CSIRO

Grain & Graze National Feedbase Project

Improving systems using opportunistic forage cropping: a simulation analysis for lablab-wheat in the Border Rivers

AM Whitbread

18 May 2007

Grain & Graze Profit through knowledge

Australian Government Land & Water Australia

mla MEAT & LIVESTOCK AUSTRALIA

GRDC Grains Research & Development Corporation

australian wool innovation limited

Enquiries should be addressed to:

Dr Anthony Whitbread

CSIRO Sustainable Ecosystems
Private Mail Bag 2
Glen Osmond SA 5064
Anthony.Whitbread@csiro.au

Within the summer dominant rainfall zone, it has been common to fallow over summer and grow cereal grain crops during the spring and winter period. Moisture that is conserved over the summer period becomes critical for reliable cereal production over the winter months when in-crop rainfall is commonly low. Opportunity cropping is also a system that is practiced in the region that involves sowing a crop whenever soil water reserves are adequate. Several studies from Queensland have shown that opportunity cropping increases profit and reduces soil erosion. Opportunity cropping, as the name suggests, involves grain crops, but forage crops could also be sown opportunistically in mixed crop-livestock enterprises and provide high quality grazing for finishing livestock. In recent years, Singh (2007) have tested a system whereby lablab, a tropical forage legume, is grown during the summer period followed by a wheat crop in the winter. This system has been tested through on-farm and on-station field trials over several seasons and produced some promising results. While the purpose of a summer fallow is to store moisture in the soil, summer fallow rainfall efficiencies are 20% or less (D. Freebairn., pers. comm.). While the consequence of growing lablab over the summer period is the use of soil water, Singh (2007) claims that there is improved rainfall interception due to the cover provided by the lablab and overall, rainfall efficiency of the system is increased. Furthermore, Singh (2007) claim that the reduced wheat production resulting from lower stored moisture is offset by the animal production from the forage resulting in higher gross margins for a lablab-wheat rotation compared to a fallow-wheat rotation. To analyse the potential of this system in the region more widely and compare it to the standard district practice of a summer fallowing followed by wheat, models in APSIM and AUSFARM have been used to simulate the forage-wheat system over the long term at several locations within the Border Rivers and Maranoa-Balonne catchments.

Materials and Methods

A lablab-wheat rotation was simulated for the period 1950-2005. The forage and crop growth were simulated using APSIM (version 5.1) and animal production of the lablab phases were predicted using the STOCK models found within AUSFARM. Three sites representing different agro-ecosystems within the Border Rivers and Maranoa-Balonne catchments were selected for the study. These were Roma (Latitude 26.57 °S Longitude 148.79 °E; elevation = 299 masl; average annual rainfall = 591 mm), Nindigully (Latitude 28.04 °S Longitude 148.58 °E; elevation = 201 masl; average annual rainfall = 517 mm) and Warialda (Latitude 29.54 °S Longitude 150.58 °E; elevation = 320 masl; average annual rainfall = 689 mm).

APSIM was set up to simulate the growth of a grazed summer lablab forage (sowing window early summer and terminated May 1st) followed by a wheat crop. The simulation was reset to starting conditions on October 1 prior to each lablab-wheat sequence and 2 separate simulations, offset by 1 year, enable a lablab –wheat simulation to occur each year. A fallow-wheat rotation was simulated for the same period using identical management logic.

The soil is based on a brigalow soil profile with a maximum rooting depth of 90 cm and a plant available water capacity (PAWC) of 117 mm for lablab and 129 mm for wheat. At initialisation, there is 500 kg/ha of wheat straw, mineral N was initialised at 44 kg/ha (0-120 cm) and organic C is 1.2 % in the 0-15 cm layer and declining with depth. Plant available water to 90 cm is set to 0. Below this depth soil water is assumed to be at drained upper limit (DUL) but this is beyond the depth of rooting. On October 1, prior to a lablab phase, soil N and residues are reset to the starting conditions described above. This reset only occurs immediately before a lablab phase with the soil conditions following the lablab phase and during the wheat phase being simulated dynamically.

Lablab phase: Lablab can be sown at any time during a sowing window (1 Dec-15 Feb) when the soil profile >50% full, and at least 30 mm of rain is received within a 5 day period. When these conditions are met, lablab cv. Highworth is sown at 5 plants/m2 at 40 mm depth. If these conditions are not met, sowing will take place on 15 February. Lablab is grown until May 1 when it is terminated. Once lablab is established, grazing will occur if the plants reach floral initiation (stage_code 5) or there is 700 kg/ha of green leaf. Grazing is simulated with 18 month old Brahman steers (2 beasts/ha, initial weight 400kg) and ceases upon termination of the lablab phase. Approximately 11 kg of dry matter is ingested daily per animal, although the exact amount is determined by animal requirements.

Soil nitrogen and water are simulated continuously throughout each lablab-wheat phase. After termination of the lablab on May 1 above ground residues are added to the surface residue module which simulates the decomposition of standing and lying plant material. Root residues join the soil fresh organic matter (FOM) pool. The soil water and organic matter dynamics (including N mineralisation-immobilisation) continue to be simulated in the intercrop period. Wheat (cv. Hartog) can be sown at any time during a sowing window (15 May-10 July) when the soil profile >75% full, and at least 30 mm of rain is received within a 3 day period. If these conditions are not met, wheat is sown on July 10. No N fertiliser is applied and wheat is harvested when ripe. There are no tillage events throughout the simulation apart from the sowing operation.

Results

Table 1: Productivity of the lablab phase in terms of biomass production, time of grazing and live weight gain per ha and per animal.

		25^{th} percentile	Median	75^{th} percentile
Biomass (kg/ha)	Nindigully	979	2618	6026
	Roma	1483	3284	6933
	Warialda	1874	3525	7175
Grazing days	Nindigully	2	57	102
	Roma	12	67	107
	Warialda	21	73	108
Total LWG	Nindigully	1	52	84
(kg/ha)	Roma	10	57	91
	Warialda	18	63	92
LWG	Nindigully	0.07	0.82	1.09
(kg/steer/day)	Roma	0.25	0.83	1.08
	Warialda	0.48	0.88	1.08

Lablab phase. Dry matter production is calculated as the cumulative daily growth of biomass from emergence until the end of the season. Live weight gain is the total change in weight of the animals grazing the lablab pasture. Warialda was the most productive location with the highest biomass production, the greatest number of grazing days and highest animal live weight gain (Table 1). Nindigully was the least reliable and productive location with 25 % of seasons producing low lablab biomass and consequently poor liveweight gain.

Soil water stored at termination of the lablab phase. At all locations there were large differences in soil water stored at the termination of the lablab phase (May 1) compared with the stored moisture following a summer fallow (Fig. 1). Nindigully had the highest probability of a completely dry profile (i.e. no stored water above the crop lower limit of lablab) occurring almost 50 % of seasons (Fig. 1a). This occurred in 40 and 25 % of seasons at Roma (Fig. 1b) and Warialda (Fig. 1c), respectively.

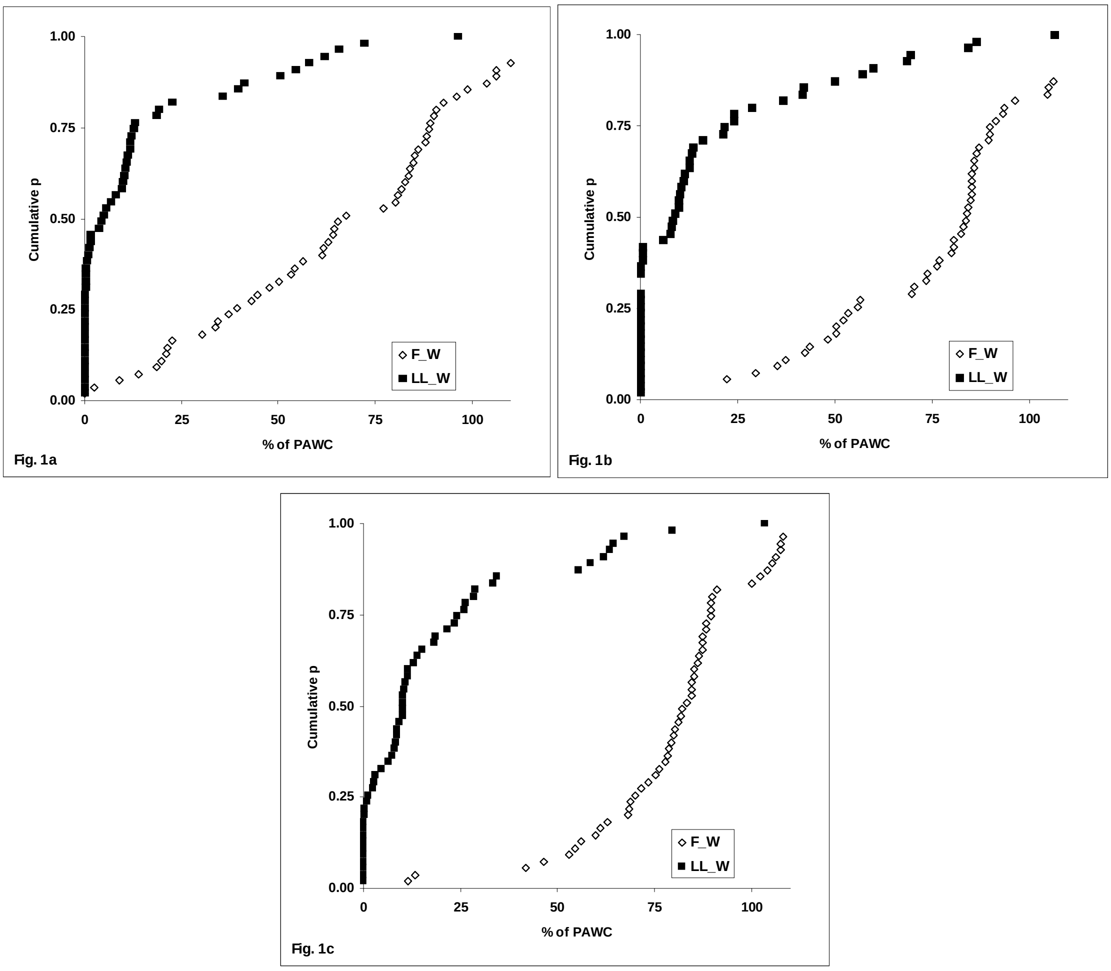

Fig. 1: Soil water content expressed as % of the PAWC on May 1 at (a) Nindigully (b) Roma and (c) Warialda.

Wheat grain yield: At all sites and in most seasons, growing wheat after a grazed summer lablab forage resulted in a yield penalties that averaged 640 kg/ha. The incidence of complete crop failure increased by approximately 20 % to 25 % of seasons simulated at Nindigully (Fig. 2a) and 20 % of seasons simulated at Roma (Fig. 2b). Crop failures at Warialda increased from 2 % of seasons to 10 % of seasons (Fig. 2c). At the Roma and Nindigully sites where the proportion of winter rainfall received is lower than at Warialda, the incidence of growing < 1000kg/ha increased dramatically. At Nindigully, a fallow-wheat system results in 22 % of seasons yielding < 1000kg/ha while a lablab-wheat system increases this risk to 64%. Similar figures are found at Roma, while at Warialda the incidence increases from 7 to 33 % of seasons.

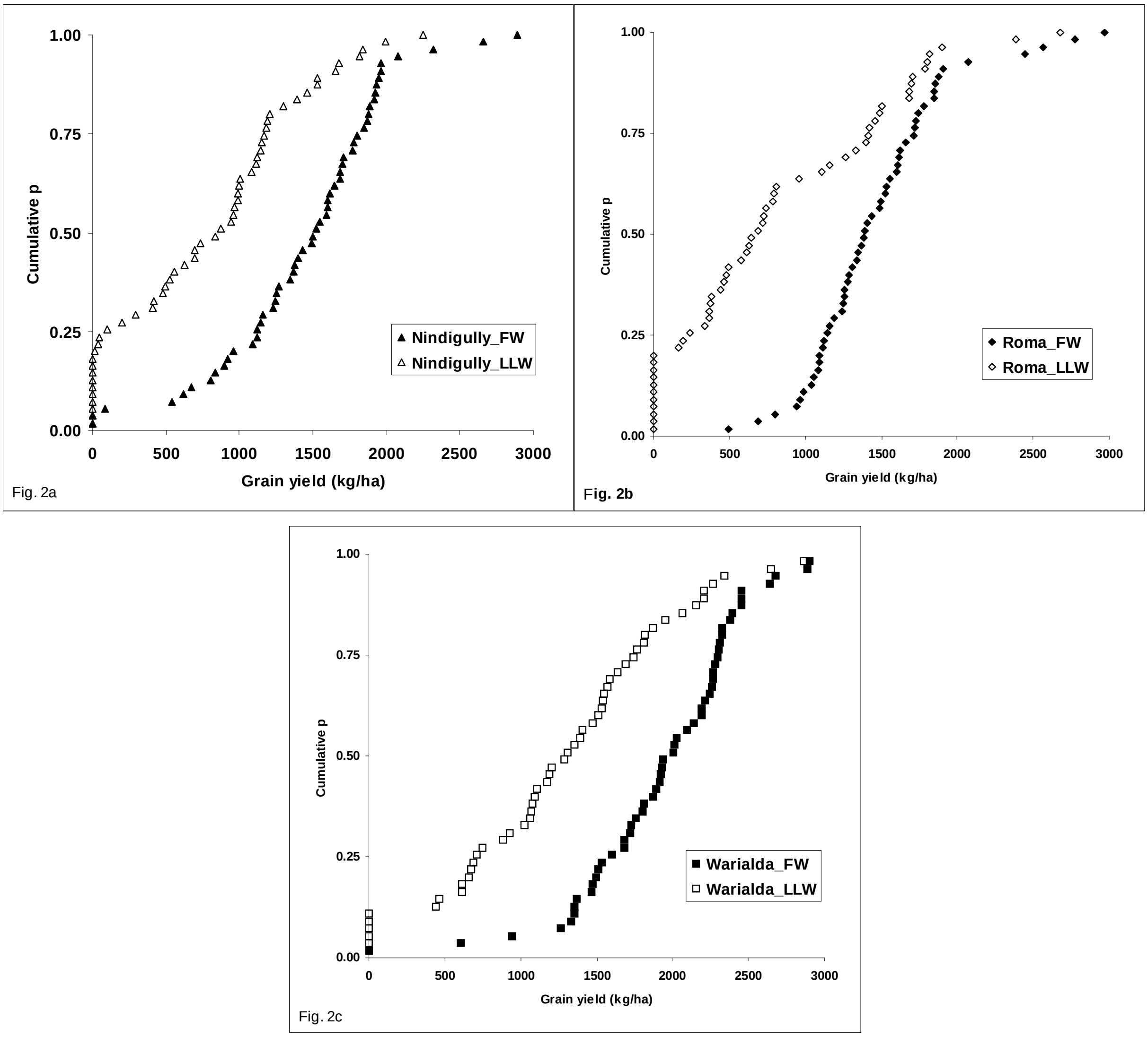

Fig. 2: Wheat grain yield (kg/ha) of a crop following a summer lablab forage or following a summer fallow at (a) Nindigully (b) Roma and (c) Warialda.

Gross return: Using the commodity prices of \$170/t and \$230/t for wheat and \$1.70/kg and \$1.90/kg of carcass weight (for beef), several scenarios of gross return were analysed. Gross margins were not calculated for these scenarios as valuing the cost of inputs, labour, seed etc under various management systems were considered to be variable and subjective. Gross return of the Fallow-Wheat system at Roma was highest at both wheat price scenarios in more than 50 % of seasons and the risk of returns < \$150/ha were also lower (Fig 3a). Varying the price of wheat had a much larger impact on returns compared with varying the price of liveweight. Returns in excess of \$350/ha were achieved in about 25% of seasons where the price of wheat was \$230/t under the lablab-wheat system. This reflects the seasons where rainfall is less limiting and more N is provided by the lablab phase. At Warialda, there was less spread in gross return indicative of the lower risk of the lablab-wheat system where winter rainfall was higher (Fig 3b). The highest return however was still achieved in a fallow-wheat system where grain was valued at \$230/t.

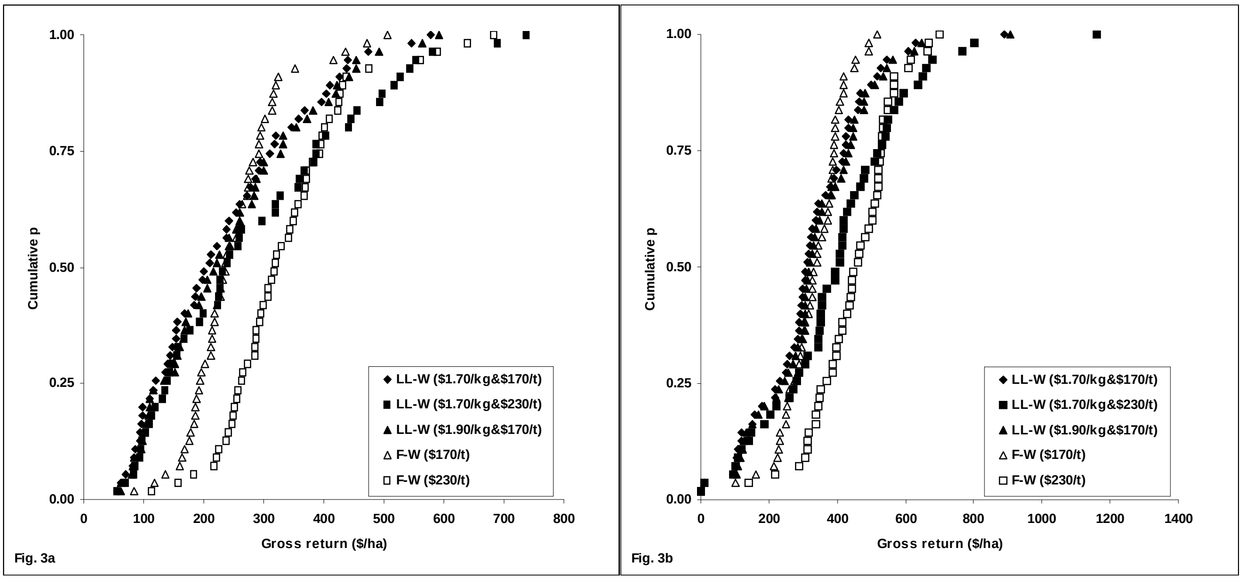

Fig. 3: Gross return of a lablab-wheat system compared with a fallow wheat system at different commodity prices at (a) Roma and (b) Warialda.

Natural resource management tradeoffs: Under best practice zero-till fallow-wheat systems, full stubble and plant cover is maintained, provided livestock are excluded from the system. This is a practice typically used in the region to control erosion and maximise soil water storage through the summer fallow. Continuous cover could not be provided by a lablab-wheat system, especially near the end of summer when all the lablab has been grazed. Furthermore, tillage may be required after a grazed lablab phase to facilitate the establishment of a wheat crop.

There may be some savings in fertiliser N requirements of a lablab-wheat system due to the residual N from lablab residues and manure return. In the scenarios presented, additional N in the lablab-wheat system could not be utilised due to water limitation in many seasons.

Conclusions

The lablab-wheat system substantially increases risk and management complexity compared with a fallow-wheat system. While there may be some increase in water use efficiency of the system as reported by Singh (2007), farmers will generally be unwilling to increase the chances of crop failure and low yields. Under the highly variable rainfall environments of the northern grains belt, making use of stored soil moisture opportunistically is a much lower risk approach than a prescriptive lablab-wheat system.

Reference

Singh, D.K. (2007). Validating economic and environmental sustainability of a short-term forage legume – wheat rotation in dryland cropping systems of southwest Queensland. In preparation.