A REVIEW OF SOYBEAN RESEARCH IN THE NORTHERN TERRITORY 1970 - 1980

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INTRODUCTION

Soybeans have long been considered a potentially suitable crop for the area of the Northern Territory between Katherine and Darwin (lats 12-15°S). For many reasons, the potential has never been realised and successful commercial soybean production has never occurred.

Renewed interest in soybean has been stimulated by the formation of the Agricultural Development and Marketing Authority (A.D.M.A.) and subsequent development of project farms in the Douglas Daly area. Soybeans are seen as one of the main crops for this area.

Prior to 1970 cultivars suitable for production in low latitude tropical regions of Australia were unavailable. However, a breeding programme conducted by Dr D. Byth of Queensland University, rectified this situation and suitable cultivars have been available for the last decade. Successful production of

Byth's cultivars has been undertaken in the Ord River Irrigation area (O.R.I.A.) (lat 15°S) of Western Australia (Beech et al 1982a, b). Given the known dominance of daylength in determining soybean adaptation (Garner and Allard 1930) one could expect that the same cultivars would be suitable for the Top End of the Northern Territory (12°-15°s). Preliminary studies (Garside and Buchanan 1982) have shown this to be the case.

In this paper I attempt to summarise the results of research during the last decade and to establish the reasons for generally inconsistent and disappointing yields. In addition, I hope that this review will provide a foundation upon which future research can be based.

AN OVERVIEW OF PREVIOUS RESEARCH

Studies with soybean in the Northern Territory are in their third phase in the last decade. Cultivar evaluation experiments and bulk cropping studies dominated the early phase between 1970 - 1973. Most of this work was carried out in the area north of Katherine.

The second phase centred on Katherine in 1977 - 78 and concentrated on cultivar evaluation, plant population and establishment studies.

The third phase commenced in the 1979 - 80 season at Douglas Daly Research Farm with studies on cultivars, plant population, and bulk area sowings. Current research is being concentrated in this area.

A striking feature throughout has been the high turnover of personnel and during the last decade at least six different agronomists have been involved in the research program.

Phase I (1970 - 1973)

Experimental results were variable with the majority of experiments producing poor yields for one reason or another. The studies between 1970 - 1973 involved both wet and dry season sowings of a range of Byth's lines bred for low latitude tropical areas.

An initial study was conducted by Airey at Tipperary Station in the 1969 - 70 wet season. In this study a range of Byth's K lines were compared with several established U.S.A. cultivars. Although yields were poor the experiment demonstrated the greater suitability of the K lines for this environment. From a December 20 sowing the main flowering times were 30 days after sowing (D.A.S.) for the U.S.A. cultivars and 41 D.A.S. for the K lines. Resultant mean yields were 250 kg ha^{-1} for the U.S.A. cultivars and 620 kg ha^{-1} for the K lines. Miller noted that seed quality was very poor and concluded that this was due to damage caused by the green vegetable bug. Relevant data is presented in Table 1.

In 1970 - 71 cultivar evaluation studies were conducted at Coomarlie Creek, Thorak's Reserve, and Tipperary by Doug Airey (File J 71/7). The results for this season were very

encouraging, particularly for the study at Coomarlie Creek. In each experiment seven K lines were tested along with Avoyelles and Improved Pelican at Thorak's Reserve and a number of introduction from Angola at Coomarlie Creek. Relevant results are presented in Tables 2 (Coomarlie Creek), 3 (Thorak's Reserve) and 4 (Tipperary).

Mean yield for the K lines at Coomarlie Creek was 3 300 kg ha^{-1} and they easily outyielded the other cultivars (Tables 2). While mean K line yields were lower at Thorak's (1 750 kg ha^{-1}) and Tipperary (1 227 kg ha^{-1}) they were sufficient to indicate the crops' potential.

Plant population is thought to have played a major part in the yields achieved. Experience in the O.R.I.A. suggests that plant populations of the order of 400 000 - 500 000 ha^{-1} are necessary for maximum yield (Beech, pers comm.; Garside, unpub. data). Mean plant populations for the K lines were 590 000, 440 000, and 216 000 ha^{-1} for Coomarlie Creek, Thorak's and Tipperary respectively. In a separate study at Tipperary Station this season Brockway and Kilpatrick (File J 71/1) showed that yield increased with increased plant population (TABLE 5) up to 860 000 plants ha^{-1} for the K lines.

Given the population at Thorak's higher yields could have been expected however a relatively wide (53 cm) row spacing was used and complete canopies were rarely formed. In his report on this experiment Airey noted that vigour was less than expected and that this could be blamed on the poor physical status of the

soil. By contrast, at Coomarlie Creek - "The growth of the crop was very vigorous, far more so than in the Thorak's Reserve experiment. The vigour of growth and the narrowness of the row spacing produced a closed canopy early in the growth of the plots, a fact which assisted in weed control".

No data on rainfall for any of these sites was presented but it was noted that - "rainfall was particularly favourable for rain-grown crops". It was thought that neither Coomarlie Creek nor Thorak's Reserve would have suffered any moisture stress whereas Tipperary may have suffered some moisture stress at the end of the season because of late planting.

Wet season cultivar evaluation studies were carried out by Rick Madin at Berrimah Research Farm in 1971 - 72 and at Tipperary Station in 1972 - 73 (File No. J72/1013). A total 20 cultivars sown at Tipperary in 1972-73 were the best selections from 146 lines sown at Berrimah in 1971 - 72.

In his summary of the Tipperary trial, Madin suggested that the relatively poor yields obtained were due to poor plant stands, bacterial pustule disease and green vegetable bug damage. The majority of the cultivars included in these experiments were Byth's K lines, 49 series, and 71 series. Most had a growing season in the range of 120 - 130 days and could be classed as mid - late seasoned. The best yields obtained were around 1 100 kg ha^{-1} from some of the 71 series lines which were the earlier maturing lines, e.g. 71-18 matured in 115 days and yielded 1 120 kg ha^{-1}.

In the 1971 - 72 evaluation these 71 series lines had produced the highest yields of up to 1 800 g plot-^{1}. No details of plot size are given.

Apart from these experiments, there were bulk sowings of soybean in the 1971 and 1972 dry seasons at Lake Deane and Adelaide River, respectively (Files J71/201 and J72/310) and the 1972 - 73 wet season at Adelaide River (File J72/983).

In the 1972 - 73 wet season cultivars Ross and Gilbert were sown at Adelaide River on January 6 and harvested on May 8 (122 days growing season). Machine harvested yields were 340 and 450 kg ha-^{1} for Ross and Gilbert, respectively. A report on this crop by Airey highlighted the problems as low plant population, severe weed competition, waterlogging, nutrient deficiency, and lack of nodulation. Captan fungicide was applied to the seed and it is thought that this killed the Rhizobia. The major reason suggested for low plant population was the deep sowing of 7.5 - 10 cm. Airey noted that where seeding was shallow, good stands occurred and quadrat yields from these areas were up to 1 600 kg ha-^{1}.

Even if reduced establishment due to deep seeding had not occurred, the initial seeding rate was inadequate to provide an acceptable plant population for January sown soybean in this environment (viz. Coomarlie Creek cultivar study; Tipperary plant population study; experience in O.R.I.A.). Cultivars Ros and

Gilbert have a seed size in the order of 9 - 11 g per 100 seeds. At the seeding rate of 34 kg ha^{-1} maximum plant population (100% establishment) could only have been of the order of 300 - 380 thousand ha^{-1}. The area harvested by quadrat sample had a population of 300 000 plants ha^{-1}. Airey noted that this population was "half the density of a stand at Coomarlie Creek in 1970 - 71 which produced yields of 3 000 kg ha^{-1}.

The dry season irrigated crops at Lake Deane in 1971 and Adelaide River in 1972 were both failures. At Lake Deane in 1971 sowing was carried out in late July - early August and harvesting from late October onwards. No yields are available but a general comment from Airey was that "growth was extremely poor".

The Adelaide River crop in 1972 was more successful. In this instance sowing was carried out in mid-June. Cultivar Ross flowered at the end of July (46 days) and harvesting commenced in early October. At harvest plants were still green but pods were mature and, in fact, some had shattered. This characteristic has also been recorded with July sown Ross in the Ord River area and is probably associated with a photoperiodic response to increasing day length.

Yield from the area was 730 kg ha^{-1}, which was poor, however a comment suggests that seed quality was good. Apart from the fact that the cultivars used, Ross and Gilbert, are unsuitable for dry season sowing, particularly for so late a sowing, there are indications that plant populations were again far from adequate.

Certainly the use of relatively wide 50 cm rows would have been unsuitable and the fact that grass weeds emerged as a problem in late August suggested inadequate ground cover.

Research into soybean was curtailed after 1973. Experiments were planned for 1973 - 74 but wet weather did not permit sowing. Further, loss of staff after cyclone Tracy in 1974 stopped all crop research for several seasons.

Phase II

The second stage of soybean research was centred on Katherine and included studies on cultivars (File 79/56), plant population (File 79/1431), and establishment (File 79/1430). This work was conducted by Putland in 1977 and 1978.

Cultivar evaluation studies were conducted in the 1977 - 78 wet season and 1978 dry season. The wet season experiment was abandoned due to extremely poor establishment even after planting twice, on December 17 and January 16. With the initial sowing, emergence seems to have been acceptable but there was a high mortality immediately after emergence. Putland described this as "wilting and dying". Hot, dry conditions are thought to have been responsible. With the January 16 sowing emergence was very poor because of surface crusting. The experiment was then abandoned.

All the cultivars planted in the above experiment were sown in the 1978 dry season. In this instance establishment was acceptable although very variable between cultivars. Sowing was carried out on April 19 and 20 at Katherine Experiment Farm. Furrow irrigation was supplied as necessary. In this experiment most of the lines were again from Byth's breeding program and the majority of these were representatives of new early maturing crosses called P lines.

In general, Putland found that most of these lines flowered in 40 - 45 days and matured in 100 - 110 days.

Plant establishment was variable and population was well below optimum. The best populations were around 200 000 plants ha^{-1} and hand harvested yields from populations of this order were 2 490 kg ha^{-1} for P25, 2 328 kg ha^{-1} for P32, and 2 014 kg ha^{-1} for P48.

In this experiment Putland collected information on characteristics such as pod height (lowest and highest), seed colour, shattering, determinancy, 100 seed weight, as well as grain yield. It is obvious from the 100 seed wt. data that large seeds were produced, e.g. 17.8 gm for P27, 13.9 g for P25, 16.3 g for P2 (dry weight basis).

The results from this experiment are quite valuable and give a good indication of varietal response in the dry season. The major limitation is that all of these lines are better adapted to wet season production and it is a pity that they were not thoroughly evaluated in the wet season.

Putland planted two other experiments in the 1977 - 78 wet season, a plant population experiment and a method of establishment experiment. The plant population experiment encountered the same establishment problems as the wet season cultivar experiments. Like the cultivar experiments, it was planted twice. The early sowing (December 19) suffered from wilting and plant death associated with very hot, dry soil conditions, and the later sowing suffered from poor emergence due to surface crusting. This experiment was abandoned.

The establishment trial was sown on January 21, 1978, under what Putland called "ideal conditions". In this experiment three planting machines were used and planting was at three different depths (2, 5 and 10 cm). Here the results showed that there was no difference between planting machines or planting depth. Putland concluded that providing conditions were suitable, planting method had little effect on establishment.

Suitable conditions were classed as moist soil at sowing, and conditions that do not encourage surface crusting nor high surface temperature.

Experimental work on soybeans at Katherine was discontinued after the 1977-78 wet season in favour of mungbeans.

Phase III

The third phase commenced at Douglas Daly Research Farm in the 1979 - 80 wet season with cultivar (File 79/1838), plant population (File 79/1836), and bulk sowings (File 79/1721) conducted by Irene Kernot.

In the cultivar evaluation study a range of Dr Byth's lines were sown on both Tippera and Blain soils. Sowing dates are not known. Results from each experiment are very sketchy and no yield data is available. The Tippera site was overgrown by weeds and the Blain site suffered from severe nutrient deficiency. One important response noted by Irene Kernot was an apparent different response to nutrient status between cultivars. She noted that Canapolis, V15 and Gilbert appeared well adapted to the Blain soil compared with the other lines.

Information collected on phenological development suggests that most of the P lines flowered in 29 - 30 days and matured in 90 days, Ross flowered in 35 days and matured in 95 days, and the V lines flowered in 45 - 50 days and matured in 120 - 130 days.

Plant population studies were conducted on each soil type (Tippera and Blain). Cultivar Ross was sown at seven (7) plant populations between 50 000 and 1 000 000 plants ha^{-1} planted at equidistant spacings to eliminate row effects. The results showed that the highest yields were obtained with 50 000 plants ha^{-1} on the Blain soil and 600 000 plants ha^{-1} on the Tippera soil.

The soybeans on the Blain were observed to be nutrient deficient and this is suggested as the reason for lack of response to population. Yield component analysis suggest there was something drastically wrong with the site. Only 10 - 11 nodes were produced regardless of population and this is considerably less than can normally be expected from a January sowing. In the O.R.I.A. normally 15 nodes are produced by January sown Ross. In addition, there was no height difference between different treatments.

On the Tippera site height differences were recorded between treatments and general nutrient status was regarded as adequate. Apparently node numbers were not recorded. Weeds were a major problem with the lower populations, leading to the conclusion that higher populations could be utilized to control weeds. Again, this lack of weed competition could in part have helped produce the better yields from the higher population treatments.

In the bulk plantings six cultivars - Ross, Canapolis, Gilbert, V15, Fitzroy and V10 - were sown on Tippera soil. Estimated yields ranged from nothing to about 1 600 kg ha^{-1}. Actual yields were considerably less due to shattering. No valid comparisons could be drawn between cultivars due to variations in plant population which ranged from 10 000 - 350 000 plants ha^{-1}. The very poor yielding cultivars, Fitzroy and V10, had the lowest plant populations.

CONCLUSIONS

The most successful studies conducted were in the 1970 - 71 season, particularly the study at Coomarlie Creek. The results from that season showed that good wet season crops of soybeans could be produced in the Top End using K line cultivars. However, given these results little has been done to properly utilise the findings. Follow up work has concentrated on further cultivar evaluation while the general agronomy has been neglected except for the establishment (Putland) and Plant population studies (Brockway and Kilpatrick; Kernot). This, I believe has been a major shortcoming of the entire soybean evaluation program in the Northern Territory. Certainly, there are now more suitable cultivars available for this area than the K lines and exhaustive cultivar testing would have eventually shown this. However cultivar testing in below optimum agronomic conditions can produce very unreliable results. Intensive cultivar evaluation for the low latitude tropics has been underway in the O.R.I.A. since 1974 (Beech et al 1982a and b) and, given the overiding influence of day length on cultivar performance, the results from that area should be applicable to the low latitude areas (12-15°S) of the Northern Territory. This in fact has been shown to be the case, for the Douglas Daly area at least (Garside and Buchanan, 1982). Hence, I believe that further exhaustive cultivar testing is not warranted at this stage.

Throughout the reports two factors are clearly highlighted. In very few instances were optimum plant populations achieved and in many cases this resulted in severe weed competition. The most successful experiment, Coomarlie Creek, had a plant population of 590 000 ha^{-1} in narrow rows and this resulted in good weed control. Low plant populations have been blamed on a number of factors and certainly the establishment problems that plagued Putland have played a major part. However below optimum seeding rates and the use of relatively wide rows in many studies have meant that problems of inadequate plant population were always likely from the outset.

Other problems have been mentioned throughout the reports. Some of these were nutrition, poor nodulation, disease and insects. Surprisingly, there was very little mention of moisture stress as a major problem, suggesting that either researchers considered moisture supply adequate or other problems were so dominant that the effect of moisture stress was minor.

The research results do show that good yields of wet season soybeans can be obtained in the Top End of the Northern Territory. However, they also show that extremely poor yields are likely if proper agronomic practices are not employed. Most importantly, they show the major deficiencies in our knowledge of soybean production in the area and indicate where future research should be directed. It is abundantly clear that our first major problem to overcome is poor establishment. I expect that major

yield increases are likely to accrue with well established plant stands at optimum populations. Once this is determined the weed situation can be placed in its true perspective and we should be able to determine what weed species are real problems and what species are problems caused by other agronomic deficiencies. Economic methods of control can then be devised.

Other possible avenues for immediate attention would appear to be plant nutrition and insect, particularly pod sucking bugs, research. In addition, I believe that moisture availability is likely to become a more important problem as other agronomic deficiencies are overcome. I see moisture conservation techniques and drought tolerant cultivars are being research priorities for the future.

Finally, in many of the reports comments were made about poor quality seed. This was blamed on a number of factors, paricularly pod sucking bugs. The production of good quality planting seed is likely to assume a very important place in the development of soybean technology for the tropics. The environment is such that seed production, harvesting and storage is always likely to be a problem. Again, considerable information is available from the O.R.I.A. and the key to good seed production, apart from careful harvesting, handling and storage, is adequate soil moisture supply until maturity. This will mean that we will be dependant on irrigated production, for seed supplies of adequate quality.

REFERENCES:-

Beech, D.F., Garside, A.L., Wood, I.M. and Done, A.C. (1982 A) - Soybenas in the Ord Irrigation Area, Western Australia. 1. Response of genotypes to sowing date and plant density during the wet season. Aust. J. Exp. Agric. Anim. Husb. (in preparation).

Beech, D.F., Garside, A.L. and Wood, I.M. (1982 b) - Phenology, plant and seed characteristics of a collection of soybean genotypes grown during the wet season in the Ord Irrigation Area, Latitute 15°39'S. Genetic Resources communication (in preparation).

Garner, W.W. and Allard, H.A. (1930) "Photoperiodic responses of soybeans in relation to temperature and other environmental factors" Jour. Agric. Res. 41 : 719-735.

Garside, A. and Buchanan, D. (1982) Report on Soybean Evaluation at D.D.R.F. in the 1980/81 Wet Season.

Miller, I. (1970) - Report on Soybean Variety Trial, Tipperary Station 1969-70.

Airey, D. (1971) - "Soybean Experiments - Thorak's Reserve, Coomarlie Creek and Tipperary Station 1970-71 Wet Season". Dept. Primary Prod. File no. J71/7.

Airey, D. (1971) - "Soybean Growing Lake Deane, 1971, Dry Season". Dept. Prim. Prod. File no. J71/201.

Airey, D. (1972) - "Soybean Seed Increase - Adelaide River - 1972 Dry Season". Dept. Prim. Prod. File no. J72/310.

Airey, D. (1973) - "Bulk Soybean Seed Increase Adelaide River, 1972-73 Wet Season". Dept. Pri. Prod. File no. J72/983.

Madin, R.W. (1973) - "Soybean Variety Trial, Tipperary 1972-73 Wet Season". Dept. Prim. Prod. File no. J72/1013.

Brockway, C.W. and Kilpatrick, E.I. (1972) - "Soybean Row Spacing Trial 1971". Dept. Prim. Prod. File no. J71/7.

Putland, S. (1978) - "Soybean Seed Increase Trial, 1978 Dry Season, K.E.F.". Dept. Primary Prod. File no. 79/56.

Putland, S. (1978) - "Soybean Seed Establishment Trial 1977-78". Dept. Primary Prod. File no. 79/1430.

Putland, S. (1978) - "Effects of Population Density on the Yield Relationships of Soybeans". Dept. Prim. Prod. File no. 79/1431.

Kernot, I. (1980) - "Soybean Line Evaluation D.D.E.S. 1979-80". Dept. Prim. Prod. File no. 79/1838.

Kernot, I. (1980) - "Soybean Population Experiment, Douglas Daly 1979-80". Dept. Prim. Prod. File no. 79/1836.

Kernot, I. (1980_ - "Soybeans Bulk Demonstration Area D.D.E.S. 1979/80". Dept. Primary Prod. File no. 79/1721.

TABLE 1: Grain Yield (kg ha^{-1}) for a Range of Cultivars Grown at Tipperary Station in 1969 - 70 Wet Season

Variety	Yield (kg/ha grain)
K44	605
K53	475
K54	809
K69	707
K74	878
K152	772
K157	320
K169	399
Hernon	112
Semstar	338
Wills	327
Hill	220

TABLE 2: Results of Soybean Cultivar Evaluation at Coomarlie Creek 1970 - 71 Wet Season

Cultivar	Yield kg ha^{-1} at 12y Moist	Plant Population Plants m^{-2}	100 Seed wt (gm dry wet)	Nodes/ Mainstem	Plant Ht. (cm)
K54	3 600	60.5	9.2	7.9	63
Daintree	3 569	63.4	8.8	7.5	64
Gilbert	3 420	56.5	8.8	6.9	58
K53	3 339	62.8	9.3	7.5	67
K152	3 326	54.2	8.8	7.7	61
Ross	3 179	61.1	8.1	7.6	74
K162	2 827	57.4	8.5	7.4	64
46412	2 558	53.1	13.0	6.5	64
46410	2 550	42.6	12.1	7.2	60
46411	2 414	40.9	12.5	7.9	75
46413	2 330	34.6	12.6	7.4	59
46416	2 252	58.8	12.1	7.6	70
46408	2 111	40.4	12.2	7.9	64
46415	1 745	21.3	15.2	6.9	54
46414	1 491	33.5	11.6	8.9	88
30725	1 278	56.5	7.0	11.4	106

TABLE 3: Results of Soybean Cultivar Evaluation at Thorak's Reserve 1970 - 71 Wet Season

Cultivar	Yield kg ha^{-1} at 12y Moist	Plant Population Plants m^{-2}	100 Seed wt (gm dry wet)	Nodes/ Mainstem	Plant Ht. (cm)
Daintree	1 981	52.3	8.7	7.8	42
K53	1 962	46.1	8.9	6.8	43
Gilbert	1 881	42.3	9.0	7.9	38
K152	1 725	38.8	9.0	6.8	39
K154	1 637	38.4	8.0	6.9	39
Ross	1 618	57.7	7.7	7.0	41
K162	1 490	46.1	8.3	7.5	30
Avoyelles	1 446	33.0	8.7	12.6	67
Improved Pelican	907	28.4	10.7	9.8	51
CPI 46415	625	22.3	14.1	7.1	30

TABLE 4: Yield Data, Soybean Variety Trial - Tipperary Station 1970-71 Wet Season

Variety	Plant Density (Plants/sq.m)	Plant heights 1.4.71 (cms)	Grain Yield Kg/Ha
Daintree	19.5	56	1 646
K53	18.5	61	1 459
K162	38.2	53	565
Ross	28.4	65	1 705
K54	14.9	57	1 395
Gilbert	17	55	1 115
K152	14.5	56	704

TABLE 5: Results of Soybean Plant Population Study at Tipperary Station in 1970-71 Wet Season

Inter Row Spacing (cm)	Intra Row Spacing (cm)	Sown Population (Seeds ha^{-1})	Estale Pop (Plants ha^{-1})	Yield (kg ha^{-1})
8.8 cm	5.0 cm	2 273 000	864 000	3 897
17.6 cm	5.0 cm	1 136 000	431 000	1 976
35.2 cm	5.0 cm	569 000	131 000	1 258
70.4 cm	5.0 cm	284 000	59 000	865