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Testing of NanoGro on established turf at fairway mowing height (15 mm)

Report from the first experimental year 2019

NIBIO RAPPORT | VOL. 5 | NR. 167 | 2019

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DATO/DATE:	RAPPORT NR./ REPORT NO.:	TILGJENGELIGHET/AVAILABILITY:	PROSJEKTNR./PROJECT NO.:	SAKSNR./ARCHIVE NO.:
18.12.2019	5/167/2019	Open	51226	19/00723

ISBN	ISSN:	ANTALL SIDER/ NO. OF PAGES:	ANTALL VEDLEGG/ NO. OF APPENDICES:
978-82-17-02469-9	2464-1162	14	4

OPPDRAGSGIVER/EMPLOYER:	KONTAKTPERSON/CONTACT PERSON:
Østfold Gress AS, Norway	Johnny Trandem
Aqua-Yield, USA	Landon Bunderson

STIKKORD/KEYWORDS:	FAGOMRÅDE/FIELD OF WORK:
Fairway, gress, rødsvingel, engrapp, tilsetningsstoffer, gjødsling, helhet, rotutvikling	Grøntanlegg og vegetasjonsøkologi
Fairway, turfgrass, red fescue, Kentucky bluegrass, additives, fertilizer, turf quality, root development	Urban greening and vegetation ecology

SAMMENDRAG/SUMMARY:

This a first report from testing of NanoGro on established fairway. The aim of the trial was to investigate the potential of NanoGro to improve turfgrass quality and reduce fertilizer cost on established turf at fairway mowing height in a Scandinavian environment.The experiment was conducted in May-October 2019 at the NIBIO Turfgrass Research Center Landvik. NanoGro improved turf quality when no fertilizer was applied. However, NanoGro had no effect when combined with turfgrass fertilizers.

LAND/COUNTRY:	Norway
FYLKE/COUNTY:	Aust-Agder
KOMMUNE/MUNICIPALITY:	Grimstad
STED/LOKALITET:	Landvik

GODKJENT /APPROVED	PROSJEKTLEDER /PROJECT LEADER
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Content

Preface

After results showing a potential of NanoPro™ to improve uptake and thus reduce the required fungicide rates on golf greens were published (Espevig et al., 2019), Johnny Trandem, CEO of Østfold Gress AS, contacted NIBIO in early spring 2019 to test another product, NanoGro™ 7-10-1 from the same producer Aqua-Yield, Salt Lake City, USA, as an additive to turfgrass fertilizers. NanoGro™ is applied in tank mixture with liquid fertilizer at the 'nano' rate of 292 ml ha^{-1}. It contains 2.5% ammonical nitrogen, 4.5% urea nitrogen, 4,3 % available phosphorus (P) and 0,83 % soluble potassium (K).

The objective of the study was to investigate the potential of NanoGro to improve turfgrass quality and reduce fertilizer cost on fairway in a Scandinavian environment. Our hypotheses were:

- Use of NanoGro at a rate of 292 ml/ha in addition to fertilizer improves turfgrass quality compared with fertilizer alone;
- NanoGro is equally effective at normal and at 40% reduced fertilization rate;
- Application of NanoGro at a rate of 292 ml/ha at 3-wk intervals cuts fertilizer costs by 40%;
- NanoGro is equally effective at 40% reduced fertilization rate when applied together with 60 kg N/ha liquid fertilizer or as applied with 30 kg N/ha liquid fertilizer + 30 kgN/ha dry granular fertilizer.

The research is funded by Østfold Gress AS and Aqua-Yield.

NIBIO Landvik, 12 December 2019

Tatsiana Espevig
Researcher

1 Materials and methods

1.1 Experimental site and general maintenance

The experiment was conducted from 15 May to 11 October 2019 on a fairway established in 2015 on a sandy loam soil (94% sand, 4% silt, 2% clay, 4.5 % OM) at NIBIO Turfgrass Research Centre Landvik, Grimstad, SE Norway (58°34'N, 8°52'E, 10 m above see level). The latest soil analyses were from 2016 showing a pH (H2O) of 6.3 and 390 mg P, 62 mg K, 94 mg Mg and 860 mg Ca per kg dry soil after extraction with ammonium-lactate. The fairway was seeded in July 2015 using a standard Scandinavian fairway seed mixture containing 55 % red fescue (20 % *Festuca rubra* spp. *commutata* 'Raisa', 15 % *Festuca rubra* spp. *commutata* 'Barswing' and 20 % *Festuca rubra* spp. *rubra* 'Frigg') and 45 % Kentucky bluegrass (*Poa pratensis*; 25 % 'Miracle', 10 % 'Yvette' and 10 % 'Limousine').

During the experiment, the fairway was mown 2 times per week to 15 mm using a 3250D Toro triplex fairway mower (The Toro Company, Minneapolis, MN, USA). The fairway was irrigated with 5 mm water after fertilization and once to the field capacity in the middle of July due to drought.

1.2 Experimental plan and implementation

The experiment was laid out according to a 2-factorial randomised complete block design with 4 replicates per treatment. Individual plot size was 3 m^2 (2.0 x 1.5 m) of which the registration plot area was 1.5 m^2 (1.0 x 1.5 m) to avoid border effects.

The experiment consisted of the following treatments which were applied in May-October (see a detailed fertilization plan in Appendix 1 and the field map in Appendix 2) (Figure 1):

Factor 1: Seasonal fertilizer inputs May-October:

1) No fertilizer (control)
2) 100 kg N/ha/year using a liquid fertilizer Wallco 5-1-4+micro, application interval 3 weeks
3) 60 kg N/ha/year using a liquid fertilizer Wallco 5-1-4+micro, application interval 3 weeks
4) 60 kg N/ha/year using 30 kg N/ha in liquid fertilizer Wallco 5-1-4+micro and 30 kg N/ha in dry granular fertilizers (ICL Proturf 12-2-20 and 21-5-6). The lquid fertilizer Wallco was applied at 3-wk interval (totally 7 times) and the dry granular fertilizer ICL Proturf was applied at 6-wk interval (totally 4 times).

Factor 2: NanoGro

1) No NanoGro (control)
2) Applications of NanoGro 7-10-1, 292 ml/ha in 1000 L per ha water every three weeks from May to October, every time in tank mixture with liquid fertilizer Wallco.

1.3 Assessments, statistical analysis and weather data

Field assessments

Turf quality was assessed using a scale from 1 (poor and uneven turf) to 9 (even and very good turf), with 5 as the lowest value for acceptable turf quality. Colour was registered either visually using a scale from 1 (very light) to 9 (very dark green) or by measuring chlorophyll index using a Fieldscout CM 1000 Chlorophyll Meter from Spectrum Technologies, Inc. Illinois (five readings per plot). Height growth was measured with a Turfcheck ® prism from Check Stinature Inc, Minneapolis, and daily height growth calculated as the mean of three readings in each plot minus the mowers' setting divided by the number of days since last mowing. The incidence of red tread caused by *Laetisaria fuciformis*,

was registered as percentage of plot area covered with diseased turf. All assessments started on 15 May and were done at 3-wk intervals always prior to fertilization. In addition, turfgrass quality, colour and height were also registered 1 week after fertilization (totally 14 times). Root depth was measured as length of hanging intact soil cylinder after extraction of a soil core of 5 cm in diameter and 25 cm deep.

Figure 1. Trond O. Pettersen applying Pro Turf granular fertilizer on 8 Aug. 2019. The liquid fertilizer Wallco, with and without NanoGro, was applied on the same day using the liquid fertilizer spreader to the left. Photo T. Espevig.

Figure 2. Trond O. Pettersen doing visual assessments on 18 Sept. 2019. Photo T. Espevig.

Statistics

All parameters were analysed using the SAS procedure PROC ANOVA for a 2-factorial randomized complete design with 4 blocks. A one-factorial ANOVA (8 combinations) was run for significant interactions. The Fisher's least significant difference (LSD) was used to separate mean values at the 5% probability level.

Weather data

Maximal, minimal and average temperature on daily basis and total precipitation on monthly basis were obtained from the local weather station (LandbruksMeteorologisk Tjeneste, https://lmt.nibio.no/agrometbase/getweatherdata_new.php) and shown in Figure 3 and 4, respectively. While air temperature was close to normal during the experimental period from May to October (Figure 4), the monthly precipitation was 12 mm, 77 mm, 18 mm, 54 mm, 16 mm and 133 mm higher than normal in May, June, July, August, September and October, respectively (Figure 4).

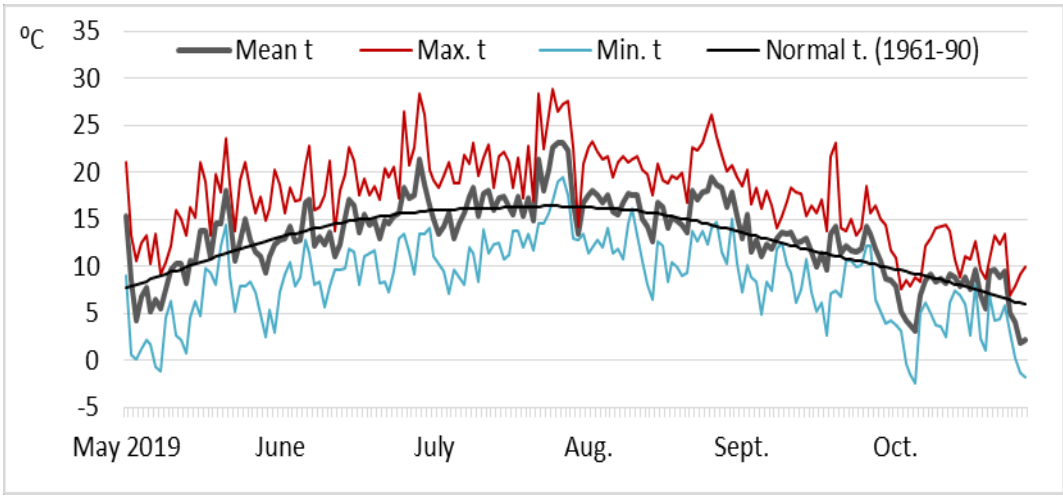


Figure 3. Daily values for air temperature prior to and during the experimental period (from May to October 2019) as compared with the 30 yr normal (1961-90)). LandbruksMeteorologisk Tjeneste.

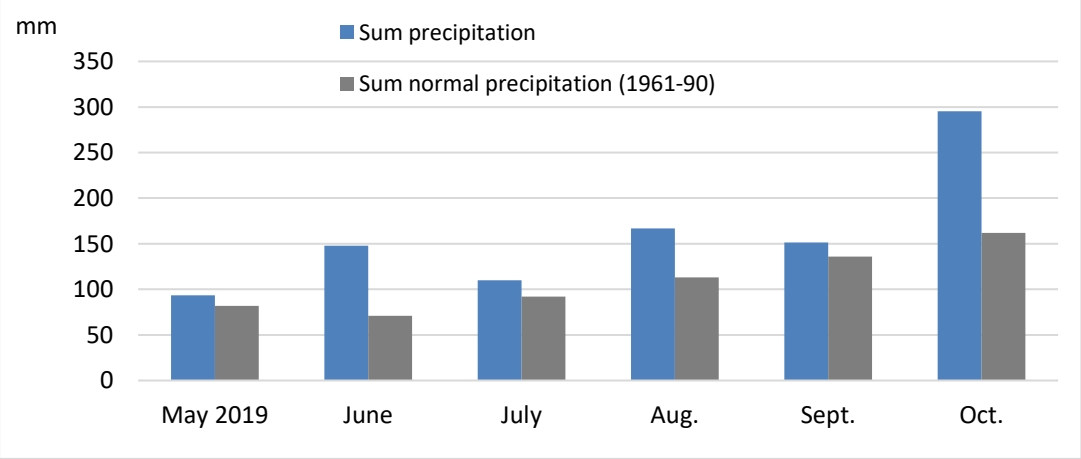


Figure 4. Monthly values for precipitation prior to and during the experimental period (from May 2018 to April 2019 vs. normal for 30 yr (1961-90)). LandbruksMeteorologisk Tjeneste

2 Results

On average for the whole experimental period from May to October (Table 1, Figures 5, 7-11), N fertility had a high influence on all parameters as expected. Except for root depth, all other parameters (overall impression, color (both visual and chlorophyll index), density and growth rate) were scored highest on the plots with 100% Wallco. The sores for these parameters on the plots with 40% reduced fertilizer input, were significantly lower but the overall impression was stil at an acceptable level. The differences between liquid fertilizer (60% Wallco) and liquid fertilizer combined with granular (30% Wallco and 30% Pro Turf) were not significant for any parameter. Scores for overall impression, color (both visual and chlorophyll index), density and growth rate on the plots which received no fertilizer were significantly lower than on the plots which recived fertilizer, and overall impression was under acceptable level except for registrations in September on the plots which received NanoGro (Figure 5). On average for the whole experiment, the most severe attack of red tread (about 4% of plot area) was registered on the plots which received no fertilizer. Compated with these plots, red tread was reduced by an average of 70% on the plots that received fertilizers.

On average for fertilizer treatments, the main effect of NanoGro was not significant for any parameter (Table 1). However, a significant interaction Fertilizer x NanoGro revealed that NanoGro significantly improved overall impression on the plots which recived no fertilizer (Table 2). This was especially pronounced in June and again in August (Figure 5). It appears that NanoGro also improved color (Figures 7 and 10) and density (Figure 8) and reduced red tread (Figure 9) on the plots with no fertilizer; however the interaction Fertilizer x NanoGro was not significant for these parameters. On 18 June 2019, the plots which received 60% Wallco and NanoGro were greener (darker) than the plots that recived 60% Wallco only (Figure 6). However, this difference was seen in one replicate only and was not persistent later in the season (Appendix 3 and 4).

Table 1. Means for visual parameters, chlorophyll index and growth rate as averaged for the whole experimental period (wks 21-41).

Fertilizer	Nano Gro	Overall impression	Colour	Density	Red tread	Root depth	Chloro -phyll index	Growth rate
		Scale 1-9	Scale 1-9	Scale 1-9	%	cm		mm / day
Main effect fertilizers								
No fertilizer		4.3 c	4.1 c	4.5 c	3.9 b	21.4	293 c	1.0 c
100 % Wallco		7.5 a	7.7 a	7.6 a	0.7 a	22.3	400 a	2.3 a
60 % Wallco		6.8 b	6.8 b	7.0 b	1.1 a	22.4	370 b	1.9 b
60 % (30% Wallco + 30% ProTurf)		6.4 b	6.6 b	6.5 b	1.7 a	20.8	364 b	1.8 b
Main effect NanoGro	-	6.2	6.2	6.3	1.8	21.7	355	1.7
	+	6.3	6.4	6.5	1.8	21.7	359	1.7
Combinatons								
No fertilizer	-	3.8 e	3.7	4.0	4.5	20.9	284	0.9
100 % Wallco	-	7.7 a	7.9	7.7	0.4	21.3	404	2.4
60 % Wallco	-	6.8 bc	6.7	7.0	0.9	23.3	366	1.7
60 % (30% Wallco + 30% ProTurf)	-	6.6 bc	6.6	6.7	1.6	21.2	367	1.9
No fertilizer	+	4.8 d	4.5	5.1	3.3	21.8	303	1.1
100 % Wallco	+	7.3 ab	7.5	7.5	1.1	23.3	397	2.2
60 % Wallco	+	6.9 bc	6.9	7.0	1.3	21.5	375	2.0
60 % (30% Wallco + 30% ProTurf)	+	6.2 c	6.6	6.3	1.8	20.3	361	1.7
			A	***N***	***O***	***V***	***A***	
Fertlizer		***	***	***	***	*ns*	***	***
NanoGro		*ns*	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*
Fertilizer x NanoGro (interaction)		*	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*

The stars indicate significant differences among the treatments : * significant at 0.05 probability level, ** significant at 0.01 probability level, *** significant at 0.001 probability level, and ns when non-significant.

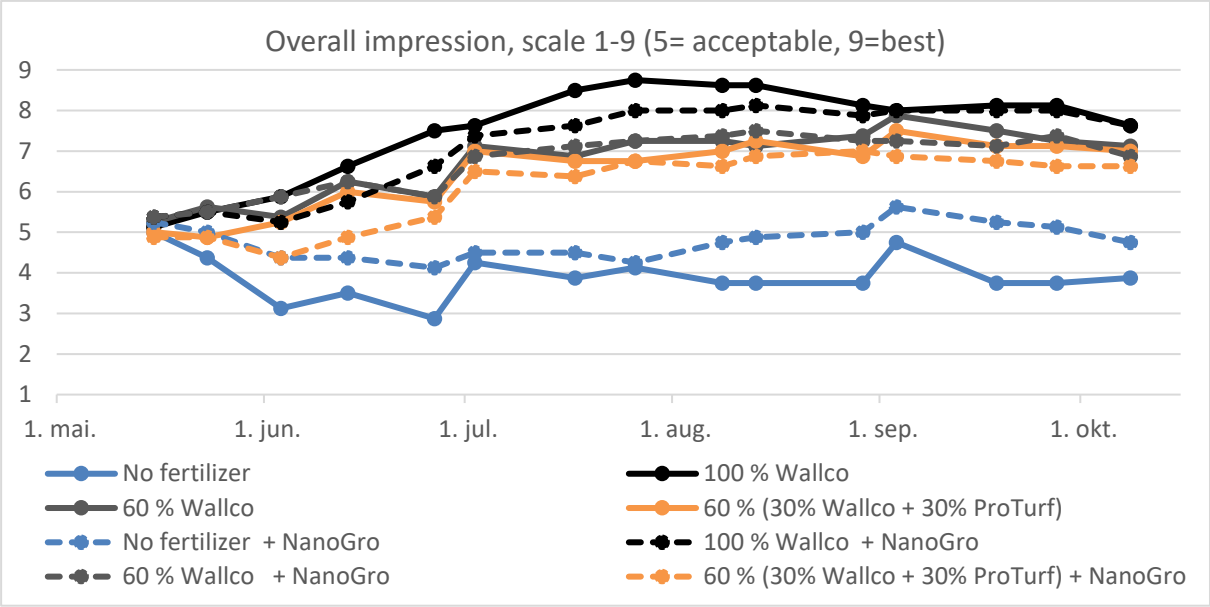


Figure 5. Effects of fertilizer and NanoGro on overall impression over time. The main effect of fertilizer was significant at 5 % probability level on all dates except for the first registration on 15 May; the main effect 'NanoGro' was not significant on any of the dates; the interaction 'fertilizer x NanoGro' was significant on 3 June (p=0.005), 13 June (p=0.047), 26 June (p=0.030) and 13 Aug. (p=0.031).

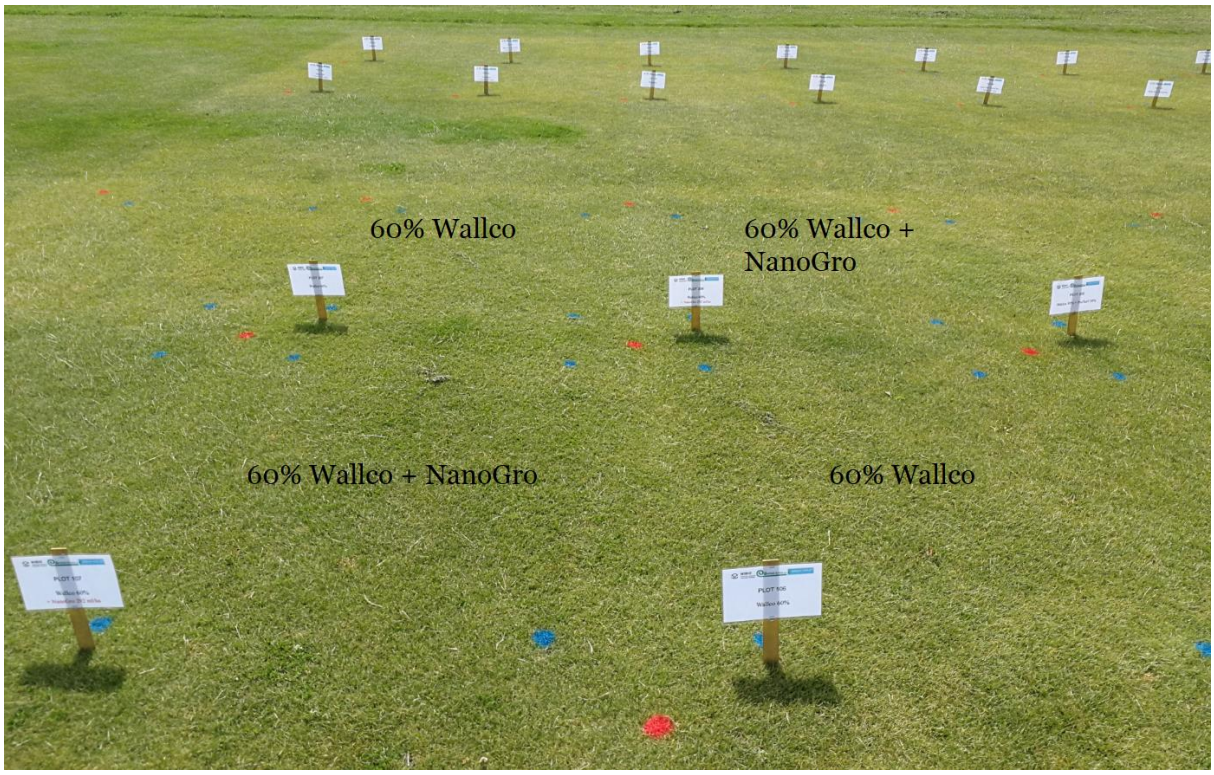


Figure 6. Effect of NanoGro in the first and second replicate on 18 June 2019. Photo: T. Espevig.

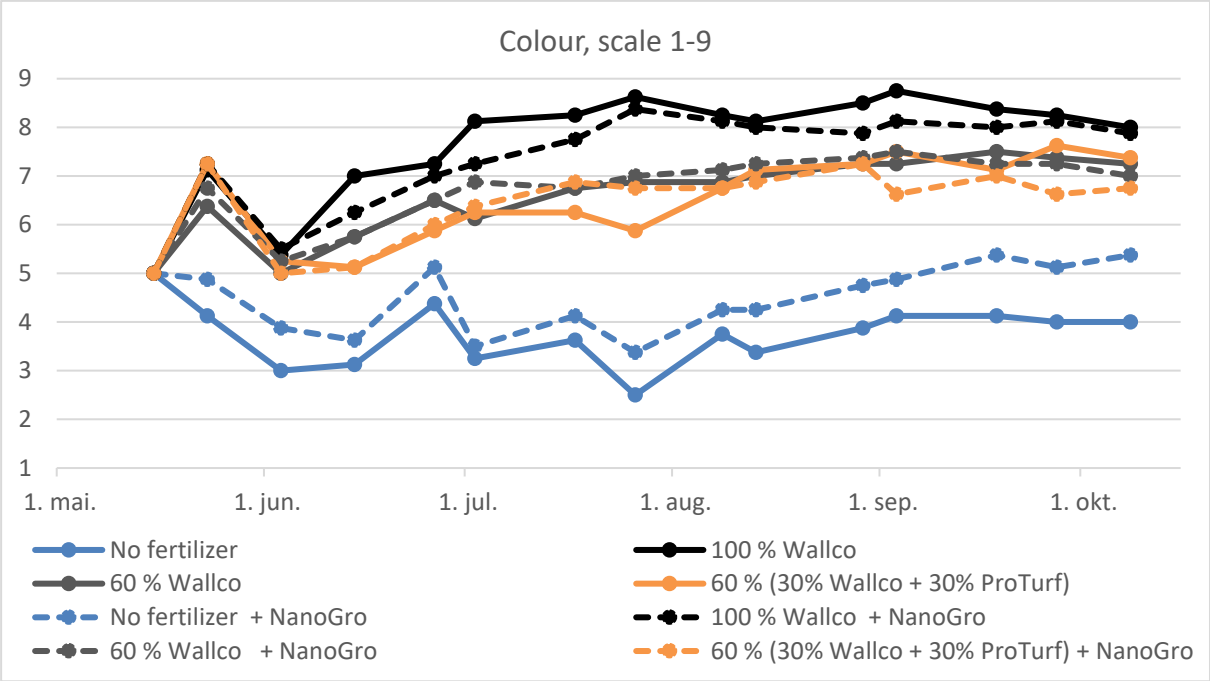


Figure 7. **Effects of fertilizer and NanoGro on color over time. The main effect fertilizer was significant at 5 % probability level on all dates except for the first registration on 15 May; the main effect 'of NanoGro' was not significant on any of the dates; the interaction 'fertilizer x NanoGro' was significant on 27 Sept. (p=0.017) and 8 Oct. (p=0.039).**

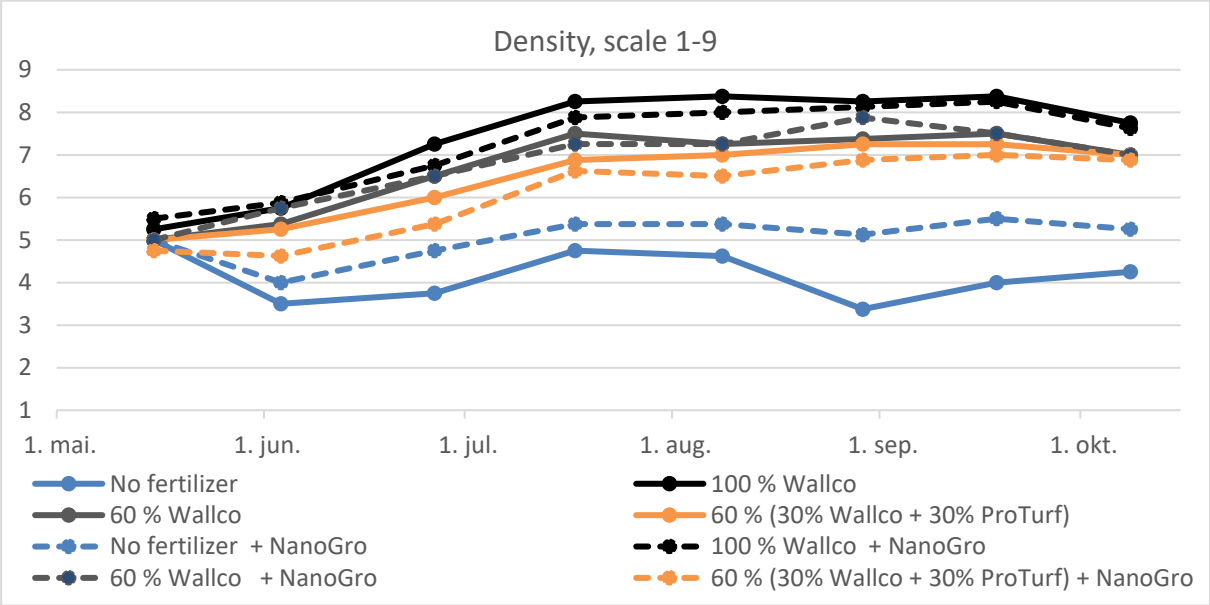


Figure 8. **Effects of fertilizer and NanoGro on color over time. Main effect of fertilizer was significant at 5 % probability level on all dates except for first registration on 15 May; neither the main effect 'NanoGro' nor the interaction 'fertilizer x NanoGro' were significant on any of the dates.**

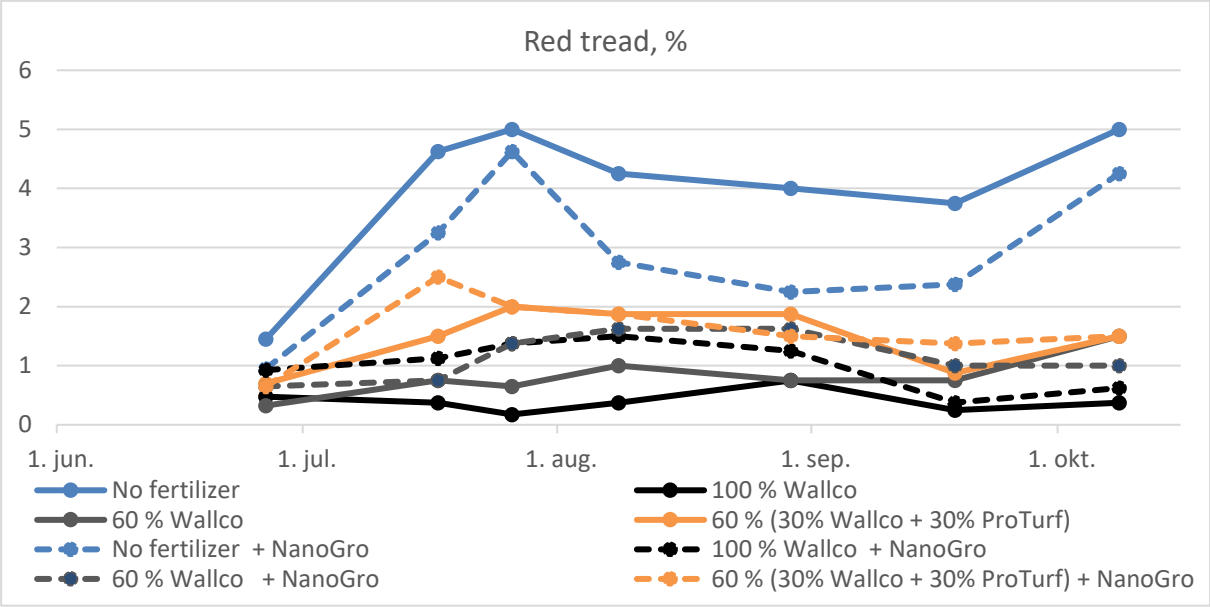


Figure 9. Effects of fertilizer and NanoGro on color over time. The main effect of fertilizer was significant at 5 % probability level on all dates except for 29 Aug. when the probability level was 8%; neither the main effect 'NanoGro' nor the interaction 'fertilizer x NanoGro' were significant on any of the dates.

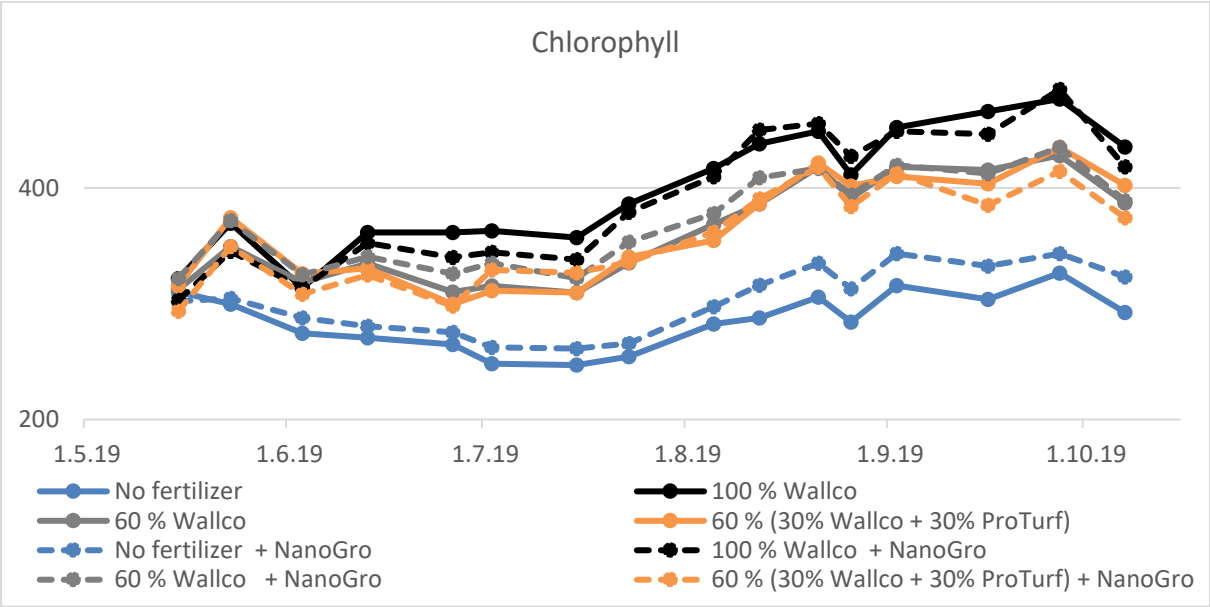


Figure 10. Effects of fertilizer and NanoGro on chlorophyll index over time. The main effect of fertilizer was significant was significant at 5 % probability level on all dates except for the first registration on 15 May; the main effect 'NanoGro' was not significant on any of the dates; the interaction 'fertilizer x NanoGro' was significant on 26 June only (p=0.023).

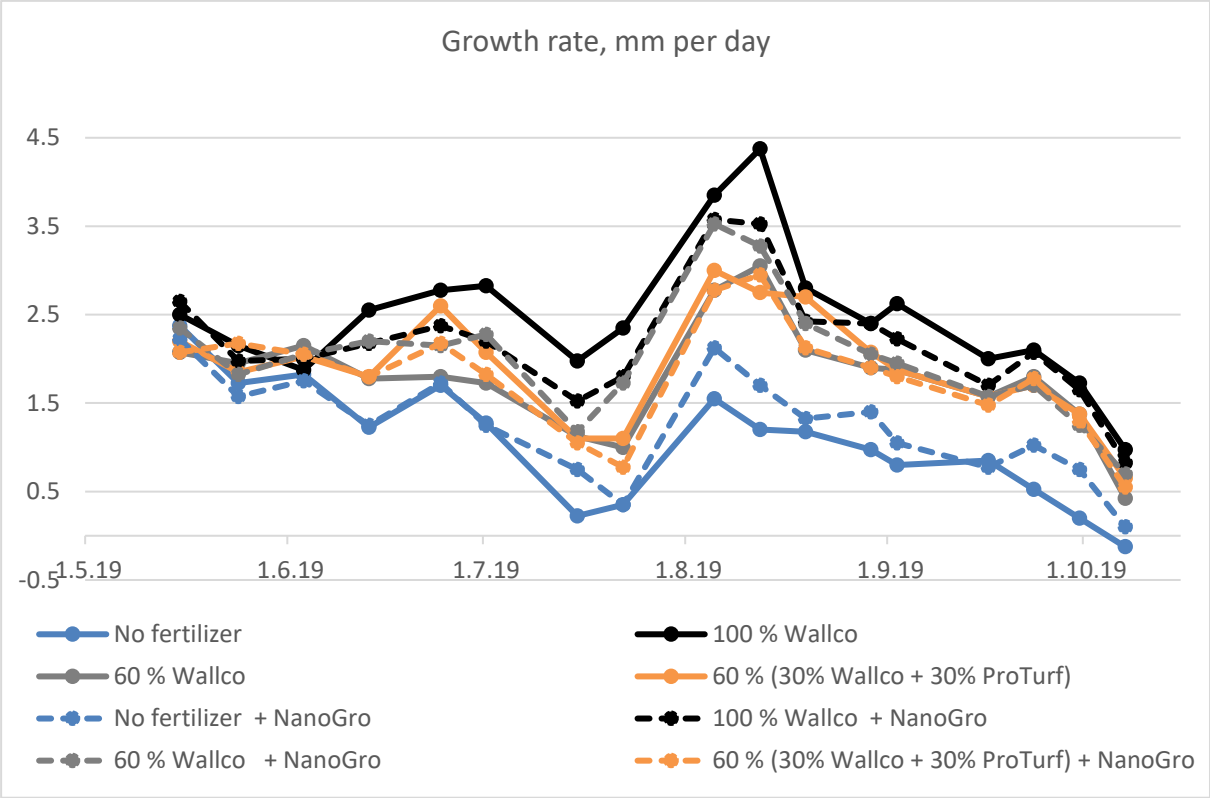


Figure 11. Effects of fertilizer and NanoGro on growth rate over time. The main effect of fertilizer was significant on all dates except for first three registrations on 15 May, 24 May and 3 June; the main effect 'NanoGro' was not significant on any of the dates; the interaction 'fertilizer x NanoGro' was significant on 22 July (p=0.032) and 16 Sept. (p=0.017)..

3 Conclusions

This is a first report on the potential of NanoGro on established turf at fairway mowing height (15 mm). NanoGro improved turf quality when no fertilizer was applied. Otherwise, NanoGro had no effect when combined with turfgrass fertilizers.

4 References

Espevig T., T.O. Pettersen and T.S. Aamlid. 2019. Potential of NanoPro to reduce fungicide rate for control of Microdochium nivale on an annual bluegrass (*Poa annua*) green. Report from the first experimental year 2018-19. NIBIO Report 5(80). 21 pp.

Appendix

Appendix 1. Fertilization plan

Ledd 2 og 6 - 100%			Tilførsel pr 100m2											
Week	**Gjødseltype**	**kg/100m2**	**kg N**	**kg P**	**kg K**	**kg Mg**	**kg S**	**kg Ca**	**kg Fe**	**kg Mn**	**kg Cu**	**kg Zn**	**kg Mo**	**kg B**
20	Wallco flytende 5-1-4	3.14	0.16	0.031	0.135	0.013	0.013	0.013	0.0005	0.0006	0.0000	0.0001	0.0000	0.000
23	Wallco flytende 5-1-4	3.73	0.19	0.037	0.160	0.015	0.015	0.015	0.0006	0.0007	0.0001	0.0001	0.0000	0.000
26	Wallco flytende 5-1-4	3.33	0.17	0.033	0.143	0.013	0.013	0.013	0.0006	0.0007	0.0001	0.0001	0.0000	0.000
29	Wallco flytende 5-1-4	3.14	0.16	0.031	0.135	0.013	0.013	0.013	0.0005	0.0006	0.0000	0.0001	0.0000	0.000
32	Wallco flytende 5-1-4	2.55	0.13	0.025	0.110	0.010	0.010	0.010	0.0004	0.0005	0.0000	0.0001	0.0000	0.000
35	Wallco flytende 5-1-4	2.16	0.11	0.022	0.093	0.009	0.009	0.009	0.0004	0.0004	0.0000	0.0001	0.0000	0.000
38	Wallco flytende 5-1-4	1.57	0.08	0.016	0.067	0.006	0.006	0.006	0.0003	0.0003	0.0000	0.0000	0.0000	0.000
SUM	Ledd 1.2 - Wallco 100%		**1.000**	0.196	0.843	0.078	0.078	0.078	0.003	0.004	0.000	0.001	0.000	0.002
Rel.	N:P:K Wallco 100%	100:12:60	100	20	84	8	8	8	0	0	0	0	0	0
Ledd 3 og 7 - 60 %			Tilførsel pr 100m2											
Week	**Gjødseltype**	**kg/100m2**	**kg N**	**kg P**	**kg K**	**kg Mg**	**kg S**	**kg Ca**	**kg Fe**	**kg Mn**	**kg Cu**	**kg Zn**	**kg Mo**	**kg B**
20	Wallco flytende 5-1-4	1.88	0.096	0.019	0.081	0.008	0.008	0.008	0.0003	0.0004	0.0000	0.0001	0.0000	0.000
23	Wallco flytende 5-1-4	2.24	0.114	0.022	0.096	0.009	0.009	0.009	0.0004	0.0004	0.0000	0.0001	0.0000	0.000
26	Wallco flytende 5-1-4	2.00	0.102	0.020	0.086	0.008	0.008	0.008	0.0003	0.0004	0.0000	0.0001	0.0000	0.000
29	Wallco flytende 5-1-4	1.88	0.096	0.019	0.081	0.008	0.008	0.008	0.0003	0.0004	0.0000	0.0001	0.0000	0.000
32	Wallco flytende 5-1-4	1.53	0.078	0.015	0.066	0.006	0.006	0.006	0.0003	0.0003	0.0000	0.0000	0.0000	0.000
35	Wallco flytende 5-1-4	1.29	0.066	0.013	0.056	0.005	0.005	0.005	0.0002	0.0003	0.0000	0.0000	0.0000	0.000
38	Wallco flytende 5-1-4	0.94	0.048	0.009	0.040	0.004	0.004	0.004	0.0002	0.0002	0.0000	0.0000	0.0000	0.000
SUM	Ledd 1.3 - Wallco 60%		**0.600**	0.118	0.506	0.047	0.047	0.047	0.002	0.002	0.000	0.000	0.000	0.001
Rel.	N:P:K Wallco 60%	100:12:60	100	20	84	8	8	8	0	0	0	0	0	0
Ledd 4 og 8 - 1/2 av 60 %			Tilførsel pr 100m2											
Week	**Gjødseltype**	**kg/100m2**	**kg N**	**kg P**	**kg K**	**kg Mg**	**kg S**	**kg Ca**	**kg Fe**	**kg Mn**	**kg Cu**	**kg Zn**	**kg Mo**	**kg B**
20	Wallco flytende 5-1-4	0.94	0.048	0.009	0.040	0.004	0.004	0.004	0.0002	0.0002	0.0000	0.0000	0.0000	0.000
23	Wallco flytende 5-1-4	1.12	0.057	0.011	0.048	0.004	0.004	0.004	0.0002	0.0002	0.0000	0.0000	0.0000	0.000
26	Wallco flytende 5-1-4	1.00	0.051	0.010	0.043	0.004	0.004	0.004	0.0002	0.0002	0.0000	0.0000	0.0000	0.000
29	Wallco flytende 5-1-4	0.94	0.048	0.009	0.040	0.004	0.004	0.004	0.0002	0.0002	0.0000	0.0000	0.0000	0.000
32	Wallco flytende 5-1-4	0.76	0.039	0.008	0.033	0.003	0.003	0.003	0.0001	0.0002	0.0000	0.0000	0.0000	0.000
35	Wallco flytende 5-1-4	0.65	0.033	0.006	0.028	0.003	0.003	0.003	0.0001	0.0001	0.0000	0.0000	0.0000	0.000
38	Wallco flytende 5-1-4	0.47	0.024	0.005	0.020	0.002	0.002	0.002	0.0001	0.0001	0.0000	0.0000	0.0000	0.000
SUM	Ledd 1.4 - Wallco 30%		**0.300**	0.059	0.253	0.024	0.024	0.024	0.001	0.001	0.000	0.000	0.000	0.001
Rel.	N:P:K Wallco 30%	100:12:60	100	20	84	8	8	8	0	0	0	0	0	0
Ledd 4 og 8 - 1/2 av 60 %			Tilførsel pr 100m2											
Week	**Gjødseltype**	**kg/100m2**	**kg N**	**kg P**	**kg K**	**kg Mg**	**kg S**	**kg Ca**	**kg Fe**	**kg Mn**	**kg Cu**	**kg Zn**	**kg Mo**	**kg B**
20	Proturf 21-5-6	0.53	0.105	0.012	0.022	0.008	0.000	0.009	0.0000	0.0000	0.0000	0.0000	0.0000	0.000
23														
26	Proturf 12-5-20	0.83	0.099	0.018	0.137	0.010	0.000	0.012	0.0000	0.0000	0.0000	0.0000	0.0000	0.000
29														
32	Proturf 12-5-20	0.60	0.072	0.013	0.100	0.007	0.000	0.008	0.0000	0.0000	0.0000	0.0000	0.0000	0.000
35														
38	Proturf 12-5-20	0.20	0.024	0.004	0.033	0.002	0.000	0.003	0.0000	0.0000	0.0000	0.0000	0.0000	0.000
SUM	Ledd 1.4 - Proturf 30%		**0.300**	0.047	0.292	0.027	0.000	0.032	0.000	0.000	0.000	0.000	0.000	0.000
Rel.	N:P:K Proturf 30%	100:12:60	100	16	97	9	0	11	0	0	0	0	0	0
SUM	Ledd 1.4. - Totalt		0.600	0.106	0.545	0.051	0.024	0.055	0.001	0.001	0.000	0.000	0.000	0.001
Rel.	N:P:K Wallco 30 & Proturf 30	100:12:60	100	18	91	8	4	9	0	0	0	0	0	0

Appendix 2. Field map

↑ N

1.5 m

	Border	0.5	→						
Border	**101** **8**	**102** **6**	**103** **5**	104 **1**	105 **4**	106 **3**	**107** **7**	108 **2**	Border
0.5	201 **1**	**202** **6**	**203** **8**	204 **2**	205 **4**	**206** **7**	207 **3**	**208** **5**	0.5
3.5 m	Border								
↓	**301** **7**	302 **2**	303 **4**	**304** **8**	305 **3**	306 **1**	**307** **5**	**308** **6**	↓
	401 **4**	402 **2**	403 **1**	**404** **7**	**405** **6**	**406** **5**	**407** **8**	408 **3**	
	Border	0.5	→						

2 m

Total trial area excl. borders: 12 m x 8 m = 96 m2

Treatment plot area: 1.5 m x 2 m = 3 m2

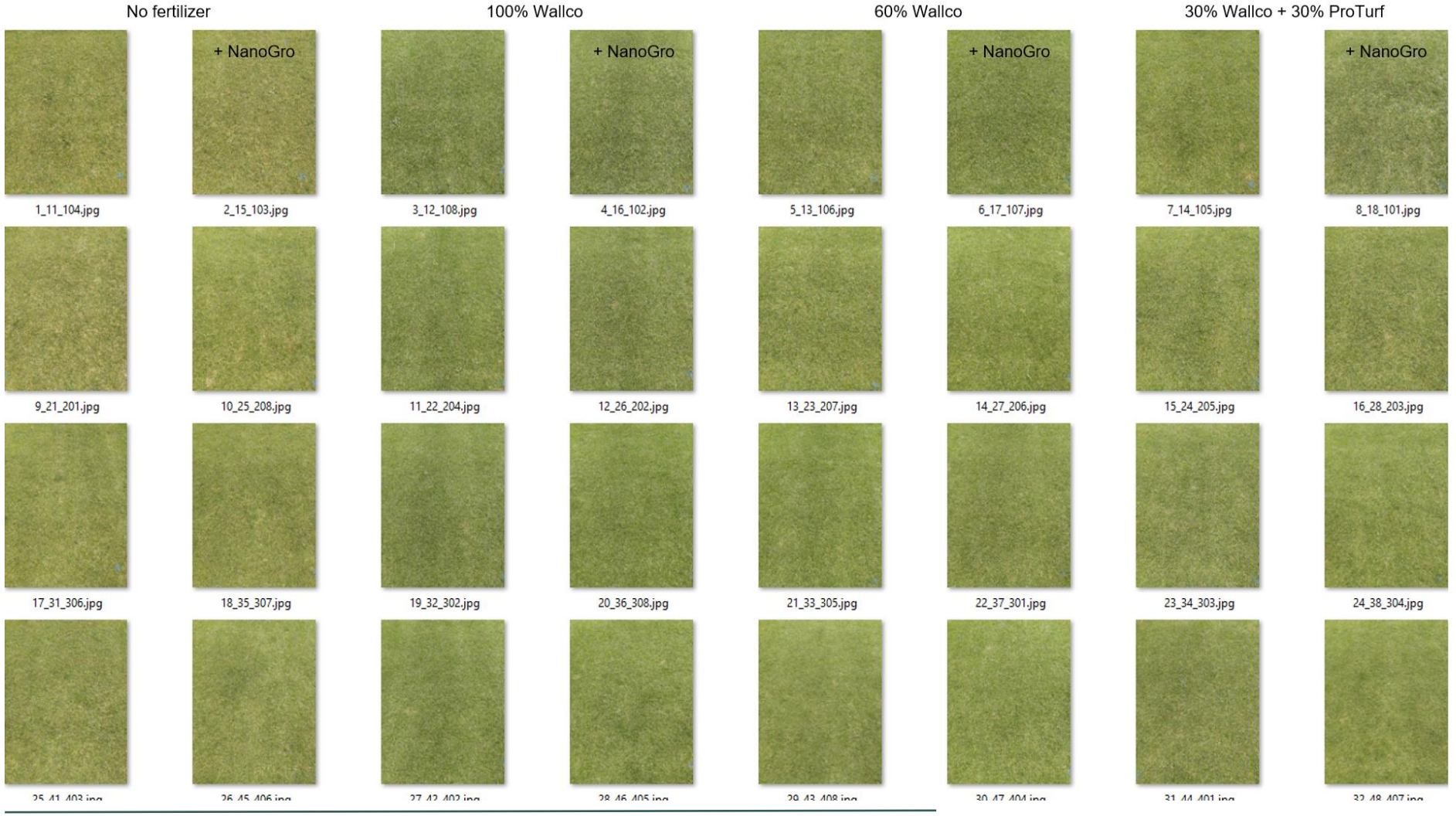
Registration plot area: 1.0 m x 1.5 m = 1.5 m2

Treatments – colour code:

Treatment	**Factor 1** = Fertilizer	**Factor 2 = NanoGro** In tank mixture with Wallco	**Water per ha**
1	No fertilizer		1 000 L water
2	100 % Wallco		1 000 L water
3	60 % Wallco		1 000 L water
4	60 % (30% Wallco + 30% ProTurf)		1 000 L water
5	No fertilizer	**NanoGro,** 292 ml/ha	1 000 L water
6	100 % Wallco	**NanoGro,** 292 ml/ha	1 000 L water
7	60 % Wallco	**NanoGro,** 292 ml/ha	1 000 L water
8	60 % (30% Wallco + 30% ProTurf)	**NanoGro,** 292 ml/ha	1 000 L water

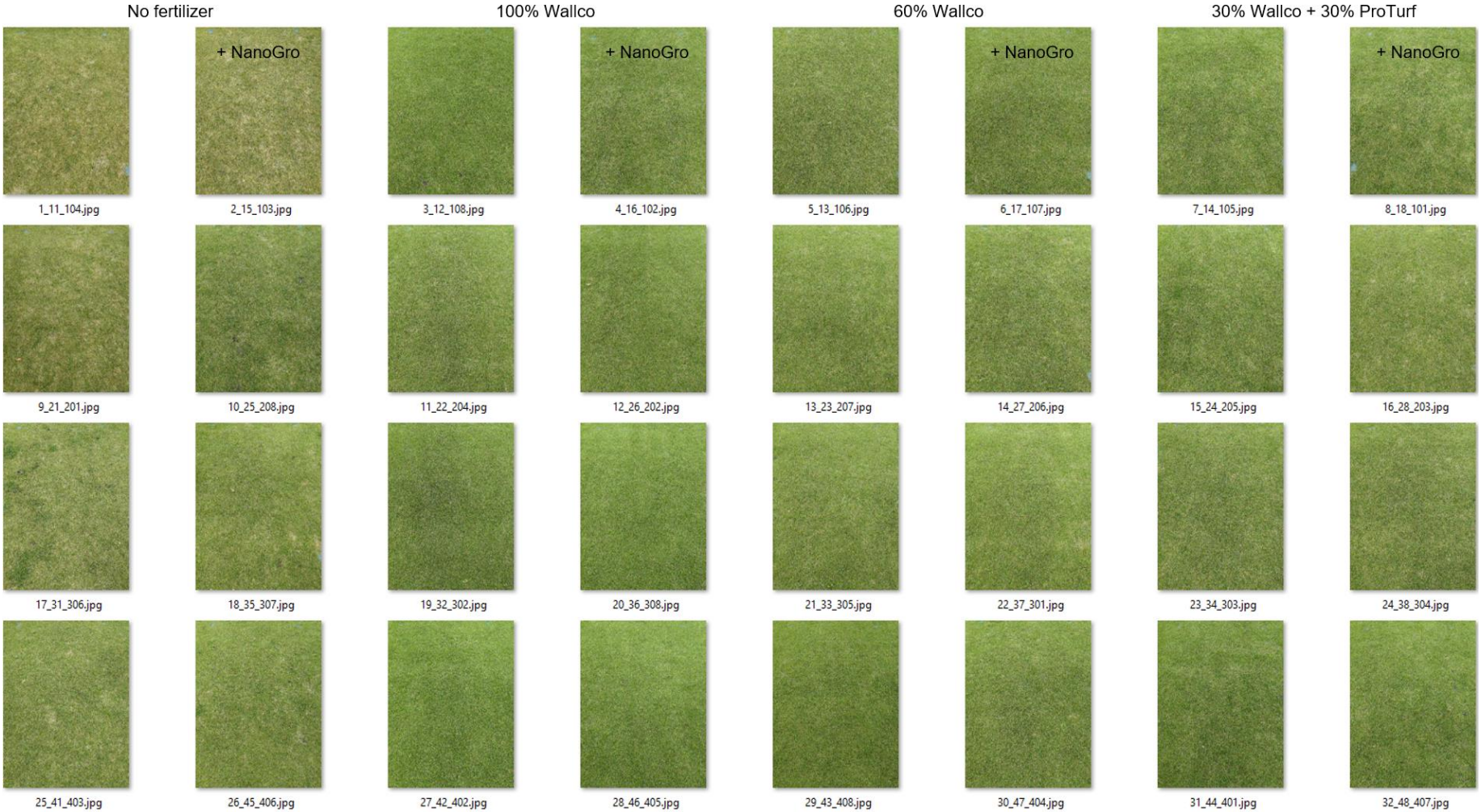
Appendix 3. All treatments in all replicates on 14 June 2019

One week after fertilization. Photos: T. Espevig.



Appendix 4. All treatments in all replicates on 7 Oct. 2019.

Photos: T. Espevig.



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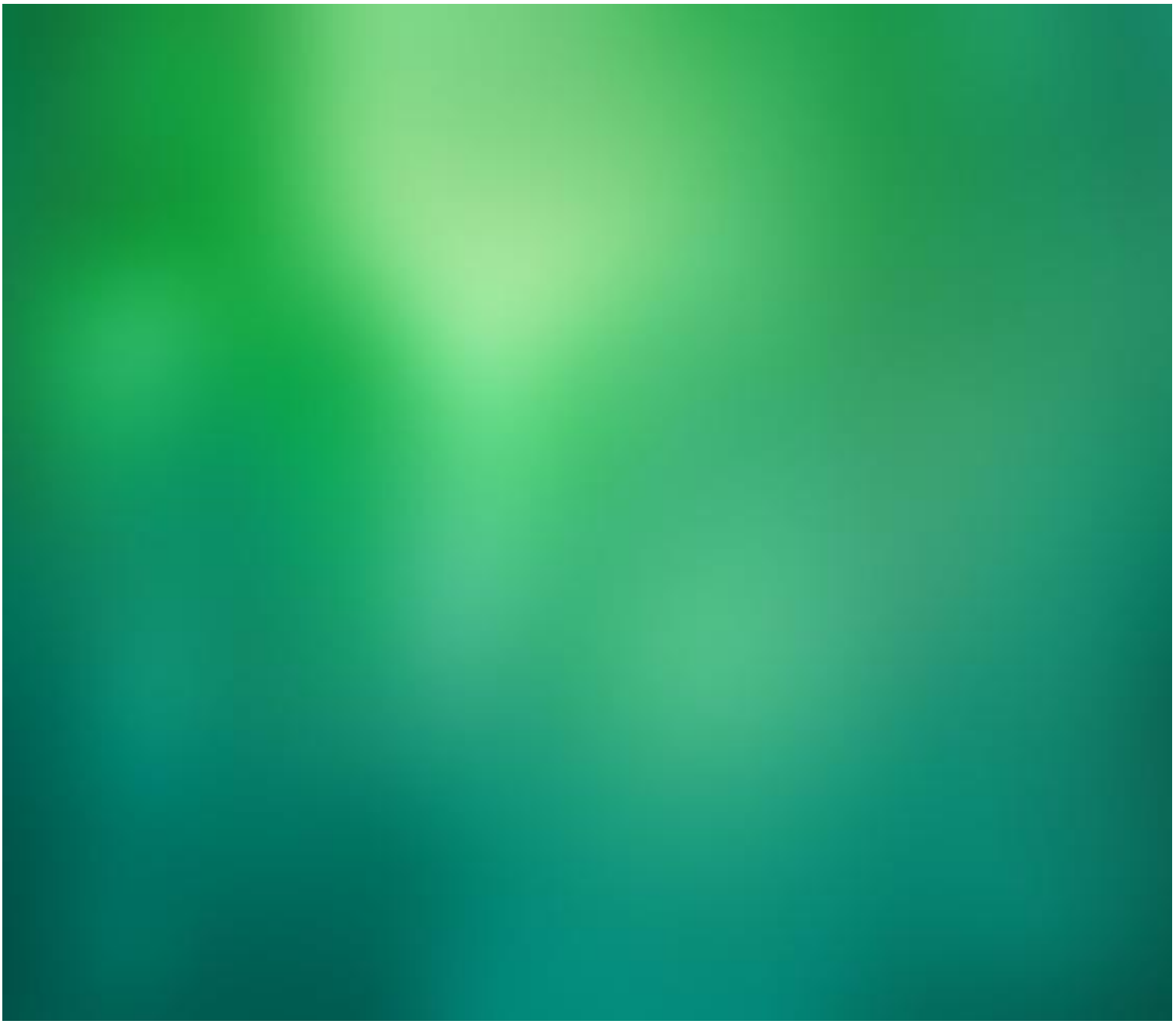

Cover photo: 18th of June 2019, Tatsiana Espevig

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