Rit LbhÍ nr. 32

„Effects of organic fertilizers on N mineralization, growth and yield of year-round organic greenhouse cucumber and sweet pepper“

FINAL REPORT

Christina Stadler

2011

Rit LbhÍ nr. 32 ISBN 9789979881052

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Landbúnaðarháskóli Íslands

Janúar 2011

Final report of the research projects

„Effects of organic fertilizers on N mineralization, growth and yield of year-round organic greenhouse cucumber“

„Effects of organic fertilizers on N mineralization, growth and yield of year-round organic greenhouse sweet pepper“

Duration:	01/11/2008 – 31/01/2010 (cucumbers) 01/11/2008 – 30/11/2009 (sweet pepper)
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Flúðasveppir was supporting the research project with mushroom compost.

Funding of the leave analyses was provided by Bröste.

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Abbreviations

Al	aluminium
B	boron
C	carbon
Ca	calcium
Cl	chloride
Cu	cooper
DM	dry matter
E.C.	electrical conductivity
Fe	iron
HSD	honestly significant difference
K	potassium
KCl	potassium chloride
M	mole
Mg	magnesium
Mn	manganese
Mo	molybdenum
N	nitrogen
Na	sodium
NH_4-N	ammonium-N
NO_3-N	nitrate-N
P	phosphor
$p \leq 0.05$	5% probability level
pH	potential of hydrogen
RCB	randomized complete block
S	sulphur
W	Watt
Zn	zinc

1 SUMMARY

In Iceland, winter production of greenhouse crops is totally dependent on supplementary lighting and has a potential to extend seasonal limits and replace imports during the winter months. Adequate guidelines for year-round cucumber production and suitable fertilizer application are not yet in place for organic cucumber and sweet pepper production and need to be developed.

An experiment with organic cucumbers cv. Cumuli (1,5 plants / m^2, 2 croppings / year) and organic sweet pepper cv. Ferrari (5 stems/m^2, 1 cropping/year) was conducted in the greenhouse of Akur, Laugarás with two different fertilizer treatments. Alternating at two-week-intervalls either compost (Fluðasveppir) and a fishmeal and seaweed - mixture or Nugro was applied. Soil NO_3^--N was analysed before transplanting and at regularly intervalls during the cropping period. During the growth period, height of plants, number of fruits, time from fruit setting up to harvest and yield parameters was analyzed. Nutrient content from leaves was determined during the growth period.

The yield was unaffected by fertilizers. However, the time of the growing season seems to influence growth parameters (height, time from fruit setting to harvest) and wintergrown vegetables seems to result in a delayed harvest. This is highlighting the importance of supplemental lighting and the impact of the solar irradiation.

Nitrate content in soil is disclosing the need to decrease N application at stages when plants do not have a high N uptake and avoid so the risk for N leaching to deeper soil layers.

It was concluded that it is possible to maintain a year-round organic production of vegetable. The mixture of fishmeal and seaweed as well as Nugro seem to provide a sufficient N supply for organically grown horticultural crops and a splitted fertilizer application to ensure a steady N supply for the plants seems to be recommended.

2 INTRODUCTION

In Iceland and other northern regions, there is an extremely low natural light level. That is the major limiting factor for winter glasshouse production. Therefore, supplementary lighting is essential to maintain year-round vegetable production. This could replace imports from lower latitudes during the winter months and make domestic vegetables even more valuable for the consumer market. So far, organic vegetable have not been grown in winter in Iceland. However, it is necessary to get knowledge about year-round vegetable production in organic horticulture with supplementary lighting. Consulting of conventional production reveals that the positive influence of artificial lighting on plant growth, yield and quality of tomatoes (*Demers* et al., 1998), cucumbers (*Hao* & *Papadopoulos*, 1999) and sweet pepper (*Demers* & *Gosselin*, 1998) has been well studied.

Nitrogen (N) fertilizer application in organic horticulture is regulated by the European Union Standards (EEC no. 2092/91) on organic production of agricultural products and additionally by standards of organic producer’s organisations. N sources in organic farming are organic fertilizers such as crop residues, legumes, animal manure and commercial organic fertilizers. In Iceland, demand of organic N fertilizers has been increased in the last years. It is common to fertilize vegetable crops mainly with mushroom compost, residues from the fish industry (fishmeal) (*Gunnlaugsson*, 1998) and “residues” from the sea (seaweed). Also, imported industrially processed animal residues e.g. Nugro (liquid fertilizer based on fishmeal) are getting more popular. It is reported that organic vegetable, fertilized with mushroom compost, yielded a good harvest of cucumbers (*Gunnlaugsson*, 1995) and tomatoes (*Gunnlaugsson*, 1997). Yield of organic cucumbers was dependent on the kind of fertilizer and was highest with fishmeal (*Gunnlaugsson* & *Guðfinnsson*, 2004). One reason may possibly be the influence of fertilizer characteristics on their N mineralization. For instance, it is known that the N release from plant-derived and industrially processed organic N fertilizers is correlated to the fertilizer N content (*Stadler* et al., 2006).

The N mineralization of commonly used N fertilizers in organic horticulture (except compost) in Iceland is expected to be rapid in greenhouses. Therefore, with respect to a plant growth adapted N supply, it is supposed that fertilizers with a high and rapid N release should be applied in split doses to result in a high N efficiency

(*Stadler*, 2006). One preliminary experiment, with a mixture of mushroom compost and fishmeal, applied at weekly or half a month intervals, has already been conducted and results of organic grown tomatoes are promising (*Gunnlaugsson*, 1998). However, more detailed and continuous observations on how fertilizer application affects nitrate content in the upper soil layer in connection with yield parameters are needed before advising for a year-round organic vegetable production.

The objective of this study was (1) to test how to grow organic vegetables the whole year exemplified by cucumbers and sweet pepper, (2) to find an adequate fertilizer treatment that enhances yield and quality and (3) to give vegetable growers advice how to improve their organic cucumber and organic sweet pepper production.

3 MATERIALS AND METHODS

3.1 Greenhouse experiment

An experiment with cucumbers (*Cucumis sativus* L. cv. Cumuli) and sweet pepper (*Capsicum annum* L. cv. Ferrari) was conducted at the nursery Akur (Grænjaxlarnir ehf.) in Laugarás. Previous to cucumbers and sweet pepper, tomatoes (*Lycopersicum esculentum* MILL.) were grown in 2008. Shoots and roots of tomatoes were removed at the middle of November. Soil was tilled to a depth of 15 cm with a rotator and mushroom compost from Fluðasveppir was mixed into soil 3 days before transplanting of cucumbers.

Cucumbers and sweet pepper were sown and later potted in a mixture of compost, peat and pumice (Tab. 1). Plants were transplanted in double rows (cucumbers: 69 cm plant to plant, 65 cm inter-row distance and 90 cm distance between the double rows, 1,5/1,7 plants/m^2 (1st / 2nd cropping), sweet pepper: 40 cm plant to plant, 65 cm inter-row distance and 90 cm distance between the double rows, 2,5 plants/m^2) in soil with a high content of silt and high in organic matter. Three croppings for each timing of cucumbers were planned to perform a year-round production, however, due to much pest, only two croppings were obtained.

Tab. 1: Dates of cropping for cucumbers and sweet pepper.

	Cucumbers				**Sweet pepper**
	1st timing		2nd timing		
	1st cropping	2nd cropping	1st cropping	2nd cropping	
Sowing	26.09.08	10.02.09	26.11.08	24.03.09	05.11.08
Potting	10.10.08	18.02.09	04.12.08	03.04.09	01.12.08
Transplanting	05.11.08	15.03.09	30.12.08	25.04.09	08.01.09

Cucumbers were fertilized with either a fishmeal and seaweed - mixture (30 + 15 g/plant) or Nugro (20 % mixture with water, mixed 1:60 with water, two l per plant). Nugro 8-3-3 was used for early growth, but from the beginning of the harvest, Nugro 5-2-7 was applied. Nugro is a liquid fertilizer based on fishmeal. The fishmeal and seaweed - mixture was watered into soil with approximately two l of water per plant. The same amount of water was applied to the Nugro treatment. Fertilizer was applied every forth week followed two weeks later by one l per plant of compost (Tab. 2), for both fertilizer treatments (Tab. 3a). Due to a missunderstanding, in the 1st cropping in the treatment “Fishmeal + Seaweed - mixture” only half of the amount of the mixture was applied during the first two times (until 23.12.2008).

Tab. 2: Characteristics of the compost (93,5 % DM) used.

Application	N	C	C/N	P	K	Ca	Mg	Na	S	Fe	pH	E.C.
	---- % ----			------------------ % in TS ------------------						mg / 100 g DM		
07.01.09	2,2	31,8	14,6	0,5	0,2	5,6	0,4	0,1	1,5	737	7,6	6,5
20.01.09	2,6	31,1	12,1	0,6	0,5	5,3	0,5	0,1	1,8	701	7,3	11,6
03.02.09	2,3	30,6	13,6	0,4	1,2	5,8	0,5	0,3	3,1	420	7,8	2,8

Tab. 3a: Fertilizer application plan for cucumbers (1st timing, 1st cropping).
For the other timing and croppings the fertilizer application was done accordingly.

Fertilizer	25.11.08	11.12.08	23.12.08	08.01.09	22.01.09	04.02.09	19.02.09	04.03.09
Fishmeal + Seaweed - mixture or Nugro	X		X		X		X	
Compost		X		X		X		X

Fertilizer application in sweet pepper was the same as in cucumbers, except that here all plants received the same treatment of both the fishmeal and seaweed - mixture or Nugro, at different times though (Tab. 3b). Two weeks after each fertilizer application, one l per plant of compost was also applied.

Tab. 3b: Fertilizer application plan for sweet pepper.

Fertilizer	16.02.09	04.03.09	18.03.09	07.04.09	24.04.09	15.05.09	26.05.09	05.06.09	16.06.09	02.07.09	15.07.09	29.07.09	13.08.09	26.08.09	10.09.09	23.09.09	09.10.09	20.10.09	05.11.09
Nugro	X		X				X				X				X		X		
Fishmeal + Seaweed - mixture					X				X				X						X
Compost		X		X		X		X		X		X		X		X		X	

Cucumbers and sweet pepper were grown under high-pressure vapour sodium lamps (180 W/m^2, top lights). Light was provided for 18 hours, but the lamps were automatically turned off when natural incoming illuminance was above a desired set-point. Temperature was kept at 22 / 21°C (day / night) for cucumbers and at 23 / 20°C (day / night) for sweet pepper and ventilation started at 25°C. Carbon dioxide was provided (800 ppm CO_2 with no ventilation and 400 ppm CO_2 with ventilation). Drip irrigation (3 tubes per bed, dripping distance 10 cm) was used. Plant protection was managed by beneficial organisms. In cucumbers “Trichoderma” was applied monthly and “Allgrow” was used weekly to protect cucumbers against mildew. Weed was regularly removed by hand.

3.3 Measurements, sampling and analyses

For cucumbers, the experimental layout was a RCB design with three (first timing) respectively four replicates (second timing). For sweet pepper, one bed was divided into three blocks and fertilizer treatments were repeated three times. Within the blocks ten randomizely selected plants acted as plants for measurements.

To be able to determine plant development, the height of plants, the number of fruits and leaves and time from fruit setting to harvest was measured each week. During the growth period, fruits were regularly collected in the blocks four / three (cucumbers / sweet pepper) times each week. Total fresh yield, number of fruits, fruit category (1^{st} class), and unmarketable fruits and for sweet pepper also colour of fruit were determined. Leaves of cucumbers and sweet pepper were analyzed at the middle and at the end of the growth period.

Composite soil samples (0-15 cm) for analysis of nitrate-N were taken at regular intervals during the growth period (for cucumbers only from the first timing), before and once a week after fertilizer and compost application. Additional samplings included soil samples from 15-30 cm once per month one week after the fertilizer application. After sampling, soil samples were kept frozen. The soil was measured for nitrate (1,6 M KCl) with a Perkin Elmer FIAS 400 combined with a Perkin Elmer Lambda 25 UV/VIS Spectrometer.

3.4 Statistical analyses

SAS Version 9.1 was used for statistical evaluations. The results were subjected to one-way analyses of variance with the significance of the means tested with a Tukey/Kramer HSD-test at $p \leq 0.05$.

4 RESULTS AND DISCUSSION

4.1 Height of plants

With longer growing period height of cucumbers increased naturally (Fig. 1) independently of fertilizer. However, the time of the season seems to influence the height of cucumbers: Plants that were growing with higher solar irradiation (Fig. 1b, 2nd cropping) were lower compared to plants that were grown at low solar irradiation (Fig. 1a, 1st cropping). The number of leaves at different heights of the cucumber plant was also independent of fertilizer (data not shown).

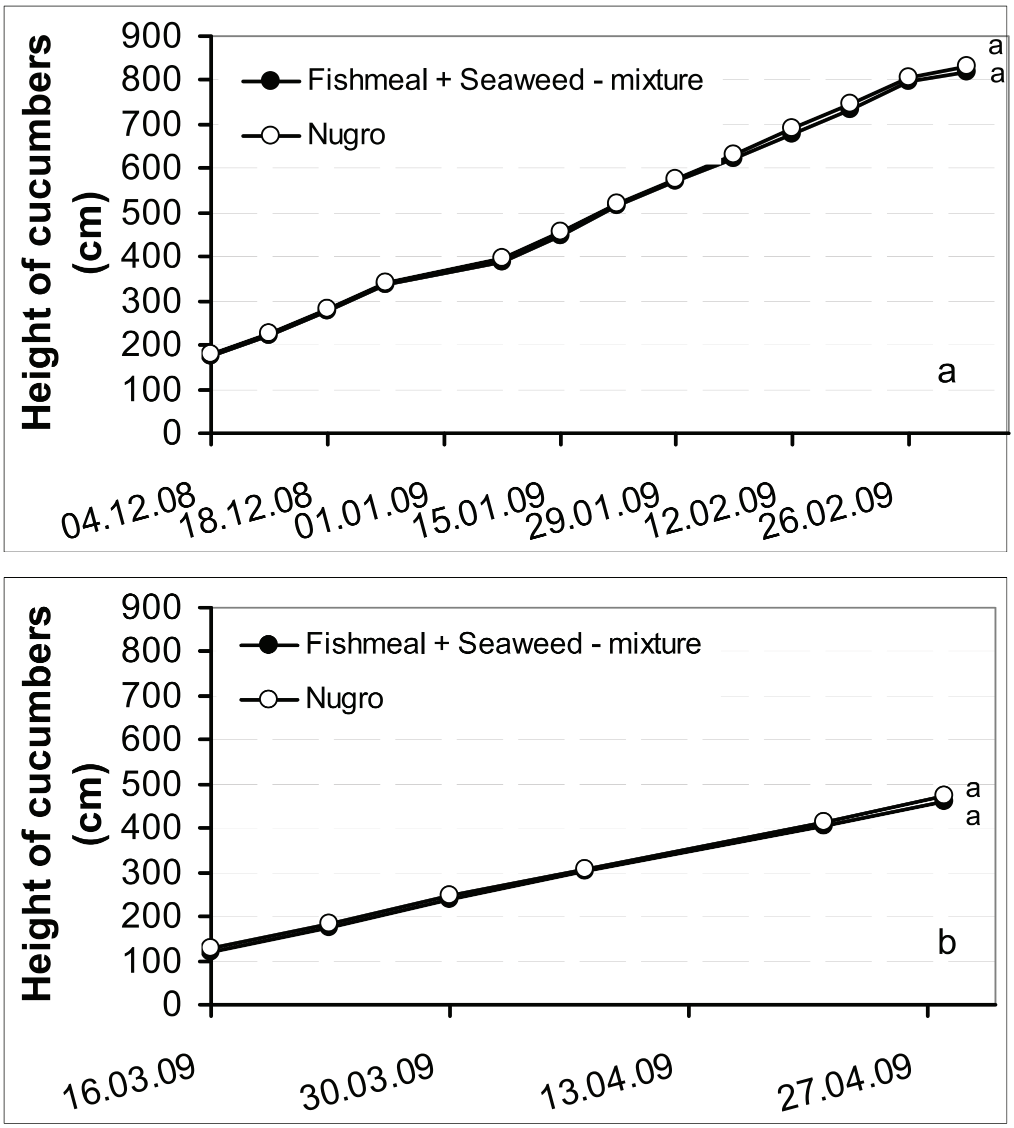


Fig. 1: Height of cucumbers from 1st timing (a: 1st cropping, b: 2nd cropping) fertilized with fishmeal and seaweed - mixture or Nugro.

Letters indicate significant differences at the end of the harvest period (HSD, $p \leq 0.05$).

Height of sweet pepper increased naturally with longer growing period, but with a decreased increase (Fig. 2).

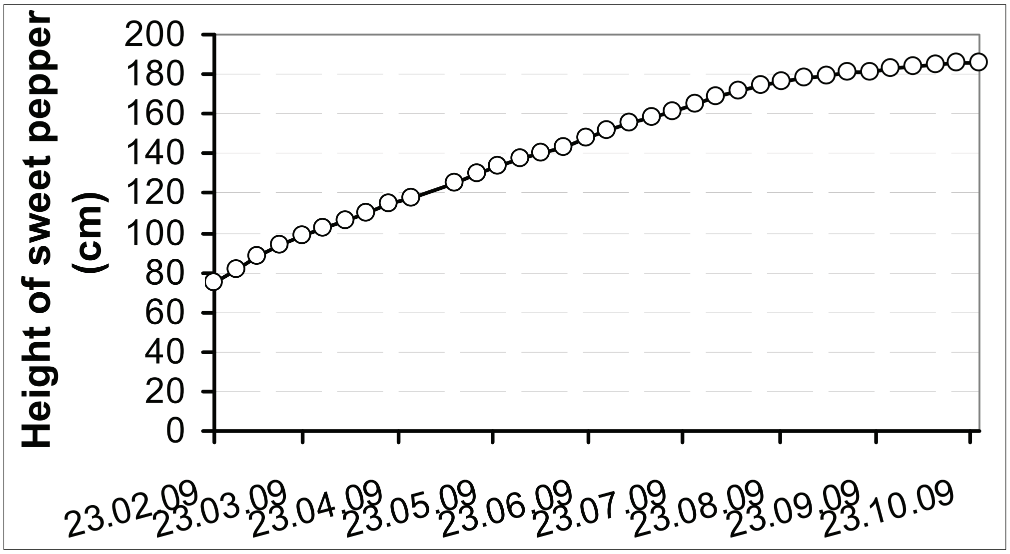


Fig. 2: Height of sweet pepper.

4.2 Number of fruits on the plant

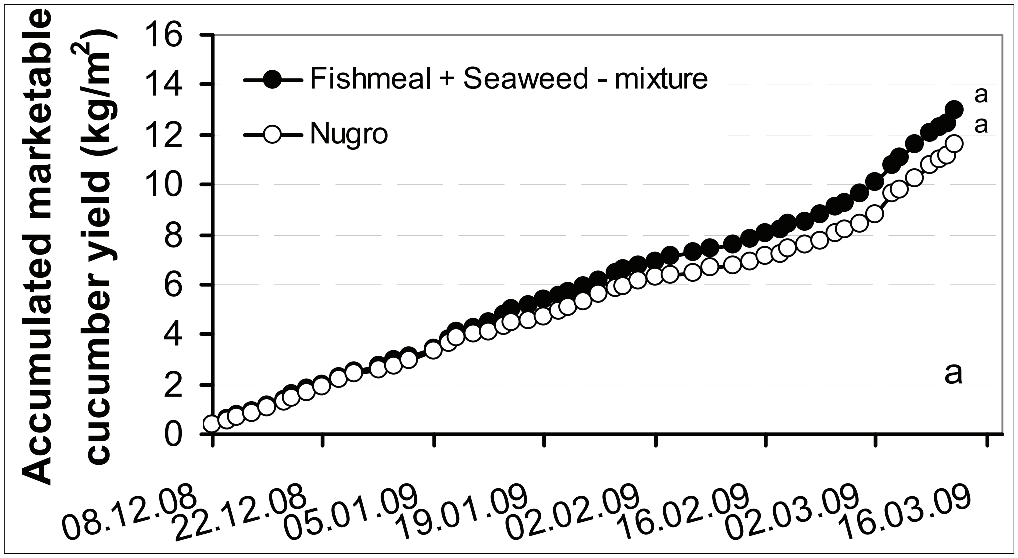
The number of fruits on the plant was independent of fertilizer and ranged 55 / 22 pieces for cucumbers (1^{st} / 2^{nd} cropping).

4.3 Yield

4.3.1 Yield of cucumbers

Yield of cucumbers was divided into 1^{st} and 2^{nd} class fruits. 7% of the 1^{st} and 0% of the 2^{nd} cropping from the first timing of the cucumbers were 2^{nd} class fruits, independent of the fertilizer. In both croppings the 1^{st} class yield level of cucumbers was also unaffected by fertilizers and ranged about 12-14 kg/m^2 (Fig. 3). However, an application of fishmeal and seaweed - mixture resulted in a somewhat higher yield compared to Nugro, but the differences were statistically not significant. It seems that this difference increased with longer growing period, suggesting that both fertilizers are mineralizing equally well, but fishmeal and seaweed - mixture may have a longer lasting N mineralization. It also has to be taken into account, that for the 1^{st} cropping accidantly only half of the fertilizer amount was applied. Also, the lower N content of the later used Nugro 5-2-7 may be a reason for the divergence of the yield (*Stadler* et al., 2006). However, for better evaluation, analysis from the soil samples for nitrate-

N, taken on regular intervals (chapter 4.5), as well as the analysis of the fertilizer N content, is needed to be able to verify assumptions. In addition, it seems that yield increased with higher solar irradiation (excluding June, which was affected with much pest), which would also coincide with the higher cucumber yield *Gunnlaugsson* & *Guðfinnsson* (2004) obtained.



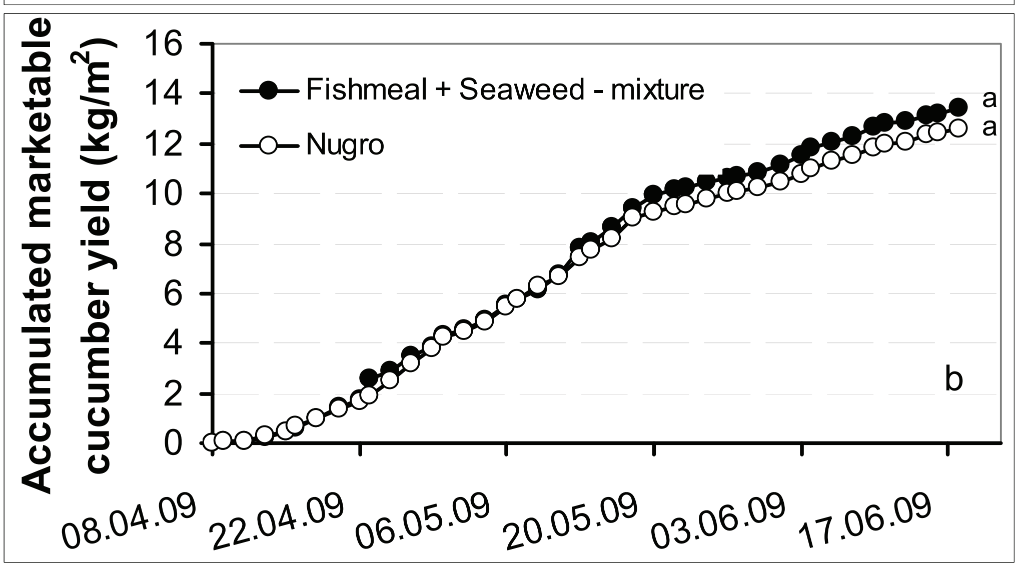


Fig. 3: Cumulative marketable yield (1st class) of cucumbers from 1st timing (a: 1st cropping, b: 2nd cropping) fertilized with fishmeal and seaweed - mixture or Nugro.

Letters indicate significant differences at the end of the harvest period (HSD, $p \leq 0.05$).

Also in the 2nd timing, the fraction of 2nd class fruits was low with 4% and was again independent of the fertilizer. In both croppings the 1st class yield level of cucumbers was unaffected by fertilizers and ranged about 25 kg/m^2 for the 1st cropping, but was for the 2nd cropping with 10 kg/m^2 much lower due to a pest problem (Fig. 4).

However, the possible yield advantage of the fishmeal and seaweed - mixture was not obvious in the 2nd timing.

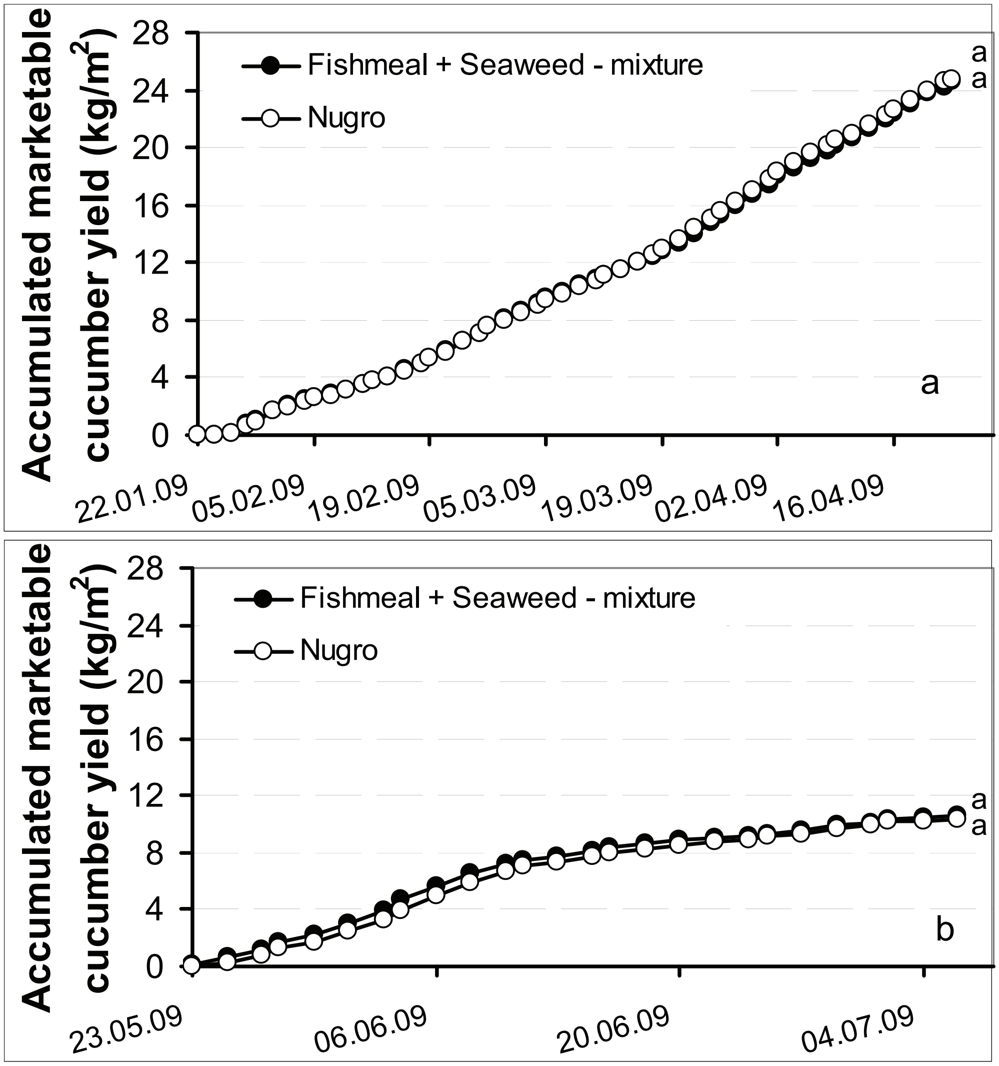


Fig. 4: Cumulative marketable yield (1st class) of cucumbers from 2nd timing (a: 1st cropping, b: 2nd cropping) fertilized with fishmeal and seaweed - mixture or Nugro.

Letters indicate significant differences at the end of the harvest period (HSD, $p \leq 0.05$).

The choice of fertilizer was not observed to affect the number of harvested fruits. Average fruit weight of cucumbers was about 370 / 400 g (1st / 2nd cropping of 1st timing, number of fruits was not counted in the 2nd timing) and independent of fertilizer. Fruits were ripe in about 16 / 13 days (1st / 2nd cropping) independent on the fertilizer, but influenced by the time of cropping. It seems that winter grown cucumbers resulted in a delayed harvest, highlighting, on the one hand, the importance of supplemental lighting and, on the other hand, the impact of solar irradiation.

4.3.1 Yield of sweet pepper

Yield of sweet pepper was divided into 1st and 2nd class fruits as well as unmarketable fruits. About 10% of the fruits were 2nd class, but close to 0% were unmarketable. 1st class fruits were about 10 kg/m^2 red and 2 kg/m^2 green (Fig. 5).

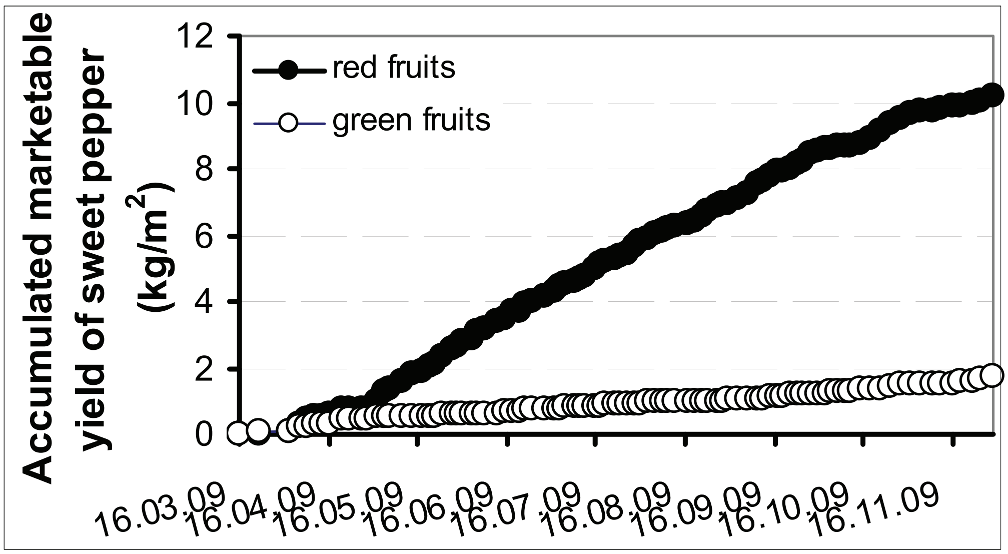


Fig. 5: Cumulative marketable yield (1st class) of sweet pepper.

Green 1st class fruits were ripe in about 6,5 weeks and red fruits in about 9,5 weeks. A high solar irradiation (summer) shortened the time from fruit setting to harvest and fruits matured earlier compared to fruits grown at lower solar irradiation. Pest in July and August delayed ripening (Fig. 6).

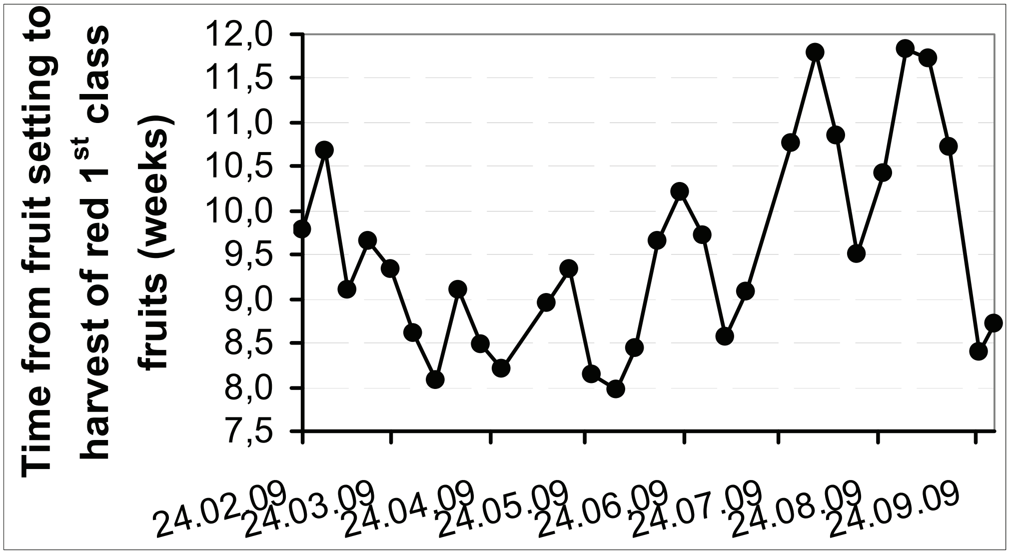


Fig. 6: Time from fruit setting to harvest of red 1st class sweet pepper fruits.

4.4 Analyses of leaves

A good soil supply is not always going along with a satisfactory supply for the plants. Therefore, analysis of leaves was done to check what plants were really able to take up and this enables a determination of requirements.

Leaves of cucumbers and sweet pepper were analysed at different dates (Tab. 4a, 4b). The amount of macronutrients in leaves was low.

The two different fertilizer treatments showed nearly now differences in the analysis of the cucumber leaf. Content of NO_3-N, P, K was generally low, whereas S, Na and Al and the trace elements Cl, B, Cu, Fe, Zn, Mo, were high, but Mn low.

Most of the nutrients (P, Mg, S, Ca, Na, Cl, Mn, Cu, Fe, Zn, Mo, Al) in the leaves increased at the latter sampling. The content of P, Mo was low, NO_3-N, K, Mn was low/good, Mg, Na, Ca, Fe was good/high and S, Al, Cl, B, Cu, Zn was high.

Tab. 4a: Leave analysis from cucumbers.

	1st timing				2nd timing	
	1st cropping (10.03.09)		2nd cropping (24.06.09)		2nd cropping (24.06.09)	
Nu-trient (mg/l)	**Fishmeal + Seaweed - mixture**	**Nugro**	**Fishmeal + Seaweed - mixture**	**Nugro**	**Fishmeal + Seaweed - mixture**	**Nugro**
NO_3-N	399-475 (low)	294-427 (low)	1-147 (low)	3-50 (low)	65-83 (low)	30-254 (low)
NH_4-N	404-610	255-609	>630	>630	>630	>630
P	91-122 (low)	79-118 (low)	93-157 (low)	75-94 (low)	74-97 (low)	85-102 (low)
K	1907-2237 (low)	2009-2119 (low)	934-1307 (low)	870-1164 (low)	757-1166 (low)	1052-1382 (low)
Mg	458-559 (high)	373-683 (high)	354-472 (high)	367-417 (high)	549-599 (high)	349-505 (high)
S	368-576 (high)	436-478 (high)	329-390 (high)	327-378 (high)	322-387 (high)	301-436 (high)
Ca	1326-2002 (good-high)	1054-2036 (good-high)	377-878 (low-good)	261-441 (low)	411-711 (low-good)	372-478 (low)
Na	184-209 (high)	162-231 (high)	297-414 (high)	295-368 (high)	244-274 (high)	213-262 (high)
Cl	2798-2905 (high)	2824-2969 (high)	>2992->3000 (high)	>3000->3100 (high)	>3000 (high)	>3000 (high)
Mn	0,3-0,5 (low)	0,4 (low)	0,4-0,8 (low)	0,4-0,5 (low)	0,4 (low)	0,4-1 (low)
B	1,38-1,58 (high)	1,42-1,61 (high)	3,27-4,49 (high)	3,21-4,51 (high)	2,82-3,57 (high)	3,08-3,63 (high)
Cu	0,38-0,63 (high)	0,45-0,49 (high)	0,46-1,14 (high)	0,4-0,53 (high)	0,36-0,45 (high)	0,41-0,54 (high)
Fe	1-1,9 (good-high)	1,1-1,3 (good)	1,2-3 (high)	1,2-1,6 (good-high)	0,8-1 (good)	1-1,2 (good)
Zn	1,5-2,4 (high)	1,6-1,9 (high)	1,3-2,3 (good-high)	1,1-1,5 (good)	1,1 (good)	1,2-1,3 (good)
Mo	0,29-0,44 (good-high)	0,32-0,36 (good)	0,28-0,32 (good)	0,31-0,41 (good high)	0,32-0,49 (good-high)	0,4-0,47 (high)
Al	0,24-0,48 (good-high)	0,13-0,36 (good-high)	0,06-0,3 (good)	0,08-0,19 (good)	0,03-0,12 (good)	0,04-0,12 (good)

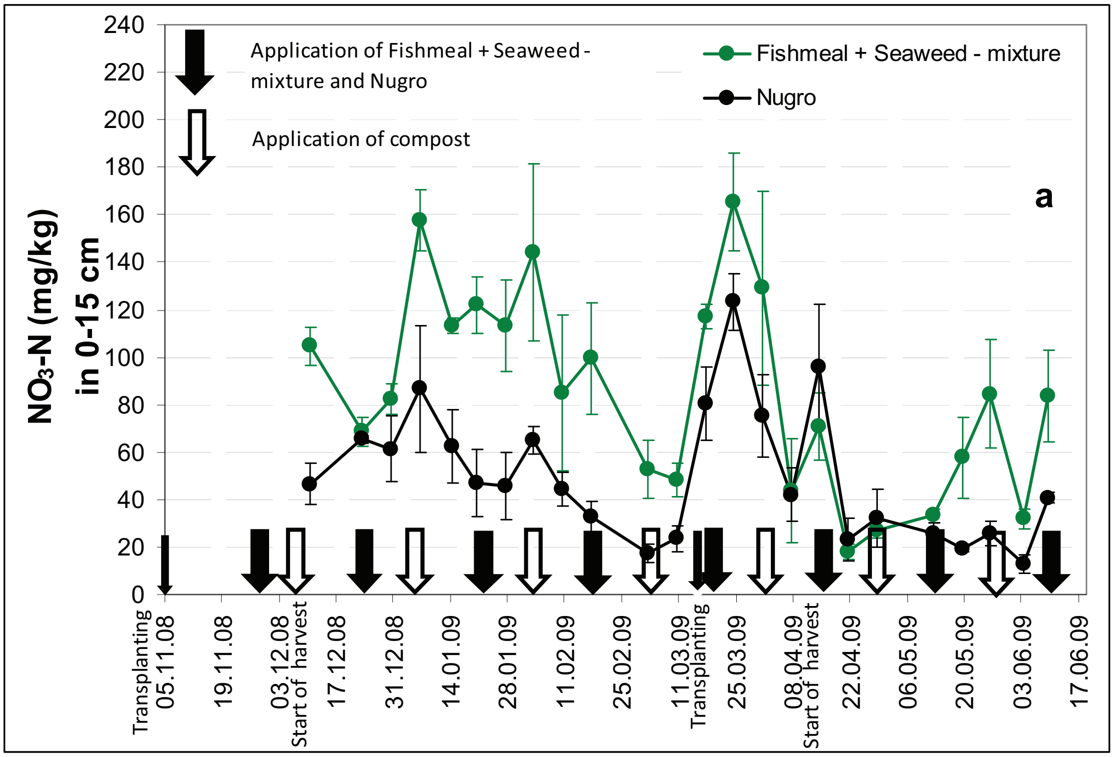
Tab. 4b: Leave analysis from sweet pepper at the middle (10.03.2009) and at the end (24.06.2009) of the growing period.

Nutrient (mg/l)	10.03.2009	24.06.09
NO_3-N	1305-1642 (good)	423-860 (low)
NH_4-N	293-457	44-48
P	239-287 (low)	368-440 (low-good)
K	4578-6232 (low-good)	4274-4793 (low)
Mg	536-638 (good)	1016-1151 (high)
S	622-749 (high)	1011-1199 (high)
Ca	479-1005 (good-high)	611-1081 (good-high)
Na	14-31 (good-high)	39-49 (high)
Cl	595-926 (high)	1457-2619 (high)
Mn	2,1-3 (low)	4,9-8 (low-good)
B	0,85-1,77 (high)	1,27-1,76 (high)
Cu	1,41-1,74 (high)	1,56-2,76 (high)
Fe	2-2,8 (good)	3,6-7 (high)
Zn	9,5-13,9 (high)	12,9-16,6 (high)
Mo	0,04-0,08 (low)	0,06-0,09 (low)
Al	1,22-2,02 (high)	2,2-5,3 (high)

4.5 Soil nitrate content

Fertilizer application in cucumbers markedly affected nitrate content in the uppermost layer in 0-15 cm (Fig. 7a), whereas deeper layers in 15-30 cm contained much less nitrate (Fig. 7b). Type of fertilizer strongly influenced the nitrate content in the soil and values were higher with fishmeal and seaweed - mixture than with Nugro.

After a peak value of 110-160 mg/kg at the beginning of the harvest of the 1st cropping (no soil samples were taken directly after transplanting) and after transplanting of the 2nd cropping, the nitrate content remained at 20-100 mg/kg. Fishmeal and seaweed - mixture cased the nitrate content of the soil to remain at a quite high level and going ahead with a decreased increment in yield in the last month of growing (Fig. 3b), while Nugro did not increase the nitrate content that much. Application of compost seems to cause N immobilisation (Fig. 7a).



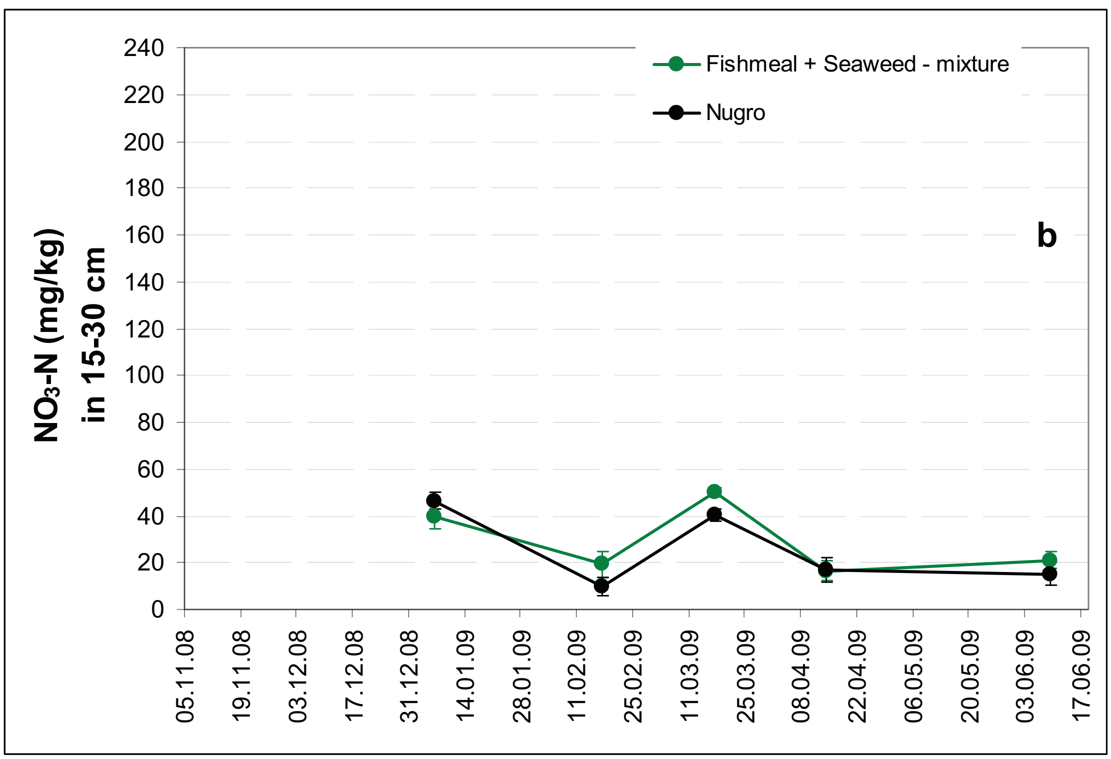


Fig. 7: Nitrate content in soil (a: 0-15 cm, b: 15-30 cm) with cucumbers fertilized with fishmeal + seaweed - mixture (30 + 15 g/plant), Nugro (20 % mixture with water, mixed 1:60 with water, two l per plant) and compost (one l per plant).

From these results it can be suggested that fishmeal and seaweed mixture might have not only a higher N mineralisation than Nugro, but also a longer lasting one.

A quite high nitrate content of 50 mg/kg in the deeper layer (15-30 cm) is going ahead with the peak values in the uppermost soil layer. Therefore, it can be expected that N leaching has taken place (Fig. 7a, Fig. 7b).

In contrast, *Gunnlaugsson* & *Guðfinnsson* (2004) reported nitrate contents from most of the time less than 100 mg/l in organic grown cucumbers when fertilised either with mushroom compost or fishmeal. Thus, it can be suggested that in the present experiment fertilizer applications should be decreased, especially directly after transplanting. At this growth stage plants are not able to take up that much N and a lower amount would decrease the risk for N leaching. When harvest has started, the applied N amount of Nugro seems to be appropriate, however the N amount of the fishmeal and seaweed - mixture should be decreased.

In sweet pepper nitrate content in 0-15 cm was varying much (Fig. 8). After transplanting nitrate content was rather low, possibly as a result of the lower number of applications as well as the type of fertilizer. However, with the application of the fishmeal and seaweed - mixture nitrate content increased to 140 mg/kg. After that nitrate content decreased to about 20 mg/kg and stayed there for two month. At the end of the harvest period, nitrate content peaked three times at 180-220 mg/kg, after which nitrate content decreased each time markedly to 20 or 80 mg/kg (Fig. 8). However, the type of fertilizer is not explaining the course of nitrate content in soil. But, at the end of the growth period a decrease in yield was observed (Fig. 5), which might explain the high nitrate contents in soil partly. Also, the high peaks are suggesting that N leaching might have occurred in deeper soil layers. Therefore, to avoid N leaching, a lower N amount should be applied especially at the end of the growing period.

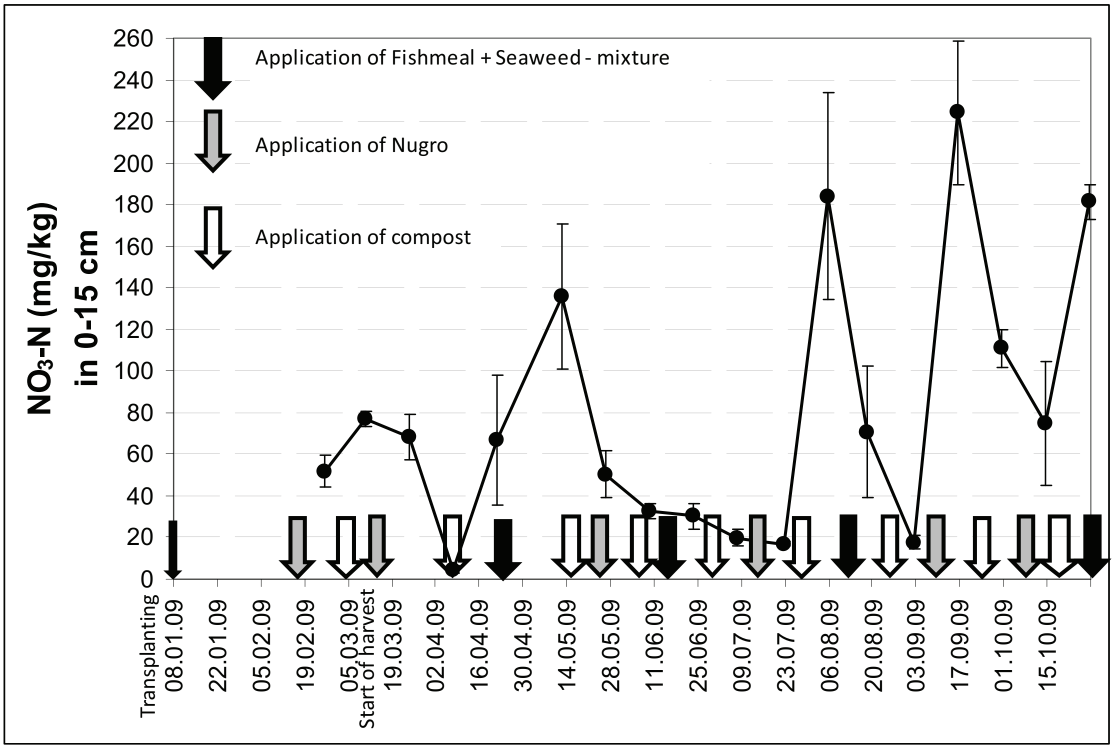


Fig. 8: **Nitrate content in soil (0-15 cm) with sweet pepper fertilized with fishmeal + seaweed - mixture (30 + 15 g/plant), Nugro (20 % mixture with water, mixed 1:60 with water, two l per plant) and compost (one l per plant).**

5 CONCLUSIONS

From the results it can be assumed that it is possible to maintain a year-round organic production of vegetable exemplary examined with cucumbers with different timings and sweet pepper with a longer growing period.

The mixture of fishmeal and seaweed as well as Nugro seem to provide a sufficient N supply for organically grown horticultural crops. It seems to be recommended to split the N amount in more applications to ensure a steady N supply for the plants. But the N amount should also be adjusted to the growth stage to avoid N leaching in deeper soil layers.

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