Maize Stubble Management Survey:
Summary of Results

D. W. Robinson and C. A. Kirkby

CSIRO Land and Water
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APPENDIX III - MAIZE GROWER'S OPINION (BY REGION) OF THE IMPACT THAT INCORPORATION OF STUBBLE HAS ON SOIL AND GROWING THE FOLLOWING CROP

1 Introduction

Current literature suggests that soil health[1] is in decline in many cropping areas around the world, including Australia. A major contributor to this decline is the reduction of organic matter in the soil. In Australia, maize (corn) is mainly grown in the cropping belt from Victoria to southern Queensland and can produce up to 15 to 20 tonnes of stubble per hectare, particularly under irrigation. This stubble has to be managed so that the land can be prepared for the following crop. The sheer bulk of maize stubble means, incorporation can be a slow, costly and inefficient process, consequently some farmers resort to burning. In the light of perceived sustainability, environmental and economic issues associated with burning maize stubble, CSIRO Land and Water have been researching techniques for incorporating maize stubble into the soil, and to quantify their potential environmental and agricultural benefits and costs.

To gain a better understanding of the issues maize growers encounter with stubble management, a survey of maize growers attitudes about stubble management practices was conducted. The main objectives of this survey were to determine:

- the percentage of maize growers from each major maize growing region who retain or burn stubble,
- an estimate of the number of maize growers per year,
- the main reasons for the preferred stubble management practices, and
- which benefits of the various stubble management practices are the most attractive to maize growers.

The survey results will help target research and extension to identify practical stubble management techniques taking into account environmental and economic factors.

2 Questionnaire Design

2.1 The Survey Design

The ideal survey design for this analysis, if we had a perfect sampling frame, would be stratified random sampling.

Stratified random sampling involves separating the population elements into non-overlapping groups, called strata, and then selecting a simple random sample from each stratum. If each stratum is relatively homogeneous in characteristics pertinent to the study, the advantage of stratified random sampling over simple random sampling is that a smaller sample is needed to estimate a parameter to a given level of precision. A smaller sample size saves time and money.

Maize growers are relatively homogeneous in maize production in certain areas due to environmental conditions such as weather and soil type therefore they could be easily segregated into strata based on geographic location using the postcodes of their mailing address.

[1] Soil health can be defined as the continued capacity of soil to function as a vital living system, within ecosystem and land-use boundaries, to sustain biological productivity, maintain the quality of air and water environments, and promote plant, animal and human health (Doran *et al*., 1996)

The survey design adopted was simple random sampling using a mailed questionnaire. There were three main reasons for adopting this design as opposed to the ideal design:

1. For simplicity due to time and budget constraints.
2. The distribution of surveys was done by a third party as access to the mailing list was not permitted due to privacy reasons and therefore we were not able to stratify the population prior to survey distribution.
3. Total population of maize growers is unknown and therefore it is not possible to estimate population parameters using stratified random sampling.

Parameters for the whole population could not be estimated using stratified random sampling however, the parameters for the population within each stratum could be. Therefore, for a more detailed analysis of results, survey respondents were stratified by geographic region and parameters within each region were estimated using simple random sampling.

2.2 Survey Population, Sampling Unit and Sampling Frame

The sampling population was all farmers in the eastern states of Australia who have grown maize for grain at some time in the last 10 years.

The sampling frame used was the Maize Association of Australia's mailing list for their newsletter, 'The Cob'.

The sampling unit was the farmer who grew the maize crop.

2.3 Sample Size Requirement

One of the main objectives of the survey was to estimate the proportion of maize growers who burn stubble, so this became the determinant of the sample size requirement. As the total population of farmers who grow maize is unknown, the required sample size (n) was determined using equation (3.1)[2]:

$$n = \left[\frac{Z_{\alpha/2}.\sigma}{B} \right]^2 \qquad (3.1)$$

where α = a value between zero and one for a desired probability of $1-\alpha$

$Z_{\alpha/2}$ = Z-value of the standard normal distribution such that the area to the right hand side of $Z_{\alpha/2}$ is equal to $\alpha/2$.

σ = the standard deviation of the population such that $\sigma = \sqrt{p(1-p)}$

p = the proportion of the population that possesses a specified characteristic

B = bound on the error of estimation

The most conservative estimate of sample size with a 95% level of confidence is 385, assuming that 50% of the population burn stubble, and using a bound on the error of estimation of 5%.

[2] This assumes that the random sample of *n* farmers is normally distributed and the required sample size is at the 100(1-α)% confidence level with a bound on the error of the estimated mean equal to B (Scheaffer et al., 1996).

However, using the average maize area per farm from the survey and the total maize area from ABARE data, the maize grower population (N) was estimated to be between 400 and 750 depending on the production year (see section 4.3). Using this estimate of the maize grower population, a more realistic sample size requirement was calculated from equation (3.2).

$$n = \frac{Np(1-p)}{(N-1)\left(\frac{B}{2}\right)^2 + p(1-p)} \qquad (3.2)$$

This resulted in a sample size requirement between 200 and 262. The sample size target for this survey was 231, being the average of this range.

2.4 Major Aspects of the Questionnaire

The major aspects of the questionnaire (Appendix I) were:

1. A covering letter

The covering letter introduced the survey by outlining the relevance and importance of the research topic. It also aimed to encourage respondents to complete and return the survey (this was aided by offering a prize to a random respondent). The other main components of the letter were:

- Who is doing the survey and for whom
- The objectives of the survey i.e. what is the survey about, why it is important, how the survey results will be used
- Who is to complete the survey
- Promise of confidentiality
- How to return the survey
- A contact name and number for any questions

2. Close-ended questions

The majority of the questions were close ended questions i.e. respondents choose one of the given responses or rank responses where required. The main reason for doing this was to make the survey quick and easy to fill out. This was expected to help increase the response rate and make the analysis of results easier.

3. Survey length

The survey was kept short so that it could be filled out quickly to try and increase the response rate.

4. Order and wording of questions

The questions were ordered so that they flowed naturally from one to another by placing questions on the same topic together. Considerable time and care was taken to avoid ambiguous, biased, repetitious and double-barrelled questions as they can generate low quality data.

3 Survey Results

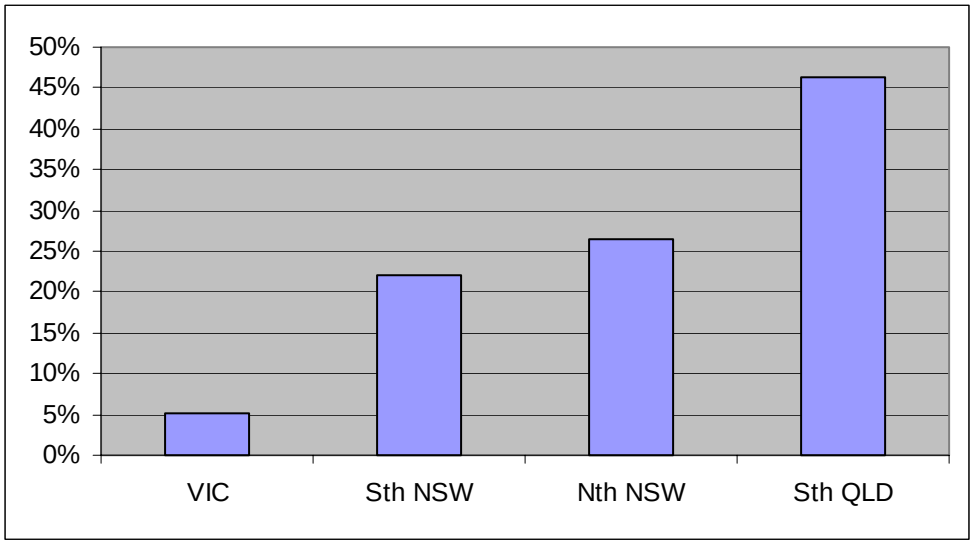
3.1 Survey Response

The population parameters were estimated and the data were stratified into the three main maize growing geographic regions or strata - southern NSW (which extends from northern Victoria to the Lachlan Valley), northern NSW and southern Queensland. Parameters of interested were analysed for each region.

Two thousand survey recipients were randomly selected from a sampling frame of 3500, the surveys were posted and 173 replies were received. The response rate was only 8.65% and fell short of the target sample size of 231. A low response rate was expected and was partly due to the sampling frame containing addresses of people with interests in the maize industry who are not necessarily maize growers. Despite the low response rate, the area sown to maize by the respondents accounts for approximately 24% of Australia's total annual area sown to maize (Table 7). Using the estimate of 400 to 750 maize growers per year (see section 3.3), and assuming that 25% of maize growers would abstain from growing maize each year due to rotational or other constraints, the response rate is estimated to be between 18% and 35% of all maize growers.

According to ABARE statistics, the average percentage of the total maize area from 1995 to 1999 in NSW and Victoria was 43%, with Queensland contributing 55% and Western Australia the remaining 2%. The highest survey response came from southern Queensland growers who constituted 46% of the returned surveys (Figure 1). However they only represented approximately 33% of the survey respondents' total maize area. Consequently, the survey results maybe biased towards the views of the more southern maize growers' as there was a proportionally higher response from growers in this region.

Figure 1 Survey response by geographic region



3.2 Demographic Profile of Maize Growers

The profiles of farmer age were similar in each region, except that there were fewer older farmers in southern NSW. Overall, 57% of the respondents were between the age of 30 and 50 with 39% over the age of 50 and only 4% below the age of 30 (Table 1).

Table 1 Age of farmer

Age	Sth NSW		Nth NSW		Sth QLD		TOTAL	
	no.	%	no.	%	no.	%	no.	%
<30	1	2%	3	7%	3	4%	7	4%
30-50	33	70%	24	52%	42	53%	99	57%
>50	13	28%	19	41%	35	44%	67	39%

Most of the respondents were experienced maize growers with 60% growing maize for more than 10 years and a further 19% who had grown maize for at least 5 years (Table 2).

Table 2 Years of growing maize

Years	Sth NSW		Nth NSW		Sth QLD		TOTAL	
	no.	%	no.	%	no.	%	no.	%
1 - 5	14	30%	8	17%	15	19%	37	21%
5 - 10	16	34%	9	20%	8	10%	33	19%
>10	17	36%	29	63%	57	71%	103	60%

Maize crops are irrigated on 61% of farms. All maize crops in southern NSW and Victoria are irrigated, compared with and approximately half in northern NSW and Queensland. The main method of irrigation in all regions is using furrows/beds. (Table 3).

Table 3 Regional percentage of irrigated maize and irrigation methods

	Sth NSW %	Nth NSW %	Sth QLD %	TOTAL %
Percentage of Irrigators	100%	50%	45%	61%
Furrow/Beds	73%	57%	57%	62%
Lasered Border Check	17%	4%	0%	8%
Pivot/Lateral Spray	4%	26%	17%	13%
Other	6%	13%	13%	16%

Maize is generally grown in rotation with other crops, with 60% of respondents preferring not to grow consecutive maize crops, and a further 36% growing no more than 3 maize crops in the same paddock. There is a tendency for more consecutive maize crops in southern NSW (Table 4 and Table 5). This is possibly attributable to northern NSW and Queensland having more summer cropping options than southern NSW with crops such as cotton, sorghum and peanuts.

Table 4 Usual number of consecutive maize crops

	Sth NSW %	Nth NSW %	Sth QLD %	TOTAL %
1	34%	51%	80%	60%
2	40%	31%	10%	24%
3	17%	16%	8%	12%
4	0%	0%	0%	0%
>4	9%	2%	3%	4%
MAX	7	7	5	7

Table 5 Maximum number of consecutive maize crops

	Sth NSW %	Nth NSW %	Sth QLD %	TOTAL %
1	26%	41%	53%	42%
2	26%	17%	22%	22%
3	26%	28%	16%	22%
4	4%	2%	4%	3%
>4	19%	11%	5%	10%
MAX	10	10*	10	10

Figure 5 one farmer had grown maize consecutively in the same paddock for 35 years

Summer crops (sorghum, cotton, soybean and peanuts) were the predominant types of break crop following maize in Queensland. However, in NSW the break crops were predominantly winter crops, particularly in the south. The main winter break crops were wheat, barley, canola and fababeans. Approximately 17% of farmers fallowed the paddock after maize (Table 6).

Table 6 Break crop type following maize

	Sth NSW	Nth NSW	Sth QLD	TOTAL
Winter	57%	50%	14%	36%
Summer	23%	37%	69%	47%
Fallow	19%	13%	18%	17%

3.3 Estimation of Maize Crop Area and Yield Per Farm and Total Number of Maize Growers Per Year

The average area of maize grown per farm has increased in the last 3 years from 133 ha to 156 ha with a bound on the error of estimation[3] ranging from 29 to 32 ha. Average yields have declined from 7.3 t/ha to 6.7 t/ha with a bound on the error of estimation close to 0.56 tonne/ha for all 3 years. It is interesting to note that ABARE statistics have deemed the average maize yield to be approximately 5 t/ha for the same period. The reason for this difference is unclear, however, this survey could be biased as the survey topic may have appealed more to the "more successful" farmers and consequently led to an overestimation of the average yield.

[3] If the population is assumed to be normally distributed, the bound on the error of estimation is equivalent to two standard deviations from the mean at a 95% level of confidence (Scheaffer et al., 1996).

The total number of maize growers was determined by $N = \hat{t} / \bar{y}_i$

where $\hat{t}$ = ABARE estimate of total maize area grown and
$\bar{y}_i$ = average maize area per farm

The 95% confidence interval for the total number of maize growers was then estimated by dividing the estimated total maize area by the farm area confidence interval. The estimated number of maize growers per year for the last 3 years ranged from 482 to 594 and with the bound on the error of estimation, the range was 402 to 751 (Table 7).

Table 7 Estimation of the average maize area and yield of Australian maize growers and the total number of maize growers from 1998/99 to 2000/01

	1998 - 1999	1999 - 2000	2000 - 2001
Average maize area per farm (ha)			
Sample no.: n	119	130	126
Mean: $\bar{y}_i$	133.3	138.1	155.6
Sd: $\sqrt{\hat{V}(\bar{y}_i)}$	14.6	14.7	15.9
Bound: $2\sqrt{\hat{V}(\bar{y}_i)} = B_a$	29.2	29.4	31.8
95% Confidence Interval: $\bar{y}_i \pm B_a$	104.1 - 162.5	108.7 - 167.5	123.8 - 187.4
Average yield per farm (t/ha)			
Mean: $\bar{y}_j$	7.3	7.5	6.7
Sd: $\sqrt{\hat{V}(\bar{y}_j)}$	0.28	0.28	0.26
Bound: $2\sqrt{\hat{V}(\bar{y}_j)}$	0.56	0.56	0.52
Total maize area			
Total maize area (ha): $\hat{t}$	66,000	82,000	75,000
Survey area (ha)	15,867	17,950	19,606
Proportion of area surveyed (%)	24.0	21.9	26.1
Total no. of maize growers			
No. of growers: $N = \hat{t} / \bar{y}_i$	495	594	482
95% Confidence Interval: $\frac{\hat{t}}{\bar{y}_i \pm B_a}$	408 - 630	491 - 751	402 - 603

Note: (I) $\hat{t}$ is the ABARE estimate of total maize area grown

(ii) $\hat{V}(\bar{y}_i)$ and $\hat{V}(\bar{y}_j)$ is the estimated variance for the average maize area and yield per farm.

(iii) B_a is the bound on the error of estimation for the average maize area per farm (a)

The average maize area and yield per farm for the whole population (Table 7) were derived using simple random sampling. Stratifying the sample population into 3 strata based on geographic location we were able to estimate the average maize growing area and yield per farm in each region, also using simple random sample statistics.

Figures 2 and 3 illustrate the significant difference in average maize area and yield per farm in each region. Average maize area for Southern NSW growers is approximately 250 ha whereas in northern NSW and southern Queensland it is approximately 100 ha. Average yields range from 10 t/ha for southern NSW growers, 7.5 t/ha for northern NSW growers and 5.2 t/ha for southern Queensland growers. The bounds on the error of estimation depicted by the error bars illustrate a relatively large range in maize area per farm in southern NSW compared to the other two regions but a smaller range in yield. The range and variation of yields between the three regions is possibly due to the different degrees of irrigation between the regions.

These results illustrate the heterogeneity between the three regions and therefore if we knew the population for each strata we could estimate the average maize growing area and yield per farm for the whole population with more precision using stratified random sampling as opposed to simple random sampling. This could be another explanation as to why the average yield per farm for the population was significantly higher than the ABARE estimate.

Figure 2 Average maize area per farm

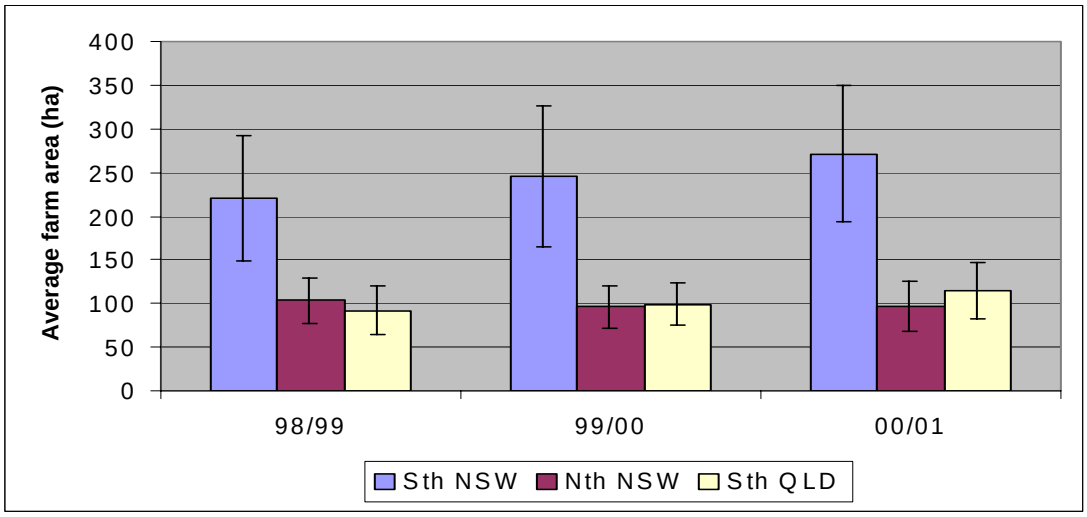
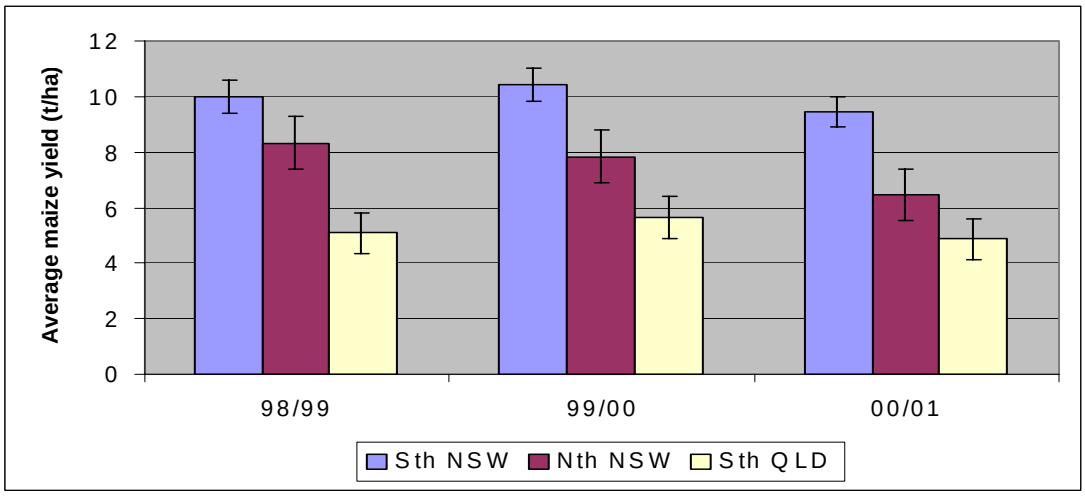


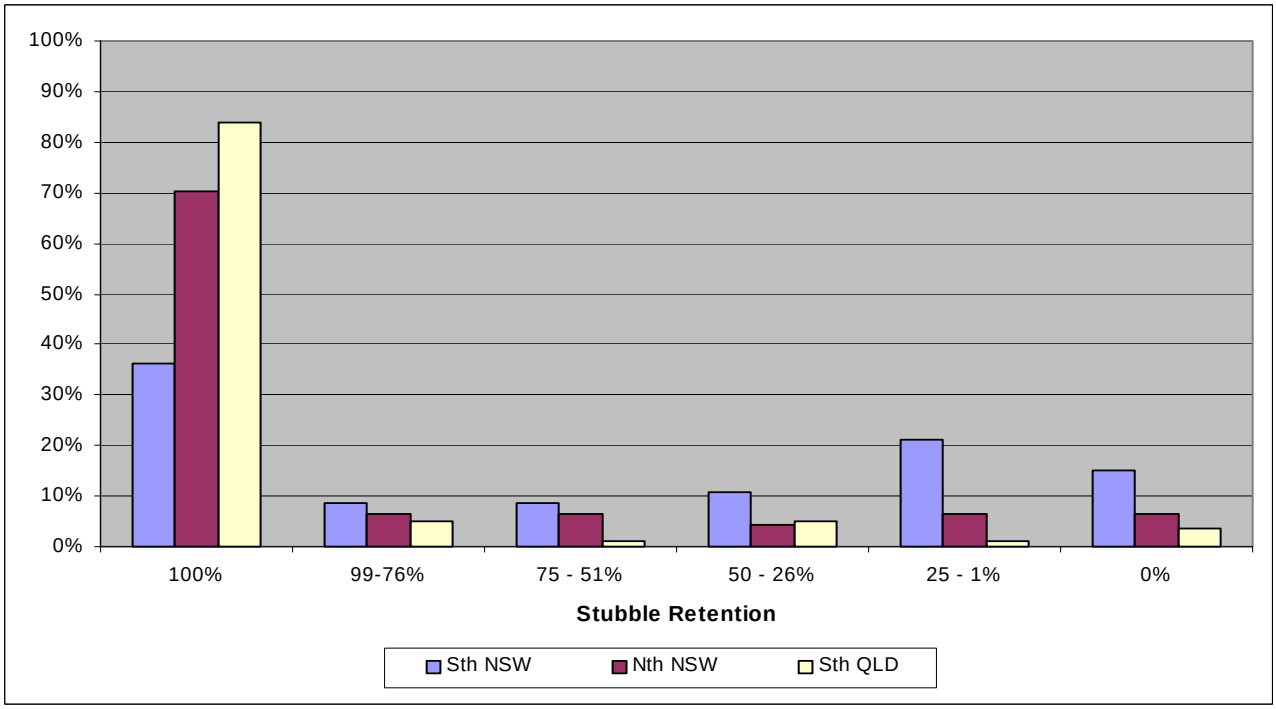
Figure 3 Average maize yield per farm



3.4 Stubble Management Practices

The majority of maize growers retain some stubble (Table 8) with 67% of respondents retaining all their stubble. Over 80% of farmers in northern NSW and southern Queensland retain at least 75% of their stubble whereas it is only 45% for maize growers in southern NSW (Figure 4).

Figure 4 Percentage of maize stubble retention per farm



Determining the proportion of growers who retain or burn stubble was one of the main objectives of the study. To determine the upper and lower limits with 95% confidence that the true proportion lies within this interval, the bound on the error of estimation is calculated from:

$$B = 2\sqrt{\hat{V}(\hat{p})} \qquad \text{and} \qquad \hat{V}(\hat{p}) = \frac{p(1-p)}{n-1}\left(\frac{N-n}{N}\right)$$

As the population of maize farmers (N) is unknown, it was assumed that the population was large and therefore the population correction factor {N-n)/N} was not used to calculate the variance on the estimated proportion of maize growers who do or do not burn stubble. As a result, the variance is possibly overestimated.

The 95% confidence interval is equal to $\hat{p} \pm B$, therefore the proportion of growers who retain some stubble is $93\% \pm 3.8\%$ and the proportion of growers who do some burning is $33\% \pm 7.2\%$ (Table 8). This is assuming that the unretained stubble is burnt.

Table 8 Proportion (and standard deviation) of farmers who retain or burn some stubble

	Sth NSW	Nth NSW	Sth QLD	TOTAL
Proportion of farmers who retain some stubble	85% (5.2%)	93% (3.7%)	96% (2.1%)	93% (1.9%)
Proportion of farmers who burn some stubble	64% (7.1%)	30% (6.9%)	16% (4.2%)	33% (3.6%)

The 6 main reasons for retaining stubble in order of preference were to increase organic matter, improve soil structure, improve soil micro-organisms, retain nutrients, improve water infiltration and reduce compaction (Table 9). Some farmers in southern Queensland indicated the importance of retaining stubble to aid in minimising soil erosion.

Table 9 Main reasons for retaining stubble

	Sth NSW rank	Nth NSW rank	Sth QLD rank	TOTAL rank
Increase organic matter	1	1	1	1
Improve soil structure	2	2	2	2
Improve soil micro-organisms	4	4	3	3
Retain nutrients	3	3	5	4
Improve water infiltration	5	5	4	5
Reduce compaction	6	6	6	6
Reduce erosion				
Reduce pollution				
Reduce greenhouse gases				

Retaining stubble did not cause too many problems in the preparation and growing of the following crop for approximately a third of growers, particularly those under dryland growing conditions. For the remaining growers there was a range of problems associated with retaining stubble. Stubble not decomposing before next crop and nitrogen tie-up were the main problems experienced by maize growers in all regions, especially in the southern NSW region (Table 10).

Table 10 Problems associated with stubble retention

	Sth NSW	Nth NSW	Sth QLD	TOTAL
No Problems	20%	33%	42%	34%
Stubble not decomposing before next crop	70%	47%	44%	51%
Nitrogen tie-up	23%	35%	25%	25%
Decrease in seedling vigour	18%	19%	8%	11%
More disease	15%	21%	5%	11%
More weeds	18%	5%	6%	9%
Decrease in plant populations	13%	14%	8%	11%
Unaccountable yield losses	15%	9%	4%	8%

The 6 main reasons for burning stubble varied in order of preference between each region. Overall, the main reasons were: stubble retention causes complication in sowing the following crop, it is a quick and easy way to dispose of stubble and farmers lacked the proper equipment to mulch and/or incorporate stubble (Table 11).

Table 11 The ranking of maize growers main reasons for burning

	Sth NSW	Nth NSW	Sth QLD	TOTAL
Stubble retention causes complications in sowing next crop	1	2	5	1
Quick and easy to dispose of unwanted stubble	2	1	4	2
Do not have equipment to incorporate stubble	5		1	3
Soil is too wet to incorporate stubble		5	6	4
Aids in controlling disease	6	3	2	5
Do not have time to incorporate stubble		6	3	6
Incorporating stubble is too costly		4		
Stubble retention causes nitrogen tie-up	3			
Aids in controlling weeds	4			

3.5 Estimation of the Area of Burning and Cost of Nutrient Loss.

From Table 8 it was estimated that approximately one third of all maize growers burn some stubble, with burning more prevalent in the irrigation districts of southern NSW and Victoria. Based on maize area per farm and the level of stubble retention indicated by the growers (Figure 4), it was estimated that the stubble on approximately one third of the total maize area was burnt. Growers in southern NSW and Victoria burnt approximately half of their stubble (Table 12).

Table 12 Maize area and estimated stubble burning area (from survey)

	Survey Area (ha)			Burnt Area (ha)			Burnt Area (%)		
	1999	2000	2001	1999	2000	2001	1999	2000	2001
Sth NSW	7,936	8,623	10,042	3,634	4,013	4,937	46%	47%	49%
Nth NSW	2,786	3,074	3,485	837	1,074	1,248	30%	35%	36%
Sth QLD	5,145	6,253	6,079	930	858	805	18%	14%	13%
TOTAL	15,867	17,950	19,606	5,400	5,945	6,990	34%	33%	36%

The proportion of maize area burnt was estimated from the survey data (Table 13). Using these percentages and total maize production statistics obtained from ABARE (2001), Australia's maize production[4] associate with stubble burning was estimated (Table 14). The quantity of stubble burnt in each region, and subsequent nutrient loss, were estimated assuming that the ratio of grain to stubble is 1:1.5[5] (Tables 15 and 16).

Table 13 Estimated maize production from the stubble burning area (from survey)

	Maize Production (tonne)			Maize Production from Burnt Area (tonne)			Maize Production from Burnt Area (%)		
	1999	2000	2001	1999	2000	2001	1999	2000	2001
Sth NSW	80,064	93,233	95,269	35,934	43,996	45,186	45%	47%	47%
Nth NSW	24,690	25,769	27,379	8,151	10,554	11,492	33%	41%	42%
Sth QLD	25,854	31,880	28,251	7,758	7,247	7,307	30%	23%	26%

[4] Excluding maize production in Western Australia which constitutes approximately 2% of national production
[5] Current literature and research trials indicate that 1 tonne of maize will produce between 1 to 2 tonnes of stubble.

Table 14 Estimated total maize production from the stubble burning area

	Total Maize Production (t) (ABARE)*			Total Maize Production on Burnt Area (%)**			Total Maize Production on Burnt Area (t)		
	1999	2000	2001	1999	2000	2001	1999	2000	2001
NSW + VIC	216,320	259,840	227,200	42%	46%	46%	91,037	119,110	104,995
QLD	114,920	138,040	120,700	30%	23%	26%	34,484	31,380	31,219
TOTAL	338,000	406,000	355,000	37%	37%	38%	125,521	150,490	136,214

Figure 5 NSW production is assumed to be 64% of total production and QLD is 34% based on the average for years 1994/95 - 1998/99 (ABARE)

** Estimates from maize stubble management survey (derived from data in Table 13)

Table 15 Estimated amount of maize stubble burnt for last 3 production years (maize yield to stubble ratio - 1:1.5)

	Quantity of Stubble Burnt (tonnes)		
	1999	2000	2001
NSW + VIC	136,556	178,665	157,492
QLD	51,725	47,070	46,828
TOTAL	188,281	227,734	206,321

In the 2000/01 season, NSW maize growers are estimated to burn stubble from approximately 46% of production which equates to approximately 157,000 tonnes of stubble. Queensland maize growers are estimated to burn stubble from approximately 26% of production which equates to approximately 47,000 tonnes of stubble. Overall, maize growers are estimated to burn stubble from approximately 38% of total production which equates to approximately 205,000 tonnes of stubble (Table 14 and 15).

Maize stubble constitutes significant amounts of nutrients that are required for crop growth. When this stubble is burnt a significant proportion of these nutrients is lost (Table 16). To replace these nutrients extra fertiliser needs to be applied.

Table 16 Straw nutrients per tonne of grain and nutrient loss from a hot burn

Nutrient	Maize Stubble Nutrients[a] (kg/tonne of maize yield)	Wheat Stubble Nutrients[b] (kg/tonne of wheat yield	Nutrient loss during a hot burn[c] (%)
nitrogen	12.5	6	82
phosphorus	4.5	1	44
potassium	9	44	40
sulphur	3	1	81
calcium	3	3	52
magnesium	3	1	47
carbon	600	480	80

[a] assuming 1 tonne yield = 1.5 tonne stubble
[b] assuming 1 tonne yield = 1.0 tonne stubble
[c] hot burn has flames 2m high

The least cost fertiliser mix to replace the nutrients lost due to stubble burning was determined by a linear programme. It was estimated that the cost of stubble burning in terms of nutrient loss is approximately $16.45 per tonne of yield (Table 17). Therefore, for a maize crop that yields 10 t/ha, the nutrient loss is equivalent to $165 per hectare in replacement fertiliser costs.

The average maize production from stubble burning areas for the last 3 years is estimated to be 137,400 tonnes, therefore the annual cost of stubble burning to maize growers has been approximately $2.26 million.

Table 17 Estimated cost of nutrient loss from burning maize stubble

	Fertilizer Nutrient Composition*				**Nutrient Loss from Burning (kg/t yield)**
	Urea	**DAP**	**Muriate of Potash**	**Gypsum****	
Fertiliser Nutrients*					
Nitrogen	46%	18%			10.25
Phosphorus		20%			1.98
Potassium			50%		3.6
Sulpher		2%		14%	2.43
Calcium				16%	1.56
Fertiliser requirement (kg)	18.4	9.9	7.2	16.2	
Fertiliser price* ($/t)	395	465	403	38	
Nutrient replacement cost	$7.27	$4.60	$2.90	$0.62	
Total Fertiliser Cost ($/t of yield)	$15.39				
Fertiliser Cartage Cost (@ $30/t)	$1.07				
Total Cost of Nutrient Loss	**$16.45**	**/ tonne of yield**			

* Pivot, Melbourne depot prices, December 2001

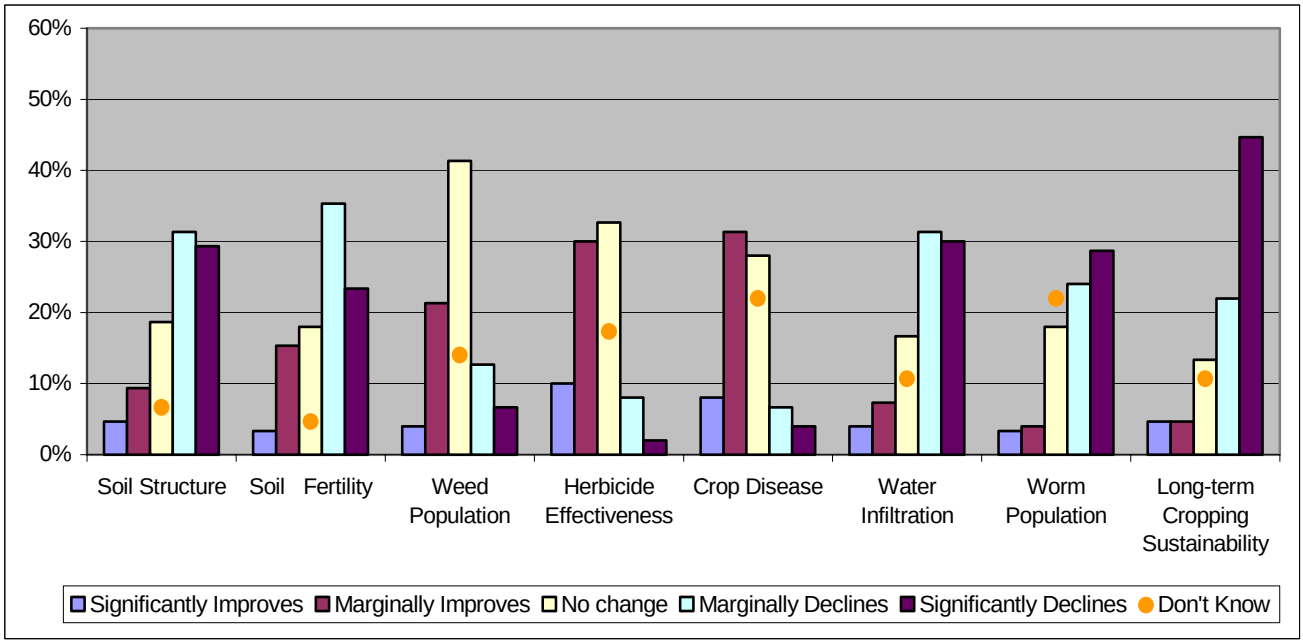
** Gypsum price includes freight

3.6 Maize Growers' Opinions on the Impact of Burning Stubble

More than 50% of all maize growers thought that burning will lead to a decline in soil structure, soil fertility, water infiltration, worm population and long term cropping sustainability. Approximately 40% of all growers thought that the burning of stubble will aid in controlling crop disease and improve herbicide effectiveness but has no impact on weed populations. There was only a relatively small percentage of growers with no opinion for each of the categories, however approximately 22% of growers were unsure of the impact of burning on crop disease and worm populations (Figure 5).

There were some major differences in opinions between regions. A higher percentage of growers in northern NSW believed that burning stubble will improve weed populations, herbicide effectiveness and crop disease than growers in southern NSW and Queensland. A higher percentage of growers in northern NSW and southern Queensland also believed that burning will lead to declines in soil structure, soil fertility, water infiltration, worm population and long term cropping sustainability than growers in southern NSW (Appendix II).

Figure 5 Maize growers' opinion of the impact that burning of stubble has on the soil for growing the following crop



Approximately half the growers thought that air pollution from burning would be minor, with a further 26% indicating they felt burning stubble caused no air pollution to their community. One-third of growers thought that the local community viewed stubble burning as possibly causing serious air pollution while a further 35% thought not. Approximately half the growers thought that burning stubble caused minor to significant greenhouse gas emissions while 40% of growers did not know. The general opinion of farmers was split on whether the community viewed the burning of stubble as causing serious greenhouse gas emissions (Table 12 and Table 13).

Table 12 Farmers' opinion on the impact of burning has on pollution and greenhouse gases

	Significant	Minor	None	Don't Know
Greenhouse Gases	10%	42%	8%	40%
Air Pollution	4%	52%	26%	18%

Table 13 Does the local community view burning as causing serious pollution and greenhouse gases - farmers' opinion

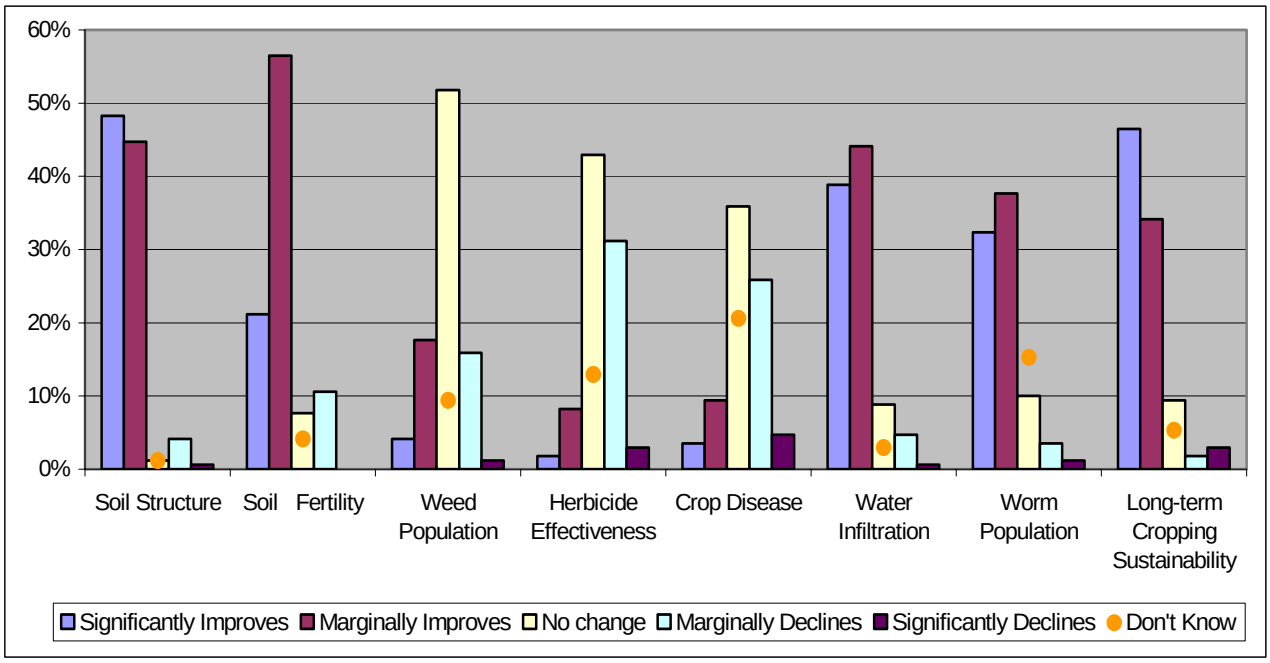
	Yes	Possibly	No	Don't Know
Greenhouse Gases	14%	32%	39%	15%
Air Pollution	9%	35%	35%	22%

3.7 Maize Growers' Opinion on the Impact of Incorporating Stubble

The majority of all maize growers thought that the incorporation of maize stubble would improve soil structure, soil fertility, water infiltration, worm population and long term cropping sustainability. Also, the majority of maize growers thought that the incorporation of stubble would have little impact on crop disease, improving herbicide effectiveness and weed populations. There were only a relatively small percentage of growers with no opinion for each of the categories, however 21% of growers were unsure of the impact of incorporating stubble on crop disease (Figure 6).

There were some major differences in opinions between regions. The majority of growers in southern Queensland thought that incorporation of stubble would *significantly* improve soil structure, water infiltration, worm population and long-term cropping sustainability whereas the majority of growers in northern NSW thought that incorporation of stubble would only *marginally* improve these same conditions. In southern NSW, approximately the same percentage of growers thought these cropping conditions would either marginally or significantly improve. Also, less than 25% of southern Queensland growers thought that incorporation of stubble would decrease herbicide effectiveness and crop disease compared with approximately 35-45% of growers in the other two regions (Appendix III).

Figure 6 Maize growers opinion of the impact that the retention of stubble has on the soil for growing the following crop



Approximately 70% of growers thought that incorporation of stubble caused the same or less air pollution and approximately 60% of growers thought that incorporation of stubble caused the same or less greenhouse gas emissions than burning however, about one-third of growers had no opinion (Table 13).

Table 13 Farmers opinion on the impact of incorporated stubble has on pollution and greenhouse gas emissions compared to burning.

	More	Less	None	Don't Know
Air Pollution	1%	45%	26%	28%
Greenhouse Gases	3%	38%	23%	36%

3.8 Farmers' Attitude to Change Stubble Management Practice

The main reason for burning and the main problem of maize growers who retain stubble is that there can be complications in sowing the following crop if the stubble has not broken down adequately. Consistent with that, only about half of the growers believe that in most years it is physically possible for maize stubble to break down adequately to minimise sowing complications in the following crop. A further 20% believed it might be achievable (Table 12). These results must be viewed with caution as the survey question did not specify if the following crop was a winter or summer crop. Farmers whose main farming practice was to sow a winter crop after maize were more likely to reply "no" due to the much shorter break down period. This could be the reason for southern NSW growers having a much lower belief in the capacity of maize stubble to break down, coupled with the greater volume of stubble due to the higher yields than the growers in northern NSW and Queensland.

Table 12 Farmers opinion on the ability of maize stubble to break down before the sowing of the following crop

	Yes	Possibly	No	Don't Know
Sth NSW	34%	38%	23%	2%
Nth NSW	54%	15%	24%	7%
Sth QLD	68%	13%	16%	4%
Total	55%	20%	20%	4%

Most growers agreed about the benefits of stubble retention as opposed to burning. Over three-quarters of growers would, and another 12% possibly would, incorporate stubble if research could identify cost effective management techniques for incorporated stubble to break down before the sowing of the next crop. The 9% that said they would not, already have other alternative stubble retention practices in place e.g. zero till. Therefore, almost all maize growers would incorporate or retain stubble if the breakdown of stubble could be maximised so complications in sowing the following crop became a rare occasion.

Growers indicated varying levels of increased maize gross margin or subsidy level required to change their practice from burning to incorporating stubble. This is because there is a cost to incorporate stubble and varying levels of risk associated with stubble retention i.e. the possibility of delayed sowing of the following crop due to maize stubble not breaking down. Approximately half of the respondents indicated an increase in gross margin up to $20 -$40/ha as a sufficient gross margin increase. The response with subsidies was varied with a certain amount of feedback from respondents indicating they do not agree with subsidies. Approximately 40% of growers indicated that up to $20 to $40/ha subsidy would be required to change their practice from burning to incorporating stubble.

3.9 Research Areas

Maize growers in general are quite aware of the potential benefits of retaining stubble. Consequently the majority of respondents indicated that the main area of research they would like to see in stubble management is better machinery to either mulch and incorporate the stubble or to be able to sow into stubble with minimal complications. They also would like to determine which is the best stubble retention method.

The other major area of research that growers would like to see are methods to enhance the process of breaking down the stubble more quickly such as spraying on biological breakdown agents (nitrogen, micro organisms, other). Other areas of interest included quantifying stubble retention benefits, nitrogen tie-up, disease, zero till and the development of shorter maize varieties (less stubble and less nutrient needs).

In general, the farmers see research in stubble management applicable to all dryland and irrigated crops. However, some farmers in Queensland indicated that this research has already been done or stubble retention is common practice and therefore research is not required.

4 Possible Errors Associated with Survey

There are 3 main sources of error

1. Non-response error

This is the failure to measure some of the units in the chosen sample. This could be due to an incomplete sampling frame, respondents not being at home or having moved to another address or just refusal to participate in the survey. Non-response error is a real possibility with this survey as there are probably maize growers that do not subscribe to the maize industry's newsletter and therefore were not included in the sampling frame. There were also 18 surveys returned with either a wrong address or the farmer had moved or possibly sold the farm. There is also a high chance of non-response due to the sampling frame containing contact details of people that are not applicable to this survey, for instance farmers who do not grow maize, farmers who grow maize for silage and industry representatives. Finally, a high proportion of non-response was probably due to growers not being interested in the survey (or the chance to win a case of wine!) or could not spare the time to fill it in and therefore did not participate.

2. Measurement error

The respondents may not possess accurate information or they may give biased answers. The grower's answers on crop area and yield may be inaccurate due to growers failing to remember correctly. Biased answers may occur if growers feel that burning of stubble maybe a sensitive issue in particular areas and therefore may give inaccurate responses. Also, the overall survey maybe biased as only the "more successful" farmers are interested or are willing to spend the time in participating in the survey. These farmers may lead to an overall bias in the results as they are more likely to have adopted the retention of stubble as a preferred management practice and achieve better than average yields.

3. Coding errors

These errors occur during the process of coding, tabulating and the analysis of results.

5 Conclusion

The population of maize growers was unknown, therefore simple random sampling statistics was used to analyse the parameters. The precision of estimation of these parameters could have been improved by using stratified random sampling if the population of maize growers could be obtained from a reliable data source such as agriculture surveys carried out by Australian Bureau of Statistics.

There were 173 replies to the survey, a response rate of 8.65%. The low response rate was expected as the mailing list probably contained a relatively high proportion of addresses of people other than maize growers. It was estimated that the total number of maize growers in the last 3 years was probably no greater than 750, therefore the number of respondents was approximately 23% of the estimated number of maize growers. This is a significant sample of the population and therefore some general conclusions about maize stubble management practices can be made.

All of the maize crops in southern NSW and Victoria are irrigated, obtaining average yields around 10 t/ha which are significantly higher than the two other regions. These high yielding crops are estimated to produce up to 15 tonne/hectare of stubble. Due to the sheer bulk of stubble in these crops, burning is a more prevalent stubble management practice as retaining stubble causes complication in sowing the following crop. This is highlighted by 64% of respondents in southern NSW burning some stubble compared with only 30% in northern NSW and 16% in southern QLD. However it was noted that some farmers who had high yielding crops were still able to incorporate all the stubble and have minimal complications in sowing the following crop, especially if it was another summer crop. The burning of stubble was more prevalent when the farmer wanted to follow the maize crop with a winter crop. Consequently, the main reason for burning highlighted by the maize growers was that it was a quick and easy method to dispose of stubble as it could cause complications in sowing the following crop.

Nutrient loss from burning stubble was estimated to cost growers approximately $16.45 per tonne of yield, an annual cost to the industry of approximately $2.26 million.

Overall, maize growers in all regions have highlighted perceived benefits of retaining stubble with approximately 93% of growers retaining some stubble and over 70% in the northern NSW and southern Queensland regions retaining all their stubble. The major benefits of stubble retention were increased organic matter and improved soil structure. The growers also believe stubble retention will significantly improve water infiltration and long-term cropping sustainability. Growers in Queensland highlighted the importance of stubble retention to minimise erosion.

Maize growers have also highlighted a range of problems associated with stubble retention, particularly in southern NSW. The main problems associated with stubble retention were stubble not decomposing before next crop and nitrogen tie-up. Other problems experienced by growers included decrease in seedling vigour, more weeds and disease, decrease in plant populations and unaccountable yield losses.

The impact of pollution and greenhouse gas emissions from the 2 main stubble management practices were not a major concern of the maize growers or, they felt, by their local communities.

Almost all of the maize growers indicated they would incorporate or retain stubble if cost effective management techniques were identified that would enhance the break down of stubble so that complications in sowing the following winter or summer crop are minimal. As a result the main area of research identified by growers for stubble management was to develop machinery and cost effective techniques capable of mulching and/or incorporating stubble or sowing into

stubble with minimal complications. This may only involve identifying farmers who are successful in stubble incorporation and who are willing to share their knowledge. The other main area of interest was the identification of biological agents that could enhance the break down of stubble.

6 References

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APPENDIX I - The Questionnaire

CSIRO Land and Water
Griffith Laboratory
Research Station Road,
Griffith NSW
Postal Address: Private Bag 3,
Griffith NSW 2680 Australia
Telephone: (02) 6960 1500
Fax: (02) 6960 1600

3 September, 2001

Dear Maize Grower,

Re: Maize Stubble Management Survey

If you grow maize (corn) for grain, we **need your help** in guiding stubble management research that comes from **your research levies** by returning the following survey and you will also have the chance to **WIN** a dozen bottles of selected wines from the Griffith region.

As part of the GRDC maize stubble management project led by CSIRO's Clive Kirkby, we are conducting a survey of maize growers about their stubble management practices. The main objectives of this survey are to determine:

- the percentage of maize growers who retain or burn stubble
- the main reasons for the preferred stubble management practices, and
- which benefits of the various stubble management practices are the most attractive to maize growers.

Survey results will aid in more targeted research to identify the practical techniques, environmental and economic conditions that are necessary for the various stubble management practices to improve soil health, increase crop yields and minimise pollution. It will also determine the areas where information and extension is sought by maize growers.

If you have grown a maize crop for grain in the last 10 years and would like to guide research in the area of maize stubble management, please fill in the following survey (it will only take about 10 minutes) and return it in the reply paid envelope provided. Confidentially will be maintained and responses will only used for research purposes.

Don't forget, every returned survey is eligible to win a dozen bottles of wine to be drawn on 30th October.
There are two prizes so don't miss out!

Your time taken to do this survey is greatly appreciated.

Yours faithfully,

David Robinson

Maize Stubble Management Survey

(For maize grain growers only)

(Confidentially will be maintained and responses will only be used for research purposes)

1. Where is your farm located?

- ❒ Victoria
- ❒ Southern NSW (includes Lachlan Valley)
- ❒ Northern NSW
- ❒ Southern QLD
- ❒ Northern QLD
- ❒ Other (please specify)

  _____

2. How old are you?

- ❒ Less than 30 years
- ❒ 30 - 50 years
- ❒ More than 50 years

3. For how many years have you grown maize?

- ❒ 1 -5 years
- ❒ 5-10 years
- ❒ more than 10 years

4. What area of maize did you grow in the last 3 years? (optional)

1998/99 _____ ha

1999/00 _____ ha

2000/01 _____ ha

5. What was the average yield of your maize crop in the last 3 years?

1998/99 _____ t/ha

1999/00 _____ t/ha

2000/01 _____ t/ha

6. How many maize crops do you usually grow consecutively in the same paddock?

Usually_____, but ranges from

_____ to _____

7. What are your two most typical crop rotations where you grow maize?

(Eg: maize, maize, canola, fallow)

1. _____

_____

2. _____

_____

8. Do you irrigate your maize crop?

- ❒ Yes
- ❒ No → **Go to Question 11**

9. What type(s) of irrigation layout do you use for maize?

- ❒ Furrow / beds
- ❒ Lasered border check
- ❒ Pivot / lateral spray
- ❒ Other (please specify)

  _____

10. On average per year, what proportion of the maize stubble area do you retain?

- ❒ 100%
- ❒ 75% - 99%
- ❒ 51% - 75%
- ❒ 26% - 50%
- ❒ 1% - 25%
- ❒ Zero (always burn) → **Go to Question 14**

On average, what do you do with your retained stubble?

- ❒ Leave stubble standing
- ❒ Mulch and leave on surface
- ❒ Incorporate
- ❒ Graze
- ❒ Other (please specify)

_____

~~12.~~11. What are your main reasons for retaining stubble? (Number <u>your</u> main reasons in order of preference)

- ❒ Retain nutrients
- ❒ Increase organic matter
- ❒ Improve soil micro-organisms
- ❒ To improve soil structure
- ❒ To improve water infiltration
- ❒ To reduce pollution
- ❒ To reduce greenhouse gases
- ❒ Reduce compaction
- ❒ Other (please specify)

_____

~~13.~~12. Have you encountered any of the following problems with retaining stubble?
(You may tick more than one box)

- ❒ Stubble not decomposing before next seasons crop
- ❒ Decrease in seedling vigour
- ❒ Decrease in plant populations
- ❒ More weeds
- ❒ More disease
- ❒ Nitrogen tie up
- ❒ Unaccountable yield losses
- ❒ Other (please specify)

_____

- ❒ No problems

If you ALWAYS burn your stubble, please go to Question 14.

If you SOMETIMES burn your stubble, please go to Question 16.

If you NEVER burn your stubble, please go to Question 17.

~~14.~~13. What do you see as the major <u>problems</u> of maize stubble incorporation?

_____
_____
_____
_____

~~15.~~14. What do you see as the major <u>benefits</u> of maize stubble incorporation?

_____
_____
_____
_____

~~16.~~15. If you burn stubble, what are your main reasons for doing so?
(Number <u>your</u> main reasons in order of preference)

- ❒ Burning is quick and easy to dispose of unwanted stubble
- ❒ Burning aids in controlling weeds
- ❒ Burning aids in controlling disease
- ❒ Stubble retention causes complications in sowing the following crop
- ❒ Do not have the necessary equipment to incorporate stubble
- ❒ Stubble retention increases nitrogen tie-up
- ❒ Stubble retention increases toxins which decreases seedling vigour
- ❒ Incorporating stubble damages soil structure
- ❒ Do not have the time to incorporate stubble
- ❒ Incorporating stubble is too costly (diesel, labour, machinery)
- ❒ Soil is too wet to incorporate stubble
- ❒ Incorporating stubble has little or no agricultural benefit

❒ Other (please specify)

_____

~~17.~~16. In your opinion, what impact does burning maize stubble have on the soil for growing the following crop?

	Significantly Improves	Marginally Improves	No Change	Marginally Declines	Significantly Declines	Don't Know
Soil Structure						
Soil Fertility						
Weed Population						
Herbicide Effectiveness						
Crop Disease						
Water Infiltration Into The Soil						
Worm Population						
Long-term Cropping Sustainability						

~~18.~~17. In your opinion, what impact does the burning of stubble by all maize growers have on national greenhouse gas emissions?

- ❒ Causes significant emissions
- ❒ Causes minor emissions
- ❒ Causes no emissions
- ❒ Don't know

~~19.~~18. In your opinion, what impact does the burning of maize stubble have on air pollution in your local community?

- ❒ Causes serious air pollution
- ❒ Causes minor air pollution
- ❒ Causes no air pollution
- ❒ Don't know

~~20.~~19. Do you think that the local community views the burning of stubble as causing serious air pollution?

- ❒ Yes
- ❒ Possibly
- ❒ No
- ❒ Don't know

~~21.~~20. Do you think that the local community sees the burning of stubble as causing serious greenhouse gas emissions?

- ❒ Yes
- ❒ Possibly
- ❒ No
- ❒ Don't know

~~22.~~21. In your opinion, what impact does the incorporation of maize stubble have on the soil for growing the following crop?

	Significantly Improves	Marginally Improves	No Change	Marginally Declines	Significantly Declines	Don't Know
Soil Structure						
Soil Fertility						
Weed Population						
Herbicide Effectiveness						
Crop Disease						
Water Infiltration Into The Soil						
Worm Population						
Long-term Cropping Sustainability						

~~23.~~22. Compared to burning, what impact do you think the incorporation of maize stubble has on greenhouse gas emissions (i.e. from decomposing stubble, burning diesel etc)?

- ❒ Causes more emissions
- ❒ Causes less emissions
- ❒ No change in emissions
- ❒ Don't know

~~24.~~23. Compared to burning, what impact do you think the incorporation of maize stubble has on air pollution (i.e. from burning diesel etc)?

- ❒ Causes more air pollution
- ❒ Causes less air pollution
- ❒ No change in air pollution
- ❒ Don't know

~~25.~~24. Do you believe in most years, it is physically possible for incorporated maize stubble to break down enough before the sowing of the next crop?

- ❒ Yes
- ❒ Possibly
- ❒ No
- ❒ Don't know

~~26.~~25. Where do you think research should focus on in maize stubble retention?

_____
_____
_____
_____

~~27.~~26. If research could identify cost effective management techniques needed for incorporated stubble to break down before the sowing of the next crop, would you incorporate stubble?

- ❒ Yes
- ❒ Possibly
- ❒ No
- ❒ Don’t know

If NO, why?

_____
_____
_____
_____
_____

~~28.~~27. What increase in the maize crop's net return (gross margin) would be necessary for you to incorporate stubble instead of burning?

- ❒ $0 - $20/ha
- ❒ $20 - $40/ha
- ❒ $40 - $60/ha
- ❒ $60 - $80/ha
- ❒ Greater than $80/ha
- ❒ Don’t know

~~29.~~28. If a subsidy were paid to you to stop burning stubble to reduce air pollution, what subsidy level would be necessary for you to stop burning stubble?

- ❒ $0 - $20/ha
- ❒ $20 - $40/ha
- ❒ $40 - $60/ha
- ❒ $60 - $80/ha
- ❒ Greater than $80/ha
- ❒ Don't know

~~30.~~29. Do you believe the research into maize stubble management practices could be applied to other crops?

- ❒ No
- ❒ Yes → **Which crops?**

Dryland	Irrigated	
❒	❒	Rice
❒	❒	Sorghum
❒	❒	Soybean
❒	❒	Wheat
❒	❒	Barley
❒	❒	Canola
❒	❒	_____

Thank you for your time in completing this survey. Any problems with the questions please do not hesitate to contact David Robinson by phone: (02) 6960 1579, fax: (02) 6960 1600 or
email: david.robinson@grf.clw.csiro.au

If you wish to enter the draw for the prize, please leave your name and contact details below.

Name: _____

Address: _____

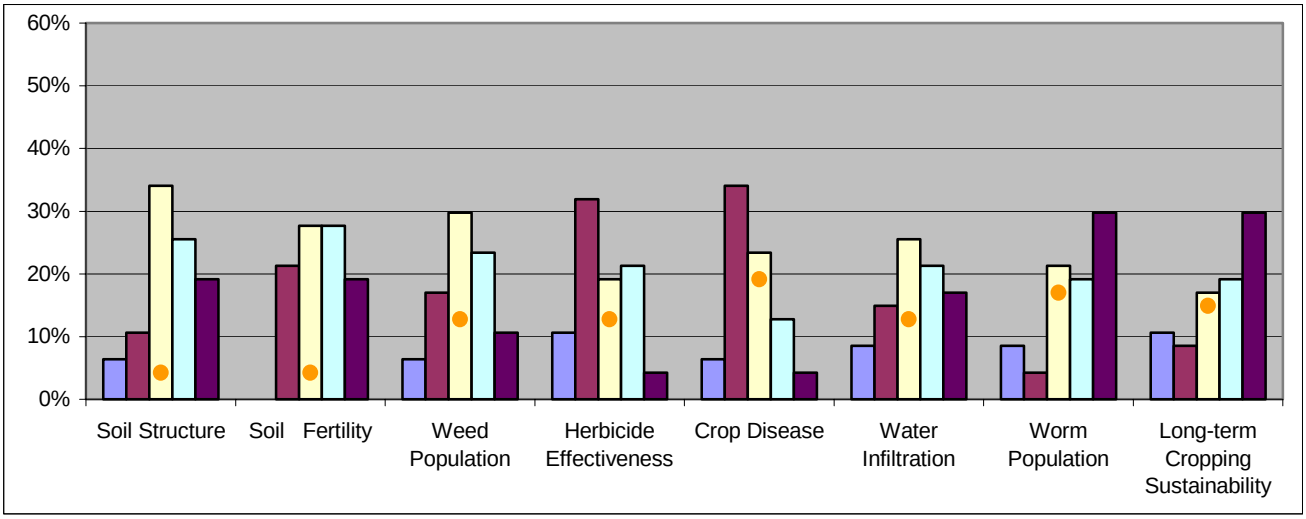
_____

Phone: _____

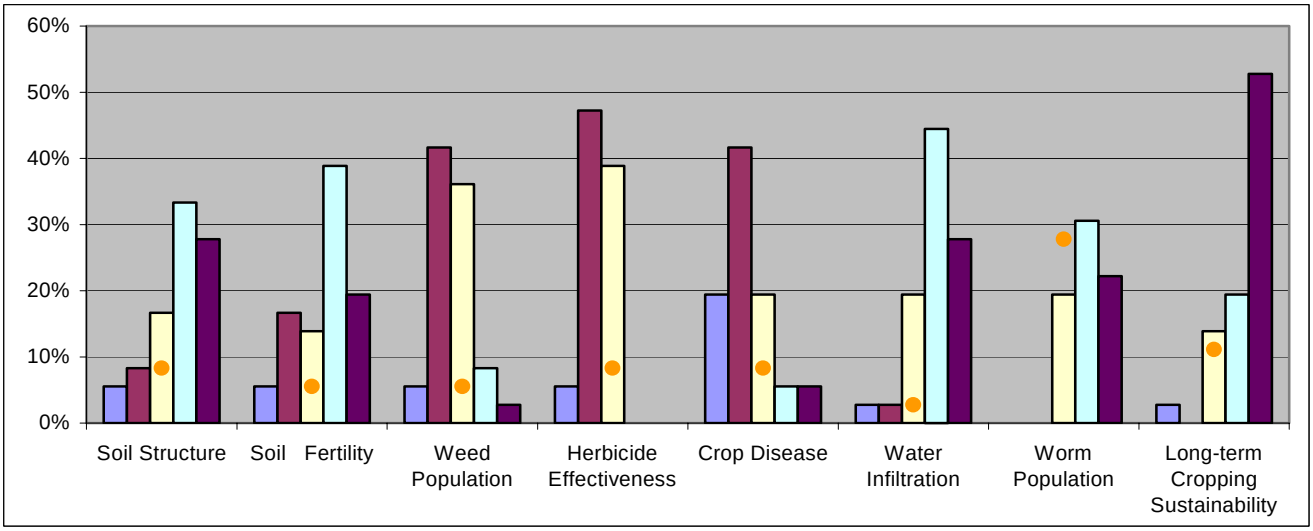
❒ Please send me a summary of the results

APPENDIX II - Maize Grower's Opinion (by region) of the Impact That Burning of Stubble has on Soil and Growing the Following Crop

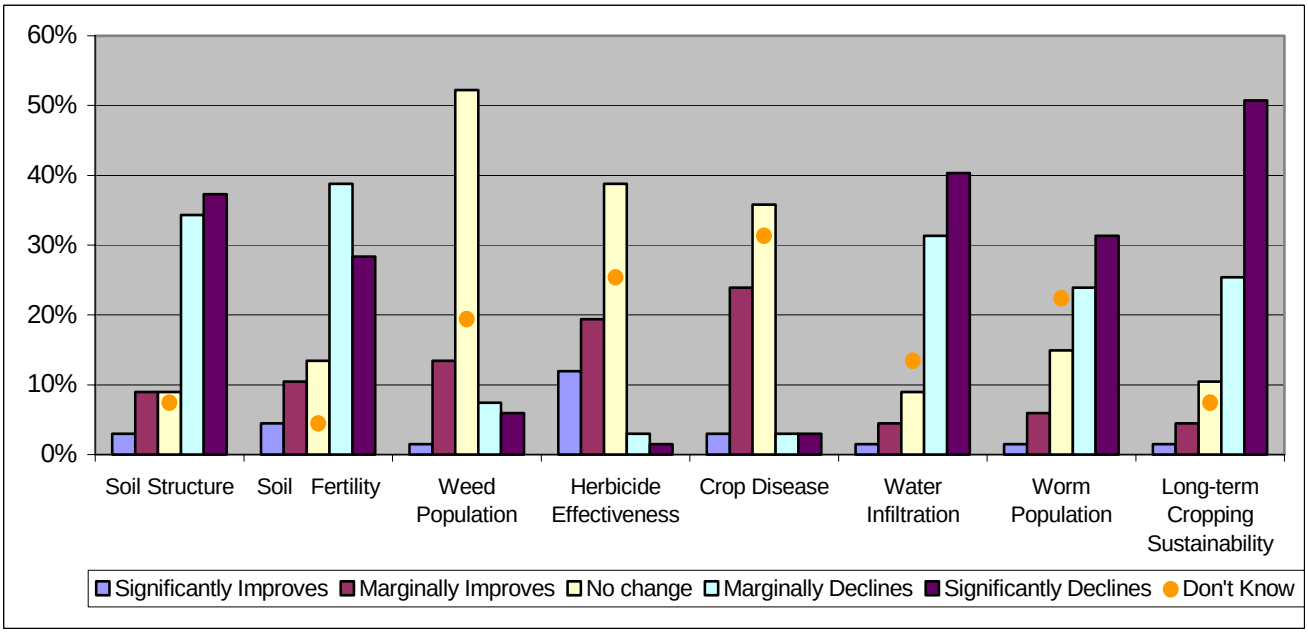
Southern NSW



Northern NSW

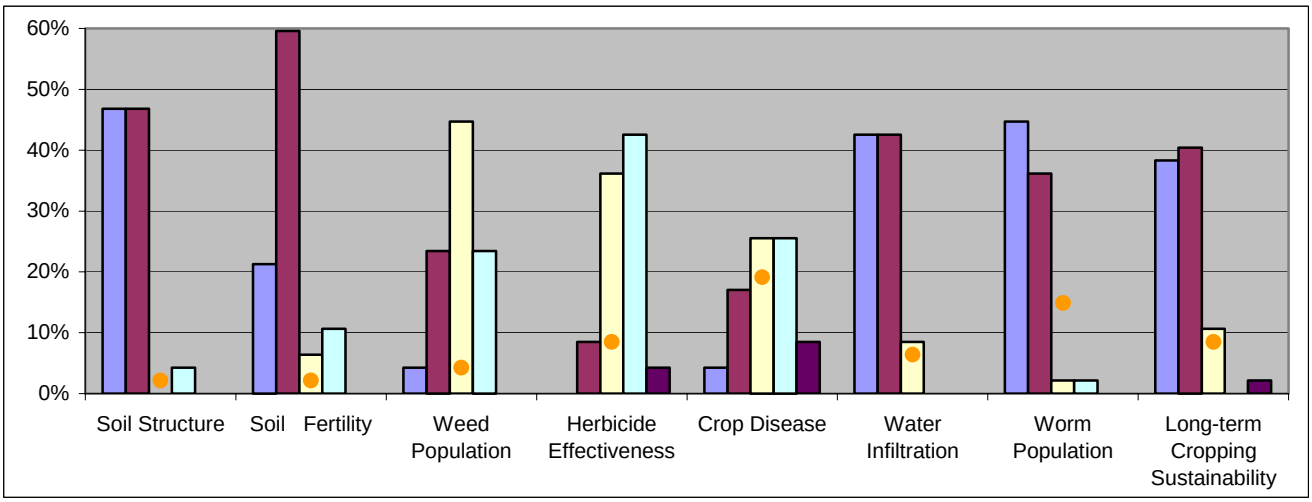


Southern Queensland

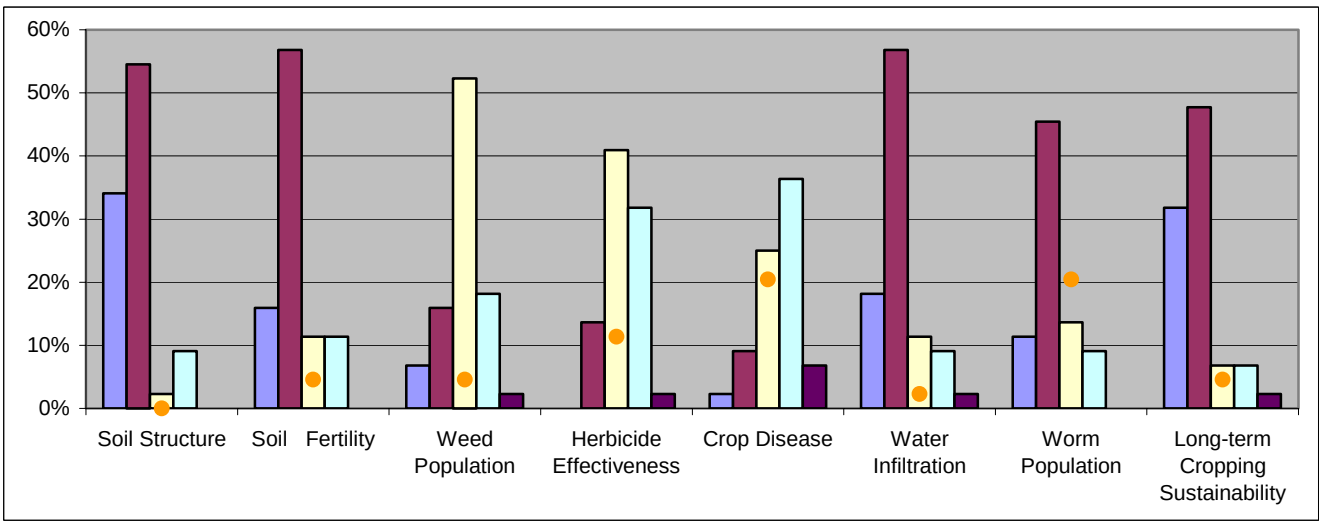


APPENDIX III - Maize Grower's Opinion (by region) of the Impact that Incorporation of Stubble has on Soil and Growing the Following Crop

Southern NSW



Northern NSW



Southern Queensland