Farming system profitability and impacts of commodity price risk

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Abstract
Choosing a cropping system strategy is a long-term decision, with unknown future yields and prices. Most analyses use average commodity prices; however, price variance affects risk and returns. To investigate price risk for the different strategies, we used experimental data from locations within the Australian northern grains region over a 4.5 year period. Then used Monte Carlo random selection from a range of historical commodity prices to generate a range of possible gross margins ($/ha) for experimental yields and costs. The inclusion of legumes and their associated price variance in cropping systems tended to increase risk and profitability. When using either recent or long-term grain prices, the profitability ranking of system strategies rarely changed. Choosing key production strategies to maximise farming system productivity outweighs responding to current commodity prices.

Keywords
Gross margins, variable costs, income, system strategies, crop rotation, rainfed cropping

Introduction
Leading farmers in the Australian northern grains regions (NGR) often achieve the yield potential of individual crops. However, the overall performance of systems is harder to measure and less frequently considered (Bell et al., 2019; Zull et al., 2020). Opportunity cropping interspersed with fallow periods to accumulate plant available water (PAW) is a key feature of rainfed cropping within the NGR. Therefore, rather than focusing on fixed crop rotations, this analysis focused on choosing key long-term system strategies to maximise profits. Commodity prices vary greatly from year-to-year and introduces risk. Therefore, growers were concerned about how prices affects strategy selection.

Methods
Data collected from a series of field-experiments was used to investigate the long-term agronomic and economic performance of different system strategies, as well as the effect of commodity price risk. Experiments commenced in 2015 at seven locations: the core site at Pampas near Toowoomba and six regional centers across Qld (Emerald, Billa Billa, Mungindi) and northern NSW (Spring Ridge, Narrabri, and Trangie). Systems with current best-commercial practices (*Baseline*) at each location were compared to alternative system strategies: *Higher nutrient supply* (budgeting for 90 percentile crop yield), *Higher legume*

Table 1. Market commodity prices (Profarmer, 2018) and range of farm gate prices including the minimum, first quartile (Q_1), expected (median), third quartile (Q_3), and maximum prices used to calculate the range of system gross margins for each crop grown across the farming systems experiments.

Crop	Port prices 10-yr median ($/t)	Farm-gate prices from 2008-2017 ($/t)† Min	Q_1	Median	Q_3	Max	Farm gate mean prices 2016-18 ($/t)†	Gap between 3-yr mean and 10-yr median prices ($/t)
Barley	**258**	177	192	**218**	254	276	**214**	**-4**
Canola	**543**	453	475	**503**	548	748	**478**	**-25**
Chickpea	**544**	367	474	**504**	679	841	**791**	**287**
Cotton#	**1267**	941	1058	**1090**	1133	1961	**1066**	**-24**
Durum	**339**	242	270	**299**	315	319	**277**	**-22**
Faba bean	**422**	254	314	**382**	433	621	**379**	**-3**
Field pea	**375**	224	265	**335**	402	422	**324**	**-11**
Maize	**321**	221	275	**281**	293	305	**285**	**4**
Mungbean	**950**	499	631	**667**	869	919	**869**	**202**
Sorghum	**261**	189	203	**221**	231	277	**215**	**-6**
Sunflower	**749**	576	637	**709**	846	1104	**865**	**156**
Wheat (APH)	**309**	218	242	**269**	283	287	**247**	**-22**

† Farm gate prices adjusted for transport, grading or bagging costs or losses. # (Lint + seed 40% turnout)

(>50% of crops), *Higher crop diversity* (decrease risks of losses to soil-borne disease and weeds), *Higher crop intensity* (plant crops with a lower PAW threshold), and *Lower crop intensity* (plant on a full soil profile). At Pampas these systems were implemented in a factorial format across systems including a mix of summer and winter crop choices, summer-dominant, and winter-dominant cropping systems.

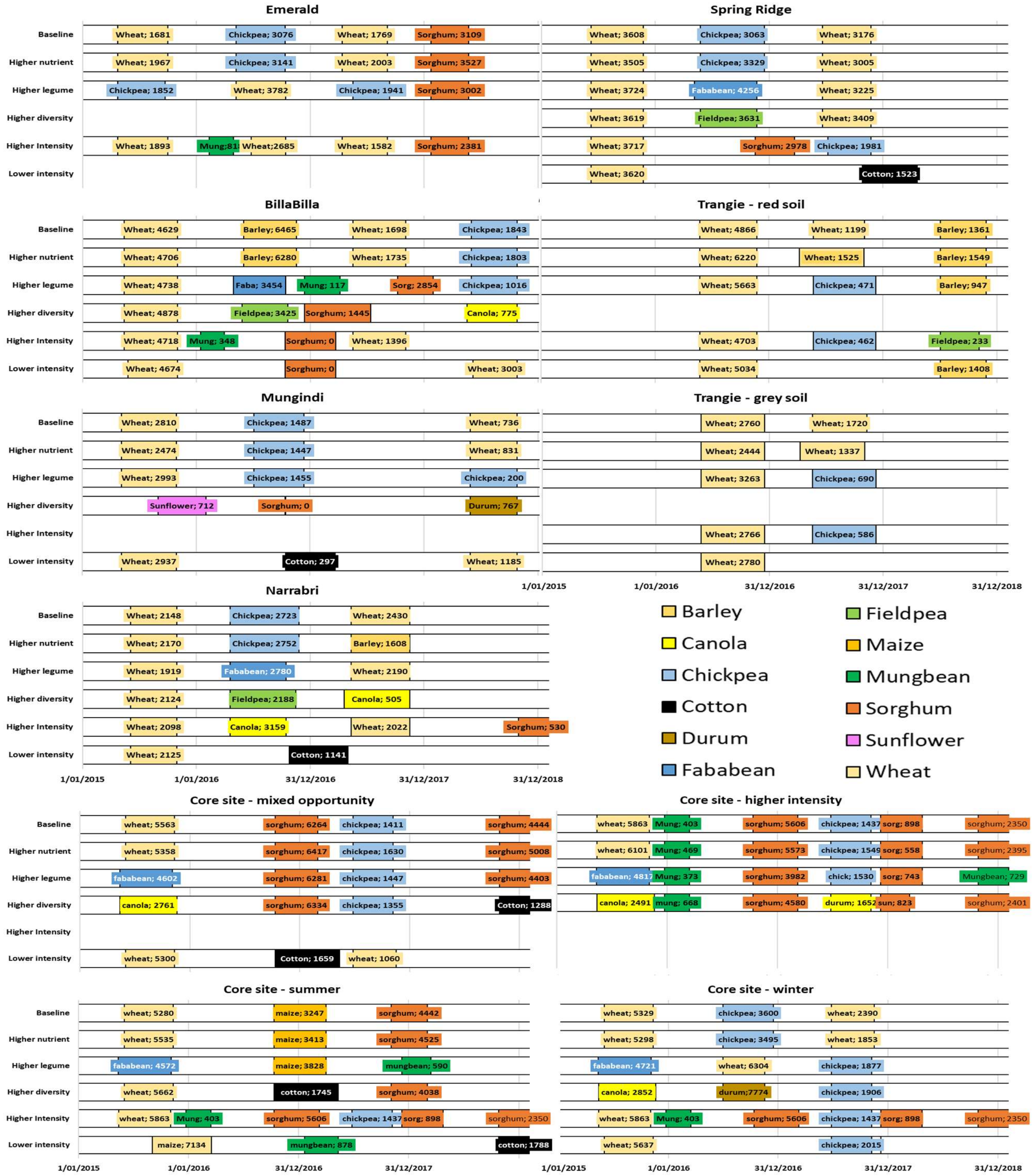

Figure 1. Crop type, growing duration and yields (kg/ha) of experimental results for each crop within each farming system strategy at seven regional sites and the core site (Pampas, Qld) from 2015 to 2018.

Data collected included crop grain yields (corrected to 12% moisture), machinery operations, and inputs of fertilisers, seed and pesticides for each cropping sequence for 4.5 years (Apr 2015 to Dec 2019; Figure 1). Farm-gate commodity prices used the median port prices over 10-years (2008 to 2017) (Profarmer, 2018) and adjusted for inflation, transportation, grading and bagging (Table 1). The same median commodity and input prices were used to calculate the accumulated income (grain yields × commodity prices) and total gross-margins (GM) for each of the cropping strategy at each location.

Monte Carlo random selection analyses was used from the range of commodity prices received over the last 10 years to generate the possible distribution of gross margins for each farming strategy over time for given experimental yields. This generated a range of possible GMs now and in the future to be estimated for the observed experimental practices and yields. We compared gross margins using the 10-year median prices and the prices received in the last 3 years (2016-2018) to see if recent commodity prices would result in changes in the relative profitability of the systems.

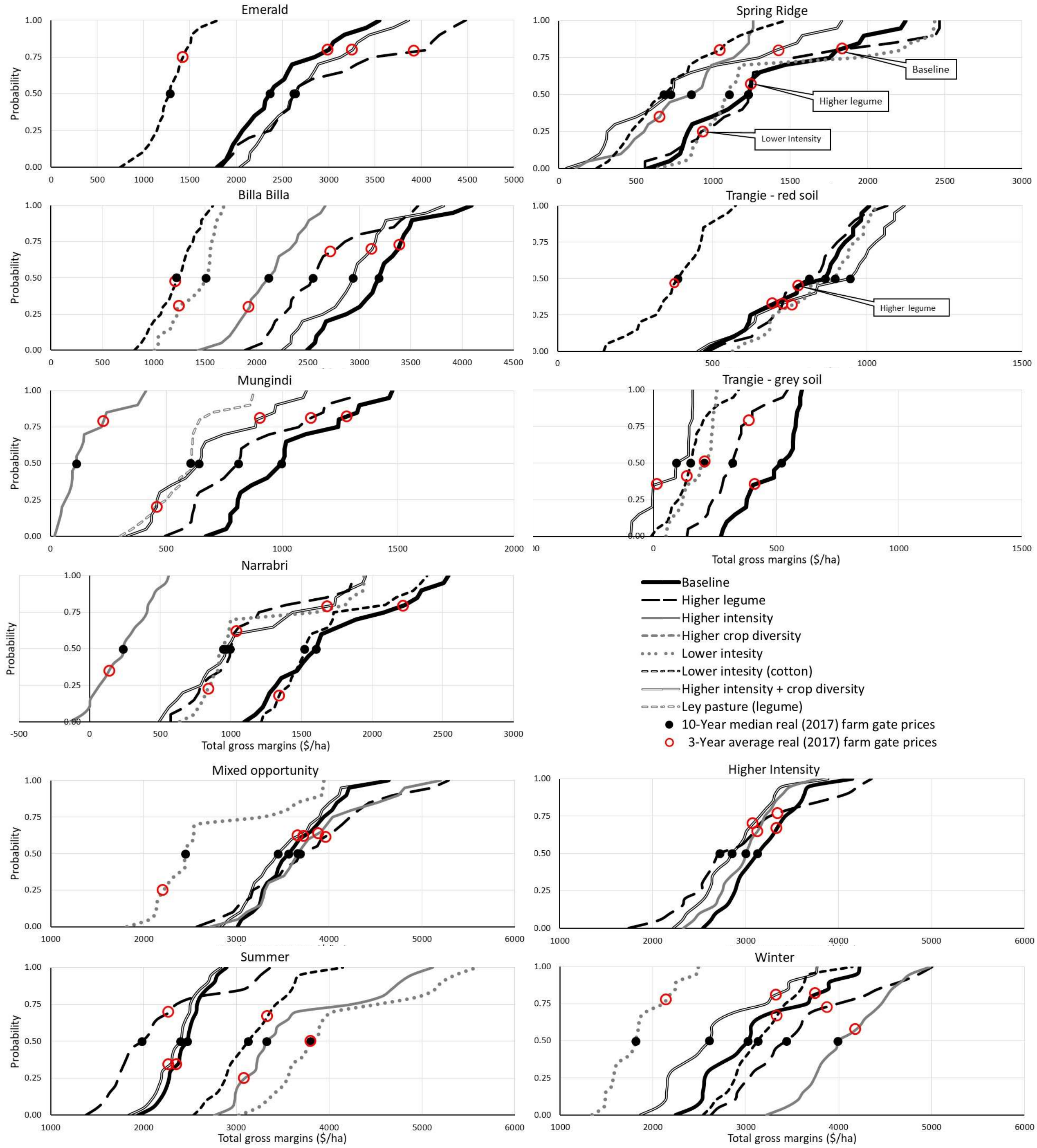

Figure 2. The possible distribution of total gross margins of systems at experimental sites, using a range of commodity prices from the last 10 years. The lowest GMs occur with the lowest grain prices (*P*=0) and the highest GMs with the highest grain prices (*P*=1). The median (*P*=0.5) total GM are shown as black dots using the 10-year median commodity prices, red circles use the 3-year average prices (2015-2017).

Results

Differences in climate and sites meant that grain production and input costs varied substantially amongst sites; hence comparisons should be amongst strategies at each site (Figure 2). For example, at Billa Billa, the *Baseline* strategy had the same number of crops as the *Higher intensity* strategy, but the latter resulted in lower yields and a failed crop (Figure 1). The *Lower intensity* strategy also had lower yields than the *Baseline* but also lower variable costs than the *Higher intensity* strategy, therefore had higher GM than the latter. A Pampas, *Higher intensity* increased median GMs by 27% in the summer-dominant system.

Compared to the *Baseline*, the *Higher nutrient supply* strategy, increased yields (Figure 1) and median total GMs at the Emerald and Trangie (red soil) sites by $274 and 82/ha, respectively (Figure 2). The *Higher legume* strategy increased the median total GMs at Emerald $255/ha; however, this increased the variable costs in most other cases – primarily from increased pesticide use. With the *Higher crop diversity*, median total GMs were lower by 30-89% ($367-1967/ha over 4.5 years or $82-437/ha/yr) than the *Baseline* system (Figure 2) at all locations, except Pampas where GM increased by ~33% ($189-215/ha/yr) for the summer and winter systems. *Higher crop intensity* did not increase total crop income at any site and GMs decreased due to increased planting and harvesting costs. *Lower crop intensity* systems incurred lower costs at 6 of the 8 trials, but also had 10-63% lower total GM than the *Baseline* system at most locations (Figure 2).

Impact of commodity price variability on system profitability

Sorghum, wheat, and maize had lower prices and price variance over the 10-years (26-40%); whereas, chickpea, mungbean, sunflower and cotton had higher price volatility (61-94%) (Table 1). This affected the possible range of total GM for each cropping system and location (Figure 2).

At Billa Billa, the *Baseline* system's median total GM was $3189/ha(Figure 2, black dots) using the 10-year median commodity price. However, total GM could be as low as $2490/ha when all commodity prices of that system are low, and as high as $4092/ha with high commodity prices. Based on the last 3-year average price, the *Baseline* median GMs at Billa Billa would have increased by 6% to $3393/ha (Figure 2, red circles). The system was more affected by the higher legume prices than the lower cereal prices.

Importantly, changing commodity prices did not change the ranking of many strategies across any sites. For example, at Billa Billa, the ranking of cropping system was consistent using both the 10-year median and the 3-year average commodity prices: *Baseline* > *Higher nutrient supply* >*Higher legume* > *Higher crop diversity* > *Lower crop intensity* > *Higher crop intensity* (Figure 2).

Conclusion

We show that by increasing crop diversity within a cropping system, commodity price risk is reduced, and GMs may increase due to higher valued crops, like chickpea, mungbean and cotton. Increasing or decreasing intensity relative to the *Baseline* system resulted in lower GMs at most sites, due to increased variable costs in *Higher crop intensity* or lower income from fewer crops and missed opportunities in *Lower crop intensity* systems. With better seasonal conditions the *Higher intensity* or *nutrient* strategy may have a higher ranking. The increased inclusion of legumes and their associated price variance in cropping systems tends to increase risk but also farm profitability. The most significant outcome was that the ranking of strategies based on total GM rarely changed when using either the 10-year median commodity price or the average price over the last 3-years (2015 to 2017). Therefore, maximising long-term farming system productivity and resilience is more important than responding to current commodity prices.

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References

Bell, L. W., Zull, A. F., Ainsthorpe, D., Lawrence, D. N., Verrell, A., Baird, J., . . . Klepper, K. (2019). Drivers of system water use efficiency in cropping systems of Australia's northern grains zone. Paper presented at the 19th Australian Agronomy Conference, Wagga Wagga, NSW.

Profarmer. (2018). Profarmer Australia: Grain commodity prices. Melbourne.

Zull, A., Bell, L., Ainsthorpe, D., Brooke, G., Verrell, A., Baird, J., . . . Lawrence, D. (2020). Farming system profitability and impacts of commodity price risk. Paper presented at the GRDC Update, Goondiwindi, Qld.