Kasetsart J. (Nat. Sci.) 27: 484-493 (2536)

Preliminary Evaluation of Promising IRCT Glandless Cotton Varieties in Thailand

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ABSTRACT

Three recent varieties of glandless cotton from IRCT-CIRAD showed similar yields to the control Si Samrong 2 variety in an on-station productivity trial carried out during 1991 rainy season. An analysis of the agronomic, lint technology, yarn technology and seed technology data obtained from this preliminary trial is presented. A tentative economic assessment of the benefits that such varieties could bring to the national ginning industry, subject to confirmation of these preliminary results by further crop protection studies and multilocation trials, is finally proposed.

The ginning outturn of these glandless varieties was 3 to 4% higher than that of the control variety and they displayed better-quality lint, especially for length, uniformity, tenacity and maturity. When compared to Si Samrong 2, they also showed very significantly lower numbers of total neps and seed coat fragments. The three glandless varieties differ in fibre length, IRCT 413 being slightly longer than IRCT 411 (which has the highest ginning outturn); IRCT 412 is a long-fibre variety with high ginning outturn, but has more neps than the two other glandless cultivars.

Key words: cotton, glandless variety, lint technology, yarn technology.

INTRODUCTION

A sharp fall in the Thai annual seed cotton production occurred during the last ten years. Production volumes decreased from nearly 200,000 tons in the early eighties, to the current level of less than one half of this maximum amount (OAE/MAC, 1986 and 1992). A regular increase in the costs of production throughout this period is usually pointed at to explain such a downward trend. Of particular importance is the increase in pesticide use and number of insecticide applications practiced by growers to control a wide spectrum of virulent insect pests.

If cotton is to remain an attractive cash crop for the Thai farmer, priority should be given to the creation of the creation of productive, sucking insect tolerant and high lint quality varieties in order to both boost the economic value of the crop and limit pesticide use (DORAS Project, 1992). The glandless character could also be of significant interest in Thailand, because of the country important deficit in vegetal protein to feed a booming agro-processing sector, if it can be proved like in other countries that the young glandless seedling can be protected at reasonable cost against early pest insects.

Large scale production of glandless cotton varieties started very recently in several West African countries, initiating a possible “”White revolution””, in which cotton would become both a food and industrial crop. For example, during the 1991-92 crop year, glandless cotton was grown on some 80,000 ha in Cote d'Ivoire, 10,000 ha in Burkina Faso, 7,000 ha in Mali and more than 2,000 ha in Benin (IRCT-CIRAD, 1992). But when explaining the adoption of such varieties by the local national cotton development companies, it has to be recognized that their very high ginning outturn and better-quality lint are playing a more important role than the glandless character alone. Thin is mainly due to the weakness of the industrial sector that is not ready to benefit from the glandless cottonseed in these western African countries. Having a well-developed animal feed and food processing sectors, the situation in Thailand is far more favorable to make use of the glandless character.

Small amount of seeds of several recently obtained glandless cotton varieties were provided by the French “Institut de Recherches du Coton et des Textiles Exotiques” (IRCT-CIRAD) to assess their degree

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of adaptation to Thai ecological conditions, levels of seed cotton and lint productivities as well as their lint, yarn and cottonseed technological properties.

MATERIALS AND METHODS

Only results obtained with the three best performing introduced IRCT glandless varieties are described here. They are compared with a control variety, which has been extensively grown in Thailand for the past 15 years and is still the best locally available variety in term of lint quality.

Planting material

The three glandless cultivars, namely IRCT 411, IRCT 412 and IRCT 413, belong to the same HAR genetic pool (interspecific cross of *Gossypium hirsutum* x *G. arboreum* x *G. raimondii*) as the control Si Samrong 2 (SR 2) variety (in fact a local re-selection of the G 115-7 variety). The glandless character was transferred to three new IRCT varieties by using the back-cross method (Hau *et al.*, 1983).

Lay-out and statistical analysis

Because of the limited amount of seeds available, a 3 x 3 balanced lattice design with four replications was used to carry out this trial with a total of nine varieties. Statistical analysis of the agronomic data was carried out by using the "Lattice" software designed by CIRAD. No replications were made neither for lint and yarn nor cotton seed technological characteristics.

Lint, yarn and cottonseed analyses

The following yarn characteristics were evaluated after microspinning to produce yarn of 20 metric yarn count:

- yarn tenacity at breaking point obtained by pulling the yarn with a dynamometer. Two types of trials exist which use either individual yarn or a 100 m long "lea" for strength measurement. Both techniques were performed. Yarn tenacity is an important breeding criteria and it can now be estimated from fibre technology data by using formulas designed by IRCT fibre technology laboratory,

- Percentage of elongation at breaking point,

- Various (imperfections) of the yarn such as its fineness, unevenness, nepposity, hairiness, *etc*. They are measured for 1000 m of yarn. The most important criteria to be considered here is nepposity and the percentage of seed coat fragments found among the neps. Too many neps (either "tangled neps" consisting of immature fibres which have not been straightened out, or seed coat neps" which are bundles of fibres attached to small fragments of seed coat) lead to a depreciation of the yarn because they have consequences on the quality of the finished cloth (poor dyeing, broken yarn, uneven aspect of the material, *etc*).

All the lint and yarn analyses were carried out, on 40 g and 100 g samples of lint respectively, at IRCT Fibre Technology Laboratory in Montpellier-France. Cottonseed analyses were made at IRCT Cottonseed Chemistry Laboratory at the same location.

Definition of the cotton "profitability index"

The "profitability index" proposed by G. Estur (Cotton Company/French Company for the Development of Textiles is used to provide a global appreciation of the lint technological value of given variety, as well as between varieties, when compared to a reference one. The calculation of this index imposed several simplifying hypotheses, such as the independence between characters and the linearity of added values provided by each of them. This is not the case in the commercial reality, because on the market characters are interactive and prices move according to thresholds. Anyway, it remains a useful indicator to give a, somewhat theoretical, image of the technological quality of a given variety (Hau, 1990).

Experimental conditions, itinerary of techniques and trial management

The productivity trial was sown with acid delinted seeds on July 12, 1991 at Suwan station in Pakchong district, Nakhon Ratchasima province, in a block that previously received two crops of Lablab green manure. Because of the dry weather following sowing two irrigations by sprinklers were necessary at germination and emergence stages. A complete insecticide protection of the trial (comprising seed treatment with carbosulfan and a total of 14 aerial applications) was also carried out to limit pest damages.

During the second and third weeks after sowing, an early attack of the first true leaves by the Chrysomelid beetle, *Monolepta signata* was observed. No difference in the extend of leaf damages could be seen between the glanded control and the introduced glandless varieties. Later, specific crop protection trials should pay more attention to the impact of such early insect pests on young glandless cotton seedings as well as to ways to limit leaf damages, especially through seed treatment with an efficient systemic insecticide.

Damping-off affected some 4 to 6% of the glandless seedlings depending on varieties, but this had no effect on the plant density which was similar for the four varieties and very close to the objective stand of 20,000 plants/ha.

The trial suffered from a heavy infestation of the block by *Cyperus rotundus* which was controlled through a combination of manual (2 times) and mechanical (Rotary tiller in interrows) weeding techniques. A to much generous nitrogen fertilization contributed to limit weed infestation after ridging, but on the other hand led to excessive vegetative growth, especially for the introduced glandless cultivars, but the rate of logded plants at harvest remained minimal. Delayed control of the weed infestation and excessive vegetative growth were partly responsible for the observed relatively modest seed cotton yields. The three seed cotton pickings were carried out in good climatic conditions between November 21 and December 23 (131 to 163 days after sowing). From sowing to harvest, the cotton crop also received a mere 169 mm of rainfall

RESULTS AND DISCUSSION

Agronomic and technological evaluation of IRCT glandless varieties

The evaluation of the three IRCT glandless cotton varieties will be done by looking successively at their agronomic performances, rates of ginning outturn, lint technology characteristics, yarn quality parameters and cottonseed properties.

Agronomic observations

A set of agronomic data is presented in Table 1. The bushy type SR 2 variety is shorter at harvest than the pyramid shaped IRCT varieties. This excessive growth of the introduced IRCT cultivars is a major inconvenient that need improvement through both breeding work and more adapted agronomic practices. While the number of vegetative branches remained very similar among varieties, the height of the first fruiting branch is higher in the case of IRCT glandless varieties. Meanwhile, no significant difference in earliness were found among those four varieties.

It can also be noticed that the three glandless varieties are moderately hairy. This character is of particular interest because it confers to those varieties a certain degree of tolerance to jassids (especially *Amreasca biguttula*, a major pest at the beginning of the crop cycle).

SR 2 showed the highest seed cotton yield, but only IRCT 411 (which also had the lowest single boll weight) dispayed a statistically significant difference in seed cotton production. In the case of IRCT 412 and IRCT 413 varieties, their higher ginning percentages helped them to compensate for their somewhat lower seed cotton productivities.

Figure 1 also shows the location of harvested bolls along the main stem for SR 2 and IRCT 412 varieties. The importance of the share of the harvested bolls located on monopodia can be noticed, as well as the different patterns of distribution of the bolls on sympodia (bolls were more grouped in the case of

Table 1 Comparison of agronomic data among four IRCT cotton varieties grown at Suwan Farm, rainy season 1991.

Criteria	SR 2	IRCT 411	IRCT 412	IRCT 413
Heitht at harvest (cm)	161^a	191^a	192^b	195^b
No. of vegeative granches	3.8^a	4.4^a	3.2^a	3.3^a
Height 1st fruiting bran (cm)	19.7^a	25.9^a	23.7^a	21.0^a
Hairiness rating	Low	Medium	Medium	Medium
First flower (days after sow.)	57^b	55^a	55^a	55^a
First open boll (days after sow.)	115^a	113^a	111^a	114^a
Density at harvest(x 1000 pl)	20.8^a	20.1^{ab}	21.2^{ab}	19.7^b
Seed cotton yield (kh/ha)	1594^a	949^b	1529^a	1367^a
Earliness (% 1st pick./total)	61.1^a	58.2^a	63.5^a	63.3^a
Single boll weight (g)	5.0^a	4.3^b	5.4^a	5.3^a

a, b Mean values of each trait followed by the same letter do not differ significanly.

Table 2 Comparison fo roller ginning data among four IRCT cotton varieties grown at Suwan Farm, rainy season 1991.

Criteria	SR 2	IRCT 411	IRCT 412	IRCT 413
Ginning outturn (% lint)	39.5[c]	44.1[a]	43.8[a]	42.7[b]
Seed index (weight 100 seeds,g)	9.5	9.3	9.4	9.8
Lint Yield (kg lint/ha)	628[a]	419[b]	670[a]	584[a]
Chalazal damages (% of seeds)	55.3[a]	28.3[b]	23.3[bc]	19.3[c]

abc Mean values of each trait followed by the same letter do not differ significantly.

Table 3 Comparison of lint technology data among four IRCT cotton varieties grown at Suwan Farm, rainy season 1991.

Criteria	SR 2	IRCT 411	IRCT 412	IRCT 413
2.5% Span Length (mm)	2.87	29.9	32.2	31.2
2.5% Span Length (inch)	1.13	1.18	1.27	1.23
50% Span Length (mm)	13.6	15.2	15.9	15.2
Uniformity Ratio (%)	47.3	50.8	49.5	48.8
Stelometer Tenacity (g/tex)	18.4	23.7	20.1	22.0
Elongation (%)	5.5	5.2	5.4	5.2
Maturity Ratio	0.86	0.92	1.04	0.91
Fiber Maturity (%)	76.6	81.3	90.4	81.1
Fineness (Hs)	165	163	135	163
Micronair index	3.4	3.7	3.9	3.7
Rdflectance (Rd-%)	77.1	74.9	75.5	77.4
Yellow index (+b-%)	9.6	10.0	10.4	9.9

IRCT 412, as well as IRCT 413, when compared to SR 2 variety).

Ginning outturn levels

Seed cotton samples were ginned by a brand new roller gin, under a litter too much dry condition. These unfavorable circumstances partly explain the high levels of chalazal damages observed on cottonseed after ginning (Table 2).

The three glandless varieties showed ginning percentages 3 to 4% higher than the control SR 2, with IRCT 412 achieving the highest lint/ha yield. At the same time, the size of their seeds remained similar to SR 2 one. IRCT 411 showed a significantly higher ginning outturn reaching 44.1% (following 30 trials, an exceptional average saw ginning outturn of more than 47% has been reported in the literature for this variety (Hau and Ouraga, 1991). IRCT412 approached that level and displayed an even lower percentage of chalazal damages.

Data also point at a very significant difference in favor of IRCT glandless varieties when the percentage of seed damages at the chalazal by the ginning process is considered. This characteristic is of special importance here because Thai spinners frequently mention the high seed coat fragments content of the domestic lint production as its major weak point. The minimum percentage of chalazal damages was obtained with IRCT 413 variety.

The superiority of these introduced IRCT varieties is also clearly illustrated by looking at the recorded lint technology data.

Lint technology results

Data presented in Table 3 were obtained from High Volume Instrument, calibrated with ICCS cotton, and 6 replications were conducted for each technological parameter. The three IRCT glandless varieties were found superior to the control SR 2 for all key parameters such as fibre length, uniformity, tenacity and maturity (Figure 2).

IRCT 411 provided a lint characterized by an

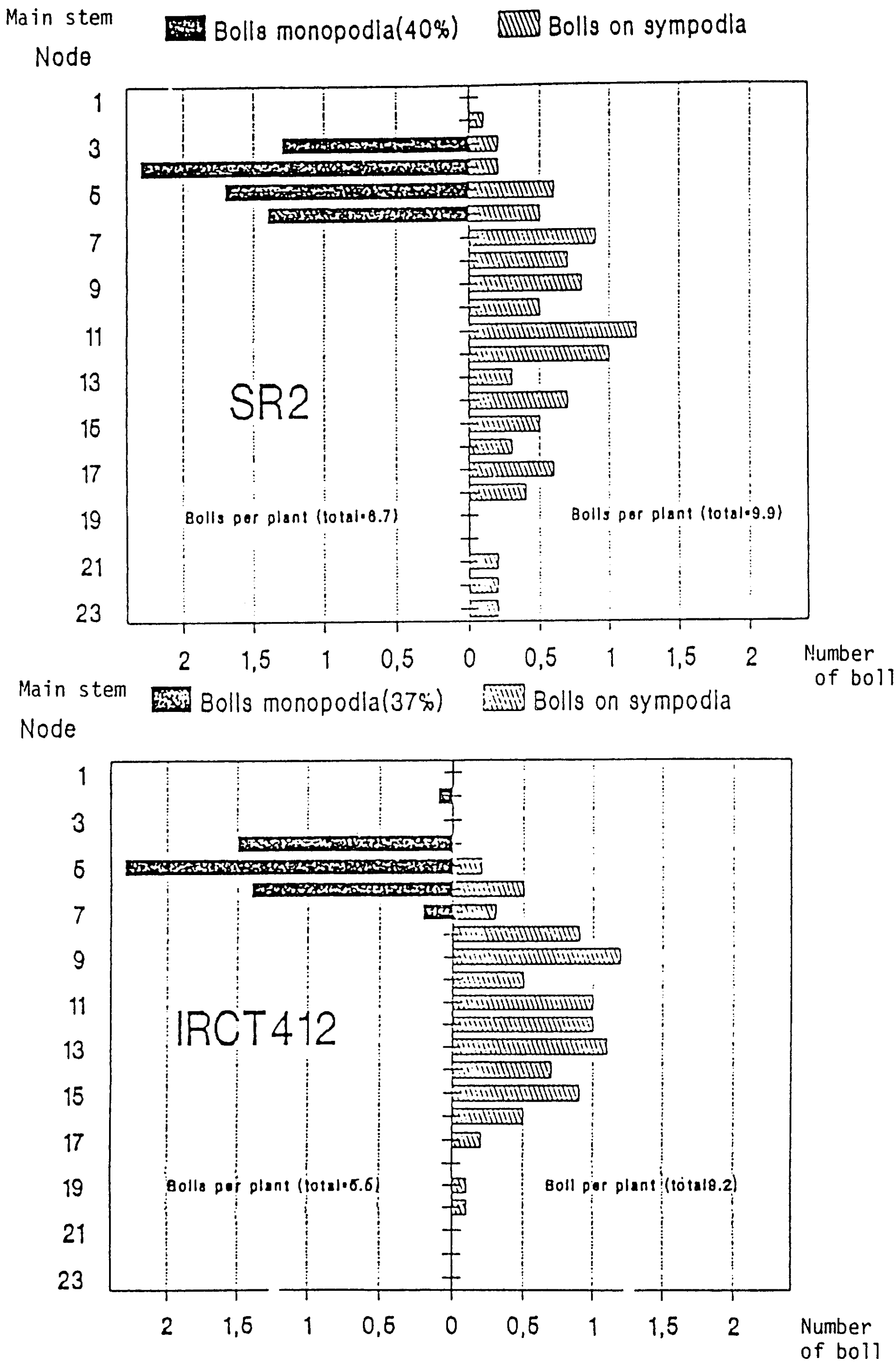

Figure 1 **Location of seed cotton production for Si Samrong 2 and IRCT 412 varieties.**

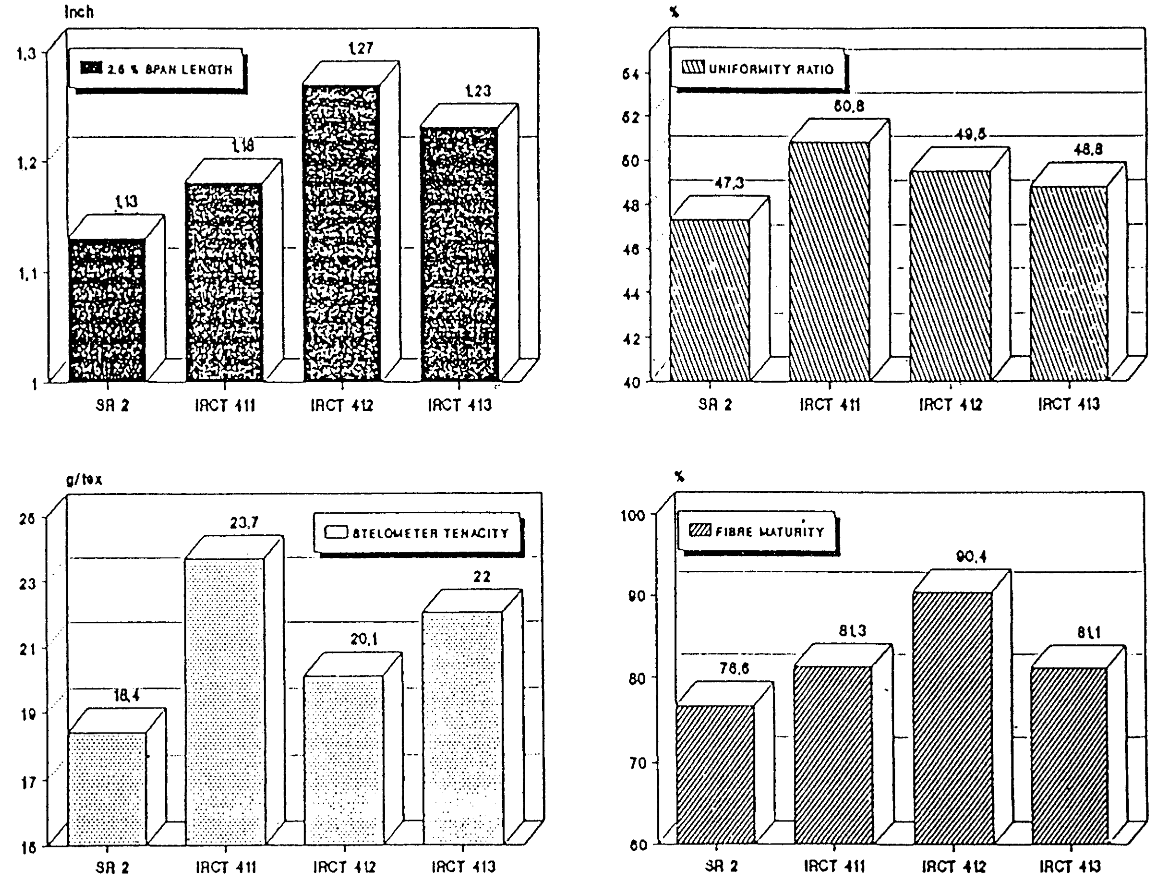

Figure 2 Graphs showing the values achieved by each cotton variety for four key lint technology parameters.

acceptable fibre length and excellent tenacity, as well as the best uniformity. An excellent fibre length was found for IRCT 412, but its tenacity, while superior to that of SR 2, was not very high. IRCT 413 lint showed the best equilibrium between all the key technological parameters of the lint (only its fibre maturity characteristic was relatively weak). The outstanding characteristics of this product led to the production of high quality yarn.

Yarn technology data

Results obtained for the four tested varieties are shown in Table 4. IRCT 411 and IRCT 413 give very resistant yarn. The tenacity of IRCT 412 yarn is better than the average quality product obtained with SR 2. All four varieties showed acceptable levels of elongation, with somewhat lower values of IRCT 411 and IRCT 413 varieties. SR 2 displayed a far too high number of neps. The value obtained for IRCT 412 is still to high and not satisfactory. Only IRCT 411 and IRCT 413 provided acceptable numbers of neps per 1000 m of yarn. The values obtained are still relatively high, but they represent already a significant improvement in comparison with preceding varieties. The seed technology data obtained for this latest variety are also interesting.

Seed technology data

Only the percentage of linters and the oil content of the seed were analysed and results are shown in Table 5.

IRCT 412 and IRCT 413 seeds seemed to be less fuzzy than for the other varieties seeds. This character could be interesting as the future of cotton planting seeds seems to be in the dissemination of delinted and treated seeds to farmers. IRCT 413 seed

Table 4 Comperison of yarn technology data among four IRCT cotton varieties grown at Suwan Farm, rainy season 1991.

Criteria	SR 2	IRCT 411	IRCT 412	IRCT 413
Resistance / Uster (cN/Tex)	15.48	17.8	16.74	18.07
Elongation / Uster (%)	7.8	7.3	6.9	6.7
Resistance / Dyn. (cN/Tex)	12.55	14.13	13.37	14.91
Elongation / Dyn. (%)	6.1	5.6	5.8	5.7
U -%	14.98	15.06	14.31	13.29
Number of Neps	1779	437	661	448
Seed Coat Fragments (%)	69.1	84.8	82.7	82.4
Hairiness	5.18	5.68	5.19	5.37

Table 5 Comperison of seed technology data among four IRCT cotton varieties grown at Suwan Farm, rainy season 1991.

Criteria	SR 2	IRCT 411	IRCT 412	IRCT 413
Linters (%)	10.53	10.74	9.82	9.79
Oil content (%, delinted seeds, at 0% H2O)	25.64	23.3	23.71	26.12

also displayed the highest oil content. As it is a glandless variety, the extraction of its oil could also be carried out at a lower cost than for ordinary glanded cotton seed.

Finally, Table 6 is presenting a kind of ranking among these four varieties that is useful to identify the most promising cultivars which deserve further studies.

A diagrammatic representation of twelve key characteristics for each variety which are summed up in "conceptual stars" is also proposed in Figure 3. The comparison of each star shapes with the ideal one helps in grading the four varieties.

Based on the very limited available data, a method for an economic global appreciation of a given variety is also illustrated in the case of the best glandless varieties IRCT 412 and IRCT 412 and IRCT 413.

Preliminary economic estimates of the impact on the industry of the possible adoption of the two best IRCT varieties

It is obvious that a single trial is not sufficient to take into account the agronomic data gathered for new varieties IRCT 412 and IRCT 413. Nevertheless, based on the observed production levels and crop management problems encountered, we can reasonably assume that their seed cotton yields could be at least equivalent to the one achieved SR 2 control variety. On the other hand, the amount of savings in insecticide applications against jassids due to leaf hairiness of these two glanded cultivars has not been studied yet.

It is well to early to assess the benefit that could be provided by the glandless character of IRCT 412 and IRCT 413 varieties (increase in oil content, sav-

Table 6 Ranking of the four studied varieties for different key characteristics.

Rank	First	Second	Third	Fourth
Agronomic data	IRCT 412	SR 2	IRCT 413	IRCT 411
Ginning outturn data	IRCT 411	IRCT 412	IRCT 413	SR 2
Seed technology data	IRCT 413	SR 2	IRCT 412	IRCT 411
Lint technology data	IRCT 413	IRCT 412	IRCT 411	SR 2
Yarn technology data	IRCT 413	IRCT 411	IRCT 412	SR 2
Overall characteristics	IRCT 413	IRCT 412	IRCT 411	SR 2

ings for oil purification costs, increased price of cake).

Because the number of neps per 1000 m of yarn obtained for the control variety is far too high, this key character cannot be taken into account below, otherwise SR 2 variety will be too much disadvantaged when compared to the two other varieties.

Only ginning outturn data and lint technology parameters will be considered in the following, very rough, assessment of the benefit that could be provided in the case of the possible adoption of these glandless varieties by farmers at national level. All this is of course subject to the confirmation, through further crop protection trials, of their tolerance to major local diseases (especially the leaf roll transmitted by aphids).

Added value provided by lint technology characteristics

Table 7 shows the characteristics of the reference variety for six key parameters, as well as the quotation of the deviations from these values in Baht per kilogram of lint. The third and fourth columns display the deviations to this reference variety for each of the three considered cultivars, first in specific units and then in Baht.

The estimated "profitability index" (without taking into account the number of neps) shows that the value reached by SR 2 is very close to the one of the reference variety, thanks to superior length and fineness performances which compensate for the other parameters. Length, maturity and fineness results give to IRCT 412 the highest PI value. Having only one small negative value for elongation in comparison to the standard variety, IRCT 413 displays again in this table the very good equilibrium between its technological characteristics.

Table 8 presents the differences between the two glandless varieties and SR 2. For a given average national lint production of some ton 38,000 achieved during five crop years (1985/86 to 1989/90), the incremental commercial value (in million baht) provided by the substitution of IRCT 412 or IRCT 413 to SR 2 would be as follows:

* if IRCT 412 is substituted to SR2:
38.00 * 6335 = 240.7
* if IRCT 413 is substituted to SR2:
38.00 * 4155 = 157.9

More benefits could come from the outstanding ginning outturn observed for these two IRCT glandless varieties.

Added value provided by high ginning outturn

The possible added value due to the very high ginning outturn recorded tor the two IRCT glandless varieties are estimated in Table 9.

Finally, the possible benefits gained at the ginning factory level from the adoption of these two glandless varieties are summed up in Table 10. Because of the several other positive characteristics of the glandless varieties that could not be quantified at this time, the above-mentioned global benefits could be considered as being minimized.

CONCLUSIONS

At this stage, IRCT 412 and IRCT 413 can be considered as the most promising glandless varieties. The superiority of the technological characteristics of their lint seems to show a clear improvement in comparison with SR2. Particularly, the improved length of their lint would be highly appreciated by Thai spinners, because a large majority of them are still using the ring spinning technique. On the other hand, the very high ginning outturn achieved by these two cultivars could help boosting the competitiveness of the local ginning industry.

Nevertheless, more studies are needed, especially in crop protection and multilocation trials before to conclude on the possibility to grow one of these high quality IRCT glandless cotton variety under Thai ecological (and socio-economic) conditions.

More breeding work is also needed to refine our knowledge one the optimum type of hairiness required to balance tolerance to the jassids with possible negative impact of this character on other insect pest populations (aphids, white flies, american bollworm). The breeder and the agronomist will also have to work together to reduce the too much "vegetative" aspect of these introduced varieties in the field. Finally, the preliminary set of data presented in this paper shows that an in-depth experimentation of the HAR genetic pool could be of great interest to improve the quality and economic value of the cotton crop in Thailand.

ACKNOWLEDGMENTS

The authors would lied to express their appreciation to Dr. Bernard Hau and Mr. Jean Couthiere, from IRCT Genetics Division, for providing seeds and advice for this experiment, as well as useful comments on a draft version of this paper. Commentaries on lint

Table 7 Computation of the deviation to the reference standard variety of SR 2 and the two best IRCT glandless varieties.

Values of the reference standard variety	Quotation of deviation per kg of lint (B=Baht)	Difference to the standard variety in unit SR 2	412	413	in Baht SR2	412	413
Length = 28.2	+1.0 B/mm	+0.5	+4.0	+3.0	+0.50	+4.00	+3.00
Uniformity = 48.0	+0.1 B/%	-0.7	+1.5	+0.8	-0.07	+0.15	+0.08
Tenacity = 21.0	+.03 B/gtex	-2.6	-0.9	+1.0	-0.78	-0.27	+0.30
Elongation = 6.0	+0.25 B/%	-0.5	-0.6	-0.8	-0.13	-0.15	-0.20
Maturity = 80.0	0.1 B/%	-3.4	+10.4	+1.1	-0.34	+1.04	+0.11
Fineness = 185	-0.025 B/mtex	-20	-50	-22	+0.50	+1.25	+0.55
Profitablity index (without neps) in baht: PT =					-0.32	+6.02	+3.84

Table 8 Estimates of differences between SR 2 and the two best IRCT glandless varieties.

Values of the reference variety	Differences between varieties (Baht/Kg of lint)[1] IRCT 412/SR 2	IRCT 413/SR 2	IRCT412/IRCT413
Length = 28.2	+3.50	+2.50	+1.00
Uniformity = 48.0	+0.22	+0.15	+0.07
Tenacity = 21.0	+0.51	+1.08	–0.57
Elongation = 6.0	–0.025	–0.075	+0.05
Maturity = 80.0	+1.38	+0.45	+0.93
Fineness = 185	+0.75	+0.05	+0.70
P.I. in baht/kg:	+6.335	+4.155	+2.18
As % of lint price:	+15.8%	10.4%	+5.5%

1 Price of one kg of lint = 40 Bahts.

Table 9 Estimates of ginning out turn benefits provided by IRCT 412 and IRCT 413 varieties compared to SR 2 variety.

Variety	% Fiber	Supplementary production at national level lint (ton)	baht (million)
SR 2		39.5	(38.000)
IRCT 412	43.8 (+4.3)	+4000 (+10%)	4000 x 46335 = 185.3
IRCT 413	42.7 (+3.2)	+3000 (+8%)	3000 x 44155 = 132.5

Table 10 Recapitulation of value added provided by varieties IRCT 412 and IRCT 413 compared to the control SR 2.

(in baht, million)

Variety	added value % fiber	added value technology	Total added value
IRCT 412	185.3	240.7	426.0
IRCT 413	132.5	157.9	290.4

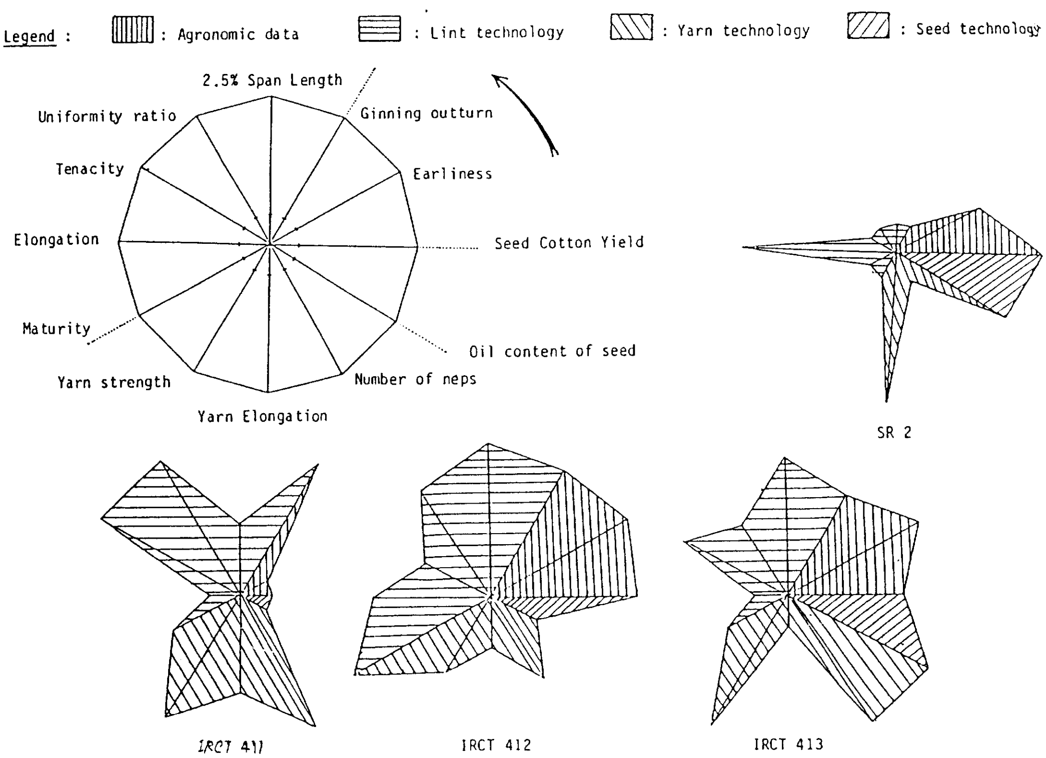

Figure 3 Diagrammatic representation of twelve key characteristics observed for the study of cotton varieties by using the star method.

and yarn technology analyses provided by Mr. Eric Hequet and Mr. R. Frydrych, both from IRCT Fiber Technology Division, were also very helpful in the preparation of this article.

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