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AND

AGRICULTURAL DEMONSTRATION OF PRACTICES AND TECHNOLOGIES INITIATIVE UNDER THE CANADA-SASKATCHEWAN GROWING FORWARD BI-LATERAL AGREEMENT

PROJECT TITLE: EVALUATING THE EFFECTS OF GLYPHOSATE AND POD SEALANTS ON THE YIELD OF STRAIGHT-COMBINED CANOLA ON A LARGE FIELD-SCALE

(CARP-SCDC 2010-16)

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Abstract / Executive Summary:
Field trials were conducted in 2010 and 2011 near Indian Head, Saskatchewan to evaluate the effects of pod sealants and preharvest glyphosate application on shattering losses and seed yields in straight-combined canola. Each plot had an approximate area of two acres and commercial equipment was used for all field operations. The treatments were a factorial combination of two harvest methods (swathed or straight-combined) and four preharvest treatments (untreated, pod sealant, glyphosate or pod sealant plus glyphosate). Overall, swathed canola yielded 21% higher than straight-combined canola; however, a cultivar which was relatively prone to shattering was purposely chosen for this study. Consistent with previous findings, pod sealants did not provide a yield benefit over untreated canola regardless of harvest treatment, but a slight benefit was observed in the visual shattering ratings of the straight-combined canola. The effect of glyphosate was not consistent from one year to the next with lower yields observed in 2010 and a tendency for higher yields with glyphosate in 2011. These differences were most evident in the straight-combined treatments as all swathed treatments tended to have similar yields regardless of the foliar treatment. Glyphosate combined with a pod sealant produced similar results as glyphosate applied on its own. The lower yields observed with glyphosate in 2010 were attributed to these treatments being visibly overripe relative to those that did not receive pre-harvest glyphosate while we speculate that the positive impact observed in 2011 may have been due to differences environmental conditions at the time of harvest. Even though we would not necessarily expect a yield benefit with pre-harvest glyphosate for straight-combined canola, it can accelerate and even out maturity while also providing weed control benefits for the following crop. Preharvest glyphosate will not be effective on Roundup Ready® canola and a desiccant such as diquat would not be expected to produce the same results as glyphosate. In conclusion, while there is a risk of increased seed loss with straight-combining, we could not show a significant benefit to using a pod sealant. Pre-harvest glyphosate may have a fit when straight-combining non-resistant cultivars as it accelerates maturity and evens out variable fields. The most important factors for canola growers interested in straight-combining are to consider a header extension that moves the cutting bar farther into the crop, choose a variety with relatively good resistance to shattering, seed at sufficiently high rates to accelerate maturity and reduce in-field variability and keep weeds and disease under control.

Background / Introduction:

The generally accepted recommendations for harvesting canola are to swath at 40-60% seed color change and combine when the seed has matured and dried to 10% moisture content. Early harvest management research with this crop focussed primarily on the effects of the timing of swathing on days to maturity, seed quality and yield (Cenkowski et al. 1989, Thomas et al. 1991, Anonymous 1998a, Anonymous 2000). An important benefit to swathing canola is that doing so hastens moisture loss and chlorophyll degradation in the seed relative to canola left standing (Cenkowski et al. 1989) and swathing helps variable fields mature evenly while also desiccating any green weeds. Timing of the swathing operation is important as swathing canola too early prevents the crop from reaching its full yield potential while the risk of yield loss due to shattering can be high when canola is swathed too late or straight-harvested (Thomas et al. 1991, Anonymous 1999, Anonymous 2000). In addition, swathing canola too early can reduce seed size and/or seed oil concentrations (Anonymous 1998a and 2000, Vera et al. 2007). Downsides to swathing which are important from a producer's perspective arise in that swathing is labour intensive, must be completed at a time when labour is in high demand and, for many growers, canola is the only crop grown which they routinely swath.

The alternative to swathing is to straight-combine. Traditionally in western Canada, straight-combining *napus* canola has not been recommended because the risks of yield loss due to shattering can frequently outweigh the potential benefits. Research data and grower experiences alike have shown that, while it is often possible to straight-harvest canola with no effect on or even slight increases in yield, substantial losses can occur and have been reported as high as 50% relative to swathing (Thomas et al. 1991; Anonymous 1998b, 1998c, 1999; Gan et al. 2008). Consequently, while there are potential benefits to straight-combining *napus* canola and many Prairie growers regularly do so with success, this practice is not without risk. Nonetheless, there is still considerable interest in straight-combining and technology has been striving to make this practice more feasible for canola growers in western Canada.

One of the first things for canola growers planning to straight-combine to consider is selecting a species and/or cultivar that is relatively resistant to shattering. Due to their improved shattering resistance, *Brassica rapa* (Polish canola) and canola quality *juncea* are often touted as being better candidates for straight-combining; however, these species tend to yield less than *napus* canola (Gan et al. 2008, Wang et al. 2007). Recent research has shown that considerable variation in resistance to shattering exists amongst *napus* varieties with certain cultivars exhibiting comparatively low losses, even under extreme conditions (Wang et al. 2007, Holzapfel et al. 2010). It has also been suggested that canola crops with high yield potential are better suited to straight-combining than lower yielding canola; thus, adequate fertility and seeding rates are important to ensure a strong, even stand (Watson et al. 2008). High plant densities have the added advantage of maturing relatively early and uniformly compared with sparser canola stands. Another attribute which many canola fields that are successfully straight-combined frequently share is a dense crop canopy where the plants are somewhat lodged and heavily intertwined with one another (Watson et al. 2008). Ag Shield Manufacturing in Manitoba produces the Yield Shield™, a device which artificially lodges the crop in attempt to reduce plant movement and make fields less prone to shattering and, consequently, better suited for straight-harvesting. Provided that the crop was not pushed too early, research at Brandon, Manitoba found that pushed canola typically yielded equal to or higher than swathed canola (Irvine 2003). Irvine (2003) also noted that pushing worked better in dense canopies as the sparser canopies tended to stand back up, especially when pushed too early. In contrast, other trials showed no benefit to pushing canola over straight-combining standing canola (Anonymous 2001a, 2001b and 2002). The greatest drawbacks of pushing is that this practice does not eliminate a field operation relative to swathing, requires specialized equipment and pushed canola must be cut closer to the ground than standing crops which slows down combining and leaves less stubble behind to capture snow for subsequent crops.

Pod sealants such as Pod Ceal DC (Brett Young 2012) and Pod-Stik (United Agri-Products 2012), are another technology available to growers who are considering straight-combining their canola. While the modes of action for pod sealants can vary, they are designed to cover the pods in a protective coating intended to reduce the risk of pod shattering as the seeds mature. If effective, pod sealants could lengthen the time period over which canola could safely be left standing, thus increasing harvest flexibility and allowing producers to better capture the benefits of straight-harvesting without some of the drawbacks of pushing. The total cost of applying a pod-sealant (product plus application) is similar to that of swathing; however more acres can be covered in a shorter time period with a high-clearance sprayer compared with a swather. Furthermore, the majority of farms already own a high-clearance. That said, data evaluating the effectiveness of pod sealants for canola in the Canadian prairies has previously been limited and the results that are available have not shown a great benefit to such products. In both North Dakota and Minessota, there was no benefit to applying pod sealants relative to straight-combining canola without a sealant in terms of either grain yields or shattering losses (Johnson et al. 2009; Porter 2010). Similarly, data from east central Saskatchewan did not show a clear benefit to pod sealants (Kim Stonehouse, personal communication). Recent work looking at pod sealant and cultivars effects on straight combined-canola reported a 216 kg ha^{-1} benefit to pod sealants at one out of eight site-years, but no benefit for either of the remaining seven site-years or when averaged across sites (Holzapfel et al. 2010). Despite uncertainty regarding their effectiveness, canola growers did show interest in pod sealants and an appreciable number of acres have been treated since these products first became available in western Canada.

The other question that often arises is whether or not it is necessary to apply a chemical desiccant or glyphosate prior to straight-combining canola. First, it is important to distinguish between desiccants, such as paraquat (Gramaxone) or diaquat (Reglone) and glyphosate, and the implications for straight-combining canola. Reglone acts very quickly and should be applied when the canola seed has virtually matured. Desiccants are useful to defoliate and dry down the crop just prior to harvest; however can increase susceptibility to shattering if harvest is not completed as soon as possible (Porter 2010). While research in North Dakota concluded that it is possible for desiccants to be used on straight-combined canola without suffering drastic shattering losses and yield reductions, Jenks et al. (2010) did observe reduced yield and seed quality when desiccants were applied too early. In contrast, glyphosate is not a desiccant, but is registered for pre-harvest weed control and, unlike desiccants, should be applied at approximately 30% seed moisture content. Glyphosate acts over a period of weeks and, while it will not quickly defoliate the crop and green weeds or accelerate drying, slowly terminates the canola and can even out variable fields prior to straight-combining. Glyphosate has the added benefit of providing perennial weed control into the next season, something which will not be achieved with desiccants. While glyphosate will not rapidly dry the crop, it can potentially shorten the length of time required before the crop is fit for harvest. An obvious but important limitation of glyphosate as an aid for straight-combining canola is that it will not be effective for Roundup Ready® cultivars, which make up a large percentage of the canola grown in western Canada.

The objectives of this study were to evaluate the effects of harvest method, pre-harvest glyphosate and commercial pod sealant applications on pod shattering and grain yields of canola under commercial field conditions.

Materials & Methods:
A field trial was conducted during the 2010 and 2011 growing seasons to evaluate the effects of harvest method and pre-harvest, chemical treatments on pod shattering and seed yields. The trial was completed on a large field scale using commercial field equipment and was located at the Indian Head Agricultural Research Foundation (IHARF) Precision Farm, 3.2 km east of Indian Head (E-28-12-18-W 2). The Precision Farm has a total area of approximately 125 ha and is divided into eight fields with areas of approximately 15.5 ha each. The current field boundaries were delineated in 1998 and, since then, each field has been continuously cropped under no-till management with a cereal-field pea-cereal-canola rotation. With eight fields, each phase of the rotation is replicated two times per year. Figure 1 is a map of the IHARF Precision Farm depicting the crops grown in 2010. In 2011, fields on the Precision Farm were combined and the crop rotations were shifted to create four fields running the full length of the farm (ie: fields 1-5 were combined, 2-6, 3-7 and 4-8). In 2010 the trial was completed on fields 4 and 5 while in 2011 fields 2 and 6 were used.

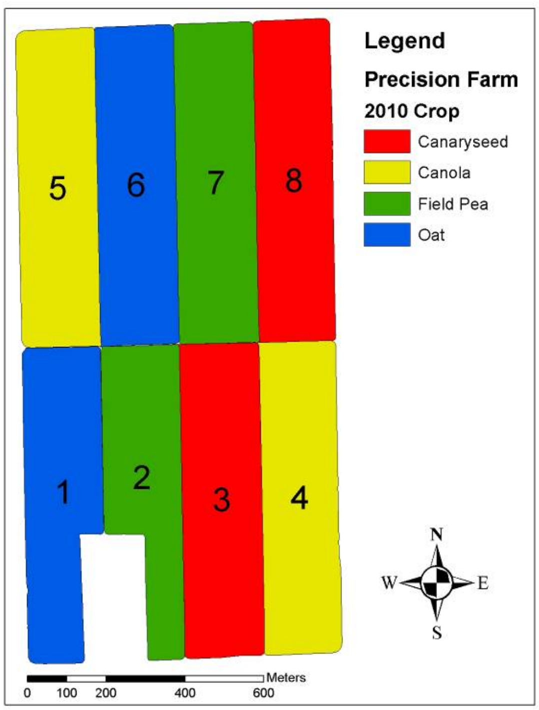

Figure 1. IHARF Precision Farm fields and crop types grown in 2010. All fields are in a cereal-field pea-cereal-canola rotation.

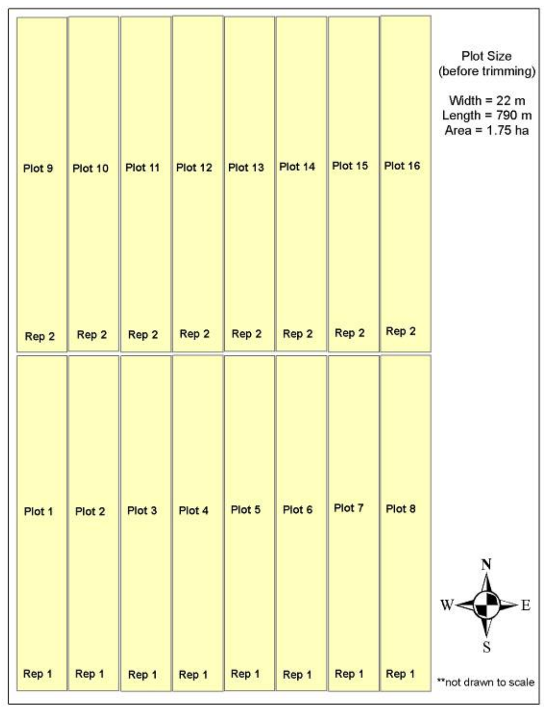

Figure 2. Plot layout in Field #4 for 2010 SaskCanola Harvest Management Study – same arrangement was used for plots 17-32 in Field #5.

In both years of the study, treatments were arranged as a randomized complete block design replicated four times. In 2010, two replications were located in Field #4 and two in Field #5; Fig. 2 illustrates the layout of the plots in each field. In 2011, one replicate was located on Field #2 north of the yard-site while the last three replicates were on Field

#6. The total area of each plot varied depending on the year but plot sizes were always between 0.75 and 1.00 ha. The treatments that were evaluated included a full factorial combination of two harvest methods (swathed versus straight-combined) and four preharvest treatments for a total of eight entries. The targeted time of application for the preharvest treatments was 30-40% pod color change and the treatments were: 1) untreated, 2) pod sealant, 3) glyphosate and 4) pod sealant plus glyphosate (combination).

InVigor 5020, a glufosinate ammonium tolerant canola hybrid that is moderately prone to shattering (Holzapfel et al. 2010), was seeded at a rate of 6.4 kg $ha^{-}1$ on May 18 in 2010 and at 6.6 kg ha^{-1} on May 16 in 2011. Seeding was completed using a 10 m wide Flexi-Coil 5000, high-clearance hoe-press drill and both fields were seeded directly north-south with a GPS assisted automatic steering system. All fertilizer was side-banded at seeding with urea ammonium-nitrate (28-0-0), ammonium thiosulfate (15-0-0-20) and monoammonium phosphate (11-52-0) as the sources. Fertilizer rates were calculated to supply 134, 33 and 17 kg ha^{-1} of N, P_2O_5 and S, respectively in both 2010 and 2011. Weeds were controlled using registered herbicides at their recommended rates with all herbicides and preharvest treatments applied using a 24 m wide, 1998 Rogator high-clearance sprayer equipped with GPS and an automatic steering system. The sprayer is also equipped with a GreenSeeker™ RT200 optical sensing / variable rate application system that was used to create as-applied maps during the treatment applications. All glyphosate and pod sealant treatments were applied on August 20 in 2010 and August 9 in 2011. For the pod sealant plus glyphosate treatments, the two products were tank-mixed and applied in a single pass. The pre-harvest foliar treatments were applied at 192 l ha^{-1} solution volume with the exception of the glyphosate only treatment where a solution volume of 96 l ha^{-1} was used. The product rates were 1.67 l ha^{-1} of Roundup Transorb HC (902 g glyphosate ha^{-1}) for the treatments that included glyphosate and 1 l ha^{-1} of Pod Ceal DC (formerly available from Brett Young) for the pod sealant treatments. The target stage for the pre-harvest treatment applications was 30-40% pod colour change; however, crop injury caused by excess moisture resulted in some variability in the actual growth stages throughout the fields. All treatments were driven through at the time of the foliar treatment applications to equalize the effects of the sprayer's wheel tracks; however, it should be acknowledged that driving through canola at this stage will result in permanent yield loss. Half of the treatments were swathed with a 7.5 m self-propelled swather on either August 25-26 (Field 5 and south half of Field 4) or September 1 (north half of Field 4) in 2010 while the straight-combined treatments were left to mature while standing. In 2011, swathing was completed on August 17. Shattering ratings were completed prior to harvest for each straight-combined plot with each plot rated five times and the average rating was used to represent the entire plot. A rating scale of 1-5 was used where 1 indicates minimal shattering and 5 indicates severe shattering losses (1 – 0-2%, 2 – 3-5%, 3 – 6-10%, 4 – 11-25% and 5 – 26-50%). In 2010, shattering ratings were completed on September 24 while in 2011, to reflect the maturity differences, ratings were completed on August 30 for the treatments which did not receive glyphosate and on September 6 for those treated with glyphosate. All treatments were harvested on September 27-28 in 2010 while in 2011 swathed canola was harvested on August 24, straight-combined canola treated with glyphosate was harvested on August 31 and the straight-combined treatments where no glyphosate was applied were combined on

September 6. All plots were combined using a 2003 New Holland TR940 equipped with either a 3.9 m pickup header or a 9 m Honeybee draper header equipped with cross auger, depending on the treatment. The combine was equipped with GPS and a New Holland yield monitoring system that recorded grain yields and seed moisture content.

Prior to statistical analyses, raw yield data were processed using ArcGIS 9.3. First, all data points from headlands and the beginning and ends of passes (where the combine was loading / unloading) were removed. Next, the mean yield and standard deviation were calculated from the remaining points for each field and all data points that fell outside of three standard deviations from the mean were removed to eliminate erroneous data. Using the sprayer passes from the treatment applications as a spatial reference, all but two combine passes from the center of each plot were deleted and plot, replicate and treatment information were added to the remaining data. Yield data were then exported into SAS 9.2 where the first step was to calculate descriptive statistics for each plot and to create a final dataset containing the mean yields for each plot (Tables A-1 and A-2). The exported yield data were then used to calculate marginal profits for each plot using the following assumptions. Gross returns were calculated by multiplying the average yield by the assumed price for canola which was set at \$500 Mt^{-1}. Only the costs of swathing, the spraying operation for applying preharvest foliar treatments and the costs of the preharvest products (pod sealant, glyphosate or both) were considered as expenses; thus these values do not reflect the actual net returns that would be realized at the farm level. The total expenses for each plot were subtracted from the gross revenues to calculate marginal net profits. The assumptions used to calculate expenses were: 1) \$35 ha^{-1} cost of swathing operation, 2) \$10 ha^{-1} cost of spraying operation (does not include products), 3) \$10 ha^{-1} cost of glyphosate and 4) \$25 ha^{-1} cost of pod sealant.

Final yield and marginal profit data were analyzed using the Mixed procedure of SAS (Littel et al. 2006) with the effects of year, harvest method and preharvest treatment considered fixed and the effects of replicate considered random. Fisher's protected LSD test was used to separate treatment means and predetermined contrast statements were used to directly compare specific treatments or groups of treatments. Shattering ratings were analyzed in a separate Mixed model that included only the relevant treatments. Results from contrast comparisons for shattering are reported where applicable and the specific comparisons were:

1) Swathed versus straight-combined (all preharvest treatments)
2) Untreated versus pod sealant (all harvest methods)
3) Untreated versus glyphosate (all harvest methods)
4) Untreated versus combo (all harvest methods)
5) Pod sealant versus combo (all harvest methods)
6) Straight cut only – untreated versus pod sealant
7) Straight-cut only – untreated versus glyphosate
8) Straight-cut only – untreated versus combo
9) Untreated only – swathed versus straight-cut

All treatment effects, differences and contrasts were declared significant at $P \leq 0.05$.

Results and Discussion:

Weather

Mean monthly temperatures and precipitation for the 2010 and 2011 growing seasons were estimated from an Environment Canada weather station located approximately 4 km east of the field trial and are reported in Table 1 (Environment Canada 2012). Overall, the 2010 growing season at Indian Head was cooler and wetter than normal. Most of April was warm with close to normal precipitation; however heavy rains at the end of the month brought total precipitation levels for the month up to nearly 190% of normal and postponed seeding in the area. For May and June, temperatures were 1.2 ºC cooler than normal and an overall average of 138% of normal precipitation was received. Nearly 100 mm of rainfall was recorded in the last two weeks of June, resulting in excess moisture accumulation and stressful conditions for the young canola plants. The worst crop injury within the study area was observed in Field 4, particularly on the north end towards which the whole field tends to slope (Fig. A-1). July was the drier than normal and, overall, crops recovered well during this period; however, frequent rains in August and early September created challenging conditions for harvest. In 2011, conditions were also wetter and cooler than normal for the first half of the growing season with 152% of normal rainfall in May and June. Similar to 2010, conditions in July and August were warm and dry, again allowing the crop to recover reasonably well from the stressful conditions earlier on. Daily weather data for the six week period leading up to the harvest operations are presented in Tables A-3 and A-4 for 2010 and 2011, respectively.

Table 1 . Monthly temperatures and precipitation levels from the 2010 growing season plus long-term (1971-2000) normals for Indian Head, Saskatchewan (Environment Canada 2012).

Month	*Mean Temperature* (ºC)			*Total Precipitation* (mm)		
	2010	2011	Normal	2010	2011	Normal
April	6.3	1.8	4.0	46.3	8.3	24.6
May	9.6	9.5	11.4	63.2	71.3	55.7
June	15.6	15.1	16.1	122.4	133.2	78.9
July	17.4	18.8	18.4	27.6	42.3	67.1
August	16.3	17.8	17.5	92.8	44.2	52.7
September	11.0	13.9	11.4	65.0	15.7	39.5
Average / Total	**12.7**	**12.8**	**13.1**	**417.3**	**315.0**	**318.5**

Pod Shattering

In 2010, pod shattering ratings for all treatments were completed on September 24. At this time we estimated that the canola was approximately 1 wk past the optimal harvest stage and some shattering was visually evident. It was noted that the treatments where glyphosate was applied were noticeably overripe relative to the treatments where glyphosate had not been applied. While harvest would have been completed earlier if not for the wet weather, the delay provided a good opportunity to assess the risks of straight-combining and evaluate the ability of pod sealants to reduce shattering losses under unfavourable conditions. While it was not unusually windy, at total of 53 mm of rain fell in September with a total of 8 days where at least 2 mm of rain was received over the three week period leading up to harvest in 2010 (Table A-3). In 2011, shattering ratings were completed twice to reflect the different harvest dates between the treatments which had been treated with glyphosate and those which had not. Overall, there appeared to be less visual pod shattering in 2011 than there was the previous year. This may be attributable to better timing of the harvest operations and / or more favourable weather leading up to harvest. Aside from a substantial 21 mm of rainfall on August 31, 2011 (immediately following the first straight-combining date), the weather was warm and dry throughout harvest and, while there were some windy days, the mature canola did not generally go through much for wetting / drying cycles (Table A-4). The results of the combined analysis for pod shatter ratings are presented in Table 2.

Table 2. Type 3 tests of fixed effects, treatment means and selected contrast comparisons for preharvest foliar treatment (pod sealant and/or glyphosate applications) on pod shattering ratings.

	Type 3 Tests of Fixed Effects		
Effect	---------------------------- *p*-values ----------------------------		
Year (Y)	<0.001		
Foliar Treatment (F)	<0.001		
Y X F	0.011		
	Least Squares Means / Multiple Comparisons†		
Foliar Treatment (F)	2010	2011	All Years (Main Effect Foliar Trt) ↓
	------------------- Pod Shatter Ratings (1-5)‡ -------------------		
Untreated	1.98 b	1.15 c	1.56 b
Pod Sealant	1.28 c	1.05 c	1.16 c
Glyphosate	2.65 a	1.30 c	1.98 a
Combination	2.10 b	1.04 c	1.57 b
All foliar treatments (Main Effect Year) →	2.00 a	1.14 b	–
	Contrast Comparisons		
Description	---------------------------- *p*-values ----------------------------		
Pod sealant versus Untreated	0.017		
Glyphosate versus Untreated	0.014		
Combo versus Untreated	0.936		
Combo versus Pod sealant	0.014		

Standard error values are 0.077 for year, 0.109 for foliar treatment and 0.155 for year x foliar treatment
†Treatment means within each group (year, foliar treatment, year x foliar treatment) followed by the same letter are not significantly different from each other according to Fisher's protected LSD test ($P \leq 0.05$)
‡Shatter losses rated September 24 (1 – 0-2%, 2 – 3-5%, 3 – 5-10%, 4 – 11-25%, 5 – 25-50%)

Visual pod shatter ratings were significantly affected by both year ($P < 0.001$) and foliar treatment ($P < 0.001$) with a significant year by foliar treatment interaction ($P = 0.011$). At 2.00 versus 1.14, the overall visual shattering ratings for 2010 were higher than in 2011 which was consistent with our initial observations. In the rating scale, a value of 1.0

corresponded to an estimated 0-2% shattered pods while a rating of 2.0 corresponded to 2-5% of the pods being shattered. Averaged across both years, pod shattering appeared to be highest when glyphosate was applied on its own (1.98), lowest when the pod sealant was applied alone (1.16) and intermediate for the remaining two treatments where either no foliar treatment or a combination of a pod sealant and glyphosate were applied (1.56-1.57). The significant year by foliar treatment interaction justifies looking at the effects of foliar treatment on pod shattering for the individual years. In 2010, the treatment rankings followed the exact same pattern as the averaged results; however, the overall ratings were higher with values ranging from 1.28-2.65 when only 2010 data were considered. In 2011, there were no significant differences amongst the foliar treatments. The relative lack of a foliar treatment effect on shattering ratings in 2011 can likely be partly attributed to harvest operations (and hence shattering ratings) being timed more closely to the optimal harvest stages as affected by the foliar treatments. Recall that in 2010, both crops were harvested on the same date, by which time the plots where glyphosate was applied were visibly overripe. In 2011, while the vast majority of plants where glyphosate had not been applied were mature and ready to harvest at the first straight-combining date (August 31), there were isolated green patches which did not exist in the plots that received pre-harvest glyphosate (Figure 3). Focussing on the contrast comparisons which take into account both years of the study, visual shattering was higher in the untreated plots than where a pod sealant was applied alone ($P = 0.017$) but lower than when glyphosate was applied on its own ($P = 0.014$). The pod sealant-glyphosate combination resulted in lower shattering losses than when a pod sealant was used on its own ($P = 0.014$) and similar losses to the untreated, standing canola ($P = 0.936$).

Figure 3. Green patches remaining in standing canola which had not been sprayed with glyphosate on August 30, 2011. Canola in background received glyphosate and is visibly less green.

Grain Moisture Content, Yield and Marginal Profits

Seed moisture concentrations were logged during combining and, while not statistically analyzed, results are provided in Table 3. Averaged across harvest treatments, seed moisture content at the time of combining in 2010 was 5.3% for Field 4 and 8.1% for Field 5. Ideally, canola should be straight-combined as soon as it is mature and falls to 10% seed moisture content where it can be safely stored. The fact that we combined at considerably less than this, even after the crop had been rained on several times in the weeks prior to harvest, affirms that combining was completed later than what would have been optimal in 2010. In Field 4, similar moisture content was observed between the swathed and straight-combined treatments (4.9% versus 5.7%), while in Field 5, the straight-combined treatments came off drier than the swathed treatments (6.6% versus 9.7%). Within each field and for any given harvest method, no consistent differences in seed moisture content were observed amongst the preharvest treatments and they were always within 1% of one another, thus neither pod sealant nor glyphosate appeared to have affected seed moisture content at time of harvest. In 2011 the overall average moisture content was 10.0%, but with the exception of treatments 7 and 8, moisture concentrations were between 8.3-9.2%, regardless of harvest method. Treatments 7 and 8 were considerably wetter with an overall average moisture content of 13.3%. The reason for the observed higher moisture content was that these treatments were combined on August 31 and actually taken off while it was starting to rain. Recall that 21 mm of rain fell on August 31, 2011. This rainfall event was forecast and, looking at the radar, inevitable. While we attempted to harvest the treatments before any precipitation had occurred it had already started to rain lightly by the time we began and, while combining went well, this was reflected in the moisture content of the grain. Again, the seed moisture concentrations for treatments which had received a pod sealant were numerically similar to the untreated checks.

Table 3. Seed moisture content of canola at harvest as affected by harvest treatment and field in field-scale harvest management study at Indian Head in 2010.

Treatment	2010 Field 4	2010 Field 5	2010 Average	2011
	Seed Moisture Content (%)[†]			
1) Swathed – Check	4.82	9.73	7.28	8.38
2) Swathed – Pod Sealant	4.68	9.55	7.12	8.55
3) Swathed – Glyphosate	5.00	9.60	7.30	9.21
4) Swathed – Combo	5.01	9.74	7.38	8.35
5) Straight – Check	5.46	6.22	5.84	8.26
6) Straight – Pod Sealant	5.58	7.14	6.36	8.64
7) Straight – Glyphosate	6.11	6.43	6.27	12.66
8) Straight – Combo	5.71	6.60	6.16	13.99
Swathed – Average	4.88	9.66	7.27	8.61
Straight – Average	5.72	6.60	6.16	11.06
Overall Average	5.30	8.13	6.71	10.00

[†]Seed moisture content measured using New Holland yield monitoring system

Yield data and marginal profits were analyzed in a similar manner as the shattering ratings, but included an additional factor (harvest method) along with all the potential interactions that came with it (harvest method × foliar treatment, year × harvest method and year × harvest method × foliar treatment). Tests of fixed effects along with the main effect least squares means for both yield and marginal profits are presented in Table 4. The results of these analysis were nearly identical for the two response variables with both yield and profits being affected by year (P = 0.001), harvest method (P < 0.001), year × foliar treatment (P = 0.021) and year × harvest method × foliar treatment (P = 0.051) but not foliar treatment (P = 0.285-0.391), harvest method × foliar treatment (P = 0.873) or year × harvest method (P = 0.0913).

Table 4. Type 3 tests of fixed effects and least squares means for year, harvest method (swathed / straight-combined), preharvest foliar treatment (pod sealant and/or glyphosate applications) on canola seed yield (kg ha^{-1}) at Indian Head, Saskatchewan.

	Type 3 Tests of Fixed Effects	
Source	**Seed Yield**	**Marginal Profits**
	-------------------------- Pr > F	----------------------------
Year (Y)	0.001	0.001
Harvest Method (H)	<0.001	<0.001
Foliar Treatment (F)	0.391	0.285
H x F	0.873	0.873
Y x H	0.913	0.913
Y x F	0.021	0.021
Y x H x F	0.051	0.051
	Least Squares Means / Multiple Comparisons [†]	
Effect	---------- kg ha^{-1} ----------	----------- \$ ha^{-1} -----------
Year 2010	2308 a	1112 a
2011	2068 b	992 b
Standard Error	88.2	44.1
Harvest Treatment Swathed	2398 a	1139 a
Straight-combined	1978 b	964 b
Standard Error	88.2	44.1
Foliar Treatment Untreated	2206 a	1086 a
Pod sealant	2277 a	1086 a
Glyphosate	2115 a	1020 a
Combination	2155 a	1015 a
Standard Error	100.9	50.4

[†]Treatment means within a specific grouping (i.e. year, harvest method, foliar treatment) followed by the same letter do not differ from each other according to Fisher's protected LSD test ($P \leq 0.05$)

Focussing on main effects first (Table 4), the overall yields were higher in 2010 than in 2011 (2308 versus 2068 kg ha^{-1}) and the same was true for marginal profits (1112 versus 992 $ ha^{-1}). For harvest method, swathing was significantly better than straight-combining with respect to both seed yields and marginal profits. Averaged across years, seed yields were 2398 kg ha^{-1} for swathed canola and 1978 kg ha^{-1} for straight-combined canola, which translated into a 21% yield advantage to swathing. Marginal profits were affected in the same manner with the straight-combined canola netting 992 $ ha^{-1} while marginal profits for swathed canola were 1139 $ ha^{-1}, or 15% higher. The smaller magnitude of the impact on marginal profits relative to seed yield is a reflection of the added cost of the swathing operation. Again, neither seed yields nor marginal profits were affected by foliar treatment when averaged across years; however, the significant year × foliar treatment and year × harvest method × foliar treatment interactions justify looking at treatment means for individual years and harvest methods (Table 5). Because marginal profits followed identical patterns as seed yield with the same levels of statistical significance, only the latter are explored further.

Table 5. Least squares treatment means for significant interactions between year, harvest method (swathed / straight-combined) and preharvest foliar treatment (pod sealant and/or glyphosate applications) for canola seed yield (kg ha^{-1}) at Indian Head, Saskatchewan.

	Least Squares Means / Multiple Comparisons†	
Effect	**2010**	**2011**
	-------------------------- kg ha^{-1} --------------------------	
	Year × Foliar	
Untreated	2361 ab	2052 cd
Pod Sealant	2531 a	2033 cd
Glyphosate	2261 abc	1969 d
Combination	2091 bcd	2220 bcd
Standard Error	122.3	
	Year × Harvest × Foliar	
Swathed – Untreated	2487 ab	2374 abc
Swathed – Pod Sealant	2659 a	2383 abc
Swathed – Glyphosate	2548 ab	2012 cdefg
Swathed - Combination	2365 abcd	2360 abcd
Straight – Untreated	2235 bcde	1730 fg
Straight – Pod Sealant	2383 abc	1684 g
Straight – Glyphosate	1974 defg	1926 efg
Straight – Combination	1817 fg	2079 cdef
Standard Error	156.7	

†Within a specific grouping (year by foliar treatment or year by harvest treatment by foliar treatment) Treatment means for individual years and averaged across years which are followed by the same letter do not differ from each other according to Fisher's protected LSD test ($P \leq 0.05$)

Averaged across both harvest treatments in 2010, the plots treated with a pod sealant yielded 440 kg ha^{-1} higher than those treated with both the pod sealant and glyphosate but were not significantly different from either the untreated or pre-harvest glyphosate treatments. In 2011, seed yields were similar regardless of foliar treatment, ranging from 1969-2220 kg ha^{-1} when averaged across the two harvest methods. The patterns observed from one year to the next were somewhat inconsistent in that the plots treated with a combination of a pod sealant and glyphosate had the lowest mean yield in 2010 and the highest in 2011, even though differences were not generally significant. When both harvest method and foliar treatment were taken into consideration, there were no significant differences amongst swathed treatments for either of the two years. With a few exceptions, swathed yields were also similar from 2010 to 2011, thus the observed effect of year was primarily attributable to the straight-combined treatments. The lack of foliar treatment effects on the swathed plots suggests that glyphosate was applied at a late enough crop stage that it did not negatively impact potential seed yield and also that the pod sealants did not provide a yield benefit for swathed canola. While it is possible that pod sealants could have a fit with swathed canola, particularly in variable fields where plants are overripe in some areas and relatively green in others, our data did not show this to be the case. Focussing on the straight-combined treatments, the effects of foliar treatment on yield were inconsistent from year-to-year. In 2010, yields were similar for the untreated check and pod sealant treatments, but significantly lower for both treatments which received pre-harvest glyphosate. This was attributed to the plants where glyphosate was applied being overripe at harvest relative to those that did not receive pre-harvest glyphosate and, therefore, pod shattering / dropping losses were likely higher. This conclusion is consistent with the results of the shattering ratings in 2010. In 2011, however, the two straight-combined treatments that received pre-harvest glyphosate tended to yield the highest and the yield of the pod sealant plus glyphosate treatment did not differ from any of the individual swathed treatments. Furthermore, the pod sealant plus glyphosate treatment yielded 395 kg ha^{-1} higher than where pod sealant was applied on its own while the latter straight-combined treatment yielded similarly to the untreated check (1684 versus 1730 kg ha^{-1}). The positive effect of glyphosate in 2011 is not entirely understood. We can speculate that additional shattering had occurred in the first week of September (after treatments 7 and 8 had been harvested) but this was not evident in the ratings. Another potential explanation is that header losses were lower for the first straight-combining date because of the damp condition of the canola plants. Recall that the straight-combined treatments that received pre-harvest glyphosate were harvested in the midst of light rain showers. Similar to 2010 and the findings of previous research (Holzapfel 2010), pod sealants did not result in any yield advantage over the untreated check for the straight-combined canola in 2011.

Finally, predetermined contrasts were used to answer several questions which were asked at the time this trial was initiated (Table 6). These comparisons take into account results from both years of the study. First, swathing resulted in higher yields and profits than straight-combining, both when averaged across all foliar treatments ($P < 0.001$) and when only the untreated plots were considered (P =0.002-0.009). Pod sealants never resulted in a yield or profit advantage over the untreated plots, either when both harvest methods were considered (P = 0.473-0.993) or when the focus was exclusively on straight-combined canola (P = 0.713-0.893). Similarly, glyphosate did not effect yield or profit either across harvest methods (0.354-0.186) or for the straight-combined treatments (P = 0.814-0.602); however, there were glyphosate effects when data from the individual years were evaluated. Finally, the combination of glyphosate and a pod sealant was not advantageous for either seed yield or marginal profits when compared with the untreated plots across harvest methods (0.604-0.154) or solely for the straight-combined treatments (P = 0.803-0.373). Similarly, there were no advantages or disadvantages to using a combination of a pod sealant and glyphosate over applying a pod sealant by itself for either yield or profit (P = 0.219-0.156).

Table 6. Predetermined contrast comparison for selected treatment effects on seed yield in field-scale canola harvest management study at Indian Head, Saskatchewan.

	Contrast Comparisons[†]	
Contrast Description	Seed Yield	Marginal Profits
	-------------------- *p*-values --------------------	
Swathed versus Straight-cut (all foliar treatments)	<0.001	<0.001
Swathed versus Straight-cut (untreated only)	0.002	0.009
Pod sealant versus Untreated (all harvest methods)	0.473	0.993
Glyphosate versus Untreated (all harvest methods)	0.354	0.186
Combination versus Untreated (all harvest methods)	0.604	0.154
Combination versus Pod sealant (all harvest methods)	0.219	0.156
Pod sealant versus Untreated (straight-cut only)	0.713	0.893
Glyphosate versus Untreated (straight-cut only)	0.814	0.602
Combination versus Untreated (straight-cut only)	0.803	0.373

Summary and Conclusions:

Overall, these results affirm that straight-combining canola can potentially result in substantial yield losses relative to swathing, especially when harvest is postponed past the optimal crop stage and a variety that is relatively susceptible to shattering is used. While the visual shattering ratings provided some evidence that pod sealants can reduce the risk of shattering in straight-combined canola, this was never confirmed with significant increases in either seed yield or marginal profits. This is consistent with our previous findings (Holzapfel 2010). As for the glyphosate, while we did observe more shattering and a tendency for lower yields when pre-harvest glyphosate was applied in 2010, this was attributed more to the year and specific environmental conditions encountered rather than to a negative effect of the glyphosate per se. When harvest operations were timed more closely with the actual maturity of the canola in 2011, the treatments that received pre-harvest glyphosate actually tended to have higher yields than those which had not. While we would not necessarily expect a yield effect of pre-harvest glyphosate when straight-combining canola, glyphosate can accelerate and even out maturity in addition to providing weed control benefits to the next crop. Had the plots in 2010 been harvested as soon as they were physiologically ready, the observed increase in shattering and reduction in yield with glyphosate would not have been expected. An important factor to consider when using a field sprayer to apply either pod sealants or pre-harvest glyphosate to canola fields which will be straight-combined is the effect of wheel tracks on seed yield. While wheel tracks were not a factor in the current study, driving over the crop at this late stage will cause irreversible damage and could reduce yields by 2-5%, depending on boom width, tire width and whether or not crop dividers are equipped. It should also be noted that we may have had improved success with straight-combining if a variety with better shattering resistance had been used. The variety grown in this study was specifically chosen because previous research showed it to be relatively susceptible to shattering, thus using this variety should have improved our ability to detect any potential benefits of the pod sealant or other foliar treatments. Header types are another factor that growers interested in straight-combining should consider. A draper header was used in this study and this type of header has been shown to perform slightly better than a rigid type header but not nearly as well as an extended header (ie: BISO) where the cutter bar is moved 45-65 cm forward relative to more conventional types (Bryan Nybo, personal communication). The major factors that canola growers who are serious about straight-combining should consider are header types, choosing cultivars which are relatively resistant to shattering, using sufficiently high seeding rates to ensure a uniform, early maturing stand and controlling disease and weed pressure.

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Appendices:

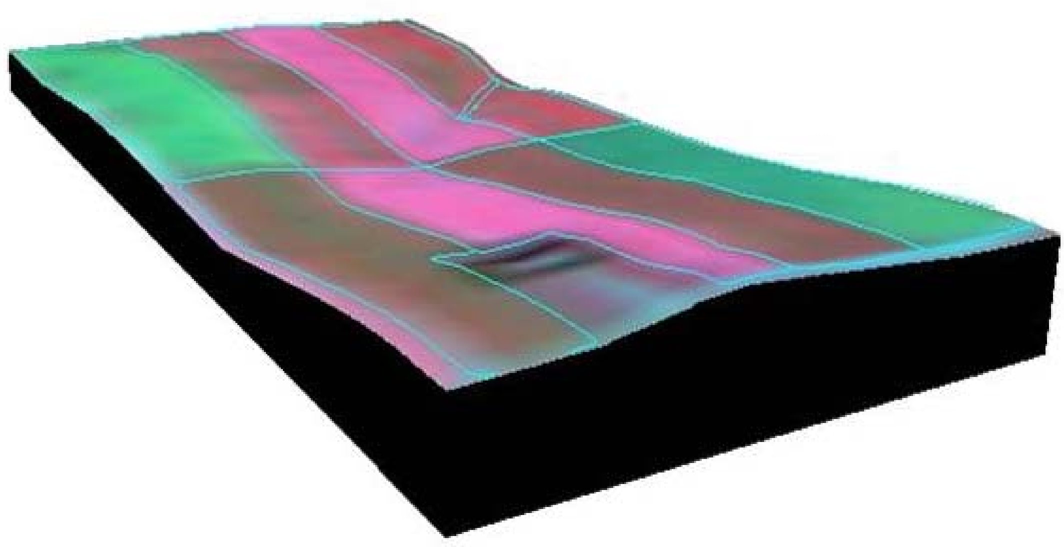

Figure A-1. Digital Elevation Model (DEM) for the IHARF Precision Farm. The difference in elevation between the lowest and highest location within the farm is approximately 11 m.

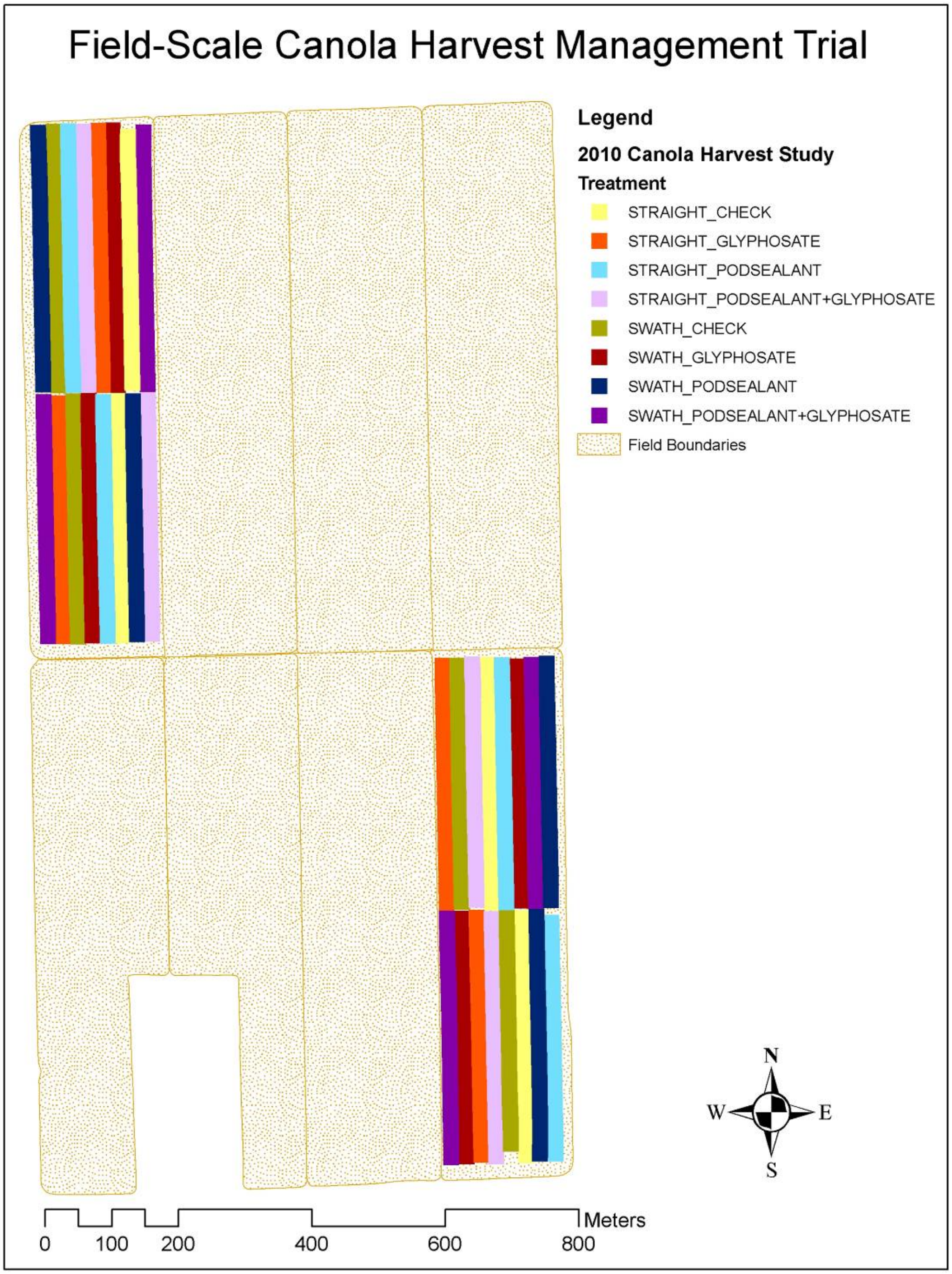

Figure A-2. Plot arrangement and treatment field plan for 2010 SaskCanola canola harvest management study at Indian Head. Data were logged during preharvest treatment applications.

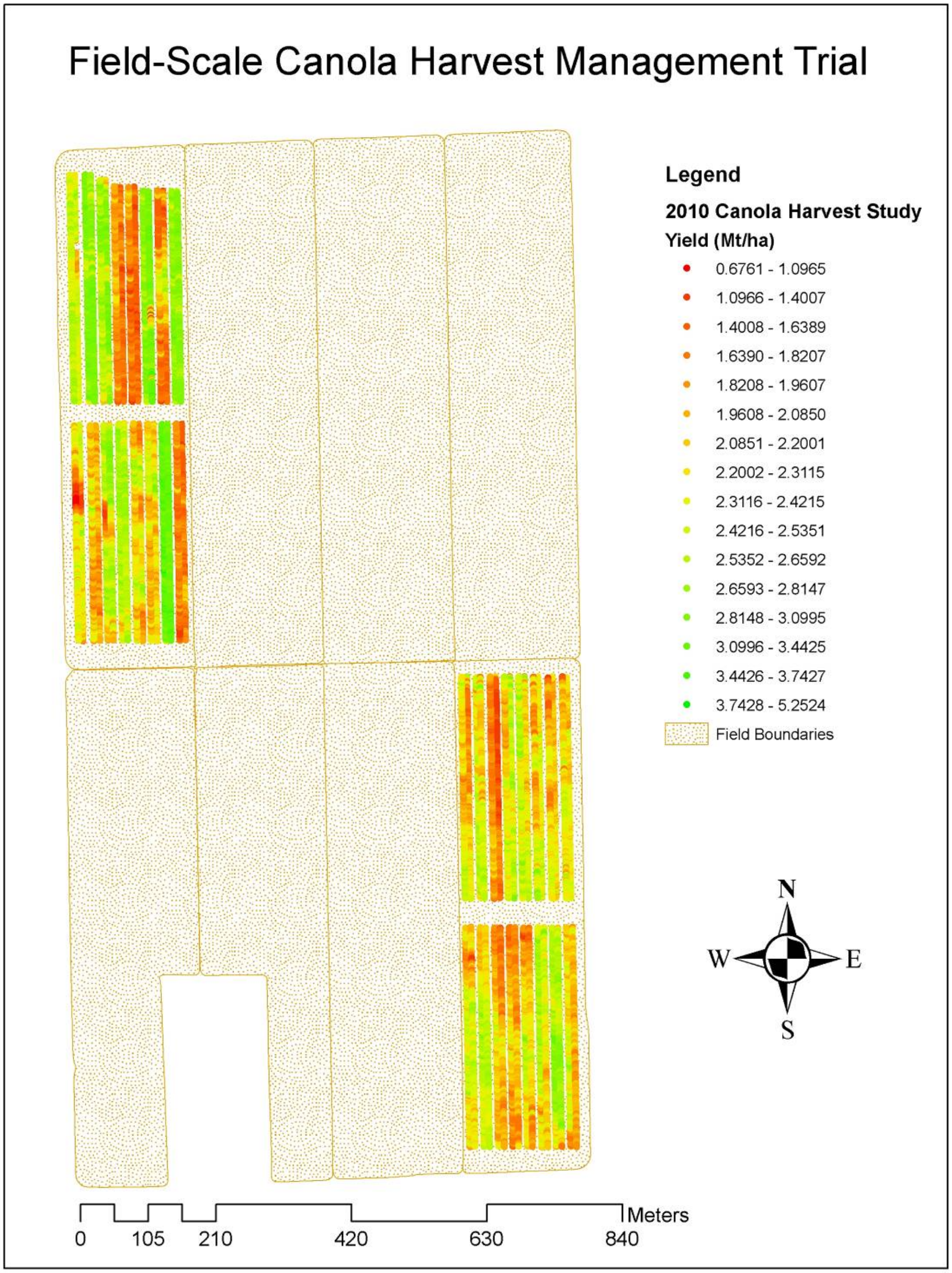

Figure A-3. Final yield map for 2010 SaskCanola canola harvest management study at Indian Head, Saskatchewan. Yield data were collected using a New Holland yield monitoring system and are moisture corrected to 10% seed moisture content.

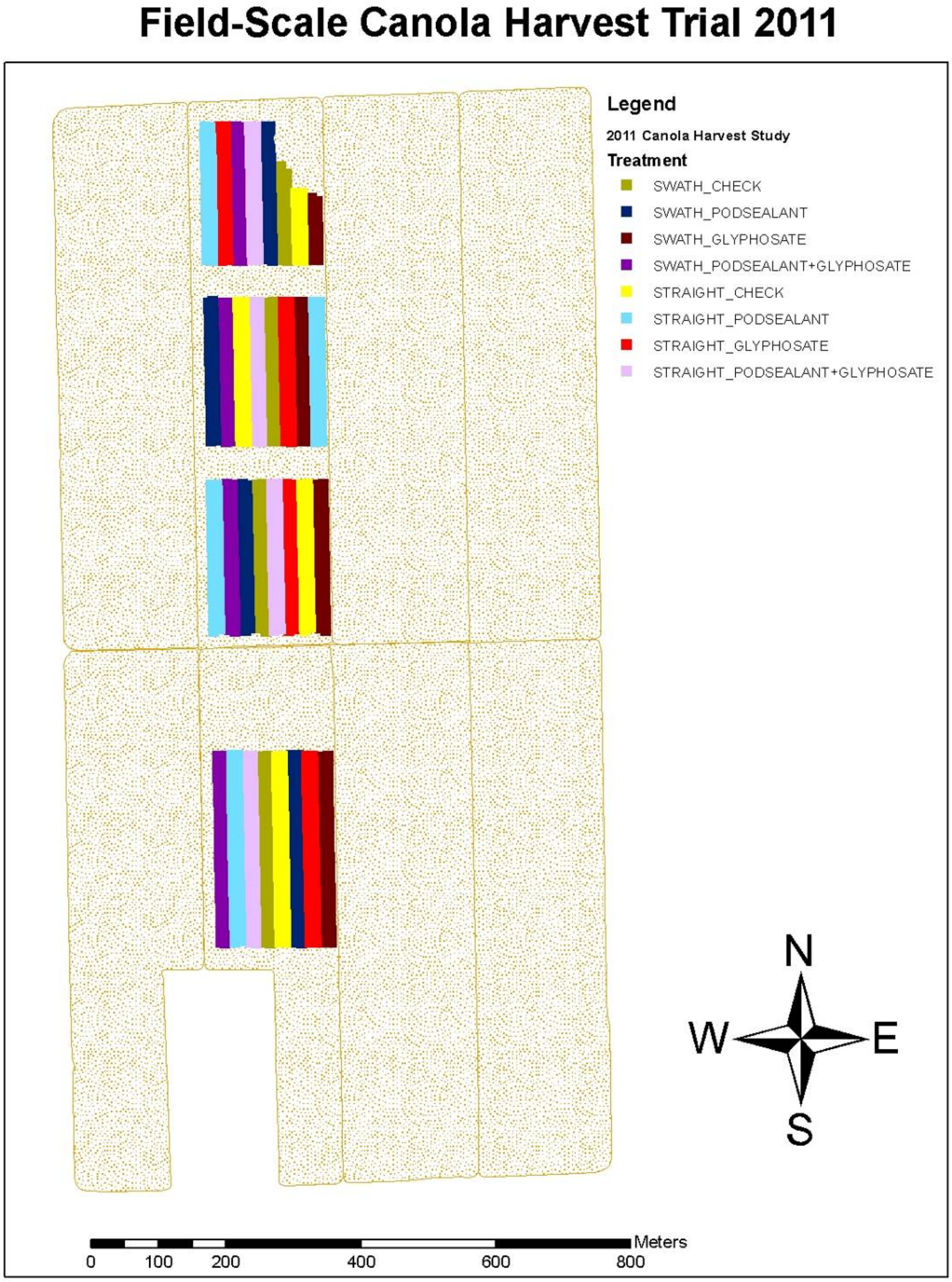

Figure A-4. Plot arrangement and treatment field plan for 2011 SaskCanola canola harvest management study at Indian Head. Data were logged during preharvest treatment applications.

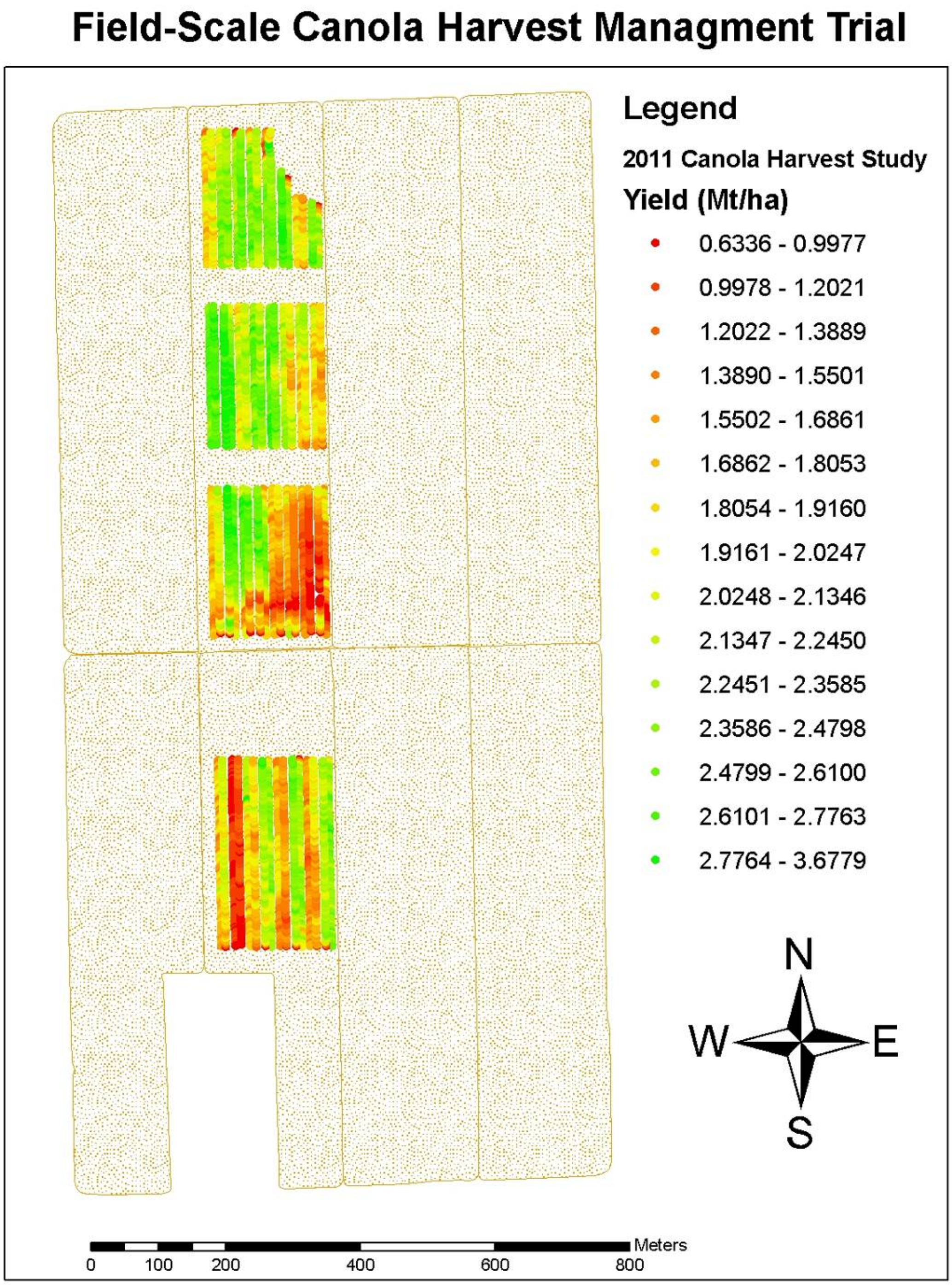

Figure A-5. Final yield map for 2011 SaskCanola canola harvest management study at Indian Head, Saskatchewan. Yield data were collected using a New Holland yield monitoring system and are moisture corrected to 10% seed moisture content.

Table A-1. Descriptive statistics for yield map data within each plot for 2010 field trial. Data were produced using the Means procedure of SAS 9.2.

Plot #	Rep #	Harvest Method	Preharvest Treatment	Entry #	N	Min	Max	Mean	Standard Deviation
						---------------------- kg ha^{-1} ----------------------			
1	1	Swathed	Combo	4	438	1147	2875	2303	251
2	1	Swathed	Glyphosate	3	412	1945	2873	2434	196
3	1	Straight	Glyphosate	7	416	1501	2669	2037	224
4	1	Straight	Combo	8	428	1538	2561	1989	196
5	1	Swathed	Check	1	422	1172	2882	2181	277
6	1	Straight	Check	5	474	1781	3067	2435	236
7	1	Swathed	Pod sealant	2	437	1716	3392	2648	220
8	1	Straight	Pod sealant	6	446	1685	2839	2172	221
9	2	Straight	Glyphosate	7	504	1509	2776	2128	263
10	2	Swathed	Check	1	428	1755	3013	2388	224
11	2	Straight	Combo	8	474	1105	2275	1703	275
12	2	Straight	Check	5	459	1756	2947	2392	223
13	2	Straight	Pod sealant	6	452	1652	2932	2407	201
14	2	Swathed	Glyphosate	3	453	1469	3023	2280	249
15	2	Swathed	Combo	4	418	1152	2672	2147	221
16	2	Swathed	Pod sealant	2	424	1290	2735	2257	195
17	3	Swathed	Combo	4	453	871	3032	2193	380
18	3	Straight	Glyphosate	7	464	1545	2849	2061	194
19	3	Swathed	Check	1	444	1235	3148	2473	366
20	3	Swathed	Glyphosate	3	434	1914	3032	2604	163
21	3	Straight	Pod sealant	6	444	1580	2951	2227	281
22	3	Straight	Check	5	476	1799	3042	2209	217
23	3	Swathed	Pod sealant	2	471	2460	3754	3258	188
24	3	Straight	Combo	8	481	1134	2368	1759	194
25	4	Swathed	Pod sealant	2	449	1836	2910	2474	174
26	4	Swathed	Check	1	475	2214	3395	2904	192
27	4	Straight	Pod sealant	6	486	1988	3316	2727	258
28	4	Straight	Combo	8	489	1318	2355	1815	200
29	4	Straight	Glyphosate	7	475	1188	2376	1668	205
30	4	Swathed	Glyphosate	3	467	1163	3711	2872	304
31	4	Straight	Check	5	493	1173	2903	1903	346
32	4	Swathed	Combo	4	481	2201	3458	2818	156

Table A-2. Descriptive statistics for yield map data within each plot for 2011 field trial. Data were produced using the Means procedure of SAS 9.2.

Plot #	Rep #	Harvest Method	Preharvest Treatment	Entry #	N	Min	Max	Mean	Standard Deviation
						---------------------- kg ha^{-1}			----------------------
1	1	Swathed	Combo	4	258	719	2357	1881	226
2	1	Straight	Pod sealant	6	317	679	1449	1076	150
3	1	Straight	Combo	8	353	1228	3121	1909	234
4	1	Swathed	Check	1	252	866	2805	2265	210
5	1	Straight	Check	5	300	946	2162	1664	198
6	1	Swathed	Pod sealant	2	258	824	2672	2301	238
7	1	Straight	Glyphosate	7	345	1072	2264	1685	209
8	1	Swathed	Glyphosate	3	256	689	2870	2305	216
9	2	Straight	Pod sealant	6	239	923	2375	1864	206
10	2	Swathed	Combo	4	195	870	3012	2441	358
11	2	Swathed	Pod sealant	2	191	652	2899	2293	471
12	2	Swathed	Check	1	191	731	2913	2153	463
13	2	Straight	Combo	8	246	701	2078	1596	275
14	2	Straight	Glyphosate	7	241	659	2250	1570	295
15	2	Straight	Check	5	233	715	1935	1221	233
16	2	Swathed	Glyphosate	3	188	634	2190	1461	376
17	3	Swathed	Pod sealant	2	185	2202	2857	2619	128
18	3	Swathed	Combo	4	184	1926	3118	2724	221
19	3	Straight	Check	5	222	1740	2546	2131	160
20	3	Straight	Combo	8	255	1963	2811	2447	183
21	3	Swathed	Check	1	180	1839	2988	2556	209
22	3	Straight	Glyphosate	7	246	1526	2584	2092	216
23	3	Swathed	Glyphosate	3	183	1425	2379	1979	209
24	3	Straight	Pod sealant	6	229	1229	2263	1859	175
25	4	Straight	Pod sealant	6	233	1242	2428	1937	198
26	4	Straight	Glyphosate	7	227	1806	2807	2356	179
27	4	Swathed	Combo	4	175	870	2792	2395	285
28	4	Straight	Combo	8	241	1409	3018	2363	236
29	4	Swathed	Pod sealant	2	175	1087	3678	2317	403
30	4	Swathed	Check	1	120	714	3014	2522	353
31	4	Straight	Check	5	112	1491	2223	1904	148
32	4	Swathed	Glyphosate	3	81	843	2786	2303	347

Table A-3. Daily, air temperature, precipitation and wind data for the six weeks leading up to harvest for a field-scale harvest management study completed at Indian Head in 2010. Data were logged at the Environment Canada weather station at Indian Head and accessed through the AAFC-AAC Real Time Weather Network (Environment Canada 2012).

	Max Air Temp	Min Air Temp	Mean Air Temp	Precip.	Peak Gust Speed	Peak Gust Direction
	------------------------- (ºC) --------------------------			(mm)	(km/h)	(degrees)
17-Aug	15.9	5.7	10.8	0.2	46.1	5
18-Aug	16.8	4.0	10.4	0.2	16.2	166
19-Aug	25.9	7.8	16.9	0	46.8	180
20-Aug	23.6	13.2	18.4	0	35.6	186
21-Aug	27.2	4.6	15.9	0	60.1	159
22-Aug	25.0	16.8	20.9	30.4	37.1	196
23-Aug	16.3	13.0	14.6	5	60.1	283
24-Aug	19.5	10.1	14.8	0	59.4	324
25-Aug	23.0	3.9	13.4	0	28.8	174
26-Aug	30.5	11.0	20.8	0	32.4	192
27-Aug	24.1	15.7	19.9	0	52.6	188
28-Aug	24.6	6.5	15.6	0.4	37.8	197
29-Aug	12.1	10.2	11.1	0.6	31.3	32
30-Aug	14.0	6.5	10.3	15.6	42.8	33
31-Aug	17.2	9.8	13.5	1	36.7	307
01-Sep	20.9	7.8	14.4	0	33.1	205
02-Sep	18.3	8.3	13.3	0.2	53.3	322
03-Sep	21.1	3.0	12.1	0	30.2	342
04-Sep	24.4	3.9	14.1	2.0	46.4	139
05-Sep	18.4	12.1	15.3	19.0	40.7	116
06-Sep	11.2	9.8	10.5	11.8	46.8	135
07-Sep	18.0	8.5	13.3	0	29.5	285
08-Sep	18.4	3.9	11.1	0	41.4	101
09-Sep	14.1	9.4	11.8	7.8	47.5	114
10-Sep	13.1	10.8	12.0	1.0	63.0	277
11-Sep	17.7	7.1	12.4	0	63.0	313
12-Sep	18.6	4.7	11.6	0	52.2	279
13-Sep	13.2	3.8	8.5	0	23.4	33
14-Sep	13.4	5.2	9.3	5.6	20.5	135
15-Sep	11.4	7.0	9.2	2.4	19.1	94
16-Sep	11.3	5.4	8.4	3.8	42.8	310
17-Sep	8.4	-0.8	3.8	0	49.7	317
18-Sep	12.8	-2.9	4.9	0	27.0	293
19-Sep	12.8	-2.2	5.3	0	43.6	135
20-Sep	10.6	7.7	9.1	11.0	42.5	309
21-Sep	9.1	5.4	7.3	0.2	42.8	309
22-Sep	7.8	1.5	4.7	0	25.6	111
23-Sep	11.5	4.8	8.1	0.2	27.4	142
24-Sep	19.1	1.9	10.5	0	40.0	168
25-Sep	21.7	0.2	11.0	0	44.3	192
26-Sep	29.5	11.3	20.4	0	43.2	263
27-Sep	21.5	8.3	14.9	0	36.7	345
28-Sep	26.7	8.4	17.5	0	49.3	193

Table A-4. Daily, air temperature, precipitation and wind data for the six weeks leading up to harvest for a field-scale harvest management study completed at Indian Head in 2011. Data were logged at the Environment Canada weather station at Indian Head and accessed through the AAFC-AAC Real Time Weather Network (Environment Canada 2012).

	Max Air Temp	Min Air Temp	Mean Air Temp	Precip.	Peak Gust Speed	Peak Gust Direction
	------------------------- (ºC)	-------------------------		(mm)	(km/h)	(degrees)
30-Jul	22.6	11.3	17	15.2	115	28
31-Jul	29.6	8.9	19.3	0	48	18
01-Aug	28	14.9	21.5	0	37	34
02-Aug	25	8.5	16.8	0	<31	–
03-Aug	26.5	12.6	19.6	0	32	32
04-Aug	24	10.7	17.4	0	<31	–
05-Aug	24.7	7.7	16.2	0	<31	–
06-Aug	23.7	8.4	16.1	2.3	44	20
07-Aug	25.3	10.2	17.8	9.6	44	32
08-Aug	20	10	15	0.5	54	33
09-Aug	24.2	8.4	16.3	0	<31	–
10-Aug	26.4	10.9	18.7	0	<31	–
11-Aug	26.5	10.9	18.7	0	43	1
12-Aug	20	9.8	14.9	0	<31	–
13-Aug	24.7	7	15.9	0	<31	–
14-Aug	30.1	14.8	22.5	0	48	18
15-Aug	26.9	14.2	20.6	0	32	27
16-Aug	20.5	9.1	14.8	8.9	59	30
17-Aug	25.1	7.6	16.4	0	<31	–
18-Aug	21.5	8.3	14.9	0	54	34
19-Aug	20.6	5.9	13.3	0.8	54	33
20-Aug	21.3	5.9	13.6	0	39	32
21-Aug	29.1	8.6	18.9	0	35	21
22-Aug	33.3	12.4	22.9	0	35	27
23-Aug	30.2	12.1	21.2	0	63	32
24-Aug	25.9	9.2	17.6	0	32	31
25-Aug	30.5	11.5	21	0	52	19
26-Aug	22.8	6.5	14.7	0	32	30
27-Aug	26.6	11.2	18.9	0	<31	–
28-Aug	28.9	7.5	18.2	0	35	34
29-Aug	27.5	9.1	18.3	1.2	50	18
30-Aug	28.2	16.7	22.5	0	44	18
31-Aug	21.1	12.2	16.7	20.9	56	34
01-Sep	17.9	9.3	13.6	0.9	44	5
02-Sep	21.1	6.8	14	0.4	63	24
03-Sep	17.3	3.7	10.5	0.7	46	33
04-Sep	21.2	0.9	11.1	0	35	20
05-Sep	26.8	8.7	17.8	0	37	20
06-Sep	28.6	5.8	17.2	0	<31	–
07-Sep	30.2	7.1	18.7	0	<31	–
08-Sep	29.4	11.3	20.4	0	<31	–
09-Sep	30	6.9	18.5	0	<31	–
10-Sep	31.2	10.8	21	0	33	27