsing
	99	Harvested product

Tm ? PP ?

Soil ?

How could you make a scale when each growth stage is directly influenced by these three indicators to develop and grow???

Gaps in classification of phenological stages by BBCH

There are no *clear* requirements for **average temperatures** on the phenophase or monthly.

There is **no *clear* suitability** for the type of **soil** described.

There are no *clear* **minimum and maximum temperatures**, **optimal or unfavorable rainfall amount** - plant withstands in phenophase resistance.

Moreover, **agroclimatic indicators** are not targeted by this scale of development.

General: plant growth is not harmonized on climatic requirements

Hence the need to **highlight** the fact that agronomy especially in Romania has provided incomplete and often ambiguous data in terms of requirements for most field crops on climate indicators.

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Gaps in maize climatic requirements

- **GDD**=the sum of temperatures above the biological threshold +10°C (Ministery of Agriculture, 1990)
- **Thermal constant**=the sum (°C) of the average daily temperatures >5°C (considered active temperatures) (Diaconu et al., 1978)
- **Termic units**= UT=$\sum_{n}^{1} \frac{t1+t2+t3+t4}{4}$ - 10, where t1=temperature measured at 1 o'clock

  t2=temperature measured at 7 o'clock

  t3=temperature measured at 13 o'clock

  t4=temperature measured at 19 o'clock (Bîlteanu et al., 1983)

°C or °F ???

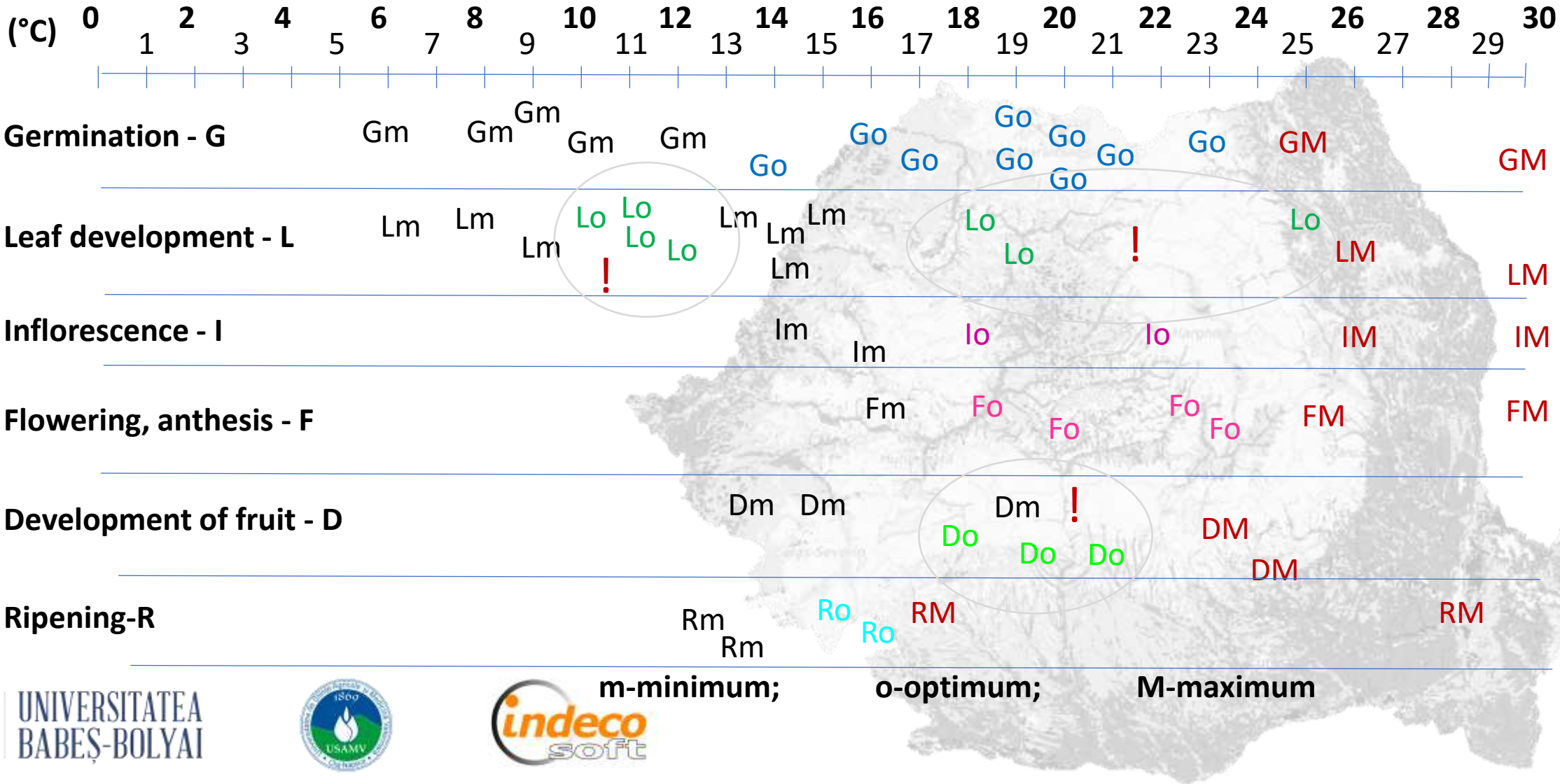
Maize – 1400-1500 **UT** + 550-600 mm – entire vegetation period (Popescu, 1995)

2200-3500**°C** – entire vegetation period (Herea and Gin, 1980)

Thermal constant – 1800-2600°C – entire vegetation period (Taindel and Vrînceanu, 1962)

1700-3700**°C** = sum of temperatures for the entire vegetation period, romanian hybrids between 1800-3000°C (Diaconu et al., 1978)

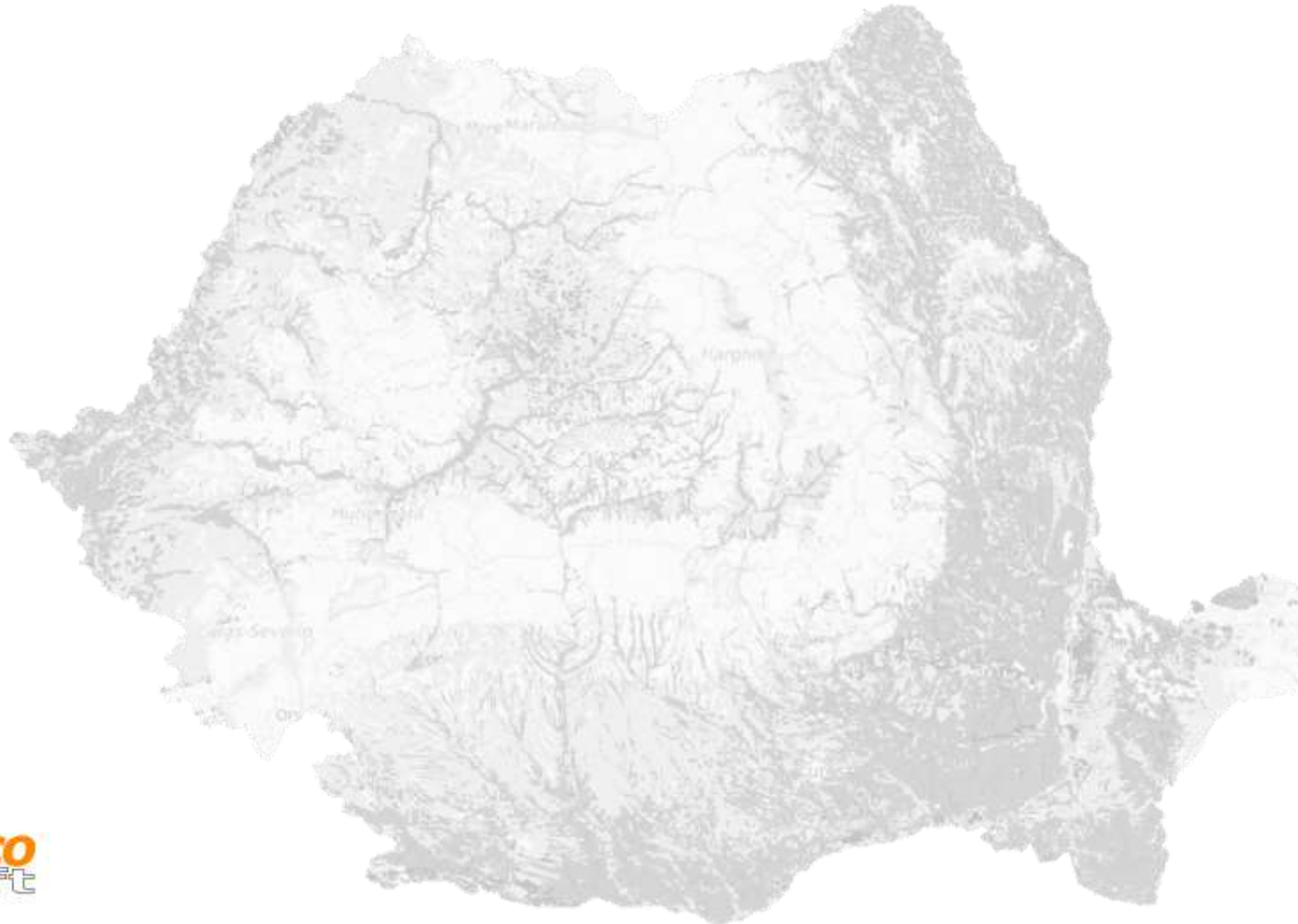
Gaps in maize climatic requirements - temperature



Maize requirements

No projects or research with all developmental stages were done and with concluding results
In a try to highlight some real requirements we took only principal growth stages

	Objective: finding temperature and precipitation			
BBCH code	**Description**	**Optimum interval – Tm**		**Possible days for each principal growth stage - Max**
0	Germination	10.1	12.0	16
1	Leaf development	12.1	14.0	23
3	Stem elongation	16.1	17.0	20
5	Inflorescence	21.1	22.0	10
6	Flowering, anthesis	21.1	22.0	10
7	Development of fruit	23.1	24.0	15
8	Ripening	18.1	19.0	20
9	Senescence	13.1	14.0	19



Maize crop requirements for precipitation

Month	Precipitation	
April	soil supply	soil supply
May	**60**	**80**
June	**100**	**120**
July	**100**	**120**
August	**40**	**60**
September	**40**	**60**

Maize crop needs:

Amount of rain distribution/vegetation period
June + July – the highest amount of water
From BBCH 3 – Stem elongation the need for water increases

200-5000 mm/year (Dincă et al.,1967)

pp ↗
- ✓ Flowering, anthesis and development of fruit (Teaci, 1980)
- ✓ 1-2 weeks before flowering until middle of Ripening (Popescu, 1995)

Minimum amount of pp /vegetation period= 250-300 mm (Salontai et al., 1982)
Optimum amount – 300-380 mm/vegetation time

Conclusions

- The maize crop has different requirements in terms of temperature and water needs based on cumulative BBCH stages that could take place in one month.
- The highest temperatures requirements are in BBCH stages 5-7 in the range 21-24°C and for water amount from precipitation in June-July for about 100-120 mm.
- We need attention and standardized methods if we want to understand, monitor and control how our crops will grow in the future if elevated CO_2, pollution, GHG concentration increases and even temperatures or precipitation trends will change.

Conclusions

- Much work and efforts must be done to connect climatic indices as today are registered with crop growth as a challenge for the new global change tendencies and crop adaptive metabolism and requirements.
- Models yes --- but until when?
- Agroclimatology = agronomy + climatology (synergy)

Agroclim.ro

Redefinirea zonelor de favorabilitate agro-climatică pentru porumb și grâul de toamnă spre o agricultură inteligentă adaptată la schimbările climatice în România

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The project in numbers

- **Project type:** Experimental-demonstrative Projects (PED)
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  Funding Contract: 292PED / 2020
- **Budget:** 662,910 RON (596,245 RON public funding and 66.665 RON private cofounding by INDECO SOFT).
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