Validating Post-Emergent N Application Algorithms for the GreenSeeker[tm] Optical Sensor in Cereals and Canola using Small Plot Studies and UAN Solution.

G. P. Lafond[1], C. B, Holzapfel[2] and W. E. May[1]
[1]Agriculture and Agri-Food Canada, RR#1 Gov. Road, Box 760, Indian Head, SK, S0G 2K0 Telephone: 306-695-5220 or 306-695-5225 Email: lafond@agr.gc.ca and mayb@agr.gc.ca
[2] Indian Head Agricultural Research Foundation, Box 156, Indian Head, SK., S0G2K0 Telephone: 306-695-4200 Email: holzapfelcb@agr.gc.ca

1.0 INTRODUCTION

Nitrogen (N) fertility management encompasses four major components, source, placement, timing and rate (Malhi et al. 2001). Research has demonstrated that there is very little difference between fertilizer forms, providing they are managed appropriately (Johnston et al. 1997; Grant et al. 2002). Placing the fertilizer in the soil, as opposed to on the surface, greatly minimizes losses from volatilization and immobilization and enhances overall N fertilizer recovery (Malhi and Nyborg 1991; Malhi et al. 2001; Grant et al. 2002). The timing of N application should be such that it is available close to the time of maximum crop uptake which in cereal grains extends from the start of elongation until heading with peak uptake during flag leaf extension (Bauer et al. 1987) and in canola from the start of flowering to the end of pod formation (Malhi et al. 2007).

The current N fertilizer rate recommendations on the Canadian prairies generally consider factors such as soil texture, residual soil nitrate levels, soil moisture at seeding, average growing season precipitation, previous crop grown, crop to be grown, target grain yield, expected commodity prices and N fertilizer prices (McKenzie 1998; Anonymous 2007). However there is much uncertainty with all of these factors due to year to year variations in climatic conditions and to spatial variability in soil nutrient levels and inherent fertility of the soil. Nitrogen release during the growing season and the major pathways of N losses (immobilization, volatilization, denitrification and leaching) are also greatly influenced by climatic conditions, making their amounts very difficult to estimate. Consequently, much uncertainty exists in determining crop N requirements and the rate of application can easily be under or overestimated with important economic and/or environmental consequences in either case.

There is interest in exploring post-emergent N applications in annual crops to refine our ability to arrive at more optimal rates of N fertilizer. Delaying some or all of the N fertilizer until after crop emergence may allow for a better sense of yield potential and expected growing conditions. Recent research with spring wheat and canola using post-emergent N applications as an N management tool compared applying all fertilizer at time of seeding in the soil with in-crop surface banded applications of liquid urea-ammonium nitrate at different times after seeding. Holzapfel et al. (2007) showed no adverse effects in canola but some yield depression was observed in spring wheat, especially in those years where little precipitation was received after N application. In order to reduce the risks associated with post-emergent N applications, recent research showed that applying 50% or more of the recommended N at seeding enhances the opportunity for in-crop applications of nitrogen in spring wheat and canola to better match the soil and climatic conditions. (Lafond et al. 2008)

With the recent introduction of commercial optical sensors as a nitrogen management tool, it is now possible to estimate crop yield potential early in the growing season in cereals (5-6 leaf stage) allowing enough time to adjust the rates of N to realize that potential (Raun et al. 2002).

The objectives of this study were to validate the application algorithms developed to date in spring and winter wheat, durum, oat, malting barley and canola using small plots in order to get an accurate assessment of the proposed algorithms. The validation consisted of applying specific amounts of UAN at the 6-7 leaf stage in cereals and the mid-bolting stage of canola using rates determined by the algorithms. The results were then compared to actual N rate studies for each crop adjacent to the plot studies where the algorithms were tested. This was to verify how well the algorithms were able to predict the best N rate possible using the N response curves from the adjacent plots as a measure of precision or accuracy.

2.0 MATERIALS AND METHODS

2.1 Experiment #1: N rate study in cereals and canola.

Crops: Spring wheat, Winter wheat, Durum, Oat, Malting Barley and Canola.
N Rates: 0, 25, 50, 75, 100 and 125 kg N/ha.
Experimental Design: Randomized complete block design with 4 replicates.
Number of Plots: 144 plots
Variables Collected:

1. Plant populations (plants m^{-2})
2. Grain yield (bus/acre)
3. Grain Protein (%)
4. Repeated measurements with the GreenSeeker from the 4^{th} leaf to flag leaf stage in cereals and from the 5^{th} leaf stage to start of flowering in canola.

2.2 Experiment #2: Test of the application algorithm for the GreenSeeker.

Crops: Spring wheat, Winter wheat, Durum, Oat, Malting Barley and Canola.
Treatments:

1. Check plot - no nitrogen added
2. N Rich strip: Rate of N 1.5-2.0x the average rate for the area and adjusted for residual Nitrate N.
3. Farmer Practice: Based on residual N level and adjusted for soil moisture conditions at time of seeding, area, soil type and crop using the recommendations from the FARM PHASE II program in use by Enviro-Test Labs.
4. Reduced N rate: 66% of rate used in Farmer Practise treatment and no further N applied.
5. 50% of Farmer Practice Rate at seeding and the balance 50% of N applied at the 6-7 leaf stage in cereals and mid-bolting stage in canola using UAN as a surface dribble.
6. 66% of Farmer Practice Rate at seeding and the balance 34% of N applied at the 6-7 leaf stage in cereals and mid-bolting stage in canola using UAN as a surface dribble.
7 50% of Farmer Practice Rate at seeding and the balance of the N applied using the application algorithm developed for the GreenSeeker optical sensor.
8. 66% of Farmer Practice Rate at seeding and the balance of the N applied using the application algorithm developed for the GreenSeeker optical sensor.

Experimental Design: Randomized complete block design with 4 replicates.
Number of Plots: 192 plots
Variables Collected:
1. Plant populations (plants m^{-2})

2. Grain yield (bus/acre)
3. Grain Protein (%)
4. Measurements with the GreenSeeker as required

2.3 Other Agronomic details.

These studies were carried out at the Indian Head Research Farm in Indian Head, SK. The soil type is a Rego Black Chernozem (Udic Haploboroll). The spring and durum, spring wheat, barley and oat plots were seeded on May 2 while the canola plots were seeded on May 9, 2007. The winter wheat plots were seeded on September 6, 2006.

All plots for study #1 and #2 were seeded with an Edwards High Clearance Hoe press drill with a row spacing of 8”. Each plot was 8’ x 35’. All nitrogen fertilizer was mid-row banded between every second opener. The phosphorus fertilizer was placed with the seed for all cereals. Mono-ammonium phosphate (11-52-00) was applied at a rate of 50 kg/ha for durum, oat and barley and winter wheat. With spring wheat, triple super phosphate (0-45-0) was applied at a rate of 67 kg/ha. With canola, triple super phosphate was used with 33 kg/ha applied with the seed and 54 kg/ha put in the mid-row band with the nitrogen fertilizer. The nitrogen source used in both experiments was urea (46-00-00).

In study #2, where the post-emergent nitrogen treatments were imposed, the post-emergent N form used was liquid UAN (urea-ammonium nitrate; 28-0-0). The UAN was applied as a surface band on 12” spacing.

All pest management was done as required using recommended products and rates appropriate for the area.

2.4 Application algorithms developed for the GreenSeeker Sensor

Table 1 provides a description of the yield potential equations used for each crop. The equations were derived from small plot trials for each crop where different yield potentials were generated with different rates of N and sensor readings taken at times deemed appropriate for use with the GreenSeeker sensor. Grain yields were taken from each plot and equations developed to relate the sensor readings to grain yields.

3.0 RESULTS AND DISCUSSION

The responses of durum, spring wheat, oat and barley to nitrogen fertilizer rates were linear and the overall responses tended to be flat given the high values for the y-intercept (Table 2). The rate of yield increase per kg of N applied (bus/kg N) was 0.2, 0.1, 0.2 and 0.3 for durum, spring wheat, oat and barley, respectively. With winter wheat and canola, the response to nitrogen was quadratic in nature and the optimum N rate estimated as 133 and 172 kg N/ha, respectively (Table 3). Given the current price of nitrogen, the economic N rate would be much lower.

The recommended rates of N used for durum, spring wheat, barley and oat in the studies pertaining to the evaluation of the optical sensor for in-crop estimates of N rates (Table 4) corresponded well to the responses observed in the nitrogen rate study (Table 2).

The results for grain yield and grain protein regarding the evaluation of the optical sensor for refining N rates in durum, spring wheat, oat and barley are presented in Table 5 and 6. The N Rich treatment (#2) yielded the same as the Farmer Practice (FP #3) for all crops indicating that the recommended N rate used was able to maximize grain yield and there was also a response to N observed for all crops (Table 5).

With spring wheat and oat, all N management treatments yielded the same and the sensor was able to reduce the N rates used by an average of 33% in spring wheat and 28% in oat (Table 5).

With barley, the split application of nitrogen gave similar yields to FP and yielded more than the reduced N rate treatment (#4) (Table 5) indicating a response to post-emergent application of UAN fertilizer. Treatment 7, where 50% of the recommended N rate was applied at seeding and the balance determined with the sensor, yielded less than treatment #3 (FP). This was not observed in Treatment #8 where 66% of the N was applied at seeding and the balance with the optical sensor. However it should be noted that the N applied was 95 kg/ha for treatment #8 vs 64 kg/ha for treatment #7. More refinements are required for the barley algorithm.

With durum, applying 50% of the recommended N rate at seeding and the balance in-crop yielded less than FP and when 66% of the N was applied at seeding., regardless of whether a uniform rate was used or a rate determine with the GreenSeeker. The results suggest that the level of starter N required for durum to maintain grain yields with post-emergent N applications is at least 66% of the targeted rate. The spring wheat algorithm was used for durum and this may have affected the results with the optical sensor. Although the N Rich (#2) and the FP (#3) treatments yielded the same, the yields were lower than N Rich for all other treatments. More refinements to N management in durum are required.

With winter wheat, a strong response to N was observed and the FP treatment (#2) yielded the same as the N Rich treatment (#2) indicating that the choice of the N rate was appropriate (Table 7). The split application of N (Treatment #7) gave similar yields to the single early spring application. The in-crop additions of N based on the optical sensors were lower than FP and the yield was also lower. The current algorithm for winter wheat is not complete and further data collection is underway to refine it. The sensor applied only 65% of the N relative to the FP treatment, explaining the overall lower grain yields with the optical sensor.

With canola, a strong response to nitrogen was observed but the N Rich treatment (#2) yielded more than the FP (#3) treatment (Table 8). This would mean that the N rate recommended or chosen for the study was not adequate to maximize grain yield. However, when the same amount of N was split applied (Treatment #5) the grain yields were similar to the N Rich treatment. Even with the use of the sensor (Treatment 6 and 7), yields were not different than the N Rich treatment (#2) but tended to be lower, This is interesting given that only 45% of the nitrogen was used. When compared to the FP treatment, the optical sensor only used 67% of the nitrogen used in the FP (#3) treatment. This is a good indication of the potential of combining in-season N applications with optical sensors for accounting for spatial variability in soil nitrogen.

4.0 CONCLUSIONS

The study supports the merits of in-crop N applications for all crops measured. This N management approach when combined with optical sensors, offers the possibility of refining N rates to match the crop with soil and crop conditions and to also take into consideration spatial variability in soil nitrogen.

5.0 REFERENCES

Anonymous. 2007. Manitoba Soil Fertility Guide – Revised 2007. 74 pages**.**
Bauer, A., Frank, A.B. and Black, A.L. 1987. Aerial parts of hard red spring wheat. I. Dry matter distribution by plant development stage. Agron. J. **79**:845-852**.**
Grant, C.A., Brown, K.R., Racz, G.J. and Bailey, L.D. 2002. Influence of source, timing and placement of nitrogen fertilization on seed yield and nitrogen accumulation in the seed of canola under reduced-and conventional-tillage management. Can. J. Plant Sci. **82**: 629-638.
Holzapfel, C. B., Lafond, G. P., Brandt, S. A., May, W. E. and Johnston, A. M. 2007. In-soil banded versus post-seeding liquid nitrogen applications on no-till spring wheat and canola. Can. J. Plant Sci. **87**: 223–232.
Johnston, A.M., G.P. Lafond, J.T. Harapiak, and W.K. Head. 1997. No-till spring wheat and canola response to side banded anhydrous ammonia at seeding. J. Prod. Agric. **10:** 452-458.
Lafond, G.P., Brandt, S.A., Irvine, B., May, W.E. and Holzapfel, C.B. 2008. Reducing the risks of in-crop nitrogen fertilizer applications in spring wheat and canola. Can. J. Plant Sci. (in press).
Malhi, S.S., Grant, C.A., Johnston, A.M., and Gill, K.S. 2001. Nitrogen fertilization management for no-till cereal production in the Canadian Great Plains: A review. Soil & Tillage Res. **60**:101-122.
Malhi, S. S., Johnston, A. M., Schoenau, J. J., Wang, Z. H. and Vera, C. L. 2007. Seasonal Biomass Accumulation and Nutrient Uptake of Canola, Mustard, and Flax on a Black Chernozem Soil in Saskatchewan. Journal of Plant Nutrition. **30**: 641 – 658.
Malhi, S.S. and Nyborg, M. 1991. Recovery of ^{15}N-labeled urea: influence of zero tillage, and time and method of application. Fert. Res. **28:** 263-269.
McKenzie, R. 1998. Crop nutrition and fertilizer requirements. Alberta Agriculture, Food and Rural Development. Agri-Facts. Agdex 540-1.
Raun, W. R., Solie, J. B., Johnson, G. V., Stone, M. L., Mullen, R. W., Freeman, K. W., Thomason, W. E. and Lukina, E. V. 2002. Improving nitrogen use efficiency in cereal grain production with optical sensing and variable rate application. Agron. J. **94**: 815-820.

Table 1. List of yield potential equation for each crop used in the study in 2007.

Crop	Yield Potential Equation[1]
Canola	$Y = 595.6\ e^{1186.5*insey}$
Spring wheat	$Y = 993.3\ e^{853.59*insey}$
Malting barley	$Y = 1655.8\ e^{704.22*insey}$
Oat	$Y = 1592.1\ e^{790.05*insey}$
Winter wheat	$Y = 1813.3\ e^{703.2*insey}$
Durum[2]	$Y = 993.3\ e^{853.59*insey}$

[1] insey=NDVI/GDD where NDVI is the reading from GreenSeeker sensor and GDD is the number of growing degree days using a base temperature of 0^oC from seeding to day of sensing.
[2] Same equation as spring wheat. Equation specific to durum is currently under development.

Table 2. The response of durum, spring wheat, oat and barley to different rates of nitrogen fertilizer.

N rate (kg/ha)	Bus/acre			
	Durum	Spring wheat	Oat	Barley
0	38.6	30.8	95.1	41.0
25	40.5	32.7	89.7	52.2
50	52.3	36.5	115.0	70.4
75	52.5	40.2	112.7	62.5
100	59.7	42.5	113.7	85.8
125	60.1	39.2	117.5	81.8
cv (%)	15.3	13.2	5.4	22.7
Contrasts	*p*-values			
linear	0.0001	0.0022	0.0001	0.0003
quadratic	ns	ns	ns	ns
cubic	ns	ns	ns	ns
Linear Regression				
Y intercept	38.8	31.7	94.3	44.6
Slope	0.1889	0.0858	0.2077	0.3376
R^2	0.92	0.79	0.68	0.85

Table 3. The response of winter wheat and canola to different rates of nitrogen fertilizer on grain yield (bus/acre).

N rate (kg/ha)	Winter Wheat		N rate (kg/ha)	Canola
0	33.2		**0**	20.4
25	38.8		**25**	27.8
50	51.2		**50**	31.0
75	56.7		**100**	37.1
100	57.9		**150**	38.3
125	59.9		**200**	41.4
150	61.0		**cv(%)**	22.3
cv (%)	10.7		***p*-value**	**<0.0001**
***p*-value**	**<0.0001**		**Y intercept**	21.7
Y intercept	32.1		x^2	-0.0006
x^2	-0.0016		**x**	0.2064
x	0.4264		R^2	0.98
R^2	0.98			

Table 4. The evaluation of different N management strategies on the amount of nitrogen fertilizer (kg N/ha) applied in durum, spring wheat, oat and barley in 2007 at Indian Head.

Treatments	Durum	Spring wheat	Barley	Oat
1. Check	0	0	0	0
2. N Rich	130	130	160	120
3. Farmer Practice (FP)	90	90	105	60
4. 66% of FP (RR)	59	59	69	40
5. 50% N at Seeding + 50% at 6 leaf stage	90	90	105	60
6. 66% N at Seeding + 34% at 6 leaf stage	90	90	105	60
7. 50% N at Seeding + balance based on GreenSeeker (GS) readings at the 6 leaf stage	52	52	64	38
8. 66% N at Seeding + balance based on GreenSeeker (GS) readings at 6 leaf stage	62	68	95	49

Table 5. The evaluation of different N management strategies on the grain yield (bus/acre) of durum, spring wheat, oat and barley in 2007 at Indian Head.

Treatments	**Durum**	**Spring wheat**	**Barley**	**Oat**
1. Check	20.8e	22.3a	38.7d	93.1b
2. N Rich	50.3a	39.1b	76.9a	104.5a
3. Farmer Practice (FP)	46.8ab	36.4b	76.1a	103.5a
4. 66% of FP (RR)	42.7bc	31.8b	63.4c	103.3a
5. 50% N at Seeding + 50% at 6 leaf stage	38.5cd	36.1b	73.0ab	104.4a
6. 66% N at Seeding + 34% at 6 leaf stage	43.9b	35.4b	71.8ab	105.7a
7. 50% N at Seeding + balance based on GreenSeeker (GS) readings at the 6 leaf stage	36.9d	37.9b	66.4bc	101.6a
8. 66% N at Seeding + balance based on GreenSeeker (GS) readings at 6 leaf stage	42.8bc	38.8b	69.9abc	106.0a
LSD(05)	5.3	7.4	8.1	7.4
cv(%)	9.0	14.6	8.2	4.9
Contrasts	***p*-values**			
Check vs Rest (1 vs 2-8)	<0.0001	<0.0001	<0.0001	0.00015
N Rich vs Remaining N treatments (2 vs 3-8)	0.0004	ns	0.032	ns
N Rich vs FP (2 vs 3)	ns	ns	ns	ns
FP vs RR (3 vs 4)	ns	ns	0.004	ns
FP vs Split (3 vs 5+6)	0.0196	ns	ns	ns
FP vs GS (3 vs 7+8)	0.005	ns	0.029	ns
FP vs Split 50% (3 vs 5)	0.004	ns	ns	ns
FP vs Split 66% (3 vs 6)	ns	ns	ns	ns
FP vs GS 50% (3 vs 7)	0.009	ns	0.021	ns
FP vs GS 66% (3 vs 8)	ns	ns	ns	ns
Split vs GS (5+6 vs 7+8)	ns	ns	ns	ns
Split 50% vs GS 50% (5 vs 7)	ns	ns	ns	ns
Split 66% vs GS 66% (6 vs 8)	ns	ns	ns	ns
Split 50% vs Split 66% (5 vs 6)	0.049	ns	ns	ns
GS 50% vs GS 66% (7 vs 8)	0.032	ns	ns	ns
RR vs Split (4 vs 5+6)	ns	ns	0.015	ns
RR vs GS (4 vs 7+8)	ns	0.047	ns	ns

Table 6. The evaluation of different N management strategies on the grain protein concentration (%) in durum, spring wheat, oat and barley in 2007 at Indian Head.

Treatments	Durum	Spring wheat	Barley	Oat[1]
1. Check	12.8de	14.7c	12.3e	-
2. N Rich	14.9a	16.2a	14.4a	-
3. Farmer Practice (FP)	14.2b	15.8a	13.5bc	-
4. 66% of FP (RR)	12.6b	14.8bc	13.2cd	-
5. 50% N at Seeding + 50% at 6 leaf stage	13.3cd	15.7ab	13.6bc	-
6. 66% N at Seeding + 34% at 6 leaf stage	13.9bc	15.5abc	13.7b	-
7. 50% N at Seeding + balance based on GreenSeeker (GS) readings at the 6 leaf stage	12.6e	15.5abc	12.8de	-
8. 66% N at Seeding + balance based on GreenSeeker (GS) readings at 6 leaf stage	12.8de	15.4abc	13.5bc	-
LSD(05)	0.7	0.9	0.5	-
cv(%)	3.3	4.2	2.3	-
Contrasts	***p*-values**			
Check vs Rest (1 vs 2-8)	0.011	0.022	<0.0001	-
N Rich vs Remaining N treatments (2 vs 3-8)	<0.0001	0.036	<0.0001	-
N Rich vs FP (2 vs 3)	0.037	ns	0.0008	-
FP vs RR (3 vs 4)	<0.0001	0.036	ns	-
FP vs Split (3 vs 5+6)	0.043	ns	ns	-
FP vs GS (3 vs 7+8)	<0.0001	ns	ns	-
FP vs Split 50% (3 vs 5)	0.009	ns	ns	-
FP vs Split 66% (3 vs 6)	ns	ns	ns	-
FP vs GS 50% (3 vs 7)	<0.0001	ns	0.005	-
FP vs GS 66% (3 vs 8)	0.0003	ns	ns	-
Split vs GS (5+6 vs 7+8)	0.0008	ns	0..008	-
Split 50% vs GS 50% (5 vs 7)	0.044	ns	0.002	-
Split 66% vs GS 66% (6 vs 8)	0.0026	ns	ns	-
Split 50% vs Split 66% (5 vs 6)	ns	ns	ns	-
GS 50% vs GS 66% (7 vs 8)	ns	ns	0.005	-
RR vs Split (4 vs 5+6)	0.002	00053	0.023	-
RR vs GS (4 vs 7+8)	ns	ns	ns	-

[1] Lab analysis of grain protein not complete.

Table 7. The evaluation of different N management strategies on the grain yield and total nitrogen fertilizer used in winter wheat in 2007 at Indian Head.

Treatments	Bus/acre	kg N fertilizer /ha
1. Check	21.4c	0
2. N Rich	60.0a	206
3. Farmer Practice (FP)	60.6a	118
4. 66% of FP (RR)	45.9b	78
5. 66% N in Early Spring and 34 % at Feekes 4-5	-[1]	-[1]
6. 66% N in Early Spring + balance with GreenSeeker (GS) at Feekes 4-5	47.6b	92
7. 34% N in Early Spring and 66 % at Feekes 4-5	62.7b	118
8. 34% N in Early Spring + balance with GreenSeeker (GS) at Feekes 4-5	46.7b	62
LSD(05)	7.9	-
cv(%)	10.7	-
Contrasts	***p*-value**	
Check vs Rest (1 vs 2-8)	<0.0001	-
N Rich vs Remaining N treatments (2 vs 3-8)	0.021	-
N Rich vs FP (2 vs 3)	ns	-
FP vs RR (3 vs 4)	0.001	-
FP vs Split (3 vs 7)	ns	-
FP vs GS (3 vs 6+8)	0.0006	-
FP vs Split 34% (3 vs 7)	ns	-
FP vs GS 66% (3 vs 7)	0.0028	-
FP vs GS 34% (3 vs 8)	0.0016	-
Split 34% vs GS 34% (7 vs 8)	0.0005	
GS 34% vs GS 66% (6 vs 8)	ns	
RR vs GS (4 vs 6+8)	ns	

[1] Treatment lost due to misapplication of nitrogen fertilizer. Not included in the analysis.

Table 8. The evaluation of different N management strategies on the grain yield and total nitrogen fertilizer used in canola in 2007 at Indian Head.

Treatments	Bus/acre	kg N fertilizer /ha
1. Check	26.6	0
2. N Rich	45.3	150
3. Farmer Practice (FP)	36.9	100
4. 66% of FP (RR)	30.8	66
5. 66% N at Seeding + 34% at the mid-bolting stage	43.1	100
6. 66% N at Seeding + balance based on GreenSeeker (GS) readings at mid-bolting stage using algorithm #1.	39.2	68
7. 66% N at Seeding + balance based on GreenSeeker (GS) readings at mid-bolting stage using algorithm #2.	38.9	66
cv(%)	14.2	-
Contrasts	***p*-value**	
CHECK VS REST (1 vs 2-7)	0.0004	-
CHECK VS REST-NR (1 vs 3-7)	0.0011	-
nr vs rest-chk (2 vs 3-7)	0.023	-
fp vs rr (4 vs 5)	ns	-
NR VS FP (2 vs 3)	0.0382	-
NR VS 66% PE (2 vs 5)	ns	-
NR VS GS (2 vs 6+7)	ns	-
FP VS 66%PE (3 vs 5)	ns	-
FP VS 66%+GS1 (3 vs 6)	ns	-
FP VS 66%+GS2 (3 vs 7)	ns	
66% VS 66%PE (4 vs 5)	0.0041	
SPLIT VS GS (5 vs 6+7)	ns	