1985

Stubble retention effects on soil water storage and yield.

D. Tennant

DEPARTMENT OF AGRICULTURE
WESTERN AUSTRALIA

SUMMARY OF EXPERIMENTAL RESULTS

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PLANT RESEARCH DIVISION

STUBBLE RETENTION EFFECTS ON SOIL WATER STORAGE AND YIELD

Three stubble retention investigations were carried out in 1985 in collaboration with Dr. A.P. Hamblin, now of the CSIRO Dryland Crops and Soils Research Group. One of the trials was managed by Mr. R. Jarvis - 84M1. We are indebted to him for all 1984 data referred to in this report and for the dry matter and yield data obtained in 1985.

84M1: Merredin Research Station on red brown earth soil type

1984 data

The trial site grew a drought affected 200 kg/ha wheat crop in 1983. Two, four and eight tonnes/ha of stubble was spread by hand in mid-January and early-May 1984 in a randomised block design with 4 replications. Plots were seeded on May 24 with a trash handling combine with 45 kg/ha Gutha wheat.

Rainfall over March, April and May 1984 totalled 180 mm, 100 mm above average. Growing season rainfall over the period June to October totalled 106 mm and was of the order of 61 per cent of the long term average. Conditions were ideal for water conservation with stubble retention over the late Autumn period and for demonstration of yield responses to these levels of water conservation. Plant establishment was not affected by straw, being nearly 120 plants m^{-2} for all treatments. Stubble applied at 8 t/ha^{-1} gave a yield increase of 376 kg/ha^{-1}, 18 per cent higher than when no stubble was present. The 2 and 4 t/ha^{-1} applications averaged a 190 kg/ha^{-1} increase, 9 per cent higher yields than the nil stubble treatment. On the basis of a 40 per cent harvest index and an expectation of 2 t/ha^{-1} as a good yield for red brown earths in the Merredin area (Smith and Perry, 1981) best levels of stubble which can be expected after wheat are of the order of 3 t/ha^{-1}. On the basis of these results, at best, a 10 per cent yield response to stubble retention is possible. However, in most years, stubble availability is only of the order of 1 to 2 t/ha^{-1}, and the yield responses found in the trial reported here would seldon be bettered.

Some water profile data were obtained March 29 and May 17, 1984. The data are limited to the 0 and 8 t/ha^{-1} stubble treatments only.

1. In the nil stubble treatment, water storage after 82 mm of rainfall was about 25 mm; i.e. 30 per cent of incident water.

2. Addition of 8 t/ha^{-1} stubble raised water storage by a further 14 mm to give 48 per cent storage of incident rain.

The 376 kg/ha^{-1} yield benefit from applying 8 t/ha^{-1} stubble was in part due to this additional 14 mm of stored water, and in part due to reduced evaporative losses during early crop growth. If we accept that yield benefits from stored soil water are of the order of 15 kg/ha^{-1} mm^{-1} (Tennant 1981), the 376 kg/ha^{-1} higher yield with application of 8 t/ha^{-1} of stubble is due to a saving of 25 mm of stored water, giving a first estimate of reduced evaporative loss during early plant growth of 11 mm. Using the same calculation, the 190 kg/ha^{-1} yield benefit from applying 2 and 4 t/ha^{-1} of stubble relates to a total water saving of 13 mm, 12 mm less than the 25 mm estimated as being saved after applying 8 t/ha^{-1} straw.

1985 Data

This trial was extended in 1985 to include two, four and eight tonnes/ha of straw applied in April 1985 and a further 8 tonnes/ha of straw applied to the treatment which had 8 tonnes/ha applied in January 1984. Trial details are supplied in Mr. R. Jarvis' experimental summary. Detailed water profile data were obtained throughout the growing season using a neutron moisture meter.

Rainfall over March, April and May totalled 46 mm, 33 mm below average. Growing season rainfall over the period June to October totalled 165 mm, 9 mm below average. Rainfall distribution over this period featured lower than average June rainfall (47 per cent) and higher than average September rainfall (141 per cent).

Though a calibration is not as yet available to convert raw neutron moisture meter data to absolute amounts of stored soil water, neutron count ratio data can be used to give relative information. Early rainfall infiltration was significantly greater with increasing stubble. Relative infiltration levels are indicated in Table 1. Subsequent relative plant water uptake increases with increasing stubble. A feature of the data is that standing stubble had as much effect as 2 and at times 4 t/ha stubble. This benefit in water infiltration and storage is translated into 30 - 35 per cent higher grain yields than if stubble had been burnt. 8 t/ha and higher stubble gave 60 per cent higher grain yield than burnt stubble.

84M5: Merredin Research Station on red brown earth soil type

Summer Data

84M5 was initiated over the summer of 1984/85 to look at stubble effects on infiltration and evaporation. Treatments included tall cut stubble, short cut stubble, stubble applied at 1, 2, 4 and 8 tonnes/ha and burnt stubble. Stubble improved infiltration of water from a sprinkler irrigation of 50 mm. Relative to burnt stubble, infiltration was 16 mm higher with 1 t/ha stubble and 28 mm higher with 4 t/ha stubble. Tall cut stubble was no more effective than applied stubble of the same weight. At 60 days after irrigation water storage relative to that of burnt stubble was 9 mm higher with 1 t/ha stubble and 12 mm higher with 4 t/ha. There was no advantage to higher than 4 t/ha stubble. Evaporation rates and amounts increased with increasing stubble to 4 t/ha.

Winter Data

In winter, part of the experiment was lightly cultivated. In order to maintain parity of stubble levels, the old straw was removed, a dummy "seeding" carried out, and fresh straw from the same bales used in summer, reapplied. A comparison of stubble weights showed almost no loss by decomposition at the lower stubble levels over summer and autumn. This contrasts with the rate of stubble decay observed in other parts of Australia which receive more summer rainfall. It may be an unexpected advantage contributing to the effectiveness of low levels of stubble, which are the norm in these drier areas.

Water balance measurements in the top meter of the profile between July and November clearly showed that stubble increased water storage. Figure 1 summarises the situation. There was little difference between stubble treatments in total water storage. By mid October, water storage was 20 mm higher under the stubble than no stubble treatments. At this point 74 per cent of rainfall on nil stubble had been lost through evaporation, leaving 26 per cent stored in the soil. In contrast, 58 per cent of incident rainfall was lost through evaporation from the stubble treatments, leaving 42 per cent stored in the soil. The absence of differences between the stubble treatments contrasts with the differences evident in the cropped trial (84Ml), and is not explicable. If we use the expectation of 15 kg/ha higher yields with each mm of water stored in the soil (Tennant 1981), 300 kg/ha from 20 mm is close to the 270 kg/ha higher grain yield with 8 t/ha than burnt stubble of 84Ml.

Evaporative losses were generally less with increasing levels of stubble (Table 2). Responses reflected rainfall intensity. Over one period (30/7 - 13/8), when rainfall incidents were light and frequent (Figure 1), water loss was greater with the high than low stubble treatments, presumably because more water was held and therefore lost through evaporation from the high than low stubble quantities. Proportionally less rainfall reached the soil in these circumstances. With higher rainfall intensities, increased water storage is mainly attributable to more rapid infiltration beneath stubble (Figure 2). More water was evaporated from the 0-5 cm layer of stubble treatments. This is considered to have given a more effective dry-mulch barrier to falling-rate evaporation from upward capillary transport in the stubble treatments.

The results are interesting. As wheat yields in the Merredin area are seldom more than 1.5 to 2 t/ha, it was not considered likely that stubble levels would be sufficient to have an effect on evaporation and infiltration. The data show yield responces (10 per cent in 1984 and 30 per cent in 1985) in dry years which appear to follow from greater water storage.

TABLE 1. 84Ml Relative rainfall infiltration and plant water uptake; and grain yields

Treatment	Relative rainfall infiltration 2/7-10/9	Relative water uptake 10/9-22/10	Grain Yield (kg/ha)
Burnt	.30	.30	424
Stubble			
0 t/ha*	.44	.42	560
2 t/ha	.40	.40	572
4 t/ha	.44	.50	572
8 t/ha	.55	.62	675
16 t/ha	.68	.66	695

Standing stubble - nil applied stubble.

TABLE 2 84M5 Stubble effects on soil evaporation (mm)

	2/7-16/7	16/7-13/9	30/7-13/8	13/8-27/8	27/8-10/9	10/9-24/9	24/9-8/10
No stubble	17.2	17.1	11.0	16.7	6.7	14.0	9.7
1 & 2 t/ha stubble	11.3	9.6	13.4	14.4	7.1	15.2	4.7
4 & 8 t/ha	11.7	5.9	16.0	14.2	6.6	15.9	6.1

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Figure 1. Relative Water Storage from July to November with water at 2nd July 1985 equated to 100%.

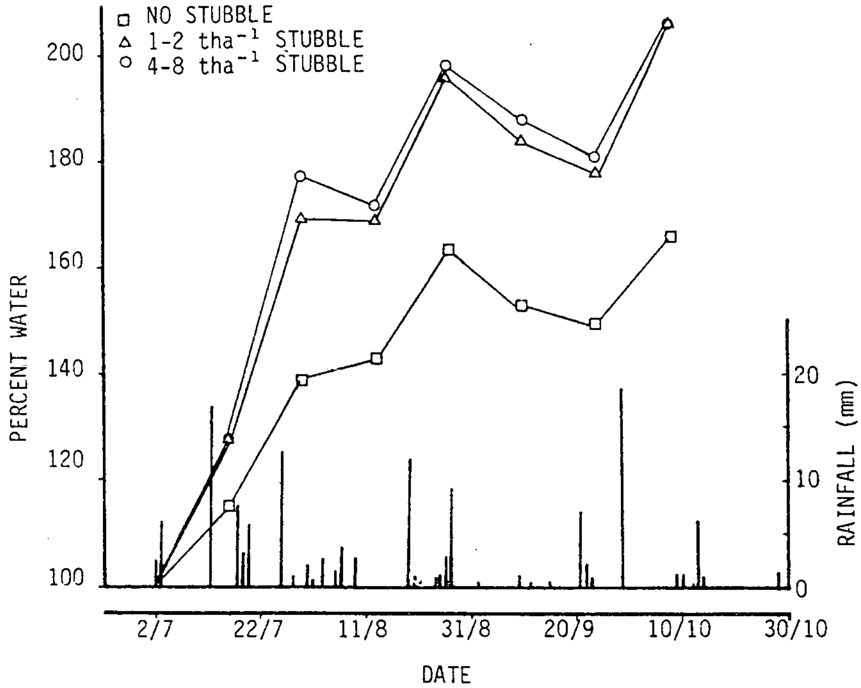

Figure 2. Infiltration profiles a week after a rainfall event of 19 mm in late September.