CASEE
Central and South Eastern Europe

University of
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Department of
Sustainable Agricultural Systems

Division of Agricultural Engineering

"Segregation of solid fertilizer blending in a conical heap and due logistic activities"

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6th CASEE conference, Slovak University of Agriculture in Nitra, May 24 – 26, 2015

Types of *compound fertilizers*

Compound fertilizer have a declarable content of at least two of the primary nutrients and obtained **chemically** or by **blending** or by combination of both (Regulation EC No 2003/2003)

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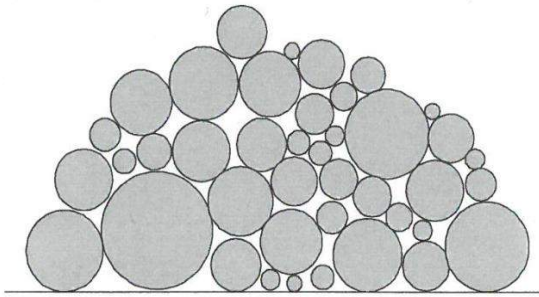
Complex fertiliser

„chemically mixed“

Each granule contains all the nutrients in their declared composition



Same material properties
(except: grain size)

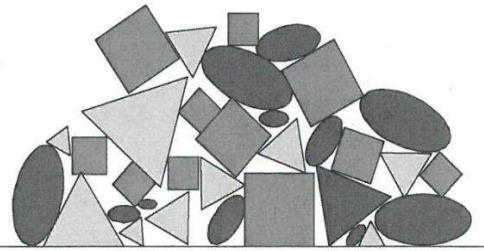
Blended fertiliser

„ mechanically mixed“

Nitrogen

Phosphorus

Potassium



Different material properties

(Marquering, 2001)

Blended fertilizer

+ **Lower costs** for specific blend formulations
+ Realisation of **flexible nutrients composition** in stationary or decentral mixing plants

- **Different material properties** of the single fertilizers can affect **segregation in the logistic system** and during **application in the field with a disc spreader.**

Segregation of CAN and Urea

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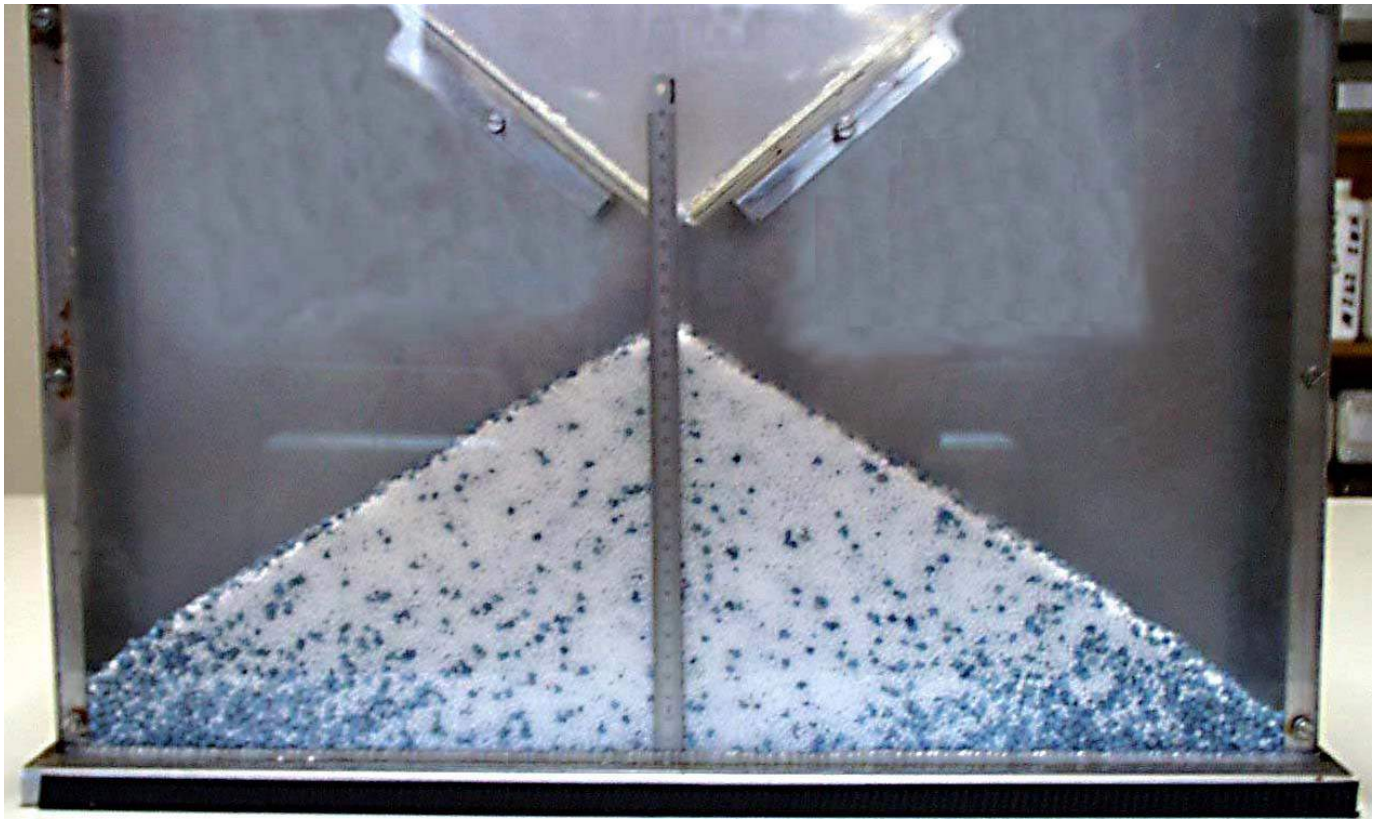

(Marquering, 2001)

Influence of different grain sizes:

Urea (46 % N): white, smaller grains
CAN (27 % N): blue stain, larger grains

Results of additional segregation during application with a disc-spreader

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Different studies (Mathes & Brübach, 1966; Heege & Hellweg 1982; Marquering, 2001) show the significant influence of **grain size distribution** and **grain shape** on the lateral distribution in the field.
Lowest segregation during application**: physical properties** (grain size, surface shape, grain density, drag coefficient) of the fertilizer components **are similar**.
Highest segregation during application: In blends with **different grain sizes**, smaller grains tend to be distributed closer to the tramline, whereas larger grains tend to be thrown wider off the tramline. If additionally the shape and grain density differs in the mixture the segregation effect during application with a two-disc spreader increases.

Research objective

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The aim of the present study was to analyse the influence of three different mineral bulk-blends on segregation in a **conical heap**

and in three different logistics systems:

tank truck

truck trailer

big bag

Material and Methods

Stationary mixing plant (Sandwich approach with mixing screw)

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Hopper 3	Hopper 2	Hopper 1
Complex: 15 % N/ 15 % K_2O/ 15 % P_2O_5+3 % S+Zn (granulated, round grain)	Muriate of Potash **(MOP);** 60 % K_2O) = Potassium chloride (compacted, angular grain)	Calcium ammonium nitrate **(CAN);** 27 % N (granulated, round grain)

Material and Methods
Analysed blends

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Blend 1: 50 % CAN (granulated, round grain)
50 % Complex (granulated, round grain)

Blend 2: 33 % CAN (granulated, round grain)
33 % Complex (granulated, round grain)
34 % MOP (compacted, angular grain)

Blend 3: 50 % CAN (granulated, round grain)
50 % MOP (compacted, angular grain)

Material and Methods
Sampling of the conical heap

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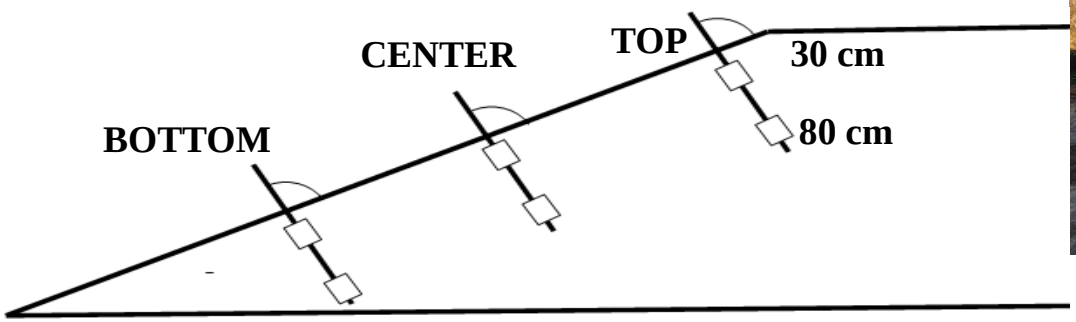
After mixing of each blend **(á 25 tons)** a conical heap was formed from which the fertilizer samples were drawn with a sampling insertion device in 80 cm and 30 cm depths at three levels of the conical heap (bottom, middle, top).



Sampling insertion device

Material and Methods

Sampling of the heap after unloading from tank truck and truck trailer and in the big bag

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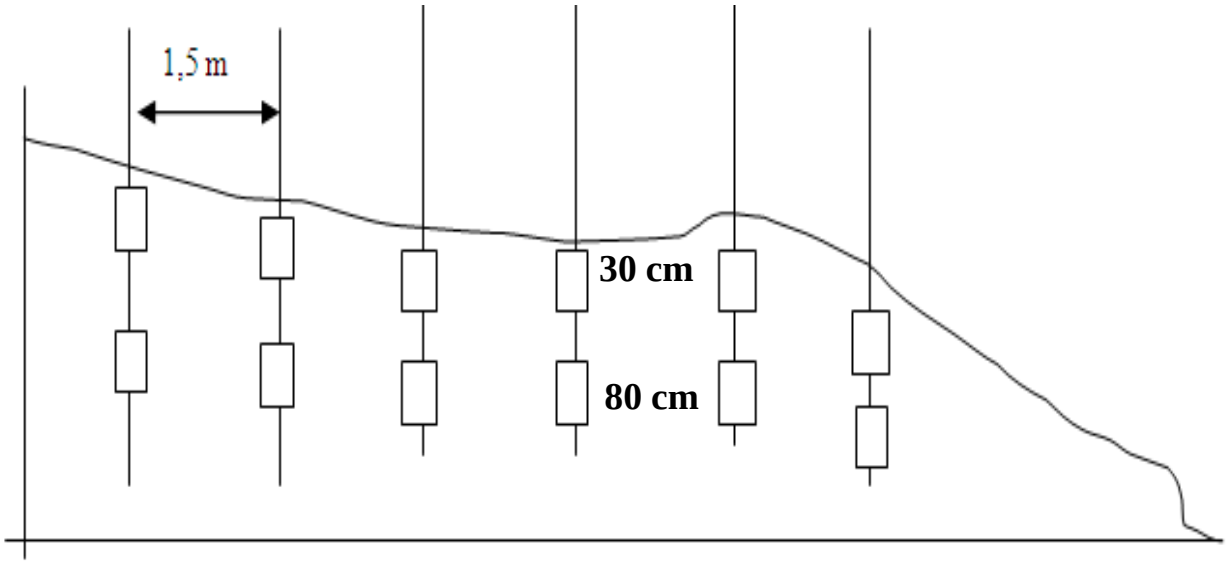

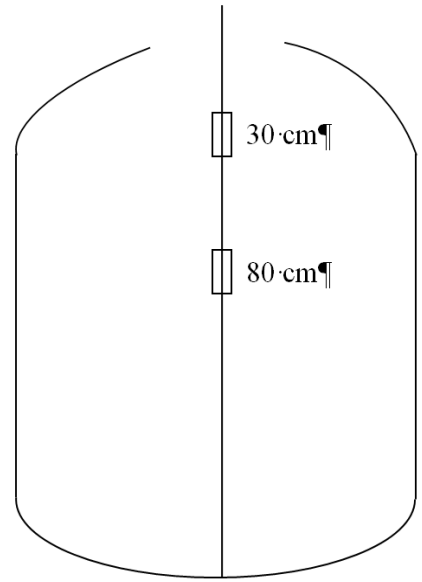

Material and Methods

Fertilizer samples for chemical and sieve analysis

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	Blend 1	Blend 2	Blend 3	Number of samples
Conical heap (SS)	16	16	16	**48**
Conical heap (RS)	2	2	2	**6**
Truck trailer after unloading (SS)	7	7	7	**21**
Tank truck after unloading (SS)	11	9	8	**28**
In big bag (SS)	6	6	6	**18**
	CAN	**Complex**	**MOP**	
Single fertilizer	2	2	2	**6**
Total number of samples				**127**

SS: systematic sampling; RS: random sampling

Results

Nutrient distribution (blend 1) in the conical heap

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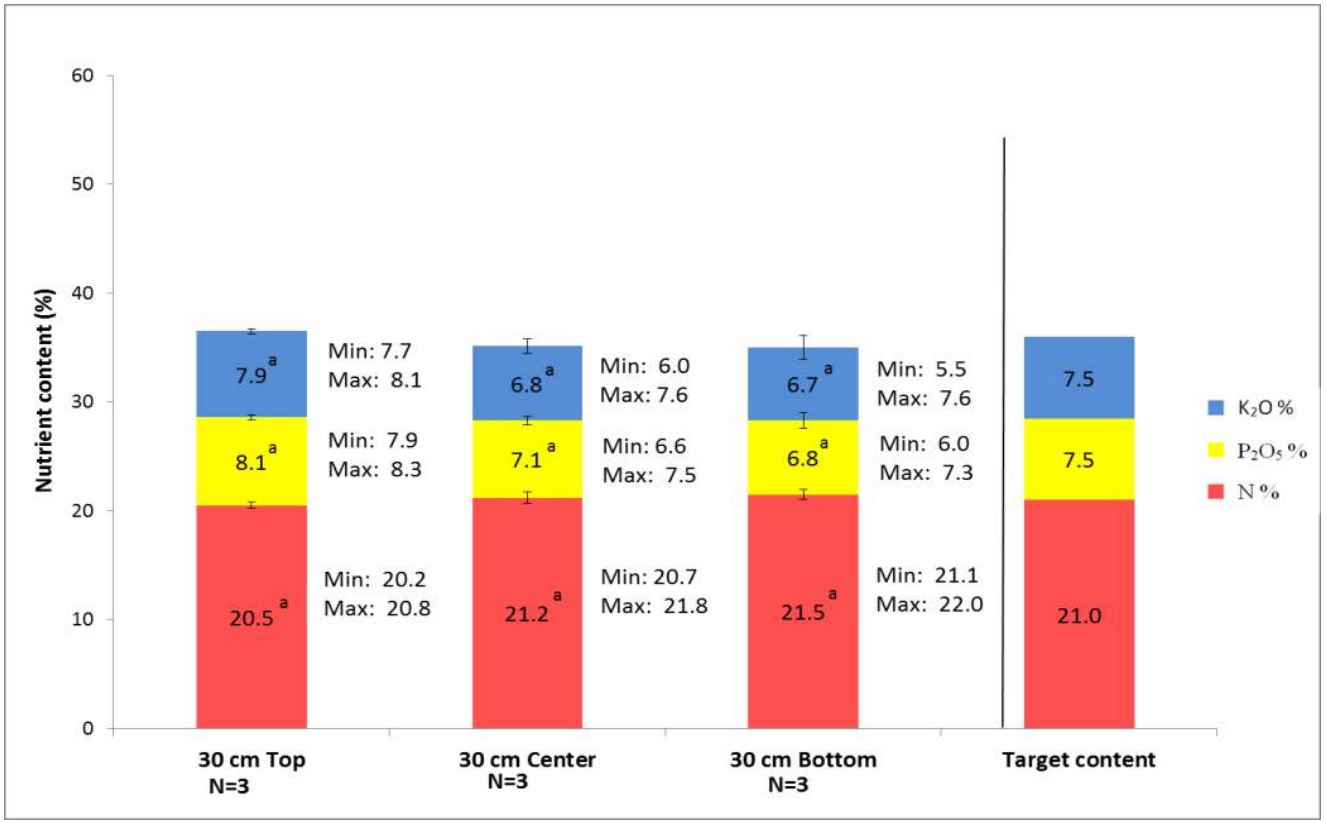

Blend 1:

50 % CAN (granulated, round grain)

50 % Complex (granulated, round grain)

Figure 8: Mean nutrient content (%) with standard deviation in **blend 1** at the Top, Center and Bottom of the conical heap in comparison to the target content. Sampling depth = 30 cm. Significant differences (Student-Newman-Keuls-Test, α=0.05) between Top, Center and Bottom are indicated with different letters.

Results

Nutrient distribution (blend 2) in the conical heap

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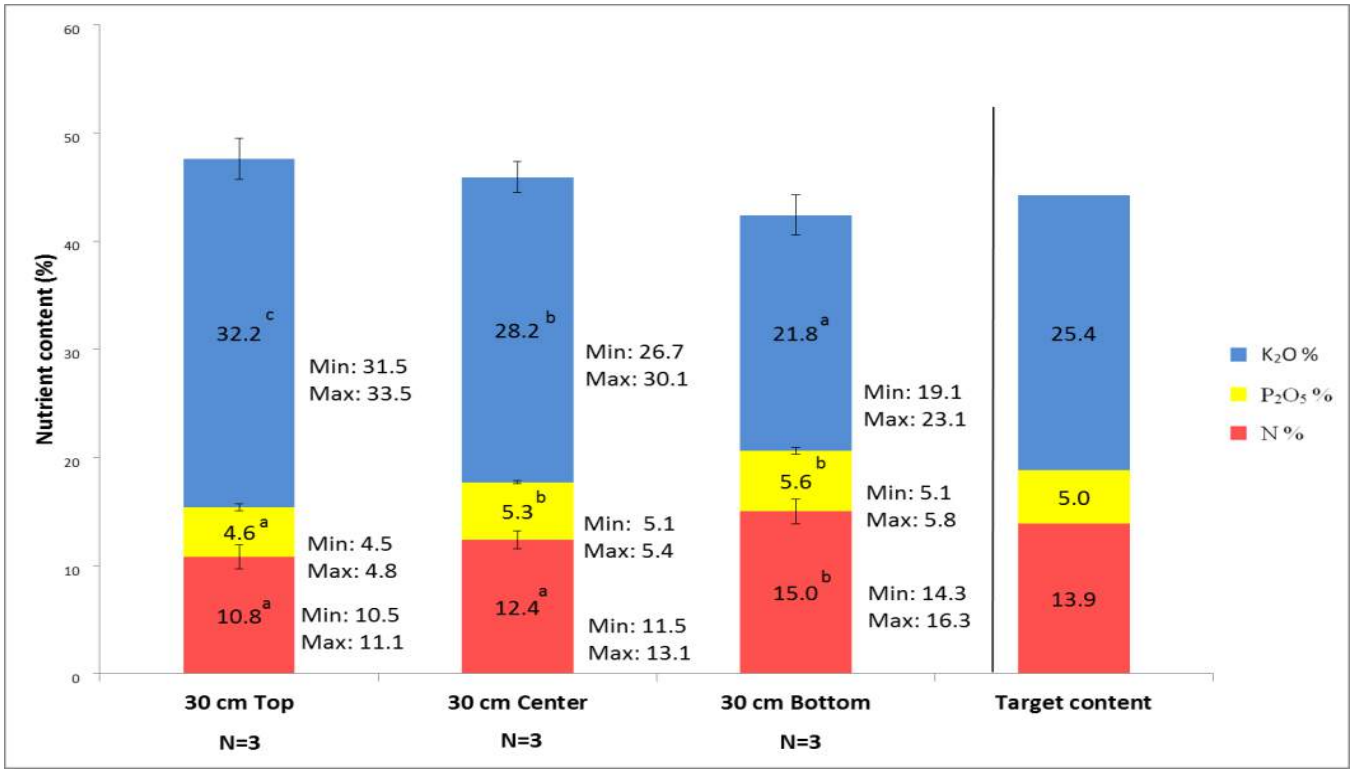

Blend 2:

33 % CAN (granulated, round grain)

33 % Complex (granulated, round grain)

34 % MOP (compacted, angular grain)

Figure 10: Mean nutrient content (%) with standard deviation in **blend 2** at the Top, Center and Bottom of the conical heap in comparison to the target content. Sampling depth = 30 cm. Significant differences (Student-Newman-Keuls-Test, α=0.05) between Top, Center and Bottom are indicated with different letters.

Results

Nutrient distribution (blend 3) in the conical heap

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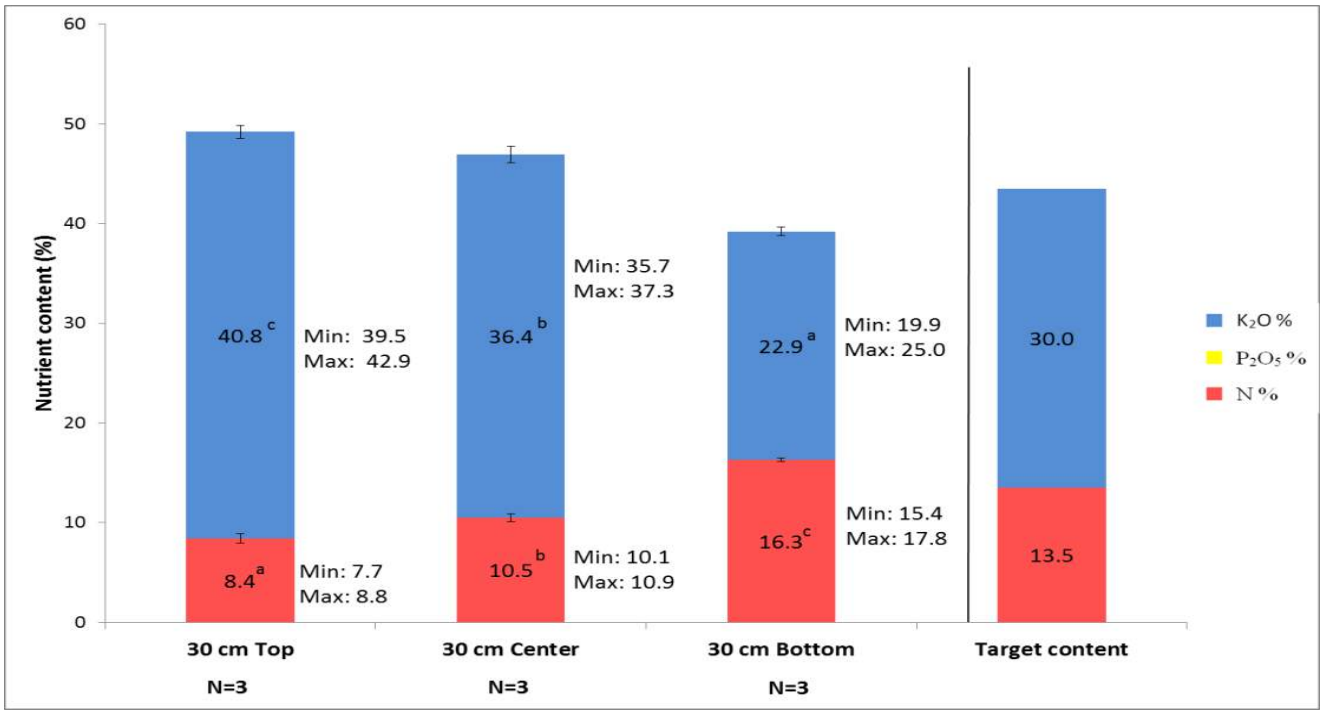

Blend 3:

50 % CAN (granulated, round grain)

50 % MOP (compacted, angular grain)

Figure 12: Mean nutrient content (%) with standard deviation in **blend 3** at the Top, Center and Bottom of the conical heap in comparison to the target content. Sampling depth = 30 cm. Significant differences (Student-Newman-Keuls-Test, α=0.05) between Top, Center and Bottom are indicated with different letters.

Results

Potential effect on nutrient amount in the field

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Table 2. Theoretical nutrient amount (kg ha^{-1}) in the field if fertilizer is applied from conical heap at a **30 cm depth**

	N	P_2O_5	K_2O
Blend 1 (Target amount)	**120**	**55**	**80**
Top	117 (-2.5 %)	59 (+ 7.3 %)	85 (+6.3 %)
Center	121 (+0.8 %)	52 (-5.5 %)	73 (-8.8 %)
Bottom	123 (+2.5 %)	50 (-9.1 %)	71 (-11.3)
Blend 2 (Target amount)	**120**	**55**	**80**
Top	94 (-21.7 %)	51 (-7.3 %)	102 (+27.5 %)
Center	107 (-10.8 %)	59 (+7.3 %)	89 (+10.1 %)
Bottom	130 (+8.3 %)	62 (+12.7 %)	69 (-13.8 %)
Blend 3 (Target amount)	**120**		**80**
Top	75 **(-37.5 %)**		109 **(+36.3 %)**
Center	93 **(-22.5 %)**		97 **(+21.3 %)**
Bottom	145 **(+20.8 %)**		61 **(-23.8 %)**

Blend 1:
50 % CAN
50 % Complex

Blend 2:
33 % CAN
33 % Complex
34 % MOP

Blend 3:
50 % CAN
50 % MOP

Oversupply and undersupply of nutrient in the field!!

Results

Potential effect on nutrient amount in the field

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Table 3. Theoretical nutrient amount (kg ha^{-1}) in the field if fertilizer is applied from conical heap at **80 cm depth**

	N	P_2O_5	K_2O
Blend 1 (Target amount)	**120**	**55**	**80**
Top	117 (-2.5 %)	59 (+7.3 %)	85 (+6.3 %)
Center	114 (- 5.0 %)	63 (+ 14.5 %)	90 (+12.5 %)
Blend 2 (Target amount)	**120**	**55**	**80**
Top	104 (-13.3 %)	54 (-1.8 %)	93 (+16.3 %)
Center	94 (-21.7 %)	52 (-5.4 %)	102 (+27.5 %)
Blend 3 (Target amount)	**120**		**80**
Top	79 **(-34.2 %)**		106 **(+32.5 %)**
Center	73 **(-39.2 %)**		112 **(+40.0 %)**

Blend 1:
50 % CAN
50 % Complex

Blend 2:
33 % CAN
33 % Complex
34 % MOP

Blend 3:
50 % CAN
50 % MOP

Oversupply and undersupply of nutrient in the field!!

Results

Nutrient distribution after transport with truck trailer

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Table 4. Mean nutrient content (%) of blend 1, blend 2 and blend 3 after transport with **truck trailer** and **unloading.**

Blend 1:
50 % CAN
50 % Complex

Blend 2:
33 % CAN
33 % Complex
34 % MOP

Blend 3:
50 % CAN
50 % MOP

	N (%)	P_2O_5 (%)	K_2O (%)
Blend 1 (Target content)	**21.0**	**7.5**	**7.5**
30 cm (N=3)	20.4	7.8	7.9
80 cm (N=2)	20.5	8.0	8.2
Blend 2 (Target content)	**13.9**	**5.0**	**25.4**
30 cm (N=3)	13.2	5.0	26.5
80 cm (N=2)	13.1	5.1	27.1
Blend 3 (Target content)	**13.5**		**30.0**
30 cm (N=3)	13.6		29.7
80 cm (N=2)	11.8		32.9

Results

Nutrient distribution after transport with tank truck

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Table 5. Mean nutrient content (%) of blend 1, blend 2 and blend 3 after transport with **tank truck** and **unloading.**

Blend 1:
50 % CAN
50 % Complex

Blend 2:
33 % CAN
33 % Complex
34 % MOP

Blend 3:
50 % CAN
50 % MOP

	N (%)	P_2O_5 (%)	K_2O (%)
Blend 1 (Target content)	**21.0**	**7.5**	**7.5**
30 cm (N=6)	20.9	7.5	7.3
50 cm (N=5)	20.8	7.5	7.3
Blend 2 (Target content)	**13.9**	**5.0**	**25.4**
30 cm (N=7)	15.2	5.1	21.8
50 cm (N=2)	15.4	5.5	21.3
Blend 3 (Target content)	**13.5**		**30.0**
30 cm (N=6)	14.9		26.1
50 cm (N=2)	13.4		29.5

Results

Nutrient distribution in big bags

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Table 6. Mean nutrient content (%) of blend 1, blend 2 and blend 3 in **big bags**

Blend 1:
50 % CAN
50 % Complex

Blend 2:
33 % CAN
33 % Complex
34 % MOP

Blend 3:
50 % CAN
50 % MOP

	N (%)	P_2O_5 (%)	K_2O (%)
Blend 1 (Target content)	**21.0**	**7.5**	**7.5**
30 cm* (N=3)	21.0	7.0	7.0
50 cm** (N=3)	20.7	7.5	7.6
Blend 2 (Target content)	**13.9**	**5.0**	**25.4**
30 cm (N=3)	15.5	5.2	21.2
50 cm (N=3)	14.3	5.1	23.8
Blend 3 (Target content)	**13.5**		**30.0**
30 cm (N=3)	16.4		20.9
50 cm (N=3)	14.1		26.7

Conclusions

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- **Systematic sampling** of a conical heap with blended fertilizers shows a **variable distribution of nutrients**.
- **Blends of grain components** with different **physical properties** results in **segregation** within the conical heap. Fertilizer within angular grains accumulates at the top of the conical heap, whereas fertilizer with ground grains accumulates at the bottom
- The **transportation of blends** with **tank trucks** can **increase** the segregation **effect after unloading**, whereas transportation with a **truck trailer** can **reduce** segregation after unloading.
- For avoiding segregation of blends in the conical heap and during spreading with a disc-sprayer, the blending components should have the **same physical properties** (grain size, grain density, grain shape).
- In particular, the **angular grains** of Muriate of Potash (MOP, 60 % potassium) **should not be mixed** with fertilizer components with **granulated round grain** (e.g. CAN, 27 % N).

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Thank you for your attention

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