Management of foliar disease in lentils on the upper Eyre Peninsula

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Location
Mount Cooper - Angus Gunn
Rainfall
Av. Annual: 421 mm
Av. GSR: 332 mm
2023 Total: 394 mm
2023 GSR: 292 mm
Soil type
Red clay loam
Paddock history
2023: Wheat
2022: Lentil
2021: Barley
Plot size
10 m x 1.76 m
Trial design
Fungicide trial: Randomised complete block design
Variety trial: Split plot design

Location
Mount Damper - AJ Michael
Rainfall
Av. Annual: 317 mm
Av. GSR: 206 mm
2023 Total: 216 mm
2023 GSR: 135 mm
Soil type
Calcareous sandy loam over calcrete
Paddock history
2023: Wheat
2022: Lentil
2021: Wheat
Plot size
12 m x 1.76 m
Trial design
Fungicide trial: Randomised complete block design
Variety trial: Split plot design

Key messages

- **Conditions in the 2023 growing season were not conducive for lentil foliar fungal diseases Ascochyta blight (AB) or Botrytis grey mould (BGM).**
- **Fungicide sprays were not needed in a decile 1-2 rainfall season for maximum gross margin in lentils on upper Eyre Peninsula (UEP) when there was low disease pressure.**
- **No lentil varieties consistently out-performed others in terms of yield or quality.**
- **Foliar disease level in lentil did not influence grain grades at delivery in a below average rainfall year (2023).**

Why do the trial?

The upper Eyre Peninsula (UEP) has been gradually incorporating more lentils into the farming system for both agronomic and economic benefits as a legume break crop. The UEP farming system is characterised by its warm, low rainfall climate with short, mild winters. Therefore, determining which existing lentil variety performs best under those conditions while being resistant to major pulse diseases, such as Botrytis grey mould (BGM) and Ascochyta blight (AB), is important in the UEP farming system. Due to the water-limiting environment, BGM and AB are less likely to impact yield in comparison to other higher rainfall regions but can still cause major financial loss if managed ineffectively, especially in a wet season like 2022.

Effective disease management requires implementing integrated disease management (IDM). This includes observing 3-4 years rotations between crops of the same type in the same paddock, sowing clean seed, and choosing disease resistant varieties that are compatible with the disease risk profile, paddock history, local climate, soil type, and agronomic management. Use of foliar fungicides should follow strategies to mitigate against development of fungicide resistance, so choosing the most suitable fungicide(s) for the situation and application at the optimum time ahead of a rain front is critical. Planning a fungicide strategy early in the season will better prepare for effective control of foliar diseases and this can reduce production losses while maximising the gross margin at the end of the season.

Due to the unique climate of the UEP and lentils being a relatively new crop in the system, more information is needed to determine if one fungicide spray is sufficient to provide disease control in most seasons or whether multiple fungicide sprays provide any additional benefit.

A number of current GRDC investments aim to develop economic frameworks around decision making for disease management in pulses across mid and high rainfall regions in SA. However, a gap exists in this investigation for the low rainfall region of the UEP region. Hence, this project aimed to:

1. Investigate if only one fungicide spray is sufficient for controlling AB and BGM in a low rainfall region in a moderately disease resistant lentil variety (GIA Thunder IMI).
2. Determine the effectiveness of various fungicide strategies in only one spray application.
3. Determine which fungicide strategies result in the highest gross margin by the end of the season.
4. Determine which lentil variety can produce the highest yield in a low rainfall region.

Location
Minnipa Agricultural Centre
Rainfall
Av. Annual: 325 mm
Av. GSR: 241 mm
2023 Total: 280 mm
2023 GSR: 169 mm
Soil type
Red loam
Paddock history
2023: Field pea
2022: Wheat
2021: Field pea
Plot size
12 m x 1.76 m
Trial design
Variety trial: Split plot design

How was it done?

This project consisted of five trials located at three trial sites, Mount Cooper (2), Mount Damper (2) and Minnipa Agricultural Centre (MAC) (1). Both Mount Cooper and Mount Damper sites had a fungicide (Table 1) and a variety trial (Table 2), whereas MAC only had a variety trial (Table 3). The trial site information is listed in Table 4. The assessments conducted at each site during growing season were plant emergence, early and late normalized difference vegetation index (NDVI), late dry matter, percent plot disease, and weather data collection. The grain was harvested and weighed using the Zurn small plot harvester. Grain quality assessments of the lentil grain harvested from two sites were compared post-harvest.

Table 1. 2023 Fungicide treatments for Mount Cooper and Mount Damper trials sown to the lentil variety GIA Thunder IMI. *Fungicides are applied at early/mid flowering at Mount Damper since canopy closure is not fully achieved.

Treatment No.	Fungicide Treatment
1	Untreated control
2	Treated control - Echo® 900WDG (Chlorothalonil) at 1 L/ha + Spin Flo (Carbendazim) at 500 mL/ha every 2 weeks. First treatment at 5 weeks after sowing
3	Veritas® Opti at 400 mL/ha at canopy closure*
4	Miravis® Star at 500 mL/ha at canopy closure
5	Aviator® Xpro® at 400 mL/ha at canopy closure
6	Echo® 900WDG at 1 L/ha + Spin Flo 500 at mL/ha at canopy closure
7	Mancozeb 750 WG at 1.5 kg/ha at canopy closure
8	Seasonal variation spray - First application: Ahead of first rain front at or after canopy closure (Echo® 900WDG at 1 L/ha + Spin Flo at 500 mL/ha). Second application: Ahead of second rain front after canopy closure, at least 14 days after first spray (Veritas® Opti at 400 mL/ha). Third application: Ahead of third rain front after canopy closure, at least 14 days after second spray (Echo® 900WDG at 1 L/ha + Spin Flo at 500 mL/ha)

Table 2. Variety trial treatment information for Mount Cooper and Mount Damper, 2023.

Whole-plot treatment (fungicide application)	Sub-plot treatment (variety)
1 Full Disease - No fungicide sprays	1 GIA Thunder IMI
	2 PBA Hallmark XT
	3 PBA Hurricane XT
	4 PBA Highland XT
	5 PBA Jumbo2
2 No Disease - Fungicide sprays every 2 weeks	1 GIA Thunder IMI
	2 PBA Hallmark XT
	3 PBA Hurricane XT
	4 PBA Highland XT
	5 PBA Jumbo2

Table 3. Variety trial treatment information for Minnipa, 2023.

Treatment	Variety
1	GIA Thunder IMI
2	PBA Hallmark XT
3	PBA Hurricane XT
4	PBA Highland XT
5	PBA Jumbo2
6	GIA Lightning IMI (coated with P-Pickel T)

Table 4. Trial site information for Minnipa, Mount Cooper and Mount Damper sites, 2023.

Site location	MAC	Mount Cooper	Mount Damper
Sowing date	8 May 2023	9 May 2023	9 May 2023
Sowing depth	60 mm	60 mm	70 mm
Fertiliser rate	MAP - 50 kg/ha	MAP - 50 kg/ha	MAP - 50 kg/ha
Inoculum	Peat in seed envelopes	Peat in seed envelopes	Peat in seed envelopes
Plant density	150 plants/m^2	150 plants/m^2	150 plants/m^2
Sowing method	Direct drilling	Direct drilling	Direct drilling
Row spacing	25.4 cm (10 inches)	25.4 cm (10 inches)	25.4 cm (10 inches)
Plot centre	2 m	2 m	2 m
Pre sowing herbicide	Glyphosate 1.5 L/ha + Hammer (50 mL/ha) + Propyzamide (700 mL/ha) + Reflex (700 mL/ha)	Glyphosate 1.5 L/ha + Hammer (50 mL/ha) + Propyzamide (700 mL/ha) + Reflex (700 mL/ha)	Glyphosate 1.2 L/ha + Hammer (30 mL/ha) + Propyzamide (600 mL/ha) + Reflex (500 mL/ha)
PSPE herbicide	Clethodim 360 330 mL/ha + Hasten 1% + Ammonium sulphate 8kg/1000L	Glyphosate 1.5 L/ha + Hammer (50 mL/ha) + Propyzamide (700 mL/ha) + Reflex (700 mL/ha)	Glyphosate 1.2 L/ha + Hammer (30 mL/ha) + Propyzamide (600 mL/ha) + Reflex (500 mL/ha)
Harvest date	16 October 2023	27 October 2023	18 October 2023

What happened?

Fungicide trials

In this low disease and low rainfall year, there were no significant difference between fungicide treatments at either Mount Damper or Mount Cooper for disease level, NDVI, grain yield or grain quality.

Disease levels, rated as percentage of the plot with AB symptoms, were very low (<8%) throughout the growing season at both trial sites (Figure 1). AB is a seed and stubble borne disease that is promoted by rain-splash in winter, whilst BGM is usually associated with mild temperatures (15-25°C) and high relative humidity (>70%) in spring. The low disease scores in both trials reflects the dry conditions in late winter and spring at the sites.

NDVI was used as a non-destructive biomass sampling method to indicate the level of biomass from each treatment. However, there was no significant difference in late NDVI values (27 September) between treatments at both sites.

Mount Damper had a higher average yield (1.59 t/ha) than Mount Cooper (1.22 t/ha) but there were no significant difference between each treatment. Due to low disease levels, only 300 grain weights were measured for quality assessment but no significant difference between treatments was observed. Lentils at Mount Damper had higher 300 grain weights on average than Mount Cooper, even though Mount Cooper had higher late NDVI values on average than Mount Damper.

Variety trials:

AB disease levels in the variety trial at both sites were also very low (Figure 2 and 3) and there was no significant difference between the Full Disease (no fungicides applied) and No Disease (fungicides applied) treatments. PBA Hallmark XT, rated MRMS to AB pathotype 2, had the highest disease scores throughout the season overall, while PBA Jumbo2, rated RMR(p) to AB pathotype 2, had the lowest disease scores, but the difference between each variety was not significant.

A positive linear correction was observed between biomass and estimated yield at Minnipa and Mount Damper (Figure 4). The Minnipa site showed the stronger biomass-yield correlation than Mount Damper. The Mount Cooper site showed no correlation.

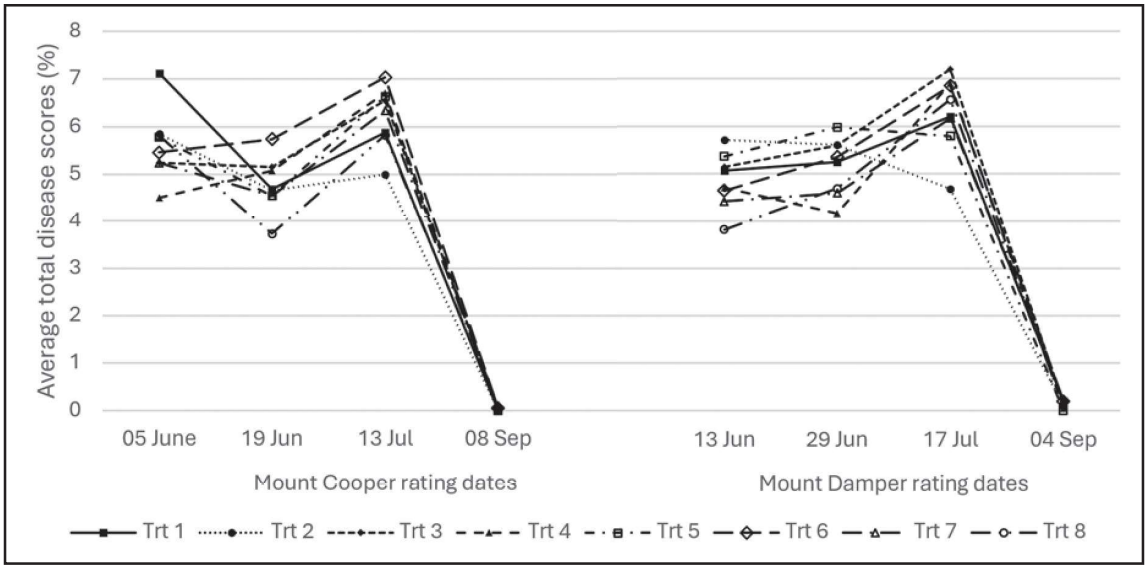

Figure 1. Average total disease scores in 2023 of the eight fungicide treatments on GIA Thunder IMI lentils rated on four occasions at Mount Cooper (5 June, 19 June, 13 July and 8 September) and Mount Damper (13 June, 29 June, 17 July and 4 September).

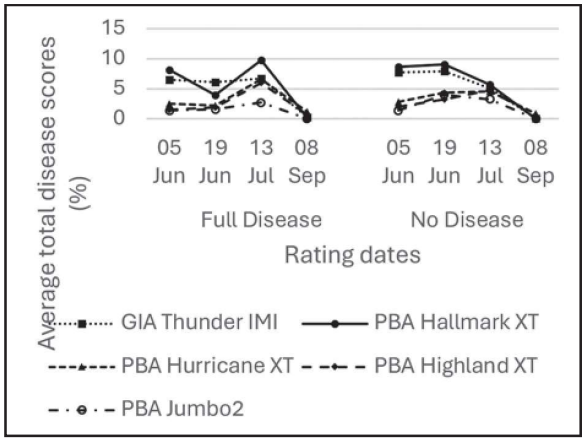

Figure 2. Average total disease scores of each of the five lentil varieties in the both the Full Disease and No Disease whole-plot treatments combined as rated on four occasions at Mount Cooper in 2023.

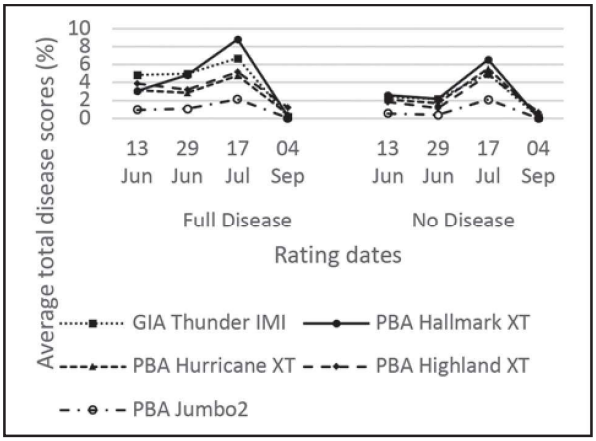

Figure 3. Average total disease scores of each of the five lentil varieties in the Full Disease and No Disease whole-plot treatments combined as rated on four occasions at Mount Damper in 2023.

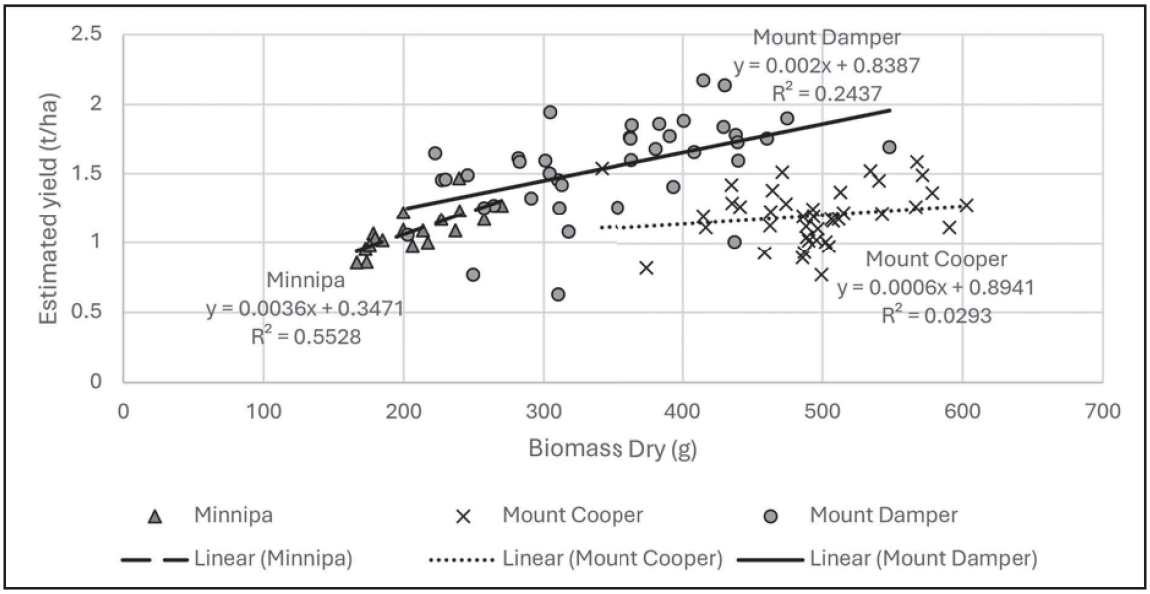

Figure 4. The relationship between biomass and estimated lentil yield at Minnipa, Mount Cooper, and Mount Damper lentil variety trials in 2023.

Trials were harvested and estimated yield calculated (Table 5). At Minnipa, GIA Thunder IMI was the highest yielding variety, and this was significantly higher than PBA Hallmark XT. At Mount Cooper, there was a significant effect of variety in the Full Disease (no fungicides applied) treatment only where PBA Highland XT recorded the highest yield, but this was statistically similar to yields for PBA Hurricane XT, GIA Thunder IMI and Jumbo2.

At Mount Damper, lentil harvestability issues were encountered during harvesting which were scored and accounted for in the statistical analysis. The harvestability issues did not appear to influence the general trend in yields after yield adjustments. No multiple comparisons were done on Mount Damper yields.

Varietal results for total defective grains varied across each site. At Minnipa, GIA Thunder IMI and GIA Lightning IMI pad the least number of total defective grains, though not statistically different from PBA Hallmark XT, PBA Hurricane XT and PBA Highland XT, whereas PBA Jumbo2 had the most total defective grains (Table 6). At Mount Cooper and Mount Damper, significant differences between varieties were detected only in the Full Disease treatment. At Mount Cooper, PBA Hallmark XT had the least total defective grains and PBA Highland XT had the most total defective grains (Table 6), while in Mount Damper, GIA Thunder had the least total defective grains, and PBA Hurricane XT, PBA Highland XT and PBA Jumbo2 had the most total defective grains. There was no significant interaction between fungicide treatment and variety.

Table 5. The estimated lentil yields (t/ha) harvested from variety trials in Minnipa, Mount Cooper and Mount Damper 2023 (*Mount Damper trial encountered harvest issues. The mean yield data displayed for Mount Damper in this table was the adjusted mean. Therefore, no multiple comparisons were done between varieties either fungicide treatment) (ns* meaning no significant difference between treatments).

Variety	Minnipa	Mount Cooper		Mount Damper* (Adjusted for harvest loss)	
		Full Disease	No Disease	Full disease	No Disease
GIA Thunder IMI	1.25 a	1.18 ab	1.24	1.87	1.15
PBA Hallmark XT	1.05 b	0.96 b	1.13	1.75	1.27
PBA Hurricane XT	1.11 ab	1.22 ab	1.42	1.76	1.59
PBA Highland XT	1.07 ab	1.27 a	1.27	1.84	1.36
PBA Jumbo2	1.04 ab	1.05 ab	1.30	1.63	1.49
GIA Lightning IMI	1.06 ab	N/A		N/A	
F prob (Variety)	*<0.05*	*<0.05*	*ns*	*ns*	*ns*
LSD (Variety) (F Prob=>0.05)	*0.28*	*0.20*	*ns*	*0.2*	*ns*
*F prob (Fungicide*Variety)*	*N/A*	*ns**		*ns*	

Table 6. The mean weight of total defective grains (g) (defective + poor colour) of lentils harvested from variety trials at Minnipa, Mount Damper and Mount Cooper in 2023.

Variety	Minnipa	Mount Cooper		Mount Damper	
		Full Disease	No Disease	Full Disease	No Disease
GIA Thunder IMI	4.46 b	3.52 ab	3.478	2.26 b	2.09
PBA Hallmark XT	6.11 ab	3.38 b	3.670	2.65 ab	2.54
PBA Hurricane XT	7.35 ab	4.39 ab	4.275	3.25 a	3.34
PBA Highland XT	6.62 ab	4.56 a	4.293	3.07 a	3.13
PBA Jumbo2	7.59 a	3.64 ab	4.290	3.09 a	3.11
GIA Lightning IMI	4.48 b	N/A		N/A	
F prob (Variety)	*<0.05*	*<0.05*	*ns*	*<0.05*	*ns*
LSD (Variety) (F prob=>0.05)	*1.96*	*0.78*	*ns*	*0.45*	*ns*
*F prob (Fungicide*Variety)*	*N/A*	*ns*		*ns*	

What does this mean?

Fungicide trials

Fungicide applications for control of lentil foliar disease were unnecessary on the UEP in 2023. The fungal foliar diseases, AB and BGM of lentils, were at very low levels likely due in part to the decile 1-2 growing season rainfall in that region. These diseases require sufficient moisture either as frequent rainfall or high humidity present in the crop as dew, fog, or high soil moisture. The retail prices (Table 7) and the cost of implementing each treatment (Table 8) suggest that UEP growers who did not put out a fungicide would have saved between $13-56 /ha. Thus, in this one-year study, it suggests that on the UEP there was no benefit from applying foliar fungicides in a below average rainfall season and in a below average disease year.

Variety trials

Aiming to maximise crop biomass to suit rainfall levels to achieve high yield is important. A positive, linear correlation between biomass and final yield (Figure 4) was revealed across low (Minnipa) and medium (Mount Damper) rainfall areas on the UEP but not higher rainfall areas (Mount Cooper).

No fungicide application was necessary at Minnipa (Decile 2-3 rainfall), Mount Cooper (Decile 5 rainfall) or Mount Damper (Decile 2-3 rainfall) in the 2023 season with the disease pressure present at these sites, and varietal differences was dependent on the site. Therefore, in a below average rainfall year like 2023, no fungicide application was required on UEP regardless of the lentil variety grown in this one-year study with little disease pressure.

The yield and quality of all varieties varied across different sites. In a season like 2023, poor colour would not play a significant role in lentil grades determination due to a lack of diseases to stain the seeds during podding. Most of the poor colour grains found in this year's trial was most likely due to the heat and drought stress crops experienced during podding.

Table 9 demonstrated the average possibility of grades for each variety tested in the trials in 2023 at Minnipa, Mount Cooper and Mount Damper. At Minnipa, GIA Lightning IMI and GIA Thunder IMI were more likely to receive NIPT1 grade with a probability of 66% and 33% respectively, with relatively low deduction if they had received NIPTB grade. At Mount Cooper, GIA Thunder IMI (87.5%) and PBA Hallmark (75%) were more likely to receive NIPT1 grade. At Mount Damper, PBA Hurricane and PBA Jumbo2 were less likely to receive top grade than other varieties. However, due to the minimal foliar disease levels observed, it is not possible to make conclusive claims about grain grades, thus more research is required to investigate the profitability of lentil varieties on the UEP.

Table 7. The retail price ($/kg or L) of each fungicide product used in 2023.

Fungicide product	Retail price ($/kg or L)
Mancozeb	$8.75
Carbendazim (Spin Flo®)	$11.50
Chlorothalonil (Echo® 900 WDG)	$14.00
Veritas® Opti	$42.00
Miravis® Star	$68.15
Aviator® Xpro®	$59.70

Table 8. The cost per hectare of each fungicide treatment in the 2023 season (machinery and labour costs excluded).

Treatment	Description	Cost/ha ($)
1	Untreated control	0
2	Treated control (Chlorothalonil 1 L/ha + Carbendazim 500 mL/ha every 2 weeks)	119
3	Veritas Opti 400 mL/ha before canopy closure	17
4	Miravis Star 500 mL/ha before canopy closure	34
5	Aviator Xpro 400mL/ha before canopy closure	24
6	Chlorothalonil 1 L/ha + Carbendazim 500 mL/ha before canopy closure	20
7	Mancozeb 1.5 kg/ha before canopy closure	13
8	Seasonal variation spray	56

*Table 9. The probability of each lentil variety harvested from the Minnipa, Mount Cooper and Mount Damper in 2023 entering each grade and their average deduction per tonne if they make it into NIPTB grade (*There is no deduction for PBA Jumbo2 as it would be rejected).*

	Minnipa				Mount Cooper				Mount Damper			
Variety	NIPT1 /LR1 (%)	NIPTA /LRA (%)	NIPTB /Reject (%)	NIPTB Deduction /t (%)	NIPT1 /LR1 (%)	NIPA /LRA (%)	NIPTB /Reject (%)	NIPTB Deduction /t (%)	NIPT1 /LR1 (%)	NIPA /LRA (%)	NIPTB/ Reject (%)	NIPTB Deduction /t (%)
GIA Thunder IMI	33	0	66	0.5	87.5	12.5	0	0	100	0	0	0
PBA Hallmark XT	0	0	100	1.83	75	25	0	0	100	0	0	0
PBA Hurricane XT	0	0	100	3	25	37.5	37.5	0.5	87.5	12.5	0	0
PBA Highland XT	0	0	100	2.17	0	75	25	0.25	100	0	0	0
PBA Jumbo2	0	0	100	N/A	37.5	50	12.5	N/A	87.5	0	12.5	N/A
GIA Lightning IMI	66	0	33	1.5	N/A				N/A			

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